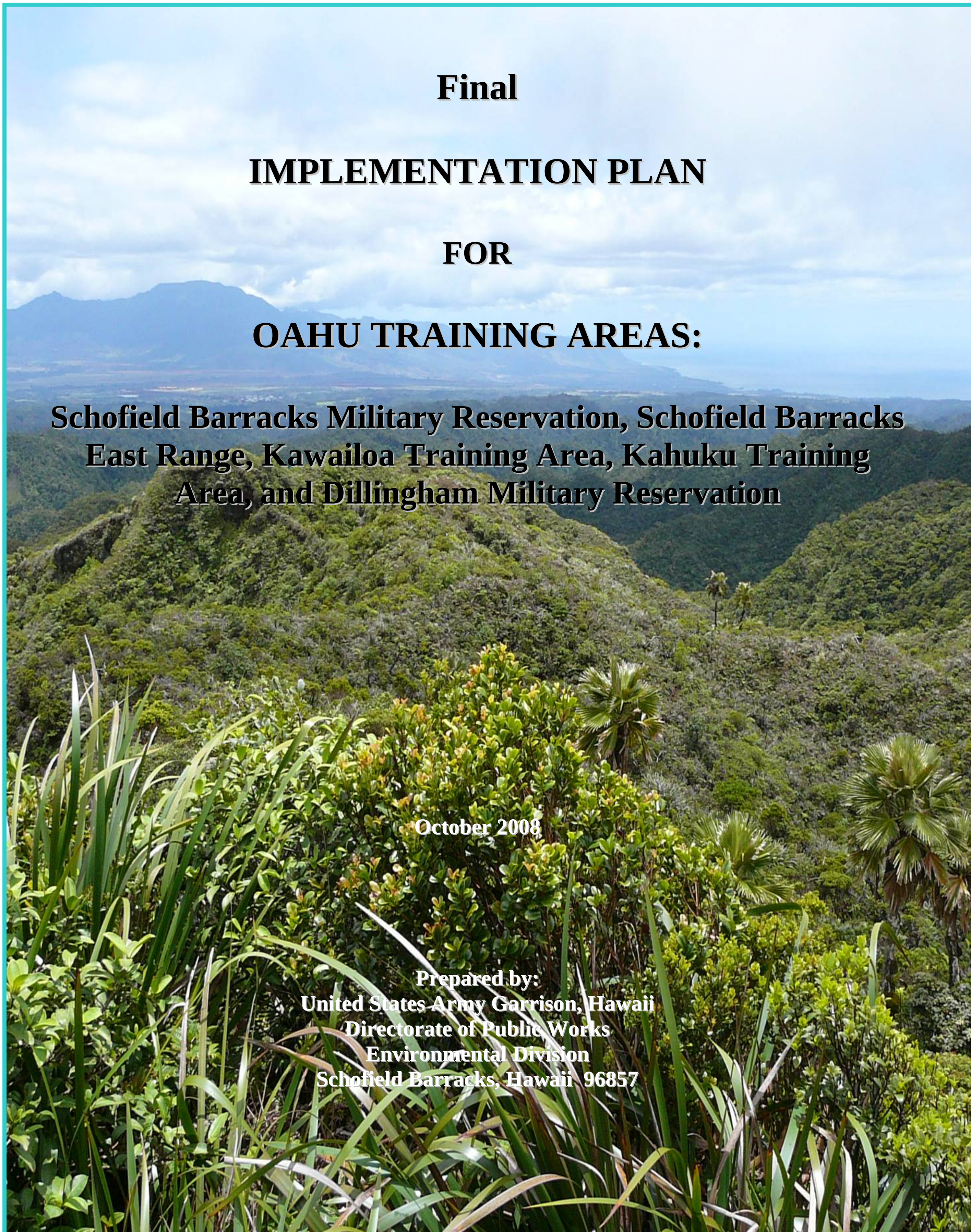

Final

IMPLEMENTATION PLAN

FOR

OAHU TRAINING AREAS:

Schofield Barracks Military Reservation, Schofield Barracks East Range, Kawailoa Training Area, Kahuku Training Area, and Dillingham Military Reservation

October 2008

Prepared by:
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DEPARTMENT OF THE ARMY
HEADQUARTERS, 25TH INFANTRY DIVISION &
UNITED STATES ARMY GARRISON, HAWAII
SCHOFIELD BARRACKS, HAWAII 96857-5013

Final
Implementation Plan
For
Oahu Training Areas: Schofield Barracks Military Reservation, Schofield Barracks East Range, Kawailoa Training Area, Kahuku Training Area, and Dillingham Military Reservation

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Final Oahu Implementation Plan 2008
Executive Summary

USFWS Consultation and the Oahu Implementation Plan

The Oahu Implementation Plan (OIP) was prepared to guide the U.S. Army Garrison Hawaii (Army) in the ongoing conservation and stabilization efforts for 23 endangered plant species, several endangered snail species, and one endangered bird species potentially affected by military training at all of the Army training installations on Oahu (except Makua). In 2003, the Army initiated formal Section 7 consultation with the U.S. Fish and Wildlife Service (USFWS) by providing a Biological Assessment (BA) for military training at Schofield Barracks Military Reservation (SBMR), Kahuku Training Area (KTA), Kawailoa Training Area (KLOA), Schofield Barracks East Range (SBER), South Range Acquisition Area (SRAA), and Dillingham Military Reservation (DMR). In October 2003, the USFWS issued a non jeopardy Biological Opinion (BO) with the condition that the Army prepare an Implementation Plan outlining the measures necessary to stabilize the listed species on these installations with less than three stable populations and/or more than 50 percent of known individuals occurring within the action area (AA). The consultation utilized an AA that encompasses all land potentially affected by military training (i.e. fire, invasive species introductions, etc.) and thus includes a small area outside the installation boundaries. Pursuant to the requirements of the 2003 BO, the Army prepared a draft OIP and submitted it to the USFWS in June 2005. Due to a heavy workload, the USFWS did not comment on the plan until 2007. During 2007 and 2008, the Army and USFWS worked together to finalize the document and address the USFWS concerns.

The content, and stabilization plans in the OIP were based on the basic premises contained in the Makua Implementation Plan (MIP) and its Addendum, finalized in 1999 and 2005. However, the general format of the OIP is slightly different than the MIP and reflects changes suggested by the Army and USFWS after utilizing the MIP for several years. In addition, the MIP was written by the Makua Implementation Team (MIT), which consisted of various biologists and field experts from the USFWS, the Army, U.S. Geological Survey, Hawaii Natural Heritage Program (HNHP), The Nature Conservancy of Hawaii (TNCH), the University of Hawaii, Honolulu City and County Board of Water Supply, and the State of Hawaii Department of Land and Natural Resources (DLNR) (MIT 1999). The OIP was written by the Army and reviewed by the USFWS. Many members of the MIT served as an informal review committee, herein referred to as the Oahu Implementation Team (OIT).

Species Stabilization Summary

Stabilization, as defined by the USFWS, is three naturally reproducing population units (PUs) for the 23 plant species, an ongoing predator control program with documented population increases for 75 pairs of Oahu elepaio (*Chasiempis sandwichensis ibidis*), and 6 PUs of at least 300 individuals of varying size/age classes of each of 4 *Achatinella* tree snail populations in the KLOA and SBER AA (USFWS 2003). Stabilization also requires that all the threats be controlled at each of the above mentioned PUs. The SBMR AA overlaps with the original Makua AA, therefore there are 12 target taxa found in both AAs. These species are currently being managed under the MIP. If the Makua AA changes due to a change in fire modeling or training to not include these overlapping species, stabilization efforts for the affected species will be adopted by the OIP based on the stabilization plans in the MIP. The Army has chosen to stabilize four population units for each plant species that is in both the Makua and Oahu AAs due to the increased risk from military training. Therefore, OIP will result in stabilization of 68 plant, 24 snail, and multiple elepaio populations. The OIP identifies additional management actions, beyond those already utilized by the Army, needed to stabilize these target taxa. If at any time there is a change in the Oahu training areas or Oahu AAs, or if there is a change in species status, or the discovery of additional taxa within the Oahu AA, the Army would be required to reinitiate consultation with the USFWS pursuant to Section 7 of the Endangered Species Act. The current status of each target taxa proposed to be managed for stability is listed in Tables II and III below. The numbers of individuals are recorded as seedlings or juveniles, immatures, or adults. The target number of individuals to reach stability is listed in parentheses beneath the scientific name. The populations that are at stabilization target numbers are in bold; however, this does not reflect threat control which is also a requirement of stabilization. The management units that proposed to protect these population units (PUs) are listed and are bolded if they have already been constructed.

Stabilization is the first step toward species recovery. However, endangered species recovery is beyond the Army's responsibilities under the section 7 consultation process. The OIP provides background information on the distribution, biology, and current status of each species in the individual taxon summaries and stabilization plans. Beyond specific species information and guidelines, the Army adopted the management guidelines discussed by the MIT. These guidelines are reproduced within this document for reference and are altered slightly to be OIP specific. In order to achieve species stabilization, threats to the managed populations must be controlled, and each managed PU must be sufficiently represented in *ex situ* collections. Threat control for the target taxa includes control of feral ungulates, fuels management, weed control, control of predators such as small mammals, and control of various insect pests and diseases. In order to control these threats, fenced management units (MUs) are proposed both inside and outside the AA in the Waianae and Koolau Mountains to encompass target taxa PUs. Approximately 33 MUs are either proposed or existing and contain a total of 3,224 acres. Although some MUs are shared with the MIP, 1,870 acres are specific to the OIP.

<u>Timeline</u>

At this time the Army currently considers Fiscal Year 2008 (1 October 2007 through 30 September 2008) OIP year 1. Therefore, OIP year 2 will begin in Fiscal Year 2009 (1 October 2008 through 30 September 2009). The timeline and costs for the OIP are projected over 20 years, wherein actions outlined in the OIP will be initiated. The Army has developed a tier system for management of the OIP species due to the minimal threat from military training on the species located in the KLOA and SBER AAs. There have been no foot maneuvers in the vicinity of target taxa within KLOA and SBER within the last 10 years. For this reason, the Army will monitor the use of these training areas and initiate stabilization only when use of the training areas will potentially affect the target taxa (see Chapter 5.1 Army Stabilization Priority Tiers). To ensure that these species persist, the Army plans to continue the current conservation efforts including building MUs for KLOA and SBER species and practicing threat control, as feasible, as part of the Army's proactive species conservation approach and Integrated Natural Resources Management Plan (INRMP).

Cost

The expected costs for each Tier are described in detail in section 3 of this document. Years two and three are presented both with and without the cost of the three large SBMR fences that have been planned as a result of unexpected training range availability. These three large fences (North Haleauau, South Haleauau, and Mohiakea) total 975.2 acres and will need to be constructed by 2011. These fences are expected to cost approximately 2 million dollars to construct. In order to meet the range availability timeline these fences will have to be contracted out.

Cost and the number of staff required for Tiers 1-3 are presented in the Table I below for years 2-10. Table II shows costs for years 2 and 3 without the large SBMR fences. The OIP is subject to the availability of funds and nothing in this plan should be interpreted to violate the Anti-deficiency Act. The Army intends to fund the program through its operating funds each year. The Army will continue to be an active member of regional conservation efforts through the OIP and MIP. Additionally, the successful implementation of the OIP ensures that the Army will be in compliance with the Endangered Species Act while still being able to accomplish its training missions.

Table I. Estimated cost by year including large West Range fences (in Millions)

	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
Tier 1 cost $	3.3295	4.1908	2.787	2.8441	3.0270	3.0094	3.1152	3.2084	3.3054
Tier 1 people #	31.5	31.8	32.0	32.6	32.8	32.8	32.8	32.8	32.8
Tier 2 cost $	3.6005	4.452	3.121	3.178	3.168	3.095	3.115	3.196	3.3389
Tier 2 people #	35.0	35.3	35.5	36.1	36.3	36.3	36.3	36.3	36.3
Tier 3 cost $	3.6183	4.478	3.148	3.205	3.194	3.121	3.141	3.222	3.3653
Tier 3 people #	35.7	36	36.18	36.77	36.94	36.97	36.98	36.99	37.016

Table II. Without WR fences

	year 2	year 3
Tier 1 cost $	2.7694	2.7225
Tier 1 people #	31.5	31.5
Tier 2 cost $	3.0404	2.991
Tier 2 people #	34.8	34.82
Tier 3 cost $	3.0313	2.991
Tier 3 people #	34.8	34.81

Organization of this plan

Section 1 of this plan is the Implementation Plan. This document is arranged somewhat differently than the Draft OIP. Within Implementation Plan, species descriptions and background information are combined directly with the conservation plans for ease of reading. Major chapters include: Geographic Scope to the Oahu Implementation Plan, Oahu Implementation Team, Management Designations, Threat Assessments, Monitoring, Individual Species Plans, and Management Unit Plans. Each species management plan (chapter 9-11) is meant to be a self contained outline of important biological background information and the conservation plan that is to be implemented. The management of each plan has been overseen and commented on by the OIT. Any changes to this document will be discussed at the annual Implementation Team meeting; usually around December or January of each year. Following Section 1 is an appendix (Section 2) that contains specific protocols on rare species management written by the Hawaii Rare Plant Restoration Group (HRPRG), the rare snail working group, and monitoring specialist Jim Jacobi. Finally, Section 3 describes the cost assumptions and cost estimates of each Tier and OIP year.

Note on the use of Hawaiian diacritical marks in this plan

The Hawaiian language is heavily used in place names and common names of target taxa. Hawaiian spelling makes use of special diacritical marks, including the glottal stop (‘) and macron (a line over a vowel, signifying a long vowel) that are considered important in correct spelling of Hawaiian words. While the importance of correct use of Hawaiian diacritical marks is recognized, the complex interface between databases, spreadsheets and word processing platforms within this document forced the simplification of spelling of Hawaiian words, dropping the use of glottal stops and macrons. A list of the proper spelling of the major Hawaiian place names used in this plan is provided in Appendix 1.1: Spelling of Hawaiian Place Names.

Table III. Oahu Implementation Plan Plant Status Summary.

OIP Plant Stabilization Status				
Species (stabilization target #)	**Manage for Stability PUs**	**Status (Bold = at target #s)**	**Genetic Storage Initiated**	**Proposed MU (Bold = completed)**
Tier 1				
Abutilon sandwicense (50)	Kaawa to Puulu	18/33/2	Yes	Manuwai MU
	Kaluakauila (Makua reintro)	0/23/0	yes	**Kaluakauila MU**
	Ekahanui and Huliwai	14/30	Yes	Ekahanui MU
	Kamaili	5/58/4	No	Kamaili MU
Cyanea acuminata (50)	Haleauau to Makaleha	**85/8/0**	Yes	**Kaala MU**
	Helemano-Punaluu summit ridge to north Kaukonahua	59/13/7	No	Poamoho MU
	Kahana and South Kaukonahua	2/0/0	No	South Kaukonahua MU
Cyanea koolauensis	Kaipapau, Koloa, and Kawainui	49/16/6	No	Koloa MU

OIP Plant Stabilization Status				
Species (stabilization target #)	**Manage for Stability PUs**	**Status (Bold = at target #s)**	**Genetic Storage Initiated**	**Proposed MU (Bold = completed)**
(50)	Kaukonahua	11/1/0	No	North and South Kaukonahua MUs
	Opaeula to Helemano	9/2/0	No	**Opaeula/Helemano MU**
Cyanea st.-johnii (50)	Helemano	6/0/0	Yes	**Opaeula/Helemano MU**
	Ahuimanu-Halawa	6/0/1	Yes	North Halawa Mu
	Waimano	8/0/20	Yes	Waimano MU
Eugenia koolauensis (50)	Pahipahialua	**81/73/1240**	Yes	**Pahipahialua MU**
	Kaunala	48/93/6	Yes	**Kaunala MU**
	Oio	17/14/40	Yes	**Oio MU**
Gardenia mannii (50)	Haleauau	3/0/0	Yes	North Haleauau MU
	Lower Peahinaia	34/1/0	No	Lower Peahinaia MU
	Helemano-Poamoho	17/0/0	No	Lower Poamoho MU
Hesperomannia arborescens (25)	Kaluanui to Kaiwikoele	**48/3/28**	No	Koloa MU
	Palikea Gulch	0/0/0	No	-
	Kaukonahua	**68/47/122**	No	South Kaukonahua MU
	Lower Opaeula	**42/0/0**	No	Lower Peahinaia II MU
Huperzia nutans (50)	Kahana and North Kaukonahua	6/0/0	No	North Kaukonahua MU
	Kawainui-Koloa summit ridge	1/0/0	No	Koloa and Kaiapapau MUs
	South Kaukonahua	1/0/0	No	South Kaukonahua MU
Labordia cyrtandrae (50)	East Makaleha to North Mohiakea	**62/0/2**	Yes	**Kaala**, East Makaleha, and South Haleauau MUs
	Manana	1	Yes	Manana MU
Melicope lydgatei (50)	Kaiwikoele-Kawainui Ridge	3/0/0 (50)	No	Kawailoa MU
	Kawaiiki and Opaeula	38/0/0	Yes	Lower Peahinaia MU
	Reintro? Manana? Poamoho?	0	0	?
Phyllostegia hirsuta (100)	South Central Haleauau	5/9/0	Yes	South Haleauau MU
	Kaluaa to South Waieli	1/2/3	Yes	**Kaluaa and Waieli MU**
	Koloa	Reintro.	Yes	Koloa MU
Phyllostegia mollis (100)	Ekahanui	13 (reintro)	Yes	**Ekahanui MU**
	Kaluaa	1; 15/38	Yes	**Kaluaa and Waieli MU**
	Pualii	0	Yes	**North Pualii MU**
Pteris lidagatei (50)	Helemano	0/2/2	No	Helemano MU (needs extension to be included)
	Kawainui (kawainui 3)	0/1/0	No	-
	South Kaukonahua	6/0/0	No	South Kaukonahua MU
Schiedea trinervis (150)	Kalena to East Makaleha	**169/206/322**	Yes	**Kaala,** South Haleauau, and Mohiakea MUs

OIP Plant Stabilization Status				
Species (stabilization target #)	**Manage for Stability PUs**	**Status (Bold = at target #s)**	**Genetic Storage Initiated**	**Proposed MU (Bold = completed)**
Stenogyne kanehoana (100)	Haleauau	1	Yes	North Haleauau MU
	South Kaluaa	36 (reintro)	Yes	**Kaluaa and Waieli MU**
	Central Kaluaa	18(reintro)	-	**Kaluaa and Waieli MU**
Tier 2				
Chamaescyse rockii (50)	Helemano	7/1/0	No	**Opaeula and Helemano MU**
	Kaipapau, Koloa, and Kawainui	20/7/2	No	Koloa MU
	Waiawa and Waimano	15/0/0	No	Waiawa MU
Cyanea crispa (50)	Kawaiiki	2/15/0	Yes	Kaipapau II and III MU
	Kahana and Makaua	6/0/0	No	Kahana MU
	Wailupe	5/1/0	Yes	Wailupe MU
Cyrtandra viridiflora (50)	Kawainui and Koloa	21/5/1	Yes	Koloa MU
	Helemano and Opaeula	40/14/6	Yes	**Helemano and Opaeula MU**
	South Kaukonahua to Kipapa summit	0/2/0	No	South Kaukonahua MU
Myrsine juddii (25)	Koloa	**25**	No	Koloa MU
	Opaeula/Helemano	**400**	No	**Opaeula and Helemano MU**
	Poamoho	**27**	No	Poamoho MU
Sanicula purpurea (100)	Poamoho summit	1/10/12	Yes	Poamoho I MU
	North of Puu Pauao	0/21/0	No	Poamoho III MU
	Schofield-Waikane Trail Summit	2/25/0	No	South Kaukonahua II MU
Viola oahuensis (50)	Helemano and Opaeula	**82/85/20**	No	**Helemano and Opaeula MU**
	Kaukonahua	25/0/0	No	South Kaukonahua MU
	Koloa	15/7/6	No	Koloa MU
Tier 3				
Cyrtandra subumbellata (50)	Punaluu	**200**	No	-
	Kaukonahua	2/0/1	No	South Kaukonahua MU
	Kahana	8/7/0	Yes	Kahana MU
Lobelia gaudichaudii subsp. *koolauensis* (100)	Kaukonahua	3/45/2 (100)	No	South Kaukonahua MU
	Kipapa	**100/20/0**	No	Kipapa MU
	Waiawa to Waimano	10/100/0	No	Waiawa MU

Table IV. OIP *Achatinella* Stabilization Status

OIP *Achatinella* Stabilization Status				
Species	**Geographic Unit**	***in situ* #s**	***ex situ* #s**	**Proposed MU (Bold = completed)**
Achatinella apexfulva	Poamoho	0	2	n/a
Achatinella bulimoides	Punaluu Cliffs	2	43	n/a
Achatinella byronii/decipiens	GU A East Range	6	30	South Kaukonahua MU
	GU B Puu Pauao	16	-	Poamoho III MU
	GU C Poamoho	69	-	Poamoho II MU
	GU D Punaluu Cliffs	3	-	-
	GU E North Kaukonahua	175	-	North Kaukonahua MU
Achatinella lila	GU A Poamoho Summit	39	544	Poamoho I MU
	GU B Peahinaia Summit	11	-	Opaeula and Helemano MU
	GU C Opaeula-Peahinaia Summit	45	-	Opaeula and Helemano MU
Achatinella livida	GU A Crispa Rock	60	-	Kaipapau II MU
	GU B Northern	5	-	Koloa MU
	GU C Radio	83	108	Kaipapau I MU
Achatinella sowerbyana	GU A Kawainui Ridge	2	-	-
	GU B Kawaiiki Ridge	3	-	-
	GU C Opaeula Helemano	344	-	**Opaeula and Helemano MU**
	GU D Poamoho Summit & Trail	302	45	Poamoho I MU
	GU E Poamoho Pond	90	-	Poamoho II MU
	GU F Poamoho-North Kaukonahua Ridge	2	-	Poamoho III MU
	GU G Lower Peahinaia	40	-	Lower Peahinaia MU; subunits I and II

Table of Contents for the Oahu Implementation Plan

SECTION 1: BACKGROUND AND METHODOLOGY

SECTION 2: APPENDIX

Appendix Standards and Guidelines for Implementation Actions

SECTION 3: COSTS

List of Tables

List of Figures

1.0 Introduction

Background and project scope

In 1998, the U.S. Army (Army) initiated formal consultation under section 7 of the Endangered Species Act (16 U.S.C. 1531 et seq.) with the U.S. Fish and Wildlife Service (USFWS) to determine if routine military training at Makua Military Reservation (MMR) would jeopardize the continued existence of 41 endangered species. This first consultation resulted in the Makua Implementation Plan (MIP), a comprehensive conservation plan to stabilize each of those species (MIT 2003). In 2003, the USFWS issued a Biological Opinion (BO) (USFWS 2003) for the Oahu Army Training Areas. These include Dillingham Military Reservation (DMR), Kahuku Training Area (KTA), Kawailoa Training Area (KLOA), Schofield Barracks Military Reservation (SBMR), Schofield Barracks East Range (SBER), and South Range Acquisition Area (SRAA). The USFWS BO concluded that the routine military training and the conservation measures identified by the Army in its Oahu Biological Assessment (BA) (Army 2001) would not jeopardize the endangered species found within the action area. The conclusion of no jeopardy was based on preparation and implementation of a wildland fire management plan and preparation and implementation of an Implementation Plan for listed species within the Oahu training areas. The OIP is modeled directly after the MIP (MIT 2003).

Like the MIP, this consultation used an action area (AA) (area potentially affected by military training) that was larger than the actual installation boundary to account for the potential impact from military training on the listed species. For example, the Koolau Mountains AA along the summit extends approximately 100 meters beyond the installation boundaries of KTA, KLOA, and SBER to account for potential weed introductions along the Koolau summit trail. For Schofield West Range, the AA follows the installation boundary line, though it encompasses all of Puu Pane outside the AA on the North side of the installation to account for potential fires from training. Although neither DMR or SRAA contain endangered species requiring stabilization pursuant to the 2003 BO, both AAs are potential sites for fire and weed introduction and will be monitored utilizing the non-management unit monitoring protocols of this document (Chapter 6.3 Monitoring and Adaptive Management; Monitoring Protocols for Areas Outside Management Units).

The current document, the Oahu Implementation Plan (OIP), is the result of the 2003 consultation. Like the MIP, the OIP identifies additional management actions beyond those the Army was already implementing or agreed to implement in the BA to stabilize the target taxa. A draft OIP was completed in 2005 and is the basis for this final version (Army 2005). The management of the endangered taxa for which either a significant portion of the populations occur within the AA or for which no populations are stable, hereafter referred to as target taxa, are the focus of this plan.

The OIP consultation includes 32 endangered plant species, one endangered bird species, and several endangered Hawaiian tree snail species that may be affected by military training activities on these Oahu Army installations. Of these 44 species, 12 plant species and one snail species are currently being stabilized under the MIP. Therefore, the OIP outlines the stabilization of the remaining 23 plant species, one bird species, and 10 snail species (four snail species are not currently known to be extant, however this document outlines extensive surveying efforts that may result in rediscovery of these taxa. See Chapter 9.1: Stabilization Plan for Four *Achatinella* Species). If at any time the MIP action area (AA) changes to not include these overlapping species, the OIP will assume stabilization responsibility for these species.

With the recent listing of several native *Drosophila* species the Army has initiated surveys to detect the presence of listed endangered fly species within the Army training areas. So far, the Army has noted *Drosophila substenoptera* from SBMR. Once surveys are complete, the Army will consult with the USFWS and the Oahu Implementation Team (OIT) and create stabilization plans if required.

To stabilize the target taxa, each taxon must be maintained with sufficient numbers of populations to ensure their long-term viability. Additionally, threats to the managed and reproducing individuals in each population must be controlled, and each taxon must be adequately represented in *ex situ* (out of the wild) collections. Stabilization is only the first step toward eventual recovery of these endangered species. However, recovery of these taxa is beyond the Army's responsibilities under Section 7 of the Federal Endangered Species Act. Due to the extensive framework already laid out by the MIP, the OIP was prepared by the Army with the review and input of the OIT. This group is the same as the MIT and consists of the Army, U.S. Fish and Wildlife Service (USFWS), the State of Hawaii, The Nature Conservancy of Hawaii (TNCH), University of Hawaii, U.S. Geological Survey, Oahu Plant Extinction Prevention program, and independent expert botanists and ornithologists (see Table 1.1).

The Army has chosen to create a tiered system for management based on the actual threat of military training versus the perceived threat, presented in Chapter 5.1: Threat Assessments: Stabilization Prioritization for the OIP. Due to the relatively low threat from military training to listed species in the Kawailoa (KLOA) and Schofield Barracks East Range (SBER) training areas, the Army is proposing a three tiered stabilization approach. Tier 1 is the highest stabilization priority and includes all target taxa with occurrences in highly utilized training areas with a fire threat such as: Schofield Barracks West Range (SBWR) and Kahuku Training Area (KTA). Tier 2 is a secondary priority to be initiated to full stabilization of Tier 2 target taxa when military training occurs along trails in the upper reaches of KLOA and SBER. Tier 3 species are the lowest stabilization priority and will receive full stabilization when military training occurs off trails in the upper reaches of KLOA and SBER or near tier 3 target taxa. Some tier 2 and 3 actions such as management unit construction, surveys, and genetic storage collections, etc., may be conducted prior to those tiers being initiated if they are in areas that also contain Tier 1 species or if management partnerships with other agencies arise. This serves as a proactive management approach in anticipation of Tier 2 and 3 training activities.

Table 1.1 Members of the Oahu Implementation Team

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The OIP provides the basis for meeting the taxon stabilization requirements of the 2003 BO. Successful implementation of the OIP assures that the Army is in compliance with the Endangered Species Act and can still accomplish its training mission. The major features of the OIP are:

- Identify areas either within the Oahu AAs or off-site for priority taxa stabilization.
- Determine a gross scale estimate of the minimum viable population for each taxon considered likely to be jeopardized by Army activities, i.e. target number of individuals for stabilization.
- Determine intermediate and final definitions of success for stabilization of each taxon.
- Determine habitat management requirements for each taxon.
- Identify the areas to be surveyed within the Oahu AA and on off-site stabilization areas for incipient weeds.
- Outline methods for monitoring, data tracking, analysis, and feedback
- Develop a schedule for completion of implementation actions and a cost estimate for implementation of each identified action.

Triggers for reinitiation of consultation
The Army is required to reinitiate formal consultation with the USFWS if:

- The amount of incidental take is exceeded.
    - For the Oahu consultation, take was set at no more than 1 occurrence of *Achatinella mustelina* of 10-40 individuals over the next 10 years. The USFWS does not anticipate any take of Koolau species of *Achatinella* because of the low level of training in the Koolaus; *A. apexfulva*, *A. bulimoides*, *A. byronnii*, *A. curta*, *A. decipiens*, *A. leucorraphe*, *A. lila*, *A. livida*, *A. pulcherrima*, and *A.*

sowerbyana. Additionally, Oahu elepaio take was set at no more than two active Oahu elepaio (*Chasiempsis sandwichensis ibidis*) pairs or active elepaio nests per year over the first five years after implementation, and no more than one elepaio pair or nest per year and/or the loss of an area equivalent to no more than one elepaio territory per year.

- New information reveals effects of the agency action that may affect listed taxa or critical habitat in a manner or to an extent not considered in any previous biological opinions.
  - Examples: Previous biological opinions include the 1999 and 2001 Makua biological opinions and the 2003 Oahu biological opinion (USFWS 1999, 2001, 2003). USFWS and the Army agree that if a taxon within the AA currently not included in this plan decreases to such a level that the Army's actions may potentially jeopardize the taxon (*i.e*., the entire taxon falls below stability levels throughout its range), the Army is required to reinitiate consultation to include that taxon. Or if there is a discovery of any new endangered taxa within the AA. Each year, the USFWS and the Army should review the current status of non-target AA taxa throughout their range as part of the IP review process. If either agency becomes aware of a change in the status of the taxon (in or out of the AA), the agency will inform the OIT.
  - If a non-target AA taxon changes in status to below stability, the Army may become responsible for its stabilization. The USFWS is responsible for tracking the status of such taxa outside of the AA. If taxa already included in the IP reach stability either through management actions or the location of additional populations, the Army would not need to reinitiate consultation, since this is the goal of the IP and measures are included in the IP to potentially reduce management actions and monitor such a taxon to ensure it maintains stability.
- The agency action is subsequently modified in a manner that causes an effect to the listed taxon or critical habitat not considered in the biological opinion.
  - Such modifications may include the use of new types of ammunition or new training maneuvers that may have a high risk for causing fire or new locations for use of current weapons/maneuvers.
- A new taxon is listed or critical habitat is designated that may be affected by the action.
  - The Army is required to reinitiate consultation once any new critical habitat is proposed to ensure that its actions do not adversely modify critical habitat for those endangered taxa within the AA which are proposed for designation. The funding and implementation of this IP may preclude the need to designate critical habitat within any of the MUs.

Integrated biological and training based approach

Similar to the MIP, the OIP has been developed from a biological perspective. Although primarily taxon-based, an emphasis on habitat restoration and ecosystem processes is recognized, focusing on 1) the intrinsic value of *in situ* biological webs in designated sensitive/special areas, 2) building on habitat restoration and threat removal/control, 3) stabilizing habitat and allowing for natural recovery, and 4) utilizing augmentation and reintroduction of a taxon as needed. However, in contrast to the MIP, the decisions on the specific management actions and the locations of these actions designated in the OIP were based on both the biological needs of the target taxa and the level of threat posed by military training to the target taxa. For instance, for the species in the Koolau AA, the Army is proposing to conduct most of the stabilization actions on-site. This is because the Army does not conduct live fire training maneuvers within KLOA or SBER. Additionally, foot maneuvers within proximity to the target taxa inside the AAs have not taken place over the last 10 years. Therefore, the current threat from fire, trampling and weed introduction from Army training is low to nonexistent. Habitat quality in the Koolau AA is also acknowledged to be much higher than habitat in either SBMR or Makua. In the event that Army training levels and subsequent threat levels caused by Army training increase in the Koolau AA, the Army will reinitiate consultation to readdress the stabilization plans for each of the target taxa to potentially include more off-site stabilization areas.

Related to this general biological approach is the recognition that intensive management efforts at taxon and habitat levels can have negative effects on the target taxa, other sensitive taxa, and native ecosystems if not properly implemented. In addition to proposing actions beneficial to the target taxa, the avoidance of negative affects of proposed actions; "do no harm" is an important guiding principle. The protocols developed for the MIP designed to minimize negative effects of human activities in native ecosystems such as inadvertent introduction of alien weeds, introduction of pathogens, trampling of vegetation, opening of trails, increased fire risk, and genetic contamination via inappropriate outplantings, will be followed closely for the OIP. These protocols protect not only the target taxa, but also other sensitive rare and endangered taxon known to occupy the proposed management areas.

The target taxa

All of the target taxa are federally endangered species endemic to the Hawaiian Islands (see Table 1.2). The majority of the target taxa are endemic to Oahu alone. Several species have current distributions restricted to within the action area. Taxa that have been recorded historically in the AA, but are currently not known to persist there have not been considered for inclusion among the target taxa. Exceptions to this decision are several *Achatinella* species. Four were included in the Oahu BA and BO as being currently extant because the last observation dates are within the last 30 years, however no individuals are known to exist. Additionally, two species of snails, *A. byronnii* and *A. decipiens*, have been considered synonymous by several field experts due to the lack of apparent morphological differentiation in the currently extant populations of these species. The Army has always managed these two species as synonymous and the USFWS treated them as a single entity in the Oahu BO. Stabilization plans for these species include genetic research on extant individuals to clear up taxonomic issues and field surveys to potentially recover species without extant populations.

A large patch of *Stenogyne kanehoana* was found in SBMR in 2004 (after the original Oahu BO was final in 2003), therefore this species was not included in the initial consultation. Following its discovery, the Army informed the USFWS and included this species in the Draft OIP (2005). Because there have only been two known locations of this species in existence in the last 20 years, this species fits the status required for stabilization as identified in the 2003 BO. This species is being incorporated into the OIP in lieu of reopening the formal section 7 process. There are also several other listed species that were included in the Oahu BO but were not considered for stabilization. Stabilization is required when a species has less than three stable populations, does not have naturally reproducing populations, or more than 50% of the individuals occur in the action area. If the status of any listed species within the action area that do not require stabilization (Table 1.3) changes to meet the stabilization criteria the Army will work with the OIT to develop stabilization plans for those species.

Table 1.2 Target taxa of the Oahu Implementation Plan

Scientific name	Hawaiian name	Action Area	Current Range*
Abutilon sandwicense	-	SBMR, MMR	W
Alectryon macrococcus var. *macrococcus*[1]	*Mahoe, Alaalahua*	SBMR, MMR	W
Chamaesyce rockii	*Akoko*	KLOA, SBER	K
Cyanea acuminata	*Haha*	SBMR, KLOA, SBER	K, W
Cyanea crispa	*Haha*	KLOA	K
Cyanea grimesiana ssp. *obatae*[1]	*Haha*	SBMR, MMR	W
Cyanea koolauensis	*Haha*	KTA, KLOA, SBER	K
Cyanea st.-johnii	*Haha*	KLOA	K
Cyrtandra dentata[1]	*Haiwale*	MMR, KLOA	K, W
Cyrtandra subumbellata	*Haiwale*	SBER	K
Cyrtandra viridiflora	*Haiwale*	KLOA, SBER	K
Delissea subcordata[1]	-	SBMR, MMR	W
Eugenia koolauensis	*Nioi*	KTA	K, W
Flueggea neowawraea[1]	*Mehamehame*	SBMR, MMR	W
Gardenia mannii	*Na`u, Nanu*	SBMR, KTA	K, W
Hesperomannia arborescens	-	SBMR, KLOA, SBER, KTA	K, W
Hesperomannia arbuscula[1]	-	SBMR, MMR	W
Huperzia nutans	-	KLOA, SBER	K
Labordia cyrtandrae	*Kamakahala*	SBMR	K, W
Lobelia gaudichaudii ssp. *koolauensis*	-	KLOA, SBER	K
Melicope lydgatei	*Alani*	KLOA	K
Myrsine juddii	*Kolea*	KLOA, SBER	K
Phyllostegia hirsuta	-	SBMR, KLOA, SBER	K,W
Phyllostegia kaalaensis[1]	-	SBMR, MMR	W
Phyllostegia mollis	-	SBMR	W
Plantago princeps[1]	*Ale*	SBMR, MMR	K, W
Pteris lidgatei	-	KLOA, SBER	K, WMA
Sanicula purpurea	-	KLOA, SBER	K, WMA
Schiedea kaalae[1]	-	SBMR, MMR	K, W
Schiedea trinervis	-	SBMR	W
Stenogyne kanehoana	-	SBMR	W
Tetramolopium filiforme[1]	*Pamakani*	SBMR, MMR	W
Viola chamissoniana ssp. *chamissoniana*[1]	*Pamakani*	SBMR, MMR	W
Viola oahuensis	-	KLOA, SBER	K
Chasiempis sandwichensis ssp. *ibidis*	*Oahu elepaio*	SBMR	K, W
Achatinella apexfulva [2]	*Pupu kaneoe, Pupu*	KLOA	K

	kuahiwi, Kahuli		
Achatinella bulimoides[2]	*Pupu kaneoe, Pupu kuahiwi, Kahuli*	KLOA	K
Achatinella byronii/decipiens	*Pupu kaneoe, Pupu kuahiwi, Kahuli*	KLOA, SBER	K
Achatinella curta[2]	*Pupu kaneoe, Pupu kuahiwi, Kahuli*	KLOA	K
Achatinella leucorraphe[2]	*Pupu kaneoe, Pupu kuahiwi, Kahuli*	KLOA, SBER	K
Achatinella lila	*Pupu kaneoe, Pupu kuahiwi, Kahuli*	KLOA	K
Achatinella livida	*Pupu kaneoe, Pupu kuahiwi, Kahuli*	KLOA	K
Achatinella mustelina[1]	*Pupu kaneoe, Pupu kuahiwi, Kahuli*	SBMR, MMR	W
Achatinella pulcherrima[2]	*Pupu kaneoe, Pupu kuahiwi, Kahuli*	KLOA	K
Achatinella sowerbyana	*Pupu kaneoe, Pupu kuahiwi, Kahuli*	KLOA	K

*Current Range abbreviations: W = Waianae, K=Koolau, WMA = West Maui,
1 Stabilization Plans for these taxa are found in the MIP
2 These species are not currently known from any extant populations. Extensive surveys are planned for these species. See Stabilization Plan for *Achatinella* species.

Table 1.3 Non-Stabilization Federally listed taxa that occur in the Oahu Action Area

Scientific name	Hawaiian name	Federal Status	Training Area	Current Range
Cyanea humboldtiana	*Haha*	Endangered	KLOA, SBER	K
Diellia falcata	-	Endangered	SBMR, MMR	W
Isodendrion longifolium	*Aupaka*	Threatened	SBMR, KLOA	W,K
Lepidium arbuscula	-	Endangered	SBMR, MMR	W
Schiedea hookeri	-	Endangered	SBMR, MMR	W
Tetraplasandra gymnocarpa	*‘Ohe‘ohe*	Endangered	KLOA, SBER, KTA	K

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2.0 Geographic Scope of the Oahu Implementation Plan

Introduction

The Oahu Implementation Plan (OIP) action area (AA) is much larger and varied in scope and size than that of the Makua Implementation Plan (MIP). The Oahu AA encompasses 6 different training areas; Schofield Barracks Military Reservation (SBMR), Schofield Barracks East Range (SBER), Kawailoa Training Area (KLOA), Kahuku Training Area (KTA), South Range Acquisition Area (SRAA), and Dillingham Military Reservation (DMR). These training areas occur in both the Waianae and Koolau Mountains. In some cases, the AA surrounding each of these training areas extends beyond the actual installation boundary due to the potential risk of damage or destruction from military activities originating from within the respective training areas (see Figures 2.1-2.5).

The geographic scope of the OIP includes the AA surrounding each training area plus the portions of the natural geographic ranges of the target taxa considered necessary to achieve stability of these taxa. Therefore, the OIP management actions are not restricted to within the AA but encompass some population units in other portions of both the Waianae and Koolau Mountains. However, due to the lower risk from military training in the KLOA, SBER, and upper KTA, most of the Koolau management actions are proposed within the action areas. This is in contrast to management actions for species within SBMR and Makua Military Reservation (MMR), where species stabilization is required outside the AA due to the higher level of threat from military training.

The Waianae region

The Waianae Mountains contain a significant portion of the botanical resources in the Hawaiian Islands. Many species are endemic to this mountain range and are also some of the State's rarest species. Most of the rare species involved in the consultation for SMBR in the Waianaes are associated with native-dominated vegetation in mesic habitats to wet boggy forest at the summit of Kaala. In SBMR, the AA follows the installation boundary along the South and West sides, while on the North and North East sides, the AA extends beyond the installation boundary to encompass Puu Pane, to account for the potential fire threat from live-fire training. The proposed management units in relation to the AAs are shown in Figure 2.1-2.3.

The Koolau region

The Koolau Mountain region within and adjacent to the AA consists of mesic and wet mesic native Hawaiian forests with large portions of the habitat relatively intact. The lower elevations within KTA, KLOA, and SBER are composed of mixed introduced and native mesic vegetation. The upper elevations and summit areas of these training areas are dominated by native mesic and wet mesic forests. These areas represent some of the most intact native forest areas on Oahu.

The KTA AA extends beyond the North and East installation boundaries. The KLOA and SBER AAs follow the installation boundaries except along the summit areas in the eastern portion, where the AA extends approximately 100m beyond the installation to account for potential weed introduction caused by military foot maneuvers along the summit trail. Current locations for the Oahu Target Taxa (see Table 1.2 for a list of species) are shown in relation to the action area and various state and federal forest reserves in Figures 2.4-5. The proposed management units in relation to the AAs are shown in chapter 12: Management Units.

Ownership and management patterns adjacent to the action areas
There are multiple landowners involved in the proposed actions for the federally listed species within the Oahu AA. These include the U.S. Government (i.e. U.S. Army), the State of Hawaii, Honolulu City and County, and private landowners. The major patterns of ownership and management are depicted in Figures 2.4 and 2.5. These maps indicate the specific jurisdiction of the parcels (*e.g.*, state, federal, private, city and county, *etc*.). The State's game management areas, public hunting areas, and members of the Koolau Mountain Watershed Partnership are also depicted.

A variety of native taxa and habitats exist in both the Waianae and Koolau and management efforts are underway on many of these lands. For example, portions of the Waianae Mountains are designated as reserves of the State Natural Area Reserves System (NARS), where the land is managed primarily to protect and preserve native ecosystems and taxa. Pahole NAR, Mt. Kaala NAR, and Kaena Point NAR all have active programs of ungulate and weed management, native vegetation restoration, native taxon reintroduction, and other protective management. The Army is already an active participant in the ecosystem level conservation of these areas through the Makua Implementation Plan (MIP) (MIT, 2003). State Forest Reserves occur in both the Waianae and Koolau Mountains and provide protective conservation zoning and programs for public hunting. Additionally, the State has proposed to turn the Poamoho portion of the Ewa Forest Reserve into a NAR. The Board of Water Supply lands in upper Makaha Valley are designated as protected watershed with limited public access. A portion of the land holdings of the Estate of James Campbell in the southern Waianae Mountains is managed by The Nature Conservancy of Hawaii as the Honouliuli Preserve, and is dedicated to native taxon and ecosystem protection. Active programs for rare plant and snail protection (including fencing, ungulate control, weed control, and predator control) are underway, as well as some native vegetation restoration projects. The Army's environmental program is engaged in a variety of active management programs in MMR and Schofield Barracks Military Reservation, as well as in other selected areas of the Waianae Mountains.

In the Koolau Mountains, the Koolau Mountains Watershed Partnership (KMWP) has facilitated conservation projects across the range and continues to secure funding for long term conservation efforts. The Oahu Plant Extinction Prevention Program (OPEP) also works in partnership with the Army, the KMWP, the State, U.S. Fish and Wildlife Service, and The Nature Conservancy of Hawaii (TNCH) in the conservation of some of the islands most endangered plant species. Additionally, the Oahu Invasive Species Committee (OISC) is actively managing Oahu's most incipient invasive species, some of which occur within the AA.

The Army's proposed management programs and the conservation partnerships with KWMP, OPEP, TNCH, and OISC include fencing for ungulate control, weed control, snail predator control, rare plant reintroduction, elepaio predator control, and limited vegetation restoration. Through the activities of these programs and various landowners, significant taxon and habitat level management is already underway, contributing to the protection of both Makua and Oahu target taxa as well as other native taxa.

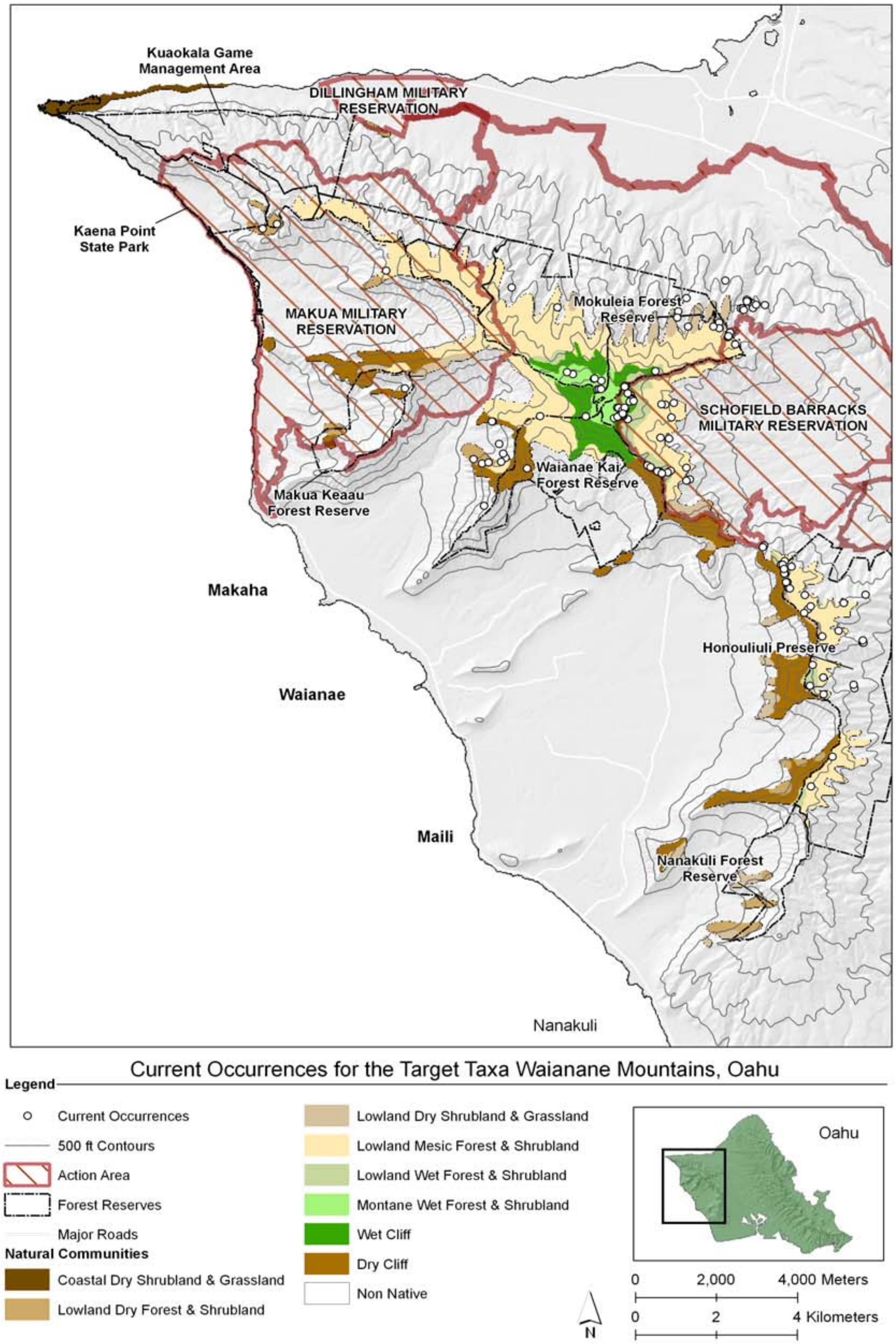

Figure 2.1 Current occurrences of Oahu Implementation Plan target taxa in the Waianae Mountains, Oahu.

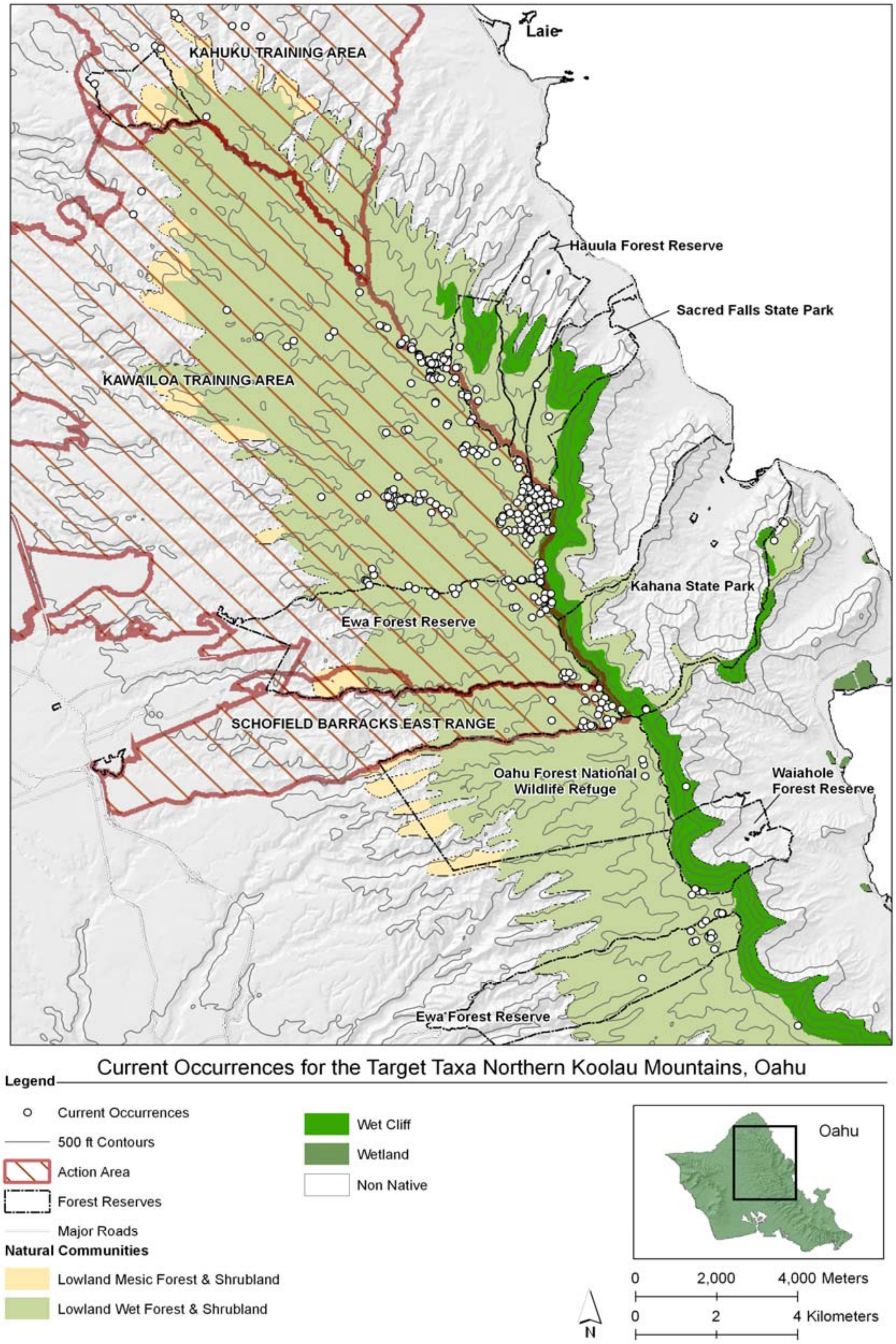

Figure 2.2 Current occurrences of Oahu Implementation Plan target taxa in the Northern Koolau Mountains, Oahu.

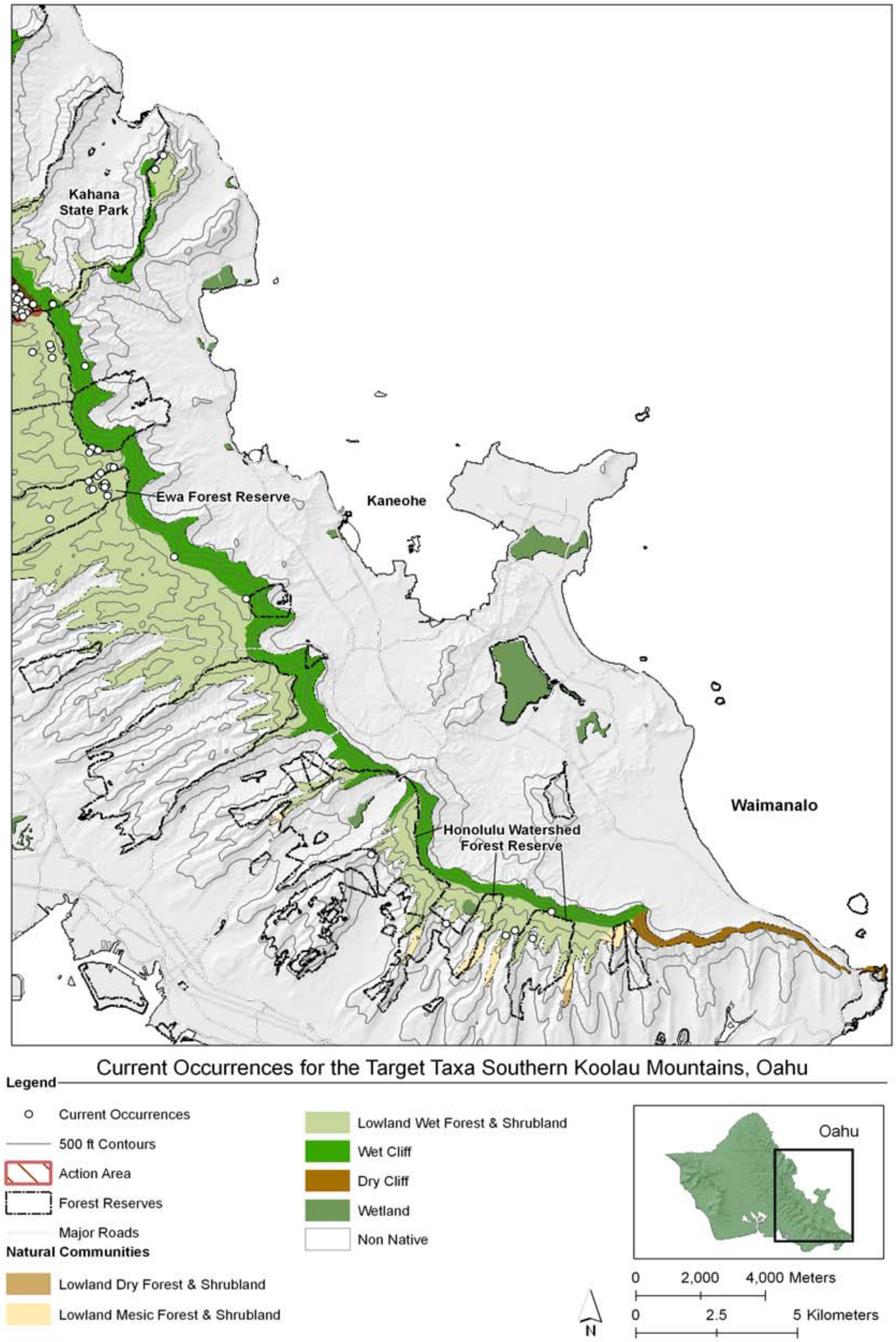

Figure 2.3 Current occurrences of Oahu Implementation Plan target taxa in the Southern Koolau Mountains, Oahu.

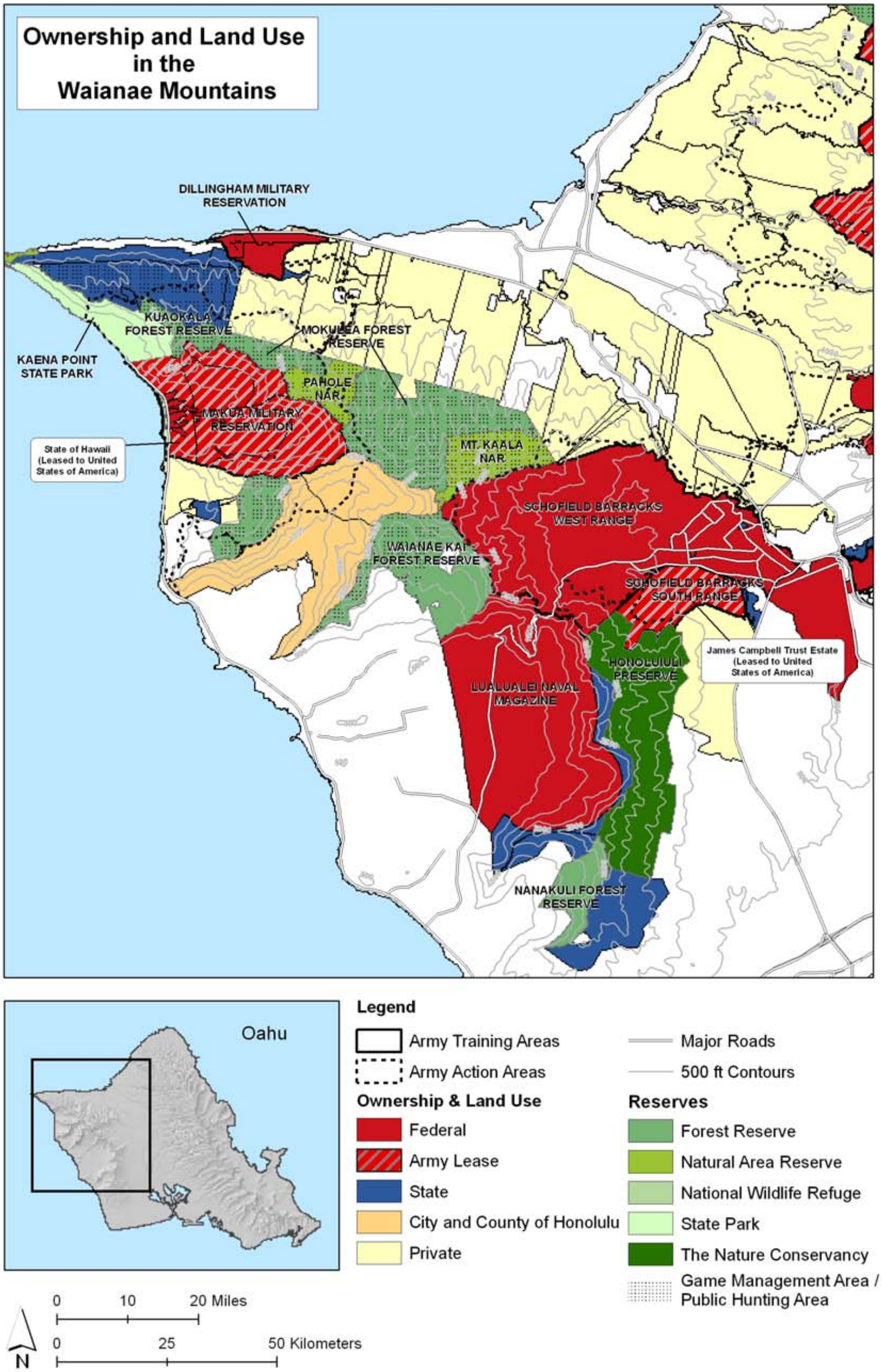

Figure 2.4 Ownership and land use in the Waianae Mountains, Oahu.

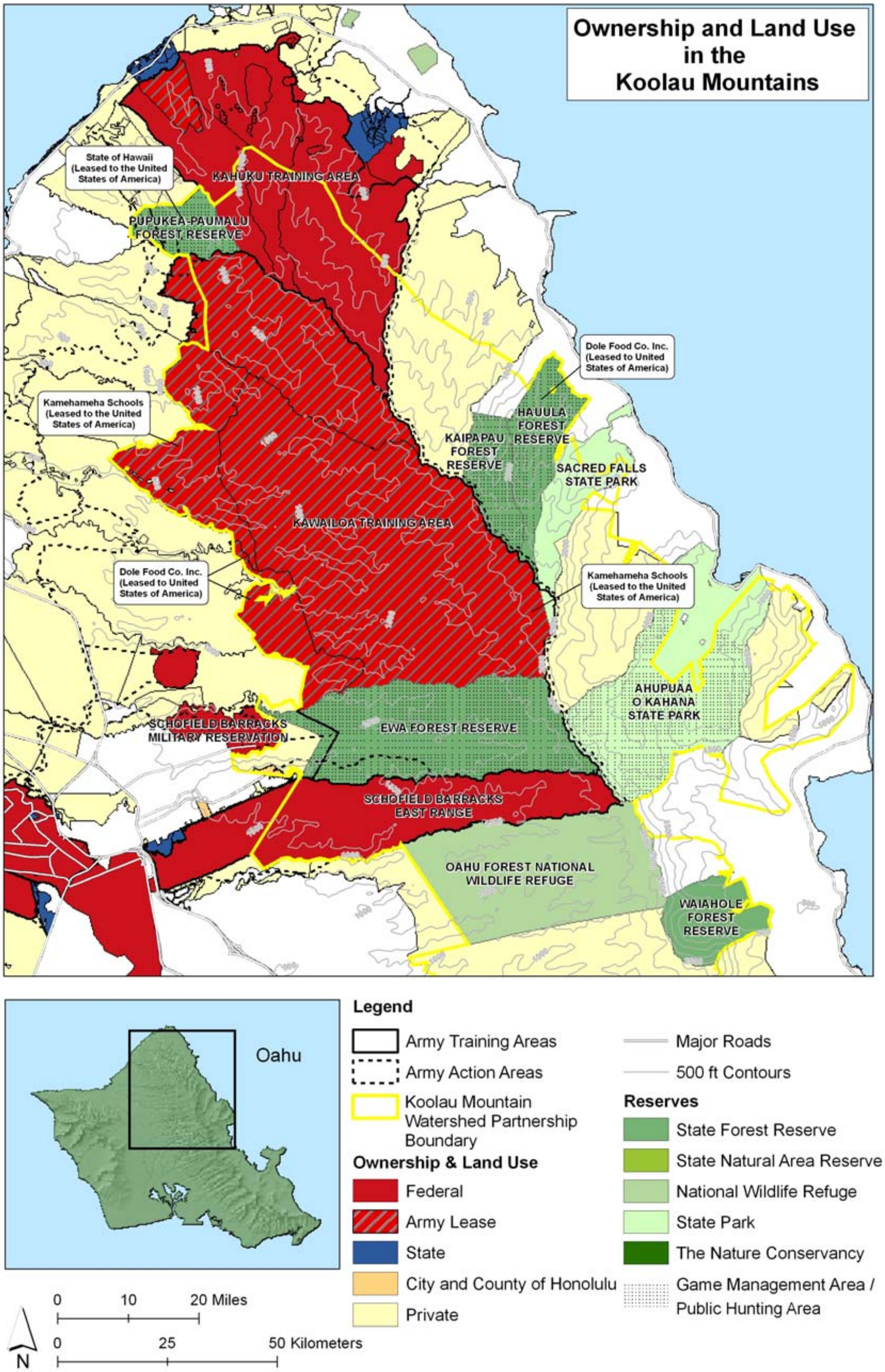

Figure 2.5 Ownership and land use in the Northern Koolau Mountains, Oahu.

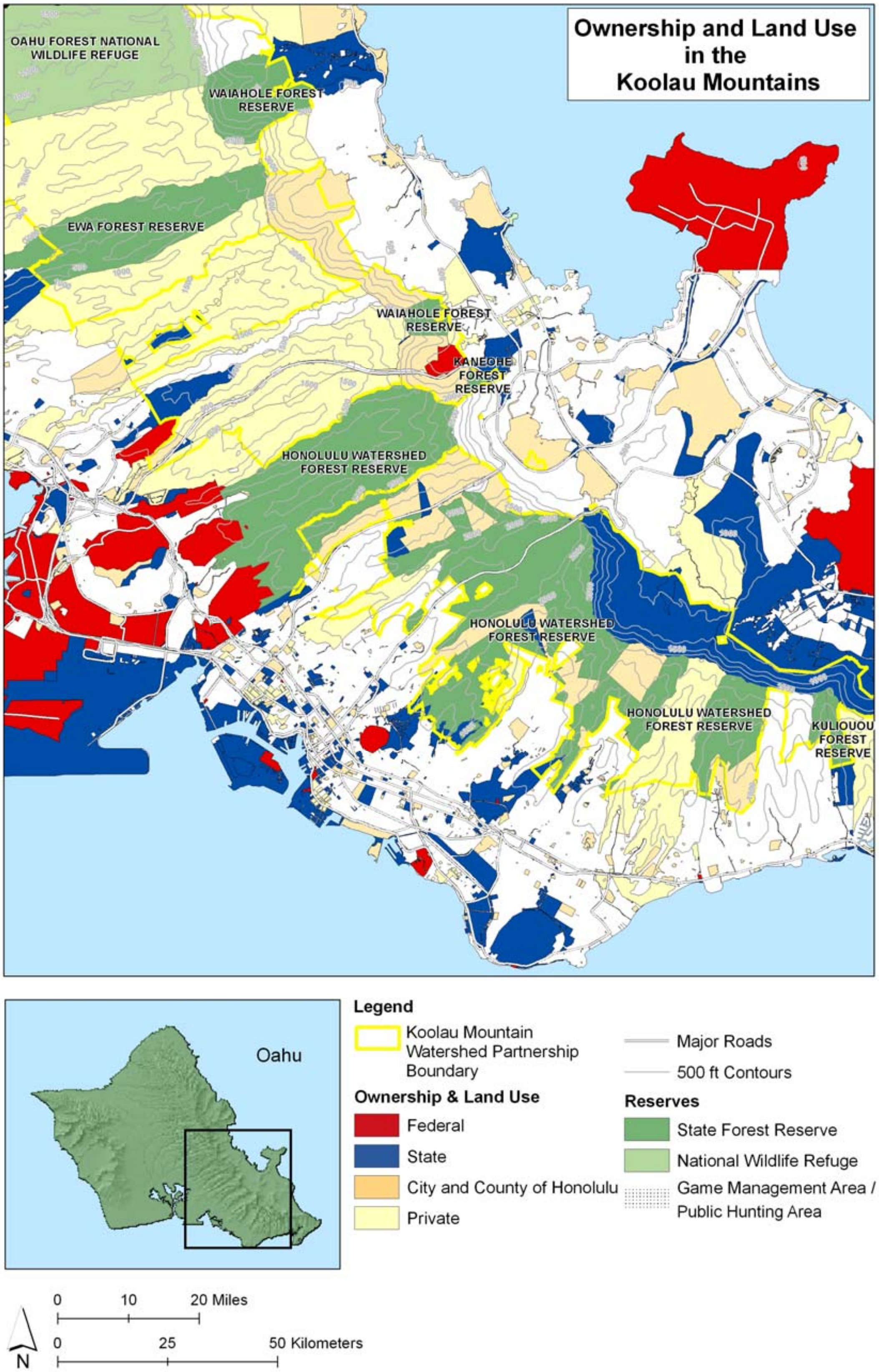

Figure 2.6 Ownership and land use in the Southern Koolau Mountains, Oahu.

3.0 Identification of Units for Management of Oahu Plant, Snail, and Elepaio Populations

The identification of units for stabilization of plant populations for the Oahu Implementation Plan (OIP) was based on the formula used by the Makua Implementation Team (MIT) for the Makua Implementation Plan (MIP). However, for the OIP, preference was given to populations within the action area (AA) in the Koolaus because of the reduced threat from military training to these populations. Therefore, unlike the MIP some plant populations were favored for stabilization inside the AA rather than attempting to capture a large geographic range across the three stabilization populations of each species. Snail population units within the Koolau action area were determined based on the knowledge of extant populations and the historical geographical range of the species (see below). Genetic analyses may aid in determining the number of populations to manage in order to capture the largest amount of genetic diversity for the species (see *Achatinella* stabilization plans for genetic analyses underway). The Elepaio population units were based on the knowledge of species and the currently occupied habitat.

Ideally, the Oahu Implementation Team (OIT) and the MIT would like to use a calculated minimum viable population (MVP) size for each species for a measure of success of stabilization. However, while determining the MVP for a given taxon is useful for measuring the likelihood of success of different management actions in reaching stability, it was agreed that the biological information needed to conduct such analyses is not available for the either the MIP or the OIP target taxa. This is especially true for those taxa with extremely small populations in highly degraded and fragmented habitats. In many cases, it is not clear how to define separate populations, since this requires knowledge of mechanisms for gene flow within and between populations for the different species, which can only be generally characterized at this point. Throughout the MVP literature, it is stressed that demographic and environmental considerations are of greater immediate concern than any population size criteria, and that management rather than population size is more likely to increase the likelihood of population stability in the short term. This means that stabilization should focus on the factors influencing rarity rather than a minimum number of individuals. However, the IT recognizes that this type of data collection can aid in the stabilization of the target taxa weather or not it is utilized for determining MVP sizes (i.e. providing opportunities for: lifecycle study, effects of aboitic factors, and interactions with other species) (Morris et al. 1999, Morris and Doak 2002). Therefore, data collection is encouraged by the IT and MVP calculations for feasible species are a recommended conservation measure of the Oahu Biological Opinion (USFWS 2003).

The major types of data needed are population size, demographic data (i.e. stage or age classes and survivorship of individuals in each class), fecundity estimates (i.e. number of fruit/offspring produced each year by each individual, *in situ* germination rates), soil seed bank estimates, etc. The Army does not currently track all of this information but some of this information is available for some species. In general population sizes are known for all target taxa, and some fecundity estimates are known.

Snail geographic units (GUs)

The Koolau *Achatinella* species have fewer individuals and populations and a much smaller geographical range than *Achatinella mustelina* in the Waianae Mountains. *Achatinella mustelina* management was addressed in the MIP, and the MIT determined that populations to be managed for *A. mustelina* would be best determined by genetic analyses. However, due to the lack of known individuals and populations for the Koolau *Achatinella* species, the OIT agreed to population units based on known occurrences as most are very discrete and geographically separated by several hundred meters. Therefore, all extant populations of *A. byronnii, A. lila,* and *A. livida* will be managed for stability. The OIT determined that the known extant PUs of these species are sufficiently disconnected from each other to be considered separate populations. Alternatively, *A. sowerbyana* has a greater extant geographical range and larger number of populations. For this reason the OIT recommended that population units be determined by genetic analyses. Until the genetic analyses are completed the OIT has based PUs on geographic occurrences, modeled after the *A. mustelina* ecologically significant units (ESU) from genetic analyses conducted for the MIP (Holland and Hadfield 2002). The Koolau *Achatinella* species were put into Geographic Units (GUs) until genetic analyses are completed (see individual stabilization plans for more information).

Plant populations units (PUs)

For the Oahu plants, the OIP followed the basic population size criteria developed by the Hawaii and Pacific Plants Recovery Coordinating Committee (HPPRCC 1994), the same criteria used in the MIP (see paragraphs below).

Because biological populations are so difficult to define, the MIT defined population units (PUs) as manageable geographic units of a given plant taxon. The term PU does not presume that the group of plants interacts genetically and ecologically, as would a true population, but more accurately describes a grouping of plants that may or may not be a viable population. PUs are defined according to geographic separation, the presence of other probable barriers to gene flow (such as ridges and habitat discontinuities), and limited likelihood of susceptibility to any given threat event. Based on the current literature on gene flow for plants, little gene flow occurs between individuals separated by over 500 meters, particularly for those taxa in which pollen from one individual must be transferred to another individual for fertilization to occur (Ellstrand *et al.* 1989). To err on the side of caution, the MIT doubled this distance, since we know so little about the pollination mechanisms and gene flow of the target taxa. As a general guideline, therefore, **PUs are comprised of one or more individuals separated by 1,000 meters from other individuals of the same taxon, or less if other factors, such as barriers to dispersal or gene flow, are also present**. Justifications describing the appropriate separating factors or potential genetic affects on wild PUs are documented in each target taxon's stabilization plans for any PU that violates the 1,000 meter separation guideline.

The OIT assessed current and historic occurrences of the target plant taxa documented from within the Oahu Training Areas and across the state of Hawaii, using the Hawaii Natural Heritage Program database and the Oahu Army Natural Resources geodatabase. From these sources the OIT identified PUs known to be extant in 1983 (20 years prior to the USFWS 2003 BO).

Elepaio Population Units (PUs)

The population unit distinction for the Oahu elepaio appears easy to define compared to the plant populations due to the disjointed extant populations and the unlikelihood of immigration and emigration to and from the surrounding available habitat. There are six large populations and several smaller remnant populations of Oahu elepaio. The smaller remnant populations generally consist of males and are not expected to persist (VanderWerf 1998,1999, 2001, 2002, 2004). The Army is required to conduct predator control on 75 breeding pairs per breading season rather than protect a certain number of PUs (USFWS 2003). See elepaio threat control plan for a table of the known populations of Oahu elepaio.

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4.0 Management Designations

For the 23 plant species, several snail species, and 1 bird species managed under the Oahu Implementation Plan (OIP) situations vary from arguably stable population units (PUs) containing hundreds of vigorous individuals to severely reduced PUs with one or a few individuals at risk of imminent extirpation. Therefore, the range of possible *in situ* management can vary from maintenance of current conditions and encouragement of natural regeneration on one end to salvage of genetic material from the last declining individual on the other.

In general, the goal for stabilization of each plant species is three stable populations. For the Koolau snails in the action area the long-term goal is 6 PUs, each with 300 individuals across the size classes. For most *Achatinella* species in the Koolaus there were not 6 PUs available to manage and therefore all extant PUs were chosen for management for stability. Pursuant to the USFWS 2003 biological opinion the goal for Oahu elepaio is to conduct threat control for a total of 75 breeding pairs across several sites. These sites may change as more information is available. Optimally, the Army and USFWS would like management to occur within the action area for the Elepaio. For the plants, the Army chose three PUs in the best habitats with the highest numbers of individuals to manage for stability, with preference given to populations within the action area. The Oahu Implementation Team (OIT) suggested that the three PUs attempt to represent the geographical, and expectantly, the genetic range of each target species, but agreed that the threat from military training is much lower for the Koolau target taxa. For some species, entire PUs may not be feasible to manage within fenced units. Therefore, if the PU is designated for stability, the individuals that fall outside the proposed management unit (MU) will be used for genetic storage collections which may be used for augmentation within the MU.

Manage for stability

Management of a PU for stability means achieving the target number of reproducing individuals for the PU, controlling threats to the PU, and ensuring that genetic material of individuals in the PU are adequately represented *ex situ*. The management designation described in the OIP for each PU will be retained even if the number of individuals falls to zero, pending review by members of the OIT. This counteracts a trend of decline for most of the endangered target taxa. In order to achieve the stability goals, threats must be managed to an existing or reintroduced PU over the long term at a broader habitat level, typically within a fenced MU. The intent of management is to remove or reduce limiting factors to individuals in the PU so that their numbers remain at, or increase to, stable levels as defined in the OIP (see chapters 9, 10, 11 for individual species management targets). Inherent in management for stability is a program of monitoring to gauge the response of target taxa to management efforts. If the number of individuals in a PU falls, management should adapt to deal with the likely causes of decline through additional threat management and/or augmentation of the existing PU. Augmentation represents a special action to bolster population levels in a declining PU, but must be dealt with carefully (see Chapter 11.3: Reintroduction and Augmentation).

Because management for stability involves a large set of coordinated tasks and subtasks, the OIT utilized the list compiled by the MIT outlining the major management actions, and the subtasks that they trigger, for application to each PU slated for such management.

Manage for stability subtasks for plants and snails are as follows:

1. Collect propagules (individuals for snails) for genetic storage
2. Assess threat management needs
3. Manage threats as needed:
    a) Ungulate control (possible short-term, small-scale fence)
    b) Weed control (control aggressive understory weeds within 2 m radius)
    c) Small mammal control
    d) Slug control
    e) Chinese rose beetle control
    f) Black twig borer control
    g) Two-spotted leafhopper control
    h) Other threats as assessed
4. Monitor response to management actions (see Chapter 6: Monitoring)
5. Manage data
6. If augmentation is indicated:
    a) Collect propagules (seeds or cuttings) for augmentation from designated source populations (see taxon stabilization plan for details); For snails- determine if lab populations are able to support a reintroduction (see rare snail reintroduction protocols USFWS 2008)
    b) Propagate for augmentation
    c) Prepare plants for outplanting following phytosanitation protocols (see Appendix 2.2: Phytosanitation Standards and Guidelines)
    d) Survey for appropriate outplanting sites
    e) Prepare site for outplanting (*e.g.*, weed control, hole preparation)
    f) Conduct augmentation
    g) Continue threat management
    h) Monitor augmentation (see Chapter 6: Monitoring)
    i) Data management

Manage for genetic storage collection

The original intent of the designation to manage a PU for genetic storage in the Makua Implementation Plan (MIP) was to achieve adequate and appropriate *ex situ* storage of a target taxon's genetic material as insurance against loss of a PU or important wild individuals. This designation was assigned for each PU in the MIP not designated as managed for stability. This is also the case for the OIP target taxa. However, genetic storage collections for species in Tiers 2 and 3 will begin opportunistically until the initiation of those tiers and after the collection from manage for stability PUs (see Chapter 5: Threat Assessments, Stabilization Priority Tiers). Therefore, the main goal of this management designation for the OIP is to function as a source for propagules for augmentation and/or as a backup in case actively managed *in situ* PUs are lost. Management of the PU and collection and storage of propagule material will continue until sufficient numbers have been met to satisfy collection goals as identified in the stabilization plans for each target taxon. Collections to refresh plant storage material will be undertaken at appropriate intervals to maintain a viable bank for implementation actions and for contingencies. However, for PUs managed only for genetic storage collections management will not continue once initial collection goals are met. Options include seed storage (preferred for taxa whose seeds are not recalcitrant), *in vitro* tissue storage, and living collections (cultivated plants. Periodic germination tests of samples in seed storage will be conducted to ensure viability of stock. If the germination rate drops by 15% from the initial rate, this will trigger a recollection effort and/or growing of the collected seed for outplanting or *inter situ* management. Guidelines on the minimum number of collections among populations and individuals to ensure good genetic representation and variability have been reviewed and summarized by the MIT/OIT in Appendix 2.4: Plant Propagule Collection Protocols.

Subtasks related to management of genetic storage collection PUs for plants are as follows:

1. Collect propagules for genetic storage
2. Assess threat management needs
3. Manage threats (as needed):
    a) Ungulate control (possible small-scale fence)
    b) Weed control (reduce competition and fire risk)
    c) Small mammal control
    d) Slug control
    e) Chinese rose beetle control
    f) Black twig borer control
    g) Two-spotted leafhopper control
    h) Other threats as assessed
4. Monitor response to management actions
5. Manage data

5.0 Threat Assessments and Stabilization Priority Tiers for the Oahu Action Area

Management unit (MU) and population units (PUs) threats
Part of the necessary background information for the management of the target taxa is a clear assessment of the threats that can hamper the stabilization of each taxon. Fire ignition and introduction of alien taxa, such as weeds and pest animals, are the most important of these threats in the Oahu action area, and have been characterized in the Oahu Biological Assessment (U.S. Army 2003). In many cases, the threats that are not training-related are held in common among all or most of the target taxa. For example, feral ungulates such as goats and pigs are primary threats to both habitat and individual rare taxa, and the distribution of pigs and goats in the Waianae region (and other target taxon population locations) is generally well known. Other threats are particularly important for certain target taxa (*e.g.*, powdery mildew affects many of the mints; *Phyllostegia* sp., *Stenogyne kanehoana*). A discussion of the threats to each target taxon, a table of the priority PUs for management actions and a table defining *in situ* threats can be found in each one of the individual taxon summaries (see individual species Taxon Summaries and Stabilization Plans). Specific threat categories assessed include:

- alien plants (weeds)
- erosion
- feral ungulates
- fire
- human activities
- invertebrate pests
- pathogens
- small mammals

In many cases, the specific threats (*e.g.*, the predatory alien snail *Euglandina rosea* as a predator of *Achatinella* species, and rats as a predator of Elepaio) are well documented. In cases where the impacts of suspected threats upon target taxa are undocumented or poorly understood (*e.g.*, invertebrate predation on target plants), research needed to gain insight as to the significance of the threat is identified. Additionally, there are impacts of a threat upon target taxa that are well documented but methods to adequately control the threat have not yet been developed (*e.g.*, black twig borer control). The Army has and will continue to support research on various threat control research projects via supporting a full time protection research specialist, supporting graduate student projects, and cooperative projects with other agencies (see http://www.botany.hawaii.edu/faculty/duffy/DPW.htm for current Army year end reports for research project descriptions). Recently the Army helped support research on slug abundance and response to slug treatment, rate of damage from black twig borer to *Fluggea neowawraea*, and is currently supporting research on *Euglandina rosea*, and rat densities.

Field experts including members of the Army natural resources staff determined the level of threat posed by each category to each particular target species. Based on this threat information the Oahu Implementation Team (OIT) integrated threat management, research and monitoring recommendations within each of the individual stabilization plans (see individual species Stabilization Plans).

The Army has been an active participant and supporter in efforts to identify and control incipient alien species through multiagency programs such as the Oahu Invasive Species Committee (OISC). Through this proactive, preventative approach the Army hopes to minimize future management costs by helping to control incipient populations.

5.1 Army Stabilization Prioritization for the OIP

Due to the current and historical low level of impact to federally listed species by military training to the summit areas (where most of the OIP target taxa are located in these training areas) of the Kawailoa Training Area (KLOA) and Schofield Barracks East Range (SBER) the Army is proposing a three-tiered approach to species stabilization in these areas. Currently, the Army may train via foot maneuvers in the upper portions of both training areas. However, in practice, foot maneuvers or bivouac in these species sensitive areas have not taken place in the past ten years. Current training maneuvers within KLOA and SBER, include the use of designated landing zones and surrounding areas for bivouac. Thus, the implementation of the Oahu Implementation Plan (OIP) within KLOA and SBER action areas will be based on the low level of threat resulting from Army training.

The Army's stabilization approach is three-tiered based on (1) current training levels within each training area (2) foot maneuvers on trails, and (3) foot maneuvers off trails. Tier 1, year 2 will begin with the finalization of this document as approved by both the USFWS and the Army. Species covered in each stabilization tier are listed in Table 5.1. Year 1 of Tier 2 will begin after the initiation of military training along major trails in KLOA or SBER. Year 1 of Tier 3 will begin after the initiation of military training both on and off major trails in KLOA and SBER.

With the implementation of each Army Stabilization Tier, full taxon stabilization is the goal of the Oahu Implementation Team (OIT). This means that when training maneuvers warrant activation of the respective Army Stabilization Tier the affected species will receive full taxon stabilization as described in each species stabilization plan, as opposed to just stabilizing the affected PUs (see individual species Stabilization Plans). The use of any of the Tier 2 and 3 areas for military training requires stabilization for all Tier 2 and 3 species.

Monitoring for Army Training Effects and Weed Spread Prevention

The Army has planned surveys for all human access points within the training areas. These include: roads, landing zones, and hiking trails. Surveys for incipient or excessively problematic invasive species will be conducted twice a year in coordination with the Oahu Early Detection (OED) Project and the Oahu Invasive Species Committee (OSIC). If incipient invasive species are found, the Army will fund the eradication of these species. These weed surveys will alert the Army DPW Natural Resources Program to any adverse impacts that may be occurring and will minimize the anticipated effects from training. The findings of these surveys may stimulate activation of the 2nd and/or 3rd stabilization tiers. Hiking trails not currently utilized in KLOA and SBER will be surveyed periodically to monitor the baseline of the target taxa prior to military training along trails. The Army Natural Resources Program will also be informed of trail use by Army Range Control. Monitoring for impacts and decline of the target taxa may also be done during regular rare plant and snail surveys conducted outside of proposed management units (see Chapter 6: Monitoring and Adaptive Management; and Cost Estimate Assumption 19.1 Non-Management Unit Incipient Control Areas).

Additionally, the Army will monitor for effects on endangered waterfowl near Dillingham Military Reservation. If impacts from training are considered a threat, noise barriers may be erected. Training in this area is not occurring at the present time however, the Army monitors the area once a quarter for the presence of endangered waterfowl. Surveys, every six months along the proposed military training route, indicate the presence of the Hawaiian Coot (*Fulica americana*) and Hawaiian Common Moorhen(*Gallinula chlorpus sandvicensis*). Both species are Federally listed endangered. The Army Natural Resources Program will propose mitigation measures for noise impacts prior to the initiation of training in this area.

Future Army Training Needs

If the Army's future training needs change, the stabilization requirements may also change. **A reconsultation with the U.S. Fish and Wildlife Service must occur in the case of any changes to the military actions affecting these species.**

Army Stabilization Tier 1

The first tier of Army stabilization is for species that are threatened by the current level of training on all Oahu Army Training Areas (excluding Makua). As a result, all eleven species occurring on Schofield Barracks Military Reservation (SBMR) and Kahuku Training Area (KTA) will have full stabilization efforts underway starting in year one of the OIP (see table 5.1). This is due to the use of live fire in SBMR and off road tactical maneuvers at KTA along with the anticipation of limited live fire training at KTA as a result of the Army Transformation (Army, 2003). Subsequent to the draft OIP, the Army determined that all the Oahu Plant Extinction Prevention (OPEP) species should also be at Tier 1 stabilization priority because of their rarity. The Army will work with OPEP to manage these species both in and out of the action area. Therefore, there are 15 plant species to be stabilized under Tier 1. In addition to the Tier 1 species the Army will conduct surveys for snail species that have no extant populations known; two days a year for each species.

Current use and impact level at KLOA and SBER is low and limited to lower elevation landing zones and roads. Helicopter over-flights are also conducted but do not pose a threat to federally listed species. LZ's and roads are monitored twice a year to minimize the impact from any new weed introductions. All military training vehicles are also washed between training areas to minimize weed introductions.

A total of 26 MUs or MU subunits are planned for Tier 1 stabilization efforts. Six of these are at or near completion. All Tier 1 MUs will be first priority for the OIP. The stabilization of these species will occur in areas with the best habitat available and will be conducted both inside and outside the action area (AA). Tier 2 and 3 fences may be constructed prior to those tiers being initiated, pending funding, as a proactive management measure.

As mentioned above, Tier 1 stabilization efforts include a program of monitoring along roads, hiking trails, and LZs utilized for military training efforts at the present time.

Army Stabilization Tier 2

The second tier of stabilization will be activated when training maneuvers occur along hiking trails in the upper boundaries of KLOA or SBER. Tier 2 stabilization will initiate the stabilization of 14 additional species. Monitoring along currently used LZs will prevent the spread of any incipient weed populations introduced there. Thus, Tier 2 will only be initialized once training maneuvers occur along hiking trails not adjacent to the LZs currently utilized. Once this type of training use is scheduled, Army Natural Resources Staff will work with the unit requesting use to educate them about the natural resources to minimize impact. In order to determine if foot maneuvers are adversely impacting the listed species baseline and periodical monitoring will be done along trails proposed for use by the Army. Thus, pre and post training monitoring will demonstrate the level of impact to the target taxa. The stabilization of these species will occur in areas with the best habitat available and will be both inside and outside the AA. Seven MUs or MU subunits are planned for Tier 2 stabilization efforts.

It is important to note however, that with the addition of a dedicated Army DPW fence crew Tier 2 MUs may be built before actual training efforts have increased to require the initiation of this second level of species stabilization. Many of the Tier 2 fenced MUs are relatively small and could be built in a few days by an experienced remote fencing crew. The Army believes this type of proactive effort will protect the habitat in the event of future training impacts to the area and these efforts are supported by the Army's Integrated Natural Resources Management Plan (INRMP) (Army 2001). These types of efforts have already benefited the upper areas of the KLOA through fenced management units built in partnership with the Koolau Mountains Watershed Partnership (KMWP). However, even with the construction of these management units, full stabilization efforts for the Oahu target taxa within those units may not be initiated until trail based training maneuvers are planned and it is determined that these maneuvers will have an effect on any of the target taxa.

Army Stabilization Tier 3

The third tier of stabilization will be initiated if training maneuvers occur off-trail in the upper reaches of KLOA or SBER action areas. If this type of training were initiated there would be a threat from trampling to 2 additional species. Therefore, with the initiation of the third Tier, all species covered in this consultation will receive full stabilization actions. The initiation of this third tier of stabilization will not require the construction of any additional MUs as the stabilization of these species is currently planned to occur within existing fenced units or within MUs slated for Tier 1 or 2 stabilization efforts.

Table 5.1 Army Target Taxa by Stabilization Priority Tiers. Some species may be located in multiple training areas.

Army Stabilization Tier	Species Name	Army Training Area
Tier 1	*Abutilon sandwicense*	SBMR
	Chasiempis sandwichensis spp. *Ibidis*	SBMR
	Cyanea koolauensis	KTA, KLOA, SBER
	Cyanea acuminata	SBMR
	Cyanea st.-johnii	KLOA
	Eugenia koolauensis	KTA, KLOA
	Gardenia mannii	SBMR
	Hesperomannia arborescens	SBMR
	Huperzia nutans	KLOA, SBER
	Labordia cyrtandrae	SBMR
	Melicope lydgatei	KLOA
	Phyllostegia hirsuta	SBMR
	Phyllostegia mollis	SBMR
	Pteris lidgatei	KLOA, SBER
	Schiedea trinervis	SBMR
Tier 2- for trail maneuvers	*Chamaesyce rockii*	KLOA, SBER
	Cyanea crispa	KLOA
	Cyrtandra viridiflora	KLOA, SBER
	Myrsine juddii	KLOA, SBER
	Sanicula purpurea	KLOA, SBER
	Viola oahuensis	KLOA, SBER
	Achatinella apexfulva	KLOA
	Achatinella byronnii/ decipiens	KLOA, SBER
	Achatinella curta	KLOA
	Achatinella leucorraphe	SBER
	Achatinella lila	KLOA
	Achatinella livida	KLOA
	Achatinella pulcherrima	KLOA
	Achatinella sowerbyana	KLOA, SBER
Tier 3- for off trail maneuvers	*Cyrtandra subumbellata*	SBER
	Lobelia gaudichaudii spp. *koolauensis*	SBER

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6.0 Monitoring and Adaptive Management

The monitoring and adaptive management assumptions for the Oahu Implementation Plan (OIP) are based on those formulated in the Makua Implementation Plan (MIP) (US Army Garrison 1999). Beginning with the implementation of the MIP in 2004 and the MIP urgent actions in 2003, the Army Natural Resources Program has benefited from the monitoring and adaptive management protocols described previously. This adaptive management strategy will continue to be extremely important for the stabilization of species in the Oahu training areas as the Army Natural Resources program will base the Army response level for species within Kawailoa Training Area and Schofield Barracks East Range based on the impact, actual or predicted, by Army training needs (see Chapter 5.1: Threat Assessments; Army Stabilization Priority Tiers).

Adaptive management is management designed to change with conditions and information, using the results of monitoring and other new information to refine the design, scope, or implementation of management actions or the monitoring program for an area or a taxon. Dynamic systems may be difficult to predict, but there are underlying rules and guidelines that can direct changes in management actions according to the results from previous actions. The population status and trends of the target taxa and their habitats are not static, but changing, and we have some idea of their likely response to the management recommended. However, the kind of management, and the intensity and timing of application depend on how the target taxa respond initially to the first actions applied. Accurately assessing the changes in status of target population units (PUs), or the response of other factors affected by management, is the intent of monitoring. Monitoring is an essential and integral part of adaptive management.

Monitoring of the *in situ* and reintroduction populations will be conducted to determine progress toward attaining taxon stability. Monitoring will also be conducted to assess the status of the management unit (MU) relative to control of alien taxa and to habitat restoration. Data to be collected will include number, vigor, and phenological phase of all or samples of the individuals in the PU by size class. This information will be evaluated using an appropriate statistical analysis to assess current and projected status of the monitored PU. Adaptive modifications to the *in situ* management, augmentation, or reintroduction strategies for the PUs for each taxon and each MU will be made based on the results of the monitoring program, and as research results in new information on reintroduction methods and threat control methods. While the stabilization of the PU is the end goal, changes in management of the PU, threats to the PU, and the surrounding habitat must be monitored to determine which factors are affecting the ability to reach stability. Adaptive management options to consider include, but are not limited to:

- increasing or decreasing the number of individuals reintroduced into a site annually during the initial reintroduction phase
- (re)initiating reintroduction or augmentation efforts for a particular PU;
- intensifying or changing post-reintroduction care (*e.g.,* watering reintroductions)
- increasing or decreasing the control of specific threats as indicated by threat monitoring

The comprehensive monitoring plan developed for the MIP follows in this chapter and is not altered from the original MIP (MIT 2003). **Final decisions to change management actions must be approved by the Army and the U.S. Fish and Wildlife Service.**

Measures of Success

The long-term goal of stabilization of the Oahu target taxa is likely to be realized only after decades of management action. The short- and intermediate- term measures of success are defined by the successful completion of the actions during the early periods of the implementation schedule proposed. These measures of success are supported and assessed by monitoring data that will indicate the positive effects of such management. Given the many variables related to the achievement of stability, the Army Natural Resources staff and the U.S. Fish and Wildlife Service (USFWS) cannot offer specific biological expectations for the response of the different target taxa to management beyond the goals listed below and the implementation of scheduled management actions. However, it is intended that biological criteria will be used to a greater extent to assess success in the intermediate and long term.

Milestones in the measures of success

The following is an outline of expected milestones in the short-, intermediate-, and long-term that will be monitored by the U.S. Army and the USFWS, and used to assess compliance with the Endangered Species Act. It is expected that after goals are achieved, maintenance of the actions will continue as needed to ensure stabilization of the target taxa. Except for Urgent Actions, all completion dates are counted from the time of each Army Response Tier initiation (see Chapter 5.1: Army Stabilization Priority Tiers). Urgent actions are defined by the USFWS as those actions that are best implemented before completion of the IP because, where imminent threats are serious for a subset of target taxa and populations, certain management actions are urgently needed.

This bulleted list was created to summarize the specific actions for target taxa and MUs required in the initial and later years of the OIP implementation. This serves as the basis for the short, intermediate, and long-term goals as outlined in the table below.

Short Term Priority Actions- to be initiated within the first 2 years following activation of each active Tier (see Chapter 5.1: Army Stabilization Priority Tiers).

- Complete programmatic NEPA process
- Initiate baseline management and monitoring for all managed populations (manage for stability, manage for genetic storage collections).
- Begin genetic storage testing
- Initiate genetic storage for all taxa in active tiers
- Initiate propagation testing
- Urgent Actions complete (for a list of urgent actions see USFWS 2003)

Short Term Priority Actions- Management Unit *(one to two major OIP MUs will be built per year- these actions should be completed within 3 years of each MU proposed construction year; i.e. South Kaukonahua proposed OIP yr 6 or 2013; the Army should have fence scoped, cleared, monitoring initiated by 2016)*

- Scope fencelines
- Clear MU/subunit fencelines
- Implement MU-level monitoring for entire MU/subunit
- Implement MU Fire management plans if necessary
- Develop MU/subunit alien plant control plans

- Develop MU/subunit ungulate control plans
- Implement ungulate control plans within MU
- Develop overall MU management plan
- Refine MU monitoring protocols

Short Term Priority Action – PU Management *(to be completed within 3 years of each specific tier activation)*

- Initiate stabilization actions of activated tier species (MU threat control and full PU management, though this does not mean that all threats have been controlled only that active management has begun)
- Initiate outplanting and reintroduction efforts, if needed/feasible
- Refine PU monitoring protocols

Intermediate Term Priority Goals *(to be completed within 10-15 years of each specific tier activation)*

- Achieve MU threat target levels (as feasible)
- Reverse and reduce decline trends
- Demonstrate regeneration, improved vigor and improved habitat conditions
- Achieve stabilization of short lived taxa by 25 years of initial tier activation

Long Term Priority Goals *(to be completed within 50 years of initial tier activation)*

- **Achieve stabilization of all target taxa**

6.1 Monitoring

Introduction
This section was initially written by the Makua Implementation Team (MIT) for the Makua Implementation Plan (MIP). It is reproduced here for reference without major modification as all monitoring protocols developed for the MIP will also be applicable to the Oahu Implementation Plan (OIP).

A natural resources monitoring program involves the repeated collection of data on characteristics of individuals of a species, a population of a species, or a habitat (*e.g.*, survival, growth, abundance, distribution, species composition or diversity, *etc.*) to evaluate change in those variables over time. The results of monitoring are used to assess progress toward achieving a predetermined management goal (*e.g.*, species distribution, population stability, community diversity), to evaluate the efficiency or success of a management action (*e.g.*, decrease or elimination of alien species impacts), or to identify new problems that may threaten the completion of a management objective. Monitoring information is crucial for designing, implementing, and refining a program to manage both the rare and more common species of an area, as well as the habitats on which they depend. A properly designed and implemented monitoring program requires a commitment of significant time and resources to allow for the collection and analysis of adequate data. This amount of effort typically translates to between approximately 5 and 10% of the cost to implement the entire resources management program.

Several recent publications (Elzinga, *et al*. 1998, Pavlik 1996, Sutter 1996, as well as other chapters in Falk, *et al*. 1996) have emphasized the importance of a well-designed monitoring and data analysis program in conjunction with natural resources management and species restoration programs. The Implementation Team (IT) has drawn from these resources, as well as from its collective experience with monitoring plant and animal populations in Hawaii and elsewhere, to develop the set of monitoring protocols to be used in evaluating the U.S. Army's (Army's) success in achieving the stability goals for the target taxa as specified in the Implementation Plan (IP). Monitoring results will primarily be used to evaluate progress toward meeting the IP stabilization goals, as well as to provide information that can help refine the Army's management techniques and strategies as part of an adaptive management program.

In this chapter, a brief overview of the characteristics and components of an effective monitoring program are presented first, followed by the set of specific monitoring protocols to be implemented as management activities under the IP. A glossary is also provided to aid the reader with definitions of the many technical terms and concepts discussed in this section (see Attachment 1 below).

Developing an effective monitoring program
An effective and efficient monitoring program has several components: 1) identifying and integrating management goals, management objectives, and sampling objectives for the particular situation, 2) selecting sampling method(s), 3) determining sampling and data analysis strategies, 4) conducting pilot studies to finalize sampling design and methodology, 5) implementing the monitoring plan, 6) analyzing and interpreting the results, and 7) using the results to refine, redirect, continue, or end the management or monitoring program through an

adaptive management feedback loop. Although standardization of data collection and analysis procedures is a basic principle of an effective monitoring program, there must be some flexibility to allow for making modifications to the monitoring protocols to better address the management objectives if the results are ambiguous. Finally, it is extremely important that a monitoring program is designed and conducted in a way that the process of collecting field data will not adversely impact the resources that are being managed.

Identifying management goals and objectives, and sampling objectives

Management goals and objectives and sampling objectives provide the foundation upon which a monitoring program is designed and implemented. A **management goal** is a general statement describing what should be accomplished if the management program is successful. It addresses questions such as should the number of individuals in a native species population be increased or maintained at a certain level, or should invasive alien species be controlled or eliminated. An example of a management goal is to maintain a population unit (PU) of *Cyanea superba* subsp. *superba* in the Kahahaiki management unit (MU) that is comprised of at least 50 mature and reproducing individuals.

Elzinga *et al*. (1998) define a **management objective** to be a clearly articulated description of a measurable standard, desirable state, threshold value, amount of change, or trend that you are striving to achieve for a particular plant population or habitat characteristic. A management objective is a more detailed description of the desired outcomes of a management goal and should include reference to several characteristics, including: 1) identification of the species or habitat variable to monitor, 2) what sites to monitor, 3) the specific attributes to monitor (*e.g*., plant density, cover, frequency, *etc*.), 4) what the management needs to accomplish or achieve, 5) the degree of change or state that needs to be achieved, and 6) the timeframe for measuring and achieving the change or desired state. An example of a management objective is to increase the number of mature and reproducing *Cyanea superba* subsp. *superba* individuals in the Kahanahaiki PU from two in year 2000 to 50 by the year 2015.

Sampling objectives, on the other hand, focus on the sampling and data analysis strategies and methods that will be used to address a particular management objective. Specifically, sampling objectives need to include information on what variables will be sampled, the levels of statistical significance and statistical power desired to determine if a change has or has not occurred or if a difference exists or not between sampling times or situations for comparison (acceptable Type I and Type II error levels), and the minimum amount of detected change that would be considered to be biologically significant. If monitoring results demonstrate a significant change or difference relative to management targets, the outcome may lead to the triggering of a new management action, a change in a management action, or a termination of a management action. An example of a sampling objective is to be 95% confident that the number of mature and reproducing *Cyanea superba* individuals in a specific PU is within 10% of the target value specified in the Stabilization Plan for this species. For the IP, the number of individuals of target taxa in each of the PUs will preferably be assessed by conducting a complete census of the mature individuals within a PU wherever possible, but the sampling objective described above will be used if a census cannot be conducted.

In the monitoring protocols developed for the IP, only monitoring goals and preliminary sampling objectives have been identified since it was felt that there is not currently adequate information to specify either management objectives or detailed sampling objectives for each species, area, or activity. These more general goals and objectives should serve as the basis for initiating surveys and pilot studies which will provide the details necessary to finalize the design of each monitoring protocol before it is implemented. **The final monitoring protocol will be approved by the IT following the review of pilot study results, before full implementation of the monitoring program should begin.**

Selecting sampling methods

There are many different methods that can be used to monitor plant or animal populations or habitat characteristics of an area. These include collecting data on growth, survival, and abundance of species as well as techniques that address more specific sampling needs, such as population structure and demographic sampling (Ferson 1990, Guerrant 1996, Guerrant and Pavlik 1997), vegetation or habitat sampling methods (Mueller-Dombois and Ellenberg 1974), or sampling tree snail populations (Hadfield *et al*. 1993).

Table 4.1 (below) summarizes the basic types of data and data collection methods that are recommended for use with the IP monitoring program. Included are methods for assessing characteristics of specific individuals of a species (such as outplanted individuals as part of an augmentation or reintroduction project or individuals of a wild population), populations of a species (both native and alien species), and communities or habitats. These methods form the foundation for the monitoring protocols that must be conducted by the Army for the IT to evaluate its success in meeting the stabilization goals for the target species and habitats covered by the plan.

Determining the appropriate sampling and data analysis strategies

Two of the most critical steps in developing a monitoring program are choosing an appropriate sampling design (*i.e.*, determining the sample units, how and where sample data are collected), and deciding on the proper data analysis methods and strategy to be used. Manly (1992) and Elzinga *et al*. (1998) provide excellent overviews on designing field sampling programs. Detailed discussions of basic parametric and non-parametric statistical analysis techniques can be found in standard statistical texts, such as Ramsey and Schafer (1996), Sheskin (1996), and Zar (1999). In the monitoring protocols for the IP we stress the need for random selection of individuals or points for all sampling that involves statistical analyses, as well as use of data analysis methods that are appropriate for the questions being addressed and the characteristics of the data.

An essential part of developing an appropriate sampling design is deciding on how many sample points are needed to adequately detect and document change in the sampled variables over time. The best way to determine sample size is to conduct a statistical power analysis. Statistical power refers to the probability that a particular test will detect a change of a given size, if such a change has in fact occurred. A high value of power in this test indicates a greater likelihood of detecting a change of a given size than a test result that indicates low power. A statistical power analysis involves estimating the variance expected in the resulting data and specifying the probability level you want to use in conducting the analysis, as well as identifying the minimum level of difference or change that is considered to be important from the biological and management perspectives. This design strategy ensures minimizing the probability of making either a Type I (false change) or Type II (missed change) error. The IT recommends setting the statistical probability level of all tests to 90% to minimize making a Type I error when interpreting the results, and sampling enough points to ensure the power of the test is at least 80% to minimize the chance of making a Type II error.

Analyses of monitoring data can be accomplished using a variety of parametric, non-parametric, and semi-parametric procedures, depending on sampling design, type of data collected, and distribution characteristics of the data. The advent of fast processors and expanded memory in personal computers has allowed for the practical use of various resampling statistical methods, including randomization, bootstrap, Monte Carlo, and exact probability techniques as described by Manly (1998), Mehta and Patel (1999), and Simon (1999). A major advantage of using resampling methods is that statistical inferences may be made by examining differences in many population parameters (*e.g*., mean, standard deviation) or standard test statistics (*e.g*., t- or f-statistics) without having to assume a normal distribution for the sampled populations. The lack of normality limitation is often the case with field data, particularly for data collected on relatively rare species. For repeated measures analyses, semi-parametric procedures, such as the use of generalized estimating equations may be preferable. The IT recommends the use of appropriate resampling analysis technique for tests with continuous data rather than shifting to non-parametric analyses when the data are found to be non-normal.

Conducting a pilot study
A pilot study involves collecting data in a scientific manner to test sampling design, data collection and analysis procedures, and to estimate basic parameters of the variables sampled. The results of a pilot study are used to refine and possibly simplify the subsequent monitoring program, and to provide realistic estimates of the time and resources required to conduct the monitoring. Pilot studies should always be conducted at the initial stages of a monitoring program, or whenever new sampling designs, data collection methods or variables are introduced into an existing program.

Implementing the monitoring plan
A baseline survey, which is the first complete set of data collected for a monitoring program, needs to be conducted prior to the initiation of management actions (*e.g.*, threat control, species augmentation, *etc*.) in an area. This initial data collection step will be followed by regular assessment of the populations or individuals through the monitoring program. The interval for data collection varies depending on the time since initiation of the action and the management questions being addressed. For example, following initial outplanting of individuals into reintroduction or augmentation sites, data on survival and growth of the plants should be collected on a monthly (or in some cases weekly) basis to assess success of the outplanting effort and to provide feedback on the need for post-planting care (*e.g*., watering, slug or rat control). However, after the first six months monitoring can shift to a longer interval, and eventually to an annual cycle, as monitoring emphasis is more focused on long-term survival of the plants and ultimately stability of the population. During its annual review the IT will use the results of the monitoring program to evaluate the need to modify the monitoring interval.

It is important that the monitoring program be conducted with consistency in data collection techniques and comparable observers over time. This involves the development of operational definitions for all elements of the specific monitoring protocols to ensure that data for all variables are collected the same way each time. Additionally, data collection forms should be designed in a way that the information is recorded in an efficient manner and can easily be input or transferred into a computer for management, analysis, and backup. The use of field data loggers or palm-top (*e.g.*, PDA's or personal data assistant) computers is recommended for collection of the data in the field, eliminating the need to manually reenter the raw data into a data file for analysis. Different types of data loggers are available ranging from sophisticated but expensive units to small, inexpensive hand-held computers. Finally, all observers involved with collection of field data must be well trained in the data collection protocols, in identification of native and alien species, and how to minimize impacts in the study area while conducting a monitoring program.

Analyzing and interpreting the results from a monitoring program
The data from all baseline surveys need to be analyzed as soon as possible after collection (*i.e.*, within six months) so the results can be used to refine aspects of the management program and/or monitoring protocols. In many cases the sampling framework for a protocol will have been based on rough estimates of the population parameters (*e.g.*, mean and variance). Better estimates of these parameters will be obtained from pilot studies, which should help refine, and possibly reduce, the number of samples needed to evaluate the sampling objectives.

Once the IP is fully implemented, the data from the various monitoring projects must be analyzed annually and summary reports prepared prior to the annual evaluation of progress by the IT. This annual review of the monitoring reports and protocols will ensure that the data collection and analysis techniques are relevant and appropriate to determine the Army's progress toward achieving stability of the target taxa.

Using monitoring results to guide an adaptive management program
One of the most tangible benefits of a monitoring program is objective data which provides the natural resources management team the means to better understand how the target resources are or are not responding relative to management actions. This information can then be used to modify or redirect either the management or monitoring program if necessary, and to evaluate how much longer these efforts need to be continued. It is essential to determine if additional monitoring should be initiated if the management activities change, since the existing monitoring protocol may not provide the best opportunity to evaluate the new or revised management program. Annual review by the IT of both the management and monitoring actions that are being conducted will be necessary to ensure these programs are properly integrated and that the results are used to assess the progress in meeting the species and habitat stabilization goals.

Monitoring and survey protocols to achieve the goals of the Makua IP
Monitoring protocols are defined as a compendium of methods that are used together to collect information on the species, populations, communities, habitats, or alien species impacts of an area. Elements of a monitoring protocol generally share a common sampling framework and data are collected as part of a single monitoring effort.

A set of seventeen protocols (see Table 4.2 below) has been developed for use in assessing the implementation of the IP and for determining if the management actions are meeting the goals of the plan. Included in the set are several species or area survey protocols to be conducted since the results of these types of surveys often provide information that forms the basis for designing and implementing components of a monitoring program. The protocols are organized in Table 2 by specific management events that trigger one or more surveys or monitoring efforts. This listing indicates the monitoring needs relative to various types of management actions including establishing and managing MUs, outplanting individuals as part of species augmentation or reintroduction projects, controlling alien species and other threats, and evaluating species distributions beyond the designated MUs.

A basic premise of the IP monitoring protocols is that the sampling design, sampling methods, and data analysis methods are scientifically sound and will yield statistically valid results. Field surveys and pilot studies will be used initially to provide more detailed information on the areas and variables to be sampled, to refine data collection methods, and to determine adequate sample size for monitoring. **Once a monitoring protocol is fully implemented, data will be collected and analyzed regularly, and the results provided to the IT and the U.S. Fish and Wildlife Service for the annual IP review process**.

A detailed description of each monitoring protocol is provided at the end of this chapter. These summaries provide information on management goals, preliminary sampling objectives, target area to monitor, the monitoring framework, types of data to be collected, recommended data analysis methods, and proposed data collection intervals for each protocol. These protocols should be used as the basis for designing and implementing specific monitoring efforts relative to the initiation of management actions specified in the IP.

Of the seventeen monitoring and survey protocols, eight are required components of the IP, while the remaining nine protocols are recommended to be conducted. **Required monitoring protocols include evaluating the status of all PUs identified for management, the status of habitat quality in the MUs, surveys for invasive plants along disturbance corridors, success of outplanting and phytosanitation safeguards associated with the outplanting program**. The remaining protocols that address general field surveys and efficacy of control for alien species are strongly recommended to be conducted as they will be extremely useful in both refining management methodologies and will expedite achieving the species and habitat stabilization goals. The impacts of management and monitoring activities on the habitats are of concern and will be addressed during annual adaptive management reviews.

Designing, implementing, analyzing, and interpreting the results of a monitoring program of this magnitude is very complex. For this reason it is essential to have a professional biologist with extensive monitoring and data analysis experience directly involved with all aspects of the monitoring program, particularly the design, data analysis, and interpretation steps.

Table 6.1 Summary of the Characteristics of Different Types of Data that may be Collected as Part of a Natural Resources Monitoring Program.

Type of Data	Description	Sample Unit	Data Analysis
Presence/absence	Any occurrence of a specific species (target native species or invasive weed) within a given area.	Any given area that is surveyed.	No statistical analysis needed; management response is triggered by any presence of the species in the area.
Census (total population count)	Total number of individuals in a given area.	Any given area that is surveyed.	No statistical analysis needed; management response is based on the total number of individuals found within the survey area.
Frequency of plots	Percentage of sampled plots that contain a specific species (either native target species or weed).	Quadrat of a specific size.	Contingency table analyses (*e.g.,* Chi-square test, Fisher's exact test; McNemar's test, depending on the sampling design); also consider loglinear models.
Percent of individuals by category	The number of individuals of a given category type (*e.g.,* vigor class or size class) per sampling unit.	Quadrat of a specific size.	Contingency table analyses (*e.g.,* Chi-square test, Fisher's exact test; McNemar's test, depending on the sampling design) also consider loglinear models.
Density	Estimated number of counting units (*e.g.*, trees, seedlings) per unit area.	Quadrat of a specific size.	Comparison of mean density using parametric tests (*e.g.,* t-test, ANOVA – either independent, paired, or repeat measures) or a resampling analog of the parametric tests if normality is a problem.
Cover	Vertical projection of the vegetation onto the ground as viewed from above, recorded as absolute value or in ordered cover classes.	Quadrat of a specific size.	Comparison of mean cover using parametric tests or a resampling analog of the parametric tests if there is a problem with normality of data; use non-parametric rank tests for cover data collected in range classes.
Size measurements	Measurements taken using continuous data for any variable (*e.g.,* dbh, stem length, shell size).	Individual plant or animal.	Comparison of mean size using parametric tests or a resampling analog of the parametric tests if normality is a problem.
Mark/recapture	Method to determine density of animal populations using data.	Individual animal (*e.g*., snail, or rat).	Various analysis methods for either open or closed populations. See Manly (1992) and Hadfield *et al*. (1993).
Species richness or diversity	Quantification of the number of species or number weighted by abundance for a given area.	Any given area or community that is sampled.	Produces an index value for species richness or diversity that can be used to compare between areas or times relative to management (Magurran 1988).

Table 6.2 Monitoring Protocols for Army Stabilization Efforts Required monitoring protocols are indicated in bolded and italicized font.

1. Management unit monitoring protocols

1.1. Map vegetation types across the management areas
1.2. Monitor alien species distribution and status in management units to guide management actions
1.3. Monitor composition and structure of the vegetation within management units
1.4. Evaluate alien plant control methods

2. Population unit monitoring protocols

2.1. Conduct field surveys for targeted native species
2.2. Assess status and stability of plant populations
2.3. Assess status and stability of **Achatinella mustelina** ***population units***
2.4. Conduct phytosanitation monitoring in greenhouse facilities
2.5. Monitor *in situ* individuals to aid with the collection of propagules for reintroduction stock and for genetic storage
2.6. Conduct phytosanitation monitoring in the field
2.7. Monitor success of outplanted individuals

3. Monitoring protocols for areas outside management units

3.1. Survey for target or other rare native species outside designated management units
3.2. Conduct surveys and monitoring of alien plants and animals outside management units
3.3. ***Survey for invasive plants along disturbance corridors***

Attachment 1. Glossary of terms used in the monitoring section

Adaptive management – using results of monitoring and other information to refine the design, scope, or implementation of management actions or the monitoring program for an area or a species.

Baseline survey – the first complete set of data collected for a monitoring program. This initial survey should be conducted prior to the initiation of management actions (*e.g.*, threat control, species reintroduction, *etc*.) in an area.

Disturbance corridors – disturbed areas, such as roads, trails, fencelines, or transects that are routes of regular or occasional travel and are at high risk of being invaded by weeds introduced from vehicles, boots, packs, *etc*., as a result of human use of that pathway.

Management goal – a general statement describing what should be accomplished if the management program is successful. It addresses questions such as should the number of individuals in a native species population be increased or maintained at a certain level, or should invasive alien species be controlled or eliminated.

Management objective – a clearly articulated description of a measurable standard, desirable state, threshold value, amount of change, or trend that you are striving to achieve for a particular plant population or habitat characteristic. Management objectives should include reference to several characteristics, including 1) identification of the species or habitat variable to monitor, 2) what sites to monitor, 3) the specific attributes to monitor (*e.g.*, plant density, cover, frequency, *etc*.), 4) what the management needs to accomplish or achieve, 5) the degree of change or state that needs to be achieved, and 6) the timeframe for measuring and achieving the change or desired state.

Matrix species – species that are dominant components of a plant community, including major tree, understory, and ground cover species that provide the basic vegetative structure of a habitat.

Microsite – specific location of a planted individual or wild plant which includes a unique set of environmental characteristics (both biotic and abiotic) that may influence the growth or survival of the plant.

Monitoring – the collection of data on characteristics of a population, a species, or a habitat (*e.g.,* survival, growth, phenology, abundance, distribution, population structure, species composition or diversity, *etc*.) to evaluate change in those variables over time. The results of monitoring are used to assess progress toward a predetermined management goal (*e.g.*, species distribution, population stability, community diversity), to evaluate the efficiency or success of a management action (*e.g.*, decrease or elimination of alien species impacts), or to identify new problems that may threaten the successful completion of a management objective.

Monitoring method – a technique used to gather information on the characteristics of a variable as part of a program to monitor natural resources or alien species impacts.

Monitoring protocol – a collection of monitoring methods that are used together to collect information on the species, populations, communities, habitats, or alien species impacts of an area. Elements of a monitoring protocol generally share a common monitoring framework and data are collected as part of a single monitoring effort.

Non-parametric statistical method –technique that uses frequency, rates, ranked scores, or percentiles as the basis for analysis and does not assume that the population follows a normal distribution.

Parameter – a quantity that describes or characterizes an attribute of a population. Examples of parameters include the population mean, variance, or standard deviation,

Parametric statistical method – analytical technique that assumes the population from which a sample is taken can be properly described by a mean and standard deviation, and further assumes that the population follows a normal distribution.

Pilot study – data collection in a scientific manner to test sampling design, data collection and analysis procedures, and to estimate basic parameters of the variables sampled. The results of a pilot study are used to refine and possibly simplify the subsequent monitoring program, and to provide realistic estimates of the time and resources required to conduct the monitoring.

Plant community – a spatial group of individuals of different plant species that generally overlap in their distribution within an area and share many similar habitat characteristics.

Population unit – a group of individuals of a species that are in close spatial proximity to each other (*i.e.,* less that 1000 m apart, as defined by the IT), and are therefore presumed to be genetically similar and capable of crossing for reproduction. Generally members of a population unit share a common habitat and are equally subject to impacts from fire, alien species (*e.g.,* ungulates or weeds), as well as major climatic events, such as hurricanes that may affect that local habitat.

Quadrat – a unit area of a specific size in which data on one or more variables are collected. Quadrats are the basic sampling units for collecting data on frequency, cover, and density of plants or animals in a monitoring program.

Resampling statistical methods – analytical techniques that can be used to calculate confidence intervals or perform significance testing on standard population parameters (*e.g.*, population mean or standard deviation) without the requirement that the population follows a normal distribution. Resampling methods are computer-intensive procedures that include randomization, bootstrap, and Monte Carlo techniques. These methods compare population parameters or standard test statistics (*e.g.,* t- or f-statistic, difference in means, *etc.*) from the sampled populations with the same statistics or parameters when all of the data values are pooled, mixed, and reselected ("resampled") into the same number of sample populations as in the original sample, with or without replacement depending on the specific technique used. After resampling is repeated many (*e.g.,* 10,000) times the value of the test statistic calculated from the original populations is compared with the test statistics from the resampled populations to determine if the original result is typical or very different from the pooled and resampled data. The resulting calculated probability is believed to be a close approximation of the exact probability for that test.

Sampling objective – an objective that relates specifically to assessing selected species, community, or ecosystem attributes as a means of measuring success or failure in meeting specific management objectives. Sampling objectives specify what variables will be sampled, as well as the levels of statistical significance desired to determine if a change has or has not occurred or difference exists or not between sampling times or situations for comparison (Type I and II error levels), and the minimum amount of detected change that would be considered to be biologically significant

Sampling unit – the base unit comprising a sample for data collection and analysis. Sampling units may be plots, quadrats, transects, points, individual plants, *etc.*

Sampling – in a general sense, sampling is often used to describe the process of collecting data. the same term also refers to the process of identifying a subset of individuals within a population from which data will be collected to characterize various attributes (*e.g.*, distribution, size, cover, growth, vigor, *etc.*) of a population. Sampling elements need to be chosen by a random selection process if they are to be used to infer characteristics of the population as a whole.

Sampling framework – the logistical and analytical basis upon which a monitoring program is designed. The sampling framework includes consideration of the number of data collection sites, how and where data collection sites are located, what information will be collected, and how the resulting data will be analyzed in order to assess meeting the management goals for an area.

Statistical power – the probability that a particular statistical test will detect a change or difference of a given size, if such a change has in fact occurred. A high value of power in this test indicates a greater likelihood of detecting a change or difference of a given size than a test result that indicates low power. Statistical power is a function of the number of sample points, the variance of the resulting data, the alpha level of probability for the test (determined to minimize the chance of making a Type I error in interpreting the results), and the minimum difference or change you are willing to consider important from a biological and management perspective. By conducting a power analysis you can determine the number of sample points needed to ensure statistical power at a specified probability level by supplying values for the population variance for each of the variables that are compared (estimated from a previous study or from a pilot study), the alpha probability for the test, and the minimum difference or change value you want to use when comparing the two sets of data.

Survey – field work designed to provide general information on the distribution, abundance, or status of species, populations, communities, or habitats within an area. In many cases a field survey is used to develop a catalog of the species and habitats within a specific area, but may not provide much detailed information on status and abundance of the species.

Type I sampling error – the conclusion of statistical analysis that a change has taken place between the sampled populations when no real change has occurred. A Type I error is also called a "false change error." The probability of making a Type I error is labeled the P-value (probability) or alpha value in a statistical test. Generally, an alpha level (probability value) less than 0.10 (*i.e.*, <10% chance of a false change error) is considered to be statistically significant.

Type II sampling error – the conclusion of a statistical analysis that no change has taken place between the sampled populations when a real change has actually occurred. A Type II error is also called a "missed change error." The probability of making a Type II error is labeled the *beta* value in a statistical test. The probability of not making a Type II error is 1 minus the *beta* value or the "power" of a statistical test. As much as possible, the power of a statistical test should be at least 0.80 (80%) or greater, reducing the chance of making a Type II (missed change) error to less than 0.20 or 20%.

Vegetation type or unit – generalized classification unit used to describe a plant community based on physiognomic characteristics (such as vegetation structure and life form) of the vegetation and/or dominant species composition. An example of a vegetation unit would be "mesic *ohia* wet forest."

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6.2 Management Unit Monitoring Protocols

*These protocols are taken directly from the Makua Implementation Plan (MIP). The Oahu Implementation Review Committee (OIRC) has determined these protocols to be applicable to the needs of the Oahu Implementation Plan (OIP). However, these protocols may change to adapt to the needs of the Army in the stabilization of the target taxa.

Monitoring Protocol 1.1 - Map Vegetation Types Across the Management Areas

Type of activity: Survey

Action: Recommended as a component of the program to stabilize Oahu target taxa.

Description: Delineate the distribution of major plant communities within and adjacent to the Implementation Plan (IP) management units (MUs) based on aerial photograph and remote image analysis supported by field surveys. The preliminary vegetation maps will be refined using field data on composition and structure of vegetation within the MUs from field surveys conducted under Monitoring Protocol 1.3.

Applicable for: Mapping the distribution of major plant communities within and immediately adjacent to the MUs.

Management goal: Ensure the plant communities within the MUs form a stable, native-dominated matrix which will be able to support stable populations of the IP rare species.

Survey objectives: To define and map the distribution of the major plant communities within and adjacent to the MUs.

Management response: These maps will serve as the basis for stratification of management and monitoring activities in each of the MUs.

Area to survey: At a minimum, the vegetation maps will encompass all of the MUs and the areas immediately outside them, to at least 100 m beyond the MU boundaries. If possible, a vegetation map will be produced covering the entire section of the Waianae Range that will be the general focus of the IP management actions, both inside and outside of the MUs.

Mapping unit: Minimum mapping unit will be 0.5 hectares where plant communities have well-defined boundaries. However, highly complex units containing many different communities of small size may be combined into aggregate communities.

Monitoring framework:

1. <u>Vegetation map preparation</u>: Plant community boundaries will be initially determined using a combination of aerial photographs, remote imagery, and ground surveys as needed to cover all areas within the scope of the vegetation map. Information collected from vegetation plots as described in Monitoring Protocol 1.3 (Chapter 4.1) will also be used to determine the

composition and structure of the mapped units. Plant communities will be defined following the National Vegetation Classification System and integrated with the vegetation mapping efforts of the Hawaii GAP Analysis Program.

2. Accuracy testing of the resulting vegetation maps: Following completion of the preliminary vegetation maps, an accuracy check will be made of the classification and distribution of the resulting map units following the validation protocol developed by the Hawaii GAP Analysis Program. This will involve an independent assessment of the plant community at random locations identified throughout the mapped area. A minimum of 30 assessment plots will be located for each of the mapped plant community types.

Data to collect:

1. Vegetation map preparation: The distribution boundaries of each mapped unit will be determined from examination of aerial photographs, remote sensing imagery, and field surveys. The plant community type in each of the mapped units will be identified following the National Vegetation Classification System.

2. Accuracy assessment of the resulting vegetation maps: At each of the randomly located validation plots we will determine the appropriate vegetation classification unit independently of how it was mapped.

Data analysis methods: The only data analysis associated with this protocol will be an accuracy assessment of the resulting vegetation map. The accuracy assessment will be conducted by comparing the mapped vegetation classification units at a random sample of points across the mapped landscape with the actual vegetation classification units based on a post-mapping field analysis. We will strive to achieve a mapping accuracy level of at least 80%.

Data collection interval: The vegetation maps will be prepared during the first two years of implementing the IP. We recommend a reassessment of the status and distribution of the mapped plant communities every 10 years.

Monitoring Protocol 1.2 – Monitor Alien Species Distribution and Status Within Management Units

Type of activity: Monitor

Action: Required as a component of the program to stabilize Oahu target taxa.

Description: Conduct a pilot study and implement a monitoring program for alien plant and animal species throughout the MU. Assess their distribution and frequency relative to the management targets defined for each population unit (PU) (see Chapter 2: Species Stabilization Plans, and Section 1, Chapter 7: Threat Assessments) and as designated in the Alien Species Control Plans which will be developed for each MU. Rodent species sampling and analysis procedures were adapted from those used by the US Dept. of Agriculture, Animal & Plant Health Inspection Service (Campbell, pers. comm. 2000).

Applicable for: Assessment of distribution and status of alien species within the MUs and in the vicinity of the PUs.

Management goal: Manage the alien plant and animal species to or below the designated target levels.

Preliminary sampling objectives:

1. Be 90% certain that the frequency or cover for each of the target alien species is equal to or less than the designated levels.
2. Identify any invasive alien species not previously considered to be a threat to the MU or not properly designated for management.

Management response: If the frequency or cover of any of the targeted alien species is greater than its specified acceptable level: 1) assess if satisfactory progress is being made to achieve that goal and continue management if this is the case, or 2) increase control effort. If the frequency or cover of targeted alien species is below the specified acceptable level, continue with the current management program or determine if management effort can be reduced and still meet the control target.

Area to monitor: The primary focus will be to monitor alien plant and animal species throughout the MUs and within the vicinity of the PUs.

Pilot studies: It is important to emphasize that the suggestions that follow regarding monitoring framework, data to collect, and data analysis methods are preliminary suggestions that need to be developed following completion of pilot studies in the PUs and MUs. Pilot studies will be used to collect data that will be used to refine the protocol relative to variables which will be sampled, plot size and shape, sampling framework, number of samples to be taken, monitoring interval, and data analysis methods to be used.

Sample unit: Groups of quadrats located along transects established throughout the MU, stratified by plant community and/or topography.

Monitoring framework: Alien species status throughout a MU will be addressed using either a systematic sample (with random start) or random sample of the MU, post-stratified by plant community and/or topography (*i.e.*, ridge, gulch, *etc.*). While the primary sampling universe will include the combined population area for all of the target taxa found within the MU, sampling will extend to the outer edge of the MU.

<u>If using a systematic sampling framework</u>, sampling will be conducted along a series of transects established throughout the study area with a minimum distance of from 100 and 500 m between adjacent transects. Transects will be oriented so they run in a mauka-makai (uphill to downhill) direction as practical. The first transect will be located randomly along the starting edge of the MU then the remaining transects will be established 500 m to either side of the reference transect following the same azimuth as the reference transect. In MUs with steep topography transects may have to follow either a ridge top or gulch bottom without regard to following a consistent azimuth. However, in these situations, it is important that an adequate number of transects and sampling points are located in each of the different vegetation types and habitats (*i.e.*, topographic position) within the MU.

Two different sampling configurations will be established along the transects to allow for collection of several different types of data:

1. A continuous series of 3 m-wide quadrats well be established at 10 m intervals along each transect for collection of information on invasive weed species frequency and ungulate presence and to assess native and alien species ground cover.

2. The 100 m interval points will be marked along each transect to serve as sampling points for collection of data on rodent populations.

<u>If using a random sampling framework</u>, sampling points will be randomly located throughout each of the major plant communities found within the MU using a random coordinate generator with ArcView GIS, with a minimum distance of 20 m between points to maintain independence of samples. A quadrat will be established at each of the sampling points (size and shape to be determined from the pilot studies) which will be used to collect data on the presence of invasive plant species and to assess native and alien plant species ground cover. The location point for the quadrat will also be used to sample rodent populations.

Data to collect:

1. <u>Alien plant species</u> – presence of all alien plant species will be recorded in each of the 3x10 m quadrats located in a continuous belt along each transect within the MU. For alien plants that are of particular concern (*i.e.*, on the invasive species list), also record the cover class for that species as defined in the following table.

Cover Class	Cover Range
0	not present
1	>0 – 10%
2	>10 – 20%
3	>20 – 30%
4	>30 – 40%
5	>40 – 50%
6	>50 – 60%
7	>60 – 70%
8	>70 – 80%
9	>80 – 90%
10	>90%

2. Rodent sampling – For monitoring rodent populations relative to a PU, trapping stations will be established in a 25x25 m grid pattern along parallel transects, centered within a PU. The sampling framework needs to extend 50 m beyond the PU boundary. Trap stations consist of one rat snap trap placed 0.5 - 1.5 m up on a tree trunk, a snap rat trap secured to the ground with a wire flag, and a snap trap secured to the ground with a wire flag. Traps should be placed logically (*e.g.*, in a manner that will lead to trap success) in the general vicinity of a trap station. Traps initially should be left unset and shredded coconut (pre-bait) should be scattered along transects to acclimate the rodents to the intended trap bait. Traps are then baited with coconut chunks prior to sunset and checked at dawn for four consecutive days during the sampling period. All carcasses captured should be collected, labeled, and brought to a laboratory for species identification. The status of traps without captures should be recorded to account for operational versus inoperable (broken, tripped, or intact traps without bait) in calculating a corrected index of trap success.

3. Ground cover sampling – Ground cover sampling will be conducted in each of the 3x10 m quadrats starting at the 100 m point along each transect, or in a subset of quadrats in each plant community if using a random sampling design. In this case the combined cover for native species and the combined cover for alien species within the quadrat will be estimated to the nearest 10% (or nearest 1% if less than 10% cover).

Data analysis methods:

1. Alien plant species

    a. The average number of all alien species, as well as invasive alien species, per quadrat will be compared between adjacent sampling periods to track changes in alien species relative to management actions within the MU. Since it is expected that the resulting data will not follow a normal distribution, comparisons will be made utilizing a resampling statistical method without replacement. Actual comparisons will be made on the difference in number of alien species recorded in a specific quadrat at subsequent sampling periods.

   b. Frequency data for individual species will be analyzed using a contingency table with subsequent sampling periods compared using McNemar's test for repeat sampling design.

2. Rodent sampling - From the field trapping results, a corrected index of trap success (corrected percentage trap success) is calculated. This index calibrates for tripped or broken traps that can cause sampling bias when total rodent captures are compared between transects or sites (*e.g*. trap success and trap tripping can vary greatly between sites). The index rates trap success between 0 - 100%, with 0% indicating low trap success (no rodent captures) and 100% indicating high trap success (all operable traps captured rodents). Total rodent captures by species are tallied for each group of sampling points for each trap day and for trap days 1-4 combined. This data are used to determine the percentage rodent species composition for transect or group of sampling points.

3. Ground cover sampling - Differences or change is ground cover for both native and alien species will be assessed by comparing mean cover within the different groups for each strata of quadrats within the MU. If the resulting data follow a normal distribution, independent t-tests and paired t-test analyses will be used. If the distribution is found to be non-normal, mean cover and difference in mean cover will be analyzed using resampling techniques.

Data collection interval: Data should be collected annually on alien species distribution and cover throughout each MU. Sampling should always be conducted at the same time of year for each MU, as long as it can be analyzed prior to the annual meeting of the Implementation Team (IT).

Monitoring Protocol 1.3 – Monitor Composition and Structure of the Vegetation Within Management Units

Type of activity: Monitor

Action: Recommended as a component of the program to stabilize Oahu target taxa.

Description: Conduct pilot studies and implement monitoring program to assess changes in composition and structure of the major vegetation units within MUs. Data to be collected include species composition, vegetation structure, and population structure of selected matrix plant species for each major plant community within MUs. This information will be useful in determining the long-term stability of these vegetation units as a habitat for the target plant taxa.

Applicable for: Assessment of the status and stability of native plant communities within a MU.

Management goal: Ensure the plant communities within the MUs are stable and native-dominated.

Preliminary sampling objectives: 1) Be 90% certain that average native species cover within the MU is >50%, and >75% within the proximity of all of the target taxa PUs found there. 2) Assess selected native matrix species of plants to determine if their population structure is indicative of long-term stability through replacement of older senescent plants by younger plants over time.

Management response: If native species cover targets are not met for the MU as a whole or within the proximity of the rare species PUs, 1) assess if satisfactory progress is being made to achieve that goal and continue management if this is the case, 2) increase control effort, or 3) consider other threat control methodologies if control impacts to native species or habitat are unacceptable. If the native species cover targets are met, continue with the current management program or determine if management effort can be reduced and still meet the control target. In all cases assess the need for additional native species restoration.

Area to monitor: Throughout the MUs.

Pilot studies: It is important to emphasize that the suggestions that follow regarding monitoring framework, data to collect, and data analysis methods are preliminary suggestions that need to be developed following completion of pilot studies in the PUs and MUs. Pilot studies will be used to collect data that will be used to refine the protocol relative to variables which will be sampled, plot size and shape, sampling framework, number of samples to be taken, monitoring interval, and data analysis methods to be used.

Sample unit: Data will be collected in a set of quadrats (size to be determined during pilot study), located along transects or randomly established throughout the MU, stratified by plant community and/or topography.

Monitoring framework:

1. Will be addressed using either a systematic sample (with random start) or random sample of the MU, post-stratified by plant community and/or topography (*i.e*., ridge, gulch, *etc*.). This sampling framework will be the same as that used in Monitoring Protocol 1.5. However different sized plots and numbers of plots will be used to monitor population structure of the plant communities in this protocol.

2. If using a systematic sampling framework, sampling will be conducted along a series of transects established throughout the study area with a minimum distance of from 100 and 500 m between adjacent transects. Transects will be oriented so they run in a mauka-makai (uphill to downhill) direction as practical. The first transect will be located randomly along the starting edge of the MU then the remaining transects will be established 500 m to either side of the reference transect following the same azimuth as the reference transect. In MUs with steep topography transects may have to follow either a ridge top or gulch bottom without regard to following a consistent azimuth. However, in these situations, it is important that an adequate number of transects and sampling points are located in each of the different vegetation types and habitats (*i.e*., topographic position) within the MU.

3. The 50 m interval points will be marked along each transect to serve as sampling points for collection of data on rodent populations and to assess native and alien species ground cover. These points will form the pool from which locations for sampling the different vegetation units in approximately 10 m-wide by 20 m-long quadrats (size of quadrat will be determined with data from the pilot studies) will be chosen. Initially 10 quadrat locations will be randomly selected for each of the plant communities found in the MU from the group of 50 m points along the transects for establishing vegetation sampling plots. If there are not at least 20 locations for plots identified for each plant community within the MU from which 10 sampling plots can be chosen, additional transects and potential plot locations may be added as needed.

4. If using a random sampling framework, sampling points will be randomly located throughout each of the major plant communities found within the MU using a random coordinate generator with ArcView GIS, with a minimum distance of 20 m between points to maintain independence of samples. A quadrat will be established at each of the sampling points (size and shape to be determined from the pilot studies) which will be used to collect data on plant species composition and structure

Data to collect:

4. Species list for the plot – All vascular plant species found within the plot or within 5 m of the plot boundary will be recorded to help with the preparation of a comprehensive list of species for the different vegetation units within a MU.

5. Understory species cover will be sampled using the pole-intercept method at 0.5 m intervals along a series of transects established within the quadrat. With this technique, a thin 2 m tall

metal or plastic pole is placed vertically on the ground at a sampling point along the transect. Record any plant species that touches the pole with either vegetative or floral material in the following height classes: 0 – 0.5, >0.5 – 1 m, >1 m – 2 m, >2 m. More than one species can be recorded for a given height class if they touch the pole.

6. Woody species counts – All woody plants <5m stem length in up to each of eight 5x5 m subplots within the quadrat will be counted and recorded by stem length class in size classes as specified below:

Stem Length Class	Size Range in cm
1	>10 cm – 50 cm
2	>50 cm – 2 m
3	>2 m – 5 m
4	> 5 m

Data analysis methods:

1. Total native and alien species cover – Average native and alien species cover of each layer will be calculated for quadrats sampled in each plant community and comparisons made between values for the different monitoring periods to determine if native species cover meets the target levels specified in the IP.

2. Understory species composition and diversity – A simple species richness index for native and alien species will be calculated for each quadrat based on the species list data. The indexes for each plant community sampled within the MU will be averaged to determine a richness index for each plant community. Comparisons will be made using the native and alien species richness values between monitoring periods using a paired t-test or resampling equivalent test when two times are being compared for the same area.

3. Woody species counts – Data collected on number of woody species in different size classes will be used to develop population structure (stage) models for the species using a program such as RAMAS Stage. This information will allow for an evaluation of the stability of the population structure for key native species that form the matrix of the habitat for the stabilization of the IP target species.

All of the information collected in the vegetation sampling plots will also be used to better describe the composition and characteristics of the major plant communities found within each of the MUs as described in Monitoring Protocol 1.1.

Data collection interval: Vegetation plots should be first monitored when a MU is established in the field and thereafter every three years. Sampling should always be conducted at the same time of year for each MU, as long as it can be analyzed prior to the annual meeting of the IT. The IT will determine the need to change the monitoring interval or if the monitoring can be terminated for a given MU based on the results of the data analysis.

Monitoring Protocol 1.4 – Evaluate Alien Plant Control Methods

Type of activity: Monitoring

Action: Recommended as a component of the program to stabilize Oahu target taxa.

Description: Assess change in alien plant distribution and abundance relative to control actions. This monitoring protocol is designed to assess the efficacy of the current alien plant control methodology. Monitoring only needs to be conducted in a few areas as the alien plant control program is being implemented. The monitoring program may be discontinued if the results of the monitoring show the alien plant control methodology is effective.

Applicable for: Assessment of efficacy of alien plant population levels relative to control methods for achieving the designated alien species target levels (see Section 1, Chapter 10: Long-term Threat Management Goals in Management Units).

Management goal: Be assured that a specific alien plant species control methodology will result in a significant decrease in the frequency and cover of the target species.

Preliminary sampling objectives: 1) Be 90% certain that the frequency and cover of controlled alien plant populations are significantly lower than values for these variables in the paired, non-controlled sites. 2) Provide information that can be used to evaluate and modify alien species control strategies, such as rate of alien tree species removal and the need for restoration with common native species.

Management response: If the population frequency and cover for a targeted alien plant species within a controlled portion of a MU is greater than the target goals in Section 1, Chapter 10: Long-term Threat Management Goals in Management Units, intensify control actions to further reduce the targeted alien plant species population.

Area to monitor: Alien plant control monitoring will be conducted in portions of areas where alien plant species are being controlled. Each alien plant control area that is monitored will be paired with another area in close proximity that has comparable habitat and is not the subject of control.

Pilot studies: It is important to emphasize that the suggestions that follow regarding monitoring framework, data to collect, and data analysis methods are preliminary suggestions that need to be developed following completion of pilot studies in the PUs and MUs. Pilot studies will be used to collect data that will be used to refine the protocol relative to variables which will be sampled, plot size and shape, sampling framework, number of samples to be taken, monitoring interval, and data analysis methods to be used.

Sample units: 3x5 m quadrats located along parallel transects established through the monitoring area and through a paired non-control area.

Monitoring framework:

1. Monitoring will be conducted in 3x5 m quadrats located at random points along transects established through the monitoring area and also through a paired non-control area.

2. Parallel transects 25 m apart (or modified to fit the terrain) will be established with a random starting point in each of the monitoring areas. To select the first reference transect, on a map establish a baseline running along the long axis of the control area, marking potential transect starting locations at 5 m intervals. Randomly choose one of these transect starting points as the reference transect then systematically establish parallel transects at 25 m intervals on either side of the reference transect. To select the quadrat sampling points, mark potential locations at 5 m intervals along all of the portions of the transects that run through the alien plant control area. From this pool of potential quadrat locations, select 50 points randomly that will be the start points for the 3 m wide by 5 m long quadrats that will be monitored. Use this same procedure to select transects and plots in the adjacent, non-controlled area. The same quadrats will be sampled for each monitoring cycle.

Data to collect: Record the presence of the targeted alien plant species in each of the 3x5 m quadrats and also record the modified Braun-Blanquet cover class for that species as defined in the following table.

Cover Class	Cover Range	Combined Area for Class
0	not present	not present
1	>0 – 1%	0.15 m^2
2	>1 – 5%	0.75 m^2
3	>5 – 10%	1.5 m^2
4	>10 – 25%	3.75 m^2
5	>25 – 50%	7.5 m^2
6	>50 – 75%	11.25 m^2
7	>75 – 90%	27.0 m^2
8	>90%	>13.5 m^2

Data analysis methods:

1. <u>Frequency data</u> will be compared between subsequent sampling periods for each of the monitored areas (alien plants controlled and alien plants not controlled), using a contingency table with a paired quadrat design (McNemar's test). Comparison of plant frequency between the controlled and non-controlled areas will be conducted using standard contingency table analyses (Chi-square or Fisher's exact test).

2. <u>Modified Braun-Blanquet cover class comparisons</u> will be made using the Mann-Whitney test for the non-paired design, and the Wilcoxon signed rank test for the paired design.

Data collection interval: Alien plant control monitoring should be conducted prior to and monthly during the active control period for each of the paired transect sets. If the monitoring results show that alien plant control methodology is successful in reducing frequency and cover of the target, this monitoring can be discontinued. If the control methodology is modified, the monitoring protocol should be reinitiated

6.3 Population Unit Monitoring Protocols

*These protocols are taken directly from the Makua Implementation Plan (MIP). The Oahu Implementation Team (OIT) has determined these protocols to be applicable to the needs of the Oahu Implementation Plan (OIP). However, these protocols have been modified to be applicable to target plant taxa, *Achatinella* species, and the Oahu Elepaio.

Monitoring Protocol 2.1 – Conduct Field Surveys for Targeted Native Taxa

Type of activity: Survey

Action: Required as a component of the program to stabilize Oahu target taxa.

Description: Conduct field surveys to determine distribution and general abundance of target taxa within a management unit (MU) or in areas outside existing MUs.

Applicable for: Target plant taxa, *Achatinella* species, and Oahu Elepaio.

Management goals: Assess known populations of target plant and snail taxa for current status and search for new populations to assist in determining management actions needed to reach taxa stabilization goals.

Survey objectives: To find new populations or to relocate historical populations of critically rare taxa by surveying appropriate habitat or former rare plant, snail, or bird location sites.

Management response: If target plants, snail, or bird populations are discovered, 1) map population, 2) reassess the stabilization plan (SP) for that taxon to select a population designation (manage to stability or manage for genetic storage collection), 3) carry out appropriate management based on designation of the population.

If no plants or snail populations are discovered: 1) determine if more surveys are necessary, 2) consider modifying or expanding surveys, or 3) determine if the SP needs to be modified.

Area to survey: Systematic survey of appropriate habitat for the target taxa. Appropriate habitat should be determined through experience with existing populations of target taxa, researching historical locations and herbarium specimen descriptions. Search for associated taxa, elevation, and physical site characteristics. Use of binoculars is recommended to improve search efficiency and range for plant taxa.

Monitoring framework: Either of several survey strategies may be used to survey for target taxa.

1. <u>Systematic survey</u>: For use in searching a new area for a target taxon. Sample systematically in appropriate habitat, documenting survey routes so as not to duplicate effort on a future day.

2. Cluster sampling: For use in searching historical locations or to locate additional individuals within the vicinity of a known target population. Search appropriate habitat near location with focus first on habitat contiguous with plants, snails or bird populations or historic point location. If plant taxa could have a persistent seed bank, search not only for mature individuals but pay special attention to ground cover of forest where seedlings of the target taxa may be found.

Data to collect:

1. Survey route - accurately map survey route taken using either Global Positioning System (GPS) or manual mapping (altimeter and hard copy map).

2. Survey effort - record information on number of people on survey team and start and end times for each survey.

3. Location of population - map exact location of target taxa using either GPS or manual mapping.

4. Data collected on individuals or population - collect information using the Hawaii rare plant recovery group (HRPRG) rare plant monitoring form (see Section 3, appendix 2.3) or appropriate data for snail and elepaio populations.

5. Voucher specimens - make voucher collections of plants but only if needed to identify or document a taxon in a particular location. Collection of listed taxa can be made only with appropriate federal and state permits.

Data analysis methods: No statistical analyses are needed for this protocol. Information collected on the survey routes and on the individuals or populations of mitigation species located will be entered into the project Geographical Information System (GIS) and database. The results of these surveys will be used to develop more detailed population monitoring strategies for the specific taxa and populations located.

Data collection interval: These surveys are conducted as needed. For some plant taxa surveying during likely times of flowering may increase the chances of detecting more individuals. For the Oahu Elepaio surveying during the appropriate seasons will also aid in finding birds and determining pairs.

Monitoring Protocol 2.2 – Assess Status and Stability of Plant Population Units

Type of activity: Monitoring

Action: Required as a component of the program to stabilize Oahu target taxa.

Description: Conduct initial baseline survey and continuing monitoring program for target taxa within a population unit (PU) to assess its status relative to the stability goal identified for that taxon. Additionally, determine if the demographic structure of this population will be able to support a stable population over time. Data are collected on the distribution, abundance, status (vigor), population structure, and phenology of plants sampled, as well as evidence of damage by alien animal species (ungulates, rats, slugs, *etc.*) within the identified PU.

Applicable for: *In situ* plant PU, augmented plant PU, or reintroduction PU after individuals achieve reproductive maturity (Chapter 4.3).

Management goal: Manage this specific PU to achieve the specified number of mature, reproducing individuals and duration as specified for that taxon in the species SP (Chapter 2).

Preliminary sampling objectives:

1. Be 100% certain that the number of mature plants capable of reproduction in the PU is equal to or greater than the minimum number specified to achieve stability for that taxon as specified in the SP.

2. Determine if demographic structure of target PU appears to be adequate to sustain a viable population of this taxon over time based on comparison of number of individuals in life-stage classes with predicted model of a stable population for this taxon.

Management response: If population stability is not achieved, one or more of the following responses are appropriate: 1) continue with the same management program for a longer time, 2) intensify threat control, or 3) implement species augmentation (see triggers for initiating an increase in management or augmentation, Section 1, Chapter 9.4: Sequencing of Actions).

Area to monitor: Systematic survey of all of the individuals in a given PU. Individuals must be within 500 m of another plant of the same taxon to be considered to be part of that PU.

Pilot studies: It is important to emphasize that the suggestions that follow regarding monitoring framework, data to collect, and data analysis methods are preliminary suggestions that need to be developed following completion of pilot studies in the PUs and MUs. Pilot studies will be used to collect data that will be used to refine the protocol relative to variables which will be sampled, plot size and shape, sampling framework, number of samples to be taken, monitoring interval, and data analysis methods to be used.

Sample unit: Quadrat for regeneration classes; entire area census for mature plants.

Monitoring framework: Either of several survey strategies may be used initially to establish the monitoring framework for this protocol. Continue to use that strategy for subsequent monitoring of the population. Size and shape of sample quadrat is determined from the results of the pilot study.

1. <u>Census of mature plants in PU</u>. All mature individuals within a PU will be located and data collected as specified below.

2. Systematic survey: Establish a grid of contiguous quadrats encompassing the entire distribution area of the PU. In this case each quadrat is the sample unit for data analysis.

3. Cluster sampling: Conduct a generalized search of the PU area focusing on suitable microsites for the target taxa. When individuals are found, establish a quadrat centered on the plant or plants found. Establish additional 10 x 10 m quadrats immediately adjacent to the central quadrat and collect data on the plants found within each new quadrat. Do not establish new quadrats adjacent to quadrats that do not contain the target taxa. Each quadrat is the sample unit for data analysis.

4. Other sampling designs: In some cases it may be impossible to establish a systematic quadrat framework in the field due to extremely steep terrain. In those situations an appropriate design will be developed that allows for a repeatable sampling strategy that will provide the data necessary to evaluate the monitoring goals for this taxon.

For subsequent monitoring, continue with the same sampling design and quadrats as used for the initial baseline survey. In either case, establish new quadrats as needed if new plants are found outside the original sampling area.

Data to collect: The fields described below are included in the HRPRG's Rare Plant Field Data Form which may be used for data collection in this monitoring protocol (see Section 3, Appendix 2.3).

1. Location of individuals – this would be quadrat number if sampling conducted along contiguous-plot belt transect, or GPS coordinates (UTM Zone 4, NAD 83 datum base) if using cluster sampling strategy. Some of the individuals in the population may be uniquely identified and tagged to help with collection of propagules for the *ex situ* program, or to allow for the collection of data on the progress of individuals through size or stage classes. Where GPS points cannot be used to locate individuals, the position of individuals will be hand-drawn in relationship to local landmarks and topography.

2. Number of individuals in the following life-stage classes as defined for each taxon in the species SP: *seedlings/sporlings*; *immature individuals*; and *reproductively mature individuals*. Each of these classes must be determined for each taxon or life form of plant. For most PUs, all of the mature plants will be located and counted. However, the number of individuals in the non-reproductive classes may be counted in only a random sample of quadrats (with the number of quadrats determined based on the results of the initial baseline survey).

3. Vigor of all individuals in the following classes: *healthy* – foliage appears green and vigorous, less than 10% dead leaves or defoliation; *moderate* – some chlorosis may be seen in the leaves, 10-50% dead leaves or defoliation; *poor* – most leaves may be dead or chlorotic, 50% dead leaves or defoliation; *dead* – no live foliage or woody tissue. Some modification of these classes may need to be made for deciduous taxa, such as *Sanicula*.

4. Evidence of damage from alien animals: data will also be recorded on the presence of sign of damage on the sampled plants from alien animals, particularly ungulates, rats, or slugs.

5. Phenological stage: record data on the presence of *buds, flowers, immature fruits/spores, mature fruits/spores,* or *vegetative state* for each plant, or if the plant is *vegetative*, or *dormant*. This information will be summarized for the population as a whole.

6. Survival and growth of marked individuals: A random subset of plants in all size classes will be mapped and marked in selected PUs and data collected on their growth and status using the formats described above. Sample size needs to be determined from a pilot study. This information will be used as the basis for conducting population demography studies for the various plant taxa.

Data analysis methods:

1. In many cases all of the mature individuals within a PU will be enumerated so direct comparisons of the resulting numbers will be made with the specified population goal.

2. If non-mature plants are counted in only a random sample of the quadrats the number of plants in a particular stage class per quadrat will be the basis for determining the density of plants for comparisons over time. Data analysis will be performed using a parametric or resampling design paired t-test when the comparisons take the form of Time 1 vs. Time 2. For comparisons of multiple times or areas regression analysis will be used.

3. The data on survival, growth, and status of the marked individuals will be analyzed using an appropriate demographic program (*e.g.* RAMAS/stage) to evaluate current and projected status of this population.

Data collection interval: Data should be collected on the status of each PU annually. It would be ideal if data collection could coincide with time of fruiting by the plants to better evaluate seed set and to allow for collection of additional propagules, if needed, at the same time. In any case data should always be collected at the same month of the year for a specific PU.

Monitoring Protocol 2.3 – Assess Status and Stability of *Achatinella* Populations

Type of activity: Monitor

Action: Required as a component of the program to stabilize Oahu target taxa.

Description: Conduct regular monitoring program for *Achatinella* species within a population to assess its status relative to the stability goal identified for that taxon in the SP. Additionally, the monitoring data will provide for an assessment of population structure of the snail populations.

Management goal: Manage the specific populations to achieve the specified number of individuals of *Achatinella* as identified in the SP for this taxon.

Preliminary sampling objectives:

1. Be 95% certain that the total number of snails in the population is equal to or greater than the minimum number specified to achieve stability for that taxon as specified in the SP.
2. Determine if the demographic structure of the population appears to be adequate to sustain a viable population of this taxon over time.

Management response: If population stability is not achieved, one or more of several responses are appropriate: 1) continue with the same management program for a longer time, 2) intensify threat control, or 3) implement species augmentation if deemed necessary.

Area to monitor: Systematic survey the entire area of a population.

Sample unit: Most of the population monitoring will be conducted within discrete snail MUs that are enclosed with a mammal (ungulate and rodent) and mollusk-proof barrier. In some cases where it is impractical to construct a barrier fence, the population boundary will be marked with survey flagging and permanent aluminum or PVC posts to facilitate repeated surveys of the same area each time.

Monitoring framework: The population, which in most cases is delineated by a rodent and snail-proof fence, will be divided into equally sized subquadrats, approximately 5 x 5 m in size.

Data to collect:

1. The only reliable method for determining densities of tree snails in any location is the multiple mark-recapture technique. This method has been successfully employed for populations of *Achatinella mustelina* at Puu Palikea, Kanehoa and Pahole, as well as with other Hawaiian tree snails (Hadfield, *et al.* 1993). During each monitoring cycle, each subquadrat within the population will be searched by 3 – 4 persons for approximately 50 – 60 minutes. All live snails found will be removed from the trees and held in screened boxes placed in damp shade. Each new, unmarked snail will be coded with waterproof ink. The length and width of each snail will be measured with calipers to 0.01 mm. Adult snails will be noted on the data sheet. After all of the snails from a tree or quadrat are marked and measured, they will be returned to the tree or subquadrat from which they were collected.

2. The shells of all dead snails will also be collected from the ground within the quadrat at the start of each visit. These shells will be sorted into size classes, numbered shells recorded, and damage due to rat predation noted.

Data analysis methods:

1. An analysis of growth rate provides the basis for estimating the age of a snail from its shell length (Hadfield *et al*, 1993). Growth rate will be analyzed by fitting the logistic growth

curve to the data, then estimating the slope and intercept using a Ford-Walford linear regression.

2. Mark-recapture analyses will be used to estimate the total number of snails in each population, and within each year class. Details of how this analysis is applied to estimating the population size of *Achatinella* are found in Hadfield *et al.* (1993).

3. In addition to a minimum number or snails, healthy populations of achatinelline tree snails also must include all size classes in a fairly typical distribution dominated by snails in the first-year size class (i.e., 4.5 – 10 mm shell length) and the terminal size class (roughly 20 mm for A. mustelina but varying in different populations; see Hadfield *et al*. 1993). Using the population estimate and the age and size class data from the field surveys, a population structure analysis will be conducted for the population each time it is sampled.

Data collection interval: Data should be collected on the status of each population at least annually, but more frequent surveys may be necessary, particularly when a new MU is established.

Monitoring Protocol 2.4- Assess Status and Stability of Oahu Elepaio Populations

Type of activity: Monitor

Action: Required as a component of the program to stabilize Oahu target taxa.

Description: Conduct regular monitoring program for Oahu Elepaio (*Chasiempis sandwichensis ibidis*) populations to assess its status relative to the stability goal identified for that taxon in the SP. Consistent predator control programs for elepaio appear to restore mate fidelity, site fidelity, female age structure, and female recruitment age to more natural conditions. Additionally, the monitoring data will provide for an assessment of population structure of the elepaio populations and the success of the predator control program.

Management goal: Manage the specific populations to achieve the specified number of individuals of elepaio as identified in the SP for this taxon.

Preliminary sampling objectives:

1. Determine the success or failure of each mating pair during the breeding season and female survivorship to evaluate the success of the predator control techniques utilized in the PU.

2. Determine if the demographic structure of the population appears to be adequate to sustain a viable population of this taxon over time.

Management response: If the population is not increasing with active predator control, one or more responses are appropriate: 1) continue with the same management program for a longer time or 2) intensify threat control.

Area to monitor: Systematic survey of entire area of a population.

Sample unit: Population monitoring will be conducted within population units previously identified. Oahu Elepaio populations may be confined within a discrete area (i.e. a valley) or run across several contiguous gulches. Most of the PUs identified for management do not fall within fenced MUs. Though several PUs may have portions that fall within existing or planned MUs.

Monitoring framework: Two strategies will be utilized in monitoring populations of elepaio. These protocols may be modified depending on their usefulness in obtaining the desired information.

1. <u>Census of the population</u>: A census is conducted by sighting and banding birds, utilizing a recorded playback of elepaio songs. Resighting and monitoring by observation with binoculars with or without a recorded playback.

2. <u>Population estimates:</u> Conduct preliminary surveys and extrapolate data to determine the predicted extent of the population.

Data to collect:

1. The location of each male or pair territory can be determined by field observations, mapped with GPS or manually (using an altimeter and hard copy map).

2. The location of each pair's nest within the territory including tree type and height in the canopy. Each nest should have a sketch map with detailed notes and flagged directions to the observation point in order to facilitate future monitoring.

3. The success of fledglings can be determined through repeated field observations. Fledglings must be sited outside of the nest in order to constitute a successful fledging event.

4. Population structure: including age determined by morphological features and the number and distribution of single males and pairs. Some of the morphological characters used to age Oahu elepaio are listed below. Determining the distribution of single males and pairs require repeated site visits and identification of individual birds in the various territories.

    a. Hatch Year (HY) = lower yellow bill, no white feathers on wing bars, head, back, throat, and upper breast tawny-cinnamon to light amber. Only HY the year hatched (i.e. if hatched in spring 2004, only HY until the end of 2004).
    b. 2nd year (SY) = all black bill (may have some yellow), plumage same as HY (i.e. rusty/tawny-cinnamon wing bars). Any birds hatched the previous breeding season after January 1st.

c. 3^{rd} year (TY) = rusty wing bars with white tips
d. After 3^{rd} year (ATY) = wing bars all white

Data analysis methods:

1. Elepaio demography
To determine the overall effect of rodent control on Elepaio demography the finite rate of population growth, lambda (λ), should be calculated using methods described in VanderWerf and Smith (2002). Values of lambda >1.0 indicate population increase, those <1.0 indicate decline, and a value of 1.0 indicated no population growth or decline.

2. Other data that can be utilized in determining the success of the rodent control program are nest success, number of fledglings per pair, fledgling survival, site and mate fidelity, age structure and recruitment.

Data collection interval: During the breeding season monitoring trips should occur frequently (i.e. bimonthly) in order to determine the location of nests and territories and the successes of the predator control programs in place. Additionally, each breeding season new birds should be banded for more accurate monitoring of individuals.

Monitoring Protocol 2.5 – Conduct Phytosanitation Monitoring in Greenhouse Facilities

Type of activity: Monitoring

Action: Required as a component of the program to stabilize Oahu target taxa.

Description: Conduct phytosanitation monitoring on potted plants designated for out-planting to ensure they are not contaminated with pathogens or other pests of concern as identified in the phytosanitation standards (see Section 3, Appendix 2.2).

Applicable for: Plants to be outplanted as part of species reintroduction or population augmentation programs.

Management goal: To prevent any introduction of pathogens or other pests of concern from the greenhouse (*ex situ*) environment into the forest ecosystem.

Preliminary sampling objectives: Be 100% certain that all of the greenhouse plants proposed for outplanting are not visibly contaminated by pathogens or other pests of concern.

Management response: If pathogens or pests are discovered within the lot of plants designated for outplanting, treat all of the plants with an appropriate pesticide and quarantine for longer period of time; reexamine the plants prior to any future outplanting. If any of the plants are found to be contaminated with a virus, destroy all of the contaminated plants and quarantine all of the remaining plants in that lot.

Group to monitor: All of the individual plants proposed for outplanting.

Monitoring framework: Examine all individual plants proposed for outplanting.

Data to collect:

1. Presence or absence of pathogens or pests of concern – record if an individual definitely has, or shows symptoms of, a pathogen or pest of concern identified in the phytosanitation standards (Section 3, Appendix 2.2).

2. Identify type of pathogen present – make a definite determination of the contaminating species.

3. Symptoms – describe in writing the pathogenic symptoms, document via photo and collect sample for analysis

Data analysis methods: No statistical analyses are needed for this protocol. However, it is essential that a proper random sample is taken of all of the plants that are in the proposed outplanting lot unless all plants are to be examined.

Data collection interval: Data must be collected after quarantine period is completed and prior to sending plants out for reintroduction. The sampling must be done just before planned outplanting date because any lag between inspection and planting may allow for new pathogens to become established.

Monitoring Protocol 2.6 – Monitor *In Situ* Individuals to Aid with the Collection of Propagules for Reintroduction Stock or for Genetic Storage

Type of activity: Monitoring

Action: Recommended as a component of the program to stabilize Oahu target taxa.

Description: Conduct monitoring of natural plant populations to determine phenology and to collect propagules for storage, propagation or experimentation.

Applicable for: Target plant taxa.

Management goals: To determine a window when collection of propagules is highly probable. To successfully collect an adequate number of propagules to meet project goals for the taxa from wild plant populations without conducting more visits than are necessary, and to avoid unnecessary impacts to the wild plant populations.

Preliminary sampling objectives: Be 100% sure that the window for collection will ensure successful seed collection if plants reproduce.

Management response: 1) Collect propagules as needed, 2) adjust schedule according to phenology patterns of a taxon or a population, 3) apply threat control if necessary to ensure fruit collection, 4) re-visit population if necessary to collect adequate fruit.

Area to monitor: Areas that contain target taxa, with the purpose of locating mature individuals from which propagules will be collected.

Monitoring framework: Conduct a complete survey of all mature individuals in a PU to determine if or when they would be flowering or fruiting.

Data to collect: Data will be collected following the HRPRG rare plant monitoring format (see Section 3, Appendix 2.3). Record location information (map and/or GPS coordinates) as needed for any new mature individuals of the target taxa found in the population.

1. Record reproductive status of all individuals – record presence of fruit (mature or immature), and flower (buds or opened), spores (mature or immature) and numbers of individuals with each.

2. Collection information – Record any collections made, assign numbers to plants sampled, designate purpose for collection before collecting.

Data analysis methods: No statistical analyses are needed for this protocol. All data resulting from the field surveys will be entered into the project database and GIS.

Data collection interval: Visit the population quarterly to determine phenology or visit at time of year when reproduction expected (*i.e.,* as determined from herbarium specimen dates, or following expert advice).

Monitoring Protocol 2.7 – Conduct Phytosanitation Monitoring in the Field

Type of activity: Monitoring

Action: Required as a component of the program to stabilize Oahu target taxa.

Description: Conduct baseline inventory for pathogens in outplanting sites and phytosanitation monitoring on outplanted individuals to determine if they are contaminated by pathogens or other pest species of concern that have been identified as possible problem species in the phytosanitation standards (see Section 3, Appendix 2.2).

Applicable for: Outplanting sites and outplanted individuals in the field as part of taxon reintroduction or augmentation programs.

Management goal: To prevent any introduction of a pathogen from the greenhouse (*ex situ*) environment into the natural ecosystems.

Preliminary sampling objectives: Be 100% certain that all outplanted individuals are not visibly contaminated by pathogens or other pest species of concern, and other individuals within the vicinity of the field planting site are not contaminated above the baseline as a result of the outplanting. Examination of plants must be conducted by trained experts capable of detecting pathogens or pest species (or indications thereof) that have been identified as known or potential problem species.

Management response: If pathogens or other pest species of concern are discovered on outplanted individuals, there are options: 1) eliminate the problem with an appropriate control technique and continue to monitor in the field, or 2) remove contaminated plants from reintroduction site and treat the contaminated planting sites with an appropriate pesticide to eliminate the problem in the field. Additionally, if contaminated plants are found in the field, it is necessary to reevaluate the greenhouse phytosanitation monitoring protocol to determine why it failed and to make modifications to that protocol if needed.

Group to monitor: All of the individual plants that were outplanted, as well as a sample of other plant taxa within the outplanting area.

Monitoring framework: 1) Examine all individual plants that were outplanted. 2) Conduct a pilot study to determine the extent and number of plants to be examined for pathogens or other pest species of concern within the study area.

Data to collect:

1. Presence or absence of pathogens or pests of concern – record if a sampled individual definitely has, or shows symptoms of, a pathogen or pest of concern identified in the phytosanitation standards (see Section 3, Appendix 2.2).

2. Identify type of pathogen present – make a definite determination of the contaminating species.

3. Symptoms – describe in writing the pathogenic symptoms, document via photo and collect sample for analysis.

Data analysis methods: No statistical analyses are needed for this protocol.

Data collection interval: Data should be collected on the status of plants at each outplanting site every month for the first three months, or every other month if watering is not needed and then every three months to complete first year.

Monitoring Protocol 2.8 – Monitor Success of Outplanted Individuals

Type of activity: Baseline survey and monitoring

Action: Required as a component of the program to stabilize Oahu target taxa.

Description: Monitor germination and/or survival, growth, reproduction, and phenology of all or a subset of individual plants that have been outplanted or introduced as seeds for a taxon in an area. This short-term monitoring project addresses specific propagation research needs as identified in each of the SPs (Section 2, Chapter 2). The results will be used to develop or refine techniques that maximize the survival of individual plants that are outplanted into the wild. Additionally the information will be the basis for determining how many individuals need to be planted in subsequent stages of an augmentation or reintroduction program.

Applicable for: Plants or seeds outplanted as part of a taxon augmentation or reintroduction program. Monitoring may just be focused on determining germination or survival and growth of all individuals outplanted in a single type of microsite in the area, or may include comparison of different types of microsites or propagation parameters (*e.g.*, age or size at planting, pot size or shape, post-planting care, *etc.*) within an augmentation or reintroduction site, depending on research/monitoring questions identified in each SP (Section 2, Chapter 2).

Management goals: 1) Determine germination and/or survival of plants, and 2) growth of plants, for a particular taxon introduced into the field from greenhouse stock are influenced by type of introduction (seeds or plants), size of plants at outplanting, size of pot, and different types of outplanting sites. A 10% difference in plant survival and average plant growth will be considered to be significant. 3) Track phenology of plants to aid with determination of best time to collect seeds for future *ex situ* propagation.

Preliminary sampling objectives: 1) Be 90% certain that at least a 10% difference can be detected in number of plants that germinate and/or survive each year (up to five years) after planting between groups using different sizes of plants at outplanting and between different outplanting sites. 2) Be 90% certain that at least a 10% difference can be detected in growth of plants each year (up to five years) after planting as measured by stem length and number of leaves between groups using different sizes of plants at outplanting and between different outplanting sites. The number of individuals within each group must be large enough to ensure that the chance of making a Type II error is less than 20%. 3) Track phenology of plants to aid with determination of best time to collect seeds for future *ex situ* propagation. Phenological information will be collected for all plants that are sampled during the monitoring but no analyses will be conducted relative to outplanting techniques or microsite characteristics.

Management response: 1) If a significant difference in plant survival exists after up to five years of sampling, the characteristics of the more successful trial (initial plant size or type of outplanting site) will be used as the basis for subsequent outplanting efforts for that taxon. If no difference is found in plant survival after monitoring, the easiest and most cost-effective methods will be used for subsequent outplanting of that taxon. 2) The results of monitoring plant growth relative to the different treatments will be used to help predict or refine the results of the plant survival analysis. The results of the analysis of survival will also be used to determine or refine the projected number of individuals to outplant for that taxon to achieve a specified number of plants that will become part of the reproductive pool.

Area to monitor: Complete or random sample of outplanted individuals within a reintroduction population or augmented *in situ* population.

Pilot studies: It is important to emphasize that the suggestions that follow regarding monitoring framework, data to collect, and data analysis methods are preliminary suggestions that need to be developed following completion of pilot studies in the PUs and MUs. Data collected from pilot studies will be used to refine the protocol relative to variables which will be sampled, plot size and shape, sampling framework, number of samples to be taken, monitoring interval, and data analysis methods to be used.

Sample unit: The basic sampling unit will be an individual plant. In cases where seeds are used for a reintroduction trial, seed planting blocks will be the initial sample unit to determine germination rate (% of planted seeds that germinate). Following germination, the individual plants will be the sampling units for monitoring growth.

Monitoring framework: All or a random sample of outplanted individuals or individuals germinated from planted seeds on the site will be monitored in several treatment categories which may include different size or age at outplanting, different pot size, post-planting care or not, and different microsite characteristics. The specific variables selected for testing are identified in each of the species SPs. The experimental design for any given project will not exceed a total of six different treatments (*e.g.*, two variables with three factors per variable), although a smaller number of treatments would be preferred as it would require fewer plants to monitor.

Plants will be assigned to treatment types randomly, either at time of repotting in the greenhouse (pot size), selection of plants to be grown to an older age in the greenhouse, assignment of plants to planting site, or selection of plants for post-planting care within a planting site. Microsites will be chosen to minimize variability as much as possible within each outplanting site.

Data to collect:

1. <u>Percent germination of planted seeds</u>: When seeds are planted as a reintroduction strategy, the number of individuals that germinate will be counted in a specific seed sowing block within the reintroduction or augmentation site. Percent germination will be calculated by dividing the number of germinants by the total number of seeds planted.

2. <u>Vigor will be recorded for all sampled individuals</u> in the following classes: *healthy* – foliage appears green and vigorous, less than 10% dead leaves or defoliation; *moderate* – some chlorosis may be seen in the leaves, 10-50% dead leaves or defoliation; *poor* – most leaves may be dead or chlorotic, 50% dead leaves or defoliation; *dead* – no live foliage or woody tissue.

3. <u>Size of individuals</u>: For each sampled plot, record size or growth measurements that may include stem length, stem diameter, number of branches, number of leaves, depending on life form and life stage of the plant. Diameter measurements will be recorded to the closest tenth

of a centimeter; stem length will be recorded to the closest centimeter, or as modified for a particular taxon.

4. Phenological stage: Record data on the presence of *buds, flowers, immature fruits/spores, and/or mature fruits/spores* on each plant sampled, or if the plant is *vegetative*, or *dormant*. The data collected on phenology as part of the regular monitoring program will be dependent on the time of year data are collected at that site, and may not be either a representative or reliable representation of the phenological status of the population at that site. Despite these limitations, the collection of phenological data for the plant taxa introduced into the various sites is easy to record and may be useful to alert management staff when it would be best to revisit the site to either collect propagules or assess survival of any offspring resulting from the outplanted individuals.

5. Damage to Plants: Any obvious damage to the plants from ungulates, rodents, or invertebrates, will be identified and recorded when each of the sampled plants is examined and measured. This information may be useful in helping to understand reduced vigor or death of some of the plants that have been outplanted into a PU.

Data analysis methods:

1. Data collected on seed germination, and vigor or survival of individual plants will be analyzed using a contingency table design.

2. Growth or size data will be analyzed using a paired t-test design or repeat measures analysis of variance.

3. Phenological data will not be analyzed using any formal statistical procedures.

Data collection interval: The first data collection time for this protocol will be just prior to moving plants out of the greenhouse and into the *ex situ* planting sites. During the first six months, data on germination (if seeds used for reintroduction) and/or survival of the plants will be assessed in accordance with the watering scheme specified in the species SP, but at least three times during this initial period. The next sampling time will be 12 months after seed sowing or planting, and thereafter the plants will be monitored annually.

6.4 Monitoring Protocols for Areas Outside Management Units

*These protocols are taken directly from the Makua Implementation Plan (MIP). The Oahu Implementation Team (OIT) has determined these protocols to be applicable to the needs of the Oahu Implementation Plan (OIP). However, these protocols may change to adapt to the needs of the Army in the stabilization of the target taxa.

Monitoring Protocol 3.1 – Survey for Target or Other Rare Native Species Outside Designated Management Units

Type of activity: Survey

Action: Recommended as a component of the program to stabilize target taxa

Description: Conduct field surveys, prior to fenceline construction, to determine distribution and general abundance of Implementation Plan (IP) targeted and other rare native species in areas outside but adjacent to a management unit (MU). This information will help identify those species that could easily be included within the MU or may be adversely affected by ungulate fence construction or other management activities within the MU.

Applicable for: Target species of plants and other rare native species in or adjacent to MUs.

Management goals: Make sure that management actions conducted as part of the Makua IP do not adversely affect any populations of the targeted species or other rare plant species found adjacent to proposed MUs.

Survey objectives: To identify populations of target taxa and animal species or other rare native plant species that could easily be included within proposed MUs or might be adversely affected by management actions within the MU. Be 100% certain that no target taxa species or other rare native plant species are found within a 10 m-wide zone centered on a proposed fenceline corridor.

Management response: If IP target plants or other rare native plants are found just outside of proposed MUs, these sites will be mapped and evaluated to determine if they can easily be included within the MU. Of particular concern will be identifying rare plants in sites that occupy proposed fenceline corridors, or may be located just outside of fencelines that may experience increased damage from feral ungulates that range up to the new fenceline.

Area to survey: Surveys will be conducted along proposed fenceline or access corridors relative to a MU, as well as up to 30 m outside of the proposed fencelines, depending on the vegetation type and terrain.

Monitoring framework:

1. Systematic surveys will be conducted in a 10 m wide continuous plot along the entire length of proposed fenceline corridors to locate any previously unknown sites containing Makua IP targeted plants or other rare native plant species.

2. Depending on the terrain and presence of suitable habitat, surveys for rare plants may also be conducted out to 30 m outside the proposed fenceline corridor in selected areas.

Data to collect:

1. Survey route - accurately map survey route taken using either Global Positioning System (GPS) or manual mapping (altimeter and hard copy map).

2. Location of population – map exact location of target taxa or other rare plant taxa using either GPS or manual mapping.

3. Data collected on individuals or population – collect information using the Hawaii rare plant restoration group rare plant monitoring form (see Section 3, Appendix 2.3).

Data analysis methods: No statistical analyses are needed for this protocol. Information collected on the survey routes and on the individuals or populations of target taxa located will be entered into the project Geographical Information System (GIS) and database.

Data collection interval: These surveys will be conducted along all proposed MU fenceline corridors prior to fence construction. For some species surveying during likely times of flowering may increase the chances of detecting more individuals. Timing of surveys should also coincide with times when species that have a dormant phase are more apt to be growing.

Monitoring Protocol 3.2 – Conduct Surveys and Monitoring of Alien Plants and Animals Outside of Management Units

Type of activity: Baseline survey and continue with monitoring.

Action: Recommended as a component of the program to stabilize Makua target taxa.

Description: Conduct aerial and field surveys in the areas between the designated or proposed MUs to determine the distribution and general abundance of selected, highly invasive and damaging alien plant and animal species (see Chapter 3) that may adversely impact the stability of the MUs.

Applicable for: Determining the general distribution and abundance of selected, highly invasive and damaging alien plant and animal species outside of the MUs.

Management goals: Ensure the plant communities within the MUs form a stable, native-dominated matrix, which will be able to support stable populations of the IP rare species.

Survey objectives: To identify the distribution and/or abundance of selected, highly invasive and damaging alien plant and animal species outside the MUs so the threats can be controlled before they adversely impact the stability of the MUs.

Management response: If an increase is found in the distribution or abundance of any of the selected, highly invasive and damaging alien plant species that may threaten the stability of the MUs, management actions may be initiated to control the problems before they adversely impact the MUs.

Area to survey: Selected aerial and ground surveys will be conducted in areas outside the MUs, as deemed necessary. In certain areas, surveys will be centered around the known or suspected distributional area for alien species of concern, These include populations of feral goats, *Myrica faya*, *Leptospermum* spp. and other species that can be easily detected from the air or from ground surveys in areas that provide a good view of large areas adjacent to the established MUs.

Monitoring framework:

1. Aerial surveys: Aerial surveys will be conducted over known or suspected distributional areas to detect the distribution and relative abundance of feral goats and selected invasive alien plant species. Survey tracks will follow along elevational contours, which will allow for mapping the distribution of the target species using GPS units and by sketch mapping from the air.

2. Ground surveys will also be conducted as needed to verify locations or species identified from the aerial surveys and to further refine the distribution of selected species in areas that are not easily seen from the air.

Data to collect:

1. Survey route - accurately map the survey route taken using either Global Positioning System (GPS) or manual mapping (altimeter and hard copy map).

2. Location of population – Map exact location of selected, highly invasive and damaging alien plant and animal species using either GPS or manual mapping.

3. Data collected on individuals or population – collect information on number of individuals detected (feral goats or easily identifiable plant species) or distribution of target alien species.

Data analysis methods: No statistical analyses are needed for this protocol. Information collected on the survey routes and on the individuals or populations of mitigation species located will be entered into the project Geographical Information System (GIS) and database.

Data collection interval: These surveys will be conducted at least annually or more frequently if needed.

Monitoring Protocol 3.3 – Survey for Invasive Plants Along Disturbance Corridors

Type of activity: Baseline survey and monitoring

Action: Required as a component of the program to stabilize Makua target taxa.

Description: 1) Conduct regular surveys of selected disturbance corridors throughout the Makua project area to identify new invasive alien plant species that may have been introduced or moved around as a result of human use of the area. Focus of this monitoring protocol is on disturbance corridors such as roads, trails, fencelines, or transects that may have alien plant species introduced from vehicles, boots, packs, *etc*. 2) Identify previously established species within the project area that appear to be expanding their distribution as a result of a human disturbance corridor. Disturbance corridors to be monitored are those that are considered to have the highest risk of new problem invasive alien plant species being introduced as a result of human use of the corridor.

Applicable for: Detecting the presence of invasive alien plant species that may become established along roads, trails, fencelines, or transects as a result of human use of the area. This information will also be used to identify other incipient alien species that may be increasing within an area and need to be controlled.

Management goals: Keep new invasive alien plant species from becoming introduced into the MUs along existing disturbance corridors such as roads, or new corridors like trails, transects, or fencelines that are created during management actions in the area. If new problem species are located along the corridors, every effort will be made to eliminate these species from the area before they are able to spread further into the MUs.

Primary monitoring objectives: 1) Be 100% certain that all known or potentially invasive alien plant species within and up to 3 m on either side of a disturbance corridor are detected. 2) Be at least 90% certain that a 10% increase can be detected in the frequency of potentially invasive alien plant species that are not the focus of an existing weed control program along the disturbance corridor.

Management response: 1) If a new invasive alien plant species or a new location for a previously established invasive alien plant species is detected along a disturbance corridor, the location will be documented and the plant or established population will be eradicated before it spreads. 2) If a potentially invasive alien plant species is found to have increased significantly, this species will be targeted for control before it can spread any further.

Area to monitor: Monitor the entire length of established disturbance corridors including an area 3 m on either side of the corridor.

Sample unit: The basic sample unit will be logical subdivisions of the disturbance corridor to allow for reliable relocation of invasive species. For example, this may be regular intervals 50 m long on transects, or unequal lengths of corridors along roadways.

Monitoring framework: The entire length of selected disturbance corridors will be monitored with contiguous plots that are established at 50 m intervals, or other irregular intervals, and include the full width and extending 3 m on either side of the disturbed corridor. The survey must ensure that all of the invasive alien plants within the plot will be detected. Any target invasive plants that are found beyond the 3 m width of the plot will also be also recorded, but there is no certainty that 100% of the area beyond 3 m on either side of the corridor will be surveyed for all invasive species, particularly those with a small life form. The 50 m points along each corridor will be marked as permanent reference points to define the length of the plots for subsequent monitoring.

Data to collect: Information to be recorded within each plot includes name of species found, plot number, and phenological stage of the plant (buds, flowers, immature fruits, and/or mature fruits). Species detected outside the 3 m limit of the plot will also be recorded if they are detected, recording the same information as for plants within the plot except the species name will also be marked with an asterisk (*) indicating it was found beyond the 3 m width of the plot.

Data analysis methods:

1. No formal statistical analysis will be conducted to determine change in frequency of invasive weed species that are targeted for control since the mere presence of one or more individuals of any of these species in any of the sampled plots will trigger their removal.

2. For those species that have data recorded but are not the target of a specific weed control program, we will use the frequency data to determine if the frequency of occurrence of any species has increased significantly between sequential sampling periods. The frequency data will be analyzed using a paired samples contingency table design (McNemar's test), testing for at least a 10% increase in frequency, at a significance (alpha) level of 0.10.

3. Phenological data will not be analyzed using any formal statistical procedures but will be useful for determining reproductive status of the target weed species.

Data collection interval: Disturbance corridor monitoring should be conducted in each of the selected areas annually.

7.0 Information Management

Implementation database
The Army utilizes an access database that contains queries and fields specifically tailored for information management for the Makua Implementation Plan (MIP). This database has proven to be invaluable in the management of the profuse amounts of data that has been gathered in the process of carrying out the MIP. This database currently tracks data related to rare plants, rare snails, and weed control. Specific data collected are the location, status, threats, and management of the individual *in situ* target taxa, population units (PUs), management units (MUs), and reintroduction sites across the island of Oahu. Additionally, this database contains data on numerous non-MIP target taxa of additional significance (i.e. additional federally listed species, candidate species, or species of concern). This information can be queried in multiple ways to analyze data and aid in management decisions.

The Army access database is utilized jointly with geodatabases and shapefiles that associate all the rare species, and management actions for weed control in the access database in spatial form. The Army access database can be linked to these geodatabases and shapefiles to make added information such as Management Unit, Management Designation, Number of plants in a population, etc available when utilizing the maps. Field maps and ArcReader documents are linked to the access database so that when a record such as a rare plant or weed control area (WCA) is being viewed in the database there is a quick link to visual information on the subject.

Data integration and inter-agency cooperation
The success of the OIP will depend on the cooperation of multiple agencies, combining efforts to eliminate duplication of effort, sharing lessons learned, and thus increasing effectiveness. The Makua Implementation Team (MIT), assembled for the development of the MIP, has been a great learning process for the Army and the various members of the MIT, on the level of coordination and teamwork required to effectively carry out the various actions described in the MIP. The MIT continues to struggle with landownership issues as they relate to MIP actions. However, as the implementation of the IP continues, knowledge is gained that will aid in eventual successful species stabilization. The Army and the Oahu Implementation Team (OIT) hope to utilize the experience gained from the Makua implementation process. Modifications to various data gathering and landownership protocols have already benefited both the MIP and the OIP.

Thus far, the Army Natural Resources program has worked hard to standardize data collection, mapping, and GIS database management systems. The data collected by the Army natural resources staff has been entered in to the Army Rare Plant Database and GIS and has been made readily available to the various partnering agencies and individuals. In turn, this organization of data has been essential to the Army in the management of numerous species, propagules, reintroductions, populations and management units, etc. The availability of data to all members of both the MIT and the OIT has and will continue to aid in the adaptive management approach to species stabilization. In this way, the status of populations are monitored and adjustments to management practices are made in order to meet the stabilization goals of the MIP and the OIP. For this reason, all data gathered for the OIP will be integrated into the Army database and will be available to any partners involved in the implementation of the Oahu plan. Currently, the

State is working on the development of a State-wide rare plant database that will be compatible with the Army's current system.

8.0 Conclusion

The Oahu Implementation Plan (OIP) is based largely on the Makua Implementation Plan (MIP) (U.S. Army Garrison 1999) with several major and minor modifications generally acknowledging: (1) valuable lessons learned from the implementation of the MIP, (2) the differences in habitat quality and species rarity between the Koolau and Waianae action areas (AAs), and (3) the level of threat to the target taxa from military training, specifically in the Koolau AAs. The Oahu Implementation Team (OIT) believes that stabilization of the Oahu target taxa can be achieved through a program of adaptive management applied at both the individual levels of target taxa (population unit (PU)) and habitat levels (management unit (MU)). In order to achieve the stabilization goals for these species, the Army will continue employing the programs initially developed for the MIP which include:

- a program of threat abatement directed at individuals, PUs, and MUs,
- a reintroduction program establishing multiple managed populations,
- an augmentation program bolstering selected PUs as needed,
- a genetic storage program securing a source for future propagation efforts,
- selected research directed at threat abatement and rare taxon biology, and
- a monitoring program to assess response to taxon and habitat management actions and to determine if stabilization goals are met.

The OIP is based on an integrated biological and military training approach. The Army believes this approach will result in the biological stabilization of the species affected by military training. The OIT was able to prioritize the actions needed for species stabilization by using the programs already established for the MIP. The full implementation of the OIP, as written, will result in 69 stable plant populations, 24 stable snail populations, and greater than 75 successfully breeding pairs of Oahu elepaio (across several sites).

The OIT, utilizing biological criteria, established priorities for implementation of these tasks and subtasks over a 20-year period (see Section 3; OIP Costs for action priorities by tier and year). This large prioritization of actions carries the stabilization process from its inception to the achievement of stabilization, decades from now. With this kind of long-term goal, no preset plan can deal with the many contingencies and decisions that biological management generates. Only a program of monitoring and dynamic response to feedback under the guidance of experts such as those serving on the Makua Implementation Team (MIT) and the OIT will provide the most appropriate course toward stabilization and compliance. The Army plans to have the formal MIT act as reviewers and consultants for the OIP on an annual basis, with the final decisions on stabilization actions being agreed upon by both the Army and the USFWS.

Both the Makua and Oahu Implementation Plans require the Army to continue acting as an active member of regional conservation efforts in support of stabilization of the target taxa. The Army has an active role to take in the conservation of the natural resources within its Oahu Training Areas and has been involved in conservation of Army training areas before the formal consultations with the USFWS began. Successful implementation of both the MIP and OIP assures that the Army will be in compliance with the Endangered Species Act while still being able to accomplish its training mission.

9.0 Strategy for Stabilization of Koolau *Achatinella* species

General Description and Biology
Achatinella species are arboreal and generally nocturnal, preferring cool and humid conditions. During the day, the snails seal themselves against leaf surfaces to avoid drying out. The snails graze on fungi growing on the surfaces of leaves and trunks. *Achatinella* are hermaphroditic though it is unclear whether or not individuals are capable of self-fertilization. All species in the endemic genus bear live young (USFWS 1993).
Taxonomic background**:** The genus *Achatinella* is endemic to the island of Oahu and the subfamily Achatinellinae is endemic to the Hawaiian Islands. A total of 41 species were recognized by Pilsbry and Cooke in a monograph of the genus (1912-1913). This treatment is still recognized for the most part by the USFWS, although several genetic studies by Holland and Hadfield (2002, 2004) have further elucidated the relationships among species.
Threats: Threats to *Achatinella* species in general are rats (*Rattus rattus, R. norvegicus,* and *R. exulans*), predatory snails (*Euglandina rosea*), terrestrial flatworms *Geoplana septemlineata* and *Platydemis manokwari,* and the small terrestrial snail *Oxychilus alliarius*. Lower elevation sites may be under more pressure from *E. rosea* and rats as human disturbed sites may have provide more ingress points for these threats.
Threats in the Action Area: The decline of these species has not been attributed to threats from any Army training maneuvers either direct or indirect. Rather, the decline is likely due the loss of genetic variation caused by genetic drift in the remaining small populations and predation by rats (*Rattus* sp.) and the introduced predatory snail *Euglandina rosea*. Possible threats from Army training to these species' habitat are trampling of host vegetation during foot maneuvers and the introduction of invasive species. However, these threats are currently low or non-existent for the areas where these species occur (Army 2003).

Defining stabilization for *Achatinella* species
The approach to the stabilization of Koolau *Achatinella* species taken in the Oahu Implementation Plan (OIP) is modeled after the plan outlined for *Achatinella mustelina* in the MIP. However, there are several significant differences regarding the management of the Koolau species, such as the threat level, quantity of individuals, type of habitat terrain, and the number of species.

The biology of Oahu tree snails has been studied for several decades in Hawaii. Life history patterns (including low reproductive rates and late age at first reproduction), population dynamics (sometimes including large fluctuations in snail densities), and vulnerability to predation, results in a set of appropriate stabilization actions. Stabilization incorporates two main activities: *in situ* management and maintaining captive breeding populations. Stabilization actions for these species will be initiated when training maneuvers occur along or off trails in the upper reaches of the Kawailoa Training Area (KLOA) and Schofield Barracks East Range (SBER) (Tier 2: see Chapter 5.1: Army Stabilization Priority Tiers) or under Tier 1 actions as a proactive management project that may be done in partnership with other landowners and conservation agencies. Due to the dire need for conservation of the Koolau *Achatinella* species, the Army will pursue partnerships for resource protection prior to the initiation of Tier 2. The Army will not be able to conserve these species without partnerships.

There are a number of challenges in attempting to stabilize populations of *Achatinella*. These include difficulties in controlling alien predators (rats and *Euglandina rosea*), large fluctuations of snails in populations due to natural disasters or predation events, the slow rate of recovery due to life history traits, and the impacts to wild populations from collection of individuals for captive propagation. In locations where habitat is either intact or restorable, and a snail population structure exists that promotes natural recruitment, a population will be managed *in situ* for stability. *In situ* management options range from threat abatement, habitat management, and stimulation of natural regeneration. If there are few individuals, and conditions for habitat rehabilitation are poor, the population might be identified for captive propagation. Captive propagation serves as a means of preserving genetic resources for future reintroduction attempts that will aid in maintaining the populations required to achieve stabilization.

Population Units (PU) designated as manage *in situ* for stability will have the following actions implemented: (1) assess population sizes; (2) assess threat management needs and choose site(s) for predator and ungulate exclosure(s); (3) habitat restoration; (4) manage threats (as appropriate), including areas adjacent to exclosure(s); (5) population monitoring (see Chapter 6 Monitoring and adaptive management), including areas adjacent to exclosure; (6) data management, analysis, reporting; and (7) adaptive management.

Population units and population size

Currently to ensure stabilization, each PU must include 300 or more snails, totaled across age classes. This number was determined largely from empirical observations on the Pahole population of *A. mustelina* (Hadfield and Mountain 1980, Hadfield 1986, Hadfield *et al.* 1993). Without predators, the size of the Pahole population of *A. mustelina* in a 25 square meters (m^2) grew from approximately 50 to 300 snails in about 4 years. When predators (rats or the introduced snail *Euglandina rosea*) entered the area, the population diminished rapidly to less than 30 individuals. Recovery from these predation events has been slow, even with active conservation efforts. The stabilization plans for all the *Achatinella* species may be modified using the adaptive management process to ensure that the best science is applied to achieve stabilization of these species.

Management for the Koolau species of *Achatinella* in the action area is modeled after the plan developed for *A. mustelina* in the MIP. Genetic analyses were completed by Holland and Hadfield (2002) which outlined evolutionarily significant units (ESUs) which followed a definite geographical pattern along the Waianae mountain range. The Makua Implementation Team (MIT) utilized these ESUs as populations to manage for stability. This type of genetic analysis has not been completed for other *Achatinella* species. Therefore, the Army designated "geographic units" (GUs) for the Koolau species based on known geographic locations of discrete snail populations until ESUs can be determined for the Koolau species. Currently, a minimum of six population units (PUs) is required for stabilization (USFWS 2003). This requirement and management goals may change based on genetic analyses. For those species that do not currently have six extant GUs, reintroductions within predator proof exclosures will be attempted using captive reared individuals.

Table 9.2 lists the current known population size of each PU, most of which are less than three hundred. Many of the species actually number less than 300 individuals for all populations combined and several species are represented by less than 6 PUs. As mentioned previously, two management designations are defined to stabilize species: manage for *in situ* stability and collect for captive propagation. Ten *Achatinella* species were included within the Service's 2003 Biological Opinion. The Army has decided to manage all extant populations units of *A. byronii/A. decipiens, A. lila,* and *A. livida* for stabilization due to the extremely low number of extant populations known. The Army will manage eight PUs for *A. mustelina* to represent the six ESUs; ESUs B and D cover a large geographic area and are represented at two separate manage for stability sites.

There are a few snail species that are considered currently in the action area (AA) but are not known from any extant populations. These species are *A. apexfulva*, *A. bulimoides, A. curta*, *A. leucorraphe,* and *A. pulcherrima*. As mentioned in the Taxon Summaries and Stabilization Plans, *A. bulimoides*, has recently been observed on several separate occasions in the summit areas above Punaluu Valley. However, on these occasions all individuals seen (except 2) were collected for captive propagation. These species are discussed in detail in Chapter 9.1. Surveys will be conducted for the remaining species (*A. apexfulva, A. bulimoides, A. curta, A. leucorraphe, A. pulcherrima)* within the action area to determine additional management actions. If any *in situ* populations of these species are found stabilization plans will be made with the input of Army natural resources biologists, U.S. Fish and Wildlife Services Biologists, landowners, and field experts.

The main goal of stabilization is to achieve stable and self sustaining populations units of each *Achatinella* species. In order to achieve this goal, *in situ* and *ex situ* management of individuals is necessary. *In situ* management includes: threat control over a broad enough area to enable population expansion, habitat restoration, reintroduction, etc. *Ex situ* management includes: collection for captive propagation, maintenance of captive propagation, genetic analyses, etc. Additionally, the Army must conduct long-term monitoring of populations for trend analyses and to determine the effectiveness of management practices. This may include timed searches, mark-recapture studies, and ground shell plots.

To determine the status of managed field populations, each manage for stability GU will be monitored each year. Data will be included in discussions at the snail working group meetings and in the Army's annual report, which will be used by the OIT to make management recommendations. Monitoring growth of snails (Table 9.1 first row) is necessary only for introduced populations, to assure that the habitat is adequate.

Table 9.1 Monitoring of *Achatinella* population size and population units.

Elements to Monitor	Monitoring Objective	Data collected	Proportion of Population to Monitor	Schedule
# and size of Snails in a PU; recruitment; range expansion	Determine the number of individuals present in each size class; survival rate;	No. of individuals; length, width, operculum orientation; spread to nearby vegetation	All individuals found; use mark-recapture	To be determined by the OIT and
Growth of re-introduced or augmented snails	Determine if site is adequate for growth	Growth per size class; shell length and width	All individuals found	
Genetic variability	Determine if initial variability is maintained	Collect small tissue samples for DNA analyses	All snails ≥ 15 mm shell length	

Stabilization Success: Success will be determined as having 300 individuals within a GU and 6 GUs for each species. In addition to a minimum number of snails and population units, healthy populations of *Achatinella* tree snails also must include all size classes in a fairly typical distribution.

Genetic Analyses

Genetic analyses will be conducted to provide additional insight on the range of genetic diversity and the locations of ESUs within and among the extant populations of 4 species: *A. byronii/decipiens*, *A. lila*, *A. livida*, and *A. sowerbyana*. This type of analysis has proven invaluable to the management of *A. mustelina* for the MIP. It is anticipated that management plans may change slightly based on the results of the genetic analyses. All changes will be approved by both the Army and the U.S. Fish and Wildlife Service.

Genetic samples will be collected from all large populations of *A. sowerbyana*, all populations of *A. livida*, and from at least one large population of *A. lila*. Genetic analyses are not necessary for the immediate management of *A. byronii/decipiens* and *A. lila in situ* as there are so few populations left that all extant occurrences will be managed for stability. Genetic analyses can aid in the determination of ESUs for *A. sowerbyana*, and in the reintroduction of *A. lila* (see individual species stabilization plans). Currently, the researchers with Dr. Hadfield and Dr. Brenden Holland's lab recommend microsatellite analyses in order to determine genetic variation among Koolau *Achatinella* species. Genetic analyses to determine management directions for the Koolau species are included in Tier 1.

Captive Propagation

The goals of the captive-rearing program, described in detail in the appendices, are to ensure against total loss of a species by propagating them *ex situ* and to provide snails that can be used to augment field populations. The captive-rearing program is essential to the stabilization of *Achatinella* species. Overall, a tree snail rearing program greatly adds to the robustness and depth of tree snail field stabilization actions. It should be noted, however, that captive propagation cannot replace the field actions. Ultimately, when field populations are secure from historic, current, and perceived threats the captive propagation program will no longer be needed.

In some locations, the number of individuals has declined to the point where natural regeneration of the populations is unlikely. For these populations, it is vital to collect a limited number of individuals for rearing in captive propagation to ensure that their genetic diversity is not lost. Living individuals from severely declining populations can be maintained in a captive propagation facility until predator control and plant habitat restoration are advanced to a condition that will support reintroduction.

Field populations used for captive propagation will be selected and prioritized based on genetic data and level of immediate threat of extinction. Initial populations should include 7-10 snails or more if sufficient numbers are present in the wild population to allow for their removal without creating a threat to the wild population. The maximum number of snails collected will be no more than 20% of the known population (USFWS permit guidelines). However, if populations are found to be in imminent danger of complete extirpation or extinction due to predation or other threats, 20-100% of known snails may be collected as a rescue operation (IT recommendation). It is preferable to get an idea of the size of field populations to determine population densities before removing snails to captive facility (i.e. monitoring via described methods). The target size for captive populations is 50 snails of each population unit.

Table 9.2 Geographic Units, ESUs, and number of individuals of *Achatinella* species.

Species name	Geographic Unit	Wild Population Size
Achatinella byronii/decipiens	**Total**	**269**
	A: East Range	6
	B: Puu Pauao	16
	C: Poamoho	69
	D: Punaluu Cliffs	3
	E: North Kaukonahua	175
Achatinella lila	**Total**	**95**
	A: Poamoho Summit	39
	B: Peahinaia Summit	11
	C: Opaeula-Punaluu Summit	45
Achatinella livida	**Total**	**145**
	A: Crispa Rock	60
	B: Northern	2
	C: Radio	83
Achatinella mustelina	**Total**	**950**
	ESU A	472
	ESU B1	377
	ESU B2	569
	ESU C	69
	ESU D1	626
	ESU D2	92
	ESU E	462
	ESU F	157
Achatinella sowerbyana	**Total**	**743**
	A: Kawainui Ridge	2
	B: Kawaiiki Ridge	3

	C: Opaeula-Helemano	344
	D: Poamoho Summit and Trail	302
	E: Poamoho Pond	90
	F: Pomoho-North Kaukonahua Ridge	2
	G: Lower Peahinaia	40
Achatinella apexfulva	Lab	2
Achatinella bulimoides	Lab (2 additional individuals were observed in the Punaluu area on the last collection trip)	43
Achatinella curta	n/a	0
Achatinella leucorraphe	n/a	0
Achatinella pulcherrima	n/a	0

Table 9.3 Captive populations of OIP *Achatinella* species.

Species name	Population Unit	Captive Population Size (2005)*	Captive Population Size 2008
Achatinella byronii/decipiens	North Kaukonahua, Poamoho	28	30
Achatinella lila	Poamoho Summit	240	544
Achatinella livida	Near radio	78	108
Achatinella mustelina	See OANRP 2007	299	180
Achatinella sowerbyana	Lower Peahinaia, North of summit, KLO-F	41	25
Achatinella apexfulva	Poamoho	12	2
Achatinella bulimoides	Poamoho	5	43

* Numbers from 2005 Draft OIP.

During field collections, habitat variables will be recorded and will include: elevation, vegetation components, and exposure (temperature, humidity, etc.). Shell characteristics of each individual should also be documented, including: color photos, length and width of shells, orientation of operculum, etc.

Laboratory space is limited for captive snail propagation. If a laboratory population remains small or declines in numbers, laboratory conditions will be evaluated to determine and correct the cause of the decline or small population and results will be discussed with the Army and USFWS. Additional snails should come from the same genetic population as the founder snails. To prevent unintentional selection for lab-adapted snails in captive propagation, a proportion of the stocks should be replaced. Prior to taking this management action, the OIP snail committee will meet to evaluate the need for supplementing the captive populations and the distribution of the existing snails in the wild.

Health of captive snails will be tracked by comparing size, fecundity, and mortality of snails in captivity with snails in the wild until other methods for documenting "health" have been determined. If snails in the captive propagation facility show signs of disease, they must immediately be isolated and carefully observed until health appears restored. Specific Captive-Rearing Protocols developed by the Hadfield group at the University of Hawaii are attached (Appendix 2.5 Captive Propagation Protocols for *Achatinella* species).

Augmentation and reintroduction

The purpose of captive propagation is to provide healthy populations of snails for eventual release into the wild, either for augmentation of existing populations or to reintroduce within their historic range where habitat is suitable and threats are controlled. Since several of the *Achatinella* species have less than 6 populations, reintroductions will be necessary in order to achieve stabilization goals.

Specific protocols for an augmentation and reintroduction plan are currently being developed by the Oahu Rare Snail Working Group (see Appendix 2-7 Rare Snail Reintroduction Guidelines). Reintroduction of captive-reared snails into sites currently devoid of *Achatinella* should occur when there are sufficient numbers of individuals in the lab to support a release, reintroduction sites are located within the historic range of the species, genotypes utilized are appropriate for the geographic location considered, habitat conditions are appropriate to support healthy snail population, and predators are absent or controllable. Augmentation of extant, *in situ* managed field populations from laboratory-reared snails will be triggered when threats at a given MU or PU site are considered eliminated or controlled; such as within a protected enclosure or in a predator free environment. If a protected field population is found to be declining, it will be necessary to determine the cause before augmentation is considered. If a species or population is determined by field experts and the OIT to have enough individuals to support a reintroduction/augmentation the Army will pursue the feasibility of this action.

This arena of *Achatinella* conservation has not been conducted on a large scale for conservation purposes other than research (i.e. previous reintroductions have focused on research rather than programmatically determined long-term conservation objectives). Therefore, monitoring will be an essential aspect of this action. In some cases genetic analyses of both captive and wild snails may aid in selecting locations to augment/reintroduce a population.
Success: The success of a reintroduction will be measured by the longevity of released individuals and the growth or decline of the population itself. Appropriate monitoring of individuals over time (prior to release and following) will aid in the determination.

Surveys

Thorough field surveys funded and conducted by the Army have been completed at historic locations for many of the extant and recently extirpated species of *Achatinella* within the action area. Additional field surveys plan to focus on undersurveyed habitat near recent *Achatinella* locations. Surveys of historic and new areas will also provide an indication of where additional reintroduction and augmentation activities can occur. The Army will complete *Achatinella* surveys two days each year for each non-extant species and will survey additional areas for currently known species when time permits.

Threat management

Stabilization also relies upon the identification, control, management, or elimination of threats. Threats currently known to impact *Achatinella* species are: fire, trampling/disturbing native vegetation that snails may be using, introduction of non-native plants, predation by rats and other species of snails, and changes in microclimates from these activities. Introduced predatory flatworms represent just one potential threat that should be monitored to ensure that it does not impact the *Achatinella* species. The threat management plan for *Achatinella* species populations is outlined below and is adapted from the MIP to cover all Achatinella species.

Threat- Ungulates: Ungulates destroy native vegetation upon which healthy populations of *Achatinella* depend.

> **Goal:** Ungulate exclusion-elimination. Total eradication of pigs and goats within a management unit is required to protect snail population units. The managed snail population units should be within larger ungulate exclosures and substantial predator exclosures.
>
> **Actions to Achieve Goal:** Construct OIP MU fences, monitor for signs of ungulate impact to *Achatinella*.
>
> **Success:** Success will be determined when the fence is constructed and all the ungulates have been removed. Maintaining an ungulate free area will be an ongoing activity where fencing maintenance and periodic monitoring will be considered success milestones.

Threat - Alien plants: Alien plants negatively impact snail habitat by out-competing native vegetation that is used by the snails as host plants. Alien plants may also alter the climatic environment at given sites.

> **Goal:** Over time, manage vegetation to maximize the percentage of appropriate native species without upsetting climatic environment. If possible achieve 75% native vegetation within 50 meters of stabilization PUs and 50% native canopy cover across MUs (see Chapter 5 Threat Assessments).
>
> **Actions to Achieve Goal:** Habitat restoration will be necessary in some areas to achieve this goal. Understory weed species will be controlled to encourage regeneration of native species and ensure maintenance of climatic environment needed to sustain the population.
>
> **Success:** Success will be determined via monitoring results for each area. A high percentage of native cover may not be possible in all situations, however, the OIT will determine the level of success restoration activities are having based on monitoring data.

Threat- Rats: Three species of rats are serious predators of native Hawaiian snails. Rats can invade areas unpredictably and rapidly decimate local snail populations.

> **Goal:** Eliminate rat predation threat; the extent of baiting area is site specific.
>
> **Actions to Achieve Goal:** Construct predator exclosures where possible and maintain with poison baits. Support research and labeling of formulation for aerial dispersal of rat bait.

Predator-exclusion fences have already been constructed by the Hawaii Natural Area Reserves crews on the Makua Military Reservation at Kahanahaiki and in the Pahole Natural Area Reserve. These barriers utilize a design first developed to protect endemic tree snails in French Polynesia. They consist of a rigid wall of corrugated metal roofing laid horizontally with the lower 15 or more centimeters buried in the earth. A 25 cm shed-like roof extends outward from the top of the fence to cover two barriers against the predatory snail *E. rosea*: a 10 cm trough filled with coarse salt (calcium chloride or sodium chloride) and a two-wire electrical barrier. The wires, energized by a battery that is kept charged by a solar panel, are attached against the wall, one 8 mm above the other. A snail that contacts both wires receives an electric shock, which causes it to drop backward off the wall. The rigid wall of the barrier also serves to deter rats, but this is augmented by abundant placement of toxic rat bait (diphacinone) both inside and outside the barrier. It is important the vegetation be kept cleared from the predator-exclusion barrier so that it cannot provide bridges for predators to reach the interior. It is worthwhile to pursue alternatives in predator exclosure design (materials and construction); however, in doing so, the necessity for vegetation clearing cannot be compromised. Modifications to this design are necessary in the extremely wet and windy environments of the Koolaus. Suggestions to the current design include using recycled plastic construction material and pepper paint as a *E. rosea* deterrent.

Monitoring: The Army will begin monitoring quarterly or biannually and will evaluate whether this is sufficient or too frequent. If an exclosure is in place that prevents rat ingression, need to reevaluate appropriate monitoring method and interval (for rat detection, quarterly visits may be appropriate; for *Euglandina* detection may need monthly visits–see more discussion below). To detect predation, the Army will conduct ground surveys to locate freshly broken shells. Rats typically eat only the larger tree-snail classes (*i.e*., snails larger than about 12 mm). Typically the larger whorls are broken off, and marks of the rat's teeth can be seen on the shells. Use additional protocols established in the monitoring section (Chapter 6).

Success: Successful control of rats in an area will be determined by monitoring data. It is assumed that rats will pose a continual threat to snail populations as there will be constant pressure of immigration of new individuals from surrounding unmanaged habitats.

Threat - *Euglandina rosea:* The introduced predatory snail *E. rosea* feeds only on other snails and is the major cause of destruction of snail populations at this time.

Goal: Eliminate *E. rosea* predation via predator exclosures where possible and with dog detection teams.

Actions to Achieve Goal:

- Build exclosures around populations selected for stabilization wherever feasible. Ensure contractors adhere to design and plans for the exclosures through close monitoring of progress throughout construction.
- Toxic *E. rosea* baiting may be done much less frequently with a predator exclosure.
- Support research on dog detection of *Euglandina*.
- Support research on molluscicide for use in natural areas, and on other exclosure designs.

Monitoring:

- Managed populations without exclosures:
  1. Determine the area occupied by an *Achatinella* population. Then select a much larger area (recommend a minimum 100 m x 100 m area) around the snail population for monitoring.

2. Monitor *Achatinella* by surveying the ground for evidence of *Euglandina* predation, which is indicated by fresh dead shells of all size classes. When predation is noted, the Army will respond quickly.
3. Some destruction of *Dicranopteris linearis* and other plants is probably necessary while searching for ground shells, but care must be taken to limit disturbance. The Army will measure effectiveness of predator monitoring.
4. The Army will use additional protocols established in the monitoring section (Chapter 6).
5. The Army may determine densities of *E. rosea* in the *Achatinella* areas utilizing dog detection squads.

Success: Success of *Euglandina* control may be difficult to measure. However, populations of *Achatinella* will be monitored for growth and persistence with these control methods.

Threat - *Platydemis manokwari:* This flatworm is a documented predator of tree snails from other Pacific Islands and does occur from low elevations on Oahu to the top of Mount Kaala. The other two species have been found feeding on the tissue of dead Oahu tree snails, but it is not known if these two animals were the cause of death or just opportunistic feeders.

Goal: To detect and eliminate predation on *Achatinella.* Nothing is currently known about control measures for *P. manokwari*, but the electric fence on the predator exclosure may deter this flatworm.
Actions to Achieve Goal: monitoring of *Achatinella* rich areas will hopefully detect this predator if present. Research on the threat of this predator to *Achatinella* is also needed.
Monitoring: Only careful visual searching in leaf litter and under logs and rocks will reveal this flatworm. The Army will conduct searches at the same time as *E. rosea* searches.
Success: Success of detection and elimination of this species will be difficult to measure. However, populations of *Achatinella* will be monitored for growth and persistence with monitoring and research.

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9.1 Tier 1 (surveys) *Achatinella apexfulva, A. bulimoides, A. curta, A. leucorraphe, A. pulcherrima*
Taxon Summaries and Stabilization Plans

Scientific name: *Achatinella* Pilsbry & Cooke
Hawaiian name: *Pupu Kanioe, Pupu Kuahiwi, Kahuli*
Family: Achatinellidae, subfamily Achatinellinae (Oahu Tree Snails)
Federal status: Listed endangered

Long Term Goals:
- Survey for extant populations a minimum of two days per year for each of the five species.
- Protect any found individuals or populations either *in situ* or via captive propagation.
- Surveys: Tier 1 Priority
- Stabilization: Tier 2 (stabilization plans to be developed on discovery of extant individuals or lab populations large enough to support a reintroduction)

Description and biology: *Achatinella apexfulva* is a species of long-lived tree snail. Adults reach up to 19 mm long and 12.5 mm wide, and have up to 6 whorls. The shells can be either dextral or sinistral. The color scheme begins with yellow at the tip followed by blackish brown to chestnut whorls with some whitish streaks and spiral lines. The lip is salmon colored and moderately thickened with a white columellar fold (USFWS 1993).

Achatinella bulimoides is a species of long-lived tree snail. Adults reach up to 21.3 mm long and 11.8 mm wide, and have up to 6 ¼ whorls. The shells can be either dextral or sinistral. The color scheme is white with a chestnut lip or whitish with chestnut bands and a chestnut lip (USFWS 1993).

Achatinella curta Newcomb is a species of long-lived tree snail. Adults reach up to 21.4 mm long and 10.3 mm wide, and have up to 5 whorls. The shells can be either dextral or sinistral.

The color scheme is polished yellow or chestnut with a plain or with a black sutural band, rarely with two or more on the last whorl (USFWS 1993).

Achatinella leucorraphe Gulick is a species of long-lived tree snail. Adults reach up to 19.0 mm long and 12.0 mm wide, and have up to 6 ½ whorls. The shells can be either dextral or sinistral. The color scheme is gray ornamented with irregularly interrupted dark cinereous streaks and a few indistinct, white, spiral lines (USFWS 1993).

Achatinella pulcherrima Swainson is a species of long-lived tree snail. Adults reach up to 20 mm long and 11.2 mm wide, and have up to 6 whorls. The shells are dextral. The color scheme is white or yellow with none to several broad bands of chestnut (USFWS 1993).

Historical distribution: *Achatinella apexfulva* was known from Poamoho and Peahinaia trails of the Northern Koolau Mountains on Oahu, but have severely declined in the last 30 years (USFWS 1993). This species has only been seen recently along the Poamoho trail (US Army Garrison 2004).

Achatinella bulimoides was last known from the summit area of the Poamoho trail (USFWS 1993).

Achatinella curta was last known from the Paalaa Uka on the ridge South of Opaeula Gulch, and on the Peahinaia and Kawailoa Trails (USFWS 2003).

Achatinella leucorraphe was last known from the Schofield Waikane Trail (USFWS 2003).

Achatinella pulcherrima was last known from the summit area near the south fork of Opaeula stream and on the Peahinaia trail approximately 1 km (0.6 mi) from the summit trail (USFWS 2003).

Population trends: A single individual of *A. apexfulva* was collected in 2005 by Army natural resources staff, prior to this *A. apexfulva* had not been seen in 2002/2003 (Army Garrison 2003b).
At total of 12 individuals of *A. bulimoides* were seen by Army natural resources staff in 2005-2006. Prior to this *Achatinella bulimoides* had not been seen since 1982 (USFWS 1993).
Achatinella curta, A. leucorraphe, and *A. pulcherrima* have not been seen in over 15 years. *A. curta* was last seen in 1990. *A. leucorraphe* was last seen in 1989. *A. pulcherrima* was last seen in 1993.

Current status: The single individual of *A. apexfulva* seen in 2004-2005 by Army natural resource staff along the Poamoho trail was collected for captive propagation. This particular tree has been known to harbor *A. apexfulva* in the past and has been thoroughly searched a few times since 2005 with no snails seen (US Army 2007). Currently there are 2 individuals in captive propagation (Holland pers. comm. 2008).
Ten of the twelve individuals of *A. bulimoides* observed were collected for captive propagation and more individuals are expected to be found in surveys of the surrounding area. Currently there are 43 individuals in captive propagation.

There are currently no known individuals of *Achatinella curta, A. leucorraphe*, and *A. pulcherrima* in the wild. Surveys are planned for these species in the last observed sites.

Table 9.4 Current Population Units of *Achatinella apexfulva.*

Location	Population Unit Name	Total Number of Individuals
Ex situ	Poamoho (founders 5 individuals 1994, 2005)	12 (2005)
		2 (2008)

Table 9.5 Current Population Units of *Achatinella bulimoides.*

Location	Population Unit Name	Total Number of Individuals
Ex situ	Poamoho (10 founders, 2005-2006)	7 (2005)
		43 (2008)

Habitat: Currently, *Achatinella apexfulva* is found at lower elevations than other species in the Northern Koolau Mountains, ranging from 1500 ft to 2000 ft elevation. Previous sightings have been in mesic to wet forests on native tree species including Ohia lehua (*Metrosideros polymorpha*) and hame (*Antidesma platyphyllum*).
Achatinella bulimoides was found at the summit and just below the summit on the windward side of the Northern Koolau Mountains. Previous sightings have been in wet forests on native tree species including Ohia lehua (*Metrosideros polymorpha*) and hame (*Antidesma platyphyllum*).
Previous sightings of *Achatinella curta, A. leucorraphe,* and *A. pulcherrima* have been in mesic and wet forests on native tree species including Ohia lehua (*Metrosideros polymorpha*) and hame (*Antidesma platyphyllum*).

Table 9.6 OIP *Achatinella* Taxa Summary

Species	Last observed in the wild	Army Action Area	Last observed Location	Potential Survey Areas
Inside AA				
Achatinella apexfulva	2005	KLOA	Poamoho Trail	Lower elevations of Poamoho Trail
Achatinella bulimoides	2006	KLOA	Poamoho summit area	Poamoho trail and summit areas including windward summit habitat; Punaluu Clifs.
Achatinella curta	1990	KLOA	Kawailoa Trail, Peahinaia Trail	Areas between Kawailoa Trail and Peahinaia Trail
Achatinella leucorraphe	1989	SBER	Schofield Waikane Trail	Schofield Barracks East Range and South of Schofield Waikane Trail
Achatinella pulcherrima	1993	KLOA	Opaeula drainage	Opaeula drainage area and Poamoho Summit area

Discussion of Recent Species Survey History

A. apexfulva- this species last seen along the Poamoho trail in 2005. The individual seen was collected for captive propagation.

A. bulimoides- this species was recently rediscovered at the summit of Poamoho trail (2005). A total of 10 individuals were collected on four separate occasions for captive propagation. Two individuals remain in the wild but occur outside Army training areas.

A. curta- recent surveys along the lower elevations of Kawailoa Trail.

A. leucorraphe- last surveyed along Schofield-Waikane trail at last sighting point.

A. pulcherrima- last surveyed in the upper Opaeula drainages.

Priority Management Actions

The highest priorities for these species are surveying and increasing captive populations of *A. apexfulva* and *A. bulimoides*. Surveys are needed in the areas nearest the last observed site and at historical sites for each species. The Army will survey with 2 people for 2 days for each of the five species each year. These surveys will be done in habitat that is appropriate for these taxa. Because some of the historical habitats overlap for some of these species survey days may cover more than one species. The Army Natural Resources program has conducted numerous and extensive surveys within the action area and has thus far been unsuccessful in locating these species (see survey route maps this section). Many of these routes have been surveyed repeatedly over the past 10 years (e.g. North Kaukonahua area, Poamoho trail, Lower Peahinaia Trail, Kawailoa Trail, and portions of the Koolau Summit trail). Army natural resources staff conducting the surveys have been trained in rare snail field searching techniques by Dr. Mike Hadfield and his students over the past 10 years.

Increasing the numbers of individuals in captive propagation may be more challenging than field surveys. The Army will consult with the OIT to find ways to assist the UH Tree Snail Lab in propagating these species. Currently, just 2 individuals of *A. apexfulva* and 43 individuals of *A. bulimoides* are in captive propagation.

A. apexfulva- It may not be possible to achieve stability for this species because of the low numbers of individuals available for propagation. Stability *in situ* would have to be reached through the reintroduction of individuals into a predator proof exclosure. The OIT may address plans to build a lower elevation predator proof exclosure when *ex situ* numbers are of sufficient size and vigor. However, this species appears to reproduce more slowly than most *Achatinella* species (Hadfield pers. comm. 2005).

A. bulimoides- This species was recently rediscovered near the summit of the Poamoho trail, in the KLOA action area. Ten individuals were seen and collected for captive propagation on four separate occasions. At the last collection survey date two individuals remained outside of the Army action area. At this time the Army plans to conduct surveys to determine the extent of the population. This species is currently increasing in the captive lab population. If this trend continues and there are enough individuals to support a reintroduction the Army will develop a reintroduction/stabilization plan specific to this species by consulting with the OIT and other partnering conservation organizations.

Map removed, available upon request

Figure 9.1 Historic distribution of *Achatinella curta* in the Northern Koolau Mountains on Oahu.

Map removed, available upon request

Figure 9.2 Historical distribution of *Achatinella curta* in the Northern Koolau Mountains on Oahu.

Map removed, available upon request

Figure 9.3 Historical distribution of *Achatinella leucorraphe* in the Koolau Mountains on Oahu.

Map removed, available upon request

Figure 9.4 Historical distribution of *Achatinella pulcherrima* in the Koolau Mountains of Oahu.

Map removed, available upon request

Figure 9.5 Last observed sites for *Achatinella apexfulva* and previous Army snail survey routes in the Northern Koolau Mountains of Oahu.

Map removed, available upon request

Figure 9.6 Last observed sites for *Achatinella bulimoides* and previous Army snail survey routes in the Northern Koolau Mountains of Oahu.

9.2 Tier 2 *Achatinella byronii/decipiens*: Taxon Summary and Stabilization Plan

Scientific name: *Achatinella byronii/decipiens* Wood
Hawaiian name: *Pupu Kanioe, Pupu Kuahiwi, Kahuli*
Family: Achatinellidae, subfamily Achatinellinae (Oahu Tree Snails)
Federal status: Listed endangered

Long Term Goals:

- Manage extant population units (PUs) and additional reintroduction PUs, up to a total of six PUs within the action area to encompass the known geographical range of the species
- Achieve at least 300 individuals in each PU
- Maintain captive propagation populations of significant PUs
- Control all threats at each managed field location
- **Tier 2** stabilization priority

Description and biology: *Achatinella byronii* and *A. decipiens* are considered by many to be synonymous. Thus far, the Army treats *A. byronii* and *A. decipiens* as the same species. The OIP follows this format in accordance with the Oahu Biological Assessment, the Oahu Biological Opinion, Army natural resource data, and preliminary morphological comparisons by various field experts (U.S. Army 2003; USFWS 2003; OANRP 2004). The two species have been described with very similar morphology both having dark chestnut colored longitudinal striae or stripes. Cooke (1912-1914) considered *A. decipiens* to be a subspecies of *A. byronii*. While the geographical delineation between the two species imposed by Pilsbry, appears to be somewhat arbitrary (Pilsbry and Cooke 1912-1914; OIT 2005). The Army will refer to the entity occurring in the action area as *A. byronii/decipiens* until further clarifications are made by malacological experts.

Achatinella byronii/decipiens is a species of long-lived tree snail. Adults reach up to 20.5 mm long and 11.0 mm wide, and have up to 6 to 6.5 whorls. The shells can be either dextral or sinistral. The USFWS described *A. byronii* as having green and yellow bands with chestnut and a pinkish gray tip and *A. decipiens* as yellow with white transverse bands or white with yellow transverse bands. Both taxa were described as having moderate longitudinal ridges or striae (USFWS 1993).

Known distribution: *Achatinella byronii/decipiens* is known from approximately five locations in the wild: Schofield Waikane trail, North Kaukonahua stream drainage, Puu Kaaumakua, West of Puu Pauao, and along the Punaluu Cliffs of the Koolau Summit Trail.

Population trends: *Achatinella byronii/decipiens* is the second most abundant species in the Koolau Mountains. However, this species is still considerably scarce as there are less than 300 individuals remaining in the wild. The populations are clumped and nearby areas of similar habitat are devoid of snails.

Current status: Currently, there are five populations of *A. byronii/decipiens* totaling approximately 269 individuals. Approximately 97% of extant individuals are found within the action areas of KLOA and SBER. Additionally, there are 30 individuals in captive propagation at this time.

Habitat: *Achatinella byronii/decipiens* is generally found in native wet Ohia forest at or just below the summit of the Koolau Mountains from 605 to 770 m. Native trees and shrubs include hame (*Antidesma platyphyllum*), olapa (*Cheirodendron* spp.), aiea (*Ilex anomala*), and ohia lehua (*Metrosideros polymorpha*).

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control			
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina
Achatinella byronii / decipiens											
GU: A East Range											
SBE-A Middle Waikakalaua-South Kaukonahua dividing ridge	Manage for stability	0	2006-06-26	0	0	0	0	No	No	No	No
SBE-B South Kaukonahua stream	Manage for stability	1	2001-02-26	1	0	0	0	No	No	No	No
SBE-C East Waikakalaua-South Kaukonahua dividing ridge	Manage for stability	1	2001-02-26	1	0	0	0	No	No	No	No
SBE-D West Waikakalaua-South Kaukonahua dividing ridge	Manage for stability	1	2002-05-01	1	0	0	0	No	No	No	No
SBE-E North branch of South Kaukonahua	Manage for stability	3	1997-09-25	1	1	1	0	No	No	No	No
	GU Total:	6		4	1	1	0				
GU: B Puu Pauao											
KLO-D Puu Pauao	Manage for stability	16	2006-08-22	15	1	0	0	No	No	No	No
	GU Total:	16		15	1	0	0				
GU: C Poamoho											
KLO-A South of Poamoho Trail	Manage for stability	0	2004-12-01	0	0	0	0	No	No	No	No
KLO-B Poamoho Cabin	Manage for stability	23	2006-04-18	18	3	2	0	No	No	No	No
KLO-C South of Poamoho Cabin	Manage for stability	1	2001-06-13	0	0	0	1	No	No	No	No
KLO-F North of Poamoho Trail	Manage for stability	45	2006-04-19	42	3	0	0	No	No	Yes	No
KLO-G Poamoho trail 1800 ft at A. apexfulva site	Manage for stability	0	2007-08-31	0	0	0	0	No	No	No	No
	GU Total:	69		60	6	2	1				

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control			
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina
GU: D Punaluu cliffs											
KLO-H Windward cliffs opposite Peahinaia summit LZ	Manage for stability	2	2006-05-04	2	0	0	0	No	No	No	No
KLO-I East of 290	Manage for stability	1	2007-04-02	0	1	0	0	No	No	No	No
	GU Total:	3		2	1	0	0				
GU: E North Kaukonahua											
KLO-E North Kaukonahua	Manage for stability	175	2002-08-21	120	40	15	0	No	No	No	No
	GU Total:	175		120	40	15	0				

Size Class Definitions

SizeClass	DefSizeClass
Large	>15 mm
Medium	7-15 mm
Small	<7 mm

Table shows the number of snails, size classes, and threats to the snails in the ESU sites. Yes = threat is being controlled; In some cases the threat may be present but not actively preying on Achatinella.

Map removed, available upon request

Figure 9.7 Current and historical distribution of *Achatinella byronii/decipiens* Koolau Mountains, Oahu.

Discussion of Management Designations
All known geographic units will be managed for stability.

Captive Propagation Information

This species has been in captive propagation for approximately 11 years. The numbers of individuals in this population have fluctuated and may benefit from the introduction of new wild individuals. All captive propagation populations will be founded by at least 7-10 individuals whenever possible. The minimum goal of each *ex situ* representation of wild stock is to reach 50 individuals (Makua Implementation Team, 2003).

The UH Snail Lab has one population of this species, comprised of 30 individuals, represented with mixed individuals from the Schofield-Waikāne Trail below KLO-E. This lab population was started in 1997. Additional lab populations are needed from all other GUs. The number of individuals in captive propagation populations should be sufficient in number to allow reintroductions before attempts are made to reintroduce the species.

Table 9.7. Captive propagation data for *Achatinella byronii/decipiens*.

Species	Year	# juv	# sub	# adult	# Individuals
A. byronii/decipiensi	2007	5	14	9	**28**
	2008	6	17	7	**30**

Management Notes

The main priorities for the management of *Achatinella byronii/decipiens* include surveys and mark recapture studies to determine the extent of the GUs, collection of individuals to establish captive propagation populations for all extant GUs, and the construction of ungulate proof fenced exclosures around the MUs. Currently there are not 6 extant GUs for stabilization. The Army will discuss meeting stabilization goals with the OIT each year following monitoring and surveys.

The Army has not conducted extensive surveys for this species in recent years. The total numbers of individuals reported here is greater than reported in the past, however, this is due more to the use of the database in keeping track of the most accurate counts rather than the most recent population visits (i.e. in some cases the Army has searched more thoroughly). This database allows us to track the ‘manage for stability’ populations and the level of threat control currently being conducted at these sites.

The database shows that approximately 250 *A. byronii/decipiens* occur within proposed or existing MUs. The Poamoho GU-C is partially protected within a rat baiting grid that is restocked every six weeks along the Poamoho summit. This population contains approximately 45 individuals.

Monitoring: GUs are currently monitored for signs of rat predation via ground shell plots. When signs of predation are observed rat baiting will be initiated. Management will consist of securing sites from feral pigs, maintaining habitat and collection of individuals for captive propagation from each GU managed for stability.

The **East Range GU-A** will be managed within the South Kaukonahua MU. The **Puu Pauao GU-B** occurs along a west facing ridge extending from the summit. The **Poamoho GU-C** occurs along the summit of the Koolau Mountains where the Poamoho trail meets the summit. This GU will be managed in 2 separate management units: Poamoho and Poamoho Pond. The **Punaluu Cliffs GU-D** has not been well monitored for population size or threats. The **North Kaukonahua GU-E** is the largest population of this species and occurs approximately 1 mile below the summit along a North facing ridge of the Schofield Waikane trail.

Table 9.8 Priority Management Actions for *Achatinella byronii/decipiens*

Geographic Unit	Specific Management Actions	Partners/Concerns	Timeline
East Range (South Kaukonahua MU) GU A	• Surveys to determine extent of PU • Collect individuals for captive propagation • Construct South Kaukonahua II MU • Set up rat bait station grid • Construct predator proof exclosure	• MU in SBE, Army owned land • MU needs an EA	• construct S. Kaukonahua I MU, OIP yr 6; 2013
Puu Pauao GU B	• Survey to determine the extent of PU • Collect individuals for captive propagation • Construct MU • Set up rat bait station grid • Construct predator proof exclosure	• MU in State Forest Reserve (proposed NAR), need license agreement with the State. • MU needs an EA	• Construct Poamoho III MU, OIP yr 9; 2016
Poamoho GU C	• Survey to determine extent of PU • Collect individuals for captive propagation • Construct Poamoho I & II MUs • Set up rat bait station grid • Construct predator proof exclosure	• MU in State Forest Reserve (proposed NAR) • MU needs an EA	• construct Poamoho I MU, OIP yr 8; 2015 • construct Poamoho II MU; OIP yr 9 2016
Punaluu Cliffs GU D	• Surveys to determine extent of PU • Collect individuals for captive propagation • Set up rat bait station grid • Determine if a predator proof exclosure is feasible (steep cliffs)	• Kamehameha Schools land, needs a license agreement prior to surveys	• begin surveys once agreement with landowner is in place; est. 2008
North Kaukonahua GU E	• Survey to determine extent of PU • Collect individuals to bolster captive propagation population numbers • Construct North Kaukonahua MU • Monitor for rat predation • Set up rat bait station grid • Construct predator proof exclosure	• MU in State Forest Reserve (Proposed NAR) • MU needs an EA	• construct N. Kaukonahua MU, OIP yr 7; 2014

9.3 Tier 2: *Achatinella lila*
Taxon Summary and Stabilization Plan

Scientific name: *Achatinella lila* Pilsbry
Hawaiian name: *Pupu Kanioe, Pupu Kuahiwi, Kahuli*
Family: Achatinellidae, subfamily Achatinellinae (Oahu Tree Snails)
Federal status: Listed endangered

Long Term Goals:

- Manage extant population units (PUs) and additional reintroduction PUs, up to a total of six PUs within the action area to encompass the known geographical range of the species
- Achieve at least 300 individuals in each PU to be managed for stability.
- Maintain captive propagation populations from each of the three PUs being managed for stability.
- Control all threats at each managed field location.
- **Tier 2** stabilization priority

Description and biology: *Achatinella lila* is a species of long-lived tree snail. Adults can reach up to 17.0 mm in length and 11.0 mm diameter and have up to 5 ½ whorls. The shells coil in the sinistral direction. The color pattern is generally whorls of yellow or green on a chestnut background with a sienna brown to whitish tip.

Known distribution: *Achatinella lila* was historically known from along the summit of the central to northern Koolau Mountains. See Figure 9.8

Population trends: Few populations of *Achatinella lila* are known and some have just a few individuals. Approximately 95 individuals total are known in the wild. Rat predation has not been documented from any of the known sites. However, nearby snail sites of other species have been observed in decline. Therefore, these populations are highly vulnerable to rapid decline.

Current status: Three geographic units (GUs) are known from the KLOA action area; Poamoho Summit GU-A, Peahinaia Summit GU-B, and Opaeula-Punaluu Summit GU-C. Currently, there are 544 individuals in captive propagation (Holland pers. comm. 2008), see table 9.6 below. The Army is currently conducting rat control at two sites, within GU-A and B. This appears to be the most successful species in captive propagation; therefore this species is a good candidate for an experimental reintroduction within an area with sufficient threat control (see Appendix 2-7; Rare snail reintroduction guidlines).

Habitat: *Achatinella lila* is known from native Ohia wet forest along the summit areas of the Northern Koolau Mountains from 2520 to 2770 ft. Native trees and shrubs include hame (*Antidesma platyphyllum*), olapa (*Cheirodendron* spp.), aiea (*Ilex anomala*), and ohia lehua (*Metrosideros polymorpha*).

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control			
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina
Achatinella lila											
GU: A Poamoho Summit											
KLO-A South of Poamoho Trail	Manage for stability	5	2000-09-25	5	0	0	0	No	No	No	No
KLO-B North of Poamoho Trail	Manage for stability	34	2004-12-01	29	2	3	0	No	No	Yes	No
	GU Total:	39		34	2	3	0				
GU: B Peahinaia Summit											
KLO-C Peahinaia Summit	Manage for stability	2	2006-05-03	1	1	0	0	Yes	Yes	Yes	No
KLO-F Below Peahinaia Summit on windward side	Manage for stability	9	2006-05-04	8	1	0	0	No	No	No	No
	GU Total:	11		9	2	0	0				
GU: C Opaeula-Punaluu Summit											
KLO-D Notch Site, Opaeula Fence	Manage for stability	3	2005-05-03	1	1	1	0	No	No	No	No
KLO-E Windward side below Sanpur outplanting	Manage for stability	42	2006-05-03	32	8	2	0	No	No	No	No
	GU Total:	45		33	9	3	0				

Size Class Definitions

SizeClass	DefSizeClass
Large	>15 mm
Medium	7-15 mm
Small	<7 mm

Table shows the number of snails, size classes, and threats to the snails in the ESU sites. Yes = threat is being controlled; In some cases the threat may be present but not actively preying on Achatinella.

Map removed, available upon request

Figure 9.8 Current and historic distribution of *Achatinella lila* in the Koolau Mountains of Oahu.

Discussion of Management Designations

All known occurrences of *Achatinella lila* will be managed for stability. A total of six manage for stability GUs with 300 individuals each will need to be managed. Reintroductions will have to be made to attain this.

Captive Propagation Information

This species has been in propagation since 1997. However, all lab individuals of *A. lila* at this time are descendants of the initial adult population collected from near the Poamoho trail summit (Hadfield, 2005). This is by far the most successfully propagated species of *Achatinella* in the Koolau Mountains. Due to the high numbers of individuals represented *ex situ* this species is the best candidate for an experimental wild reintroduction within a protected area. However, before a reintroduction/augmentation to the Opaeula summit area can be done, modifications to the predator proof exclosure design are needed.

Prior to the reintroduction, the UH Snail Lab would like to compare the level of genetic variation of lab populations versus the wild populations and the degree of similarity within and among the lab and wild populations. Genetic samples from all the populations are being collected to facilitate this comparison. This information will aid the development of a reintroduction plan for this species. The Army recently helped to organize a reintroduction protocol, to be utilized by any conservation agency, in anticipation of a reintroduction of either *A. mustelina* or *A. lila* (see Appendix 2-7: Rare Snail Reintroduction Protocol).

Table 9.9 Captive propagation data for *Achatinella lila*.

Species	Year	# juv	# sub	# adult	# Individuals
A. lila	2007	215	246	8	**470**
	2008	151	372	21	**544**

Management Notes

Poamoho GU-A was recently known to have extant individuals both north and south of the Poamoho trail. However, in recent thorough surveys no individuals south of the trail were seen. More surveys are needed in the area. The **Peahinaia summit GU-B** occurs along the Opeaula/Helemano MU fenceline and the majority of individuals known are within the ungulate exclosure. The Army is conducting rat control at a portion of this site. The **Opaeula-Punaluu summit GU-C** was likely once contiguous with the individuals known in the Peahinaia Summit (GU-B). However, at this time the two populations are not known to overlap. More surveys are needed to determine the extent of this GU as more indivduals have been observed on the windward side of the summit outside of the Opaeula/Helemano MU.

The target number of six GUs of this species, each with 300 individuals, will likely only be reached via reintroductions within predator free areas. An experimental predator proof tree snail enclosure is proposed for this species within an existing ungulate fence. Management for stability will consist of securing sites from feral pigs, maintaining habitat, and collecting of individuals from all populations for captive propagation.

Table 9.10 Priority Management Actions for *Achatinella lila*

Geographic Unit	Specific Management Actions	Partners/Concerns	Timeline
Poamoho Summit GU A	• Construct Poamoho MU • Continue rat bait grid restocking for North Poamoho PU • Construct predator proof exclosure • Conduct reintroductions as feasible	• MU in State Forest Reserve (proposed NAR) • MU needs an EA	• construct Poamoho I MU (Tier 1), OIP yr 8; 2015
Peahinaia Summit GU B	• Construct predator proof exclosure at summit LZ area, reintroduce snails • Continue rat bait grid restocking • Collect for captive propagation	• MU fence completed	• OIP Tier 2, YR1
Opaeula-Punaluu Summit GU C	• Survey/ determine if additional ungulate fencing is necessary • Construct predator proof exclosure • Collect for captive propagation	• MU fence completed	• OIP Tier 2, YR1

9.4 Tier 2: *Achatinella livida*
Taxon Summary and Stabilization Plan

Scientific name: *Achatinella livida* Swainson
Hawaiian name: *Pupu Kanioe, Pupu Kuahiwi, Kahuli*
Family: Achatinellidae, subfamily Achatinellinae (Oahu Tree Snails)
Federal status: Listed endangered

Long Term Goals:

- Manage extant population units (PUs) and additional reintroduction PUs, up to a total of six PUs within the action area to encompass the historical geographical range of the species
- Achieve at least 300 individuals in each PU
- Maintain captive propagation populations from each extant PU
- Control all threats at each managed field location
- **Tier 2** stabilization priority

Description and biology: *Achatinella livida* is a small long-lived tree snail. Adults can reach up to 17 mm in length and 9.0 mm diameter and have up to 6 whorls. The colors generally are livid brown to livid purple that gradually change to white at the tip. The shell suture is marked with a line of deep orange brown (USFWS 1993).

Known distribution: *Achatinella livida* was historically known from middle to upper elevations in the central to northern Koolau Mountains.

Population trends: Populations of *Achatinella livida* are clumped and widely spaced. Nearby areas of similar habitat are either devoid of snails or single individuals have been seen.

Current status: Currently, approximately 148 individuals are known from 3 populations in the Kawailoa training area. There are 108 individuals in captive propagation at this time (Holland pers. comm. 2008).

Habitat: *Achatinella livida* is known from native Ohia wet forest along the summit areas of the Koolau Mountains from 2320 to 2560 ft. Native trees and shrubs include *Antidesma platyphyllum, Cheirodendron* spp., *Ilex anomala,* and *Metrosideros polymorpha*.

2008-09-24 Page 1 of 1

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control			
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina
Achatinella livida											
GU: A Crispa Rock											
KLO-A Crispa Rock	Manage for stability	60	2004-07-21	38	15	7	0	No	No	Yes	No
	GU Total:	60		38	15	7	0				
GU: B Northern											
KLO-B Northern	Manage for stability	5	2008-02-26	2	1	2	0	No	No	Yes	No
	GU Total:	5		2	1	2	0				
GU: C Radio											
KLO-C Radio	Manage for stability	77	2004-07-20	40	21	16	0	No	No	Yes	No
PAP-A Windward side of radio	Manage for stability	6	2006-06-24	6	0	0	0	No	No	No	No
	GU Total:	83		46	21	16	0				

Size Class Definitions

SizeClass	DefSizeClass
Large	>15 mm
Medium	7-15 mm
Small	<7 mm

Table shows the number of snails, size classes, and threats to the snails in the ESU sites. Yes = threat is being controlled; In some cases the threat may be present but not actively preying on Achatinella.

Map removed, available upon request

Figure 9.9 Current and historic distribution of *Achatinella livida* in the Koolau Mountains of Oahu.

Discussion of Management Designations

All known occurrences of *A. livida* will be managed for stability. A total of six manage for stability GUs with 300 individuals each will need to be managed. Reintroductions will have to be made to attain this.

Captive Propagation Information

Achatinella livida has been in captive propagation since 1997. There are currently 4 subpopulations totaling approximately 108 individuals. However, all captive individuals are descendents of the initial adult population from Radio GU-C. All captive propagation populations will be founded by at least 7-10 individuals whenever possible (Makua Implementation Team, 2003). The minimum goal of each *ex situ* representation of wild stock is to reach 50 individuals (Makua Implementation Team, 2003).

The Army will consider starting additional lab populations for the other two extant populations, Crispa (KLO-A) and Northern (KLO-B).

Table 9.11 Captive propagation data for *Achatinella livida*.

Species	Year	# juv	# sub	# adult	# Individuals
A. livida	2005	50	66	6	**122**
	2008	28	75	5	**108**

Management Notes

There are currently three extant GUs of this species; Northern GU-B, Crispa Rock GU-A, and Radio GU-C. The Army has been monitoring and baiting for rats at the sites for the past 9 years. The Army will continue to restock baiting grids twice per quarter (weather permitting) at each site in the coming year. Each baiting grid will be reevaluated and expanded if necessary. A priority for all three extant GUs is a thorough monitoring for number of individuals that includes night searches. Management for stability will consist of securing all three wild sites from feral pigs, construction of six predator proof exclosures, maintaining habitat through weed control and the collection of individuals for captive propagation.

Northern GU-B is the least populous GU with just five snails observed in early 2008. Once a thorough search is conducted at this site the Army and the OIT will determine how many individuals should be brought into the lab to secure the population from extinction. This site will be protected within the Koloa MU.

Crispa Rock GU-A contains has not been thoroughly monitored for a total number of individuals since 2004 and no individuals from this GU are represented in captive propagation. A ground shell plot was installed in 2006. The ground shell plot has not revealed any rat predated shells or high numbers of fresh dead individuals although a live *Euglandina rosea* was found. This plot will be re-read annually. This site will be protected within the Kawaiiki subunit I MU (Tier 2).

Radio GU-C is the largest in numbers of individuals, however a thorough monitoring has not been conducted since 2004. Monitoring and possible adjustment of the rat control grid are top priorities for this GU.

Genetics: Preliminary genetics research comparing sequences from CO1 (the same gene used to delineate ESUs in *A. mustelina*) revealed that individuals sampled within populations of *A. sowerbyana,* near the Opaeula MU, contained *A. livida* haplotypes. This data is interesting because to date no *A. livida* have been known from this area and all snails sampled had dextral chirality, which is characteristic of *A. sowerbyana* in this area. However, more research needs to be conducted before any conclusions are made. The Army is working with the UH Tree Snail Lab to provide samples for more genetic analyses.

Table 9.12 Priority Management Actions for *Achatinella livida*

Geographic Unit	Specific Management Actions	Partners/Concerns	Timeline
Crispa Rock GU A	• Survey and determine numbers of individuals • Construct Kaipapau II MU • Continue rat baiting • Collect for captive propagation • Construct predator proof exclosure	• Need license agreement with landowner, Kamehameha Schoools • MU needs an EA	• construct Kawaiiki I MU, OIP yr 10; 2017 (Tier 2)
Northern GU B	• Survey and determine numbers of individuals • Collect for captive propagation • Construct Koloa MU • Continue rat baiting • Collect for captive propagation • Construct predator proof exclosure	• Need license agreement with landowner, Hawaii Reserves Inc. • MU needs an EA	• Construct Koloa MU, OIP yr 4; 2011 • (Tier 1)
Radio GU C	• Survey and determine numbers of individuals • Collect for captive propagation • Construct Kaipapau III • Continue rat baiting • Collect for captive propagation • Construct predator proof exclosure	• Need license agreement with landowner, Kamehameha Schools • MU needs an EA	• construct Kawaiiki II MU, OIP yr 10; 2017 (Tier 2)

9.5 Tier 2 *Achatinella sowerbyana*
Taxon Summary and Stabilization Plan

Scientific name: *Achatinella sowerbyana* Pfeiffer
Hawaiian name: *Pupu Kanioe, Pupu Kuahiwi, Kahuli*
Family: Achatinellidae, subfamily Achatinellinae (Oahu Tree Snails)
Federal status: Listed endangered

Long Term Goals:

- Manage extant population units (PUs) and additional reintroduction PUs, up to a total of six PUs within the action area to encompass the historical geographical range of the species
- Achieve at least 300 individuals in each PU to be managed for stability.
- Maintain captive propagation populations from each PU being managed for stability
- Control all threats at each managed field location.
- **Tier 2** stabilization priority

Description and biology: *Achatinella sowerbyana* is a small long-lived tree snail. The shells can be either dextral or sinistral. Adults can reach up to 18.0 mm in length and 9.0 mm diameter and have up to 6 whorls. The whorls are slightly convex. The shell colors are generally glossy tawny buff and streaked with darker shades (USFWS 1993).

Known distribution: *Achatinella sowerbyana* is currently known from middle to upper elevations in the central to northern Koolau Mountains. Historically it was also known from lower elevations.

Population trends: Populations of *Achatinella sowerbyana* appear to be sparse and scattered. Nearby areas of similar habitat are either devoid of snails or single individuals have been seen.

Current status: *Achatinella sowerbyana* is the most abundant *Achatinella* species in the Koolau Mountains. Currently, there are 46 individuals in captive propagation (Holland pers. comm. 2008).

Habitat: *Achatinella sowerbyana* is known from native Ohia wet forest along the summit areas of the Koolau Mountains from 1780 to 2760 ft. Native host trees and shrubs include *Antidesma platyphyllum, Cheirodendron* spp., *Ilex anomala,* and *Metrosideros polymorpha*.

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control			
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina
Achatinella sowerbyana											
GU: A Kawainui Ridge											
KLO-Q Pinch ridge	Manage for stability	2	2001-09-05	2	0	0	0	No	No	No	No
KLO-R Freckled-Toothed Ridge	Manage for stability	0	2007-05-15	0	0	0	0	No	No	No	No
	GU Total:	2		2	0	0	0				
GU: B Kawaiiki Ridge											
KLO-K Bloody finger	Manage for stability	2	2007-05-17	1	1	0	0	No	No	No	No
KLO-P Ptelid gulch upstream from the Ptelid	Manage for stability	1	1997-08-06	1	0	0	0	No	No	No	No
	GU Total:	3		2	1	0	0				

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control			
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina
GU: C Opaeula-Helemano											
KLO-BB Below Peahinala trail in Helemano	Manage for stability	3	2004-07-21	2	0	1	0	Yes	Yes	No	No
KLO-CC Helemano southwest of KLO-12 transect	Manage for stability	1	2004-07-21	0	1	0	0	Yes	No	No	No
KLO-D Peahinala Summit	Manage for stability	6	1997-09-04	0	0	0	6	Yes	Yes	Yes	No
KLO-DD Helemano Southwest of KLO-12 transect, middle site.	Manage for stability	1	2004-07-21	0	1	0	0	Yes	No	No	No
KLO-E Cyrvir, photopoint pole pe`ahinal`a trail	Manage for stability	1	1998-05-28	0	0	0	1	Yes	Yes	No	No
KLO-EE Helemano Southwest of KLO 12 transect, eastern site.	Manage for stability	1	2004-07-21	0	1	0	0	Yes	No	No	No
KLO-F Pe`ahinal`a trail pulcherima like snails	Manage for stability	5	2006-07-18	2	3	0	0	Yes	No	No	No
KLO-G South ridge of Helemano fenceline	Manage for stability	1	2006-05-03	0	1	0	0	Yes	No	No	No
KLO-H Ilex spot near palm grass site at sta 260 KLO-12	Manage for stability	2	1997-06-06	1	0	1	0	Yes	Yes	No	No
KLO-HH West Helemano, below Palm grass site	Manage for stability	5	2004-12-01	4	1	0	0	Yes	Yes	No	No
KLO-I Above goose wing	Manage for stability	1	2003-06-27	1	0	0	0	Yes	Yes	No	No
KLO-II West Helemano, above stream 30m, below large flat ridge	Manage for stability	1	2004-12-01	1	0	0	0	Yes	No	No	No
KLO-J Hypalon	Manage for stability	232	2007-09-18	60	142	30	0	Yes	Yes	Yes	No
KLO-JJ South Helemano fenceline	Manage for stability	6	2006-03-22	2	2	2	0	Yes	No	No	No
KLO-KK Second ridge off Peahinala trail	Manage for stability	2	2006-05-02	1	0	1	0	Yes	Yes	No	No
KLO-L Sta 290 on summit trail along Pe`ahinala fence	Manage for stability	30	2005-12-08	20	5	5	0	Yes	Yes	Yes	No

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control			
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina
KLO-LL **East of 290**	Manage for stability	3	2007-04-02	3	0	0	0	No	No	No	No
KLO-M **Shaka**	Manage for stability	15	2007-05-16	10	4	1	0	Yes	Yes	Yes	No
KLO-N **Lizard-back ridge**	Manage for stability	1	2005-01-05	1	0	0	0	Yes	Yes	Yes	No
KLO-O **Close to shelter just above waterfall in Opaeula fence**	Manage for stability	3	2002-01-01	3	0	0	0	Yes	Yes	Yes	No
KLO-U **Rich Ridge**	Manage for stability	22	1997-12-11	0	0	0	22	No	No	No	No
KLO-Y **KST and Shelter ridge junction**	Manage for stability	1	2001-10-18	1	0	0	0	No	No	No	No
KLO-Z **Peahinaia south side of goose-head ridge**	Manage for stability	1	2003-08-27	0	0	0	1	Yes	Yes	No	No
	GU Total:	344		112	161	41	30				
GU: D	**Poamoho Summit & Trail**										
KLO-C **North of Poamoho Summit**	Manage for stability	177	2007-09-18	49	90	38	0	No	No	Yes	No
KLO-FF **South of Poamoho Summit**	Manage for stability	19	2003-03-18	0	0	0	19	No	No	No	No
KLO-GG **Poamoho trail upper 1/3**	Manage for stability	106	2003-02-17	90	15	1	0	No	No	No	No
	GU Total:	302		139	105	39	19				
GU: E	**Poamoho Pond**										
KLO-A **Poamoho Pond**	Manage for stability	90	2004-12-02	59	19	12	0	No	No	No	No
	GU Total:	90		59	19	12	0				
GU: F	**Poamoho-North Kaukonahua Ridge**										
KLO-AA **Little Italy**	Manage for stability	2	2004-05-19	2	0	0	0	No	No	No	No
	GU Total:	2		2	0	0	0				

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control			
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina
GU: G Lower Peahinaia											
KLO-S Puu Roberto	Manage for stability	35	2000-10-25	0	0	0	35	No	No	No	No
KLO-T Near Frog Pond	Manage for stability	0	1996-08-31	0	0	0	0	No	No	No	No
KLO-V Lower Peahinaia trail Hesarb site	Manage for stability	5	1999-12-13	0	0	0	5	No	No	No	No
	GU Total:	40		0	0	0	40				

Size Class Definitions

SizeClass	DefSizeClass
Large	>15 mm
Medium	7-15 mm
Small	<7 mm

Table shows the number of snails, size classes, and threats to the snails in the ESU sites. Yes = threat is being controlled; In some cases the threat may be present but not actively preying on Achatinella.

Map removed, available upon request

Figure 9.10 Current and historic distribution of *Achatinella sowerbyana* in the Koolau Mountains of Oahu.

Discussion of Management designations

Until genetic analyses are completed the Army has designated all extant GUs as manage for stability. However, GUs A, B, and F consist of just 2 or 3 individuals and may not be managed for stability if no other individuals are found in those areas. The GUs with the largest number of individuals will be proposed to be managed for stability. Many of the populations, 87% of known wild individuals, will be protected from habitat degradation by feral pigs.

Captive Propagation Information

Currently, there are 25 individuals in captive propagation. All PUs managed for stability will have a captive breeding population founded from at least 7 to 10 individuals. The minimum goal of each *ex situ* representation of wild stock is to reach 50 individuals.

Table 9.13 Captive propagation data for *Achatinella sowerbyana*.

Species (GU represented)	Year	# juv	# sub	# adult	# Individuals
A. sowerbyana	2004	12	23	12	**47**
	2007	4	14	3	**21**
	2008	8	14	3	**25**

Management Notes

All GUs need surveying to determine the extent of individuals and the threats present. Management will consist of securing sites from feral pigs, maintaining habitat via weed control and collecting of individuals from discrete populations for captive propagation. It may be difficult to set up a rat bait grid for many of the PUs, as the known individuals are spread over a large area. Genetic analyses will help to provide insight for management and reintroductions.

The **Kawainui Ridge GU-A**, **Kawaiiki Ridge GU-B**, and **Poamoho-North Kaukonahua Ridge GU-F** are designated as manage for stability but may be dropped due to their low numbers of individuals or difficult access due to the remote nature of sites and the distance between recently known individuals.

The **Opaeula-Helemano GU-C** is the largest with recent capture-mark-recapture studies estimating greater than 400 individuals at a single site within the GU (UH PhD Candidate Kevin Hall pers. com, 2008). The Army conducts rat control at several sites within this GU, all within the Opaeula/Helemano MU.

The **Poamoho summit trail GU-D** is the second largest known GU though recent surveys of known sites along the upper Poamoho trail have seen a large decline (Joel Lau pers. com. 2008). The Army plans to conduct surveys in this area and establish a rat control program in the area.

There was a large population (90 ind.) of *A. sowerbyana* observed at **Poamoho Pond GU-E** in 2004, though recent surveys have not been conducted.

There were also a large number of individuals observed at **Lower Peahinaia GU-G**. However, this GU has not been surveyed in many years. Surveys for extant individuals in GU-G and E are high priorities for the conservation of this species.

Table 9.14 Priority Management Actions for *Achatinella sowerbyana*

Geographic Unit	Specific Management Actions	Partners/Concerns	Timeline
Opaeula – Helemano GU C	• Surveys and mark recapture studies to determine the extent of the PU • Collect individuals for captive propagation • Construct predator proof exclosure	• Opaeula/Helemano fence complete	• Surveys and mark recapture ongoing
Poamoho Summit and Trail GU D	• Surveys to determine the extent of the PU • Collect additional individuals for captive propagation • Construct Poamoho MU • Construct predator proof exclosure	• On both Kamehameha schools and State Forest Reserves Land (proposed NAR) • MU needs an EA	• construct Poamoho I MU, OIP yr 8; 2015 (Tier 1)
Poamoho Pond (Kaukonahua-Punaluu) GU E	• Surveys to determine the extent of the PU • Collect individuals for captive propagation • Construct Poamoho Pond MU	• On State Forest Reserves Land (proposed NAR) • MU needs an EA	• construct Poamoho II MU, OIP year 9; 2016 (Tier 2)
Lower Peahinaia GU G	• Surveys to determine the extent of the PU • Construct Lower Peahinaia MU	• Need license agreement with landowner, Kamehameha Schools • MU needs an EA	• construct Lower Peahinaia MU, MIP year 8; 2011

10.0 Strategy for Management of *Chasiempis sandwichensis ibidis*

Defining Oahu Elepaio Management for the Army

The approach to management of the Oahu elepaio, *Chasiempis sandwichensis ibidis*, taken in the Oahu Implementation Plan (OIP) is based on the requirements outlined in the U.S. Fish and Wildlife Service's Biological Opinion (BO) (USFWS 2003). The numbers and distribution of Oahu elepaio have severely declined since the arrival of humans. The Oahu elepaio currently occupies approximately 4 percent of its original distribution. Over the last 30 years the range of the species has been reduced by 75 percent (VanderWerf et al. 2001, VanderWerf et al. 2007).

This reduction is likely due to a combination of factors that include historical habitat loss due to human use, habitat degradation by invasive alien species, and recent low adult survival and low reproductive success. The current low adult survival and reproductive success is attributed to nest predation by rats (*Rattus rattus*) and introduced diseases such as avian pox (*Poxvirus avium*) (VanderWerf 1999, 2001, 2004, VanderWerf and Smith 2002). Compounding the decline is a skewed sex ratio. Females are more susceptible to rat predation because they exclusively incubate the nests at night. Thus populations are often lacking female birds (VanderWerf 2001, VanderWerf and Smith 2002).

There are six large subpopulations remaining on Oahu, one of which occurs on SBMR West Range. This population was estimated to contain approximately 300 individuals in the mid-1990s, which was approximately 17 percent of the total estimated population of 1,980 birds across the island at that time (VanderWerf et al. 2001). However, more recent surveys of SBMR indicate the number of elepaio has declined (US Army unpubl. data). Historically, Oahu elepaio also occurred within KLOA and SBER action areas (Shallenberger and Vaughn 1977).

Rat control has proven to be a highly effective conservation action for this species (VanderWerf and Smith 2002). A ground based rat control program using snap traps and diphacinone bait stations has successfully increased reproductive success and the survival of adult females in southeast Oahu. Similar rat control programs have been in place at SBMR and MMR since 1998, in the Honolulu Forest Reserve since 1997, at The Nature Conservancy's Honouliuli Preserve since 2000, in Lualualei Valley since 2002, in Moanalua Valley since 2006, and in Makaha since 2003.

In order to stabilize the Oahu elepaio, the Oahu BO recommends a long-term rat control program for 75 elepaio territories at SBMR and/or outside the action area. The target number of pairs to manage was determined to be roughly half of the estimated number of elepaio pairs within SBMR (USFWS 2003). The Army and the USFWS determined that there would be a mix of management inside and outside the action area that would total 75 pairs per season. This is due to the difficulty in obtaining enough field days within SBMR to manage all 75 pairs that are required. In addition, there has been a decline in the numbers of Oahu elepaio found within SBMR since the last estimate in the mid-1990s (U.S. Army unpubl. data).

Development of the Oahu implementation plan elepaio management plan
The Army has relied on the expertise of Eric VanderWerf via personal communication and published literature in the development of management plans for the Oahu elepaio (VanderWerf 1993, 1994, 1998, 1999, 2001, 2004; VanderWerf *et al.* 1997; VanderWerf *et al.* 2001;, VanderWerf et al. 2007, VanderWerf and Smith 2002). Comparable to the stabilization efforts planned for *Achatinella* and plants, the emphasis for the Oahu elepaio is on threat control and habitat management. There are no immediate plans for captive propagation and eventual release of elepaio at this time.

On the ground management of Oahu elepaio requires a highly intensive effort during the breeding season from approximately December through June. Based on previous elepaio research by Army staff and Eric VanderWerf, the Army has been placing on average 3-4 bait stations and 6-12 snap traps in each mating pair's territory. Because rats must have access to a constant supply of bait for 5-8 days in order to consume a lethal dose, this requires restocking the bait stations at least every 2 weeks for approximately 7 months. Monitoring success of elepaio nests also requires visiting each territory at least every two weeks. Monitoring efforts will play a major role in determining the success of the rodent control program. Thorough monitoring from year to year provides information on the nest success, fledgling and female mortality, site and mate fidelity, and emigration (if fledglings can be banded). Based on the results of these efforts modifications to current management tactics will be considered at the annual IT meetings.

Population Units and Management
As mentioned previously, the Oahu elepaio population units (PUs) were relatively easy to define compared to the plant PUs due to their disjunct and restricted ranges. The requirement from the 2003 Oahu BO (USFWS 2003) states that the Army must conduct threat control for 75 breeding pairs each breeding season. The Army has chosen to manage these 75 pairs at Schofield Barracks West Range, Ekahanui, Makaha, Moanalua, Palehua, and Waikane. The Army also manages any pairs found within the Makua Military Reservation as part of the Makua BO (USFWS 2007).

Management: The bulk of elepaio management consists of predator control, habitat management, and monitoring. At the beginning of each breeding season, surveys are conducted to determine the territory boundaries and whether each territory contains a breeding pair or a single male utilizing playbacks, mist netting, and visual observations of individuals. Rat bait stations and snap traps are then established within each breeding pairs' territory. Occasionally, if a single male territory is found between two breeding pairs within a gulch the Army will still conduct rat control in the area to create a continuous rat free area. Or, it sometimes appears that a territory has a breeding pair and will be baited for the season only to find that it was a single male. In theory baiting for territories between breeding pairs may help the protected populations expand into new areas.

Habitat management can consist of ungulate and weed control. Ungulate control is an important factor in reducing pig wallows and therefore the abundance of mosquitoes which carry both avian malaria and avian pox virus. Weed control helps to restore native forest habitat, although elepaio will often nest in non-native trees (VanderWerf 1998, OANRP 2007). Many of the alien trees used for nesting by elepaio bear fruit and nuts that may attract rats into the forest canopy, possibly increasing the risk of nest predation (VanderWerf and Smith 2002).

Monitoring and Success: Without monitoring during the breeding season it is not possible to know whether the rodent control program is effective. For example, monitoring is necessary to determine whether nests are successful and whether breeding adults have survived from one season to the next. Monitoring is also needed to determine where nest sites are and rat bait stations and snap traps may be moved depending on the location of the nest. Additionally, if the first nest fails then monitoring may reveal a second nesting attempt, in which case a baiting station may need to be moved again. Field observations are accompanied by GIS records of territories and baiting grids.

The number of successful fledglings is essential information in the determining if the population is benefiting from management actions. Eventually, the success of the Army's elepaio management actions will be partially determined by a demographic analysis calculating the populations growth rate (λ).

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10.1 Management Plan for *Chasiempis sandwichensis ibidis*

Long Term Goals:
- Maintain predator control programs for 75 breeding pairs of elepaio
- Monitor predator control effectiveness (i.e. band, re-sight, document fledgling success and adult survivorship)
- Control other threats at each managed field location
- Tier 1 management priority

Table 10.1 Army Elepaio Management Summary

SUBPOPULATION	TOTAL POP SIZE	# PAIRS	# PROTECTED PAIRS	# PROTECTED NON-PAIRS	NOTES
Waianae Mountains					
Palehua,	**27**	**11**	**11**	**7**	
South Ekahanui	**53**	**22**	**20**	**6**	
Schofield Barracks West Range (gulches)	**>47**	**13**			
(Mohiakea)	**14**	**3**	**3**	**7**	
(Banana)	**10**	**1**	**0**	**0**	
(Baby water)	**3**	**1**	**1**	**0**	
(North Haleauau)	**15**	**6**	**6**	**0**	
(South Haleauau)	**6**	**2**	**0**	**0**	
Makaha	**57**	**8**	**8**	**2**	
Makua	**7**	**2**	**2**	**1**	
Koolau Mountains					
Waikane	**19**	**4**	**4**	**3**	
Kahana	14	7			Candidate for management (State parks)
Moanalua	**82**	**32**	**26**	**3**	**State owned**
Totals:			**81 protected pairs**	**29 protected non-pairs (i.e. single males)**	

*Populations in bold are managed or are proposed for management.

Taxon Specific Issues

The Oahu elepaio (*Chasiempis sandwichensis ibidis*) has been in serious decline for the past few decades due to low adult survival and low reproductive success (VanderWerf et al. 2001, VanderWerf and Smith 2002). The two main causes of decline are nest predation by non-native black rats (*Rattus rattus*) and introduced diseases such as avian pox virus (*Poxvirus avium*) and avian malaria (*Plasmodium relictum*). This decline will likely continue without systematic rat control programs (VanderWerf and Smith 2002, VanderWerf et al. 2007). Ungulate control programs may also aid in reducing mosquitoes, the vector for both avian diseases.

Discussion of Management Designations

Management of the Oahu elepaio, *Chasiempis sandwichensis ibidis*, on Oahu Army training areas involves a predator control program for at least 75 breeding pairs, roughly half of the originally estimated 150 pairs at SBMR (Oahu BO USFWS 2003). The USFWS encouraged the Army in the

2003 Oahu BO to try to manage as many individuals in SBMR as possible. However, the management of all 75 pairs in SBMR is problematic as it is currently in use as a live fire training area. As a result, the Oahu Implementation Team (OIT) determined that a combination of management inside and outside of the action area could be utilized to meet the target number of 75 breeding pairs.

The Army has a separate requirement for the Makua Military Reservation (MMR), which is to conduct predator control for all pairs within the MMR action area. In 2008, the Army conducted rat control for 2 pairs and an additional single male territory (previously a pair in 2007).

The population units currently managed by the Army include SBMR West Range (10 pairs), South Ekahanui (20 pairs), Moanalua (26 pairs), Makaha (8), Waikane (4), Palehua (11). The total protected for the 2008 breeding season was 79 pairs for the OIP and 2 pairs for the MIP. Although the number of pairs managed at each site is listed here, the numbers will vary year by year due to fluctuation in the elepaio population. The goal of this management approach is to direct threat control across a range of populations to help in preserving the current distribution of elepaio on Oahu. The Army has chosen to focus on areas where there are no other management efforts underway and wherever there are sufficient numbers of breeding pairs to make predator control worthwhile. The Southern Koolaus were not proposed by the Army for management due to current management by other agencies (State of Hawaii) and volunteers.

The OIT recommended that, if given a choice, larger PUs should be protected rather than smaller PUs. This is due to the potential loss of birds to unprotected surrounding areas through emigration, and the larger “edge effect” in smaller PUs. In other words, many of the fledglings produced in a small protected group of breeding birds (i.e. sources) may emigrate to unprotected areas (i.e. sinks), thereby reducing the effectiveness of the control program. Whereas fledglings from a larger protected population are more likely to replace birds in existing territories as they die or establish new territories within the protected area. This is why the Army controls rats in some territories that currently contain only a single male. Currently, some of the populations managed by the Army may be considered too small (i.e. having too few individuals in too small of a geographic area). The number of pairs necessary to make management worthwhile is debatable and may change with new information. The OIT and the Elepaio Working Group will meet yearly to discuss priority populations to manage on Oahu based on monitoring and management data.

The Army has delineated elepaio predator control areas (Figures 10.1-6) that represent areas where active management may occur to reach the target number of breeding pairs. Currently, active management consists of monitoring and predator control in the form of rat bait stations and snap traps. The elepaio predator control areas do not follow the current proposed or existing MU fencelines but rather incorporate a pattern of the highest density of individuals, nearby historically known sites, and potential habitat close to existing individuals. Current locations of elepaio may change slightly over time as territories change and new individuals are discovered. Any aerial broadcasting of rodenticide will protect breeding pairs and allow flegelings to expand into ungulate free, protected areas.

Threats in the Action Area

Within the action area at SBMR West Range, threats to Oahu elepaio include direct impact from live-fire training, fire, habitat degradation by invasive alien plants and feral ungulates, introduction of new alien plant and animal species, nest predation by introduced rats and possibly feral cats and mongoose, and diseases carried by alien mosquitoes. One elepaio territory is known to occur partially across the firebreak road and has been affected in the past by road maintenance. It is assumed that all PUs are equally threatened by predators. Restrictions on access to elepaio management areas also limits the level of protection birds in the Action Area can receive.

Management Notes

Management for the Oahu elepaio will require extensive work during the breeding season, approximately December thru June. This work includes rat control for each breeding pair, monitoring adult survival, and monitoring nesting success. Additionally, each management site should be fenced to exclude ungulates. Once ungulates are removed, the Army may consider utilizing aerially applied rodenticide. As mentioned, the elepaio management areas (shaded in blue in Figures 10.1-10.8) do not follow proposed or existing fencelines but are representative of areas that may receive active management via monitoring and rat control.

The **SBMR** population (Figure 10.3) has received rat control in Mohiakea, Baby Water, and North Haleauau drainages for the past several years. The Army began rat control for elepaio in 1998 for a few territories. The Army has recently announced Schofield Barracks West Range will be open for conservation management 4 days/week during a range construction project through 2011. The Army natural resources program is proposing to build 3 significantly large fences within the next 2 years. These fenced units will provide approximately 975 ungulate free acres which may be candidate locations for aerial broadcasting of rodenticide. The use of aerially broadcasted rodenticide would allow for a much larger number of breeding pairs to be protected within SBMR. However, these fences are larger than any others proposed by this program and have not been scoped and there is a significant amount of unexploded ordnance in the area. Safety and funding concerns will be important considerations in determining if these fences can be constructed.

Portions of the **Ekahanui** population (Figure 10.4) have been protected for several years, initially by The Nature Conservancy in 2000, and for the last 4 years by the Army. This year, the Ekahanui subunit II fence will be complete, providing just over 200 acres for plant, snail, and elepaio management. The large number of pairs within the fence also makes this MU a good candidate for aerial broadcasting of rodenticide.

The **Makaha** population (Figure 10.5) has received rat control since 2003. This valley has not been thoroughly monitored by the Army in a couple of years. More pairs may be detected with additional monitoring in this coming year. There are a significant number of single males in this area.

The **Moanalua** population (Figure 10.8)has received rat control since 2006 and is also currently protected via a baiting and monitoring contract. In the last year 26 breeding pairs were protected. The Army plans to conduct additional monitoring this year to see if more pairs can be protected feasibly. The valley is now owned by the State and an overarching license agreement between the State and the Army is currently being drafted.

The Army began predator control for the **Waikane** population (Figure 10.7) in 2007. This site was chosen to be managed because there are no other management sites for this species on the windward side of the Koolau Mountains and was thought to be a significant contribution to the stabilization of the species in a geographic sense. However, this is the smallest of all populations that the Army manages, just 4 pairs were protected in the last year. The OIT has discussed either expanding the scope of predator protection to include more pairs or trying to manage 4 additional pairs in another population (i.e. dropping management at this site). In the coming year, the Army will conduct surveys to determine how many additional pairs may be feasibly managed in Waikane and neighboring Kahana valley. If there are few birds or the pairs are spaced too far apart, the Army may choose not to manage this population in the future. All changes will be discussed with the OIT.

The **Palehua** population was recently detected in 2006 along the Palehua subdivision road by Dr. Eric VanderWerf. The Nature Conservancy began baiting for this population in 2006 and the Army is working with TNC to provide financial support and monitoring; in the last year, 11 pairs were protected and monitored. This population appears to be expanding slowly.

Table 10.2 Priority Management Actions for the Oahu Elepaio Army Predator Control Populations

Population	Specific Management Actions	Partners/Concerns	Timeline
South Ekahanui (Honouliuli Preserve)	• Investigate aerial rodenticide drops • Baiting through contract for 20 pairs • Monitor adult survival and nesting success	• Need agreement with new landowner	• Continue baiting and monitoring via contract each breeding season
Schofield West Range	• Construct Mohiakea and North Haleauau MUs • Baiting • Monitor adult survival and nesting success	• Access not reliable	• Construct Mohiakea and North Haleauau MUs in OIP yr 3; 2010 • Continue bating + monitoring each breeding season
Makaha	• Bait through contract • Monitor adult survival and nesting success	• Need new MOU with BWS landowner	• Continue bating + monitoring each breeding season
Moanalua	• Bait through contract • Monitor adult survival and nesting success	• Need license agreement with the State	• Continue bating + monitoring each breeding season
Waikane/Kahana	• Conduct surveys in Kahana to determine the extent of the PU • Monitor adult survival and nesting success	• Have yearly ROE with landowner, Waikane Investment Corp., for access and baiting. • Need license agreement with the State	• Continue bating + monitoring each breeding season
Palehua	• Baiting during breeding season • Monitor adult survival and nesting success	• Currently have informal agreement with Palehua residents via TNCH for baiting. • Access via TNCH.	• Continue bating + monitoring each breeding season

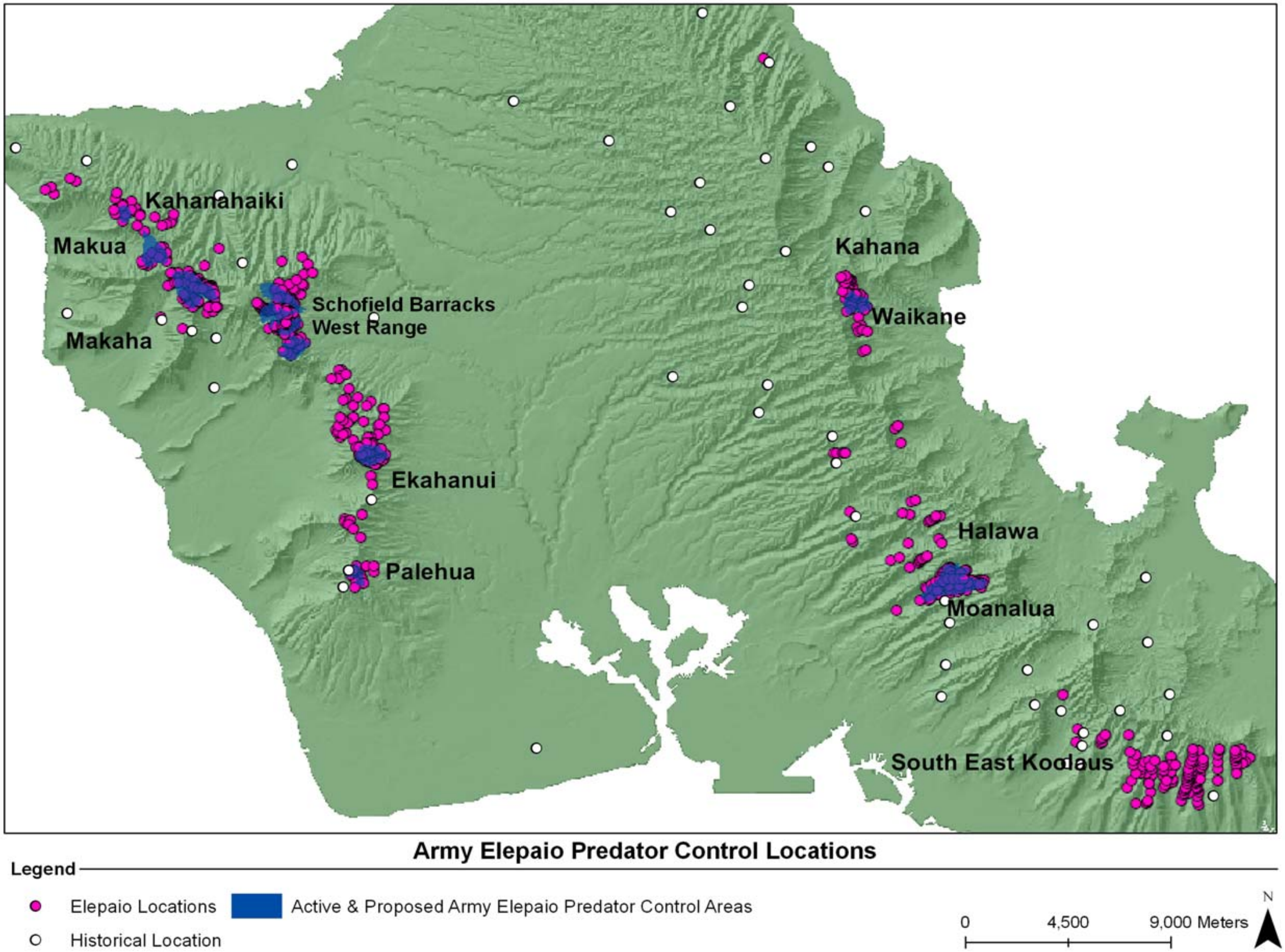


Figure 10.1 Current and historical locations of elepaio and Army active and proposed elepaio predator control areas on Oahu.

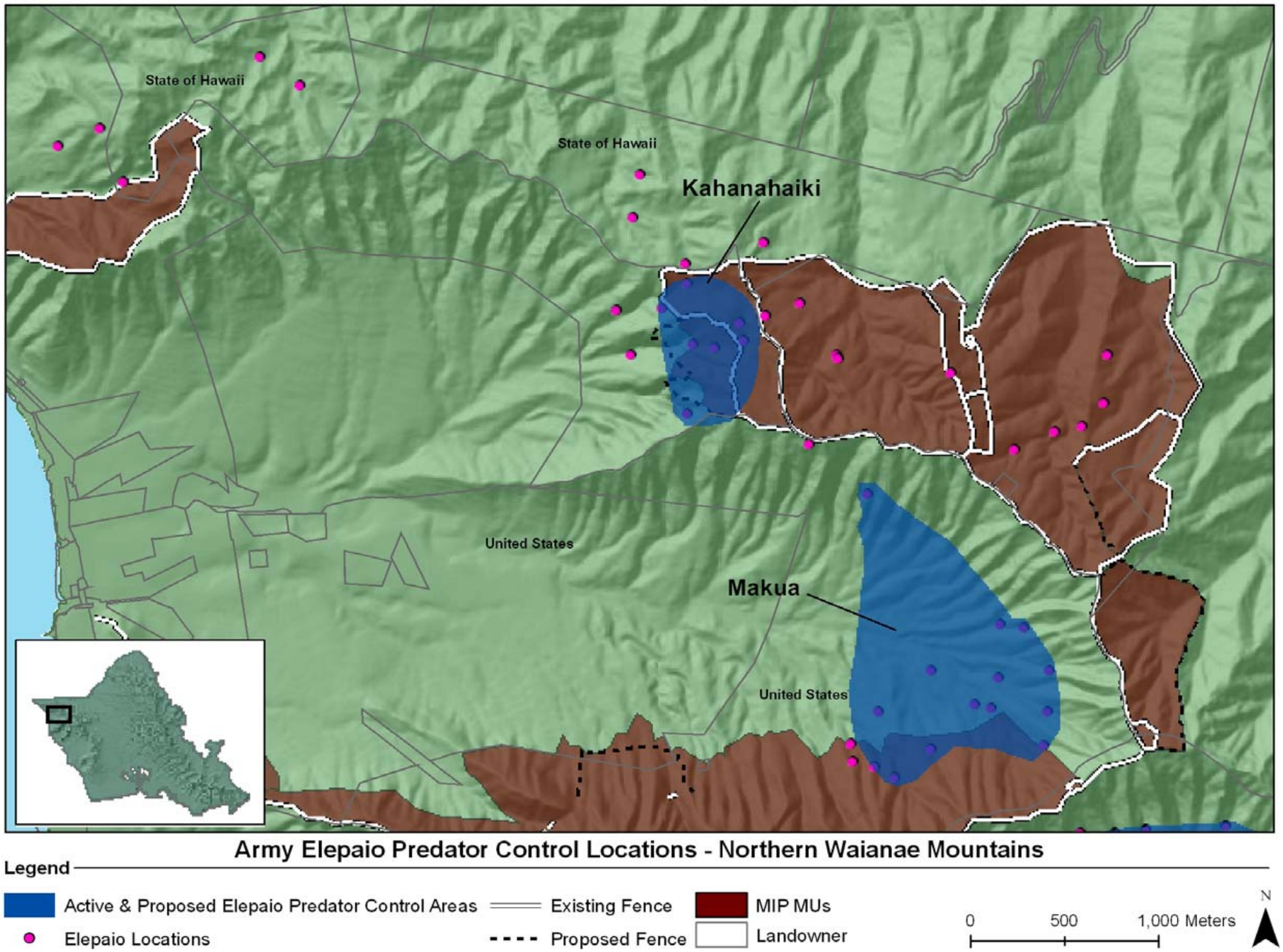


Figure 10.2 Current and historic elepaio locations and Army elepaio predator control areas in the Makua Action Area Northern Waianae Mountains, Oahu.

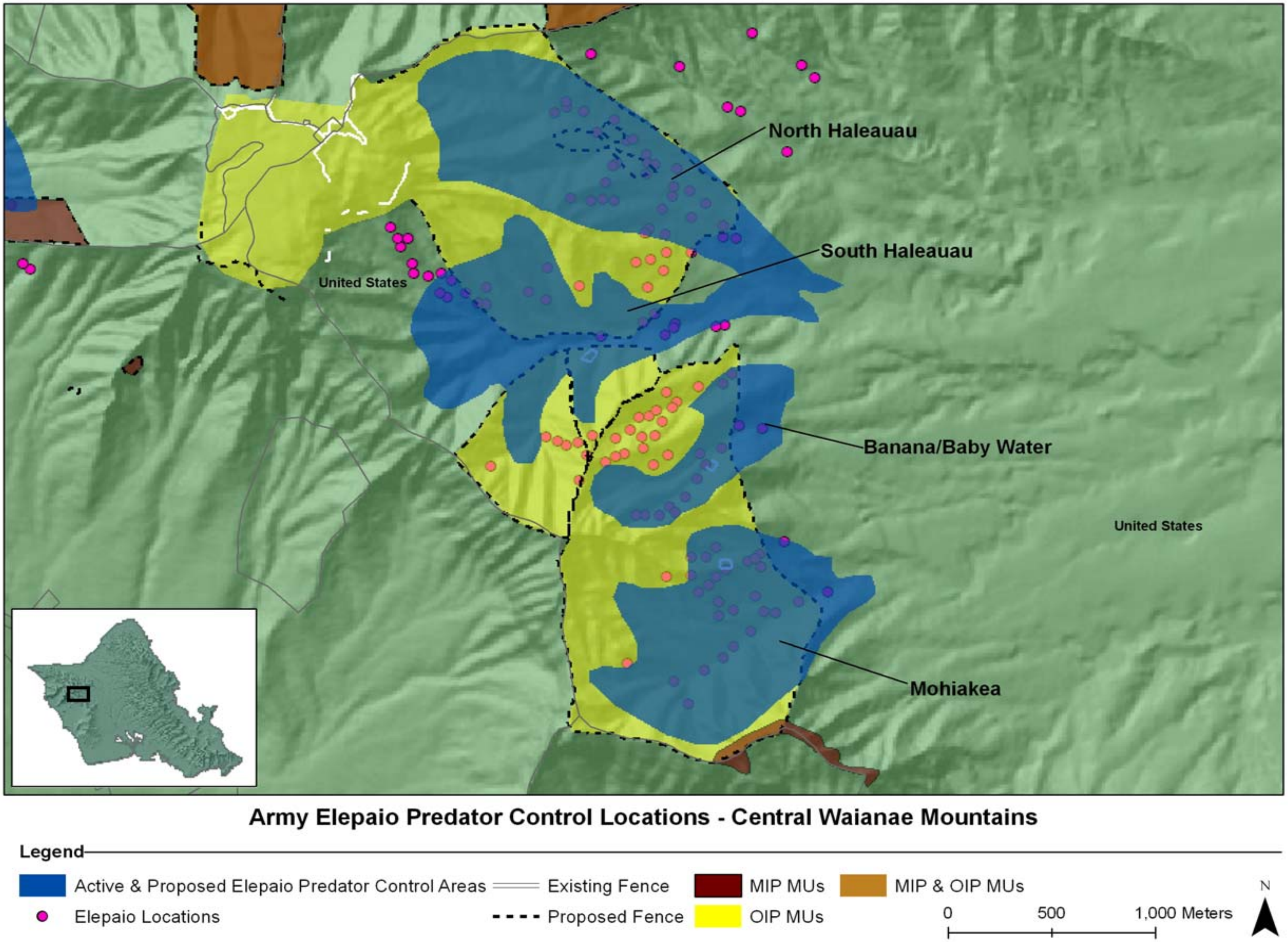


Figure 10.3 Current and historic elepaio locations and Army elepaio predator control areas in the Schofield Barracks West Range Action Area, Central Waianae Mountains, Oahu.

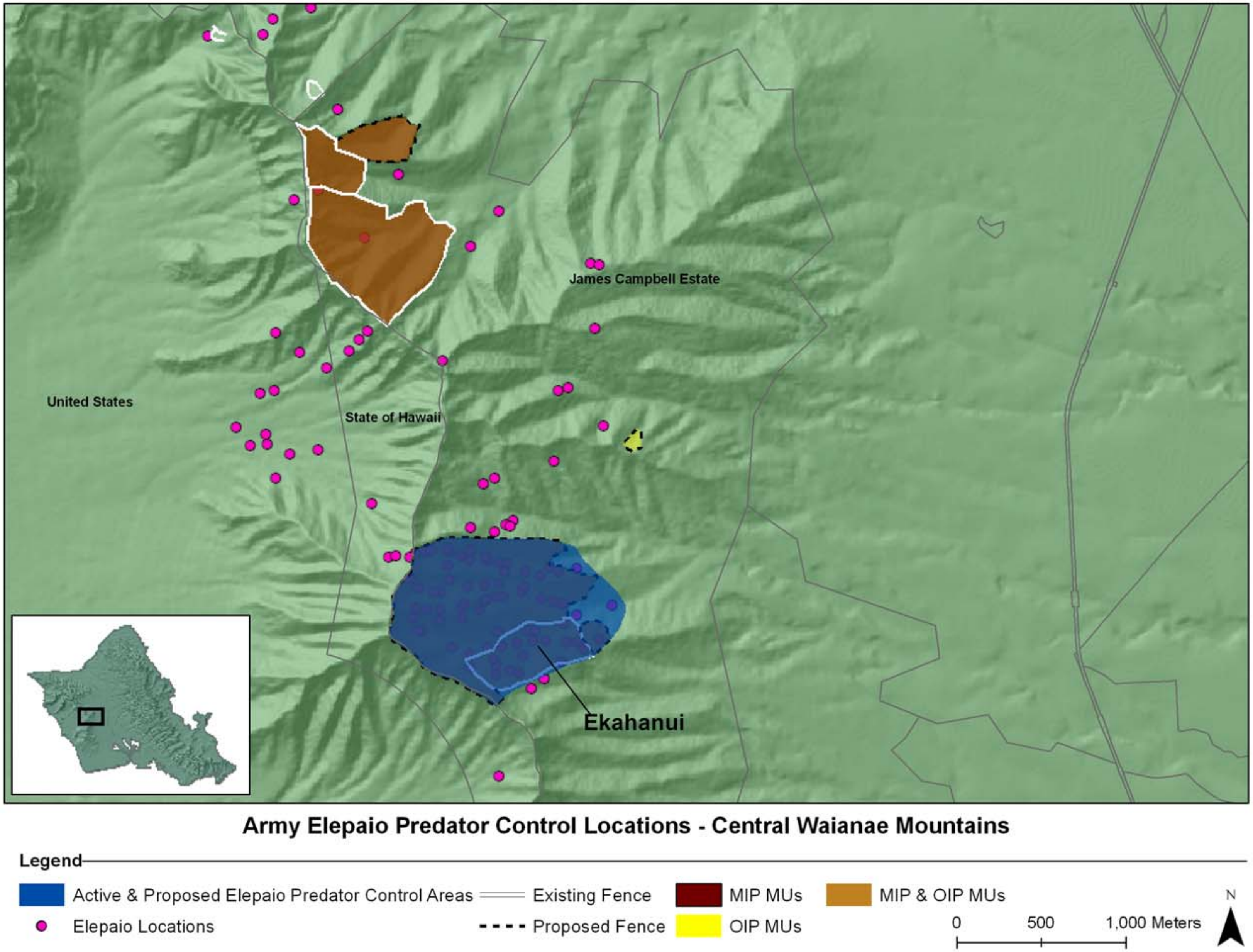


Figure 10.4 Current and historic elepaio locations and Army elepaio predator control areas in the Central Waianae Mountains, Oahu.

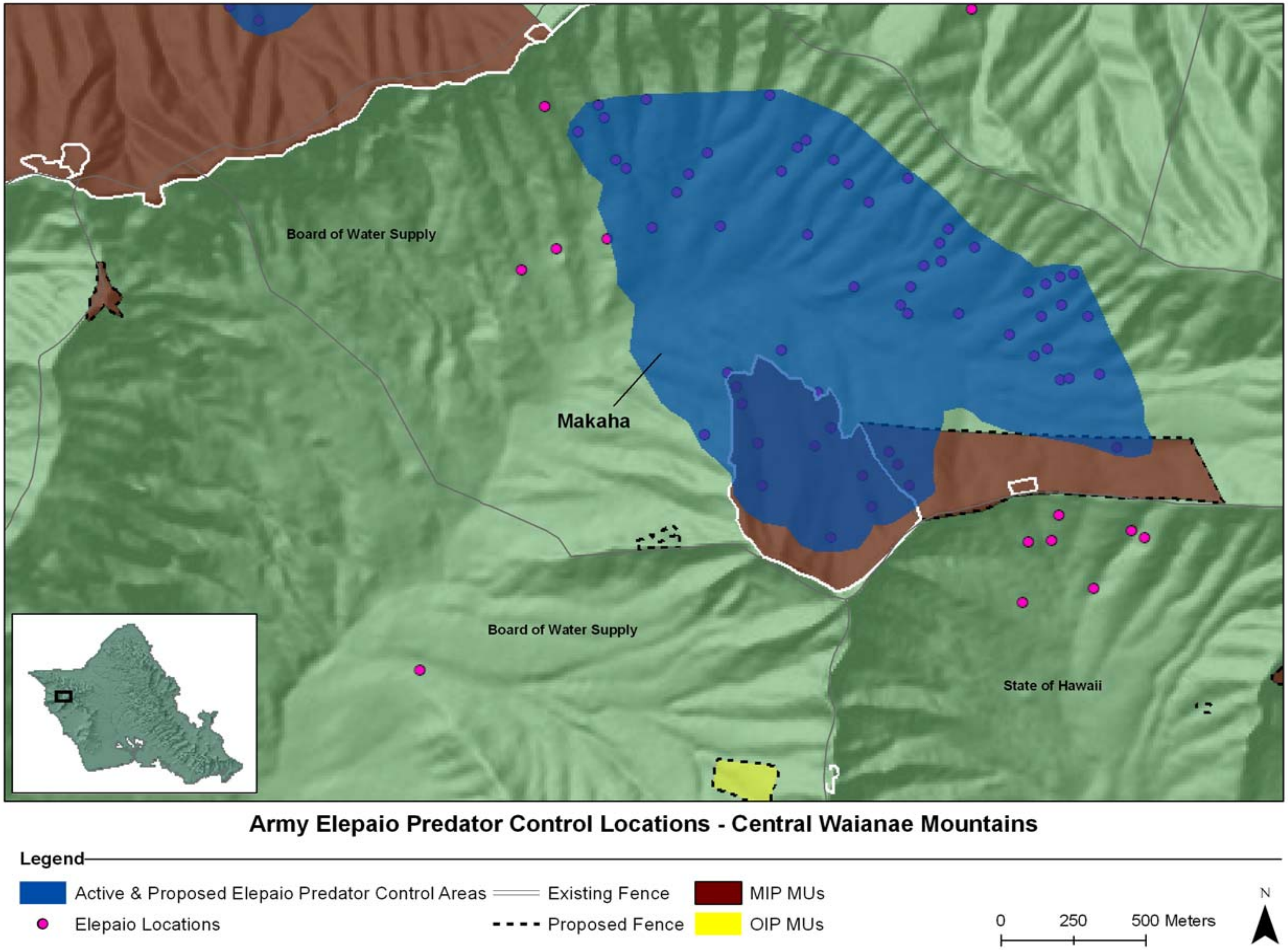


Figure 10.5 Current and historic elepaio locations and Army elepaio predator control areas in the Central Waianae Mountains, Oahu.

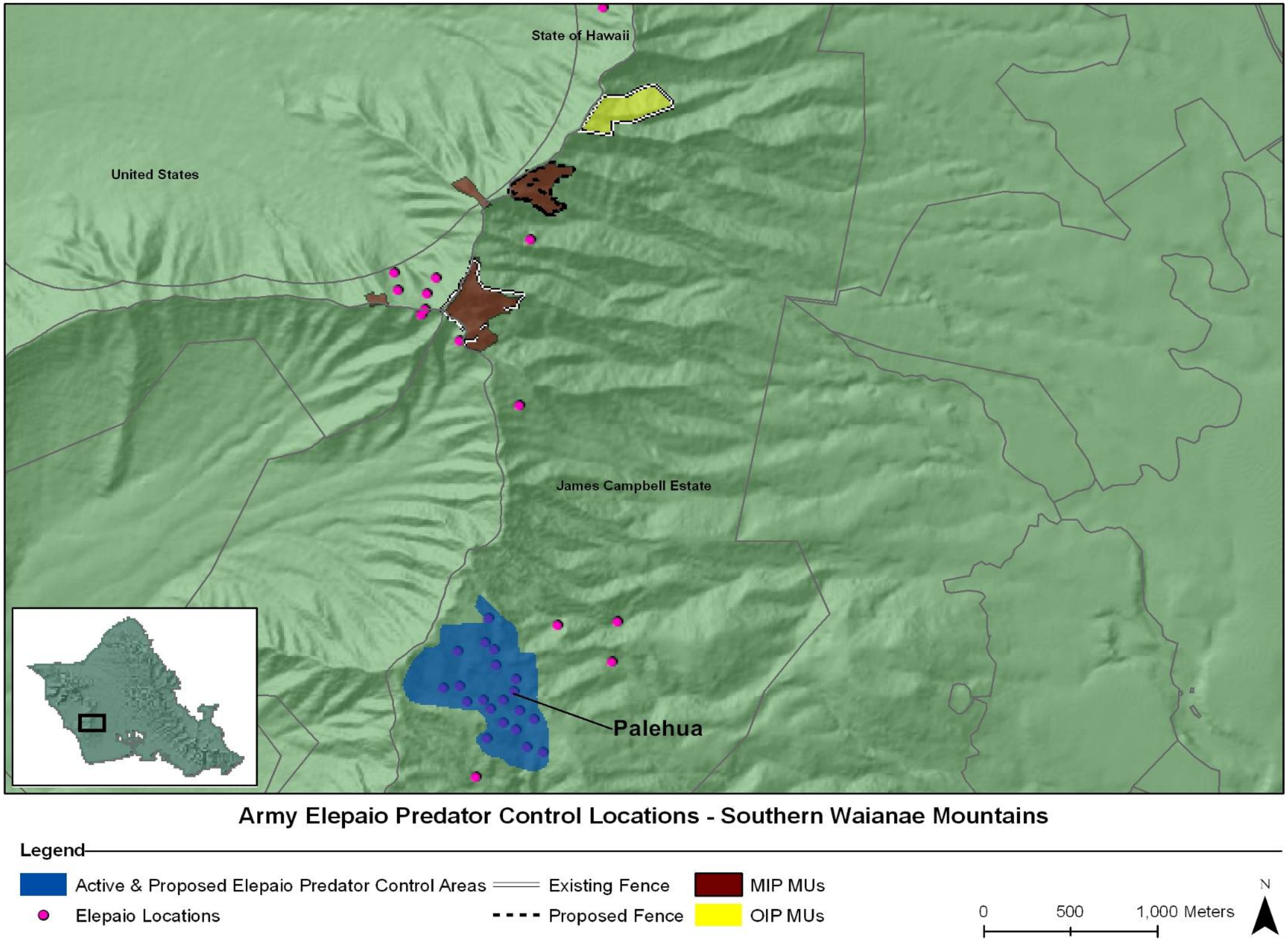


Figure 10.6 Current and historic elepaio locations and Army elepaio predator control areas in the Southern Waianae Mountains, Oahu.

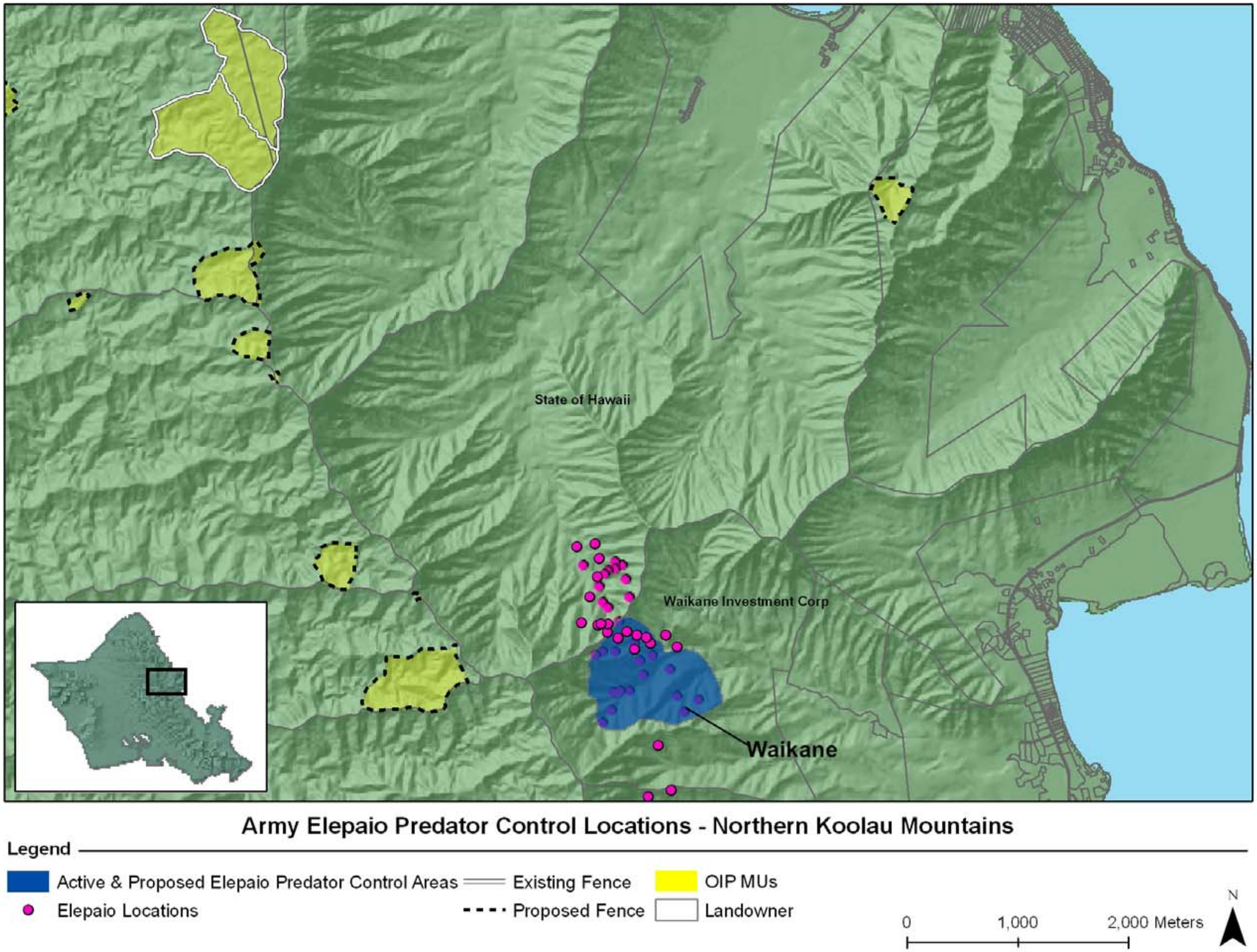


Figure 10.7 Current and historic elepaio locations and Army elepaio predator control areas in the Northern Koolau Mountains, Oahu.

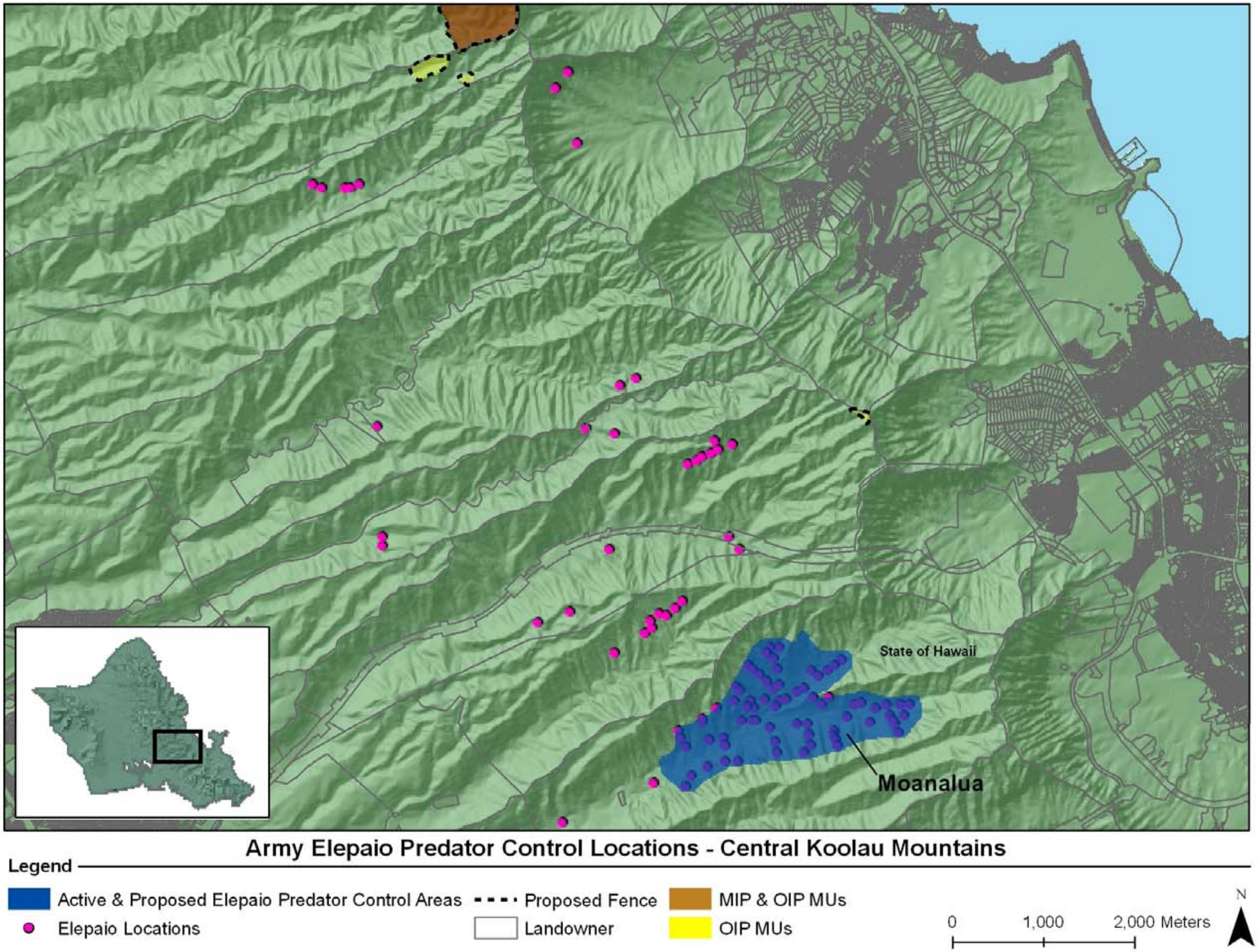


Figure 10.8 Current and historic elepaio locations and Army elepaio predator control areas in the Central Koolau Mountains, Oahu.

11.0 Strategy for Stabilization of the OIP Target Plant Taxa

The Oahu Implementation Team (OIT) based the plant stabilization plans for the Oahu Implementation Plan (OIP) on the format set forth in the Makua Implementation Plan (MIP). However, due the reduced threat from military training within Schofield Barracks East Range (SBER) and Kawailoa Training Area (KLOA), preference was given to populations within the action area (AA) for stabilization. The U.S. Fish and Wildlife Service (USFWS) defines plant stabilization according to the recommendations published by the Hawaii and Pacific Plants Recovery Coordinating Committee (HPPRCC), a group of botanical experts gathered together by the USFWS to offer guidance on the recovery of listed plants in the Pacific. The HPPRCC decided that a taxon would be considered stable if it met the following three criteria: 1) it has sufficient numbers of regenerating individuals in a minimum number of populations; 2) threats are controlled at these populations; and 3) these populations are fully represented in an *ex situ* collection (USFWS 1998b). It is important to note that the requirements for stabilization are far below those required for delisting or downlisting, and that stabilization is *not* synonymous with recovery. The OIT reviewed the HPPRCC guidelines and the stabilization plans in the MIP and refined the target number of reproducing individuals required per population for some taxa. Revisions were based on life history and other factors described in Table 11.1.

Factors that were assessed regarding stabilization included threats that contribute to the decline of the target taxa, and aspects of their biology (especially reproductive biology) that are pertinent to natural regeneration, as well as the state of knowledge regarding propagation, cultivation, and *in situ* care of wild individuals.

Setting Stabilization Targets for the OIP Plant Species

The determination of stabilization targets for the Oahu Implementation Plan (OIP) species was based primarily on the outline used in the Makua Implementation Plan (MIP) as summarized below.

It is difficult to determine if a given population structure and distribution will ultimately result in a stable population for a particular taxon. Equally problematic is determining the number and life stage or age class of individuals that need to be introduced or maintained within a population to ensure the long-term stability of a reintroduced population (see Chapter 3: Identification of Units for Stabilization of Plant and Snail Populations).

The HPPRCC (1994) recommended stability goals as three populations of plants with a minimum of either 25 mature and reproducing individuals of long-lived perennials (>10 year life span), 50 mature and reproducing individuals of short-lived perennials (<10 year life span) or 100 mature and reproducing individuals of annual taxa per season (<1 year life span). In addition to numerical criteria, genetic storage must be in effect for the taxon and all major threats must be controlled for a population to be considered stable. These recommendations are consistent with the guidelines of the Center for Plant Conservation (CPC) (Falk and Holsinger 1991). The HPPRCC believes that sustaining a population with this number of reproducing individuals over the short-term ensures that there will be an adequate reservoir of smaller or younger individuals that can develop into mature, reproducing plants with each subsequent generation to prevent extinction, even though it is not adequate long-term to achieve full recovery of the taxon. The target number of individuals per population for the OIP is meant to encompass the effective population size (N_e), which is the number of genetically distinct individuals in a population that are successfully producing viable offspring. The total population size (N) is the N_e plus the remaining individuals in the population. The bulk of research on N_e focuses on animal taxa, however, Mace and Lande (1991) found that for plants, the N_e is typically 20 to 50 percent of N.

The Makua Implementation Team (MIT) adopted the HPPRCC population targets as the base population targets for plant taxon stabilization. Though, they recognized that some factors might modify the base population target upward for some taxa. The OIT determined that these factors are also applicable to the OIP target taxa. These factors are described below with OIP specific examples. Modified target numbers are found in Table 11.1.

Factors affecting stabilization targets

The following factors can influence $N_{e,}$ thereby requiring a larger number of individuals to reach an equivalent N_e to the original stabilization targets. The numbered sections below correspond with the factors for modifying the base population targets in Table 11.1. Not all of these factors require that target numbers be adjusted but are important factors to consider when stabilizing these species.

1. Obligate outcrossing

The fertilization of a flower of a genetically distinct individual by the pollen of another genetically distinct individual is known as outcrossing. For taxa incapable of self-fertilization, outcrossing is obligatory. Once a population of an obligately outcrossing taxon becomes too small, or the distance between its individuals increases beyond the range of pollination mechanisms, the population's regeneration rate may decrease, leading to a decline in the number of individuals. Therefore, for taxa that are obligately outcrossing, the base population target should be doubled. None of the target taxa are known to be obligate outcrossers, although some may prove to be such through the study of their breeding systems.

Table 11.1 Target Number of Mature, Reproducing Individuals per Plant Population to Ensure Stability

TAXON	LIFE FORM+	Base Population Target	Modified Population Target	FACTORS*
Abutilon sandwicense	S	50	-	8
Chamaesyce rockii	L	25	-	
Cyanea acuminata	S	50	-	
Cyanea crispa	S	50	-	
Cyanea koolauensis	S	50	-	
Cyanea st.-johnii	S	50	-	
Cyrtandra subumbellata	S	50	-	
Cyrtandra viridiflora	S	50	-	
Eugenia koolauensis	L	25	50	pathogens
Gardenia mannii	L	25	50	5
Hesperomannia arborescens	L	25	-	
Huperzia (Phlegmariurus) nutans	S	50	-	3
Labordia cyrtandrae	S	25	50	2, 6
Lobelia gaudichaudii ssp. *koolauensis*	S	50	100	4, 5
Melicope lydgatei	L	25	50	pathogens
Myrsine juddii	L	25	-	
Phyllostegia hirsuta	S	50	100	7
Phyllostegia mollis	S	50	100	7
Pteris lidgatei	S	50	-	
Sanicula purpurea	S	50	100	4, 5
Schiedea trinervis	S	50	-	
Stenogyne kanehoana	S	50	100	3, 4, 6
Viola oahuensis	S	50	-	

+LIFEFORMS: L = long-lived (>10yrs), S = short-lived (<10 yrs)

***FACTORS:**
1 obligate outcrossing
2 dioecy
3 vegetative reproduction
4 infrequent or inconsistent flowering
5 large percentage of non-flowering or non-fruiting plants
6 low seed set or poor seed viability
7 tendency for large declines or fluctuations in population size
8 persistence of the seed bank

2. Dioecy

Dioecy is term applied to a plant taxon where an individual plant produces only functionally staminate (male) or pistillate (female) flowers. Dioecious plants require the presence of both male and female individuals within pollination range that are flowering at the same time in order to effect fertilization and successful seed set. It is therefore much more difficult to ensure conditions for regeneration with dioecious taxa, especially when it may not be possible to determine the sex of a plant before it matures. For dioecious taxa the base population target should be doubled, so that the chances of having adequate numbers of both sexes established in a managed population are increased. *Labordia cyrtandrae* is the only dioecious species covered by the Oahu Implementation Plan.

3. Vegetative reproduction

Plants that reproduce vegetatively produce clones of themselves, so that an area that appears to be composed of unique individuals may actually be composed of many genetically identical individuals. These groups of individuals are often more genetically similar within populations and more distinct between populations than taxa that reproduce sexually. Although it may not be necessary to increase the target population goal of vegetatively reproducing taxa, some way to detect genetically distinct individuals must be developed so that population target goals account for unique individuals, rather than clones of one another. *Stenogyne kanehoana* has been observed to reproduce vegetatively when sprawling branches touch the ground and root. As flowering is seasonal and seed set appears to be low, this may have been one of the primary methods of reproduction for this species.

4. Infrequent or inconsistent flowering

Since flowering is a key component of reproduction, any inconsistency in flowering or reduction in the frequency of flowering reduces N_e and therefore reduces the likelihood of maintaining stability. For example, there are some cases where, although the great majority of individuals in a population flower, flowering occurs infrequently. The likelihood of environmental events reducing mass flowering and successful fruiting is much greater for plants that flower sporadically or infrequently than for plants that flower more regularly or frequently. In those taxa with known infrequent or inconsistent flowering, the population target is doubled. *Lobelia gaudichaudii* spp. *koolauensis* and *Sanicula purpurea* are both monocarpic, meaning they flower only once before senescence.

5. Large percentage of non-flowering or fruiting plants

This problem is similar to the infrequent or inconsistent flowering factor described above, but concerns populations in which, even during peak flowering times, the majority of individuals do not flower, or are not able to produce fruit or seed. The N_e is much lower than the N in this case, and the population target is doubled. *Lobelia gaudichaudii* ssp. *koolauensis* and *Sanicula purpurea* also have a large percentage in each population that do not flower in any given year due to their monocarpic nature.

6. Low seed set or poor seed viability

Low seed set or poor seed viability, whether due to seed predation, disease, pollination failure, or other factors, can potentially lead to decreases in reproductive potential. For taxa with low seed set or poor viability, the target population goal is doubled. Low seed set may be a factor in the rarity of *Stenogyne kanehoana*; more observations and seed collections are needed.

7. Tendency for large declines or fluctuations in population size

Large declines in population size, even if balanced by large increases at other times, reduce the stability of the population through a reduction in N_e. Any negative events during a major low point in a population fluctuation could extirpate the population. For taxa prone to large declines or fluctuations in population sizes, the population target is doubled. *Phyllostegia mollis* and *P. hirsuta* both have a tendency to seasonal or stochastic fluctuations in population size. *Phyllostegia mollis* prefers rocky, unstable talus slopes and therefore maybe subject to occasional landslides.

8. Persistence of the seed bank
This factor does not warrant increasing the population target, but suggests that surveys of historical occurrences should be conducted to check for regeneration from the seed bank, even years after the last observation of mature individuals at the site. A persistent seed bank in a population of short-lived individuals could buffer fluctuations in population size. Additionally, there may also be a tendency for ferns and fern allies to be persistent in the gametophyte stage until favorable conditions occur. Most pteridophyte gametophytes are minute and unknown. For all of the Oahu IP taxa the persistence of seed banks or gametophytes remains to be studied.

Plant Propagule Collection and Storage

Because of a trend of decline in population units (PUs), largely due to unmitigated threats to wild populations, there is an urgent need for collection of propagules for the purpose of safeguarding genetic variability, and for providing stock for outplanting efforts. Significant effort will be required to gather propagules (seeds or cuttings) from all PUs identified for long-term genetic storage and for reintroduction and/or augmentation material. Priorities for collections of material for genetic storage and/or reintroduction are outlined in each species stabilization plan but generally are to first collect from all manage for stability PUs in tier 1. Secondly, collect from all tier 1 genetic storage PUs. The same formula would apply for each additional tier initiated. However, any opportunistic propagule collections of the target taxa would be beneficial in determining the best propagation and storage parameters for each species. The benefits of using seeds versus cuttings or other propagules are discussed in Appendix 2.1: Plant Propagule Collection Protocols.

These genetic storage collections will be utilized to guard against loss of wild populations (in storage) and as propagule sources to support reintroduction efforts, if necessary. A secure seed/propagule storage facility is required to realize the short, medium, and long-term propagule storage needs related to Oahu target plant taxa stabilization actions. The Center for Conservation, Research, and Training (CCRT) Seed Conservation Lab and Lyon Arboretum Micropropagation Lab have been invaluable in securing genetic material against loss for numerous Hawaiian species. Both of these facilities have been utilized in the implementation of the Makua Implementation Plan (MIP). Because of the large seed collection effort initiated by the Army under the MIP more seed storage information is now available for native Hawaiian genera. The Army has recently initiated its own seed storage facility that will conduct storage and research on all the MIP and OIP plant taxa.

If seeds from a particular taxon are known to be recalcitrant (not storable under standard freezing techniques), collection of vegetative material and research on alternative storage methods will be required. If storage potential for a target taxon is not yet known, further collection for the purposes of seed storage testing will be required. Current knowledge of seed storage potential for target taxa can be found in individual species stabilization plans. If propagation techniques for any target taxa are not yet known, collection for the purpose of propagation testing will be required, following guidelines in Appendix 2.1: Plant Propagule Collection Protocols.

These protocols were developed by the MIT, for the MIP, for propagule collection and were derived from a balance between the need to remove seed or other living material in sufficient quantity to serve the purposes of stabilization without harming wild plants or unduly reducing potential natural regeneration. The MIT, in turn consulted with The Center for Plant Conservation and the Hawaii Rare Plant Restoration Group (HRPRG). Each has worked with rare Hawaiian plant taxa and developed specific, recommended protocols for propagule collection (see Appendix 2.4: HRPRG Collecting and Handling Protocols). These protocols are applicable to the needs of the OIP and are reproduced in this document without modification (see Appendices).

Reintroduction and Augmentation

The reintroduction and augmentation protocols for the OIP are adapted (without major modification) from those developed for the MIP. Modifications to this text stem from differences in the knowledge base for the OIP taxa on specific augmentation information and the decision to move away from the sequencing of actions as included in the MIP. These guidelines are based on the Hawaii Rare Plant Restoration Group (HRPRG) Reintroduction Guidelines (See Appendix 1.2).

Given the historical trend of reduction in geographic range, numbers of populations, and numbers of individuals of endangered taxa in Hawaii, one of the strategies in the stabilization of the Oahu IP target taxa is reintroduction of individuals into suitable managed habitat within the known historical range or likely suitable habitat of a taxon. **Reintroduction** is defined in this plan as establishing a number of individuals into a geographic area within a taxon's historic range that is currently not known to contain the taxon, with the express purpose of establishing a sustained or growing population. The plant reintroduction and augmentation strategies presented in the MIP were based on other efforts, including the HRPRG reintroduction. These guidelines are also applicable to the OIP target taxa.

Most of the target taxa have declined to such levels that threat management alone will not allow return of the taxa to stable levels. Reintroduction supports the primary strategy of active *in situ* management of extant wild populations toward stability. While reintroduction might be necessary to achieve stability, activities involved in reintroduction can be extremely harmful unless care is taken to minimize impacts such as damage to habitat or other native taxa via trampling, introduction of disease and alien taxa, and genetic contamination of target taxa or other native taxa.

Reintroduction must be distinguished from **augmentation**, which involves the addition of individuals to a geographic area that is currently known to contain the taxon. The express purpose of an augmentation is to increase the number of individuals in a population to enhance the possibility of cross-pollination between the plants. It is also used to increase the genetic variability of the population by introducing individuals that bring new alleles into the population that may have become lost over time as the population declined. A major concern in augmentation lies in the increased potential to negatively impact the genetic makeup of the pre-existing population. This is discussed in more detail below.

Genetic considerations

It is important to carefully consider potential genetic consequences when choosing individuals for use in reintroduction and augmentation. Reintroduction and augmentation can be carried out using plants from a single source or by mixing plants from more than one source. Each strategy may have both positive and negative consequences and the risks of each must be carefully balanced.

When a large and healthy source population is available, it is generally wise to use a variety of individuals from a single source for reintroduction. For such a population, it can be assumed that genetic problems such as inbreeding are not manifested and will likely produce a genetically healthy reintroduction.

Large healthy populations are not always available. In these situations, the risks of mixing versus using a single source must be weighed. For normally outcrossing plants with small populations, random genetic drift may play a larger role in the genetic structure of a population than natural selection. The consequence of this is often a reduction in fitness known as inbreeding depression. Such a reduction in fitness occurs because inbreeding increases homozygosity, which may lead to the expression of recessive deleterious alleles. In addition, an inbred population may lack the allelic diversity required for a population to change gene frequencies in order to adapt to a changing environment over time. Small population size and inbreeding are not necessarily problematic for plants that are normally self-pollinated because such plants may have already purged their deleterious alleles.

To ensure adequate genetic diversity and to avoid inbreeding depression so that a population can evolve over time, multiple sources may be mixed for both reintroduction and augmentation. Using multiple sources does, however, introduce the risk of reduced fitness due to outbreeding depression. Outbreeding depression is thought to be a consequence of crossing individuals that are locally adapted for different environments. The result is offspring that are poorly adapted to either of the parental environments. Outbreeding depression may also result due to the disruption of coadapted gene complexes when highly unrelated individuals are crossed. This may be less of a concern when working in already degraded sites because plants may be adapted to formerly pristine habitats and are no longer adapted to current conditions.

The risks of inbreeding and outbreeding depression are serious, yet such genetic problems are difficult to detect with certainty. In order to reduce the risks of each, both the MIT and the OIT have chosen to approximate naturally occurring genetic interactions by choosing stock for augmentation from the same population unit (PU) or a geographically adjacent PU. Similarly, stock for reintroduction is normally chosen from one or more sites that are in close geographic proximity to each other. In certain cases in which populations are known to have recently declined to very low numbers, more aggressive mixes of sources are proposed as experiments.

In addition to avoiding the risks of inbreeding and outbreeding depression in order to create genetically viable *populations*, it is important to maintain the genetic variability of the *taxon* as a whole. For taxa in which unique populations are managed separately, other management actions, such as reintroduction or augmentation using stock from a larger population or mixed stock, will also be conducted in order to avoid relying solely on populations that carry a higher possibility of being inbred.

Given the genetic concerns of augmentation in particular, to distinguish geographically between a proposed reintroduction and an augmentation (especially given the uncertainty of the presence or absence of wild individuals of the target taxa in a reintroduction/augmentation area) the MIT originally proposed that for plants, reintroduction sites be selected using the distance criterion developed to distinguish between separate *in situ* PUs. The same protocol is proposed for the OIP. This being the case, **a reintroduction is any outplanting of a taxon that occurs 1,000 meters or more from known wild individuals of that taxon.** There is one caveat to the 1,000 meter rule, which is applied if there are natural barriers to gene flow between the outplanted and the wild individuals (such as a major ridge or habitat discontinuity). In those cases, **a proposed reintroduction may occur as little as 500 meters from a wild population, but the barrier to gene flow must be described and the consequences of the reintroduction should be monitored carefully for unwanted genetic effects**. In cases where a reintroduction occurs within 1,000 meters of an *in situ* PU, the justification based on natural barriers is described in the stabilization plans (SPs). **An augmentation is any addition occurring within a 1,000 meter radius of wild individuals**, if there are no barriers to gene flow.

For plant taxa, concern over genetic interactions between outplanted individuals and closely related taxa via hybridization is another complication that might argue against reintroductions or augmentations where such related taxa are present. For the MIP, the MIT determined very explicit protocols on locations for outplanting each species that required reintroduction. This was mainly due to the very discrete geographical distributions of some of the MIP species, the distance between populations in the Makua AA, and the potential for each PU to be adapted to their respective local environments in the highly fragmented native forests of the Waianae Mountains. These general guidelines will be followed for the Waianae Mountain taxa covered in the OIP (see species specific stabilization plans). However, for the Koolau OIP plants, in particular, many species have a much wider geographical distribution, more intact habitat, and generally more abundant numbers of individuals. Therefore, it is anticipated that any reintroduction sites needed will be addressed based on the definitions described above.

By the same token, a conservative approach was taken with regards to the potential negative genetic consequences of initial reintroductions or augmentations involving very different stocks. Therefore, the mixing of individuals from widely separated geographic locations is generally not included in the SPs except an exception was made for the reintroduction of *Phyllostegia hirsuta* in the Koolau mountains see Stabilization Plan for *Phyllostegia hirsuta*. Likewise, the mixing of distinct ecotypes or morphologically distinct forms is generally not recommended by the OIT. Discussions of genetic stock to be used in reintroductions/augmentations will be held at the annual OIT meetings.

Genetic analysis

Genetic analysis for the Oahu plant target taxa have been considered for *Stenogyne kanehoana* and other species, see individual species stabilization plans for more discussion.

Sanitation concerns

The second major concern (common to both reintroduction and augmentation) is contamination of the pre-existing population of the same taxon, as well as any other taxa in the area, with new pathogens (*e.g.*, diseases, parasites, invertebrate pests, or non-native plants) that might be brought to an area with the introduced plant or animal material. Although this risk is also important in reintroductions, the risk is even higher in augmentations because any pathogen that is deleterious to the introduced individuals is more likely to affect the individuals of the same taxon in the augmented population. Great care must be taken to avoid harm to the augmented population, especially in initial augmentations, when the protocols are being validated. The sanitation concern can be addressed by taking several actions:

- thorough surveying of a prospective augmentation or reintroduction site for the presence of rare taxa (*i.e.*, target taxa and other rare taxa)
- strict sanitation and pest control measures at facilities preparing propagules or individuals for augmentation
- strict protocols for prevention of contamination during the augmentation process
- careful selection of augmentation sites
- careful management of the augmentation sites
- intensive monitoring of augmentation sites for contamination

Careful monitoring will address the effectiveness of the sanitation protocols and some of the initial restrictions may be relaxed. With the implementation of the MIP the Army began to outplant plants grown under the MIP phytosanitation protocols. To date, the Army staff have monitored these outplants and are satisfied that the plants pose no pathogen threats to any nearby taxa. Therefore, the Army staff is comforatble with planting greenhouse plants grown under these protocols within 100 meters of other rare taxa in the area (see individual management unit summaries for lists of rare taxa located in each MU.). The full phytosanitation guidelines developed by the MIT are presented in Appendix 2.2: Phytosanitation Standards and Guidelines.

Reintroduction and augmentation guidelines

The selection of reintroduction sites is based on careful review of biological criteria designed to provide appropriate habitat for the target taxa within management units (MUs). Initially, until effective and safe outplanting techniques are developed, reintroduction locations within a site, while still within appropriate habitat, will avoid the most pristine areas to avoid contamination and minimize harm to *in situ* native taxa and their habitats. If needed the OIT will revisit this requirement to determine if exceptions to the rule are warranted.

The initial reliance on *in situ* management and reintroductions, using augmentation only when threat management does not result in adequate natural regeneration, is a fundamental approach for all of the stabilization strategies. The decision to augment an *in situ* population must be approved by the IT and the USFWS. **In general, no augmentation will be conducted until after at least one year of partial or full PU management.** Augmentation of plant populations will be initiated if any of the following changes are detected at a PU despite active threat management for at least one year:

- If the number of mature individuals is five or less

- If no evidence of regeneration is detected over two subsequent years in which more common community constituents are showing significant regeneration
- If the numbers of mature individuals show declines of 10% or more (5% for long-lived taxa) between successive years for two subsequent years, and there is no significant regeneration
- If the numbers of mature individuals decline >20% in a single year

In special cases, the Army managers may decide on the need for augmentation prior to a year of threat management. Similarly, they may decide that augmentation is unnecessary. Such decisions are subject to review at annual OIT meetings.

Augmentation is justified only if there is no regeneration response as a result of threat management (*e.g.*, ungulate removal, weed control, *etc*.) over time. **Initial augmentations will be done conservatively, using source stock only from the same PU.** Mixing will be avoided unless genetic problems, such as inbreeding depression or loss of variability, are suspected. In general, any mixing will use sources from populations as near as possible to the planting site, both geographically and ecologically.

Reintroduction population size

Determining the optimal number of individuals for initial reintroductions is difficult at best (Guerrant 1996). The long-term goal is to attain a genetically diverse and viable PU, but the actual number of individuals needed to reach that goal is not well understood. The OIT developed target numbers of individuals for each taxon it feels are adequate to achieve the long-term goal, through the maximization and equalization of genetic representation of the initial outplanted individuals (within the constraints identified above in Genetic considerations), and the maximization of survivorship and reproductive output of those individuals.

For the MIP, the MIT developed detailed lists of the number of individuals that the Army might expect to need to outplant in order to reach the stabilization target numbers. For the OIP however, the OIT determined that not enough information is currently known about reintroductions and outplanting for the Oahu taxa to prepare a useful list like the one used in the MIP. Additionally, very little outplanting in general has been done in the Koolau Mountains. Therefore, survivorship rates are unknown.

The Army will monitor any reintroductions and track survivorship for all Oahu target taxa. Thus, adaptive management will play a key role in predicting the total number of outplants that are needed to meet stabilization goals over time.

Approach to Plant Stabilization in the OIP

Development of the Oahu implementation plan plant stabilization plans

In writing the Oahu Implementation Plan (OIP), the Oahu Implementation Team (OIT) recognized the value of the Makua Implementation Plan (MIP) and based the stabilization of the Oahu taxa on the MIP model. Information was gathered on the specific threats and habitat needs of each target species in order to determine a stabilization plan (SP) for each species. Each SP identifies the PUs targeted for stabilization, taxon specific issues, propagation, genetic storage, and reintroduction information, and priority management actions.

As a result, 23 plant SPs were developed and are compiled in this chapter. The protocols to support these stabilization actions were developed for use in the MIP. Protocols for plant propagule collection, phytosanitation standards, and rare plant monitoring are reproduced in this document without major modification (see Appendices 2.1-2.3).

Each SP will be followed closely and changes must be discussed by the OIT and approved by the U.S. Fish and Wildlife Service (USFWS).

How to use the SPs

Each SP can be used as a stand-alone document that outlines the goals, taxon status, and recommended stabilization actions at the time of writing. For the purposes of specific stabilization actions for each target taxon, that taxon's SP provides the primary guide for management actions.

The goal of each SP is to provide the information and necessary actions to achieve stabilization for each taxon. The strategy is to undertake specific and quantifiable taxon-specific actions, that along with habitat level management actions and adaptive management against changing conditions and/or population unit status, will result in stability for each target taxon. To effectively and fairly measure progress, a program of monitoring has been designed to give the OIT sufficient data to rigorously assess the success of actions and strategies and guide adaptive management. Each plan follows a similar outline that provides the following information:

- Requirements for stability
- Summary of the current status of known PUs inside and outside of the action area (AA)
- Identify specific PUs designated for *in situ* management actions
- Discussion of management designations
- Discuss pertinent propagation, storage or reintroduction information including identifying any research and/or experimentation needed
- Notes specific to the stabilization of each taxa from a management perspective
- Identify priority management actions
- Identify specific threats to each PU

11.1: Tier 1 *Abutilon sandwicense*: Taxon Summary and Stabilization Plan

Scientific name: *Abutilon sandwicense* (Deg.) Christoph.
Family: Malvaceae (Mallow Family)
Hawaiian Name: Kooloa
Federal status: Listed endangered

Requirements for Stability

- 4 population units (PUs) (4 due to presence in both Makua and Oahu AAs)
- 50 reproducing individuals in each PU (short-lived perennial)
- Threats controlled
- Genetic storage collections from all PUs
- Tier 1 stabilization priority

Description and biology: *Abutilon sandwicense* is a large shrub or a tree. Its branches grow to up to 10 m (33 ft) long (Degener 1932). The plant is covered with white to yellowish stellate hairs and glandular tomentulose pubescence. The leaf blades are cordate-ovate to cordate-orbicular in shape, and measure 8-22 cm (3.1-8.7 in) in length. The pendulous flowers are solitary in leaf axils. The petals are 4-5 cm (1.6- 2 in) long and 1.4-2 cm (0.55-0.79 in) wide at the distal end, yellowish green to reddish in color, and extend beyond calyx. The fruits are vase-shaped capsules 17-25 mm (0.7-1.0 in) long comprised of 8-10 mericarps. Each mericarp contains several seeds. The dull brown seeds are up to 3 mm (0.1 in) long, and are triangular-reniform in shape.

The flowers of *A. sandwicense* are large and showy, indicating that the original pollinating agent of the species may have been nectar-feeding birds. Nowadays introduced honeybees can be observed visiting flowers. Flowering can be observed at any time of the year, but the peak flowering months are April through June. Dispersal agents for this species are unknown. Reproduction in this species is primarily by seed. The seeds are probably viable for years, as are many Hawaiian Malvaceae species. Cultivated plants usually take at least 3-4 years to reach maturity (Lau pers. comm.). For the purposes of the Implementation Plan, *A. sandwicense* is categorized as a short lived plant.

Known distribution: *Abutilon sandwicense* is endemic to the Waianae Mountains of Oahu. It occurs on both the windward and leeward sides of the range, from 293-732 m (960-2,400 ft) in elevation.

Population trends: Only a few population units of *A. sandwicense* have been tracked for a decade or more. Some of them have increased in population size, and others have decreased.
One colony of plants that has grown in recent years is located in Huliwai Gulch in The Nature Conservancy's Honouliuli Preserve. These plants are right alongside the Honouliuli Contour Trail, which has been a major hiking trail since the 1930's. Although historically recorded from Honouliuli Preserve, there had been no recent observations of the species in the preserve until a single plant was spotted just below the Honouliuli Contour Trail at the Huliwai Gulch site in 1994. Today there are at least 7 mature and 28 immature plants at the site. The discovery of *A. sandwicense* in Huliwai Gulch and the subsequent increase in the number of plants at the site may be part of a general trend of re-colonization of the native plant species along the Honouliuli Contour Trail in recent decades after serious degradation in the 1800's and into the early 1900's. Several of the common native tree species along the trail are present as a few old individuals along with numerous younger individuals (Lau pers. comm. 2005). The control of invasive alien weeds at the Huliwai Gulch site since the discovery of *A. sandwicense* has presumably contributed to the sharp increase in population size.

The North Mikilua and Halona PUs are both located in Lualualei on land owned by the U.S. Navy. They were both discovered in 1994 during a botanical survey of Lualualei. When observed again in 2004, ten years after its discovery, the North Mikilua PU had increased in population size. In 1994 only two mature plants were observed, while in 2004, two mature plants and 39 immature plants were counted. In contrast, in the same time span, the number of plants in the Halona PU went from seven mature plants to only two mature and seven immature plants. After the discovery of the two *A. sandwicense* PUs, fences were constructed around both sites to exclude feral pigs. Invasive alien plants may be a major factor leading to the divergent population trends in these two population units. The Halona site has a more serious weed problem than does the North Mikilua site

Current Status: *Abutilon sandwicense* is still found throughout its recorded range in the Waianae Mountains. There are approximately 115 mature individuals with the majority individuals occurring on the leeward and northern sides of the Waianae Range. The current population units and numbers of individuals are listed in the status table below and their locations are plotted on Figure 11.1.

Habitat: *Abutilon sandwicense* grows on gulch slopes and in gulch bottoms in dry to dry-mesic forests, which are commonly dominated by the native trees *lama* (*D. sandwicensis*), *lonomea* (*Sapindus oahuensis*), and/or *wiliwili* (*Erythrina sandwicensis*). Other common associated species include *mehame* (*Antidesma pulvinatum*), *nioi* (*Eugenia reinwardtiana*), *kokio keokeo* (*Hibiscus arnottianus*), *kolea* (*Myrsine lanaiensis*), *olopua* (*Nestegis sandwicensis*), *mamaki* (*Pipturus albidus*), *papala kepau* (*Pisonia sandwicensis*), *hoawa* (*Pittosporum* spp.), *halapepe* (*Pleomele forbesii* and *P. halapepe*), *alahee* (*Psydrax odorata*), *hao* (*Rauvolfia sandwicensis*), and *ohe-o-kai* (*Reynoldsia sandwicensis*).

Taxonomic background: There are four species of *Abutilon* native to Hawaii. Three are endemic to Hawaii, and one also occurs naturally outside Hawaii. Three occur on Oahu – the common, non-endemic *A. incanum*, and the rare, listed endangered Hawaiian endemics *A. menziesii* and *A. sandwicensis*.

Outplanting considerations: *Abutilon sandwicense* is not known to occur in close proximity to the other two native *Abutilon* species on Oahu. The common *A. incanum* grows only in extremely arid habitats, and would not be found near outplantings of *A. sandwicense* established within *A. sandwicense*'s appropriate habitat.

The two known populations of *A. menziesii* on Oahu are on the leeward side of the island in low elevation, arid areas in Lualualei and on the plains of Ewa. However, based on the larger body of information on the habitat requirements of *A. menziesii* throughout its historically documented range, which includes the islands of Maui, Lanai, and Hawaii, the species on Oahu would have extended much farther inland and higher in elevation than the two remaining stations, and the species' range would have overlapped the lower, drier portions of *A. sandwicense*'s range. These two *Abutilon* species appear to be closely related, and are very easily artificially hybridized in cultivation, resulting in fertile offspring (Lau pers. comm. 2005). The flowers of the two species differ markedly in several respects, most noticeably in the flowers' size and shape, so the two presumably had different pollinating agents prior to the arrival of humans in Hawaii. If this was the case, the two species could have had overlapping ranges, yet continue to exist as distinct, separate species through time in the region of overlap. Nowadays, however, pollination in both species may be effected mainly by non-native honeybees or other generalist pollinators, and the planting of one species near preexisting populations of the other could possibly lead to the formation of hybrid populations and the loss of genetic distinctiveness of both species. *Abutilon sandwicense* outplantings should be established only where wild or planted *A. menziesii* is not in close proximity.

Abutilon grandifolium is a weedy naturalized species of *Abutilon* that commonly occurs in *A. sandwicense* habitat. No putative hybrids between the two species have been reported to date. The potential for hybridization between the two species is not known. There are also non-native *Abutilon* species cultivated in Hawaii either as ornamentals or as sources for lei-making materials. The potential for the cultivated species of *Abutilon* to cross with *A. sandwicensis* is also not known.

Threats: Major threats to *A. sandwicense* include fire, black twig borer (*Xylosandrus compactus*), Chinese rose beetle (*Adoretus sinicus*), cattle, feral pigs and goats, and invasive alien plant species. The major alien plant threats to *A. sandwicense* include Hamakua pamakani (*Ageratina riparia*), *kukui* (*Aleurites moluccana*), Koster's curse (*Clidemia hirta*), Chinese banyan (*Ficus microcarpa*), silk oak (*Grevillea robusta*), comb hyptis (*Hyptis pectinata*), airplant (*Kalanchoe pinnata*), *koa haole* (*Leucaena leucocephala*), pride-of-India (*Melia azedarach*), molasses grass (*Melinis minutiflora*), tree daisy (*Montanoa hibiscifolia*), basketgrass (*Oplismenus hirtellus*), guinea grass (*Panicum maximum*), *huehue haole* (*Passiflora suberosa*), allspice (*Pimenta dioica*), strawberry guava (*Psidium cattleianum*), common guava (*Psidium guajava*), coral berry (*Rivina humilis*), Christmas berry (*Schinus terebinthifolius*), Java plum (*Syzygium cumini*), and Australian red cedar (*Toona ciliata*).

Threats in the Action Area: The only threat from army training activities to *A. sandwicense* in the action area is wildfire, which is considered low. Additionally, throughout the range of this species there is also competition from non-native plant species, habitat degradation by feral pigs, and predation by the black twig borer and the Chinese rose beetle.

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Abutilon sandwicense — TaxonCode: AbuSan

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaawa to Puulu	Manage for stability	36	88	6	0	0	0	34	84	0	**36**	**88**	6	To be managed within the Manuwai MU (ANU); GSC will be done for all pop ref codes outside the MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
AbuSan.AAW-A	Kaawa by the Fluneo	In situ		3	1
AbuSan.ALI-A	Lower Palikea Gulch below the road	In situ	0	0	0
AbuSan.ALI-B	Palikea Gulch above the Rd	In situ	10	3	
AbuSan.ALI-C	Palikea E. Branch below road	In situ	1		
AbuSan.ANU-A	Manuwai Gulch	In situ		10	
AbuSan.ANU-B	Manuwai Gulch	In situ	3		
AbuSan.ANU-C	Gulch south of Nerang Gulch	In situ	2	30	3
AbuSan.ANU-D	Near bottom fenceline	In situ		11	
AbuSan.ANU-E	Gulch south of big Colopp patch	In situ		8	1
AbuSan.ANU-F	Plants on cliff below Caecav	In situ	8	2	
AbuSan.ANU-G	On southwest proposed fenceline ridge	In situ	8	4	
AbuSan.IKI-A	Kaomoku Iki Gulch	In situ	1	15	
AbuSan.IMU-A	Kaimohole Gulch	In situ	3	2	1
AbuSan.KIH-A	Kihakapu Gulch	In situ	0	0	0

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kahanahaiki	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	In the Makua AA; This individual is dead.

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
AbuSan.MMR-A	Kahanahaiki	In situ	0		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaluakauila	Manage reintroduction for stability	0	0	0	0	4	0	0	0	0	**0**	**4**	**0**	In the Makua AA; Kahanahaiki stock will be managed for stability here

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
AbuSan.MMR-B	Kaluakauila Upper patch reintro	Reintro		4	
AbuSan.MMR-C	Kaluakauila Lower Planting	Reintro			

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Keaau	Genetic Storage	1	0	10	0	0	0	1	0	0	**1**	**0**	**10**	In Makua AA

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
AbuSan.KEA-A	Kea'au	In situ	1		10

		NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling
	Total for Taxon:	37	88	16	0	4	0	35	84	0	**37**	**92**	**16**

Action Area: Out

TaxonName: Abutilon sandwicense TaxonCode: AbuSan

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
East Makaleha	Genetic Storage	2	2	40	0	0	0	2	7	0	**2**	**2**	**40**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
AbuSan.LEH-A	Central Makaleha	In situ	2	2	40

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Ekahanui and Huliwai	Manage for stability	14	30	0	0	0	0	17	15	0	**14**	**30**	**0**	Ekahanui MU w/ extension; Huliwai small fence; Augment EKA- A with Huliwai stock

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
AbuSan.EKA-A	South Ekahanui South Branch-nr. Palai Gulch	In situ	7	2	
AbuSan.HUL-A	huliwai gulch along honouliuli trail	In situ	7	28	

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Halona	Genetic Storage	0	0	0	0	0	0	1	4	0	**0**	**0**	**0**	Army has no current info for this PU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Makaha Makai	Manage for stability	73	27	6	0	0	0	50	7	0	**73**	**27**	**6**	to be managed within Kamaili MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
AbuSan.KAM-A	Kamaileunu ridge	In situ	15		
AbuSan.MAK-B	Makaha, Kamaili	In situ	35	7	5
AbuSan.MAK-C	Kamaili on Ridge above Fluneo	In situ	23	15	1
AbuSan.MAK-D	Kamaili 4 gulches east fluneo MAK-F	In situ		5	

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Makaha Mauka	Genetic Storage	5	58	4	0	0	0	40	100	0	**5**	**58**	**4**	There has been a decline since initial estimates; This PU will be protected within Makaha Subunit III MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
AbuSan.MAK-E	Makaha/ Nerang shelf	In situ	5	58	4

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Nanakuli	Genetic Storage	0	0	0	0	0	0	30	0	0	**0**	**0**	**0**	Army has no current info for this PU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Action Area: Out

North Mikilua	Genetic Storage	2	39	0	0	0	0	2	39	0	**2**	**39**	**0**	protected by a fence built by the Navy

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
AbuSan.MIK-A	Mikilua Exclosure	In situ	2	39	

South Mikilua	Genetic Storage	0	0	0	0	0	0	4	0	0	**0**	**0**	**0**	Army has no current info for this PU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Waianae Kai	Genetic Storage	2	0	0	0	0	0	15	17	0	**2**	**0**	**0**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
AbuSan.WAI-A	Waianae Kai Kawiwi Slot Gulch	In situ	1		
AbuSan.WAI-B	Waianae Kai gulch	In situ	1		

West Makaleha	Genetic Storage	0	2	0	0	0	0	0	2	0	**0**	**2**	**0**	not in new Makua AA

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
AbuSan.LEH-B	West Makaleha	In situ		2	

	Total for Taxon:	98	158	50	0	0	0	161	191	0	**98**	**158**	**50**

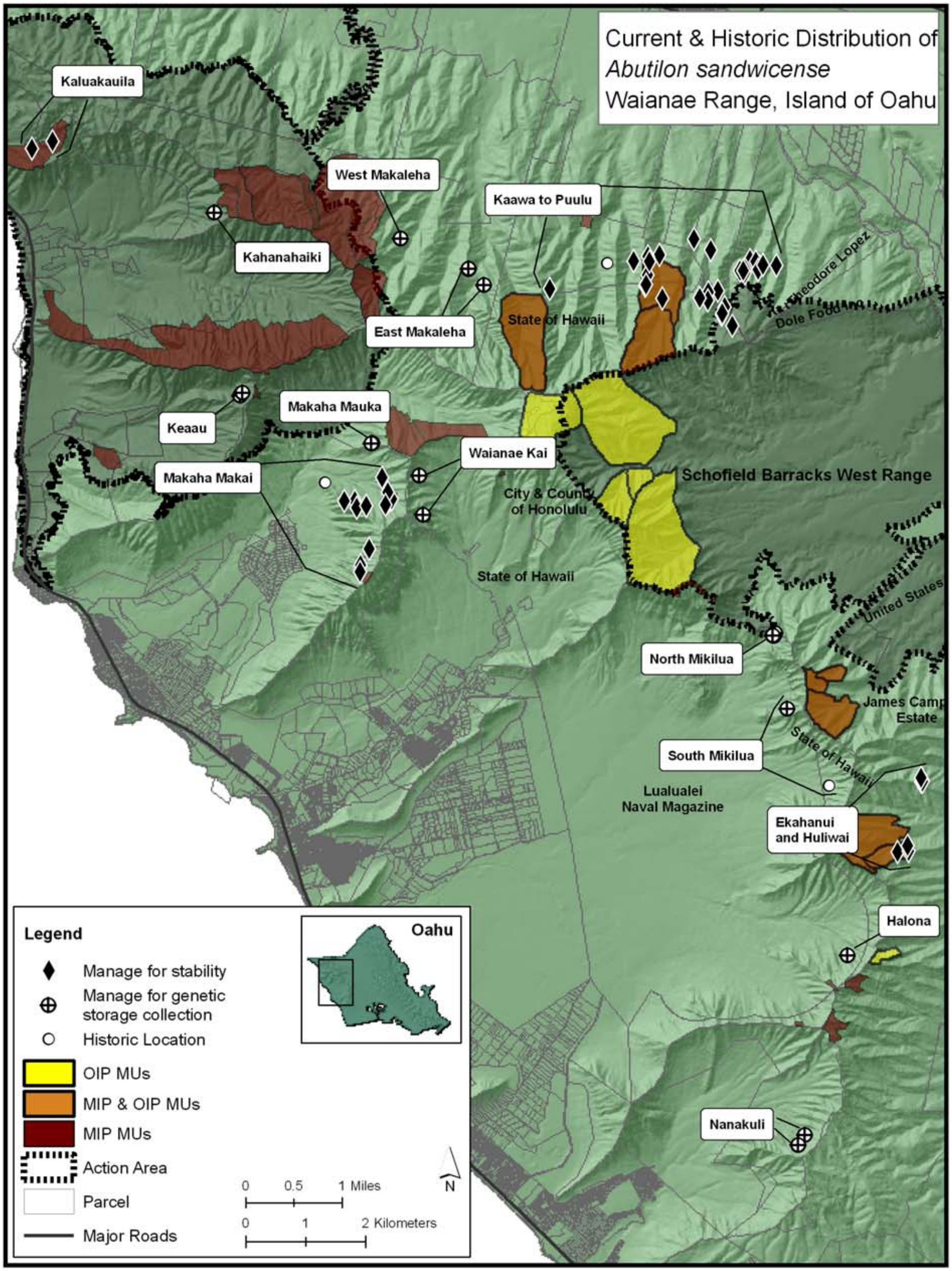


Figure 11.1 Current and historical distribution of *Abutilon sandwicense* in the Waianae Mountains of Oahu.

Discussion of Management Designations

The PU within the Oahu action area, Kaawa to Puulu, was chosen to be managed for stability within the Manuwai MU. However, the entire PU may be used as a propagule source for outplanting within the Manuwai MU and will be represented in genetic storage collections. The Ekahanui and Huliwai PU was chosen for stability over the Nanakuli, North and South Mikilua, and Halona PUs due to the substantial conservation and restoration efforts already underway in Ekahanui and the remote location of the other PUs. The Waianae Kai and Makaha Mauka and Makai PUs are less than 1000m apart, however they are all separated by dry ridges and/or exposed cliffs and are therefore considered distinct. The Makaha Makai PU was chosen for stability rather than the Mauka PU due to larger number of individuals in the Makai population. A fourth Manage for Stability PU Kaluakauila MU representing Makua stock, was designated due to the occurrence of this species within both the Makua and Oahu Action Areas. Other source PU stock may also be used in this reintroduction pending surveys to determine which is the closest geographically.

Propagation and Genetic Storage

Viable seed has been collected from this taxon from many different populations. The collection of vegetative cuttings has also been a successful means of propagation. Seeds have physical dormancy requiring scarification to stimulate germination. Seeds may have an additional physiological or morphophysiological dormancy that will continue to be researched. Seeds display traditional orthodox behavior in storage and will continue to be stored at dry, freezing conditions. Seeds collected from wild and reintroduced plants will be stored to meet genetic storage requirements for this taxon when available. Vegetative cuttings can be taken from wild founders and maintained as living collection in a nursery when seed is not available. Reintroductions will be created using material grown from seeds and cuttings.

Management Notes

The **Makaha Makai PU** is currently at or near stabilization target numbers and may only need fencing to control ungulate threats and weeding to increase the number of individuals. This PU will be protected within the Kamaili MU in lower Makaha. The Army will maximize the number of *Abutilon sandwicense* individuals within this MU.

The **Ekahanui and Huliwai PU** will need to be fenced and augmented in order to reach stability. Propagules for augmentation will come from both the Ekahanui and Huliwai. This means the Ekahanui MU will need an extension to capture the appropriate habitat for management of this species and the Huliwai plants will need to be fenced. Both of these sites will be managed however if there is difficulty in reaching stabilization targets this stock may be reintroduced in other nearby gulches such as Pualii.

The **Kaawa to Puulu PU** will be stabilized within the Manuwai MU. The Manuwai MU currently contains 66 individuals and may not need augmentation to sustain stability goals. However, all individuals in the PU will be represented in genetic storage collections that may be utilized in augmentations.

The **Kaluakauila PU** is a reintroduction that represents a single individual from Kahanahaiki, within the Kaluakauila MU. Due to just one founding individual the Army may choose to add additional founders representing individuals from the closest geographic population. Surveys will be conducted in OIP year 1 and 2 in the surrounding areas and visits will be made to the nearest geographic populations and a decision to incorporate any new genetic material will be discussed at the next Implementation Team meeting.

Genetic storage collections will be made from all PUs of this species.

Table 11.2 Priority Management Actions for *Abutilon sandwicense* Army Stabilization PUs

Population Unit	Specific Management Actions	Concerns/ Partners	Timeline
Kaawa to Puulu PU (Manuwai MU)	• Construct Manuwai MU • Control priority weeds • Genctic storage collections sampling range of PU for storage and reintroduction within Manuwai	• Fence requires State agreement. • Final EA (FONSI) done	• Construct Manuwai MU MIP yr 6 (2010)
Makaha Maikai (Kamaili MU)	• Construct Kamaili MU • Control priority weeds • Collect propagules from Subunit III for genetic storage (near stability)	• Final EA (FONSI) done • BWS agreement needed	• Construct Kamaili MU OIP yr 6
Ekahanui and Huliwai (Ekahanui and Huliwai MU)	• Extend Ekahanui Fence (100mX100m) • Fence Huliwai plants if needed • Control priority weeds • Genetic storage collections from Ekahanui and Huliwai plants for storage and augmentation within fence (need approx. 41+ plants)	• TNC anticipates leaving the Honouliuli Preserve at the end of 2008.	• Extend fenceline w/ fence crew (2009)
Kaluakauila PU (Kahnahaiki reintroduction within Kaluakauila MU)	• Continue to monitor outplanted individuals for reproduction. • Conduct surveys within and near Makua for additional individuals to build the reintroduction population	• Fence completed 2001.	• Kaluakauila fence complete; reintroduction underway • Begin surveys OIP yr 1; 2008

11.2 Tier 1:
Cyanea acuminata: Taxon Summary and Stabilization Plan

Scientific name: *Cyanea acuminata* (Gaudich.) Hillebr.
Hawaiian name: Oha, haha, ohawai
Family: Campanulaceae (Bellflower Family)
Federal status: Listed endangered

Requirements for Stability

- 3 population units (PUs)
- 50 reproducing individuals (short lived perennial)
- Threats controlled
- Genetic storage collections from all PUs
- Tier 1 stabilization priority

Description and biology: *Cyanea acuminata* is a shrub 0.3-2.0 m (0.98-6.6 ft) tall. The leaves are 11-32 cm (4.3-13 in) long and 3-9 cm (1.2-3.5 in) wide, and are oblanceolate to narrowly obovate or elliptic. The flowers are borne 6-20 in axillary inflorescences. The corollas are white, sometimes tinged purplish, and measure 3.0-3.5 cm (1.2-1.4 in) long. The globose berries are yellow to yellowish orange, and 4-6 mm (0.16-0.24 in) long.

Flowering and fruiting has been observed at all times of the year. As with other *Cyanea*s with their long tubular flowers, this species is thought to have been pollinated by nectar-feeding birds. A study by Lammers and Freeman (1986) found that most Hawaiian lobelioids have a nectar sugar profile typical of bird-pollinated flowers. It is probably capable of self-pollination, as several other species of *Cyanea* have been found capable of selfing in cultivation. The species' orange berries are indicative of seed dispersal by fruit-eating birds. *Cyanea acuminata* is categorized as a short-lived species for the purposes of the Implementation Plan.

Known distribution: *Cyanea acuminata* is endemic to Oahu. It has long been known throughout the Koolau Mountains. Only in recent years has it been found in the Waianae Mountains, on the windward side of Kaala. This species occurs from 300-915 m (985-3,000 ft) in elevation in the Koolau Mountains, and 911-1,120 m (2,990-3,660 ft) in the Waianae Mountains.

Population trends: Population trends for this species have not been well documented.

Current status: *Cyanea acuminata* is still extant throughout its recorded range. The total number of mature plants known is less than 250. The species occurs in the action areas of KLOA and SBMR East Range in the Koolau Mountains, and in the West Range part of the SBMR action area. More than half of the known plants known are found within these army action areas. The current population units and the number of plants they contain are given in Table 11.3 and their locations are plotted on Figures 11.2-4 below.

Habitat: *Cyanea acuminata* is found in mesic to wet *ohia* (*Metrosideros polymorpha*)-*uluhe (Dicranopteris linearis*), *koa* (*Acacia koa*)-*ohia* or *lama* (*Diospyros sandwicensis*)-*ohia* forest.

Taxonomic background: There are approximately 60 species in the endemic Hawaiian genus *Cyanea*.

Outplanting considerations: *Cyanea* taxa potentially occurring with or near *C. acuminata* are *C. calycina*, *C. koolauensis*, *C. humboldtiana*, *C. lanceolata*, *C. st.-johnii*, *C. crispa*, and *C. angustifolia*. All except *C. angustifolia* are rare species. Another rare *Cyanea* occurring with *C. acuminata* in the northern Koolau Mountains is one that appears to represent a distinct, but currently unrecognized taxon. It was described as *Rollandia degeneriana* F. Wimmer (Wimmer 1956). It was considered a possible hybrid in the latest taxonomic treatment of *Cyanea* (Lammers 1990), but it was known only from the type specimen at that time. Field observations indicate that this *Cyanea* occurs in populations not originating from recent or ongoing hybridization, but instead, exists as an independent taxon. Hybridization concerns are minimal with respect to the aforementioned *Cyanea*s since they naturally co-occur with *C. acuminata*.

Threats: The major threats to *C. acuminata* include feral pigs. In the Waianae Mountains, the species is additionally threatened by feral goats. Invasive alien plants also threaten the species. In the Waianae Mountains, the worse alien plant threats to *C. acuminata* include the prickly Florida raspberry (*Rubus argutus*) and strawberry guava (*Psidium cattleianum*). In the Koolau Mountains, the major weeds affecting *C. acuminata* include Koster's curse (*Clidemia hirta*), strawberry guava, octopus tree (*Schefflera actinophylla*). Rat and slug predation represent potential threats to *C. acuminata*

Long-billed, nectar-feeding native Hawaiian birds, which are the presumed original pollinators of *C. acuminata*, have become extremely rare on Oahu. Although the species is probably capable of selfing, the loss of its normal pollinating vectors is likely to result in decreased genetic variability within its populations over successive generations.

Threats in the Action Area: Potential threats in the action area due to military training activities include fire, trampling by foot traffic and competition with non-native plant species introduced via military training activities. However, due to the remote location of this species, the threat from trampling is very low. The fire threat for *Cyanea acuminata* in the Koolau mountains ranges from low to very low. In the Waianae mountains the fire threat is very low. Additional threats include habitat degradation and direct consumption by feral ungulates (i.e. goats and pigs). This species is also consumed by slugs which eat seedlings and leaves, and rats that eat fruit and sometimes the bark.

Specific threats to the Waianae Mountain population includes competition from *Hedychium gardnerianum* and *Rubus argutus.*

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Cyanea acuminata   TaxonCode: CyaAcu

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Helemano-Punaluu Summit Ridge to North Kaukonahua	Manage for stability	59	13	7	0	0	0	50	40	0	**59**	**13**	**7**	To be managed within Poamoho MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaAcu.KLO-A	Poamoho-Summit Trail	In situ	59	13	7

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kahana and South Kaukonahua	Manage for stability	2	0	0	0	0	0	8	4	0	**2**	**0**	**0**	To be managed within South Kaukonahua MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaAcu.SBE-A	South Kaukonahua Stream	In situ	2		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kawaiiki	Genetic Storage	0	0	0	0	0	0	1	0	0	**0**	**0**	**0**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Makaleha to Mohiakea	Manage for stability	85	33	0	0	0	0	55	0	0	**85**	**33**	**0**	To be managed within Kaala and East Makaleha Mus

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaAcu.ALA-A	Kaala	In situ	50		
CyaAcu.ALA-B	Ka'ala, one gulch N of Alstri ridge	In situ	19		
CyaAcu.ALA-C	Ka'ala,off w. end of Hale'au'au fence line	In situ	1		
CyaAcu.ALA-D	Kaala 2 gulches north of Blue Trail	In situ	7		
CyaAcu.LEH-A	East Makaleha	In situ	3		
CyaAcu.SBW-A	Puu Kalena	In situ	2	25	
CyaAcu.SBW-B	Near Phyhir SBW-D gulch	In situ	3	8	

		NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling
	Total for Taxon:	146	46	7	0	0	0	114	44	0	**146**	**46**	**7**

Action Area: Out

TaxonName: Cyanea acuminata   TaxonCode: CyaAcu

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kahana and Makaua	Genetic Storage	5	0	0	0	0	0	5	0	0	**5**	**0**	**0**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaAcu.KNA-A	Btw. Kahana and Makaua	In situ	5		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaipapau	Genetic Storage	0	0	0	0	0	0	1	0	0	**0**	**0**	**0**	Army has no current info for this PU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaluanui and Maakua	Genetic Storage	0	0	0	0	0	0	12	0	0	**0**	**0**	**0**	Army has no current info for this PU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Konahuanui	Genetic Storage	0	0	0	0	0	0	30	0	0	**0**	**0**	**0**	Army has no current info for this PU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Pia	Genetic Storage	0	0	0	0	0	0	4	0	0	**0**	**0**	**0**	Army has no current info for this PU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Puukeahiakahoe	Genetic Storage	3	0	0	0	0	0	3	0	0	**3**	**0**	**0**	Army has no current info for this PU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaAcu.MOO-A	Puu Keahiakahoe	In situ	3		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Puuokona	Genetic Storage	0	0	0	0	0	0	1	0	0	**0**	**0**	**0**	Army has no current info for this PU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

		NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling
	Total for Taxon:	8	0	0	0	0	0	56	0	0	**8**	**0**	**0**

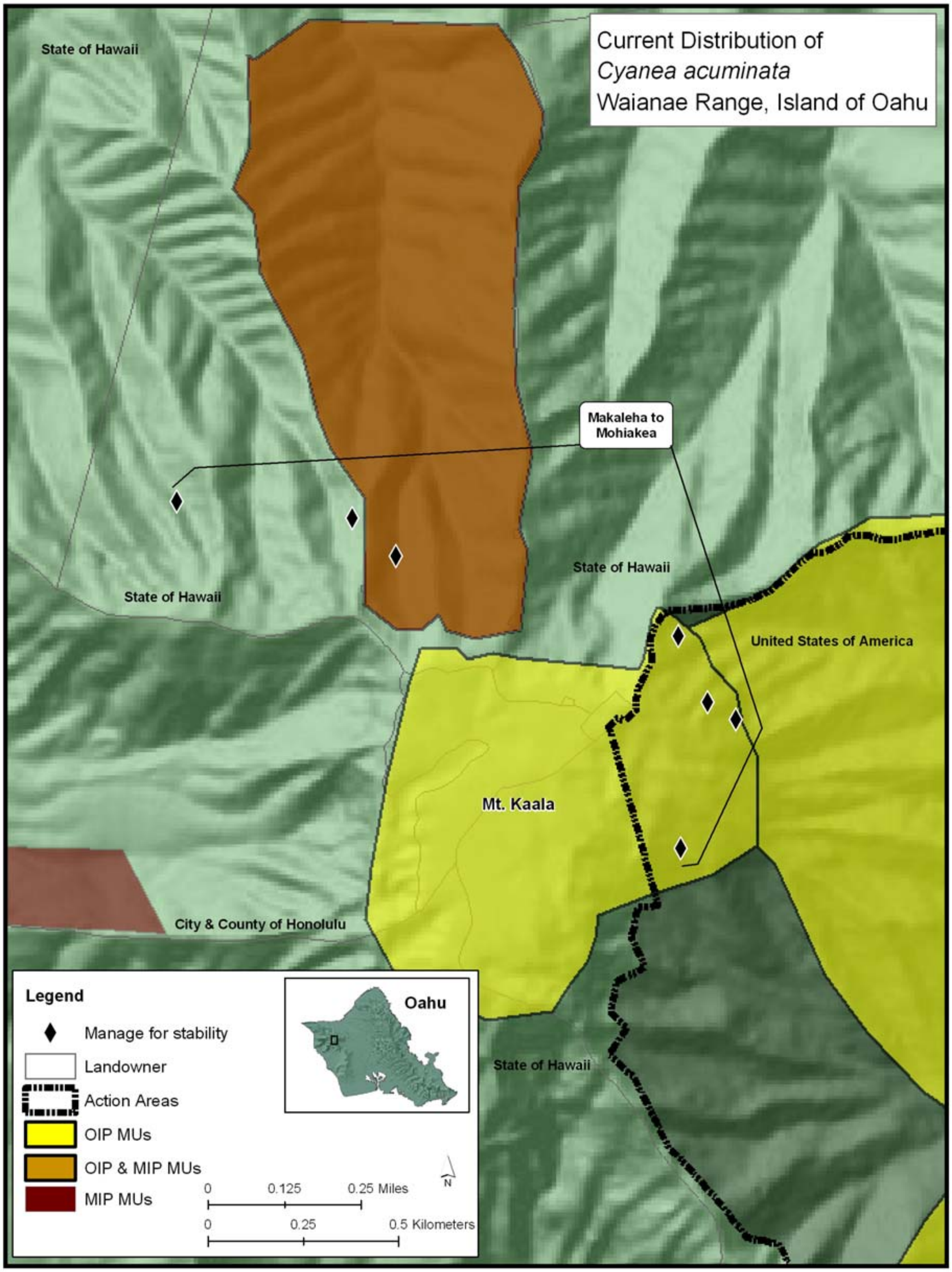


Figure 11.2 Current distribution of *Cyanea acuminata* in the Waianae Mountains of Oahu.

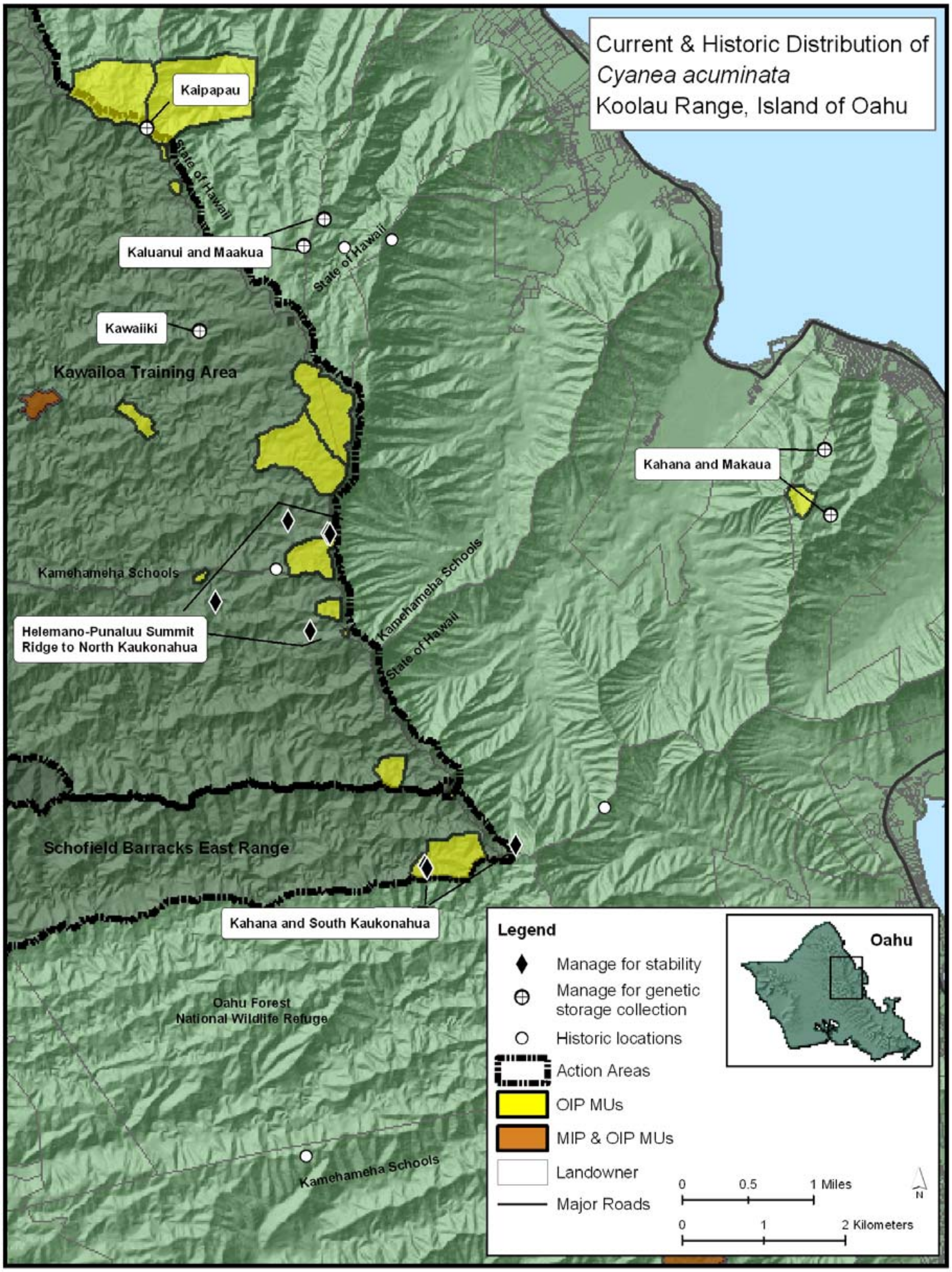


Figure 11.3 Current and historical distribution of *Cyanea acuminata* in the northern Koolau Mountains of Oahu.

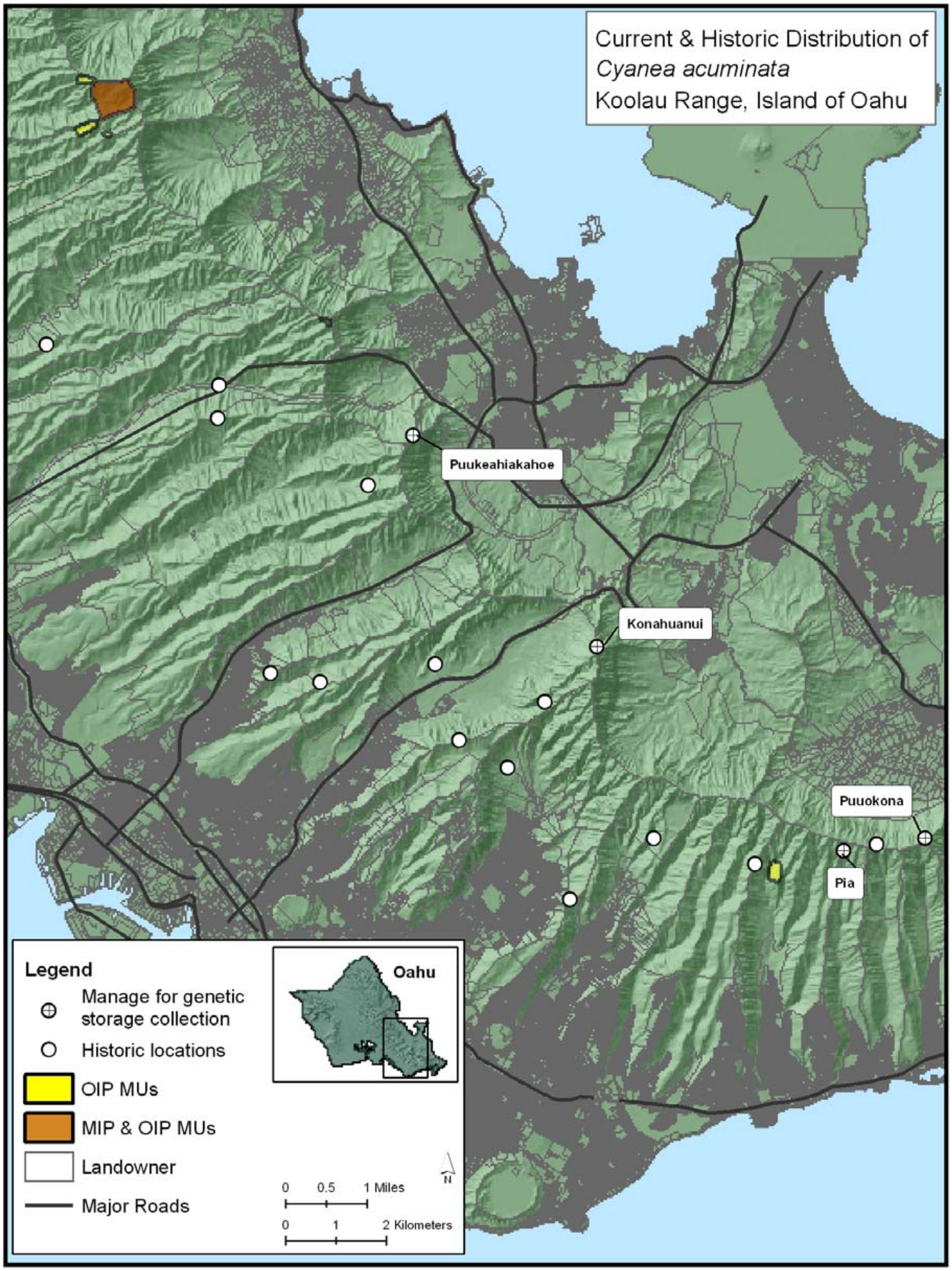


Figure 11.4 Current and historical distribution of *Cyanea acuminata* in the southern Koolau Mountains of Oahu.

Discussion of Management Designations

Some of the PUs designated for this species cover a large geographic area that would be difficult to manage as a whole (i.e. too large to fence all individuals). Therefore, as with many of the other OIP and MIP species, the Army may protect a portion of any PU within a management unit and utilize the rest of the PU for genetic storage collection as a source for augmentations within the protected area. The Helemano-Punaluu Summit Ridge to North Kaukonahua PU was chosen to be managed for stability due to the high numbers of individuals, quality of habitat, and proximity to other species management. The Punaluu portion of the PU is in need of fencing and as many individuals as possible will be included in the Poamoho MU. Strategic fencing will protect much of the Makaleha to Mohiakea PU within the Kaala MU and some individuals occur within the upper part of the East Makaleha MU. The South Kaukonahua portion of the South Kaukonahua to Kahana PU will be within the large South Kaukonahua MU, subunit I. The Army is aware of the low numbers of individuals in this PU and may choose to manage one of the other Koolau PUs following surveys to the Kaipapau and Kaluanui area over the next year. The Kaipapau, Kaluanui to Maakua, and Konahuanui PUs were not chosen for stability due to the difficulty of working in the steep terrain typical of these areas and the lack of recent surveys in these areas. While the Kahana and Makaua, Pia, Puuokona and Waahila PUs were not chosen because of the small numbers of individuals in the PUs and their distance from the action area. This species often occurs on steep windward facing slopes a habitat that is undersurveyed. It is expected that numbers will increase with survey.

Propagation & Genetic Storage

Vegetative (clonal) propagation has not been attempted for this taxon. Vegetative propagules may be collected from certain founders. This may be most appropriate for outlying or non-reproductive individuals. Seed has been collected from wild plants has displayed variable viability. Complete floral and fruiting phenology will be observed to determine characteristics of fruit that should contain mature seeds. Fruit appearance has not indicated a stage at which seeds would be mature for collection. If it is not clear as to what fruit characteristics depict maturity, studies may also investigate breeding and mating system to determine if pollen source or amount of pollination and/or fertilization may somehow inhibit complete fruit and/or seed maturation. Research is ongoing to determine the optimal conditions (particularly temperature) for long-term seed storage. Currently, all studied species of *Cyanea* exhibit unique storage requirements, consisting of an inability to tolerate frozen storage temperatures. Collaborative research at the USDA-ARS National Center for Genetic Resources Preservation aims to determine the cause of this anomaly, focusing on lipid composition of seeds of taxa of *Cyanea*. Samples of this taxon will be sent to NCGRP for lipid analysis. Since seed has been a successful tool to maintain genetic representation of founders for all studied species of *Cyanea*, seed will likely be used to meet genetic storage goals. The establishment of storage protocols for this taxon will initiate the collection of seed from wild plants for genetic storage requirements. If seed cannot be obtained or stored, other methods to meet genetic storage goals will be explored. A living collection will be established for the founders represented by vegetative propagules, with the hopes that this stock will flower in the nursery or at reintroductions. This would allow for genetic storage via seed for all founders. Seed collected *in situ* will be used to establish reintroductions.

Management Notes

The number of individuals known is likely to increase with surveys in appropriate habitat. Surveys should also be done within and around proposed MUs to incorporate as many individuals within the proposed fences as possible. The **Helemano-Punaluu Summit Ridge to North Kaukonahua PU** will be managed within the Poamoho MU. The plants along the summit trail within the proposed MU are currently within a rat baiting grid and most likely benefit from reduced rat predation in the area.

The **Kahana and South Kaukonahua PU** will be managed within the Kaukonahua II MU fence with propagules from the area. This PU has the fewest individuals of all the manage for stability populations with only 2 individuals. If no other individuals are found within this area the OIT will discuss options to manage another Koolau PU for stability. Candidates for management include the Kaipapau and Kaluanui PUs. If more individuals are found within the Kaipapau area this PU could be managed within the Kaipapau MU.

The **Kalena to Makaleha PU** is the only representation of this species within the Waianae Mountain Range and is therefore important to preserve for the species. The majority of this PU is currently protected from ungulates within the Kaala MU. This PU will also be represented within the proposed East Makaleha and South Haleauau MUs. This PU currently has stable numbers with 85 mature individuals.

Additionally, all the non-manage for stability PUs are designated as manage for genetic storage collections. Collections for these PUs should begin after the manage for stability PUs.

Table 11.3 Priority Management Actions for *Cyanea acuminata* Army Stabilization PUs

Population Unit	Specific Management Actions	Concerns/Partners	Timeline
Helemano-Punaluu Summit Ridge to North Kaukonahua PU	• Construct Poamoho MU fence • Control priority weeds • Collect propagules for genetic storage (currently at stability target #s)	• Fence requires KS license agreement. • EA required.	• construct Poamoho MU OIP yr 7; 2014
Kahana and South Kaukonahua PU	• Construct South Kaukonahua II MU fence • Control priority weeds • Collect propagules for augmentation and genetic storage from plants (need to survey for more individuals)	• EA required.	• construct South Kaukonahua MU OIP yr 5; 2012

Kalena to Makaleha PU	• Complete East Makaleha and South Haleauau MU • Control priority weeds • Collect propagules for genetic storage from a geographic range of individuals (currently at stability target #s)	• EA required for South Haleauau MU. • EA with FONSI complete for East Makaleha MU. • Kaala MU strategic fencing 95% completed in 2006.	• Kaala MU strategic fence 90% completed • Complete S. Haleauau MU, OIP yr 3; 2010 • complete E. Makaleha MU MIP yr 6; 2010

11.3 Tier 1:
Cyanea koolauensis: Taxon Summary and Stabilization Plan

Scientific name: *Cyanea koolauensis* Lammers, Givnish & Sytsma
Hawaiian name: Haha
Family: Campanulaceae (Bellflower Family)
Federal status: Listed endangered

Requirements for Stability

- 3 population units (PUs)
- 50 reproducing individuals per MFS PU (short-lived perennial)
- Threats controlled
- Genetic storage collections from all PUs
- Tier 1 stabilization priority

Description and biology: *Cyanea koolauensis* is an unbranched shrub 1-1.5 m (3.3-4.9 ft) tall. The leaves are linear to narrowly elliptic, glabrous, and have a whitish lower surface. The leaf blades measure 16-36 cm (6.3-14.2 in) long, and 1.5-4 cm (0.6-1.6 in) wide. The inflorescences are axillary, and bear 3-6 flowers. The corollas are magenta, 5-9 cm (2.0-3.5 in) long, and glabrous. The berries are yellow or orange, globose, and contain numerous brown to black seeds.

Flowering has been observed primarily in June and July, and fruiting in August and September. As with other *Cyanea*s with their long tubular flowers, this species is thought to have been pollinated by nectar-feeding birds. A study by Lammers and Freeman (1986) found that most Hawaiian lobelioids have a nectar sugar profile typical of bird-pollinated flowers. It is probably capable of self-pollination, as several other species of *Cyanea* have been found capable of selfing in cultivation. The species' orange berries are indicative of seed dispersal by fruit-eating birds. *Cyanea koolauensis* is categorized as a short-lived species for the purposes of the Implementation Plan.

Known distribution: *Cyanea koolauensis* is known primarily from the wetter portions of the leeward Koolau Mountains. Recorded elevations for the species range from 518-814 m (1700-2670 ft).

Population trends: Population trends have not been well documented for this species.

Current status: Approximately 130 mature individuals of *C. koolauensis* are known. About half are within the Koolau Range action areas. The current population units and the number of plants they contain are given in the status table below.

Habitat: *Cyanea koolauensis* occurs in gulch bottoms, on gulch slopes, and on ridge tops in *ohia lehua-uluhe* (*Metrosideros polymorpha-Dicranopteris linearis*) wet forest. Additional associated species include koa (*Acacia koa*), *mehame* (*Antidesma platyphyllum*), *kokoolau* (*Bidens macrocarpa*), *ahakea* (*Bobea elatior*), *kanawao keokeo (Broussaisia arguta*), *alani (Melicope* spp.), *hoawa* (*Pittosporum glabrum*), *loulu* (*Pritchardia martii), kopiko (Psychotria* spp.), *amau* (*Sadleria* spp.), *naupaka* (*Scaevola* spp.), *ohia ha* (*Syzigium sandwicensis),* and *akia* (*Wikstroemia oahuensis*).

Taxonomic background: *Cyanea koolauensis* was formerly included in the genus *Rollandia*, as *R. angustifolia* (Lammers 1990). Studies have since indicated that *Rollandia* constitutes a subgroup within the genus *Cyanea* (Lammers, Givnish and Sytsma 1993).

Outplanting considerations: *Cyanea* taxa potentially occurring with or near *C. koolauensis* are *C. calycina*, *C. acuminata*, *C. humboldtiana*, *C. lanceolata*, *C. st.-johnii*, *C. crispa*, and *C. angustifolia*. All except *C. angustifolia* are rare species. Another rare *Cyanea* occurring with *C. koolauensis* in the northern Koolau Mountains is one that appears to represent a distinct, but currently unrecognized taxon. It was described as *Rollandia degeneriana* F. Wimmer (Wimmer 1956). It was considered a possible hybrid in the latest taxonomic treatment of *Cyanea* (Lammers 1990), but it was known only from the type specimen at that time. Field observations indicate that this *Cyanea* occurs in populations not originating from recent or ongoing hybridization, but instead, exists as an independent taxon. Hybridization concerns are minimal with respect to the aforementioned *Cyanea*s since they naturally co-occur with *C. koolauensis*.

Almost all of the windward side of the Koolau Mountains is not included within *C. koolauensis*'s known range. Outplantings of *C. koolauensis* should not be established in this region, especially since there are two rare *Cyanea* species endemic to the windward side of the Koolau Range. One is *C. truncata*, which is now known from a single colony of three plants. The other is *C. purpurellifolia*, which is narrowly endemic to the area from Punaluu to Kaipapau. An outplanting line has been drawn on Figures 16.20 and 16.21 that restricts outplantings of *C. koolauensis* to the species' known range.

Cyanea species not known to be extant in the Koolau Mountains include *C. longiflora*, which persists in the Waianae Mountains, and *C. sessilifolia*, which has been documented only from the northern end of the mountain range. Also thought to be extinct is *C. superba* subsp. *regina* of the southeastern Koolaus. All of these species typically occurred in mesic areas drier than where *C. koolauensis* occurs, but their ranges may have overlapped *C. koolauensis*' range to some extent. In case any of these taxa are actually still extant in the Koolaus, the outplanting line in Figures 16.20 and 16.21 separates the likely ranges of these *Cyanea* taxa from the potential *C. koolauensis* outplanting areas.

Threats: Major threats to *C. koolauensis* include feral pigs, which degrade the species habitat and harm the plants through feeding on them, trampling them, or uprooting them when rooting for food. Alien plants threaten *C. koolauensis* by altering the species habitat and competing with it for sunlight, moisture, nutrients, and growing space. The major alien plant threats to C. koolauensis include Koster's curse (*Clidemia hirta*) and strawberry guava (*Psidium cattleianum*). Rats pose a threat to the species through their predation on bark and fruit. Introduced slugs and snails threaten the species by feeding on its leaves, stems, and seedlings. The species is threatened by human impacts, such as trail clearing and hiking.

Long-billed, nectar-feeding native Hawaiian birds, which are the presumed original pollinators of *C. koolauensis*, have become extremely rare on Oahu. Although the species is probably capable of selfing, the loss of its normal pollinating vectors is likely to result in decreased genetic variability within its populations over successive generations.

Threats in the Action Area: Potential threats in the action area due to military training activities include fire, trampling by foot traffic, and competition with non-native plant species introduced via military training activities. This species occurs within Kahuku Training Area (KTA) and is therefore considered to be a Tier 1 priority, due to the current and potential impact from invasive species within the heavily utilized KTA. However, due to the location of this species within KTA, the threat from fire and trampling ranges from low to none. Additional threats include habitat and population degradation by feral ungulates. This species is also preyed on by slugs which eat seedlings and leaves, and rats that eat fruit and sometimes the bark.

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Cyanea koolauensis   TaxonCode: CyaKoo

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaipapau, Koloa and Kawainui	Manage for stability	51	25	6	0	0	0	38	5	0	**51**	**25**	**6**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaKoo.KLO-D	West of Kahuku Cabin, top of ridge	In situ	4		
CyaKoo.KLO-E	Down ridge west of Kahaku Cabin	In situ	1	4	
CyaKoo.KLO-I	West of Kahuku Cabin down old snare ridge	In situ	6		
CyaKoo.KOL-A	Middle ridge Upper Koloa Gulch	In situ	4	1	
CyaKoo.KOL-B	Koloa, gulch below Kahuku cabin	In situ	23	9	6
CyaKoo.KOL-D	Koloa Gulch northern fenceline	In situ	1		
CyaKoo.KOL-E	North of Kahuku Cabin, near HupNut	In situ	1	4	
CyaKoo.KOL-F	Koloa West branch	In situ	8	5	0
CyaKoo.KOL-G	On east side of proposed Koloa fenceline	In situ		1	
CyaKoo.PAP-A	Kaipapau Paperbark gulch	In situ	2		
CyaKoo.PAP-C	S. proposed fenceline ridge	In situ	1	1	

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kamananui-Kawainui Ridge	Genetic Storage	6	2	0	0	0	0	4	2	0	**6**	**2**	**0**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaKoo.KLO-L	North of Puu Kainapuaa on Kawailoa Trail	In situ	1		
CyaKoo.KLO-M	Kawailoa Trail, below transect	In situ	3	2	
CyaKoo.KTA-A	KTA on KST in Malaekahana Gulch	In situ	2		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaukonahua	Manage for stability	11	1	0	0	0	0	9	0	0	**11**	**1**	**0**	South Kaukonahua Subunit I and North Kaukonahua Mus

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaKoo.KLO-B	North Kaukonahua, below PhlNut (Dead)	In situ	0	0	0
CyaKoo.SBE-A	South Kaukonahua, off of Haku Lei	In situ	6		
CyaKoo.SBE-B	South Kaukonahua, off of Sch-Wai trail	In situ	1		
CyaKoo.SBE-C	Puu Kaaumakua Ridge, above big HesArb pop	In situ	1		
CyaKoo.SBE-D	Between Puu 1951 and Y-Puu	In situ	2		
CyaKoo.SBE-E	Puu Kaaumakua Ridge, above lower HesArb on ridge top	In situ	1	1	

Action Area: In

Kawaiiki	Genetic Storage	3	4	0	0	0	0	3	4	0	**3**	**4**	**0**

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaKoo.KLO-C	Kawaiki	In situ			
CyaKoo.KLO-K	Lower Alien Man	In situ	2	4	
CyaKoo.KLO-N	South of CyrVir A Puu	In situ	1		

Lower Opaeula	Genetic Storage	3	1	0	0	0	0	4	5	0	**3**	**1**	**0**

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaKoo.KLO-A	Lower Peahinaia, Transect KLO-5, Station 370	In situ	3	1	

Opaeula to Helemano	Manage for stability	**10**	3	0	0	0	0	8	2	0	**10**	**3**	**0**

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaKoo.KLO-F	Peahinaia, just past SetPal on ridge to North	In situ	3	2	
CyaKoo.KLO-G	Lower Helemano	In situ	1		
CyaKoo.KLO-J	Helemano Drainage	In situ	2		
CyaKoo.KLO-O	Opaeula	In situ	2		
CyaKoo.KLO-P	Pe'ahinai'a trail at 2480	In situ	2		
CyaKoo.KLO-Q	Halemano lower stream crossing	In situ		1	

Poamoho	Genetic Storage	12	0	0	0	0	0	2	0	0	**12**	**0**	**0**

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaKoo.KLO-H	Poamoho, south of trail	In situ	12		

Total for Taxon:	96	36	6	0	0	0	68	18	0	**96**	**36**	**6**

Action Area: Out

TaxonName: Cyanea koolauensis   TaxonCode: CyaKoo

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Halawa	Genetic Storage	0	0	0	0	0	0	3	0	0	**0**	**0**	**0**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Halawa-Kalauao Ridge	Genetic Storage	0	0	0	0	0	0	6	0	0	**0**	**0**	**0**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Lulumahu	Genetic Storage	0	0	0	0	0	0	10	0	0	**0**	**0**	**0**	Army has no current info for this PU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Waialae Nui	Genetic Storage	0	0	0	0	0	0	2	0	0	**0**	**0**	**0**	Army has no current info for this PU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Waiawa to Waimano	Genetic Storage	1	0	0	0	0	0	2	0	0	**1**	**0**	**0**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaKoo.ANO-A	North Waimano	In situ	1		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Wailupe	Genetic Storage	0	0	0	0	0	0	15	0	0	**0**	**0**	**0**	Army has no current info for this PU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaKoo.UPE-A	Wailupe	In situ			

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Waimalu	Genetic Storage	0	0	0	0	0	0	2	0	0	**0**	**0**	**0**	Army has no current info for this PU
	Total for Taxon:	1	0	0	0	0	0	40	0	0	**1**	**0**	**0**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

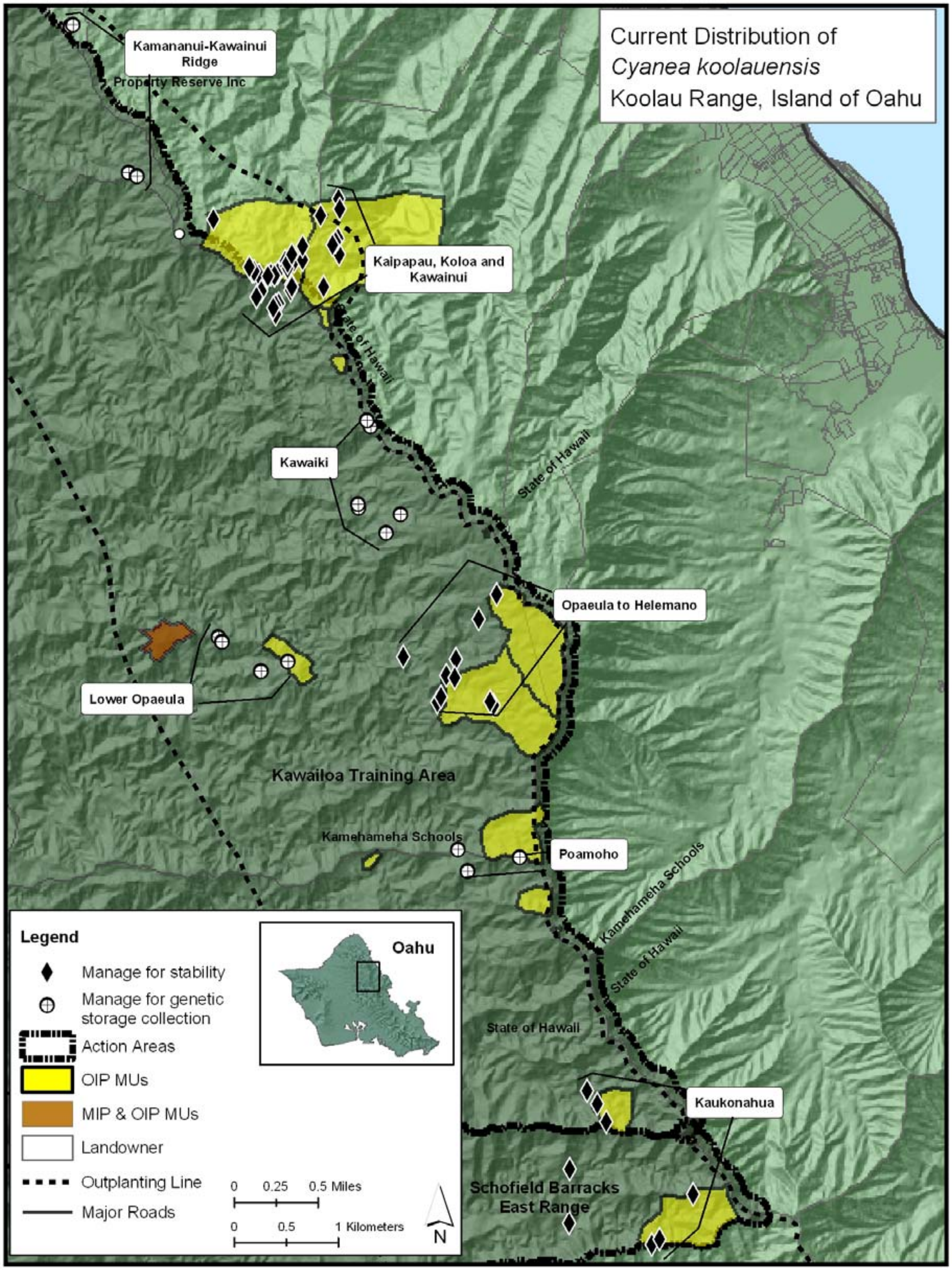


Figure 11.5 Current and historical distribution of *Cyanea koolauensis* in the Northern Koolau Mountains of Oahu.

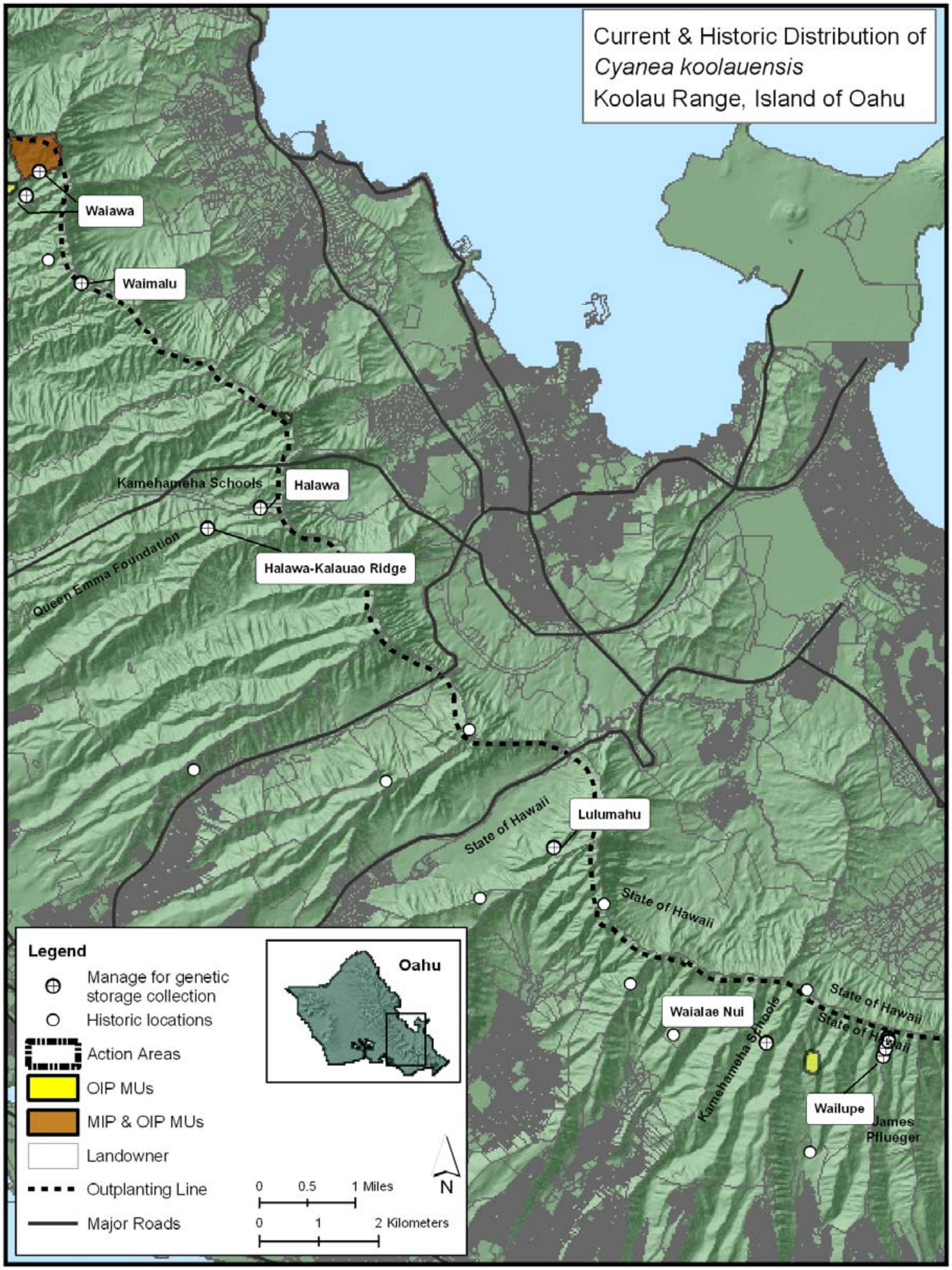


Figure 11.6 Current and historical distribution of *Cyanea koolauensis* in the southern Koolau Mountains of Oahu.

Discussion of Management Designations

This species is arranged in small clusters of individuals that are distributed over a broad geographical range (i.e. the North and South Kaukonahua drainages). Therefore, within the PUs chosen to be managed for stability some individuals may not be fenced. However, all individuals not fenced but within the PU, will be used as a propagule source for augmentation within the respective fenced MUs. The Kaipapau, Koloa, and Kawainui PU stock will be managed within the Koloa and Kaipapau MUs which will be approximately 441 acres combined (though not all of the Kaipapau MU will be suitable for *C. koolauensis*). The Opaeula to Helemano PU stock will be managed within the Opaeula/Helemano MU fence that totals 272 acres. The Kaukonahua PU will be within protected within the North Kaukonahua and South Kaukonahua MUs which will be approximately 128 acres collectively. The Lulumahu PU was not chosen to be managed for stability because of the remote and weedy nature of the site (i.e. this area contains a large population of *Oxyspora paniculata*). The Halawa, Halawa-Kalauao Ridge, Manana-Waiawa Ridge, Niu and Wailupe, Waialae Nui, Waimalu, and Waimano-Waiawa Ridge PUs were not chosen for management because of their low numbers and distance from the action area. All non-manage for stability PUs are designated as manage for genetic storage collections.

Propagation & Genetic Storage

Vegetative (clonal) propagation has not been attempted for this taxon. Vegetative propagules may be collected from certain founders. This may be most appropriate for outlying or non-reproductive individuals. Micropropagation techniques have been successful in germinating seeds from immature fruit collected from wild plants. Research is necessary in order to determine the ideal fruit characteristics for collection, assess seed viability, and create germination, propagation and seed storage protocols. Research will focus on determining the optimal conditions (particularly temperature) for long-term seed storage. Currently, all studied species of *Cyanea* exhibit an inability to tolerate frozen storage temperatures. Research is ongoing with collaborators at the USDA-ARS National Center for Genetic Resources Preservation to determine the cause of this anomaly, focusing on lipid composition of seeds of taxa of *Cyanea*. Samples of this taxon will be sent to NCGRP for lipid analysis. Since seed has been a successful tool to maintain genetic representation of founders for all studied species of *Cyanea*, seed will likely be used to meet genetic storage goals. The establishment of storage protocols for this taxon will initiate the collection of seed from wild plants for genetic storage requirements. If seed cannot be obtained or stored, other methods to meet genetic storage goals will be explored. A living collection will be established for the founders represented by vegetative propagules, with the hopes that this stock will flower in the nursery or at reintroductions. This would allow for genetic storage via seed for all founders. Reintroductions may not be necessary for this taxon. If this later changes, seed collected *in situ* will likely be used to establish these outplantings.

Management Notes: Many individuals in manage for stability PUs fall outside proposed MUs. Surveys should be done prior to fence construction in order to include the greatest number of individuals. Those individuals that fall outside the fence line will be used as propagule sources for augmentation within the MU. Based on *in situ* observations of low density occurrences, outplanting should be done over as broad an area as possible to manage effectively within the proposed MUs, in order to replicate natural occurrences. As augmentations are conducted, if there does not appear to be enough suitable habitat available within the designated MUs the OIT will discuss additional fence options.

The **Kaipapau, Koloa, and Kawainui PU** will be managed within the Koloa MU. This MU was projected to be constructed within the first year of funding for the OIP. The Army is however still awaiting a license agreement with the landowner, Hawaii Reserves Inc. It is anticipated that this agreement will be in place by the end of 2009. This PU has not been fully surveyed for this species and more individuals are expected to be located during surveys for the Koloa MU. Genetic collections for storage and augmentation will be made during MU surveys and following the completion of the MU fence. A high priority for this area is the removal of ungulates once the fence is complete, as pig damage has been documented to be relatively high in some areas.

The **Opaeula to Helemano PU** will be managed within the Opaeula and Helemano fenced MUs and the proposed Lower Opaeula MU. Most of the known individuals in this PU occur at the lower end or just outside the MU fence. Re-monitoring and genetic collection of these individuals is needed. Further survey of the area between the Opaeula to Helemano PU and the Lower Opaeula PU may show these populations to be contiguous. If this is the case these PUs may be merged following discussion with the OIT.

The **Kaukonahua PU** will be managed within the North and South Kaukonahua MUs. Management was split among these two MUs, this will provide additional space to manage this patchily distributed species. A priority for this PU is the completion of the MU fences and re-monitoring of known individuals. Once an assessment of the number of individuals in the PU is made the OIT can decide how to manage the Kaukonahua PU across two non-contiguous MUs.

The genetic storage collections from non-manage for stability PUs should begin opportunistically and ramp up following genetic collections of manage for stability PUs.

Table 11.4 Priority Management Actions for *Cyanea koolauensis* for Army Stabilization PUs

Population Unit	Specific Management Actions	Partners/Concerns	Timeline
Kaipapau, Koloa, and Kawainui PU	• Construct Koloa MU fence • Survey • Collect propagules for augmentation and genetic storage from all accessible plants in the PU • Control priority weeds • Augment within the Koloa MU	• Koloa MU on Hawaii Reserves Inc. property requires license agreement. • Requires EA.	• Construct Koloa MU, OIP yr 4; 2011
Opaeula to Helemano PU	• Collect propagules for augmentation and genetic storage: most individuals in this PU occur @ lower end of MU fence, re-monitoring of these individuals is needed. • Construct Lower Peahinaia MU • Control priority weeds • Potentially augment within the Lower Peahinaia MU	• Lower Peahinaia MU requires KS license agreement.	• Opaeula/ HelemanoFence completed • Construct Lower Peahinaia MU MIP yr 8; 2011
Kaukonahua PU	• Construct North and South Kaukonahua MU fences • Survey • Collect propagules for augmentation and genetic storage • Control priority weeds • Augment within Kaukonahua MUs	• North Kaukonahua MU on State Forest Reserves. • North and South Kaukonahua MUs require an EA.	• Construct N. Kaukonahua MU, OIP yr 6; 2013 • Construct S. Kaukonahua I OIP yr 5; 2012

11.14 Tier 1:
Cyanea st.-johnii: Taxon Summary and Stabilization Plan

Scientific name: *Cyanea st.-johnii* Hosaka
Hawaiian name: Haha
Family: Campanulaceae (Bellflower Family)
Federal status: Listed endangered

Requirements for Stability

- 3 population units (PUs)
- 50 reproducing individuals (short-lived perennial)
- Threats controlled
- Genetic storage collections for all occurrences
- Tier 1 stabilization priority: This species was originally listed as a Tier 3 stabilization priority due to the presence of this species within the KLOA training area off hiking trails. However, the Army chose to elevate this species to Tier 1 stabilization priority because of its rarity.

Description and biology: *Cyanea st.-johnii* is an unbranched or sparingly branched shrub 30-60 cm (12-24 in) tall with rigid, lanceolate to oblanceolate leaves 6-13 cm (2.4-5.1 in) long and 1.5-2 cm (0.6-0.8 in) wide. The upper leaf surface is glabrous while the lower leaf surface is pubescent along the veins. Leaf margins are strongly revolute. The inflorescences are axillary, and bear 5-20 flowers. The corollas are white, and measure 3-6 cm (1.2-2.4 in) long. The berries are orange, and contain numerous brown to black seeds.

Flowering has been observed primarily from June through September. Fruits have been recorded from about August through December. As with other *Cyanea*s with their long tubular flowers, this species is thought to have been pollinated by nectar-feeding birds. A study by Lammers and Freeman (1986) found that most Hawaiian lobelioids have a nectar sugar profile typical of bird-pollinated flowers. It is probably capable of self-pollination, as several other species of *Cyanea* have been found capable of selfing in cultivation. The species' orange berries are indicative of seed dispersal by fruit-eating birds. *Cyanea koolauensis* is categorized as a short-lived species for the purposes of the Implementation Plan.

Known distribution: *Cyanea st.-johnii* is endemic to the Koolau Mountains. It has been recorded from widely scattered sites on or near the summit ridge of the mountain range, ranging from the Wailupe-Waimanalo area in the south, to as far north as Helemano in the central Koolau Mountains. The species ranges from 668-853 (2190-2800 ft) in elevation.

Population trends: Population sizes have been poorly recorded for *C. st.-johnii*, as most of the known plants have not been known for very long and many of the plants are in remote parts of the Koolau Range.

Current status: Currently there are about 55 individuals known of *C. st.-johnii* from six population units. One of these PUs is in an action area, the Helemano PU in KLOA, which contains six plants. The current population units and the number of plants they contain are given in the status table below and their locations are plotted on figures 11.30-31.

Habitat: *Cyanea st.-johnii* occurs on or close to ridge crests, in wet, windswept shrubland dominated by *ohia lehua* (*Metrosideros polymorpha*) and *uluhe* (*Dicranopteris linearis*) shrubland. Associated plant species include include *lehua papa* (*Metrosideros rugosa*), *kokoolau* (*Bidens macrocarpa*), *olapa* (*Cheirodendron trigynum*), *lapalapa* (*C. platyphyllum*), *Dichanthelium koolauense*, *pukiawe* (*Leptecophylla tameiameiae*), *uki* (*Machaerina angustifolia*), *Plantago pachyphylla*, *amau* (*Sadleria pallida*), and *ohelo* (*Vaccinium dentatum*).

Taxonomic background: There are approximately 60 species in the endemic Hawaiian genus *Cyanea*. *Cyanea st.-johnii* was formerly included in the genus *Rollandia* (Lammers 1990). Studies have since indicated that *Rollandia* constitutes a subgroup within the genus *Cyanea* (Lammers, Givnish and Sytsma 1993).

Outplanting considerations: *Cyanea* taxa potentially occurring with or near *C. st.-johnii* are *C. calycina*, *C. acuminata*, *C. humboldtiana*, *C. koolauensis*, *C. crispa*, and *C. angustifolia*. All except *C. angustifolia* are rare species. Another rare *Cyanea* occurring near *C. st.-johnii* in the northern Koolau Mountains is one that appears to represent a distinct, but currently unrecognized taxon. It was described as *Rollandia degeneriana* F. Wimmer (Wimmer 1956). It was considered a possible hybrid in the latest taxonomic treatment of *Cyanea* (Lammers 1990), but it was known only from the type specimen at that time. Field observations indicate that this *Cyanea* occurs in populations not originating from recent or ongoing hybridization, but instead, exists as an independent taxon. Hybridization concerns are minimal with respect to the aforementioned *Cyanea*s since they naturally co-occur with *C. st-johnii*.

Threats: Major threats to *C. koolauensis* include feral pigs, which degrade the species habitat and harm the plants through feeding on them, trampling them, or uprooting them when rooting for food. Alien plants threaten *C. koolauensis* by altering the species habitat and competing with it for sunlight, moisture, nutrients, and growing space. Alien plant species that may compete with *C. st.-johnii* include *Andropogon virginicus, Axonopus fissifolius, Clidemia hirta,* and *Sacciolepis indica*. Rats pose a threat to the species through their predation on bark and fruit. Introduced slugs and snails threaten the species by feeding on its leaves, stems, and seedlings. The species is threatened by human impacts, such as trail clearing and hiking.

Long-billed, nectar-feeding native Hawaiian birds, which are the presumed original pollinators of *C. koolauensis*, have become extremely rare on Oahu. Although the species is probably capable of selfing, the loss of its normal pollinating vectors is likely to result in decreased genetic variability within its populations over successive generations.

Threats in the Action Area: Threats to *Cyanea st.-johnii* posed by military training are trampling during foot maneuvers and the introduction of new non-native plant species. However, the threat from trampling is very low due to the remote summit habitat occupied by this species. There is no fire threat to the PU in the action area. Additionally, this species is threatened throughout its range by habitat or direct destruction by feral ungulates, competition by non-native plant species such as *Clidemia hirta* and *Psidium cattleianum*, and predation on seedlings and fruit by slugs and rats.

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Cyanea st.-johnii   TaxonCode: CyaStj

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Helemano	Manage for stability	6	0	0	0	0	0	3	4	0	**6**	**0**	**0**	within Helemano MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaStj.KLO-A	Helemano, Moku Haha	In situ	6		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
North of Puu Pauao	Genetic Storage	0	0	0	0	0	0	0	1	0	**0**	**0**	**0**	The Army did not observe this plant when the area was surveyed. Further surveys are needed to determine its status.

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

		NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling
	Total for Taxon:	6	0	0	0	0	0	3	5	0	**6**	**0**	**0**

Action Area: Out

TaxonName: Cyanea st.-johnii   TaxonCode: CyaStj

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Ahuimanu-Halawa Summit Ridge	Manage for stability	14	0	20	0	0	0	12	1	0	**14**	**0**	**20**	changed to GSC in favor of managing Waimano for Stability

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaStj.LAW-A	Halawa/Iloekaa Summit	In situ	14		20

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Waiahole-Waiawa Summit Ridge	Genetic Storage	6	0	1	0	0	0	9	1	0	**6**	**0**	**1**	To be managed within Waiawa MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaStj.AHO-A	Waiahole Valley	In situ	1		
CyaStj.AWA-A	Waiawa Gulch	In situ	5		1

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Waihee-Waimalu summit ridge	Genetic Storage	10	0	0	0	0	0	10	0	0	**10**	**0**	**0**	Population estimates reported by PEP

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaStj.HEE-A	Waihee-Waimalu Summit Ridge	In situ	10		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Waimanalo-Wailupe Summit Ridge	Genetic Storage	11	0	0	0	0	0	12	1	0	**11**	**0**	**0**	Population estimates reported by PEP

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaStj.NAL-A	Waimanalo/Hawaii Loa Ridge Summit	In situ	11		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Waimano	Manage for stability	14	5	0	0	0	0	12	0	0	**14**	**5**	**0**	To be managed for stability within Waimano MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaStj.ANO-A	North Waimano	In situ	14	5	

		NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling
	Total for Taxon:	55	5	21	0	0	0	55	3	0	**55**	**5**	**21**

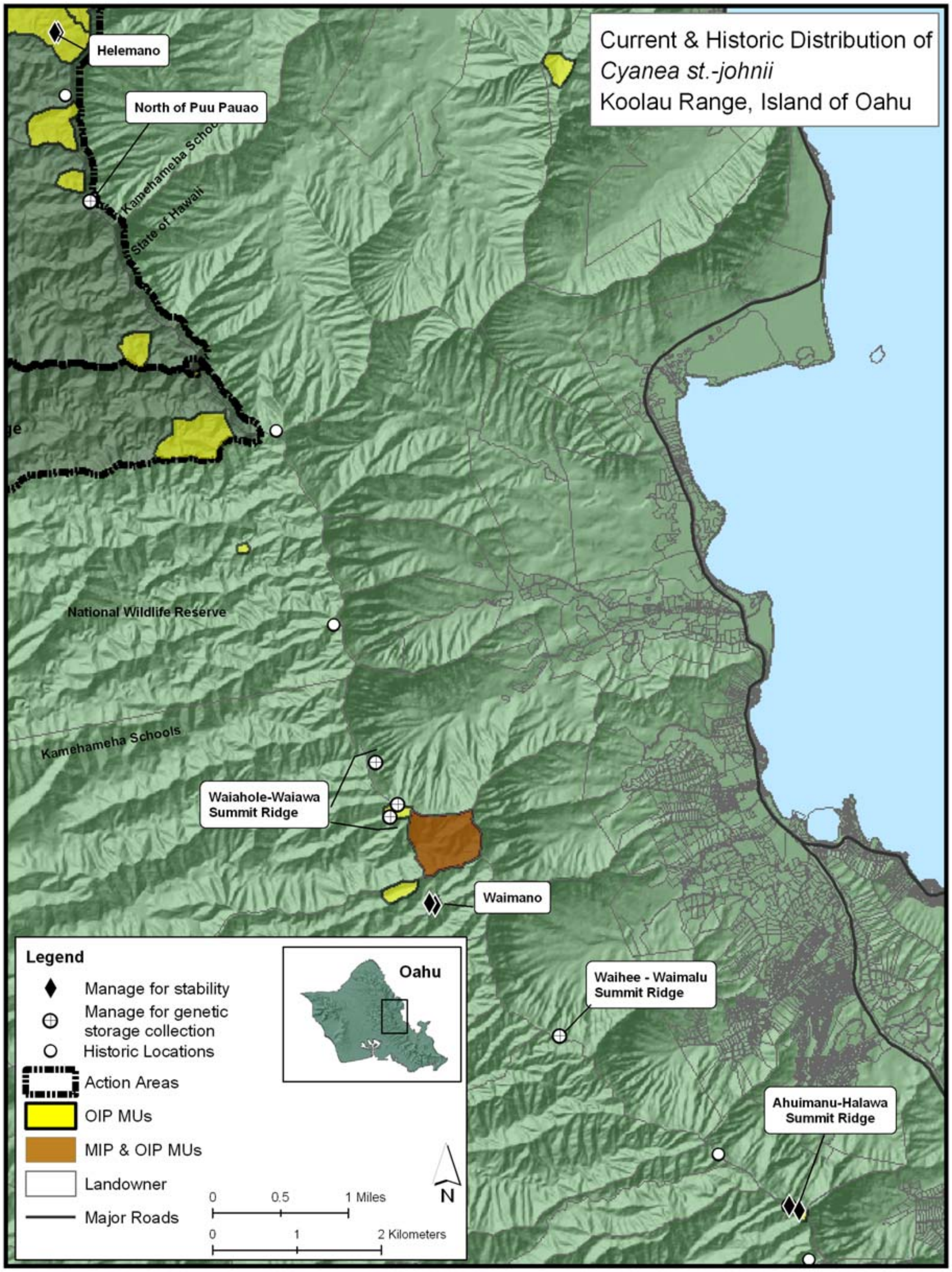


Figure 11.7 Current and historical distribution of *Cyanea st.-johnii* in the Northern and Central Koolau Mountains of Oahu.

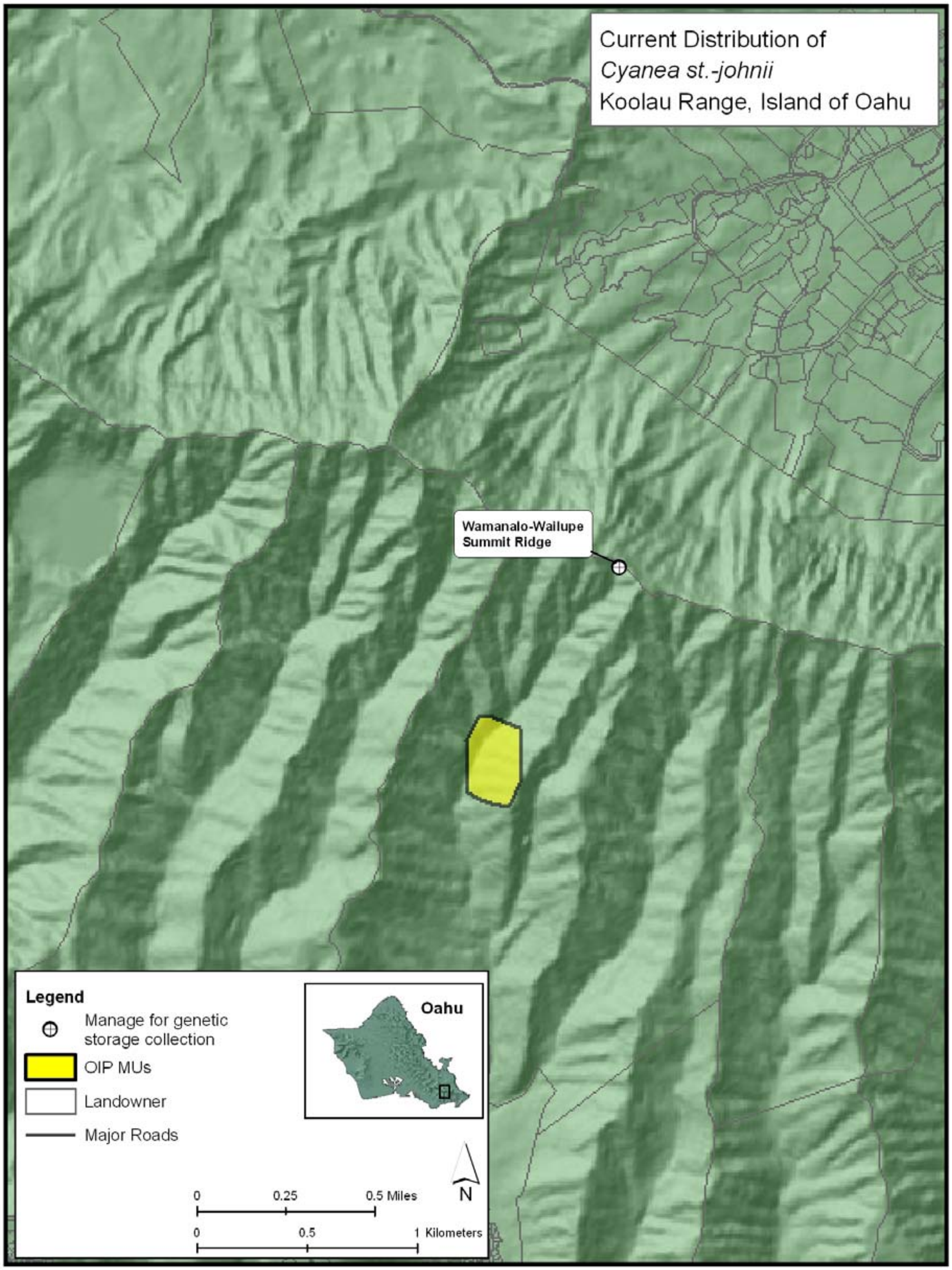


Figure 11.8 Current distribution of *Cyanea st.-johnii* in the Southern Koolau Mountains, Oahu.

Discussion of Management Designations

The three PUs chosen for stabilization encompass a large portion of the geographical range of the species from Helemano to Halawa. The Helemano PU was chosen because it occurs within the action area within the Opaeula/Helemano MU fence. The North of Puu Pauao PU is an occurrence of a single individual recorded by the Hawaii Biodiversity and Mapping Program in 1994. The Army will revisit the site and try to find this individual. The Ahuimanu-Halawa PU was chosen to be managed for stability over the Waiahole-Waiawa Summit Ridge PU due to the larger number of individuals. However, the Waiahole-Waiawa Summit Ridge occurs on Kamehameha Schools land and will be within the Waiawa subunit II MU. The Waimano PU was chosen to be managed for stability because of the habitat quality and number of individuals. The other PUs have been managed by the Oahu Plant Extinction Prevention program (OPEP) and the Army will continue to partner with them on the management of this species.

Propagation and Genetic Storage

Vegetative propagation has been attempted numerous times by Oahu Plant Extinction Prevention Program (and twice by the Army) and has not been successful. Various clonal propagaules have been collected from various sites and brought to Harold L. Lyon Arboretum Micropropagation Lab, but none survived. Attempts at vegetation propagation will likely not continue. Mature fruit of this taxon has never been observed or collected by the Army. Fruit appears to abort prior to maturation on many of the individuals. Fruiting plants within the Helemano PU have been observed for several years. No mature fruit has been observed at this site. Fruit either disappear or rot prior to maturity. At this time, it is unclear as to why this occurs. Most of the collections have low germination rates in comparison to other taxa of *Cyanea*. Typically, seeds found in immature fruit do not store well and the collection of immature material is not recommended for seed-banking practices (Priestley 1986). Phenology and breeding and mating system studies will likely be conducted to try and determine the limiting factors for full fruit and seed maturation. For fruit collected with immature seeds, micropropagation has been a necessary technique, yet this species remains one of the hardest species of *Cyanea* to propagate for the Harold L. Lyon Arboretum Micropropagation Lab (Nellie Sugii, pers. comm.). Seedlings grow very slowly or not at all. Propagation methods will be studied and protocols established. Mature seeds will need to be collected to determine appropriate storage conditions and meet genetic storage requirements. Currently, all studied species of *Cyanea* exhibit unique storage requirements, consisting of an inability to tolerate frozen storage temperatures. Research is ongoing with collaborators at the USDA-ARS National Center for Genetic Resources Preservation to determine the cause of this anomaly, focusing on lipid composition of seeds of taxa of *Cyanea*. This taxon will be incorporated into this study when mature seed is collected. The establishment of storage protocols for this taxon will initiate the collection of seed from wild plants for genetic storage requirements. If mature seed cannot be obtained or immature seed cannot be sotred, other methods to meet genetic storage goals will be explored. A living collection may be established from seed collected from wild plants. Seed collected *in situ* will be used to establish reintroductions.

Priestley, D.A. Seed Aging: Implications for Seed Storage and Persistence in the Soil. Ithaca: Cornell University Press, 1986.

Outplanting Issues: Outplanting will be necessary at all of the MFS PUs once they are fenced. No outplanting of this species has been attempted to date. The Army will attempt to augment this species into the Helemano MU once enough propagules are available.

Management Notes

This species flowers and fruits in late summer and fall. Army NRS will work with the OPEP program to collect propagules for genetic storage from each extant PU. The **Helemano PU** was fenced within the Helemano MU fence in 2006 and genetic collections from this PU have been made. This PU does not require significant weed control at this time and collections for augmentation propagules and genetic storage collections is the highest priority.

The **Ahuimanu-Halawa PU** is currently threatened by *Axonopus fissifolius* and pigs and will be protected within the Halawa MU. This land parcel was recently acquired by the Hawaii Department of Transportation (DOT) and an agreement with this landowner needs to be made prior to management of this PU. This PU should be monitored at least yearly by the Army and/or the OPEP program for genetic storage collections and threats. This PU is planned for OIP year 8; 2015. However, the in house Army fence crew may be able to construct this fence at an earlier date.

The **Waimano PU** is currently being managed by the OPEP program and some genetic collections have been made. A small scale fence is planned for this population by the Army in coordination with OPEP and the State Forest Reserves in late 2008 or early 2009.

Table 11.5 Priority Management Actions for *Cyanea st.-johnii* PUs.

Population Unit	Specific Management Actions	Concerns/ Partners	Timeline
Helemano PU	• Control priority weeds • Continue collecting propagules for augmentation and genetic storage • Augment PU	• Kamehameha Schools owned land; leased by Army.	• Helemano MU completed OIP yr 0; 2006
North of Puu Pauao PU	• Survey site from 1994	• State Forest Reserves;	• OIP yr 2-3; 2009-2010
Waimano PU	• Collect for genetic storage • Small scale fence planned around the PU • Augment	• State Forest Reserves; Managed in partnership with OPEP	• construct Waimano MU, OIP yr 2; 2009
Ahuimanu-Halawa Summit Ridge PU	• Obtain permission from landowner for management • Collect for genetic storage • Construct Halawa MU	• DOT recently acquired this parcel from Kamehameha Schools • Managed in partnership with OPEP	• Construct Halawa MU; OIP yr 8; 2015
Waiahole-Waiawa Summit Ridge PU	• Construct Waiawa subunit II MU • Control priority weeds • Collect propagules for augmentation and genetic storage • Augment within Waiawa MU	• Kamehameha Schools owned land (license agreement required prior to fence construction). • Managed in partnership with OPEP	• construct Waiawa MU, OIP yr 12; 2019
Waihee-Waimalu Summit Ridge PU	• Collect for genetic storage	• Borders BWS and Elizabeth Stack property • This PU managed by OPEP	
Waimanalo-Wailupe Summit Ridge PU	• Collect for genetic storage	• This PU managed by OPEP	

11.5 Tier 1
Eugenia koolauensis: Taxon Summary and Stabilization Plan

Scientific name: *Eugenia koolauensis* Degener
Hawaiian name: *Nioi*
Family: Myrtaceae (Myrtle family)
Federal status: Listed endangered

Requirements for Stability
- 3 population units (PUs)
- 50 reproducing individuals (long-lived perennial; doubled target number due to threat from Ohia rust (*Puccinia psidii*))
- Threats controlled
- Genetic storage collections from all PUs
- Tier 1 stabilization priority

Description and biology: *Eugenia koolauensis* is a small tree or shrub 2-7 m (6.6-23 ft) tall. The oppositely arranged leaves are concave, and are 2-5 cm (0.8-2.0 in) long, and 1-3.3 cm (0.4-1.3 in) wide. The leaf margins are strongly revolute. The upper leaf surfaces are glossy, and hairless, or bear short hairs near the veins. The lower leaf surfaces are densely covered by short brown hairs. The flowers are white, borne 1-2 in the leaf axils, and bear four petals and about 150 stamens. The berries are yellow to red, ovoid in shape, measure 0.8-2.0 cm (0.3-0.8 in) in length, and usually contain a single globose seed.

The species flowers and fruits year round. The flowers of *E. koolauensis* are presumably insect pollinated. The species' red and yellow fleshy berries suggest that fruit eating birds are the main dispersal agents for the species. Since the seeds are large and without a durable seed coat, the seeds would not be expected to remain viable long after the fruit ripens. Immature cultivated plants are slow growing (Lau pers. comm. 2005), and it seems likely that immature plants in the wild would also be slow growing. *Eugenia koolauensis* is a long-lived species. The tree in Papali Gulch has been observed for 25 years, but it has not increased very much in size during that time (Lau pers. comm. 2005).

Known distribution: *Eugenia koolauensis* has been found on the islands of Oahu and Molokai. On Oahu, the species has been recorded primarily from the northern Koolau Mountains, on both the windward and leeward sides of the mountain range, from 100-300 m (328-1,000 ft) in elevation. The species has also been recorded from Waianae Mountains in the area inland of Waialua. It was collected in this area by O. Degener in 1932 in the "gully having prominent dyke, north-northeast of Puu Kamaohanui" (Wilson 1958). In 2000, a few plants were discovered in the same general area in Palikea and Kaimuhole Gulches. Recorded elevations for the species in the Waianae Mountains are from 232-293 m (760-960 ft). Since the species grows in dry forests in the Waianae Range, it is possible that it formerly also occurred in the region between the two mountain ranges. If the species did indeed occur in that region, the now separated Koolau and Waianae plants would likely have been in genetic communication.

On Molokai, the species is known from only two specimens collected by the Joseph F. Rock. One of the specimens was collected in 1918, and the other in 1920 (Wilson 1958). These specimens were collected from the upper elevations of Maunaloa, which is the extinct volcano that formed West Molokai (see Map 16.28 below). Although elevations were not recorded for the West Molokai specimens, the plant or plants were likely located near the summit of Maunaloa, which is 421 m (1,381 ft) high in elevation. Little native vegetation remains on Maunaloa, and it seems unlikely that any *E. koolauensis* plants survive there. Although the species has not been recorded from East Molokai to date, that part of the island could have been part of the range of *E. koolauensis* since there probably once was unbroken suitable habitat extending from West Molokai to East Molokai over the plain of Hoolehua that connects the two mountain masses.

Population trends: The largest number of individuals occurs within the Kahuku Training Area in the Northern end of the Koolau Mountains. Most of the populations of *E. koolauensis* in the Kahuku area contain seedlings and saplings. While it seemed that the numbers of individuals were increasing just a few years ago due to the high level of regeneration at the Kahuku populations, the species is now severely declining (see population status table for numbers of individuals). This species has been severely affected by the recently introduced Ohia Rust (*Puccinia psidii*). The first sign of rust on *Eugenia koolauensis* was reported in March of 2006. The entire Kahuku Training Area contains significant stands of *Syzigium jambos*, a primary carrier of the Ohia rust. Other possible hosts are also abundant, including *Metrosideros polymorpha*, *Eucalyptus robusta*, and *Melaleuca quinquenervia*. The rust primarily affects the new growth. Some small, immature plants exhibited partial or total defoliation. This suggests the rust may limit the growth rate of this already slow-growing species, and perhaps even limit recruitment as flowers are also affected. All size classes of plants are affected by the rust.

Current status: *Eugenia koolauensis* is still extant in the northern Koolau Mountains and in the area inland of Waialua in the northern Waianae Mountains. Only three trees have been found to date in the Waianae Mountains, two in Palikea Gulch and one in Kaimuhole Gulch. The center of abundance for the species is in the KTA action area and the northern end of the KLOA action area. The approximately 168 mature and 197 immature plants in these action areas represent more than 80% of the extant individuals of the species. The only additional plants known to be extant in the Koolau Mountains are four mature plants in the Hauula area on the windward side of the mountain range. All plants observed have been heavily impacted by Ohia rust (*Puccinia psidii*).

The current population units and the number of plants they contain are given in the status table below and their locations are plotted on Figures 11.6-7.

Habitat: *Eugenia koolauensis* occurs in dry to mesic forests, usually on gulch slopes. In the Koolau Mountains the plants occur in dryish mesic forests dominated by *ohia lehua* (*Metrosideros polymorpha*) and/or *lama* (*Diospyros sandwicensis*). The known plants in the Waianae Mountains are located in dry forests dominated by *lama*, *wiliwili* (*Erythrina sandwicensis*), and/or *lonomea* (*Sapindus oahuensis*). On Maunaloa, Molokai, the original dry forest vegetation has been largely destroyed, and there are no detailed descriptions of its original composition. However, this dry forest was possibly dominated by *wiliwili*, which is today perhaps the most common tree species amongst the remnant native trees in the area.

Taxonomic background: *Eugenia koolauensis* is one of only two native Hawaiian species of *Eugenia*. The other species is the closely related *E. reinwardtiana*, whose range extends beyond Hawaii through much of the tropical Pacific Ocean. *Eugenia reinwardtiana* is a rare plant in Hawaii except for the northern Waianae Mountains, where it can be fairly common. There are certain populations of *Eugenia* in the Koolau Mountains with plants whose morphology is intermediate between the two *Eugenia* species. These intermediate population units have not been included among the population units included in this taxon summary. In the Waianae Mountains, *E. reinwardtiana* occurs in the same gulches containing the typical *E. koolauensis* trees, but in different parts of the gulches. There appears to be a zone of intergradation in these gulches between the typical plants of each of the two *Eugenia* species (Lau pers. comm. 2005).

Outplanting considerations:
It can be presumed that *E. koolauensis* and the more common *E. reinwardtiana* are capable of interbreeding, given the existence of intermediate populations in the Koolau Mountains, and a zone of intergradation between the two species in the Waianae Mountains. As such, *E. koolauensis* would be at risk of being genetically swamped by *E. reinwardtiana* if it is outplanted close to *E. reinwardtiana*. An outplanting line for the species in the Koolau Mountains has been drawn on Map 11.6 that would limit outplanting to the portion of the mountain range where only *E. koolauensis* has been found. For the Waianae Mountains, an outplanting line has been drawn that approximates the upper edge of the area occupied exclusively by *E. koolauensis* (see Map 11.7 below).

There is at least one naturalized alien species of *Eugenia* in Hawaii, namely the Surinam cherry (*E. uniflora*). It is not known whether it can hybridize with *E. koolauensis*. The species is not yet known to have spread into *E. koolauensis* habitat.

Threats: The largest threat to *Eugenia* at this time is the Myrtaceous rust, *Puccinia psidii*. The rust was first observed on this species by the Army in 2006. The rust affects the new growth of plants. Some small, immature plants exhibited partial or total defoliation. Mature plants that are heavily infected are often not be able to produce flowers and/or set seed due to rust damage. All size classes are affected by the rust. Threats to *E. koolauensis* include habitat degradation and competition by a variety of non-native plants. In the Koolau Mountains, the most serious weed threats include shoebutton Ardisia (*Ardisia elliptica*), Formosan koa (*Acacia confusa*), Christmas berry (*Schinus terebinthifolius*), strawberry guava (*Psidium cattleianum*), *kukui* (*Aleurites moluccana*), ironwood (*Casuarina equisetifolia*), Koster's curse (*Clidemia hirta*), *huehue haole* (*Passiflora suberosa*), and silk oak (*Grevillea robusta*). In the Waianae Mountains, the most serious invasive alien plant threats include guineagrass (*Panicum maximum*), Christmas berry (*Schinus terebinthifolius*), *kukui* (*Aleurites moluccana*), Java plum (*Syzygium cumini*), Australian red cedar (*Toona ciliata*), comb Hyptis (*Hyptis pectinata*), and wait-a-bit (*Caesalpinia decapetala*).

Feral pigs pose a threat to all of the extant populations, and in the Waianae Mountains the species is also threatened by feral goats. In the KTA area, this species is additionally threatened by foot and motorcycle traffic, and by military training. Fire is another potential threat to the species, with the plants in the dry gulches in the Waianae Mountains especially fire threatened. Cattle ranching was probably the most important factor in the disappearance of the species on Maunaloa, Molokai. On Oahu, cattle were likely to have impacted populations of the species, particularly where the range of the species extended into dry forest areas.

The long-term survival of *E. koolauensis* could be threatened by the naturalization and spread of non-Hawaiian stocks of *E. reinwardtiana*. A non-Hawaiian stock of *E. reinwardtiana* planted in a botanic garden setting has been observed to produce numerous volunteering seedlings, and the stock appears to have the potential of aggressively spreading into the habitat of *E. koolauensis* in the Kahuku area, where native *E. reinwardtiana* does not naturally occur (Lau pers. comm. 2005). If this were to happen, the *E. koolauensis* populations could be vulnerable to genetic swamping from the *E. reinwardtiana* of alien origin.

Threats in the Action Area: Major threats in the action area due to army training are fire, trampling, and the introduction of competing non-native plant species. Fire in the action area has been documented to have affected populations of this species twice in the last 10 years, and the fuel load near some plants is high. Additionally, some of the onsite populations are threatened by habitat disturbance from motor cross bikes.

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Eugenia koolauensis   TaxonCode: EugKoo

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Aimuu	Genetic Storage	0	0	0	0	0	0	5	3	0	**0**	**0**	**0**	
Kaiwikoele and Kamananui	Genetic Storage	16	16	15	0	0	0	15	16	0	**16**	**16**	**15**	
Kaunala	Manage for stability	48	93	6	0	0	0	26	44	200	**48**	**93**	**6**	Kaunala MU; Seedling number was an estimate in the Draft OIP.
Ohiaai and East Oio	Genetic Storage	5	8	10	0	0	0	12	40	78	**5**	**8**	**10**	Oio MU; KTA-D + I will be collected for genetic storage
Oio	Manage for stability	18	56	0	0	0	0	7	33	21	**18**	**56**	**0**	Oio MU, monitored more closely for evidence of reproduction to determine if truly mature or immature.
Pahipahialua	Manage for stability	57	234	1	0	0	0	81	73	0	**57**	**234**	**1**	Pahipahialua MU
	Total for Taxon:	144	407	32	0	0	0	146	209	299	**144**	**407**	**32**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
EugKoo.KTA-H	Aimuu Gulch	In situ			
EugKoo.KLO-A	Kaiwikoele-Kamananui Stream	In situ	1		
EugKoo.KLO-B	Kamananui gulch	In situ	15	16	15
EugKoo.KTA-B	Kaunala	In situ	43	90	
EugKoo.KTA-E	Kaunala, above B	In situ	5	3	6
EugKoo.KTA-D	MK/Sandee's	In situ	5	8	10
EugKoo.KTA-I	Upper Ohia gulch-West fork	In situ	0	0	0
EugKoo.KTA-F	East of Oio Gulch	In situ	18	56	
EugKoo.KTA-A	Pahipahialua	In situ	57	234	1

Action Area: Out

TaxonName: Eugenia koolauensis   TaxonCode: EugKoo

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Hanaimoa	Genetic Storage	1	0	0	0	0	0	3	0	0	**1**	**0**	**0**	The Draft OIP numbers were an error. Only one mature plant was observed in 1999 not the 3 mature shown in the Draft OIP.

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
EugKoo.HAU-A	Hauula	In situ	1		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaleleiki	Genetic Storage	25	30	250	0	0	0	25	30	200	**25**	**30**	**250**	within the State's Kaleleiki fence

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
EugKoo.KTA-C	Kaleleiki	In situ	25	30	250

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Palikea and Kaimuhole	Genetic Storage	3	0	0	0	0	0	3	0	2	**3**	**0**	**0**	Manage stock above road;

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
EugKoo.ALI-A	Palikea Gulch	In situ	2		
EugKoo.IMU-A	Kaimuhole	In situ	1		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Papali	Genetic Storage	0	0	0	0	0	0	1	0	0	**0**	**0**	**0**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

		NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling
	Total for Taxon:	29	30	250	0	0	0	32	30	202	**29**	**30**	**250**

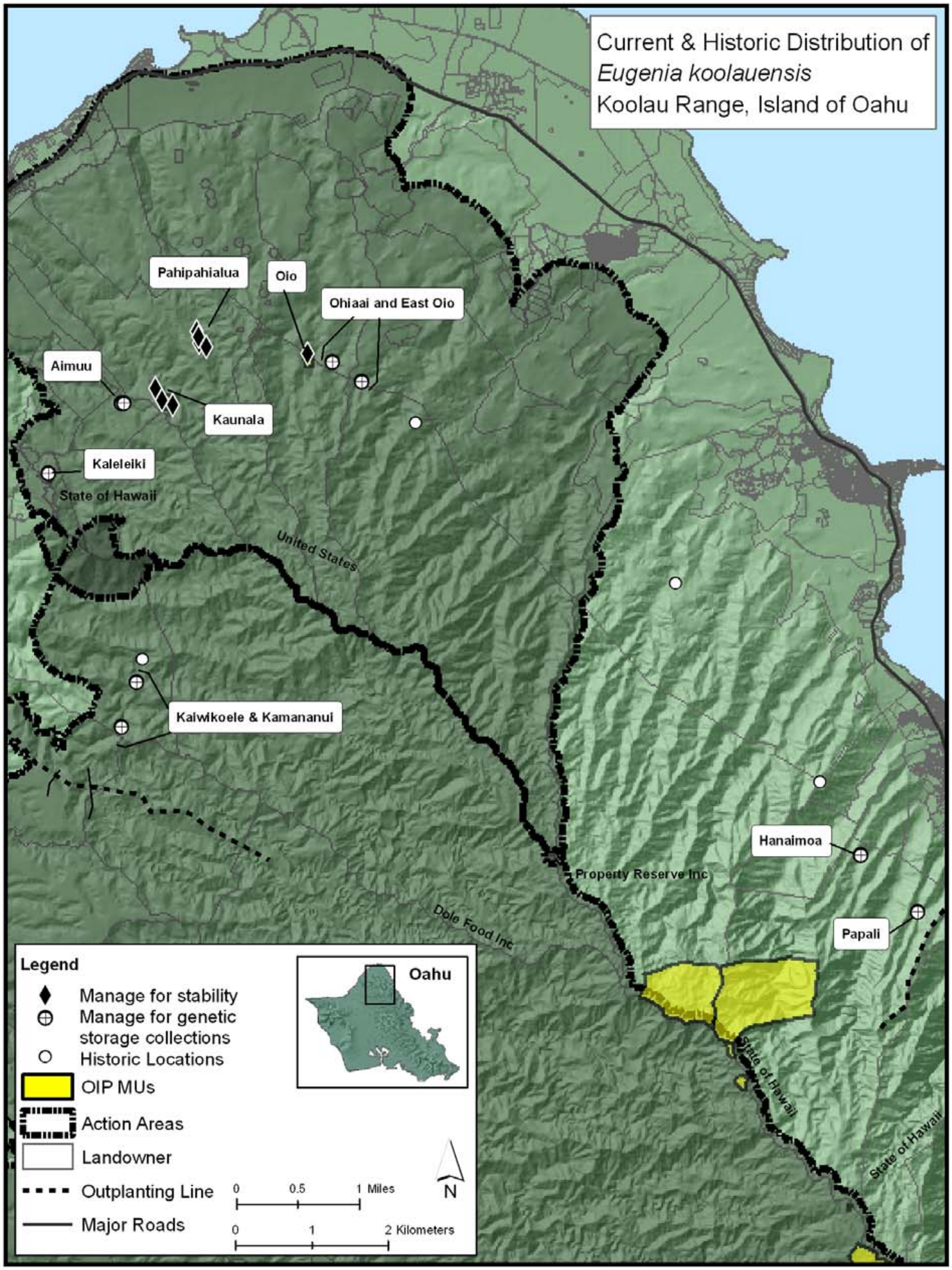


Figure 11.9 Current and historical distribution of *Eugenia koolauensis* in the Koolau Mountains of Oahu.

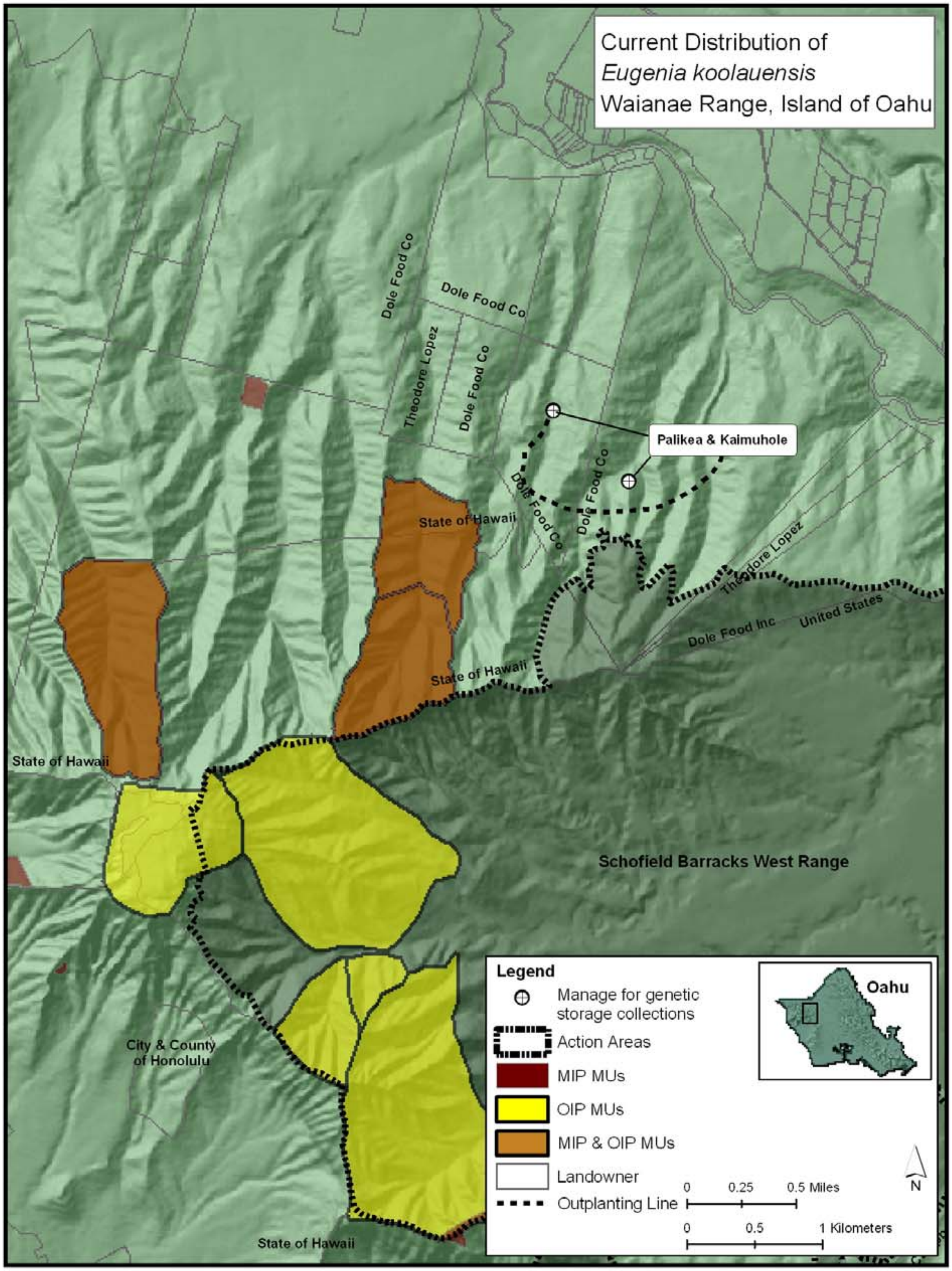


Figure 11.10 Current distribution of *Eugenia koolauensis* in the Waianae Mountains of Oahu.

Discussion of Management Designations

The Army has chosen 3 manage for stability PUs within Kahuku Training Area (KTA) because these populations are the most threatened by military training activities and this area holds the highest density of known individuals. The three manage for stability PUs are Oio, Kaunala, and Pahipahialua. These PUs have been fenced and have had some fuel control due to the potential fire threat in KTA. The Oahu BO (USFWS 2003) stated there was a need to fence all the KTA populations to protect them from motorcross damage. The Army is working with ITAM to keep the motocross access restricted to the approved areas which do not overlap with *Eugenia koolauensis* individuals.

There are several geographically close PUs within KTA but are considered separate populations because they are separated by dense non native forested ridges and gulches. Other PUs within KTA will be fenced if they are determined necessary via routine monitoring. The Waianae population within Palikea Gulch was not chosen to be managed for stability due to the low numbers of individuals and relatively low level of threat from military training. This PU will be one of the first non-manage for stability PUs to be collected from as these plants appear to be adapted to drier habitat conditions where the *Puccinia* rust is not as abundant. All non-manage for stability PUs will be managed for genetic storage collections. All PUs will be monitored for the effects of *Puccinia psidii* and will be treated if a control method becomes available.

Propagation and Genetic Storage

Plants of this taxon can be propagated via cuttings, but rooting success is very low and cuttings are very slow to root and grow. Fruit collections have been made for both wild and nursery plants and seed viability for this taxon is high. Similar to vegetative propagules, seedlings are very slow-growing. Long-term seed storage for this taxon is unlikely. Seeds are not orthodox and there has yet to be a viable method of storage identified. Storage research, however, is ongoing and ultra-low temperature treatments will be tested with additional seed collections. Until proper seed storage methods are identified, genetic storage of this taxon will be maintained via *ex situ* living collections. Horticultural methods to control *Puccinia psidii* will first need to be explored to maintain a healthy living collection. Once control methods for the rust have been established, both seed collected *in situ* and vegetative propagules will likely be used to establish reintroductions.

Management Notes

Fuel reduction actions were carried out by the end of 2005 for the 3 Manage for Stability PUs: **Oio, Kaunala, and Pahipahialua**. As a result there is significantly less ironwood within each of the three enclosures. Common native plant species have been outplanted in these areas to help restore the native species matrix.

The three MFS PUs have similar stabilization needs. One of the highest priorities for this species is the development of propagation techniques (i.e. timing and location of cuttings, airlayers, and/or timing of fruit collection, etc.). Another high priority is the research of *Puccinia* rust control and prevention on both *in situ* and *ex situ* material. The Army is currently funding Dr. Janice Uchida of the University of Hawaii, College of Tropical Agriculture and Human Resources (CTAHR) in her work on *Puccinia* rusts.

Genetic storage collections should be made from all individuals once there is a reliable technique for collection and a method to reduce or eliminate rust in propagation.

A high priority for genetic storage collections is the representation of the Palikea Gulch PU, although not designated as manage for stability it is significant in habitat and location.

Table 11.6 Priority Management Actions for *Eugenia koolauensis* Army Stabilization PUs

Population Unit	Specific Management Actions	Partners/ Concerns	Timeline
Oio	• Monitor/assess/treat *Puccinia psidii* • Control priority weeds • Educational signs for ITAM	• MU/ Fuel control completed 2005 • Working with and providing funding for *Puccinia psidii* researchers • Work with ITAM to control motorcross	• ongoing
Kaunala	• Monitor/assess/treat *Puccinia psidii* • Control priority weeds • Educational signs for ITAM	• MU/ Fuel control completed 2005 • Working with and providing funding for *Puccinia psidii* researchers • Work with ITAM to control motorcross	• ongoing
Pahipahialua	• Monitor/assess/treat *Puccinia psidii* • Control priority weeds • Educational signs for ITAM	• MU/ Fuel control completed 2005 • Working with and providing funding for *Puccinia psidii* researchers • Work with ITAM to control motorcross	• ongoing
All PUs	• Fund and participate in *Puccina psidii* research • Conduct propagation trials	• Currently funding UH research • Army working with various horticulturalists to develop propagation and rust control techniques.	• ongoing

11.6 Tier 1
Gardenia mannii: Taxon Summary and Stabilization Plan

Scientific name: *Gardenia mannii* St. John & Kuykendall
Hawaiian name: Nau, nanu
Family: Rubiaceae (Coffee family)
Federal status: Listed endangered

Requirements for Stability

- 3 population units (PUs)
- 50 reproducing individuals (long-lived perennial; Large percentage of non-flowering/ fruiting plants)
- Threats controlled
- Genetic storage collections from all PUs
- Tier 1 stabilization priority

Description and biology: *Gardenia mannii* is a tree 5-15 m (16-49 ft) tall with leaves 6-27 cm (2.4-11 in) long and 3.5-10 cm (1.4-3.9 in) wide, clustered at the tips of the branches. The fragrant flowers are solitary and terminal. The calyxes bear 4-6 terminal spurs. The corollas are cream colored externally, white within, and are 7-9 lobed. The fruits are broadly ellipsoid, 1.8-4.5 cm (0.7-1.8 in) in diameter, yellow to orange when ripe, and contain numerous seeds. The seeds are compressed, 1.8-2.2 mm (0.07-0.09 in) long, and embedded in a bright reddish orange pulp.

Gardenia mannii can be found to be flowering or fruiting at any time of the year. However, it is often difficult to find fertile individuals of *G. mannii*. It appears that many trees do not produce viable fruit. The flowers are very fragrant with a scent similar to that of cultivated *Gardenia*s, and they are presumed to be insect pollinated. The seeds of *G. mannii* are embedded in a bright reddish orange pulp, suggesting seed dispersal by fruit eating birds. Seed dispersal by birds would help to explain the normal pattern of distribution of the species, which generally occurs as widely scattered individuals. Seldom can several plants be found growing next to one another.

It appears that there are very few mature individuals of *G. mannii* in cultivation in spite of the species' attractive flowers that are pleasantly scented, unlike the other native *Gardenia* of Oahu, *G. brighamii*, which is now commonly planted as an ornamental plant in Hawaii. As such, for *G. mannii*, there is very little biological information available that might be obtained from cultivated plants. To date there are a few individuals at Wahiawa Botanic Garden and Waimea Audubon Center. *Gardenia mannii* is known to be a long lived species. There are particular trees along major trails that have been known to botanists for decades.

Known distribution: *Gardenia mannii* is endemic to Oahu, and it occurs in both the Koolau and Waianae Mountain Ranges. The species occurs along the entire length of the Koolau Mountains, on both its windward and leeward sides. In the Waianae Mountains it has been recorded from only three areas on the windward side of the mountain range. Two of these areas are in the southern part of the Waianae Mountains in the Honouliuli Preserve - Ekahanui Gulch and the area of Kaluaa and Maunauna Gulches. The third area in the Waianae Mountains is Haleauau Gulch in back of SBMR West Range. The species has been found at elevations ranging from 270-730 m (900-2,400 ft) in elevation.

Population trends: The number of individual plants of *G. mannii* appears to be declining, and the plant has disappeared from locations where it was formerly recorded. Immature plants are rarely observed.

Current status: There are fewer than 100 currently known individuals of *G. mannii*. Only five of these are in the Waianae Mountains. About three-fourths of these are within the Oahu action areas, including both the West Range and East Range portions of the SBMR action area, and the KLOA and KTA action areas. The current population units and the number of plants they contain are given in the status table below and their locations are plotted on Figures 11.8-11.

Habitat: *Gardenia mannii* in the Koolaus occurs in wet forests, or in forests that are transitional between mesic and wet, and often far to the lee of the main summit divide of the Koolau Range. These forests are usually dominated by *ohia lehua* (*Metrosideros* spp.) and *uluhe* (*Dicranopteris linearis*). In the drier reaches of these forests, koa (*Acacia koa*) is often a co-dominant tree species. The few records of *G. mannii* in the Waianaes have all been from mesic forests. The species can be found on ridge tops, on gulch slopes, and in gulch bottoms.

Taxonomic background: The genus *Gardenia* is represented in Hawaii by three endemic species, two of which are found on Oahu, *G. brighamii* and *G. mannii*. The third species is *G. remyi*, which is closely related to *G. mannii,* and occurs on Kauai, Molokai, Maui, and Hawaii.

Outplanting considerations: *Gardenia brighamii* is much more endangered than *G. mannii*, with fewer than 15 trees known statewide. Only three trees are known to remain on Oahu, all in the southern Waianae Mountains. There are also historical records of the species in Makaleha in the northern Waianae Mountains, and from Nuuanu Valley in the southern Koolau Mountains. It is unknown whether *G. mannii* and *G. brighamii* can hybridize. Because of the extreme rarity of *G. brighamii*, any outplantings of *G. mannii* must be located away from remaining individuals of *G. brighamii*, or in areas potentially containing the species. The habitats of the two species do not overlap, with *G. brighamii* known only from dry forests, while *G. mannii* is known only from mesic and wet forests. So as long as *G. mannii* is outplanted in its appropriate habitat, outplanting concerns with respect to *G. brighamii* would be minimal. There are also several non-native species of *Gardenia* cultivated in Hawaii. It is not known if they are capable of hybridizing with *G. mannii*.

Threats: Major threats to *Gardenia mannii* include feral pigs and invasive alien plants, and impacts from military activities such as foot traffic and fire. The species is also susceptible to predation by rats and the black twig borer. The most serious of the invasive alien plant species currently threatening *G. mannii* include Koster's curse (*Clidemia hirta*), strawberry guava (*Psidium cattleianum*), manuka (*Leptospermum scoparium*), and octopus tree (*Schefflera actinophylla*).

Although the potential for fire affecting *G. mannii* is probably greater in the Waianae Mountains than in the Koolau Mountains, the Koolau plants could also be affected by fire, since the wet forests of the Koolau Mountains can burn in times of drought. Historically there have been large fires in native forests on the leeward side of the central Koolau Mountains that have burned out of control for many days and have destroyed many acres of native vegetation. Among the endangered plants of the wet forests of the Koolau Mountains, *G. mannii* would be particularly threatened since many individuals occur at relatively low elevations far to the lee of the summit ridge of the Koolau Range close to potential ignition sources. For instance, in the Helemano and Poamoho population unit, some individuals are located not very far off the road that leads to the Poamoho Trail trailhead.

Threats in the Action Area: Within KTA, SBMR and SBER, fire threat ranges from low to very low for this species due to the remote mesic forest habitat it occupies in relation to areas where live fire munitions are approved. And within KLOA, KTA, and SBER the threat of trampling by foot traffic is very low for trees and ranged from low to high for seedlings. Additionally, this species is threatened throughout its range by predation by rats, habitat degradation by feral pigs, and competition with non-native plants.

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Gardenia mannii TaxonCode: GarMan

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Haleauau	Manage for stability	2	0	0	0	0	0	3	0	0	**2**	**0**	**0**	Monitoring showed no change in the last year. Need representation from last plant.

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
GarMan.SBW-A	North Haleauau Hame ridge	In situ	2		
GarMan.SBW-B	South Haleauau (Dead)	In situ	0		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Helemano and Poamoho	Manage for stability	18	0	0	0	0	0	17	0	0	**18**	**0**	**0**	No monitoring in the last year.

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
GarMan.KLO-A	Poamoho Trail, around MelLyd	In situ	0		
GarMan.KLO-D	Upper Poamoho	In situ	3		
GarMan.KLO-F	Helemano Gulch, off Poamoho Road	In situ	10		
GarMan.KLO-G	KLO/Poamoho/Little Italy LZ	In situ	1		
GarMan.KLO-H	Middle Poamoho	In situ	2		
GarMan.KLO-M	Poamoho John Obata Lindsea Puu	In situ	0		
GarMan.KLO-Q	Poamoho near end of road	In situ	1		
GarMan.KLO-R	Poamoho 2 ridges from AchApe	In situ	1		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaiwikoele, Kamananui, and Kawainui	Genetic Storage	20	0	0	0	0	0	10	0	0	**20**	**0**	**0**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
GarMan.KLO-C	Kawailoa	In situ	9		
GarMan.KLO-E	Kawainui	In situ	1		
GarMan.KLO-I	Ridge between Kawainui and Kawaiiki	In situ	5		
GarMan.KLO-J	Bowl/Ridge SE of Eursan on Kawaiki/Kawainui Ridge	In situ	4		
GarMan.KLO-N	Upper Kawainui Gulch	In situ	1		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaukonahua	Genetic Storage	2	0	0	0	0	0	2	0	0	**2**	**0**	**0**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
GarMan.SBE-A	Schofield-Waikane	In situ	2		
GarMan.SBE-B	South Kaukonahua	In situ			

Action Area: In

Lower Peahinaia	Manage for stability	37	1	0	0	0	0	28	0	0	37	**1**	**0**	No monitoring in the last year.

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
GarMan.KLO-B	Lower Peahinaia	In situ	28		
GarMan.KLO-K	Lower Peahinaia, South of Curta (by Mellyd hot-spot)	In situ	6	1	
GarMan.KLO-P	Lower Opaeula Puu Ohe Naupaka	In situ			
GarMan.KLO-S	Lower Peahinaia above Puu Ohe Naupaka	In situ	2		
GarMan.KLO-U	Just west of Puu Roberto on Peahinaia trail	In situ	1		

Opaeula	Genetic Storage	8	0	0	0	0	0	1	0	0	**8**	**0**	**0**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
GarMan.KLO-O	Opaeula-Lower Peahinaia	In situ	1		
GarMan.KLO-T	Puu Melicope	In situ	7		

Opaeula/Helemano	Genetic Storage	1	0	0	0	0	0	0		0	**1**	**0**	**0**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
GarMan.KLO-L	Helemano North Fence Line	In situ	1		

	Total for Taxon:	88	1	0	0	0	0	61	0	0	**88**	**1**	**0**	

Action Area: Out

TaxonName: Gardenia mannii **TaxonCode: GarMan**

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Ihiihi-Kawawainui ridge	Genetic Storage	2	0	0	0	0	0	2	0	0	**2**	0	0	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
GarMan.KTA-A	Ihilhi-Kahawainui ridge	In situ	2		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kahana and Makaua	Genetic Storage	0	0	0	0	0	0	2	0	0	**0**	0	0	The Army has no current info for this PU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaipapau to Punaluu	Genetic Storage	0	0	0	0	0	0	4	0	0	**0**	0	0	The Army has no current info for this PU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kalauao	Genetic Storage	0	0	0	0	0	0	4	0	0	**0**	0	0	The Army has no current info for this PU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaluaa and Maunauna	Genetic Storage	1	0	0	0	0	0	6	0	0	**1**	0	0	Surveys needed in all known and historical sites as was counted in initial OIP report

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
GarMan.KAL-A	South Kaluaa Gulch	In situ	1		
GarMan.KAL-B	above contour trail below kanehoa ridge	In situ			

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kamananui-Malaekahana Summit Ridge	Genetic Storage	13	0	0	0	0	0	13	0	0	**13**	0	0	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
GarMan.KTA-B	Kamananui-Malaekahana Summit Ridge	In situ	13		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kapakahi	Genetic Storage	4	0	0	0	0	0	3	0	0	**4**	0	0	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Action Area: Out

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
GarMan.AHI-A	Kapakahi Gulch Lower	In situ	3		
GarMan.AHI-B	Kapakahi gulch above Waialae	In situ	1		

Manana-Waimano Ridge	Genetic Storage	0	0	0	0	0	0	4	0	0	**0**	**0**	**0**	The Army has no current info for this PU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Pukele	Genetic Storage	1	0	0	0	0	0	1	0	0	**1**	**0**	**0**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
GarMan.PUK-A	Pukele Gulch in Palolo	In situ	1		

Waialae Nui	Genetic Storage	0	0	0	0	0	0	1	0	0	**0**	**0**	**0**	The Army has no current info for this PU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

	Total for Taxon:	21	0	0	0	0	0	40	0	0	**21**	**0**	**0**

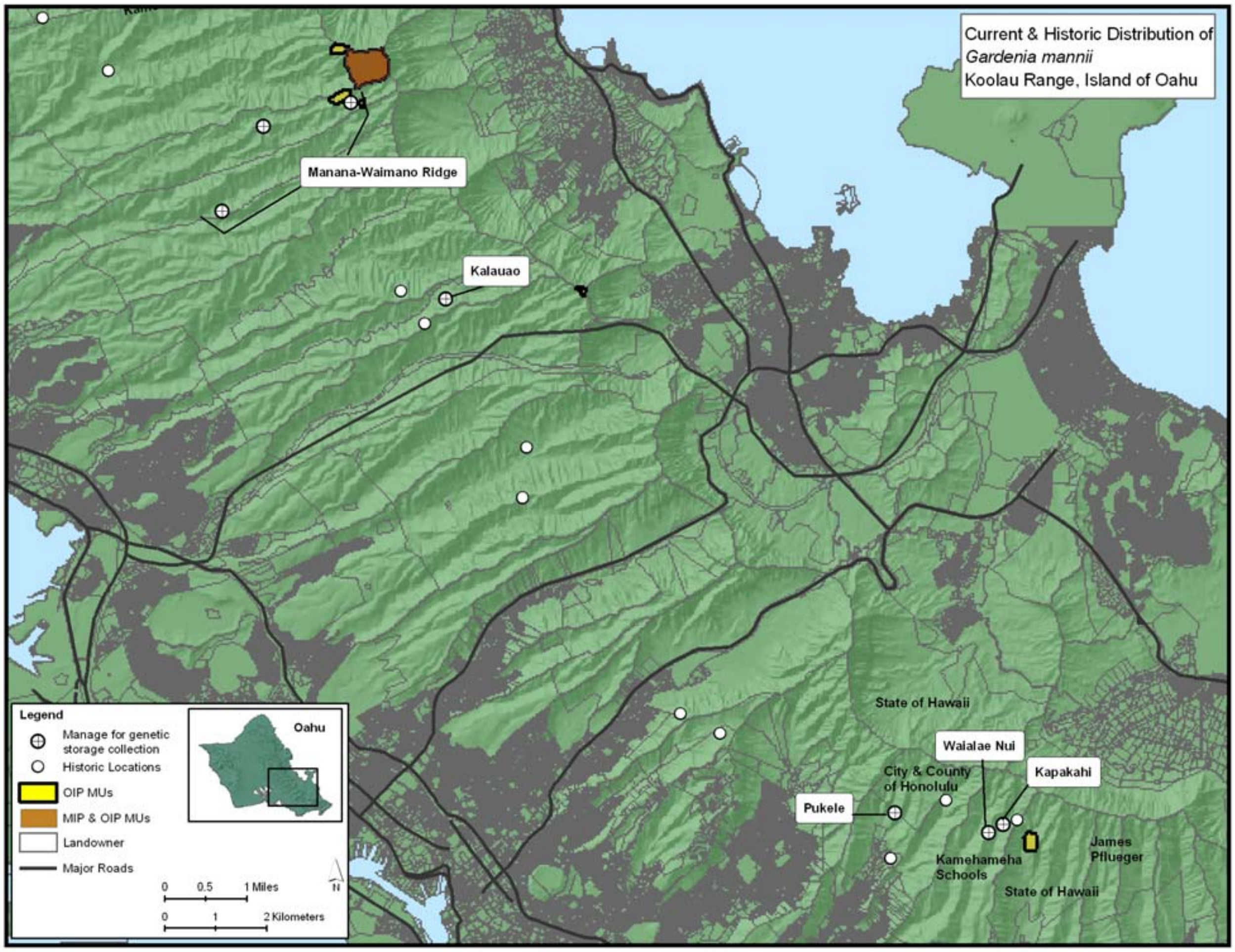


Figure 11.11 Current and historical distribution of *Gardenia mannii* in the Southern Koolau Mountains of Oahu.

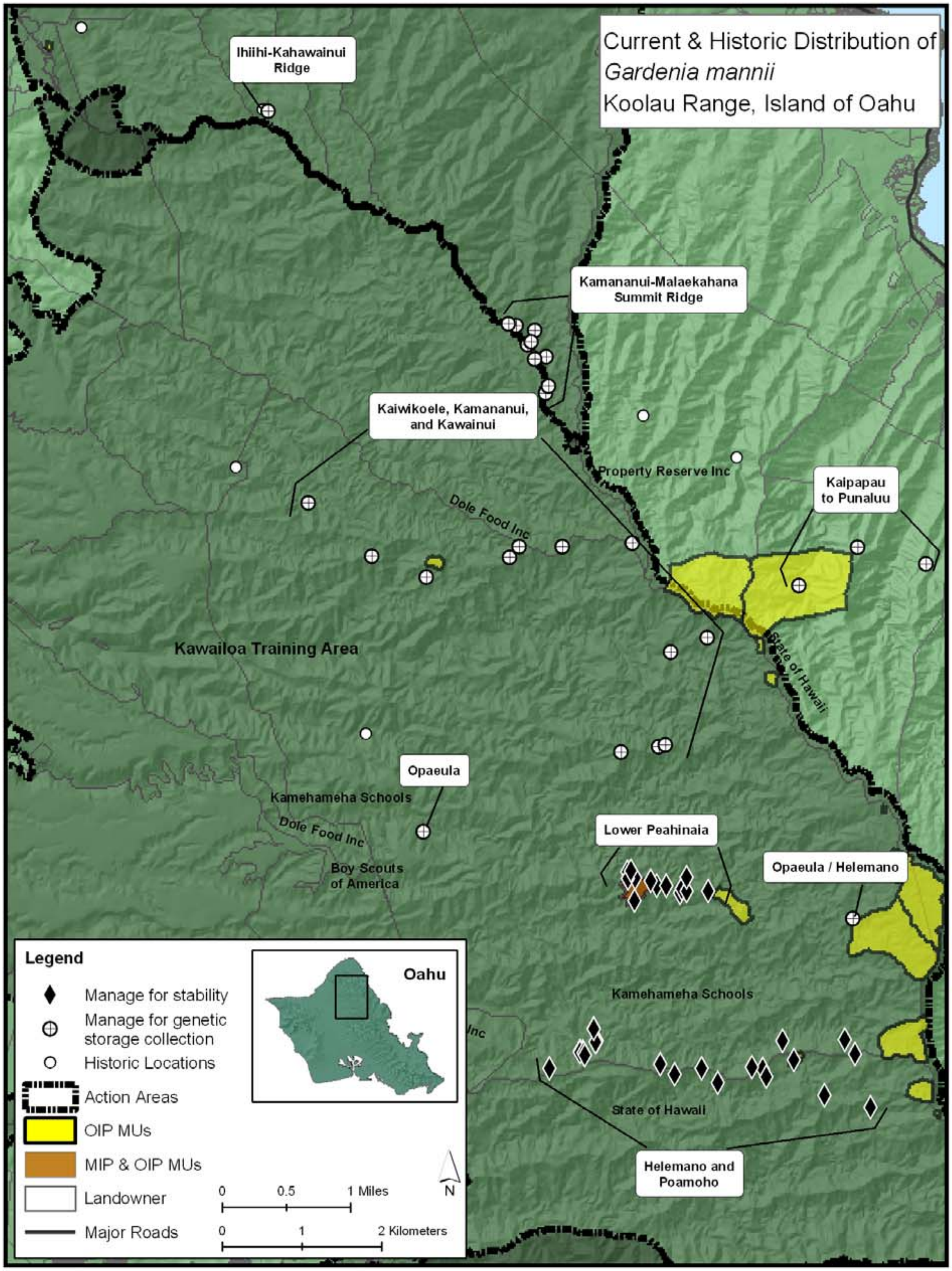


Figure 11.12 Current and historical distribution of *Gardenia mannii* in the Northern Koolau Mountains of Oahu.

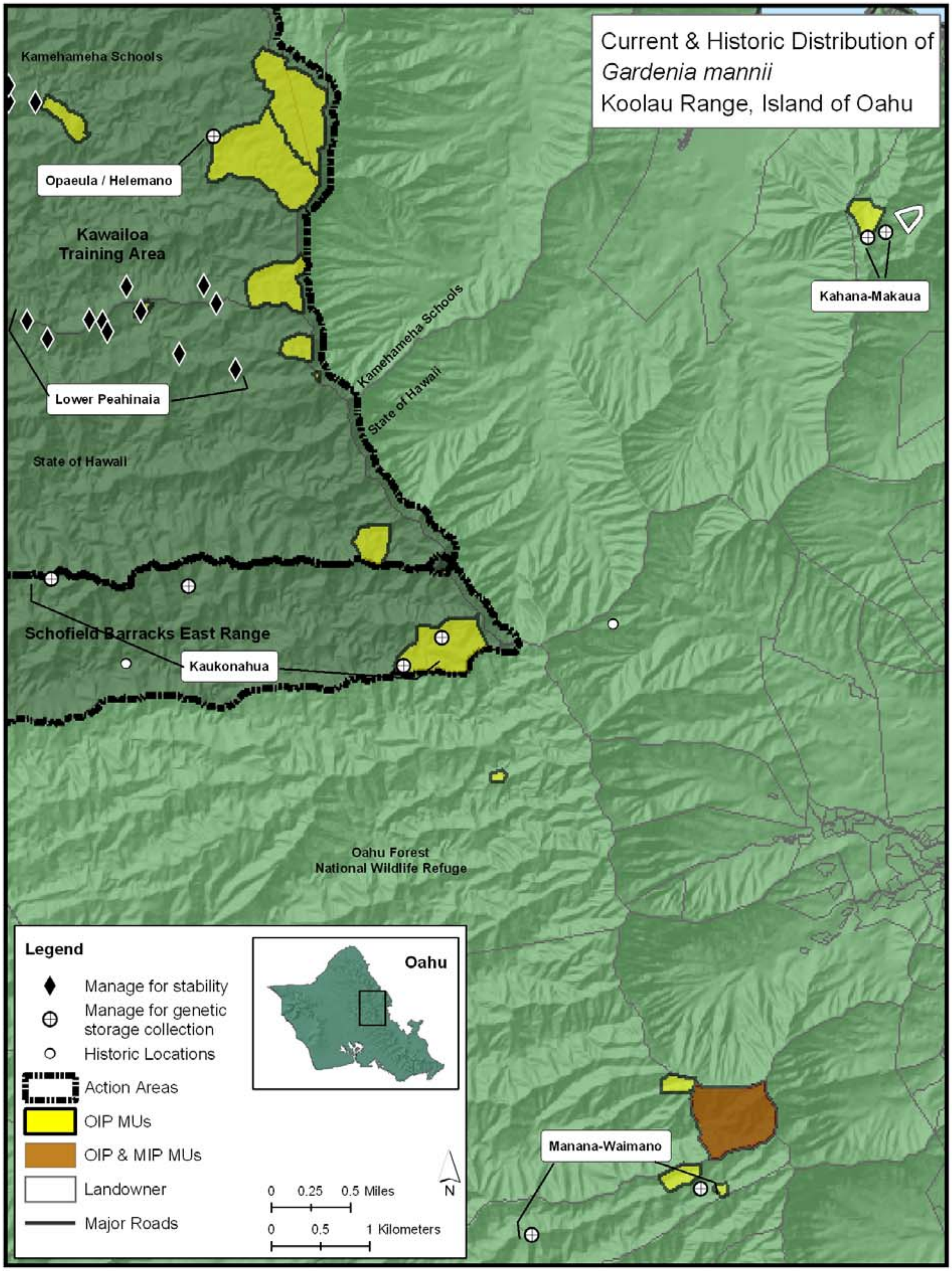


Figure 11.13 Current and historical distribution of *Gardenia mannii* in the Central Koolau Mountains of Oahu.

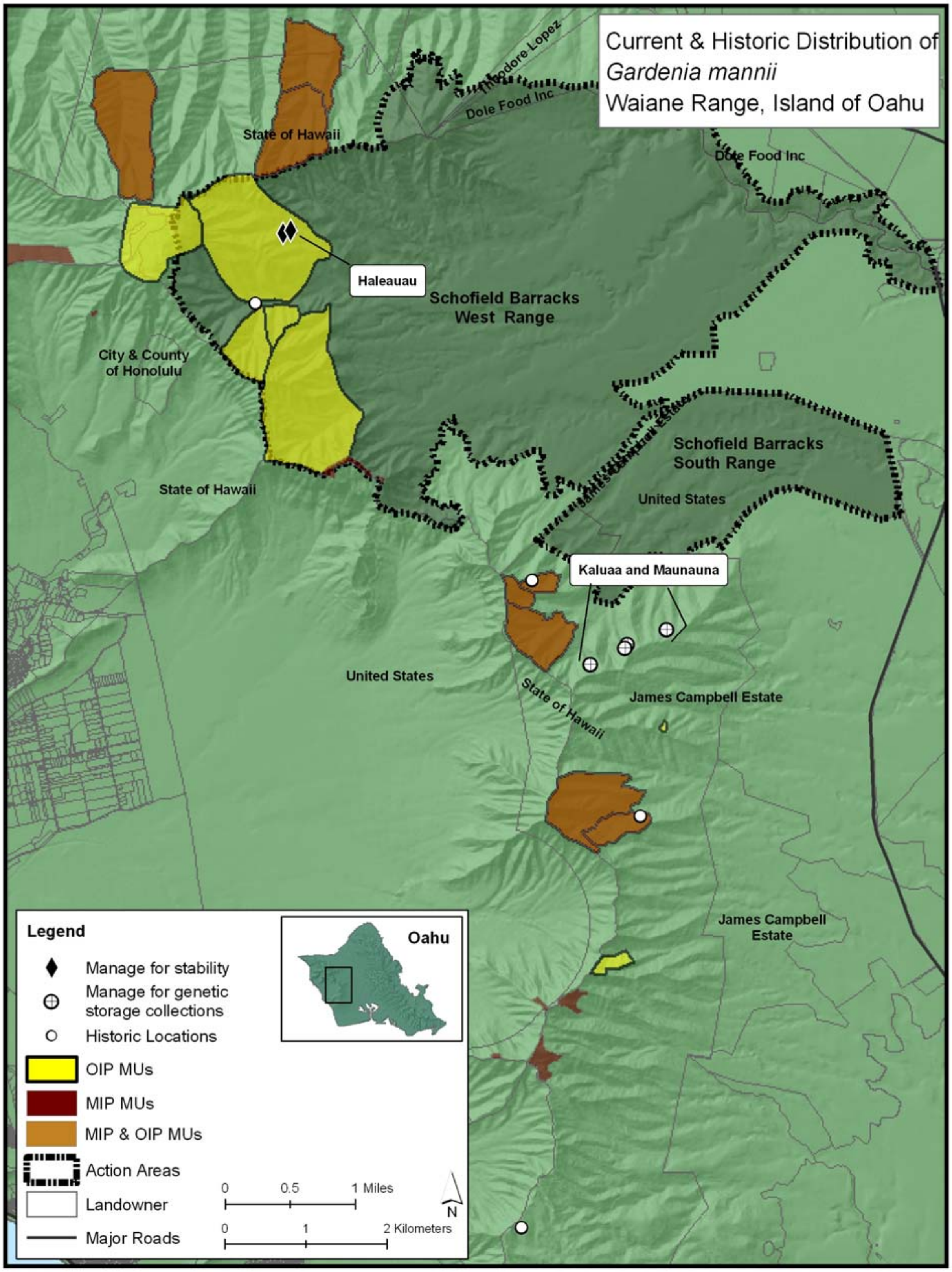


Figure 11.14 Current and historical distribution of *Gardenia mannii* in the Waianae Mountains of Oahu.

Discussion of Management Designation

The PUs chosen to be managed for stability each cover a wide geographical range (i.e. along Poamoho and Opaeula Trails). Therefore, although there is a fenced management unit associated with each manage for stability PU, entire population units may not be fenced. The three manage for stability PUs are Lower Peahinaia, Helemano-Poamoho, and Haleauau. The Lower Opaeula subunit I MU will contain approximately 14 wild individuals in the Lower Peahinaia PU. Propagules from outside this fence will be collected for augmentation within the MU. The Helemano-Poamoho PU was chosen due to the large number of individuals found along the Poamoho trail, a frequently accessed area within the action area. This PU will be managed along the trail and within the Lower Poamoho MU. Additional management units may be needed for the stabilization of this PU. The Haleauau PU was chosen to be managed for stability because there are only five known individuals in the Waianae Mountains and this PU occurs in the Schofield Barracks West Range action area.

Within the action area the Kaiwikoele, Kamananui, and Kawainui PU was not chosen for management in order to manage the Waianae Mountain stock. The Kawainui and Kaukonahua PUs were not chosen for management due to the low number of individuals. Outside the action area none of the PUs in the Koolau Mountains were chosen for management in order to focus stabilization efforts on larger populations and within the areas most likely to be affected by Army training. Additional surveys will likely enhance the numbers of individuals known to exist throughout the range of this species, especially in the Koolau Mountains.

Propagation and Genetic Storage

As stated earlier, few plants have produced viable seed. Plants in the Haleauau PU that have been observed flowering for several years have produced a large number of fruit with no seeds, suggesting that fertilization has not occurred. A few of these flowers have been closely observed and did not present a functional androecium (stamens present without pollen). The plants in the Koolau Mountain range have been observed very infrequently. Only two plants have been collected, and they did contain viable seed. Initial germination appears very high. The germination occurred at Harold L. Lyon Arboretum's Micropropagation Laboratory and many plants were produced from a few fruit. Phenology will be monitored and the pollination biology of populations in the Waianae and Koolau Mountain Ranges will be studied to better understand seed collection potential. Fruit collections will be made first from individuals known to produce viable seed. This seed will be used to determine appropriate storage conditions and assess the practicality of using seed to meet genetic storage goals. If seed storage is not a reliable option for preserving genetic representation, a living collection in a nursery will be initiated for all PUs. Vegetative propagation via air layers has been initiated on wild plants in the Waianae Mountains and has been successful. Clonal propagation can be used to acquire genetic representation from both individuals that do not produce viable seed and at sites with individuals that are known to produce viable seed. These collections and more observations of wild plants will be used to determine the breeding systems of this taxon and serve as a seed production source for reintroductions and genetic storage requirements.

Research Issues

The main priority for research is obtaining viable seeds and determining seed storage potential for this species.

Management Notes

According to the current plan, large portions of the two Koolau stabilization PUs will not be fenced. The Army will monitor for direct impacts from feral pigs throughout the range of the populations chosen to be managed for stability. Providing hunters access to previously closed areas may reduce habitat destruction caused by pigs and potentially help to reduce competition. Regular monitoring of the level of impact from ungulates will guide stabilization actions for this species and results may require large fences to protect these populations.

The **Helemano and Poamoho PU** is spread along the Poamoho drainage and will be protected within the Lower Poamoho MU. This MU will protect approximately 1 acre. The highest priority for this PU is monitoring and collection of propagules for augmentation and genetic storage. The Lower Poamoho MU does not currently contain any extant individuals and will therefore require augmentation within the fenced unit. The Army recognizes the need for additional fences within this PU and a second subunit is planned for the Lower Poamoho MU in the lower elevations of this PU. The Army will determine the location of this subunit following monitoring of the PU.

The **Lower Peahinaia PU** will be managed within the Lower Opaeula MU. This is the largest PU with 34 mature individuals. The Army will capture as many individuals as possible in the two subunits of this MU. These subunits will provide approximately 50 acres of protected habitat in which to manage this PU.

The **Haleauau PU** will be managed within the North Haleauau MU. There are only three individuals within this PU and the Army will mix this PU with the only other extant Waianae Mountain PU, Kaluaa and Maunauna, if no viable seed can be collected from the MFS PUs.

Table 11.7 Priority Management Actions for *Gardenia mannii* Army Stabilization PUs.

Population Unit	Specific Management Actions	Partners/ Concerns	Timeline
Helemano-Poamoho	• Fence Lower Poamoho MU • Collect propagules for augmentation and genetic storage • Augment population if necessary • Control priority weeds	• State Forest Reserves (proposed NAR) • MU needs an EA	• Write OIP EA OIP yr 2; 2009 • Construct Lower Poamoho MU; OIP yr 7; 2014
Lower Peahinaia	• Construct Lower Peahinaia (I and II) MU • Monitor PU for signs of direct impact from feral pigs and/or humans • Collect propagules for augmentation and genetic storage • Augment population if necessary • Control priority weeds	• Kamehameha Schools owned; • License agreement needed • EA completed (MIP EA 2006)	• Construct Lower Peahinaia I MU, MIP yr 8; 2011 • Construct Lower Peahinaia II MU, OIP yr 6; 2016
Haleauau	• Construct North Haleauau MU • Collect propagules from all Waianae range individuals for augmentation within Haleauau MU and genetic storage • Augment within MU • Control priority weeds	• Army owned • MU needs an EA	• Construct North Haleauau MU, OIP yr 3; 2010

11.7 Tier 1:
Hesperomannia arborescens:
Taxon Summary and Stabilization Plan

Scientific name: *Hesperomannia arborescens* A. Gray
Hawaiian name: None known
Family: Asteraceae (Sunflower family)
Federal status: Listed endangered

Requirements for Stability

- 3 population units (PUs)
- 25 reproducing individuals (long-lived perennial)
- Threats controlled
- Genetic storage collections from all PUs
- Tier 1 stabilization priority

Description and biology: *Hesperomannia arborescens* is a small tree 1.5-5 m (4.9-16 ft) tall. The alternate leaves are lanceolate to oblanceolate, obovate, or sometimes elliptic in shape, and usually 2-4 times long as wide. The leaves are glabrous or sometimes minutely puberulent, especially along the veins and midrib. The flower heads are terminal, solitary or in clusters of 2-10, and are 5-7 cm (2.0-2.8 in) high. The tubular corollas are yellow, and 2.4-3 cm (0.94-1.2 in) long. The achenes are 1.2-1.4 cm (0.47-0.55 in) in length. The achene's stiff terminal bristles are yellowish brown or tinged purple, and are 2.5-3 cm (0.98-1.2 in) long.

Flowering and fruiting often occurs from about March through September. *Hesperomannia* flowers are visited by birds, and are presumably pollinated by them (Carlquist 1974). Bristle-bearing achenes are characteristic of the wind-dispersed members of the sunflower family. However, the achenes of *H. arborescens* are very large and heavy in comparison to continental wind-dispersed members of the family, and seemingly would not be capable of being carried on the wind over long distances. Furthermore, this species usually grows in tight colonies (Lau pers. comm. 2005), supporting the supposition that the seeds are not widely dispersed. Judging from observed growth rates and the size of the largest plants, the plants may live at least 20 years (Lau pers. comm. 2005).

Known distribution: *Hesperomannia arborescens* on Oahu (see the Taxonomic Background section below for a discussion of the taxonomic and nomenclatural issues for *H. arborescens*) is predominantly known from scattered populations in the Koolau Mountains on Oahu. The species had not been recorded from the Waianae Mountains until a population was discovered in 2000 inland of Waialua in Palikea Gulch, within the SBMR action area. Recorded elevations for this species ranges from 360- 750 m (1,180-2,460 ft) in elevation in the Koolau Mountains, and 670-730 m (2,200-2,400 ft) in the Waianae Mountains.

Population trends: *Hesperomannia arborescens* occurrences in the Koolau Mountains have been declining in number. There are a number of historical locations where the species can no longer be found. And with respect to the current occurrences that have been known for decades, population sizes have generally declined. *Hesperomannia arborescens* has been known from the Waianaes for only five years, but within this short period of time, the number of known individuals went from six to only one.

Current status: *Hesperomannia arborescens* is still found across its historical range in the Koolau Mountains. There are approximately 215 mature individuals known currently. Of these, more than 80% are located within the SBER and KLOA action areas. The species was also historically known from the KTA action area. It has not been observed there since the 1960's. However, undocumented plants potentially still survive there. The Palikea Gulch PU is within the SBMR action area. Only two plants are known to remain there. The current population units and the number of plants they contain are given in the status table below and their locations are plotted on Figures 11.12-14.

Habitat: In the Koolau Mountains, *H. arborescens* occurs in wet forests and shrublands from gulch bottoms to ridge tops. Unlike the Koolau populations, the only population known to date in the Waianae Mountains is located in a mesic habitat. These plants have been found growing on gulch slopes.

Taxonomic background: *Hesperomannia arborescens* has been considered to include plants from Oahu, Molokai, West Maui, and Lanai (Wagner *et al*. 1990). However, a recent genetic study has shown that the Oahu populations should be considered a separate species from those on the other islands (Ching-Harbin 2003, MS Thesis UH Manoa). This new species delineation would result in a nomenclatural change where Oahu plants would be referred to *H. swezeyi* Deg., and the rest of the islands' plants would retain the name *H. arborescens*. However, this taxonomic reclassification has not yet been published, and so for the purposes of this implementation plan, the Oahu plants will continue to be called *H. arborescens*, but are recognized to constitute a separate species from the plants of the rest of the islands.

Outplanting considerations: *H. arborescens* is the only species recorded from the Koolau Mountains. In the Waianae Mountains, there is a second species of *Hesperomannia*, *H.*

arbuscula. It had been thought to be the only species occurring there until the recent discovery of the *H. arborescens* plants in Palikea Gulch. Although *H. arbuscula*'s known range spans almost the entire Waianae Range, it has not yet been found within 2.5 km (1.6 mi) of the Palikea Gulch site of *H. arborescens*.

Although no hybrids have been documented between *Hesperomannia* species, the potential for hybridization may exist should one species be outplanted within the pollination range of the other species. Since *H. arbuscula* is an extremely endangered plant, with a total of fewer than 20 mature wild plants known to survive, it is likely that reintroductions will be attempted in the future in the Waianae Mountains as part of the recovery strategy for that species. In order to minimize the chance of hybridization between the two species, the establishment of any reintroductions of *H. arbuscula* should be away from the population of *H. arborescens* in Palikea Gulch. Likewise, any reintroductions of the Waianae *H. arborescens* should be restricted to the part of the mountain range in which it naturally occurs, and away from the closest populations of *H. arbuscula*. An outplanting line has been drawn on Map 16.35 between the Palikea Gulch site and the nearest locality where *H. arbuscula* has been documented. *Hesperomannia arborescens* outplantings should be restricted to areas east of the line, and outplantings of *H. arbuscula* to areas west of the line.

Outplantings and/or augmentations of *H. arborescens* should take into account the likelihood that the Koolau and Waianae plants constitute distinct populations that have been separated for a long time. The suitable habitat for the species in the two mountain ranges is widely separated by the relatively dry plains between the mountain ranges. Moreover, the Waianae plants are distinct from the extant Koolau plants in their leaf morphology. The leaf shape of the Waianae plants is proportionately longer and narrower than the leaf shapes of the extant Koolau populations, although at least one historical Koolau collection, namely the type specimen of *H. bushiana* collected in 1935 (Degener 1937), has a leaf shape similar to that of the Waianae plants.

The habitat of the Palikea Gulch population is also quite different from any of the known populations in the Koolau Mountains. In the Koolaus, all of the recorded locations for the species are in wet forests and shrublands, whereas the Palikea Gulch site is in a mesic area, and thus are likely to be uniquely well-adapted to mesic vegetation.

Threats: Major threats to *H. arborescens* in the Koolaus include feral pigs and alien plants such as Koster's curse (*Clidemia hirta*), *manuka* (*Leptospermum scoparium*), Hilo grass (*Paspalum conjugatum*), and strawberry guava (*Psidium cattleianum*). The occurrence in the Waianaes is threatened by feral pigs and goats, and by invasive alien plants, including Christmas berry (*Schinus terebinthifolius*), Australian red cedar (*Toona ciliata*), strawberry guava, and Koster's curse. Since this occurrence is in a relatively dry area, it is more fire threatened than the Koolau occurrences. However, fire represents a threat to the *H. arborescens* in the Koolaus as well, particularly ones located far to the lee of the Koolau summit ridge.

Threats in the Action Areas: Within KLOA and SBER the threats to *Hesperomannia arborescens* from training are trampling from foot maneuvers and the introduction of non-native plant species, spread by movement of personnel and equipment from one training area to another or within a single training area. However, this threat is considered very low. Within SBMR, the

Palikea gulch population is potentially threatened by stray munitions landing outside the impact area. Additional threats throughout the range of this species include habitat degradation by feral pigs and competition from non-native plant species.

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Hesperomannia arborescens   TaxonCode: HesArbo

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kamananui to Kaluanui	Manage for stability	54	45	14	0	0	0	73	11	0	**54**	**45**	**14**	combined Kaiwikoele, Kamananui, and Kawainui and Kaipapau to Kaluanui PUs; to be managed within Koloa MU; needs more surveys

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
HesArbo.KLO-G	Kawailoa Trail, Puu Kainapuaa	In situ	1	1	
HesArbo.KLO-H	Bloody Finger	In situ	7	14	14
HesArbo.KLO-I	Kawailoa Trail, 1918 Puu	In situ	2		
HesArbo.KLO-K	Kahuku Cabin	In situ	1		
HesArbo.KLO-L	Puu Kainapuaa	In situ	5	1	
HesArbo.KLO-M	Radio LZ Hesperomannia Hill	In situ	29	28	
HesArbo.KLO-O	Freckled Tooth Ridge	In situ	3		
HesArbo.KLO-S	Ridge between Kawainui and Kawaiiki	In situ	4		
HesArbo.KLO-U	North side of Puu above LZ	In situ		1	
HesArbo.KOL-A	South of northern Livida site, 5 minutes	In situ	2		
HesArbo.PAP-A	Kaipapau	In situ			

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaukonahua	Manage for stability	76	51	122	0	0	0	68	44	0	**76**	**51**	**122**	North and South Kaukonahua Mus

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
HesArbo.KLO-C	Iiwi Gulch	In situ	1		
HesArbo.KLO-D	Byronii Site	In situ	2	1	
HesArbo.KNA-A	Windward side of Haku lei ridge	In situ	8	4	
HesArbo.SBE-A	Kaaumakua Ridge, HesArb Flats	In situ	35	43	122
HesArbo.SBE-B	South side of Kaukonahua Stream	In situ	5		
HesArbo.SBE-C	Puu 1952	In situ	25	3	

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Lower Opaeula	Manage for stability	9	15	0	0	0	0	42		0	**9**	**15**	**0**	To be managed within Lower Opaeula MU; subunit II

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
HesArbo.KLO-B	Lower Peahinaia b/t Puu Kaka and Roberto	In situ	2		
HesArbo.KLO-J	Puu Roberto	In situ	4	15	

Action Area: In

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
HesArbo.KLO-V	East of Puu Roberto on Peahinaia Trail	In situ	3		

Ohiaai ridge	Genetic Storage	0	0	0	0	0	0	5	1	0	**0**	**0**	**0**	NRS have not monitored

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Palikea Gulch	Manage for stability	0	0	0	0	0	0	1	0	0	**0**	**0**	**0**	Known individuals are now dead

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
HesArbo.ALI-A	Palikea Gulch below Puu Pane	In situ	0		

Poamoho	Genetic Storage	38	16	3	0	0	0	36	14	0	**38**	**16**	**3**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
HesArbo.KLO-A	Poamoho Stream	In situ	1		
HesArbo.KLO-P	Poamoho south of Little Italy	In situ	6		
HesArbo.KLO-Q	Poamoho East of Puu 2068	In situ	5	2	3
HesArbo.KLO-R	Poamoho Puu 2068	In situ	24	12	
HesArbo.KLO-T	WW Poamoho trail by mid elev. LZ	In situ	2	2	

Total for Taxon:	177	127	139	0	0	0	225	70	0	**177**	**127**	**139**

Action Area: Out

TaxonName: Hesperomannia arborescens   TaxonCode: HesArbo

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Halawa	Genetic Storage	0	0	0	0	0	0	3	0	0	0	0	0	NRS have not monitored
							TaxonCode PopRefSiteID	PopRefSiteName			InExsitu	Mature	Immature	Seedling
Kapakahi	Genetic Storage	0	0	0	0	0	0	1	0	0	0	0	0	NRS have not monitored
							TaxonCode PopRefSiteID	PopRefSiteName			InExsitu	Mature	Immature	Seedling
Niu-Waimanalo Summit Ridge	Genetic Storage	0	0	0	0	0	0	4	0	0	0	0	0	NRS have not monitored
							TaxonCode PopRefSiteID	PopRefSiteName			InExsitu	Mature	Immature	Seedling
Waimano	Genetic Storage	0	0	0	0	0	0	1	0	0	0	0	0	NRS have not monitored
							TaxonCode PopRefSiteID	PopRefSiteName			InExsitu	Mature	Immature	Seedling
	Total for Taxon:	0	0	0	0	0	0	9	0	0	0	0	0	

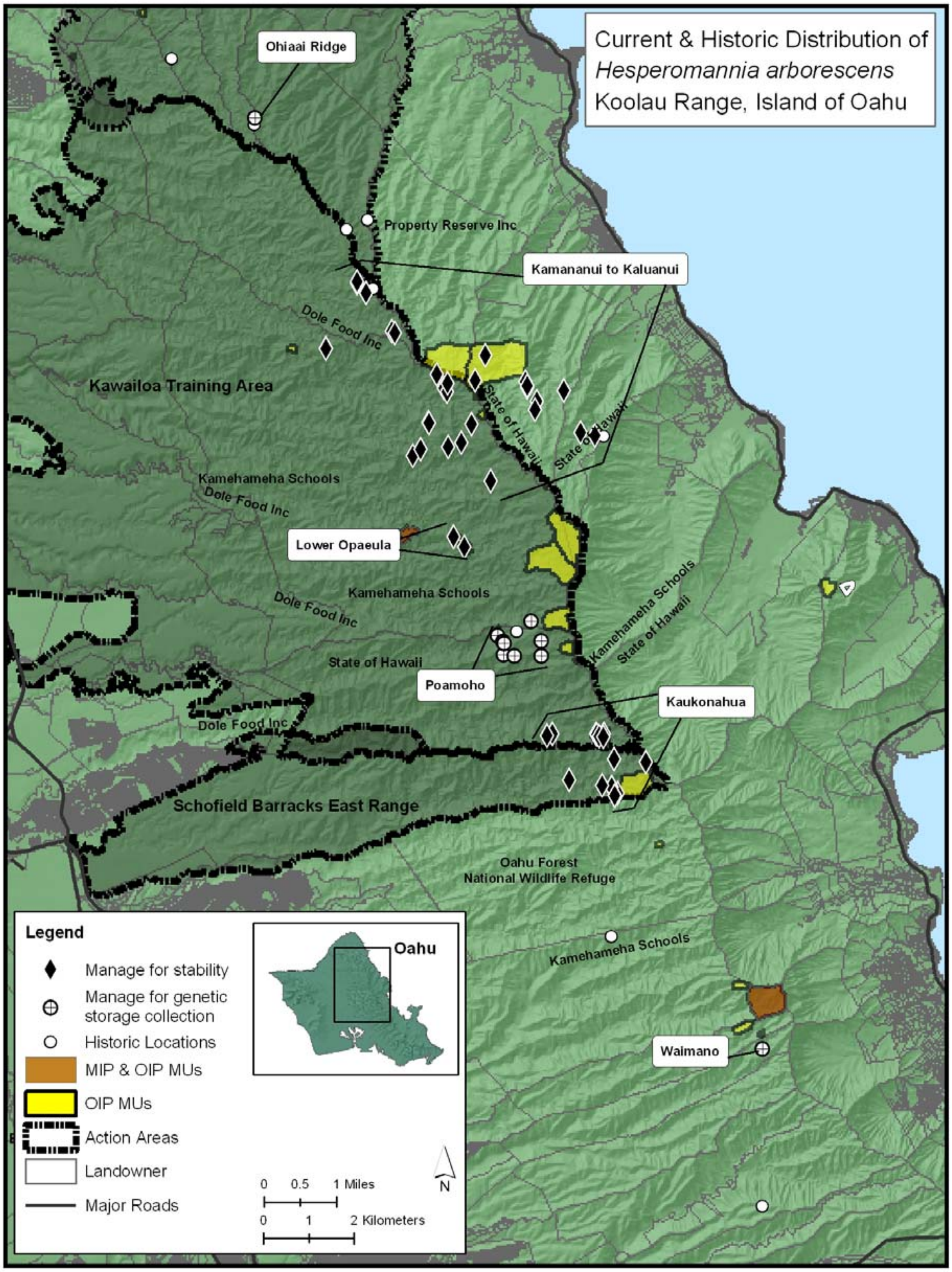


Figure 11.15 Current and historical distribution of *Hesperomannia arborescens* in the Northern Koolau Mountains of Oahu.

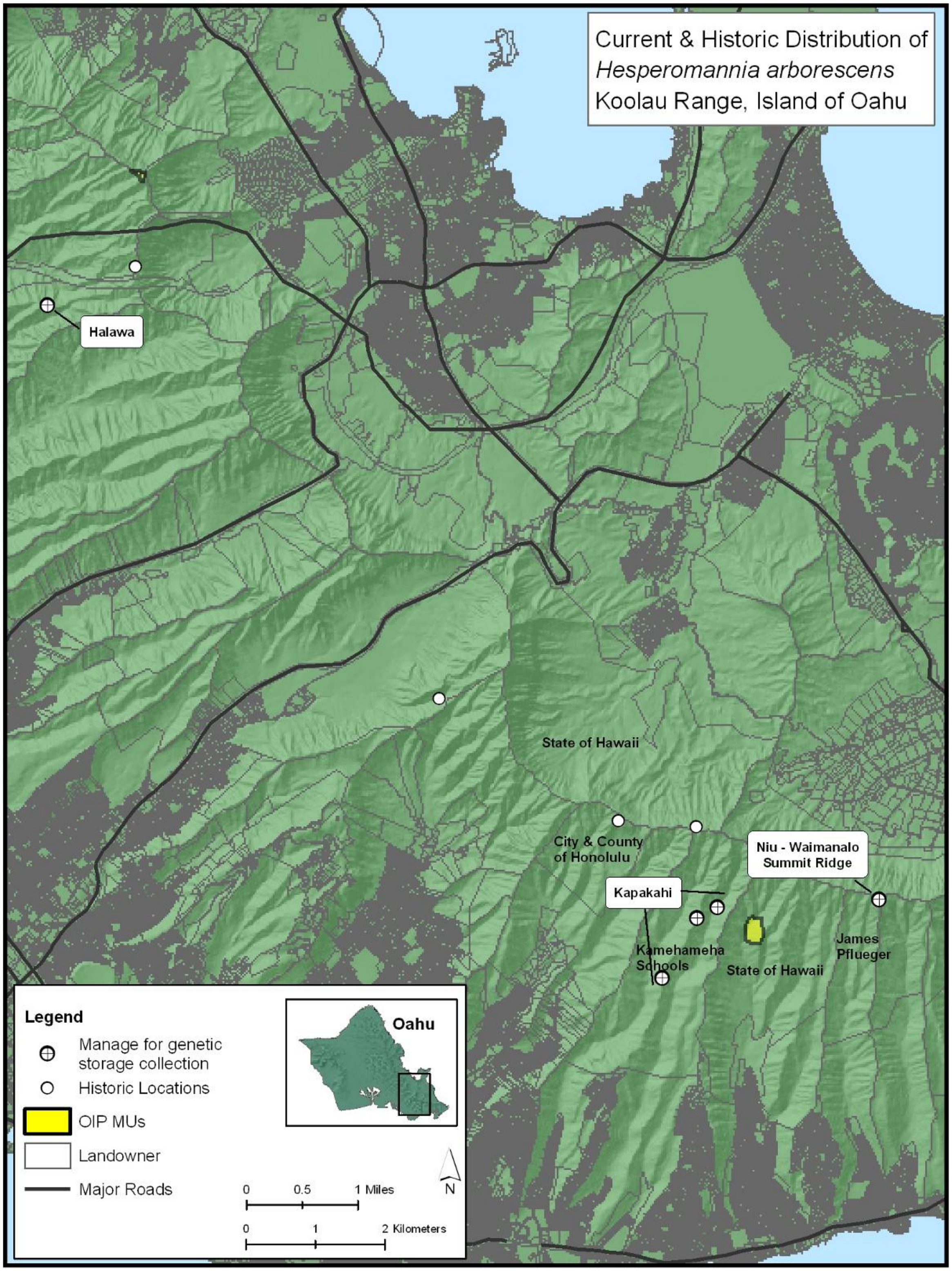


Figure 11.16 Current and historical distribution of *Hesperomannia arborescens* in the Southern Koolau Mountains of Oahu.

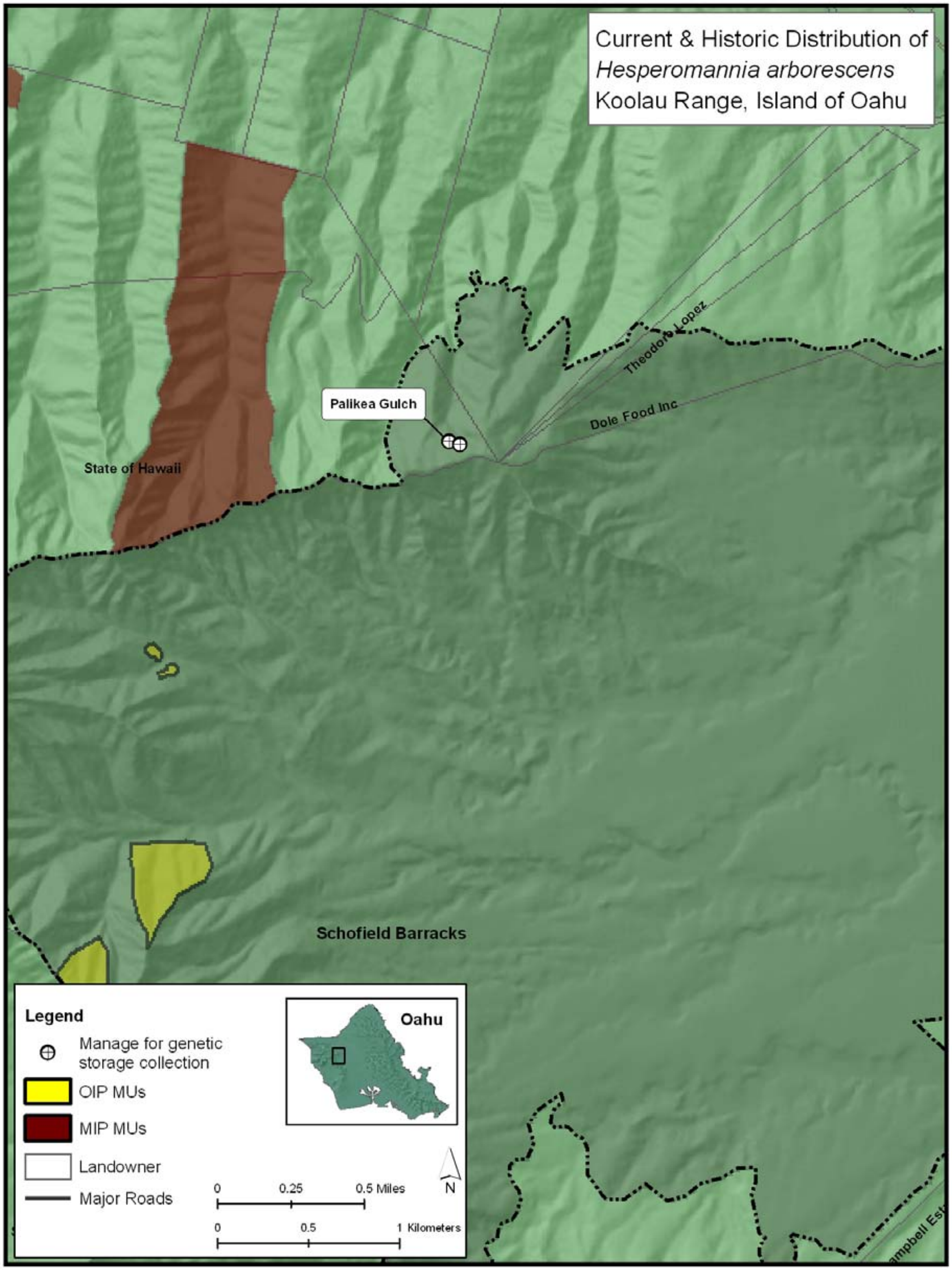


Figure 11.17 Current distribution of *Hesperomannia arborescens* in the Waianae Mountains of Oahu.

Discussion of Management Designations

The Palikea gulch PU is of evolutionary significance due to its distinct flower morphology, however at this time there are no extant individuals known. In the Koolaus this species occurs in populations that may spread over a large geographical range because of the intact nature of the habitat. This makes it difficult to define PUs and within the PUs designated to be stabilized some individuals may not be fenced. This is the case for the Kaukonahua and Kaluanui to Kaiwikoele PUs. The target number for stability will remain the same, and individuals within the PU that are outside the proposed fences will be managed for genetic storage collections. The Poamoho PU was not chosen to be managed for stability due to the large distances between the plants. The Lower Opaeula PU was chosen to be MFS due to the high numbers of mature and immature individuals. All the PUs chosen to be managed for stability are within the action area due to the high numbers of individuals in these PUs and the desire to work within the training area where there is a large area of intact habitat.

Propagation & Genetic Storage

Fruit has low seed set, though viable seeds have high germination in the one collection the Army has made from this taxon. This trend has been substantially documented in its cogener, *H. arbuscula*. Seedlings that germinate from seeds collected from immature fruit are not as vigorous as seedlings propagated from mature fruit. Only dry, mature infructescences should be collected for storage testing and genetic storage requirements. Seed storage longevity tests have been initiated but more collections are needed to determine the most appropriate storage conditions. Vegetative propagation will only be explored if there is not enough viable seed production or seeds are not able to be stored long term. If reintroductions are necessary, seed will likely be used to establish the outplantings.

Management Notes

This species appears to reproduce readily in the wild in some populations. Ungulate fence construction may be all that is needed to reach stabilization target numbers for the Koolau populations chosen to be managed for stability. Though, seed storage testing is needed as some seed are less viable than others.

The **Palikea gulch PU** is designated as manage for stability even though there are no extant individuals known. It is the occurrence of this PU within the Schofield action area that designates this species as a Tier 1 stabilization priority. Therefore, the location of any live individuals is the highest priority. This population shows significantly distinct reproductive and vegetative morphology, having pendant flowering heads with green involucral bracts and narrowly lanceolate leaves. This population may represent a distinct taxonomic entity.

The **Kaukonahua PU** is going to be managed over both the North Kaukonahua and South Kaukonahua MUs. Each proposed MU contains known individuals and all occurrences outside the MUs will be managed for genetic storage collections.

The **Kaluanui to Kaiwikoele PU** will be managed within the Koloa and Kaipapau MUs. This PU is significantly larger than designated in the Draft OIP (2005). This is due to the combining of three previously designated PUs in the area. Once surveys within the proposed MUs are completed the Army will have a better perspective on the need for augmentation from stock collected from the rest of the PU. If there are significantly large groups of plants outside the

Koloa and Kaipapau MUs the Army may choose to fence these sites rather than augment within the fence.

The **Lower Opaeula PU** is in need of survey and genetic collections. This PU may be managed within the Lower Opaeula II MU. This MU currently encompasses all of the known individuals in this area.

Table 11.8 Priority Management Actions for *Hesperomannia arborescens* Army Stabilization PUs

Population Unit	Specific Management Actions	Partners/Concerns	Timeline
North Kaukonahua (Kaukonahua PU)	• Construct North Kaukonahua MU • Collect propagules for genetic storage • Conrol priority weeds	• MU needs an EA. • Within proposed NAR, currently Army leased.	• construct North Kaukonahua MU, OIP yr 6; 2013
South Kaukonahua (Kaukonahua PU)	• Construct South Kaukonahua MUs • Collect propagules for genetic storage • Control priority weeds	• MU needs an EA.	• construct S. Kaukonahua I MU, OIP yrs 5; 2012
Kaluanui to Kaiwikoele PU	• Construct Koloa MU • Collect propagules for genetic storage • Control priority weeds	• MU needs an EA and a license agreement with the landowner, Hawaii Reserves Inc.	• Construct Koloa MU, OIP yr 4; 2011
Lower Opaeula PU	• Construct Lower Opaeula/Peahinaia II MU • Survey known sites and within MU • Collect propagules for genetic storage • Control Priority weeds	• MU has an EA w/ FONSI. • Army still awaiting a license agreement with the landowner, Kamehameha Schools.	• Construct Lower Peahinaia II MU, MIP yr 8; 2011
Palikea gulch PU	• Survey for extant individuals. • Control priority weeds • collect propagules for augmentation and genetic storage testing	• PU occurs within Kaala NAR and the SBMR AA. • Work with State NARS on surveys.	• Conduct surveys OIP yr 2; 2008

11.8 Tier 1:
Huperzia nutans: Taxon Summary and Stabilization Plan

Scientific name: *Huperzia nutans* (Brack.) Rothm.
Hawaiian name: Wawaeiole
Family: Lycopodiaceae (Clubmoss family)
Federal status: Listed endangered (listed as *Lycopodium nutans*)

Requirements for Stability

- 3 population units (PUs)
- Help to develop propagation techniques
- 50 reproducing individuals (short-lived perennial)
- Threats controlled
- Genetic storage collections from all PUs
- Tier 1 stabilization priority: This species was originally listed as a Tier 2 stabilization priority due to the presence of this species within the KLOA and SBER training areas along hiking trails. However, the Army chose to elevate this species to Tier 1 stabilization priority because of its rarity.

Description and biology: *Huperzia nutans* is an herbaceous plant up to 50 cm (20 in) tall. A mature plant consists of a cluster of several erect stems arising from the plant's base. The stems may be unbranched, once-forked, or twice forked. The sterile leaves are lanceolate, 13-20 mm (0.51-0.79 in) long and 2-3.5 mm (0.08-0.14 in) wide, and are arranged in 6 ranks of leaves along the stem. The strobili arise from the ends of all mature branches, curve downward, and are simple, or are branched once or twice. The sterile leaves on the stems gradually transition into the smaller fertile leaves on the strobili. The fertile leaves measure 10-20 mm (0.39-0.79 in) long and 1.5-2.5 mm (0.06-0.10 in) wide, and bear reproductive sporangia in the axils (Degener 1934, Palmer 2003).

Fertile plants of *H. nutans* have been observed at various times of the year. Many species of *Huperzia* are capable of vegetative reproduction through the production of gemmae (a kind of vegetative propagule). *Huperzia nutans,* however, does not reproduce in this manner.

The species can be either terrestrial or epiphytic, however, most of the currently known plants of *H. nutans* are terrestrial. Individuals of the species are widely scattered. To date, no more than two plants have been found at a single location, and the plants are often solitary. Individuals of *H. nutans* are presumed to be relatively short-lived.

The gametophytes of *H. nutans* have not been studied. However, with species of *Huperzia* whose gametophytes have been well studied, the gametophytes grow underground, or if they grow epiphytically, they are buried in the humus on tree trunks or limbs. They lack chlorophyll, are non-photosynthetic, and must form a symbiotic relationship with mycorrhizal fungi to survive.

Known distribution: All records of *H. nutans* are from the Koolau Mountains of Oahu, except for a single collection from Kauai (see Maps 16.36-16.38). The Kauai specimen was collected in the Wahiawa Mountains in the southeastern part of the island, at an unknown elevation. In the Koolau Mountains, *H. nutans* has been documented from elevations of 488 to 646 m (1,600 to 2,120 ft).

Population trends: In a 1934 publication (Degener 1934), Otto Degener, who was a botanist who collected extensively in Hawaii starting in the 1920's, characterized *H. nutans* as being "extremely rare." The botanist William Hillebrand, who collected many Hawaiian plant specimens while residing in Hawaii from 1851 to 1871, wrote that the species was "not common" (Hillebrand 1888). And according to the collection data of the type specimen, which was collected in 1840, the species was "rare (Brackenridge 1854)." These historical reports, together with the fact that the species has seldom been collected, indicate that the plant has been scarce for many years.

At the present time it is not possible to detect any clear trends in population sizes of this species as all of the known plants have been found within the last 15 years. Even over a longer period of time, it would be difficult to obtain data on population trends stemming from the fact that the individual plants of this species are hard to detect and are very sparsely distributed over rough terrain and thick vegetation. Typically, only one or two individual plants are found per spot within a population unit.

Current status: The known plants of *H. nutans* are clustered in two general areas. One is Koolau summit area between Kahana Valley and Kaukonahua Gulch. The second area is in the Koolau summit area where Kawainui, Koloa and Kaipapau Gulches meet. All plants except for two in Kaipapau Valley are within either the KLOA or SBER action areas. The current population units and the number of plants they contain are given in the status table below and their locations are plotted on Figure 11.26.

Habitat: *Huperzia nutans* occurs on the ridge tops to the gulch bottoms. It grows in wet shrublands and forests, often dominated by *ohia lehua* (*Metrosideros* spp.) and *uluhe* (*Dicranopteris linearis*). Common associated species include *mehame* (*Antidesma platyphyllum*), *ohia ha* (*Syzygium sandwicensis*), *kokoolau* (*Bidens macrocarpa*), *kanawao keokeo* (*Broussaisia arguta*), *hapuu* (*Cibotium* spp.), *pilo* (*Coprosma longifolia*), *uluhe lau nui*

(*Diplopterygium pinnatum*), *naenae* (*Dubautia laxa*), *manono* (*Hedyotis terminalis* and *H. fosbergii*), *uki* (*Machaerina angustifolia*), *alani* (*Melicope* spp.), *kolea* (*Myrsine* spp.), *kopiko* (*Psychotria* spp.), and *akia* (*Wikstroemia oahuensis*).

Taxonomic background: *Huperzia nutans*' closest relative is *H. phyllantha*, a species native to Hawaii that occurs from India through Polynesia. *Huperzia phyllantha* is relatively common in many mesic and wet forest areas in Hawaii. It can be found growing near *H. nutans* only at the lower elevations of *H. nutans*' range.

Huperzia nutans is distinguished from *H. phyllantha* by the gradual gradation of its sterile leaves into the fertile leaves of the strobili at the branch tips. It was only a few years ago that it was noticed that there are apparent intermediates between the two species, and that some of the herbarium specimens previously identified as *H. nutans* actually represent these intermediates between *H. nutans* and *H. phyllantha* (W. H. Wagner *et al*. 1999). The type specimen of *H. nutans* may be one of these intermediates (Palmer 2003). If critical examination of the type specimen leads to the conclusion that it is indeed a an intermediate, then the rare species that is now going by the name *H. nutans* will be nameless and will have to be renamed.

The intermediates are probably hybrids between the two species, but it is also possible that they are an intermediate form leading to the development of *H. nutans* as a separate species (Palmer 2003). The intermediate plants sometime resemble one species more than the other. Some of them greatly resemble *H. nutans* vegetatively, so the identification of *H. nutans* appearing plants is difficult if the plants are not reproductive (Lau pers. comm. 2005).

Outplanting considerations: Several *Huperzia* taxa aside from *H. phyllantha* occur in wetter portions of the Koolau Mountains, including *H. erosa*, *H. erubescens*, *H. serrata*, and *H. subintegra*, along with various hybrid combinations of *Huperzia* species (Palmer 2003). No hybridization has been detected between these *Huperzia* taxa and *H. nutans*. As these other *Huperzia* taxa potentially occur naturally with *H. nutans* and none of them are considered rare, *H. nutans* outplanting considerations involving them are minimal.

If *H. nutans* were to be planted near *H. phyllantha* there could be some risk of the two hybridizing. This risk could be minimized by locating *H. nutans* outplanting sites higher in elevation than *H. phyllantha*'s upper elevational limit.

Threats: Threats to *H. nutans* include feral pigs, and competition with non-native plant species such as Koster's curse (*Clidemia hirta*), Hilo grass (*Paspalum conjugatum*), strawberry guava (*Psidium cattleianum*), and Glenwood grass (*Sacciolepis indica*), and trampling by foot traffic.

Threats in the Action Area: Potential threats to *Huperzia nutans* in the action area consist of wildfire caused by training activities, trampling by foot maneuvers, and the introduction of non-native plants via transport of personnel and equipment between training areas. However, the threats from fire and trampling are considered low due to the wet and remote location of the various populations. In addition this species is threatened throughout its range via habitat degradation by feral pigs.

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Huperzia nutans TaxonCode: HupNut

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kahana and North Kaukonahua	Manage for stability	6	0	0	0	0	0	4	0	0	**6**	**0**	**0**	To be managed within North Kaukonahua MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
HupNut.KLO-A	Schofield-Waikane Trail	In situ	1		
HupNut.KLO-B	North Kaukonahua Stream	In situ	1		
HupNut.KLO-D	Joel's	In situ	1		
HupNut.KLO-E	In Loulu grove.	In situ	1		
HupNut.KNA-A	Kahana	In situ	2		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Koloa and Kaipapau	Manage for stability	3	0	0	0	0	0	4	0	0	**3**	**0**	**0**	within Koloa and Kaipapau Mus

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
HupNut.KOL-A	Kahuku Cabin/Koloa side	In situ	1		
HupNut.PAP-A	Kaipapau Joel Lau spot	In situ	2		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
South Kaukonahua	Manage for stability	1	0	0	0	0	0	1	0	0	**1**	**0**	**0**	within South Kaukonahua MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
HupNut.SBE-A	Hakulei	In situ	1		

		NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	
	Total for Taxon:	10	0	0	0	0	0	9	0	0	**10**	**0**	**0**	

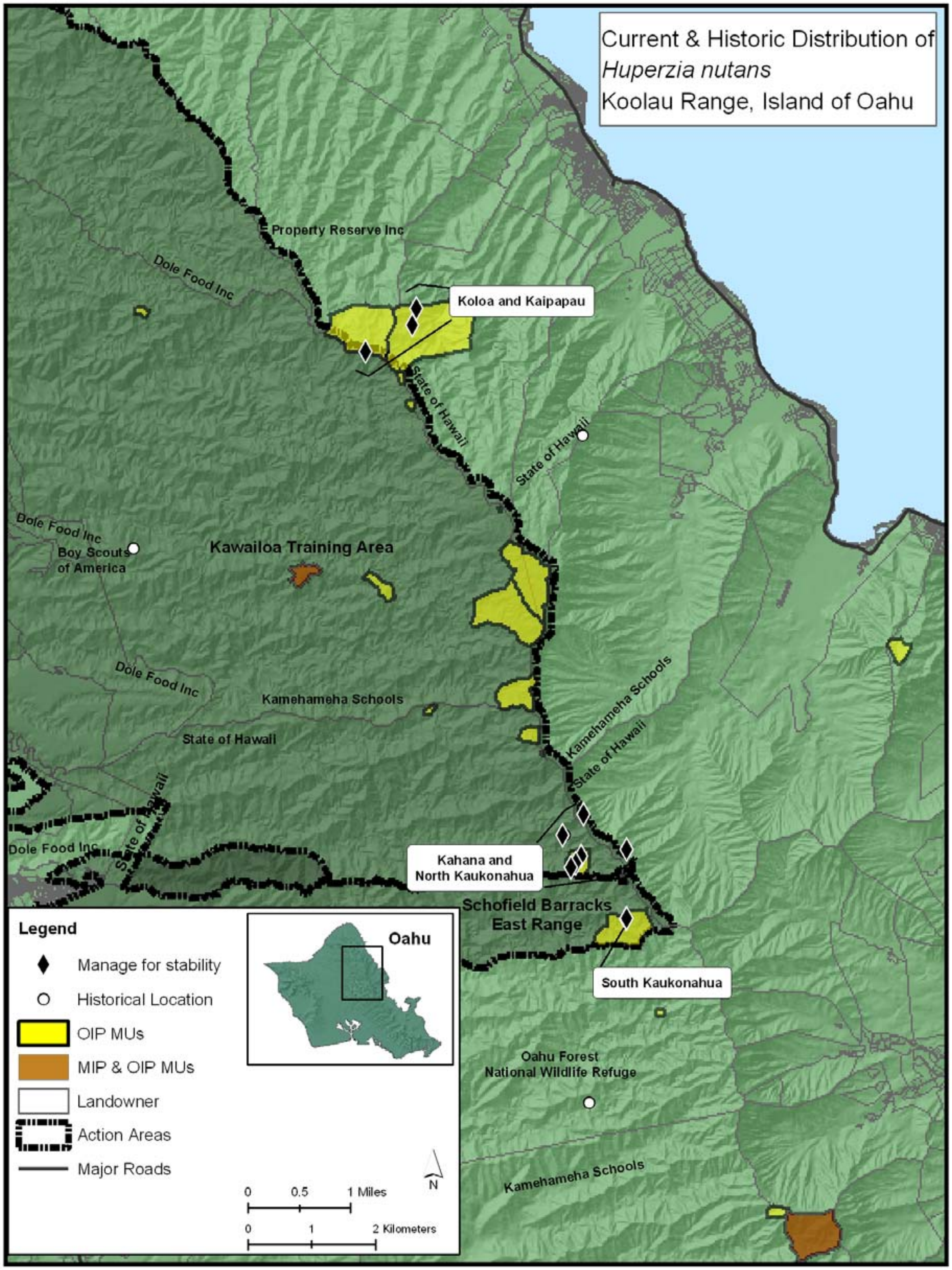


Figure 11.18 Current and Historical distribution of *Huperzia nutans* in the Northern Koolau Mountains of Oahu.

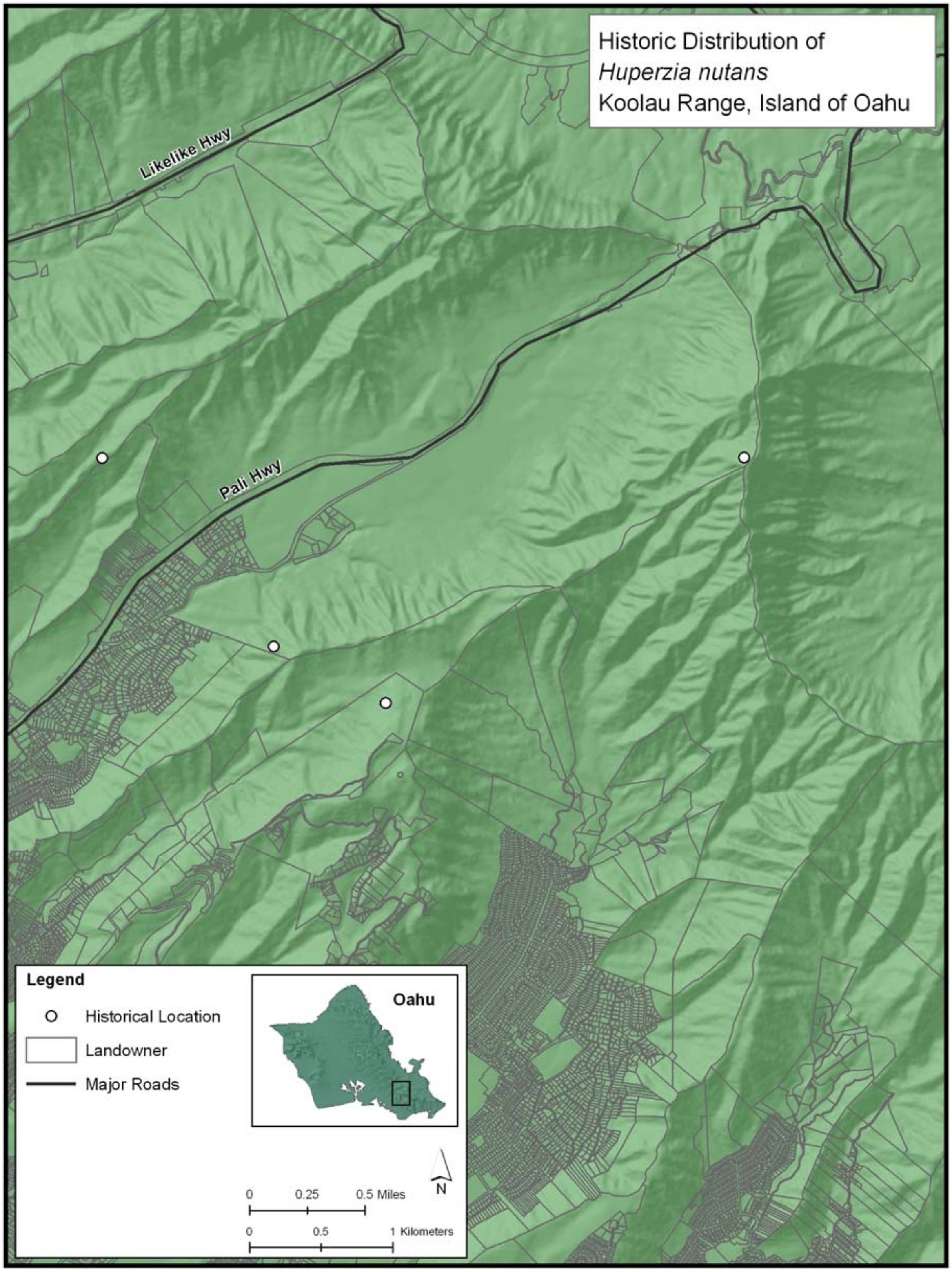


Figure 11.19 Historical distribution of *Huperzia nutans* in the Central Koolau Mountains, Oahu.

Discussion of Management Designations

There are only three known PUs of this species. They are all designated as manage for stability.

Propagation and Genetic Storage

In order to develop propagation protocols, the Army made collections of cuttings from *H. phyllantha* from the Poamoho Trail in February 2007. Propagation techniques were determined based on correspondence with Chad Husby, a fern ecophysiologist at Florida International University. Our trial indicated that a specific method of preparation was successful in producing roots, new vegetative growth and strobili, although six months elapsed prior to new growth. *H. phyllantha* will continue to be used to develop additional *in situ* propagation protocols (including air layers and variations of air layers) prior to working with *H. nutans*. Clones of *H. phyllantha* will also be grown in the nursery prior to clonal collection from *H. nutans*. Spore storage may be explored as a potential genetic storage method, as well as micropropagation techniques to maintain sporophytes (from spores) as another *ex situ* storage method. Both spores and cuttings have been attempted at the Harold L. Lyon Micropropagation Lab with no success. *Ex situ* protocols need to be studied for sporophyte production from spore collections. Spores of *H. phyllantha* may be collected to help develop protocols. Efforts to create successful vegetative propagation protocols will be developed prior to *ex situ* spore germination studies. Ideally, a living collection of *H. nutans* will eventually be created via clonal propagation of all wild plants. Additional plants will be propagated from this living collection to establish augmentations or reintroductions and meet genetic storage goals.

The Army recognizes that reintroductions are necessary for this species to reach stability. The scarcity of plant material, however, is severely limiting propagation techniques. At this time, the emphasis will be to reintroduce clones and allow them to sexually reproduce *in situ* within PUs. Mixing between PUs will need to be discussed with the OIT when propagation techniques are developed and plants from multiple PUs become available for reintroduction. As more information is gathered, priorities will adjust accordingly.

Research Issues

The main priority for research is developing propagation techniques. Due to the low number of extant individuals and the risk of removing material from the known plants, more testing should be done on the more common *H. phyllantha*. Vegetative-propagation techniques will continue to be tested at the Army Nursery. Strobili collections will also be made to experiment with spore germination at the Lyon Arboretum Micropropagation Laboratory.

Management Notes

Stabilization target numbers can only be reached for managed PUs if propagation techniques become available. It appears the target number of 50 individuals is arbitrary as the largest PU contains six individuals within $1000m^2$. If propagation techniques make reintroduction a possibility, the target number for stability will need to be readdressed in order to prevent creating unnatural densities of this species in the field.

The top priority for this species is the development of propagation techniques. New propagule collection techniques and testing should continue on *H. phyllanthus* rather than *H. nutans*. If a successful propagation technique is developed the Army will make genetic storage collections from all existing individuals. Surveys for additional individuals and protection from ungulates are also priorities. The Army will work with the Oahu Plant Extinction Prevention (OPEP) program in the management of this species.

The **Koloa and Kaipapau PU** consists of two individuals. The Koloa individual has several above ground stalks and has been monitored since 3/2001, and the other (in Kaipapau) has not been monitored by the Army. These plants will be protected within the Koloa and Kaipapau MUs. Ungulate protection is a high priority for both individuals in this PU.
One individual in the **Kahana and North Kaukonahua PU** has been monitored since 7/1996. Several of the plants have been observed reproductive. However, no immature plants have been seen. Three of the six individuals will be protected within the North Kaukonahua MU. Surveys and monitoring are high priorities for this PU. Monitoring of individuals that will not be protected within the proposed MU are needed to determine if small fences are necessary to protect these individuals while propagation techniques are being developed.
The **South Kaukonahua PU** contains just one individual known since 1999. It will be protected within the South Kaukonahua I MU. Surveying and monitoring are high priorities for this PU.

Table 11.9 Priority Management Actions for *Huperzia nutans* Army Stabilization PUs.

Population Unit	Specific Management Actions	Partners/Concerns	Timeline
Koloa and Kaipapau PU	• Construct Koloa and Kaipapau MU Fences • Control priority weeds	• MUs need an EA and license agreement with landowner, Hawaii Reserves Inc. and the State of Hawaii.	• construct Koloa MU. OIP yr 4; 2011 • construct Kaipapau MU. OIP yr 5; 2012
North Kaukonahua PU	• Construct North Kaukonahua MU Fence • Monitor individuals outside proposed MU to determine fencing needs • Control priority weeds	• This MU needs an EA. • Within proposed Poamoho NAR.	• construct North Kaukonahua MU. OIP yr 7; 2014
South Kaukonahua PU	• Construct South Kaukonahua II MU Fence • Control priority weeds	• This MU needs an EA.	• construct South Kaukonahua MU. OIP yr 6; 2013

11.9 Tier 1:
Labordia cyrtandrae: Taxon Summary and Stabilization Plan

Scientific name: *Labordia cyrtandrae* (Baill.) St. John
Hawaiian name: Kamakahala
Family: Loganiaceae (Logania family)
Federal status: Listed endangered

Requirements for Stability

- 100 individuals from East Makaleha to North Mohiakea (serves as 2 PUs), 50 individuals from the Manana area (long-lived perennial; dioecious; low seed set)
- Threats controlled
- Genetic storage collections from
- Tier 1 stabilization priority

Description and biology: *Labordia cyrtandrae* is a shrub 0.7-1.5 m (2.3-4.9 ft) tall with opposite leaves that are crowded at branch tips. The leaf blades are 15-30 cm (6.0-12 in) long and 4-14 cm (1.6-5.5 in) wide. The upper surfaces of the leaves are glabrous and the lower surfaces are moderately or sometimes sparsely hairy. The flowers are borne 8-80 or more in compound paniculate cymes. The flowers' corollas are tubular, pale greenish yellow or pale yellow, and measure 20-35 mm (0.79-1.4 in) in length. The capsules are lanceoloid-ellipsoid in shape, and are 32-35 mm (1.3-1.4 in) long.

Labordia cyrtandrae is sporadically fertile year round, but is most often observed flowering from May through June and fruiting from July through August. The plants are functionally dioecious, with male and female flowers on separate plants. *Labordia cyrtandrae* belongs to a section of the genus whose species are apparently bird pollinated (Motley and Carr 1998). Upon ripening, *Labordia* fruits split open to reveal their juicy, orange to greenish pulp, in which are embedded numerous seeds. This suggests that fruit eating birds act as dispersal agents for *Labordia* species. A small amount of vegetative reproduction has been observed in *L. cyrtandrae*, where branches have rooted to form separate individuals.

The number of years it takes to reach maturity is unknown. The species has been in cultivation now for at least 5 years. For the purposes of this Implementation Plan, *L. cyrtandrae* is categorized as a long-lived species.

Known distribution: *Labordia cyrtandrae* is endemic to Oahu and is known from both the Waianae and Koolau Mountains. In the Koolaus the species has been documented from various locations along the mountain range on both the windward and leeward sides. In the Waianaes, the species has been recorded primarily from the windward slopes of the mountain range from Kaala to Puukalena. A specimen of *L. cyrtandrae* collected in 1909 in Makaha Valley represents the only record of the species on the leeward side of the mountain range. The elevational range for the species in the Waianae Mountains is 744-1,137 m (2,440 ft to 3,730 ft), and 430-701 m (1,411 ft to 2,300 ft) in the Koolau Mountains.

Population trends: Population trends for *L. cyrtandrae* in the Waianae Mountains are not clear since all of the plants known today were found only within the last 15 years. However, the number of populations in the Koolau Mountains appears to have declined since the 1800s based on the historical record. The species had been found in at least 10 locations in the Koolaus into the 1930s, whereas from the 1940s until today the species has been found at only two locations in the Koolaus. Furthermore, the two plants at one of these locations have died since their discovery, leaving only a single known location for *L. cyrtandrae* in the Koolau Mountains.

Current status: A single individual of *L. cyrtandrae* is known to remain in the Koolau Mountains. It is located in Manana Gulch in the central leeward part of the mountain range. In the Waianae Mountains, *L. cyrtandrae* is known from the windward side of the mountain range in the gulches of Haleauau, North Mohiakea and East Makaleha, with a total of 70 plants. Three of these plants are located within the SBMR action area. Although only a few plants of *L. cyrtandrae* are known, there is still much unexplored potential habitat, particularly in the Koolau Mountains. The current population units and the number of plants they contain are given in the status table below and their locations are plotted on Figures 11.15-16.

Habitat: *Labordia cyrtandrae* typically grows in gulch bottoms, and on gulch slopes, sometimes in steep terrain. In the Koolau Mountain Range, *L. cyrtandrae* has only been found in wet vegetation. In the Waianae Mountains it occurs mostly in wet vegetation, but extends into the mesic forests as well. In both mountain ranges, the *L. cyrtandrae* habitats are often dominated by *ohia lehua* (*Metrosideros polymorpha*) and *uluhe* (*Dicranopteris linearis*). In the Waianae Mountains, other common associated native species include *Boehmeria grandis*, *mamaki* (*Pipturus albidus*), *haiwale* (*Cyrtandra waianaensis*), and *olomea* (*Perrotettia sandwicensis*).

Taxonomic background: *Labordia* is an endemic Hawaiian genus with 15 species. *Labordia cyrtandrae* is most similar to *L. hirtella*, which occurs on several islands including Oahu (Wagner *et al*. 1990).

Outplanting considerations: The range of *L. cyrtandrae* overlaps the ranges of several other species of *Labordia*. In the Waianae Mountains, the *Labordia*s potentially occurring near *L.*

cyrtandrae are *L. waiolani*, *L. kaalae*, and *L. tinifolia*. In the Koolau Mountains, the potential species are *L. sessilis*, *L. fagraeoidea*, *L. hosakana*, *L. tinifolia*, *L. hirtella*, and *L. waiolani*.

A study involving artificial hybridization of various species of *Labordia*, including *L. cyrtandrae*, has shown that there is a lack of genetic barriers that prevent hybridization between *Labordia* species. While natural hybridization could possibly occur in *Labordia* due to the lack of genetic barriers, it apparently rarely happens among *Labordia* species at present (Motley and Carr 1998). Some *Labordia* plants have been suspected to be hybrids (Wagner *et al.* 1990), but these suspicions have not been verified. Hybridization concerns with respect to the outplanting of *L. cyrtandrae* are therefore minimal.

Threats: In the Koolau Mountains the primary threats to *L. cyrtandrae* are alien plants and feral pigs. In the Waianaes, feral goats represent an additional threat. The primary alien plant threats in the Koolau Mountains are Koster's curse (*Clidemia hirta*), and strawberry guava (*Psidium cattleianum*). In the Waianaes, the worst weed threats to the species include prickly Florida blackberry (*Rubus argutus*), strawberry guava, Koster's curse, and Christmas berry (*Schinus terebinthifolius*).

Threats in the Action Area: Within the action area *Labordia cyrtandrae* is potentially threatened by wild fire and the introduction of non-native species spread by movement of personnel and equipment from one training area to another. However, the threat of fire where individuals occur ranges from low to none. The majority of the plants have no fire threat. Additionally this species is threatened throughout its range by fruit predation by insects, habitat destruction by feral pigs, and non-native plant species such as *Rubus argutus*.

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Labordia cyrtandrae TaxonCode: LabCyr

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
East Makaleha to North Mohiakea	Manage for stability	69	0	2	15	16	0	39	1	0	**84**	**16**	**2**	Most individuals will be protected within the East Makaleha and Kaala Mus; all individuals outside these MUs (SBW) will be represented ex situ.
	Total for Taxon:	69	0	2	15	16	0	39	1	0	**84**	**16**	**2**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
LabCyr.ALA-A	Kaala Summit-view of electric pole ridge	Reintro	10		
LabCyr.ALA-B	Ka'ala radio tower, crater rim	Reintro	4		
LabCyr.ALA-C	Ka'ala, radio tower road	Reintro		4	
LabCyr.ALA-G	Kaala, South of Balls	In situ	6		
LabCyr.ALA-H	Kaala, North of Balls	In situ	3		
LabCyr.ALA-I	840 on the transect	In situ	1		
LabCyr.ALA-J	on Hale'au'au fence line	In situ	1		
LabCyr.ALA-K	Rainbow ridge	In situ	10		
LabCyr.ALA-L	gulch just below SW end of Hale'au'au fence	In situ	8		2
LabCyr.ALA-M	Smeagol gulch	In situ	1		
LabCyr.ALA-N	down 320 ridge bowl on right	In situ	2		
LabCyr.ALA-O	Blue Trail Re-intro	Reintro	1	12	
LabCyr.ALA-P	Near ledge fence piece	In situ	16		
LabCyr.KAO-A	Kaumokunui	In situ	8		
LabCyr.LEH-A	East Makaleha, Culvert-56/57	In situ	1		
LabCyr.LEH-B	East Makaleha, Culvert-56/57	In situ	3		
LabCyr.LEH-C	East Branch of East Makaleha Culvert 69	In situ	1		
LabCyr.LEH-D	East Makaleha First gulch West of DuPont Tr.	In situ	1		
LabCyr.SBW-A	Water Gulch	In situ	2		
LabCyr.SBW-B	Banana Gulch	In situ	0	0	0
LabCyr.SBW-C	Hame Ridge	In situ	4		
LabCyr.SBW-D	Water, Kolekole side gulch off of main gulch	In situ	1		

Action Area: Out

TaxonName: Labordia cyrtandrae   TaxonCode: LabCyr

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Manana	Manage for stability	1	0	0	0	0	0	1	1	0	**1**	0	0	To be protected within the Manana MU;
	Total for Taxon:	1	0	0	0	0	0	1	1	0	**1**	0	0	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
LabCyr.ANA-A	Manana Gulch	In situ	1		

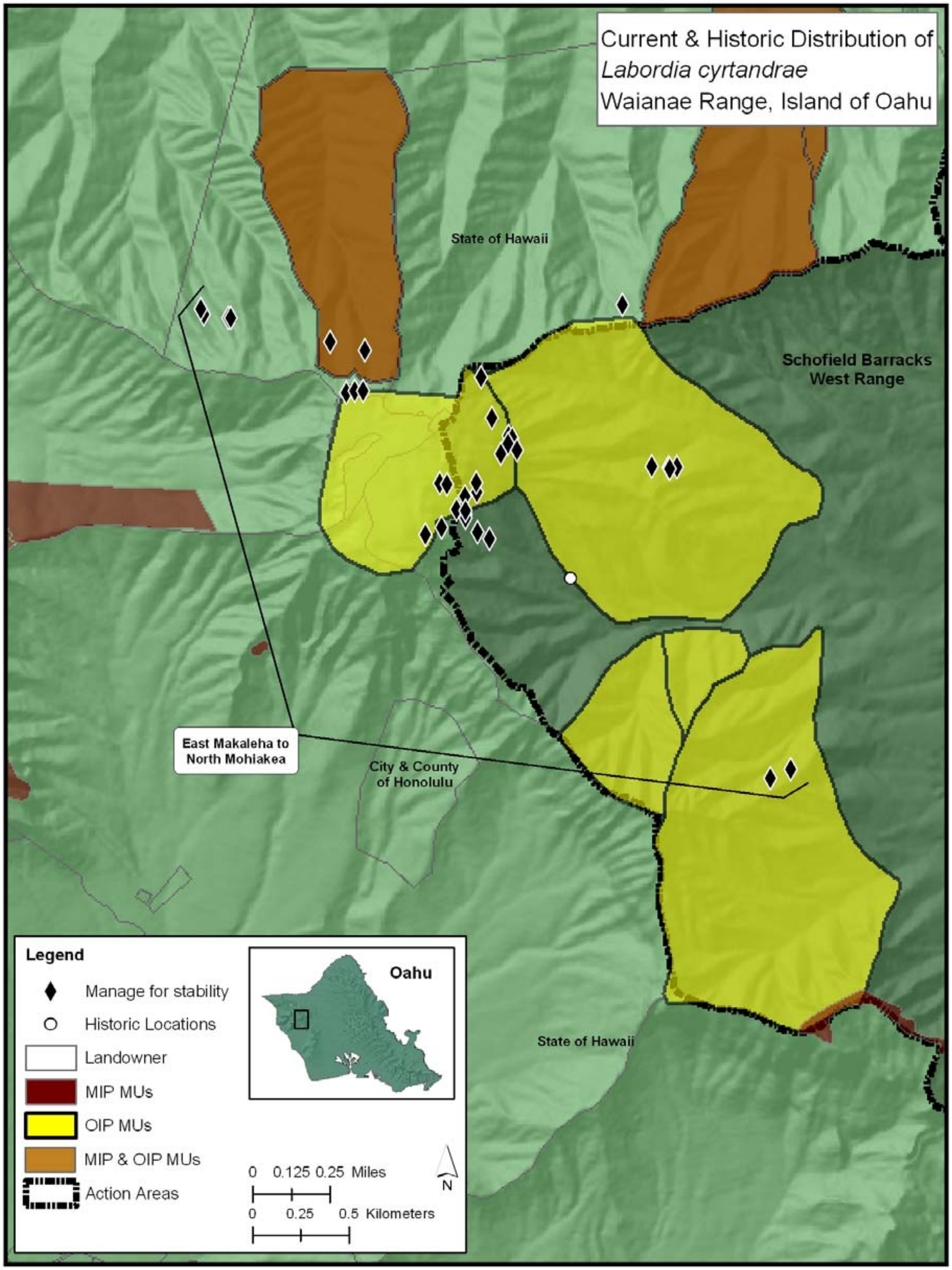


Figure 11.20 Current and historical distribution of *Labordia cyrtandrae* in the Waianae Mountains of Oahu.

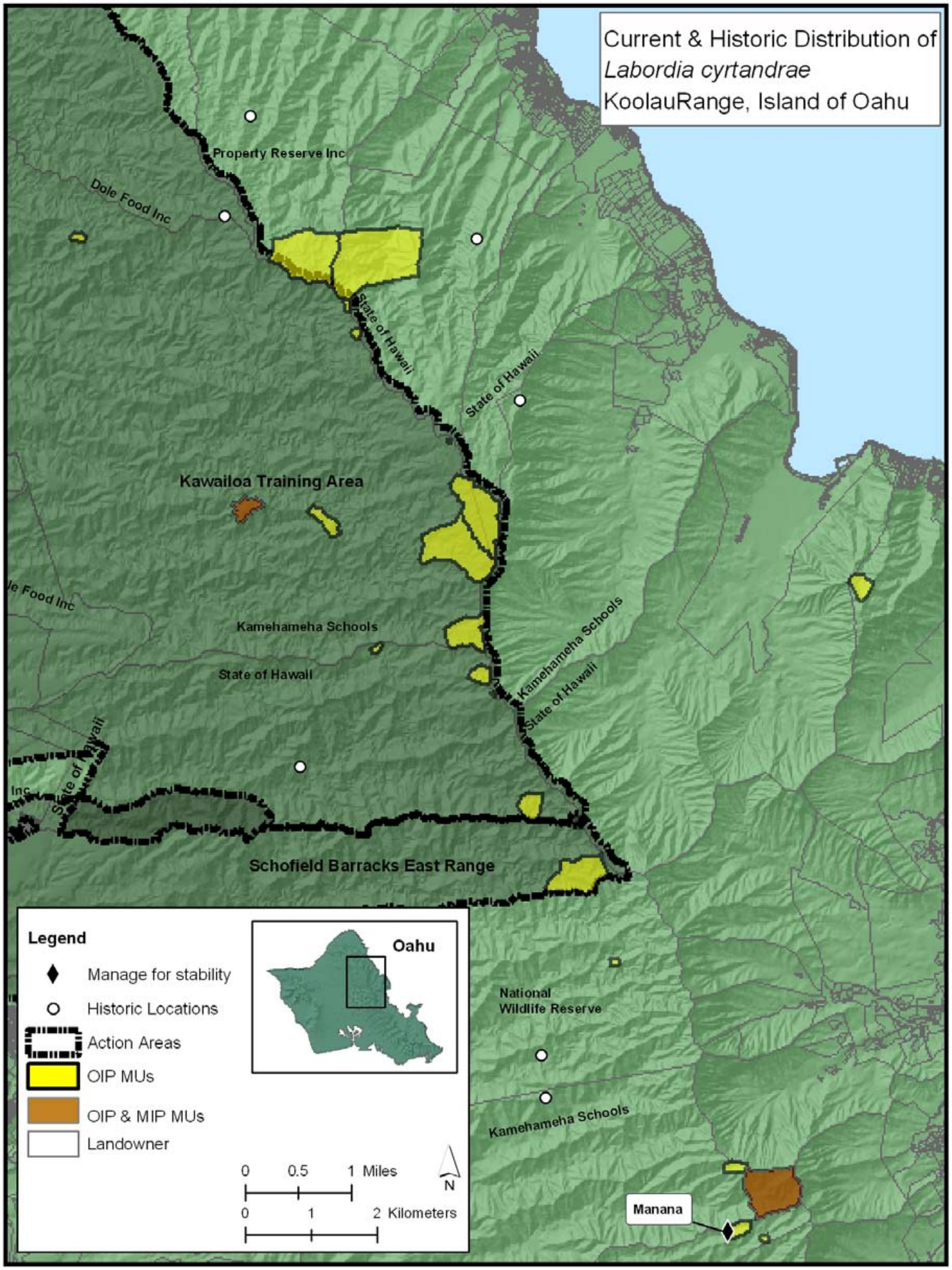


Figure 11.21 Current and historical distribution of *Labordia cyrtandrae* in the northern Koolau Mountains, Oahu.

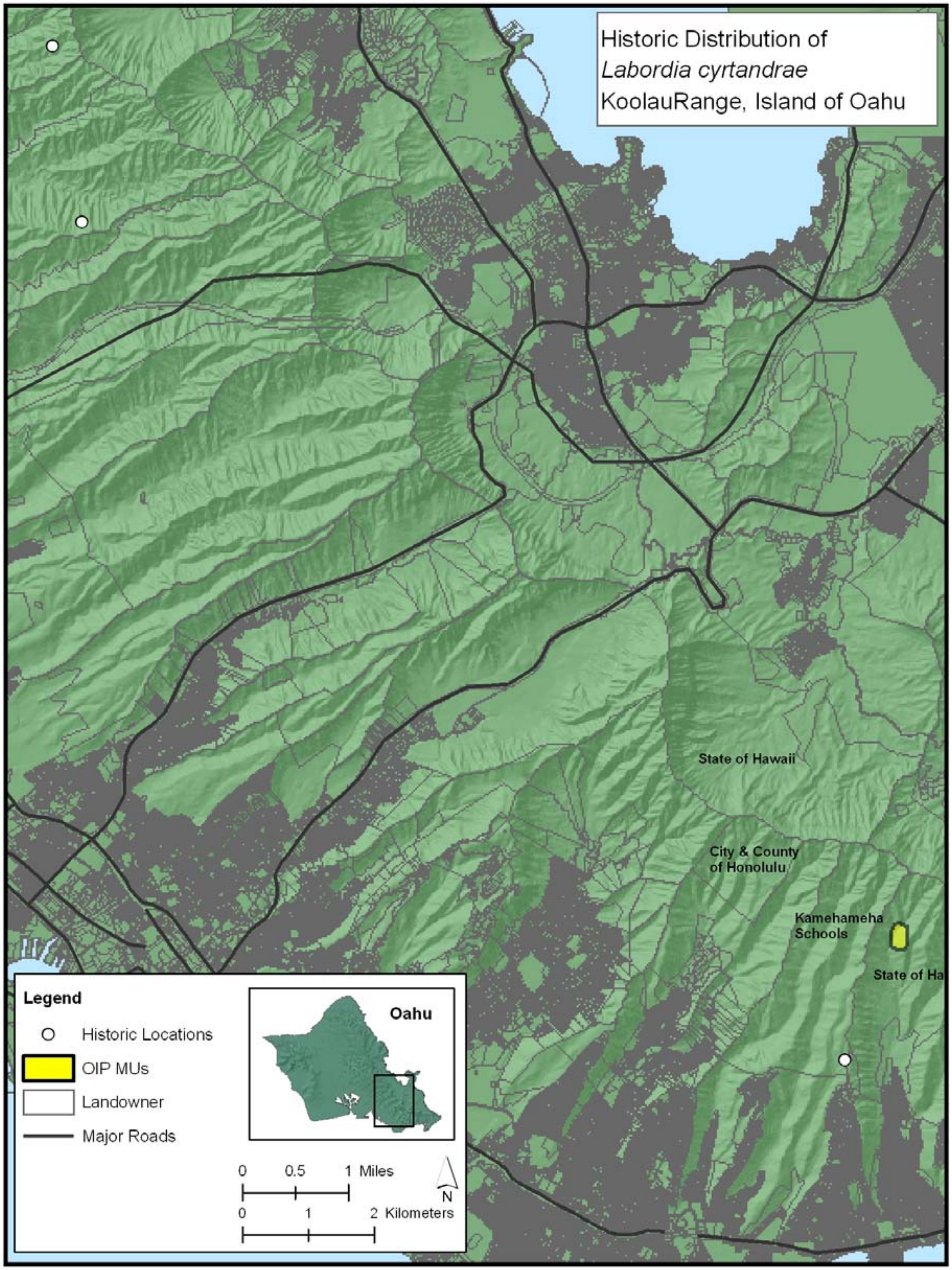


Figure 11.22 Historical distribution of *L. cyrtandrae* in the southern Koolau Mountains, Oahu.

Discussion of Management Designations

The current center of abundance for this species is around Mount Kaala, in the Waianae Mountains. This large population was likely contiguous from Mohiakea gulch to East Makaleha. Stabilization of this PU will involve management from several access points including Haleauau gulch, Kaala, and East Makaleha. The stabilization target numbers for this PU are doubled to represent two manage for stability populations. If a third population is discovered the OIT will determine a new stabilization strategy for this species. Strategic fencing around the Kaala area will protect most of the known individuals. Several individuals also fall within the East Makaleha MU. There are also a few individuals that will be protected within the North Haleauau MU. There are currently no known individuals in Mohiakea gulch. There are numerous historical accounts of this species in the Koolaus, however currently there is just one plant known. This plant will be protected within the proposed Manana MU. Surveys throughout the Koolau Mountains are needed to locate possible additional individuals.

Propagation and Genetic Storage

Vegetative cuttings taken from *in situ* individuals have never rooted, although air layering is a viable option. For many reasons, it has been difficult to collect mature viable seeds from wild plants. First, the fruit take several months to develop and it is difficult to determine maturity. Second, fruit appear to be bored by an insect and seed predation is commonly observed. Third, plants are dioecious, and many fruit have been observed intact (seed predation absent) with empty seeds (no embryos). This suggests that females may produce fruit regardless of fertilization. With pollen dispersal and range unknown, it is not clear how regularly female individuals are pollinated, regardless of male proximity. There are three known sites where viable seed has been collected and each of these sites has a known reproductive male. Viable mature and immature seed delivered to the Harold L. Lyon Micropropagation Lab has germinated, propagated *in vitro*, grown in the nursery, and successfully outplanted. Mature seed has also been propagated without tissue culture techniques. No initial viability tests were conducted on these collections, so the seed quality of these two collections remains uncertain. Since viable seed is rare, efforts are currently aimed at increasing seed production of *ex situ* collections. These collections have produced enough seed to initiate seed storage studies, though more will be collected to continue testing and propagate plants for reintroductions. Fresh *in situ* pollen collections successfully fertilized nursery stock. Pollen storage studies suggest that pollen is inviable after one year of storage, though only one treatment was tested and more will be explored. However, approximately one-half of the taxa in the family Loganiaceae (in which *Labordia* is placed) present trinucleate pollen at anthesis. Trinucleate pollen grains are short-lived and typically do not tolerate desiccation and are therefore incapable of long-term storage (Brewbaker 1967). Additional storage research will continue to try and extend pollen longevity throughout the flowering season, as different individuals flower later than others with very little overlap.

There are 71 plants that are considered potential *in situ* founders. Of these 63, 21 are known female, five are male including the Manana plant and the rest are still unknown. The establishment of a living collection grown from air layers of all 63 founders has been initiated. Prioritization of air layer installation is as follows: 1) all males; 2) unknowns in underrepresented sites; 3) unknowns in represented sites; 4) collect from females not within an ungulate fence; 5) collect from females to accomplish even representation throughout sites.

Since there are so few males, focusing efforts on unknown individuals may increase the number of known males. Including the flowering females already present in the nursery, this approach will hopefully create a living collection with sufficient flower production for hand pollination trials and enough seed for storage research and reintroduction. The living collection will be used to meet genetic storage goals until seed storage protocols are established. Males will continue to be clonally propagated *ex situ* to augment into wild sites currently void of males. An inter-situ site may also be established with clonal stock as a seed source for reintroductions and genetic storage.

Brewbaker, J.L. The distribution and phylogenetic significance of binucleate and trinucleate pollen grains in the angiosperms. *American Journal of Botany* **54**(9): 1069.

Genetic Storage Summary

Population Unit Name	# of Potential Founders: Current Mature	Current Imm.	NumWild Dead	Partial Storage Status: # Plants >= 10 in Seedbank	# Plants >=1 Microprop	# Plants >=1 Army Nursery
Labordia cyrtandrae						
East Makaleha to North Mohiakea	70	0	2	2	4	11
Manana	1	0	0	0	0	0
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**
				2	4	11

Outplanting Issues: Four outplanting sites have been established inside the Kaala MU to augment the East Makaleha to North Mohiakea PU. Three are on State land and the other site is planted on Army land on Schofield Barracks West Range (SBW). The stock was grown from both seed and air layers collected from plants in the East Makaleha to North Mohiakea PU. No stock from the Makaleha section of this PU has been outplanted yet. Survivorship in all sites has been high (33/38) and plants grown from air-layers have begun to flower. NRS will continue to augment the site on SBW and will search for additional outplanting sites in the coming year. As discussed in the Propagation and Genetic Storage section above, the stock from hand-pollinated fruit in the reintroduction sites and the greenhouse will be used for propagation and storage testing. Once germinated, the plants will be used to supplement the SBW reintroduction.

Research Issues: Research on the black twig borer may help protect this species. This threat and other insect predation may contribute to the little/ low recruitment.

Management Notes

Due to the restricted range and numbers of individuals this species has only two PUs. The **East Makaleha to North Mohiakea PU** will be managed across the PU within the Kaala, East Makaleha, and North Haleauau MUs. All the previously known plants in Lower Mohiakea have

died. Any individuals that fall outside proposed MUs will also be the first priority for propagation. Priorities for the Kaala area are to airlayer as many individuals as possible for genetic storage and outplanting (see genetic storage section).
The **Manana PU** contains a single individual that is monitored regularly by the Oahu Plant Extinction Prevention (OPEP) program. This individual appears to be male and will be crossed with stock from the East Makaleha to North Mohiakea PU in the greenhouse. Pollen from this individual has been collected and is being stored for crossing. Surveys of historical sites in the Koolaus area high priority. Plans for augmentation to this PU will not be solidified by the Army and/or the OIT until the surveys are conducted.

Table 11.10 Priority Management Actions for *Labordia cyrtandrae* Army Stabilization PUs.

Population Unit/Subunit	Specific Management Actions	Partners/Concerns	Timeline
Haleauau (North Haleauau MU)	• Airlayer and/or collect seed to represent plants prior to fence construction	• Access is difficult to SBMR	• OIP yr 1; 2008 • construct North Haleauau MU, OIP yr 3; 2010
East Makaleha (East Makaleha MU)	• Fence East Makaleha MU • Control priority weeds • Survey • Airlayer from unrepresented individuals	• MU has an EA w/ FONSI. • State Forest Reserve.	• construct MU, MIP yr 7; 2010
Kaala (Kaala MU)	• Complete strategic fenceline • Control priority weeds • Determine sex of known plants • Continue airlayering unrepresented individuals • Monitor outplanting	• Kaala MU 90% secure. • Work with State NARS.	• ongoing
Manana (Manana MU)	• Survey • Construct Manana MU • Control priority weeds	• MU needs an EA. • State Forest Reserve.	• construct MU, OIP year 5; 2012

11.10 Tier 1:
Melicope lydgatei: Taxon Summary and Stabilization Plan

Scientific name: *Melicope lydgatei* Hillebr.
Hawaiian name: alani
Family: Rutaceae (Rue family)
Federal status: Listed endangered

Requirements for Stability

- 3 population units (PUs)
- 50 reproducing individuals (long-lived perennial with threats from invertebrates)
- Threats controlled
- Surveys to find one additional PU
- Genetic storage collections from all PUs
- Tier 1 stabilization priority: This species was originally listed as a Tier 2 stabilization priority due to the presence of this species within the KLOA training area along hiking trails. However, the Army chose to elevate this species to Tier 1 stabilization priority because of its rarity.

Description and biology: *Melicope lydgatei* is a shrub with pubescent new growth, with the leaves becoming glabrous with age. The leaves are opposite or ternate (leaves borne three per node), oblanceolate to obovate, oblong, or sometimes oblong-ovate, 4-13 cm (1.6-5.1 in) long, and 1.5-6.5 cm (0.59-2.6 in) wide. The greenish white flowers are borne 1-3 in axillary cymes. The flowers are functionally unisexual or rarely perfect. The capsules are 14-22 mm (0.55-0.87 in) wide and 7-11 mm (0.28-0.43 in) long. The four carpels of the capsule are joined for 1/4 to 1/3 of their length. Each carpel contains 1 or 2 seeds that are glossy and black, and about 5 mm (0.20 in) long.

Flowering and fruiting in *M. lydgatei* appears to occur year round. It is not known if the plants are self-compatible. The species is presumably insect pollinated. The seeds of this species may be bird-dispersed, since as the capsules mature and dry, they split open to reveal the glossy black seeds, which remain attached to the capsule for some time. The species is a long lived plant.

Known distribution: *Melicope lydgatei* is endemic to the Koolau Mountains, and it has been recorded on both the windward and leeward sides of the mountain range. Recorded elevations for this species range from 396 to 640 m (1,300 to 2,100 ft).

According to Stone *et al*. 1990, *M. lydgatei* has been recorded from three disjunct areas of the Koolau Mountains - Hauula to Kahana on the windward side of the mountain range, the area of Manana and Waimano in the leeward central Koolaus, and Palolo to Wailupe in the leeward southern Koolaus (see Maps 16.42 and 16.43). However, some historical specimens from locations outside these three areas had been overlooked, for instance specimens collected from the Helemano-Opaeula Ridge, the Helemano-Poamoho Ridge, Kipapa, and Kalihi. Furthermore, the species has recently been found off the Kawailoa Trail in the northern portion of KLOA, farther north than any previously documented locations. So it would be inaccurate to consider the species as being naturally limited to three separate areas of the Koolau Mountains. Instead, the historical range of the species should be considered to include all sections of the mountain range.

Population trends: As most of the plants of *M. lydgatei* known today were found only within the last 10 years, too short a time has passed for population trends to be evident. However, it seems certain that the species in general has been declining in light of the paucity of recorded observations in recent decades.

Current status: All of the plants of *M. lydgatei* known to be extant are in KLOA. The largest concentration of plants is on the ridge between Helemano and Opaeula Gulches, where approximately 38 individuals have been located. A single plant that was found off the Poamoho Trail on the Helemano-Poamoho Ridge a few years ago is now dead. Recently, in 2004, the species was found off the Kawailoa Trail in the northern part of KLOA, where the species had not been previously recorded. There are three plants in that area. Outside KLOA, there are only two records of the species since the 1930s. The records are two specimens collected by Kenneth Nagata. One of his specimens was collected on Wiliwilinui Ridge in the leeward southern Koolau Mountains in 1966 (*Nagata 478*, HLA), and the other was collected in 1983 on the ridge between Manana and Waimano Gulches in the leeward central Koolaus (*Nagata 7819*, HLA). The current population units and the number of plants they contain are given in the status table below and their locations are plotted on figure 11.28-29.

Habitat: *Melicope lydgatei* is known from mesic and wet forests usually dominated by *ohia lehua* (*Metrosideros* spp.) and *uluhe* (*Dicranopteris linearis*), and sometimes *koa* (*Acacia koa*). Other common native associates include *mehame* (*Antidesma platyphyllum*), *kopiko* (*Psychotria* spp.), *ahakea* (*Bobea elatior*), *hapuu* (*Cibotium* spp.), and ohia ha (*Syzygium sandwicensis*).

Taxonomic background: *Melicope* is a large Pacific genus. There are 48 species of *Melicope* native to Hawaii (Wagner *et al*. 1999). The Hawaiian species of *Melicope* had long been placed in the genus *Pelea*, which was thought to be comprised of the Hawaiian species of *Melicope* in addition to two species in the Marquesas Islands.

Outplanting considerations: No hybrids have ever been reported among the Hawaiian species of *Melicope* (Stone *et al*. 1990), so hybridization concerns in the outplanting of *M. lydgatei* are minimal.

As discussed above in the Known Distribution section, the historical range of *M. lydgatei* should be considered to include the entire Koolau Range, and if any outplantings of the species are to be established in the future, suitable habitat throughout the Koolaus can be considered as potential outplanting areas.

Threats: Major threats to *M. lydgatei* include feral pigs and invasive alien plant species. The species is potentially threatened by fire. The black twig borer (*Xylosandrus compactus*) may represent a threat to *M. lydgatei*.
Threats in the Action Area: Potential threats to *Melicope lydgatei* in the action area consist of trampling of seedlings by foot maneuvers, fire and the introduction of non-native plants via transport of personnel and equipment between training areas. However, the threats of trampling and fire are very low for the habitat occupied by this species. Additional threats to this species throughout its range include habitat degradation by feral pigs, predation by the black twig borer, and competition from non-native plant species.

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Melicope lydgatei TaxonCode: MelLyd

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaiwikoele-Kawainui Ridge	Manage for stability	3	0	0	0	0	0	3	0	0	3	0	0	Kawailoa MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
MelLyd.KLO-K	Kawailoa Trail	In situ	3		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kawaiiki and Opaeula	Manage for stability	43	0	0	0	0	0	16	0	0	43	0	0	Lower Opaeula MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
MelLyd.KLO-A	Lowest Peahinaia	In situ	0		
MelLyd.KLO-B	Mid Peahinaia	In situ	2		
MelLyd.KLO-C	Mid Peahinaia	In situ	2		
MelLyd.KLO-D	By JoiAsc	In situ	1		
MelLyd.KLO-E	Peahinaia Flats	In situ	4		
MelLyd.KLO-F	B/t Curta and Melicope Puu	In situ	5		
MelLyd.KLO-G	B/t Puu Ohe Naupaka and Puu Melicope	In situ	2		
MelLyd.KLO-I	North of Frogpond	In situ	3		
MelLyd.KLO-J	Near landslide	In situ	1		
MelLyd.KLO-L	South of Puu Curta	In situ	21		
MelLyd.KLO-M	Puu Curta slope to Frogpond JGs	In situ	1		
MelLyd.KLO-N	Opaeula Stream north side	In situ	1		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Poamoho	Genetic Storage	0	0	0	0	0	0	1		0	0	0	0	Historical population for re-survey.

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
MelLyd.KLO-H	Poamoho Trail, near snail tree (DEAD)	In situ	0		

		NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling
	Total for Taxon:	46	0	0	0	0	0	20	0	0	46	0	0

Action Area: Out

TaxonName: Melicope lydgatei

TaxonCode: MelLyd

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Manana	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	Historical Populations for re-survey.
	Total for Taxon:	0	0	0	0	0	0	0	0	0	0	0	0	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

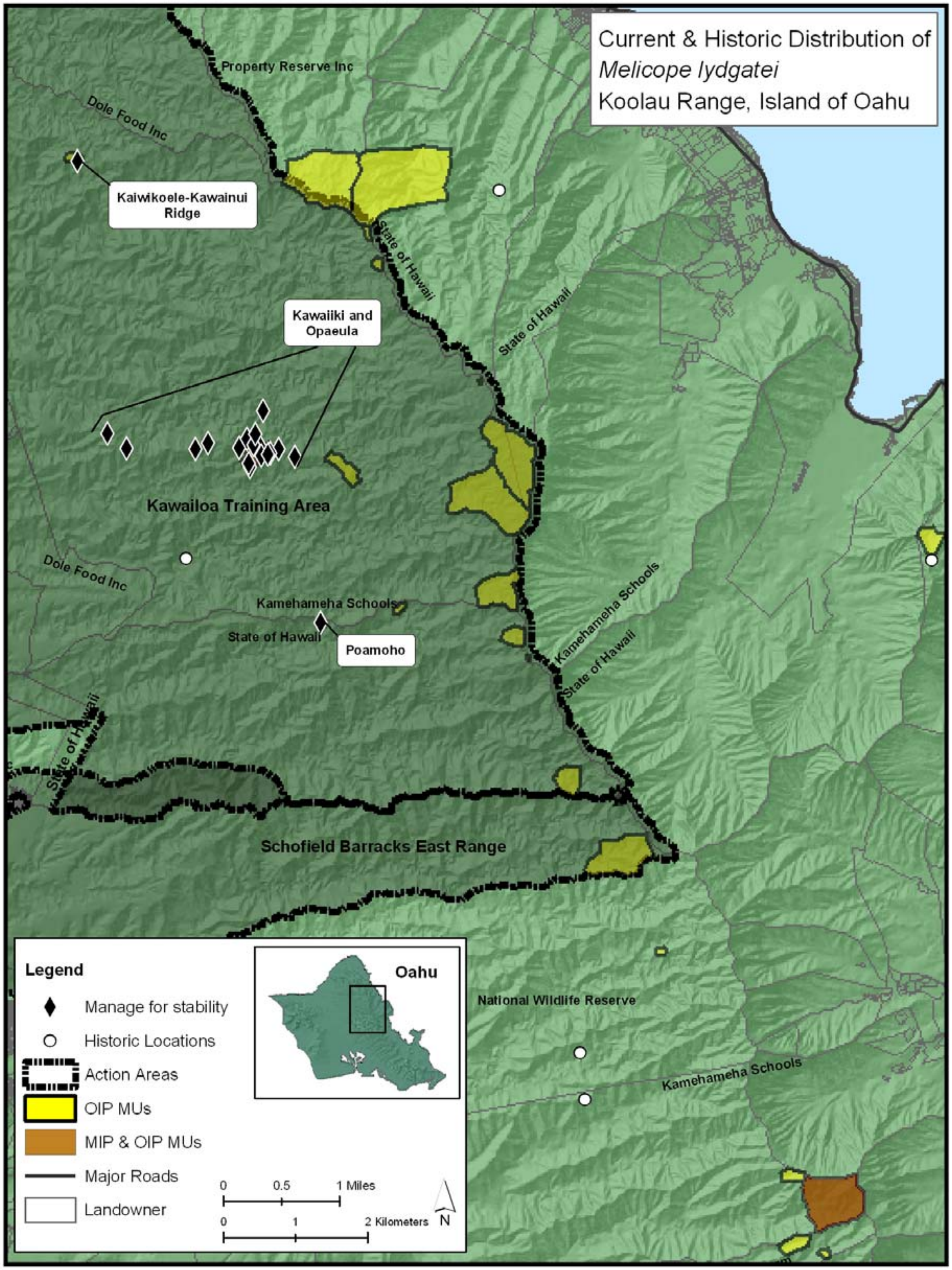


Figure 11.23 Current and historical distribution of *Melicope lydgatei* in the Northern Koolau Mountains of Oahu.

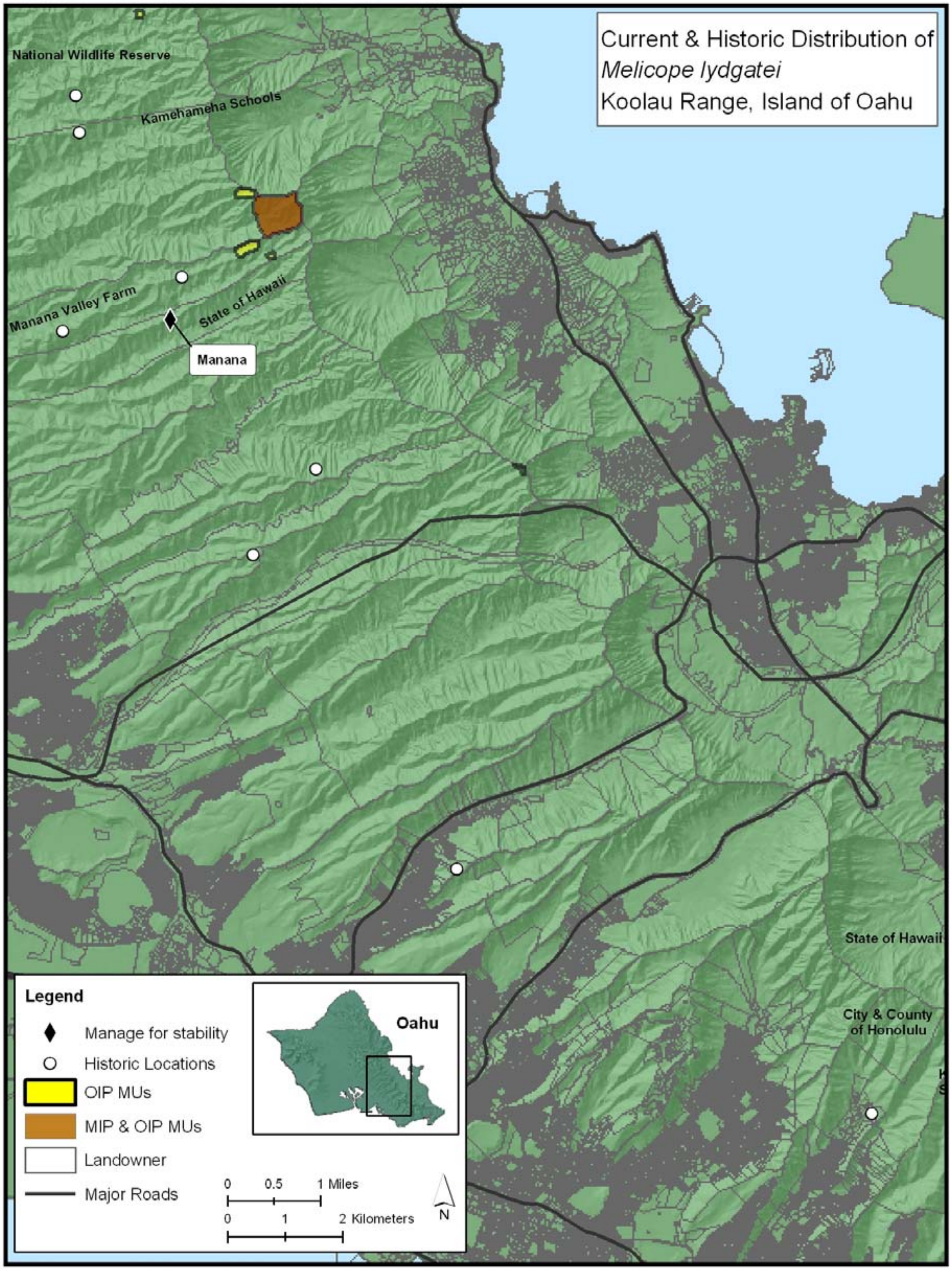


Figure 11.24 Historic distribution of *Melicope lydgatei* in the Central and Southern Koolau Mountains of Oahu.

Discussion of Management Designations

The Kaiwikoele-Kawainui Ridge PU was recently discovered in August of 2004 (OANRP 2004). Additional surveys are needed to determine the extent of the population. The Kawaiiki and Opaeula PU is concentrated in relatively manageable habitat. All individuals will be within the Kawaiiki and Opaeula MU fence. The Poamoho and Manana areas have recent historical observations of this species and may likely harbor additional individuals. Surveys are required to locate another possible PU for management. Based on the survey findings, management designations will be revisited and MU boundaries may be extended.

Propagation and Genetic Storage

Vegetative cuttings have successfully rooted in the nursery, where plants have flowered year round. There is less fruit produced than the number of flowers observed on this nursery stock, and the reproductive biology and breeding system will be studied. The Army has had difficulty germinating taxa in Rutaceae. Seeds likely have some type of dormancy, yet this is hard to determine as large amounts of seed are not possible to collect. *Melicope lydgatei* has a very thick seed coat, which suggests that it is water impermeable and may have physical dormancy. Often seeds that are scarified, to allow water permeation, rot quickly. Seeds left unscarified, however, may take months to germinate or not germinate at all. Seeds may have some combination of morphological/physiomorphological and physical dormancy, and scarification prior to complete embryo development may inhibit germination. When seeds do germinate, germination is very slow. It can take up to a month from radicle emergence to complete germination (radicle + cotyledons emergence). The Army will continue to try to collect seeds, either *in situ* or *ex situ*, to determine germination protocols. The Army will focus collection efforts on more common species of *Melicope* on which to practice proposed germination techniques. Only after germination and dormancy is understood will storage testing commence. Seeds may also be intermediate in storage behavior, where seeds may not be tolerant of dry, frozen conditions. Several other agencies, including the Harold L. Lyon Micropropagation Lab, the USDA-ARS National Center for Genetic Resource Preservation and the Royal Botanical Garden, Kew, continually work on other species in this family and information will hopefully be available to guide efforts. At least for the short term, living collections in the nursery will be used to meet genetic storage goals until seed storage research indentifies storage conditions that promote longevity. Efforts will be made to increase clonal propagation to create a living collection representing approximately ten wild plants. From these plants pollination studies will be done in an attempt to increase seed set. Once more is known regarding reproductive biology and seed viability, it will be decided whether to continue to increase the living collection, rotate founders through the living collection for seed production, or switch entirely to *in situ* seed collection. It is uncertain as to whether seeds or vegetative propagation, or both, will be used to establish reintroductions.

Management Notes

As there are just 41 individuals known, it is important to propagate material from all known individuals. Surveys are needed in last observed areas including Manana trail, Poamoho Trail, Kawailoa Trail, Opaeula Trail and Wiliwilinui Ridge area and at all historic occurrences. The **Kaiwikoele-Kawainui Ridge PU** will be managed within the Kawailoa MU, a smaller scale MU designed specifically for *Melicope lydgatei* individuals and surrounding habitat. A priority for this PU is the survey for the extent of the population the construction of the MU fence.

The **Kawaiiki and Opaeula PU** will be managed within the Lower Peahinaia MU. This MU has been planned for several years and has been held up by a pending license agreement with the landowner Kamehameha Schools. Once an agreement is finalized the MU will be built with the help of the Koolau Mountain Watershed Partnership (KMWP). The original proposed MU has been expanded to include additional individuals found recently.

Table 11.11 Priority Management Actions for *Melicope lydgatei* Army Stabilization PUs.

Population Unit	Specific Management Actions	Partners/Concerns	Timeline
Kaiwikoele-Kawainui Ridge PU	• Survey • Collect propagules • Construct Kawailoa MU • Control priority weeds • Augment within fence	• This MU requires and EA and licence agreement with landowner, Kamehameha Schools.	• construct Kawailoa MU, OIP yr 4; 2011
Kawaiiki and Opaeula PU	• Survey • Construct Lower Peahinaia MU • Control priority weeds • Collect propagules • Augment within fence	• This MU has an EA w/ FONSI. • Requires a license agreement with landowner, Kamehameha Schools.	• construct Lower Opaeula/Peahinaia MU, As soon as a license agreement is finalized. MIP yr 8; 2011
3rd MFS PU to be determined	• survey all historical sites, if no additional PUs are located the OIT will discuss a reintroduction to manage for stability	• need landowner consent for surveys	• Begin OIP yr 2; 2008

11.11 Tier 1:
Phyllostegia hirsuta: Taxon Summary and Stabilization Plan

Scientific name: *Phyllostegia hirsuta* Benth.
Hawaiian name: None known
Family: Lamiaceae (Mint family)
Federal status: Listed endangered

Requirements for Stability

- 3 population units (PUs)
- 100 reproducing individuals (short-lived perennial)
- Threats controlled
- Genetic storage collections from all PUs
- Tier 1 stabilization priority

Description and biology: *Phyllostegia hirsuta* is an erect subshrub or a vine with oppositely arranged leaves. The leaf blades are ovate, measure 17-30 cm (6.7-12 in) long and 7.3-18 cm (2.9-7.1 in) wide, and are covered with long hairs on both surfaces. The flowers are born in a compound inflorescence usually 10-20 cm (3.9-7.9 in) long that usually consists of a principal axis and two to several secondary, rarely tertiary, lateral branches. The corollas of the flowers are white and 7-11 mm (0.43 in) long. The nutlets are about 2.5-3 mm (0.10-0.12 in) long.

Flowering occurs mainly from January through June. The flowers are presumably insect-pollinated. Seed dispersal may be effected by fruit eating birds. Some of the reproduction in *P. hirsuta* is by vegetative means. The plant produces stolons that run along the ground for several centimeters. This allows a small plant to eventually form a larger clonal patch of several plants. The species is categorized as a short-lived plant for the purposes of the Implementation Plan. There are some indications that populations of *P. hirsuta* may fluctuate in size, but more data gathered over long periods of time are needed for a confirmation of this.

Known distribution: *Phyllostegia hirsuta* is endemic to both the Waianae and Koolau Mountain Ranges on Oahu. The range of the species included almost the entire length of both mountain ranges. It has been found from 305-1,100 m (1,000-3,610 ft) in elevation (see Figures 11.18-20).

Population trends: Population trends of most *P. hirsuta* population units are not clear since most of the known plants have been located fairly recently, and many population units that have known for a long time have not been well tracked. However in the case of a colony of plants North Palawai Gulch, the population size has definitely declined in size. When first observed in 1991, the plants were estimated to number 10-20. When the site was revisited in 1998 only two plants could be found. In several visits from 2000 on, no plants could be found at the site (Lau pers. comm. 2005).

Phyllostegia hirsuta appears to be extirpated in parts of its recorded range. In the Koolau Mountains, no plants of *P. hirsuta* are known today south of South Kaukonahua Gulch in SBMR East Range. The currently known range of the species in the Waianae Mountains extends only from the Kaala area in the north to Ekahanui Gulch in the south.

Current status: The species occurs in the West Range and South Range portions of the SBMR action area in the Waianae Mountains. In the Koolau Mountains it occurs in the East Range portion of the SBMR action area and the KLOA action area. The action areas contain between one-half and three-fourths of the total number of plants known. There are only historical specimens of *P. hirsuta* from the MMR and KTA action areas. There is still a considerable amount of potential habitat where unrecorded plants of this species may yet be found, particularly in the higher elevation gulches of the northern and central Koolau Mountains. The current population units and the number of plants they contain are given in the status table below and their locations are plotted on Figures 11.18-20.

Habitat: *Phyllostegia hirsuta* in the Koolau Mountains occurs primarily in wet forests dominated by *ohia lehua* (*Metrosideros polymorpha*) and *uluhe* (*Dicranopteris linearis*). In contrast, the species in the Waianae Mountains occurs primarily in mesic forests. In both mountain ranges the species is found in gulch bottoms and on gulch slopes.

Taxonomic background: There are currently 32 recognized Hawaiian species in the genus *Phyllostegia*. There are also two non-Hawaiian members of the genus, one in Tahiti and the other in Tonga (Wagner 1999). *Phyllostegia hirsuta* is closely related to *P. parviflora*, which also an endangered species endemic to Oahu (Wagner *et al*. 1999).

Outplanting considerations: Herbarium specimens that appear to represent hybrids between *P. hirsuta* and *P. glabra* have been collected from the Koolau and Waianae Ranges (Wagner 1999). *Phyllostegia hirsuta*'s geographical and ecological ranges broadly overlap those of several other listed endangered species of *Phyllostegia* in the Waianae Mountains, namely *P. mollis*, *P. kaalaensis*, and *P. parviflora* subsp. *lydgatei*, and the non-endangered *P. glabra* and *P. grandiflora*. Also potentially occurring with *P. hirsuta* in the Waianae Range is the newly recognized *P. micrantha*, which is represented by only a single herbarium specimen that was collected in 1910 in the area of Kaluaa Gulch in the southern Waianae Mountains (Wagner 1999). In the Koolau Mountains, *P. hirsuta* potentially occurs with the listed endangered *P. parviflora* subsp. *parviflora*, as well as the non-endangered species *P. glabra*, *P. grandiflora*, and *P. lantanoides*. Since it is natural for these *Phyllostegia* species to co-occur with *P. hirsuta*, their presence in a given area should not preclude the outplanting of *P. hirsuta*, as long as they are not outplanted in the immediate vicinity of any pre-existing wild populations of the other endangered taxa of *Phyllostegia*.

Threats: The primary threats to *P. hirsuta* are feral pigs and invasive alien plants. The alien plant threats to the species in the Waianae Mountains include Christmas berry (*Schinus terebinthifolius*), Koster's curse (*Clidemia hirta*), strawberry guava (*Psidium cattleianum*), *huehue haole* (*Passiflora suberosa*), *Blechnum appendiculatum*, prickly Florida blackberry (*Rubus argutus*), molasses grass (*Melinus minutiflorus*), and Australian red cedar (*Toona ciliata*). The major alien plant threats in the Koolau Mountains include Koster's curse and strawberry guava.

Threats in the Action Area: Major threats to *Phyllostegia hirsuta* due to army training include wild fire, trampling and the transport of non-native plant species from other training areas. However, the threats from fire and trampling are considered low due to the remote forest and steep terrain this species inhabits. Additionally, this species is threatened throughout its range by feral ungulates, predation by rats, and rockslides.

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Phyllostegia hirsuta TaxonCode: PhyHir

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Haleauau to Mohiakea	Manage for stability	6	12	0	0	0	0	95	25	25	**6**	**12**	**0**	Combined former PUs; Sites within North Haleauau, South Haleauau, and Mohiakea Mus

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
PhyHir.SBW-A	Water Gulch	In situ		3	
PhyHir.SBW-B	Kalena Notch	In situ	0	0	0
PhyHir.SBW-C	North Mohiakea North Fork	In situ	0	0	0
PhyHir.SBW-D	Puu Kalena	In situ	5	9	
PhyHir.SBW-E	Banana	In situ	1		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Helemano and Opaeula	Genetic Storage	14	5	6	0	0	0	4	4	0	**14**	**5**	**6**	GSC for potential management within Koloa MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
PhyHir.KLO-B	Behind Peahinaia Camp LZ	In situ	12		6
PhyHir.KLO-C	Helemano Stream	In situ	1	4	
PhyHir.KLO-E	Mauka of Puu Roberto	In situ		1	
PhyHir.KLO-G	Lower Peahinaia	In situ	1		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Helemano to Poamoho	Genetic Storage	1	0	0	0	0	0	2	0	0	**1**	**0**	**0**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
PhyHir.KLO-A	Poamoho Trail, camp spot	In situ	0		
PhyHir.KLO-F	Poamoho Stream	In situ	1		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaipapau and Kawainui	Genetic Storage	7	0	0	0	0	0	5	0	0	**7**	**0**	**0**	one individual within Kaipapau MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
PhyHir.KLO-H	Kawainui Stream JL site	In situ	4		
PhyHir.KLO-I	Kawainui Gulch	In situ	1		
PhyHir.PAP-A	Kaipapau L gulch above Cyapur	In situ	1		
PhyHir.PAP-B	Kaipapau, near Koloa	In situ	1		

Action Area: In

Kaukonahua	Genetic Storage	4	2	0	0	0	0	4	2	0	4	**2**	0	GSC for potential management within Koloa MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
PhyHir.SBE-A	S. S. Kaukonahua	In situ	4	2	

Kawaiiki	Genetic Storage	0	0	0	0	0	0	2	0	0	0	0	0	GSC for potential management within Koloa MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
PhyHir.KLO-D	Bloody Finger	In situ	0		

Laie & Puu Kainapuaa	Manage for stability	0	0	0	0	0	0			0	0	0	0	one individual found and collected in 2007

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
PhyHir.KOL-A	Koloa Gulch	In situ	0	0	0

Total for Taxon:	32	19	6	0	0	0	112	31	25	**32**	**19**	**6**	

Action Area: Out

TaxonName: Phyllostegia hirsuta TaxonCode: PhyHir

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Ekahanui	Genetic Storage	0	0	0	0	0	0	1	0	0	**0**	**0**	**0**	Plants have died; no representative ex situ stock available

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
PhyHir.EKA-A	Ekahanui	In situ	0	0	0

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Hapapa to Kaluaa	Manage for stability	11	9	7	0	0	0	9	12	0	**11**	**9**	**7**	within the Kaluaa and Waieli MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
PhyHir.ELE-A	Waiele Gulch	In situ	2	2	1
PhyHir.ELI-A	South Waieli	In situ	0		
PhyHir.ELI-B	Southwest corner of Waieli fence	In situ		1	
PhyHir.ELI-C	Between north Waieli fenceline and Boundary Ridge	In situ		1	
PhyHir.KAL-A	Kaluaa #1 Son	In situ	1	0	3
PhyHir.SBS-A	Hapapa bait grid Btw. #3 and #8	In situ	1		
PhyHir.SBS-B	Hapapa VC's spot	In situ	7	5	3

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Huliwai	Genetic Storage	0	0	0	0	0	0	11	10	0	**0**	**0**	**0**	population belived to be extirpated; one individual represented ex situ. To be used as propagule source for augmentation in Kaluaa and Waieli MU.

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
PhyHir.HUL-A	Huliwai Phyhir	In situ	0	0	0

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaluanui	Genetic Storage	5	0	0	0	0	0	5	0	0	**5**	**0**	**0**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
PhyHir.NUI-A	Kaluanui Joel Lau mystery site	In situ	5		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Makaha-Waianae Kai Ridge	Genetic Storage	2	0	0	0	0	0	2	0	0	**2**	**0**	**0**	NRS have not monitored; may be repressented in a reintroduction in Kaala MU.

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
PhyHir.MAK-A	Makaha-Waianae Kai Ridge	In situ	2		

Action Area: Out

Palawai	Genetic Storage	0	1	0	0	0	0	0	0	0	**0**	**1**	**0**	regeneration at an old site. Stock to be used in augmentations in Kaluaa and Waieli MU.

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
PhyHir.PAL-A	North Palawai, Mid-Ridge	In situ		1	

Total for Taxon:	18	10	7	0	0	0	28	22	0	**18**	**10**	**7**

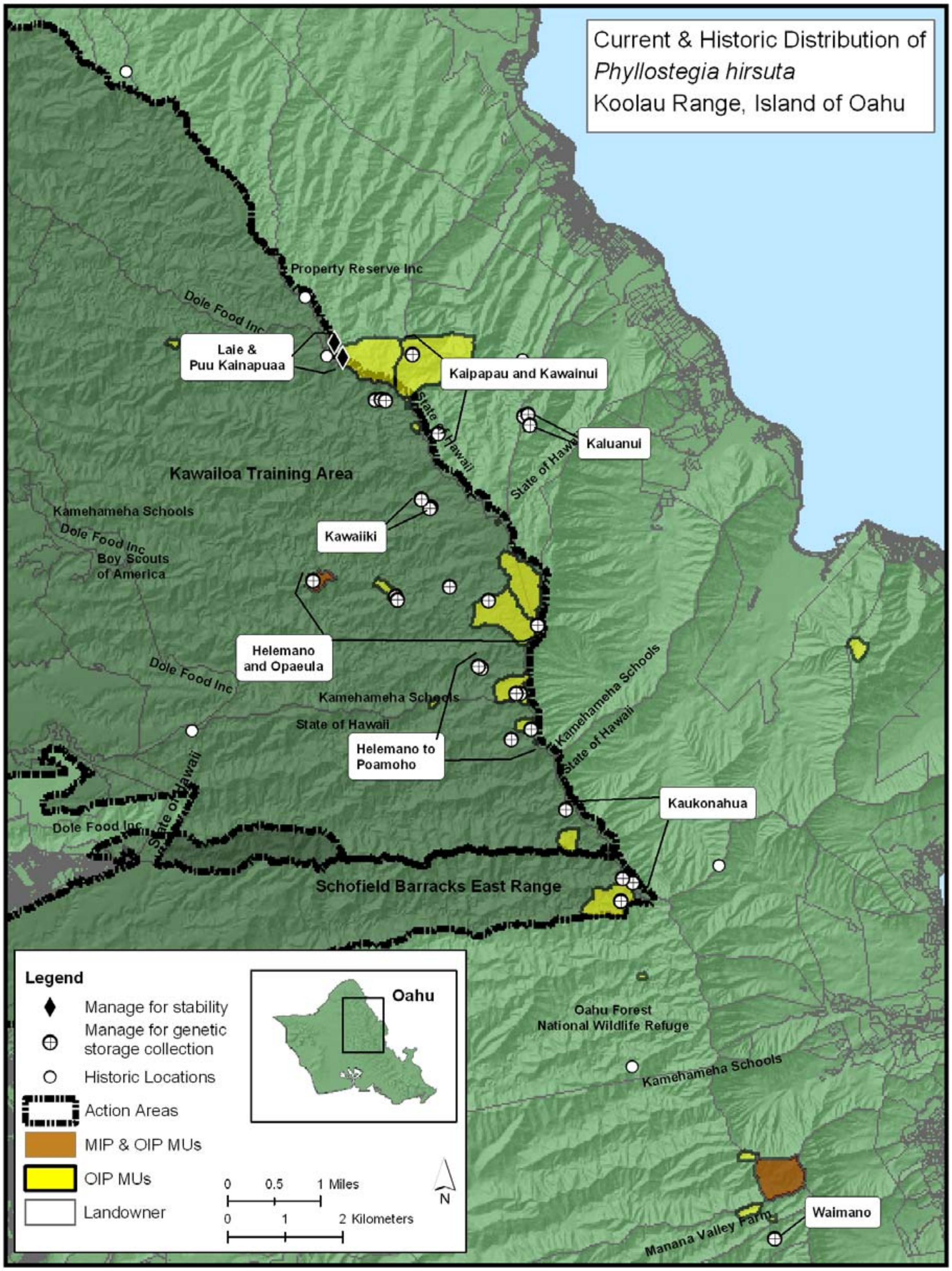


Figure 11.25 Current and historic distribution of *Phyllostegia hirsuta* in the Northern Koolau Mountains of Oahu.

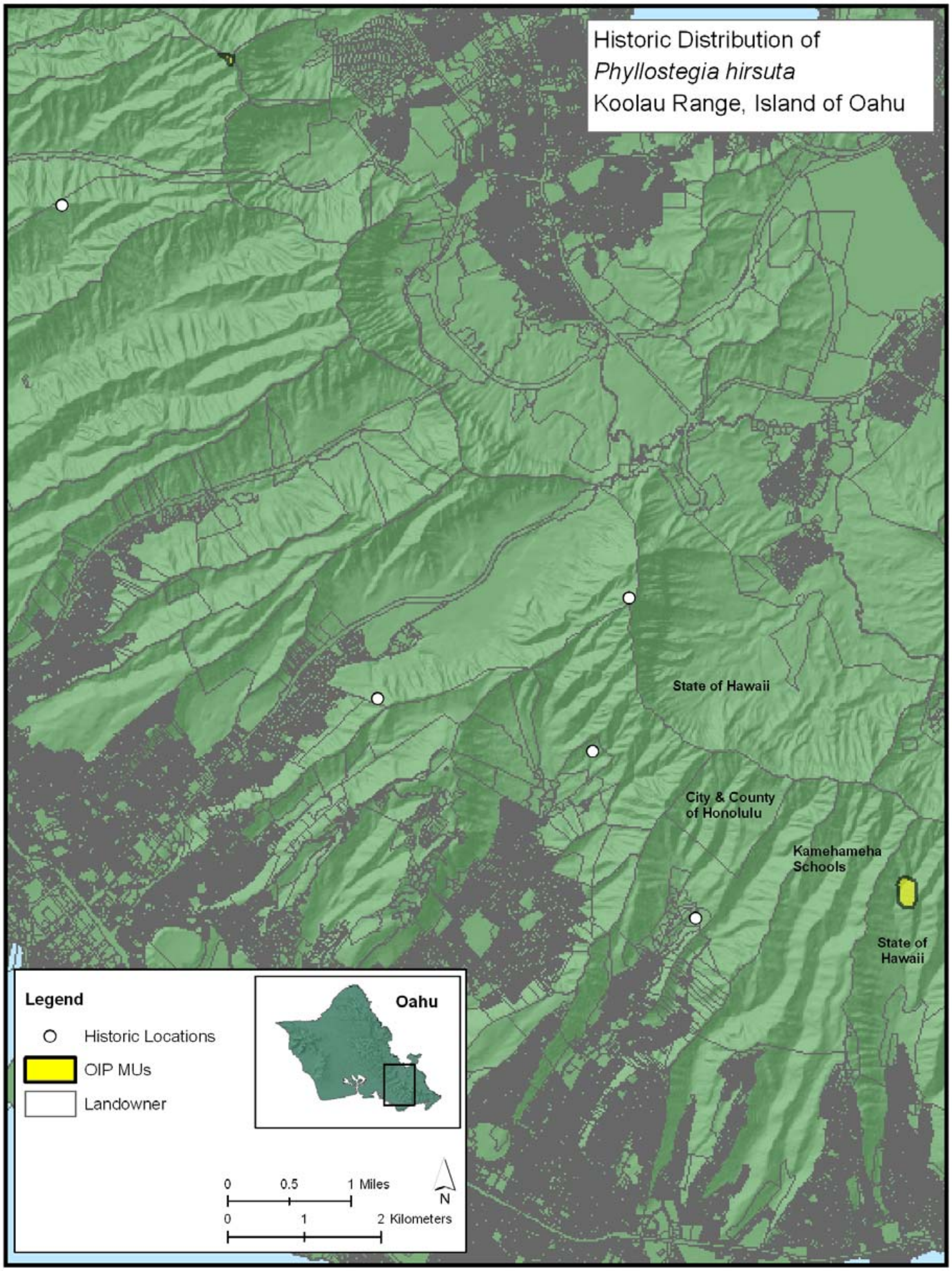


Figure 11.26 Historic distribution of *Phyllostegia hirsuta* in the Central and Southern Koolau Mountains of Oahu.

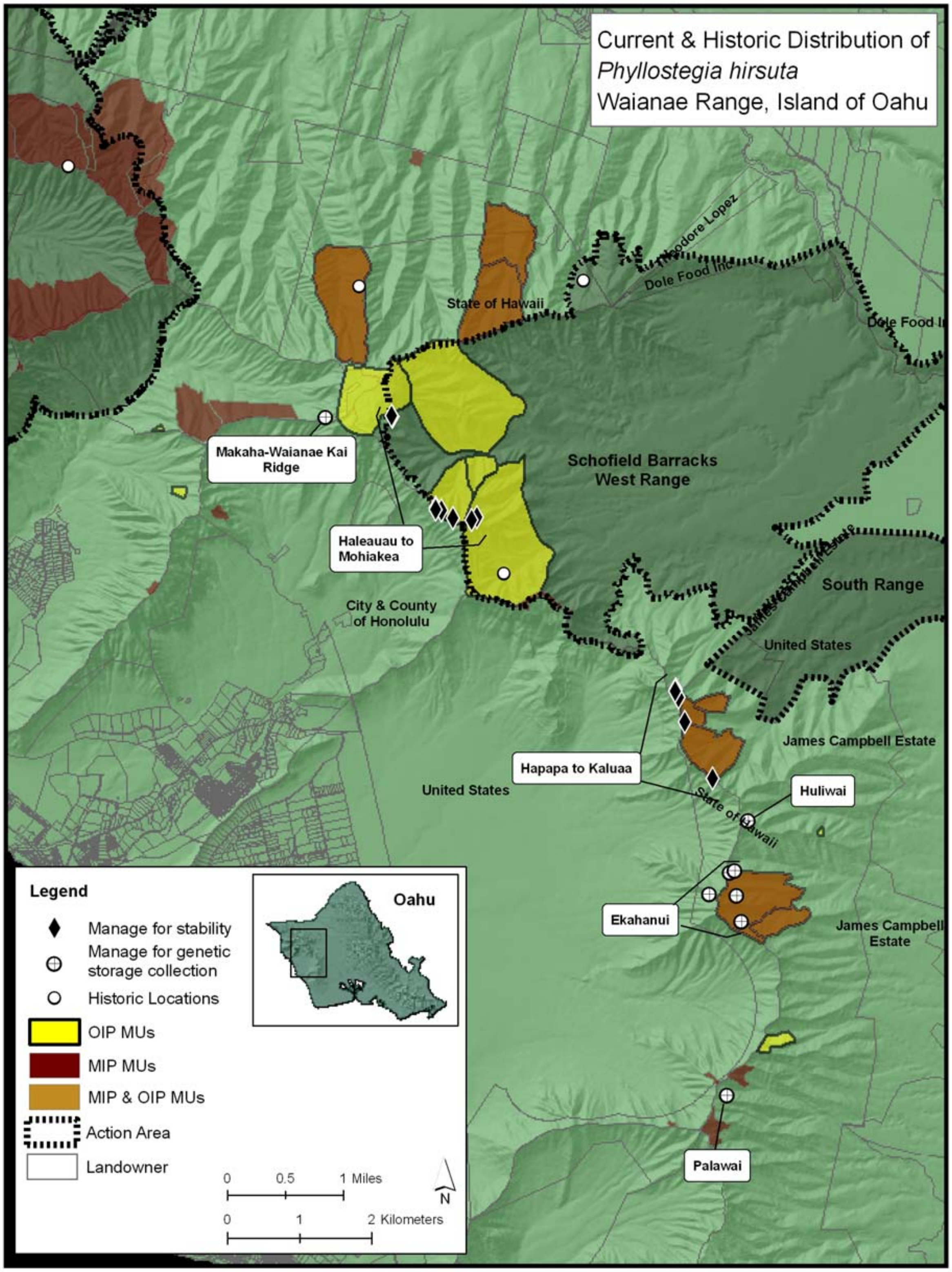


Figure 11.27 Current and historic distribution of *Phyllostegia hirsuta* in the Waianae Mountains of Oahu.

Discussion of Management Designations

In the Koolau Mountains *Phyllostegia hirsuta* has a widely scattered distribution that makes it difficult to encompass 100 individuals within one MU. Therefore, all the populations within the action area (from Kawaiiki to South Kaukonahua) in the Koolaus will be managed as a propagule source for a Koloa PU reintroduction. The other Koolau PUs were not considered to be managed for stability because of the dramatic decline of this species in the Waianae Mountains and a seemingly greater need for management at these populations. In the Waianae Mountains this species tends to occur in larger groups of individuals with large fluctuations in populations. Two Waianae range PUs were designated as manage for stability. The North and South Haleauau MUs and the Mohiakea MU will encompass the Haleauau to Mohiakea PU. The Hapapa to Kaluaa PU is designated as manage for stability. However, all PUs south of Kolekole pass will be represented within Kaluaa MU. The Kaluaa MU currently contains both a wild and a reintroduced population. In addition to the existing Hapapa to Kaluaa PU in the MU, stock that will be represented in augmentations include Central Waieli, Ekahanui, Huliwai, and Palawai PUs.

Propagation and Genetic Storage

Plants are easily propagated from vegetative cuttings and seeds, though fruit and seed set are low. The reproductive biology of this taxon will be studied. Studies will be conducted to attempt to increase seed set in the nursery stock. Fresh seeds have high germination rates and seedlings grow vigorously. Seeds have been germinated at the Harold L. Lyon Micropropagation Lab and plants can be subcultured and maintained in vitro from seed and cutting material. Seed storage longevity for this taxon is unknown, but based on results from the congener *P. mollis*, it is likely that seeds will be able to be stored to meet genetic storage goals. The living collection in a nursery will produce seed for storage testing and genetic storage requirements. Until seed storage is determined, micropropagation techniques and a living collection will be used to meet genetic storage goals.

The Army recognizes that reintroductions are necessary to reach stability for this taxon. Clonal propagation of living collection stock will be used to produce material for establishing reintroductions. Any seeds (either naturally derived, or as a result of artificial crosses within PUs) may be used to create more genetically diverse reintroductions and may also be used to fulfill genetic storage requirements. Seeds produced at reintroductions may be collected, propagated *ex situ*, and planted back into the reintroduction site in order to increase the chance that these propagules will survive. These actions may be necessary for reintroductions representing founders from the Waianae Mountain Range, as there are fewer founders available as compared to the Koolau Mountain Range.

Genetic Storage Summary

Population Unit Name	# of Potential Founders: Current Mature	Current Imm.	NumWild Dead	Partial Storage Status: # Plants >= 10 in Seedbank	# Plants >=1 Microprop	# Plants >=1 Army Nursery
Phyllostegia hirsuta						
Ekahanui	0	0	0	0	0	0
Haleauau to Mohiakea	56	12	0	0	1	1
Hapapa to Kaluaa	11	9	0	1	0	2
Helemano and Opaeula	14	5	1	0	0	4
Helemano to Poamoho	1	0	0	0	0	1
Huliwai	0	0	3	0	0	1
Kaipapau and Kawainui	7	0	0	0	0	0
Kaluanui	5	0	0	0	0	0
Kaukonahua	4	2	0	0	0	0
Kawaiiki	2	0	0	0	0	0
Laie & Puu Kainapuaa	0	0	0	0	0	0
Makaha-Waianae Kai Ridge	2	0	0	0	0	0
Palawai	0	1	1	0	0	1
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**
				1	1	10

Outplanting Considerations

It should be noted that previous reintroduction attempts in Waianae Sites for this species have not been very successful (see OANRP 2007). Any problems encountered will be discussed at yearly Implementation Team meetings. No reintroductions have been attempted in the Koolau Mountains.

Management Notes

All Koolau plants within the action area will be managed for genetic storage collections to be used for augmentation within the **Koloa MU**. Therefore priority for the Koolau PUs in the action area are collection of propagules for reintroduction. These PUs include: Helemano and Opaeula, Kaukonahua, Kawaiiki, Kawainui, South Helemano, and Koloa.

In the Waianaes priorities are to collect propagules from the **Haleauau to Mohiakea PU** for augmentation within the North Haleauau MU, South Haleauau MU and Mohiakea MU. This PU has the highest number of potential founders (65 individuals) and will be interesting to compare to other manage for stability PUs with fewer founding individuals. However, the last survey of the largest subpopulation in North Haleauau did not find any individuals.

The second manage for stability population in the Waianaes will be in Kaluaa MU composed of propagules from the manage for stability **Hapapa to Kaluaa PU**, along with Central Waieli, Ekahanui, Huliwai, and Palawai PUs.

Table 11.12 Priority Management Actions for *Phyllostegia hirsuta* Army Stabilization PUs

Population Unit	Specific Management Actions	Partners/Concerns	Timeline
Haleauau to Mohiakea PU	• Construct North Haleauau, South Haleauau, and Mohiakea MUs • Collect propagules for augmentation and genetic storage from South Central Haleauau Mohiakea • Control priority weeds	• MUs need an EA.	• Construct MUs • North Haleauau OIP yr 3; 2010 • South Haleauau OIP yr 2; 2009 • Mohiakea OIP yr 3; 2009
Koloa MU	• Construct Koloa MU fence • Collect propagules from all Koolau sites within the action area for augmentation within Koloa MU and genetic storage • Control priority weeds	• MU needs an EA and license agreement with landowner, Hawaii Reserves Inc.	• Construct Koloa MU, OIP yr 4; 2011
Kaluaa to South Waieli MU	Collect propagules from Kaluaa to South Waieli, Central Waieli, Ekahanui, Huliwai, and Palawai PUs for augmentation and genetic storage • Control priority weeds	• MU completed • Work with new Honouliuli landowner.	• Can begin OIP yr 1; 2008
Kaala MU	• Collect propagules from Mohiakea and Makaha-Waianae Kai Ridge PUs for augmentation in Kaala MU.	• Partner with State and BWS.	• 2nd priority after MFS PUs

11.13 Tier 1:
Phyllostegia mollis: Taxon Summary and Stabilization Plan

Scientific name: *Phyllostegia mollis* Benth.
Common name: None known
Family: Lamiaceae (Mint family)
Federal status: Listed endangered

Requirements for Stability

- 3 population units (PUs)
- 100 reproducing individuals (short-lived perennial, with tendency for large declines or fluctuations in population size)
- Threats controlled
- Genetic storage collection from all PUs
- Tier 1 stabilization priority

Description and biology: *Phyllostegia mollis* is a suberect perennial herb. Its leaves are oppositely arranged. The leaf blades are ovate to occasionally elliptic-ovate, measure 6-24 cm (2.4-9.4 in) long, and 2.5-7.0 cm (0.98-2.8 in) wide, and are covered by fine pubescence. The flowers are borne in inflorescences 8-17 cm (3.1-6.7 in) long, which usually consist of a principle axis and two shorter lateral branches immediately below. The corollas are white and 8.5-12.0 mm (0.33-0.47 in) long. The nutlets are about 2-3 mm (ca. 0.1 in) long.

The biology of the species has not been well studied. Flowering occurs mainly from January through June. The flowers are presumably insect-pollinated. Seed dispersal may be effected by fruit eating birds. Some of the reproduction in *P. mollis* is by vegetative means. The plant produces stolons that run along the ground for several centimeters. This allows a small plant to eventually form a larger clonal patch of several plants. The species is categorized as a short-lived plant for the purposes of the Implementation Plan. There are some indications that *P. mollis* populations tend to fluctuate in size to some degree, and may even completely disappear from a site only to reappear as seedlings.

Known distribution: *Phyllostegia mollis* is endemic to the island of Oahu. It has been recorded from the windward side of the Waianae Mountains and was collected once from Makiki in the Honolulu portion of the Koolau Mountains (see Map 16.49). Recorded elevations for the species range from 455-855 m (1,500-2,800 ft).

Population trends: It appears that *P. mollis* has been declining in range. There are several population units known from previous decades that are now extirpated. Population sizes also seem to be falling. During a botanical survey of the SBMR in 1994, 19 mature plants were found in South Mohiakea Gulch. These numbers have declined to approximately five mature plants today. This decline may largely be due to the uncontrolled feral pig populations in the vicinity of these plants.

Current status: No *P. mollis* populations are known to be extant in the Koolau Mountains and in the northern Waianae Mountains. There is only 1 mature and 4 seedlings known to be extant in Kaluaa and Mohiakea PUs. However, there are several PUs represented *ex situ* that will be utilized in the stabilization of this species. The species' current population units and the number of plants they contain are given in the status table below and their locations are plotted on Figure 16.48.

Habitat: *Phyllostegia mollis* is found in gulch bottoms and on gulch slopes in mesic forest. Common associated species include *ohia lehua* (*Metrosideros polymorpha*), *papala kepau* (*Pisonia* spp.), *kalia* (*Elaeocarpus bifidus*), *mehame* (*Antidesma platyphylla*), *kolea* (*Myrsine lessertiana*), *poola* (*Claoxylon sandwicensis*), and *maile* (*Alyxia oliviformis*).

Taxonomic background: There are currently 32 recognized Hawaiian species in the genus *Phyllostegia*. There are also two non-Hawaiian members of the genus, one in Tahiti and the other in Tonga. These two, however, have not been taxonomically evaluated, unlike the Hawaiian species (Wagner 1999).

Certain *Phyllostegia* populations from Molokai and Maui were included within *P. mollis* in the first edition of the Manual of Flowering Plants of Hawaii (Wagner *et al*. 1990). Subsequent study led to a taxonomic rearrangement of *P. mollis*, in which the Molokai and Maui populations were separated from *P. mollis* and recognized as constituting a distinct species endemic to Molokai and Maui, *P. pilosa* (Wagner 1999).

Outplanting considerations: There have been no reports of putative hybridization between *P. mollis* and other *Phyllostegia*s. However, natural hybrid combinations involving other *Phyllostegia* species have been identified among the Hawaiian *Phyllostegia*s (Wagner *et al*. 1990), and so it seems that there is some potential for P. *mollis* to hybridize with other *Phyllostegia*s. *Phyllostegia mollis*' geographical and ecological ranges broadly overlap those of several other listed endangered species of *Phyllostegia* in the Waianae Mountains, namely *P. hirsuta*, *P. kaalaensis*, and *P. parviflora* subsp. *lydgatei*. Also potentially occurring with *P. mollis* is the newly recognized *P. micrantha*, which is represented by only a single herbarium specimen collected in 1910 in the area of Kaluaa Gulch in the southern Waianae Mountains (Wagner 1999). In North Palawai and Pualii Gulches, *P. mollis* has been found growing within a few meters of *P. parviflora* subsp. *lydgatei* (Lau, pers. comm. 2005). Since it is natural for these

Phyllostegia species to co-occur with *P. mollis*, their presence in a given gulch should not preclude the outplanting of *P. mollis*, as long as they are not established in the immediate vicinity of any pre-existing wild populations of the other endangered taxa of *Phyllostegia*.

One outplanting concern with *P. mollis* involves the proper identification of the planting material. *Phyllostegia parviflora* var. *lydgatei*, which is known only from Honouliuli Preserve, and is even rarer than *P. mollis*, can be difficult to distinguish from *P. mollis*, particularly when the plants are not in flower or fruit. In the past there has been a considerable amount of confusion with the respect to the identity of some of the cultivated material of *P. mollis* and *P. parviflora* var. *lydgatei*. With this pair of taxa there needs to be a heightened level of awareness among the caretakers of in situ plant material of the possibility for cultivated plants to become misidentified.

Threats: The major threats to *P. mollis* include feral pigs and invasive alien plants such as Christmas berry (*Schinus terebinthifolius*), strawberry guava (*Psidium cattleianum*), Australian red cedar (*Toona ciliata*), Koster’s curse (*Clidemia hirta*), and white moho (*Heliocarpos popayensis*).

Threats in the Action Area: Threats to *Phyllostegia mollis* due to army training activities include wildland fire, and the transport and introduction of non-native plant species from other training areas. However, the threat from fire is considered low. Additionally, this species is threatened throughout its range by habitat destruction by feral ungulates, competition from non-native plant species, and rockslides.

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Phyllostegia mollis   TaxonCode: PhyMol

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Mohiakea	Genetic Storage	0	4	0	0	0	0	0	0	4	0	4	0	to be managed within Kaluaa MU; mix with KAL, SBS, and ELI stock

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
PhyMol.SBW-A	Mohiakea	In situ		4	

		NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling
	Total for Taxon:	0	4	0	0	0	0	0	0	4	0	4	0

Action Area: Out

TaxonName: Phyllostegia mollis TaxonCode: PhyMol

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Ekahanui	Manage for stability	0	0	0	35	0	0	0	0	0	**35**	**0**	0	Stock to be reintroduced in Ekahanui MU; mix with Huliwai stock

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
PhyMol.EKA-A	South Ekahanui North Branch	In situ	0	0	0
PhyMol.EKA-B	Cyanea Gulch	In situ	0	0	0
PhyMol.EKA-C	Ekahanhui REINTRO	Reintro	35		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Huliwai	Genetic Storage	0	0	0	0	0	0	1	0	0	**0**	**0**	0	Managed within Ekahanui MU; Mix with Ekahanui stock

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
PhyMol.HUL-A	North Huliwai, South Branch	In situ	0	0	0

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaluaa	Manage for stability	1	0	0	37	11	0	0	0	0	**38**	**11**	0	Manage for stability in Kaluaa MU; mix with SBS, SBW, and ELI stock

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
PhyMol.KAL-B	Kaluaa	Reintro	0		
PhyMol.KAL-C	Gulch 3 Outplanting site (Above Raingauge)	Reintro	37	11	
PhyMol.KAL-D	Gulch 3 near KAL-B Delsub	In situ	1		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Pualii	Manage for stability	0	0	0	0	0	0	0	0	0	**0**	**0**	0	one founder represented ex situ; to be managed for stability within Pualii MU;

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
PhyMol.PUA-A	North Pualii	In situ	0	0	0
PhyMol.PUA-B	Pualii REINTRO NOT DONE YET	Reintro			

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Waieli	Genetic Storage	0	0	0	0	0	0	1	0	0	**0**	**0**	0	to be managed within Kaluaa MU;

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
PhyMol.ELI-A	Waieli, south of the boundary	In situ	0	0	0
PhyMol.SBS-A	Moho Gulch	in situ	0	0	0
PhyMol.SBS-B	NEW Moho exclosure reintro NOT planted yet	Reintro			

	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling
Total for Taxon:	1	0	0	72	11	0	2	0	0	**73**	**11**	0

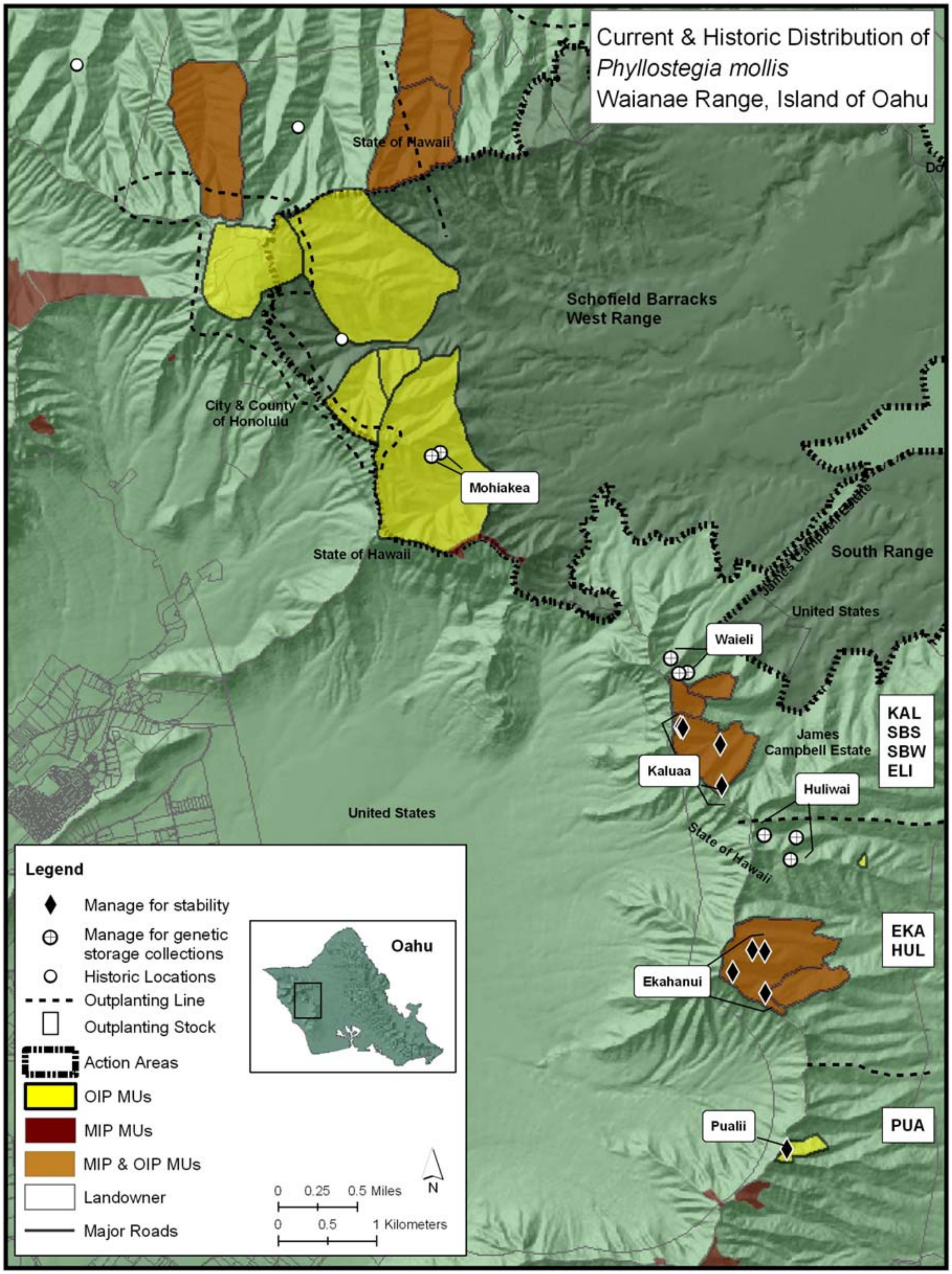


Figure 11.28 Current and historic distribution of *Phyllostegia mollis* in the Waianae Mountains of Oahu and outplanting stock lines are shown. (population reference codes: KAL- Kaluaa; SBS-Schofield Barracks South Range; SBW- Schofield Barracks West Range; ELI- Waieli; EKA-Ekahanui; HUL-Huliwai; PUA-Pualii).

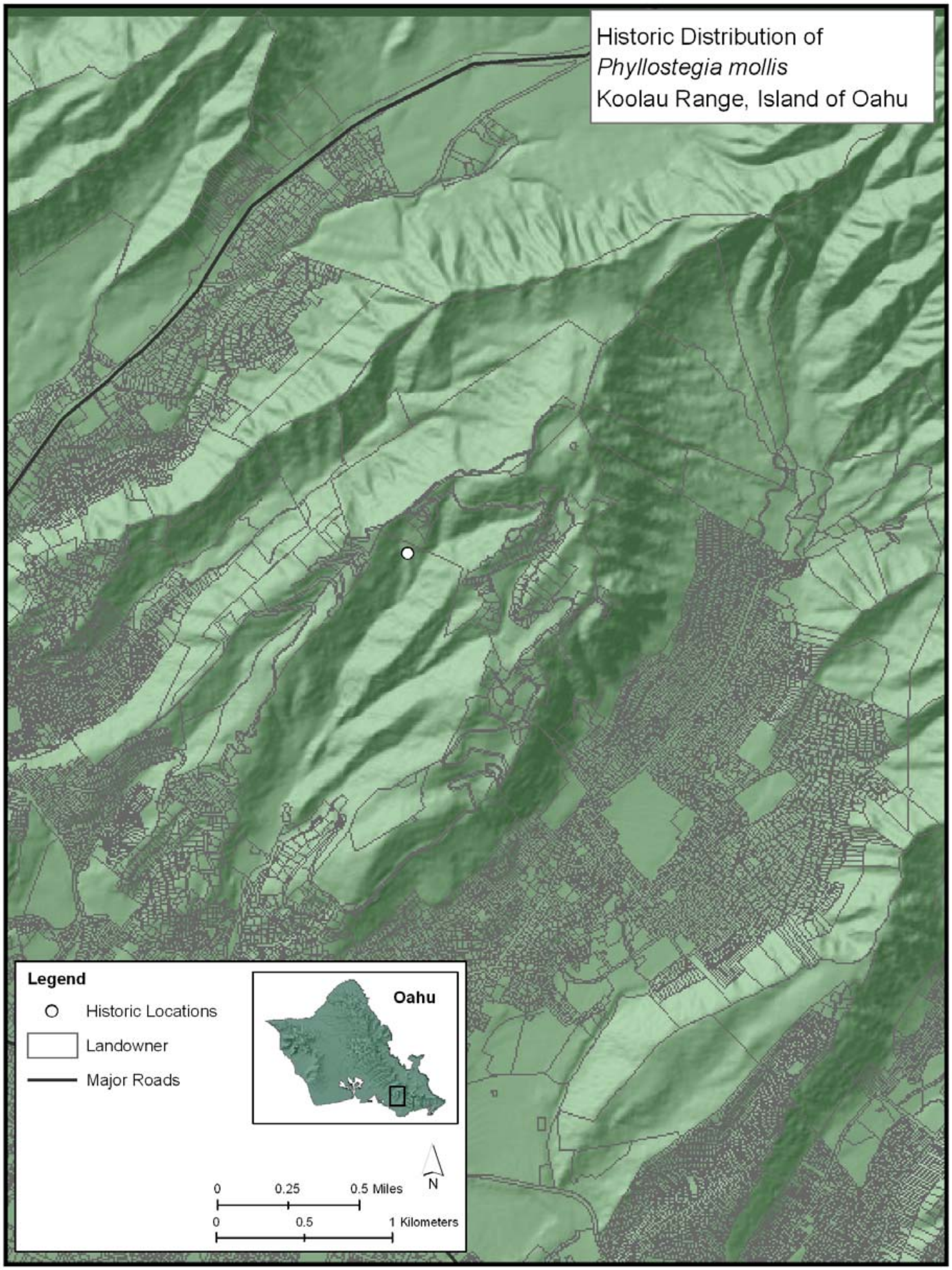


Figure 11.29 Historic location for *Phyllostegia mollis* in the Koolau Mountains of Oahu.

Discussion of Management Designations

All wild individuals and any additional genetic stock available will be managed for genetic storage and represented in one of the three manage for stability populations according to the outplanting zones shown in Figure 11.28. Considering there are so few extant individuals and all *ex situ* stock will be utilized in one of the three reintroductions, the management designations (i.e. Manage for Stability or Manage for Genetic Storage Collections) are somewhat artificial. However, if a new population is discovered its use in the reintroduction scheme will be discussed with the OIT. In the past the Mohiakea population was difficult to access due to Schofield Range issues. However, with new construction on the range there may be more opportunities for access in the next couple of years. All recently known populations should be revisited periodically to monitor for seedlings.

Propagation and Genetic Storage

Clonal propagation via vegetative cuttings has been highly successful in both a nursery setting and through micropropagation techniques. Both of these methods are utilized for propagation for reintroductions and genetic storage for this taxon. Both fruit set and seed set are low for this taxon, collections have been made from nursery stock to initiate seed storage testing, and preliminary results indicate that seed storage will be a viable genetic storage method. The reproductive biology of this taxon will be studied. Studies will be conducted to attempt to increase seed set in the nursery stock. Soil seed bank potential has been tested in the laboratory, and seeds show no decrease in viability after one year of dark, wet field soil-mimicked conditions.

Currently, vegetative propagation has been used to establish reintroductions. Seed produced from nursery stock may also be used for establishing reintroductions as plants flower easily in the nursery. Any seeds (either naturally derived, or as a result of artificial crosses within PUs) may be used to create more genetically diverse reintroductions and may also be used to fulfill genetic storage requirements. Seeds produced at reintroductions may be collected, propagated *ex situ*, and planted back into the reintroduction site in order to increase the chance that these propagules will survive.

Genetic Storage Summary

Population Unit Name	# of Potential Founders: Current Mature	Current Imm.	NumWild Dead	Partial Storage Status: # Plants >= 10 in Seedbank	# Plants >=1 Microprop	# Plants >=1 Army Nursery
Phyllostegia mollis						
Ekahanui	0	0	1	0	1	1
Huliwai	0	0	1	1	1	1
Kaluaa	1	0	0	0	0	0
Mohiakea	0	0	12	1	5	5
Pualii	0	0	1	0	1	1
Waieli	0	0	5	3	5	5
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**
				5	13	13

With the exception of stock from Mohiakea PU, genetic storage goals have largely been met for this species. Cuttings from the immature plant at Kaluaa will likely be made this year.

Founders Represented in Outplantings

TaxonName: Phyllostegia mollis **TaxonCode: PhyMol**

Total Num Plants based upon Plants that have been numbered

PopulationUnitName	Management Designation	Number of Founders	Number of Founders Represented
Ekahanui	Manage for stability	1	1
Huliwai	Genetic Storage	1	1
Kaluaa	Manage for stability	1	0
Mohiakea	Genetic Storage	12	3
Pualii	Manage for stability	1	0
Waieli	Genetic Storage	5	5
	Total for Taxon:	**21**	**10**

Number of Founders = Number of Mature, Immature, and Dead founder plants.
Number of Founders Represented = Number of founder plants represented in reintroductions.

Research Issues

Outplanting techniques and site selection require some research as reintroduction survival rates over time are low for this taxon. Perhaps research in the area of drought and fungal susceptibility of this taxon would assist managers in understanding reasons for dramatic declines. Additional genetics would not be useful as all techniques will be limited by sample size. Slug control research will also benefit this species.

Management Notes

It is important to build up *ex situ* stock of all the populations both for genetic storage and outplanting at the same time as protecting any *in situ* populations from any immediate threats. The Army has observed that Powdery Mildew affects both wild and reintroduced plants in the wetter months.

The manage for stability strategy for this taxon involves substantial reintroductions. Figure 11.32 below, shows the designated population reference codes to be planted into the three core management sites, Kaluaa, Ekahanui and Pualii. Within **Kaluaa and Waieli MU** four source PUs will be represented: Kaluaa, Waieli and Mohiakea.
The **Ekahanui MU** will have augmentations with Ekahanui and Huliwai PUs.
While Pualii stock will be the only PU represented within the **Pualii MU**. TNC has already conducted some outplanting of this stock has already within this MU.
This species may reappear at historic sites via regeneration from the seed bank. Any new PUs and rediscovery of individuals should be discussed at the annual implementation team meetings.

Table 11.13 Priority Management Actions for *Phyllostegia mollis*.

Population Unit	Specific Management Actions	Partners/Concerns	Timeline
Ekahanui	• Build up stock from EKA and HUL for outplanting and genetic storage • Complete Ekahanui Subunit II	• Work with new Honouliuli landowner. • Ekahanui Subunit II to be completed 2008	• current
Kaluaa	• Build up stock from SBW, ELI, SBS, and KAL for outplanting and genetic storage	• Work with new Honouliuli landowner.	• current
Pualii	• Build up stock from Pualii for outplanting and genetic storage	• Work with new Honouliuli landowner. • TNC completed Pualii fence in 2006	• current

11.13 Tier 1:
Pteris lidgatei: Taxon Summary and Stabilization Plan

Scientific name: *Pteris lidgatei* (Baker) Christ
Hawaiian name: None known
Family: Pteridaceae
Federal status: Listed endangered

Requirements for Stability

- 3 population units (PUs)
- 50 reproducing individuals (short-lived perennial)
- Threats controlled
- Genetic storage collection from all PUs
- Tier 1 stabilization priority: This species was originally listed as a Tier 3 stabilization priority due to the presence of this species within the KLOA and SBER training areas off hiking trails. However, the Army chose to elevate this species to Tier 1 stabilization priority because of its rarity.

Description and biology: *Pteris lidgatei* is a medium sized terrestrial fern 0.5-1.0 m (1.6-3.3 ft) tall with creeping rhizomes 1.5 cm (0.59 in) thick, and 10 cm (3.9 in) or longer in length. The fronds are 1-pinnate to 2-pinnate-pinnatifid, oblong-triangular to broadly ovate-triangular, and measure 30-95 cm (12-37 in) long, and 12-45 cm (4.7-18 in) wide. The leaf has 4-6 pairs of pinnae. The leaf blade is dark gray green, and thick and brittle. The sori are marginal, and either divided into many short, separate sori, or form a single unbroken marginal sorus (Palmer 2003, W. H. Wagner 1949).

Very little is known of *P. lidgatei*'s biology since it has not been often observed in the wild, and it has not been cultivated. Sori can be found on the species' fronds year round, but it is not yet known if sporulation also occurs year round. The gametophytic generation of the species has not been studied. The sporophytes of the species are presumed to be short-lived.

Known distribution: *Pteris lidgatei* has been found in the Koolau Mountains of Oahu, on Molokai, and on West Maui (see Maps 16.50-16.52). The species occurs from 488 to 719 m

(1,600 to 2,360 ft) on Oahu. The recorded elevations for the species on West Maui are higher, ranging from 747 m (2,450 ft) to 1,097 m (3,600 ft). The elevation recorded for the single Molokai collection is "3,000 ft? (*Forbes 556.Mo*, BISH)."

Population trends: There is little information on population trends for *P. lidgatei* since all of the populations now known were discovered only since 1993, when plants were found in KLOA and the East Range of SBMR. It appears that the species has long been a rare plant, based on the historical infrequency of observations and collections.

In many of the recorded colonies of *P. lidgatei*, most or all of the plants have been recorded as being mature. However, immature and sporeling sized plants are likely to be undetected or undercounted. At a location in South Kaukonahua Gulch in SBMR East Range, a colony of plants was observed to consist of two mature plants, about six immature plants, and about 50 sporelings. In the Kawainui site in KLOA, no mature plants were seen when the colony was discovered in 1993. The three plants observed on that occasion were all immature.

Current status: *Pteris lidgatei* is currently known from Oahu, Maui and Molokai. Approximately 17 individuals are known on Oahu. More than half of the known plants on Oahu are within the KLOA and SBMR action areas. The current population units and the number of plants they contain are given in the status table below and their locations are plotted on figures11.32-33.

Habitat: *Pteris lidgatei* is found in wet forest areas on steep rocky embankments that are constantly moist, such as steep streambanks, and on the nearly vertical banks next to waterfalls.

Taxonomic background: There are five species of *Pteris* native to Hawaii. *Pteris lidgatei* differs from most of the other members of the genus in its atypical sori (Wagner 1949).

Outplanting considerations: No hybridization involving *P. lidgatei* has been reported to date. The other native species of *Pteris* usually occur in drier habitats than does *P. lidgatei*, and have not yet been observed to grow with *P. lidgatei*. Thus concerns about the outplanting of *P. lidgatei* are minimal with respect to other *Pteris* species.

Threats: Among the major threats to *P. lidgatei* are the various alien plants that are invading the species' habitats. These include species such as Koster's curse (*Clidemia hirta*) and strawberry guava (*Psidium cattleianum*). Throughout its range, *P. lidgatei* is threatened by feral pigs. Many of the plants cannot be reached by feral pigs since they are situated on steep embankments. However, the presence of pigs in the general area of a *P. lidgatei* population accelerates the degradation of the plant's habitat. If any plants of *Pteris lidgatei* are still extant on Molokai, they would likely be threatened by Axis deer and feral goats in addition to feral pigs. Threats to the population units are identified in figure 11.35.

Threats in the Action Area: The threat from fire caused by military training activities is very low within SBER and nonexistent within KLOA. However, the fire threat to this species is considered none as it grows on steep waterfalls or wet slopes. Additional threats inside the action area include trampling from occasional foot maneuvers, and the introduction of non-native plants via transport of personnel and equipment between training areas. However, the trampling threat is potentially none as this species generally is found on very steep slopes or waterfalls. Additional threats to this species throughout its range include habitat degradation by feral pigs and competition from non-native plant species such as *Clidemia hirta* and *Setaria palmifolia*.

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Pteris lidgatei **TaxonCode: PteLid**

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Helemano	Manage for stability	0	2	2	0	0	0	0	0	0	**0**	**2**	**2**	Just outside Helemano MU.
Kawaiiki	Manage for stability	3	0	0	0	0	0	3	0	0	**3**	**0**	**0**	
Kawainui	Genetic Storage	0	1	0	0	0	0	3	10	0	**0**	**1**	**0**	
North Kaukonahua	Genetic Storage	0	0	0	0	0	0	1	0	0	**0**	**0**	**0**	GSC at this PU in favor of MFS at Helemano
South Kaukonahua	Manage for stability	6	0	0	0	0	0	10	3	0	**6**	**0**	**0**	Ouside South Kaukonahua MU;
	Total for Taxon:	9	3	2	0	0	0	17	13	0	9	3	2	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
PteLid.KLO-C	Helemano pools (below fence)	In situ		2	2
PteLid.KLO-A	Waterfall plants	In situ	3		
PteLid.KLO-D	Kawainui below Kahuku Cabin	In situ		1	
PteLid.KLO-B	North Kaukonahua Stream	In situ	0		
PteLid.SBE-A	Talbert's plants	In situ	6		

Action Area: Out

TaxonName: Pteris lidgatei TaxonCode: PteLid

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaluanui	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	NRS have not monitored

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
PteLid.NUI-A	Kaluanui Gulch	In situ	0	0	0

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Waimano	Genetic Storage	0	2	0	0	0	0	3	0	0	**0**	**2**	**0**	NRS will partner with PEP for more frequent monitoring

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
PteLid.ANO-A	Waimano	In situ		2	

		NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling
	Total for Taxon:	0	2	0	0	0	0	3	0	0	0	**2**	0

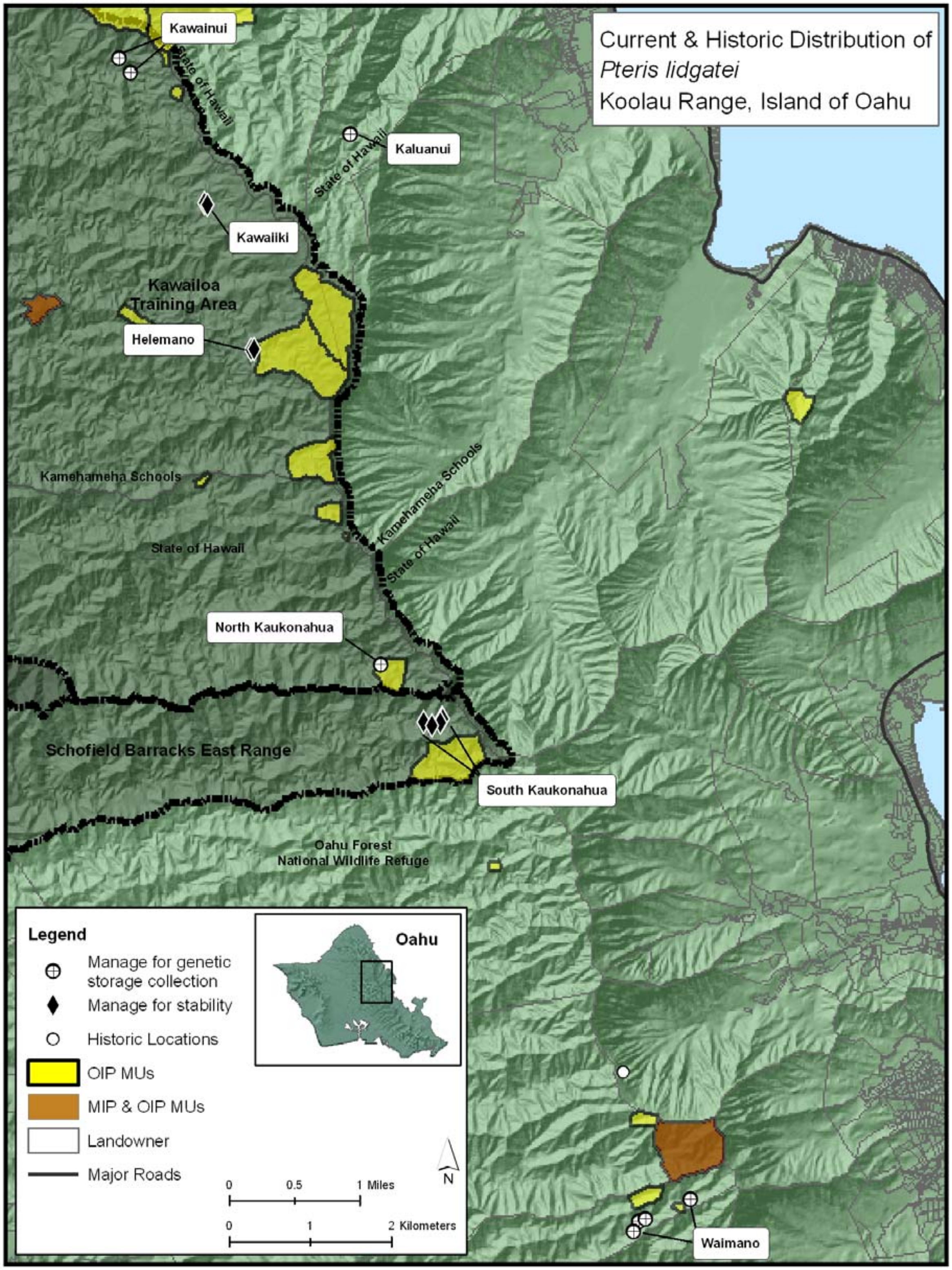


Figure 11.30 Current and historical distribution of *Pteris lidgatei* in the Northern Koolau Mountains of Oahu.

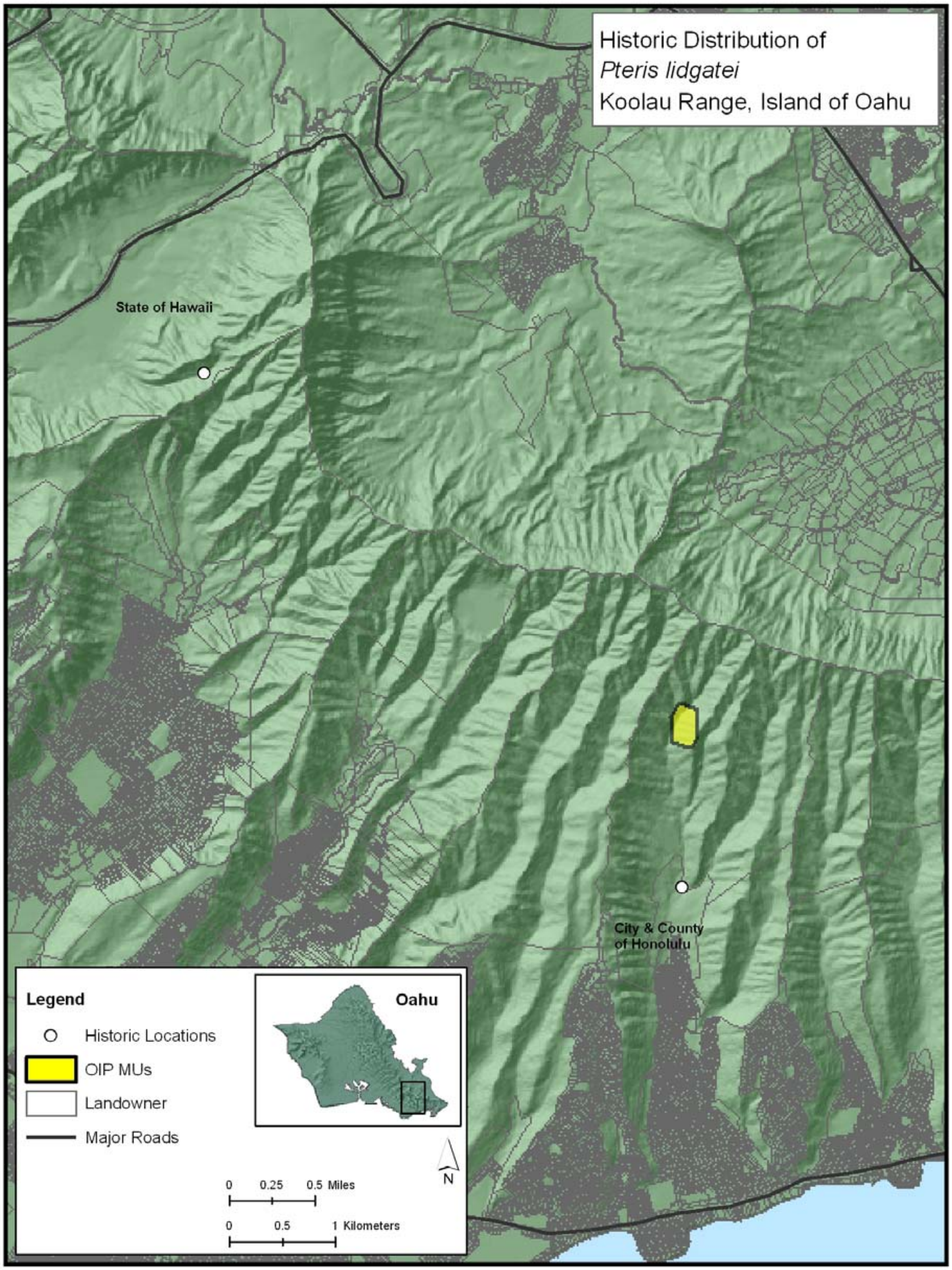


Figure 11.31 Historic distribution of *Pteris lidgatei* in the southern Koolau Mountains of Oahu.

Discussion of Management Designations

Typically, populations occur along steep stream banks and/or waterfalls and are naturally protected from direct ungulate impacts. Populations may not require fencing, though it may help to reduce erosion and improve the overall ecosystem. This steep habitat will also be difficult for reintroductions. The North Kaukonahua PU falls just inside the proposed North Kaukonahua MU but has not been observed in recent visits. Therefore, the Helemano PU was chosen for stability instead. The Helemano plants fall just outside the Helemano MU but occur on steep stream banks with abundant available habitat within the MU. The South Kaukonahua and Kawaiiki PUs were chosen for management to try to encompass the geographic range of the species inside the action area. Stabilization target numbers can only be reached when successful propagation techniques become available. The Maui and Molokai populations will not be stabilized because there is no threat from Army training and any propagules from different islands should be kept separate at this time.

Propagation and Genetic Storage

Spores have been collected and successfully germinated to yield gametophytes and sporlings via micropropagation techniques at Harold L. Lyon Arboretum. Seven years elapsed between spore sowing and healthy, large sporlings. Sporlings were transplanted but later died, though gametophytes from this collection still remain in vitro. Collections of mature fronds will be collected from all PU's to propagate via spore germination. Propagation efforts will continue by establishing plants in the nursery and then at reintroductions. Genetic storage goals will first be met by maintaining gametophytes via micropropagation. Plants will later be maintained *ex situ* in the nursery. Spores will hopefully be collected from this material and stored. Genetic storage methods will be adjusted as necessary. Fern spore storage research will be initiated in conjunction with germination efforts at the Lyon Arboretum Micropropagation Laboratory to determine storage longevity of spores for this taxon.

Outplanting Issues

All three MFS PUs will require augmentation to achieve the numbers needed for stability. NRS will develop propagation techniques once mature sori are collected. Outplanting *P. lidgatei* into the waterfall and stream bank habitat may be challenging.

Research Issues

The biology of this species is not well known and research on the gametophyte and sporophyte generation is needed. Propagation methods are not developed.

Management Notes

The highest priority for management is the development of propagation techniques. No mature spores of this species have been collected in the past 8 years on Oahu. Therefore, regular monitoring of wild populations may help propagation techniques as fertile spores may be difficult to collect at the proper time. Stabilization may not be achieved if this species cannot be propagated. Additionally, surveys need to be conducted around the known sites to determine the extent of the PUs. The manage for stability PUs (**Kawaiiki, Helemano,** and **South Kaukonahua**) should be revisited in coordination with OPEP at least yearly for threats and potential genetic collections.

Table 11.12 Priority Management Actions for *Pteris lidgatei* Army Stabilization PUs.

Population Unit	Specific Management Actions	Partners/Concerns	Timeline
Kawaiiki PU	• Survey, monitor for mature fronds • Construct fence if needed • Control priority weeds	• Kamehameha Schools land-license agreement needed for fencing.	• Monitor yearly
Helemano PU	• Survey, monitor for mature fronds • Control priority weeds	• Helemano Mu constructed in 2006	• Monitor yearly
South Kaukonahua PU	• Survey, monitor for mature fronds • Construct fence if needed • Control priority weeds	• MU needs an EA.	• Construct South Kaukonahua MU;OIP yr 5; 2012

11.14 Tier 1:
Schiedea trinervis: Taxon Summary and Stabilization Plan

Scientific name: *Schiedea trinervis* (H. Mann) Pax & K. Hoffmann
Hawaiian name: None known
Family: Caryophyllaceae (Pink family)
Federal status: Listed endangered (listed as *Alsinidendron trinerve*)

Requirements for Stability

- Maintain at least 150 reproducing individuals throughout the range of the species (between Kalena and E. Makaleha)
- Threats controlled
- Genetic storage collection from 50 individuals across the range of the species
- Tier 1 stabilization priority

Description and biology: *Schiedea trinervis* is an upright shrub 30-80 cm (12-31 in) tall. Its oppositely arranged leaves are elliptic-ovate or sometimes oblanceolate, measure 6-12.5 cm (2.4-4.9 in) long and 2.3-6 cm (0.91-2.4 in) wide, and are hairless except for the margins. The inflorescences are pseudoaxillary cymes bearing 18-34 pendant flowers, which do not open fully. The flowers are without petals, but their green and white sepals are petal-like in appearance. The sepals are 6-8 mm (0.24-0.31 in) long. As the capsule matures the surrounding sepals enlarge to 9-10 mm (0.35-0.39 in) long, become dark purple and fleshy. The capsules are ovoid to subglobose, measure 8-12 mm (0.31-0.47 in) long, and contain numerous small black seeds.

Schiedea trinervis flowers and fruits year round, but flowering is usually heaviest in the winter and spring. The species is self-pollinating (Wagner, Weller and Sakai, 2005). The sepals that enclose the capsule become purple and fleshy when the capsule is mature, causing the fruit to outwardly resemble a berry. This ‘false berry’ is presumed to attract fruit-eating birds that ingest the seeds and act as dispersal agents. Most of the reproduction in the species is by seed. The plants can begin flowering when less than two years old. The longevity of individual plants is unknown, but they assumed to be relatively short-lived.

Known distribution: *Schiedea trinervis* is endemic to the northern Waianae Mountains from Kaala to Puukalena. It grows on all sides of Kaala, up to the edges of the mountain's summit plateau, but has not been observed to grow on top of the plateau itself. It has been recorded from 700-1,220 m (2,300-4,000 ft) in elevation.

Population trends: Most of the plants of *S. trinervis* on the slopes of Kaala have been found within the last decade, and have been known for too short a time to for population trends to be well documented.

Immature plants have occasionally been observed in abundance around a mature plant or group of mature plants. This suggests that this species could have fluctuating numbers of individuals within a given colony of plants.

Current status: Currently, there are about 170 mature indivduals and approximately 500 immature plants including seedlings. About 95% of these plants are within the SBMR action area. The current population units and the number of plants they contain are given in the status table below and their locations are plotted on Figure 11.24.

Habitat: *Schiedea trinervis* typically grows on gradually sloped to steep terrain in wet forests usually dominated by *ohia lehua* (*Metrosideros* spp.). Common associates include *uluhe* (*Dicranopteris linearis*), *mamaki* (*Pipturus albidus*), *Boehmeria grandis*, *alani* (*Melicope* spp.), *olomea* (*Perrottetia sandwicensis*), and *hoio* (*Diplazium sandwichianum*).

Taxonomic background: The endemic Hawaiian genus *Schiedea* constitutes a complex of 34 species thought to be descended from a single colonizing ancestor. There are 11 species of *Schiedea* native to Oahu, nine of which have been recorded from the Waianae Mountains (Wagner *et al*., 2005).

Schiedea trinervis and *S. obovata*, both endemic to the Waianae Mountains, along with two species endemic to Kauai, had almost universally been placed in the genus *Alsinidendron*, which was thought to be an endemic Hawaiian genus closely allied to *Schiedea*. However, genetic studies over the past few years have led to the conclusion that *Alsinidendron* should be subsumed into the genus *Schiedea* (Wagner *et al*., 2005).

Outplanting considerations: Although no reintroductions of *S. trinervis* are proposed in this plan, the augmentation of existing population units or the establishment of new population units may be warranted in the future. Of greatest concern with regard to the outplanting of *A. trinervis* involving *S. trinervis*'s closest relative, *S. obovata*. Like *S. trinervis*, it is an endangered plant endemic to the Waianae Mountains. The species has been recorded from two widely separated areas of the Waianae Mountains. One of these areas, where the species still survives, is the northwestern Waianae Mountains extending from Pahole Gulch through West Makaleha Valley. The second area, where no plants are known to persist, is in the southern part of the mountain range from the Palehua area to Puuhapapa. *Schiedea obovata* is a mesic forest plant, whereas *A. trinervis* occurs in wet forests. *Schiedea trinervis* should not be reintroduced within the historical range or habitat of *S. obovata*. An outplanting line was drawn by Joel Lau (OIT member) (see Figure 16.55) demarcating the area where outplantings of *S. trinervis* could be located with minimal chance of negatively affecting *S. obovata*.

Schiedea pentandra is another *Schiedea* species whose ecological and geographical ranges may overlap marginally with that of *S. trinervis*. It is a species that is not listed as endangered, but is nevertheless a rare plant, and so when planning for outplantings of *S. trinervis*, it is another species whose populations should be taken into consideration.

One outplanting concern with *S. trinervis* involves the proper identification of the planting material. *Schiedea trinervis* and *S. obovata* can be difficult to distinguish, particularly when the plants are not in flower or fruit. In the past there has been a considerable amount of confusion with the respect to the identity of some of the cultivated material of *S. trinervis* and *S. obovata*. With this pair of species there needs to be a heightened level of awareness among the caretakers of in situ plant material of the possibility for cultivated plants to become misidentified.

Threats: The major threats to *S. trinervis* are invasive alien plant species, and feral pigs and goats. The prickly Florida blackberry (*Rubus argutus*) is the most serious invasive alien weed currently impacting *S. trinervis*.

Threats in the Action Area: Threats in the action area include fire from military training activities and invasion by non-native plants spread by training maneuvers. The fire threat for this species is low for the Kalena and Kalena Kaala ridge subpopulations and very low for the Kaala and East Makaleha subpopulations. Therefore, although the majority of individuals of this taxon are located within the action area the majority of those individuals have an insignificant threat from fire. Additional threats for all occurrences are habitat degradation by feral ungulates non-native plant species such as *Rubus argutus* and *Hedychium gardnerianum*.

Action Area: In

TaxonName: Schiedea trinervis

TaxonCode: SchTri

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kalena to East Makaleha	Manage for stability	180	196	318	0	0	0	166	169	0	**180**	**196**	**318**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
SchTri.ALA-A	Kaala	In situ	1	3	
SchTri.ALA-B	2 Pole Ridge	In situ	3		
SchTri.ALA-C	Lower 2 Poles Ridge	In situ	5	5	4
SchTri.ALA-D	Metal tower gulch	In situ	12	6	
SchTri.ALA-E	Kaala, on north side of transect Sta 500 heading out	In situ	10		
SchTri.ALA-H	Waterfall population	In situ	11	5	62
SchTri.ALA-I	Old Transect Ridge	In situ	4	2	
SchTri.ALA-J	Kaala-First big transect gulch	In situ	6		24
SchTri.ALA-K	one ridge north of the rust house	In situ	5		
SchTri.ALA-L	50m on trasect gulch	In situ	3	4	6
SchTri.ALA-M	near bottom of 320 ridge	In situ	2	2	
SchTri.ALA-N	w end of Hale'au'au fence line	In situ	1		
SchTri.ALA-O	590 on transect	In situ	25	40	100
SchTri.ALA-P	left of pink flag trail	In situ	8	18	3
SchTri.ALA-Q	right gulch off of Pink flag trail	In situ	2		
SchTri.ALA-R	Makaha waterfall	In situ	17		
SchTri.ALA-S	one gulch N. of Alstri ridge	In situ		50	
SchTri.ALA-T	below telephone pole	In situ	3	3	3
SchTri.ALA-U	Ka'ala, off transect 1010	In situ	2	2	
SchTri.ALA-V	590 on transect, far down	In situ	5	5	5
SchTri.ALA-W	One gulch W of Blue Ridge	In situ	8	11	
SchTri.ALA-Y	Kaala, 850 on transect, E. side	In situ	5	5	5
SchTri.ALA-Z	W. side of pink trail	In situ	15		1
SchTri.KAO-A	Kaomoku nui	In situ	2		
SchTri.LEH-A	East Makaleha	In situ	2		5
SchTri.SBW-F	Kaala-Kalena Ridge (Kaala side)	In situ	13	27	74
SchTri.SBW-G	Kalena, in notch	In situ	0	0	0
SchTri.SBW-I	Puu Kalena near the top	In situ	2	2	
SchTri.SBW-J	Puu Kalena kaala side of the top	In situ	8	6	26

	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling
Total for Taxon:	180	196	318	0	0	0	166	169	0	**180**	**196**	**318**

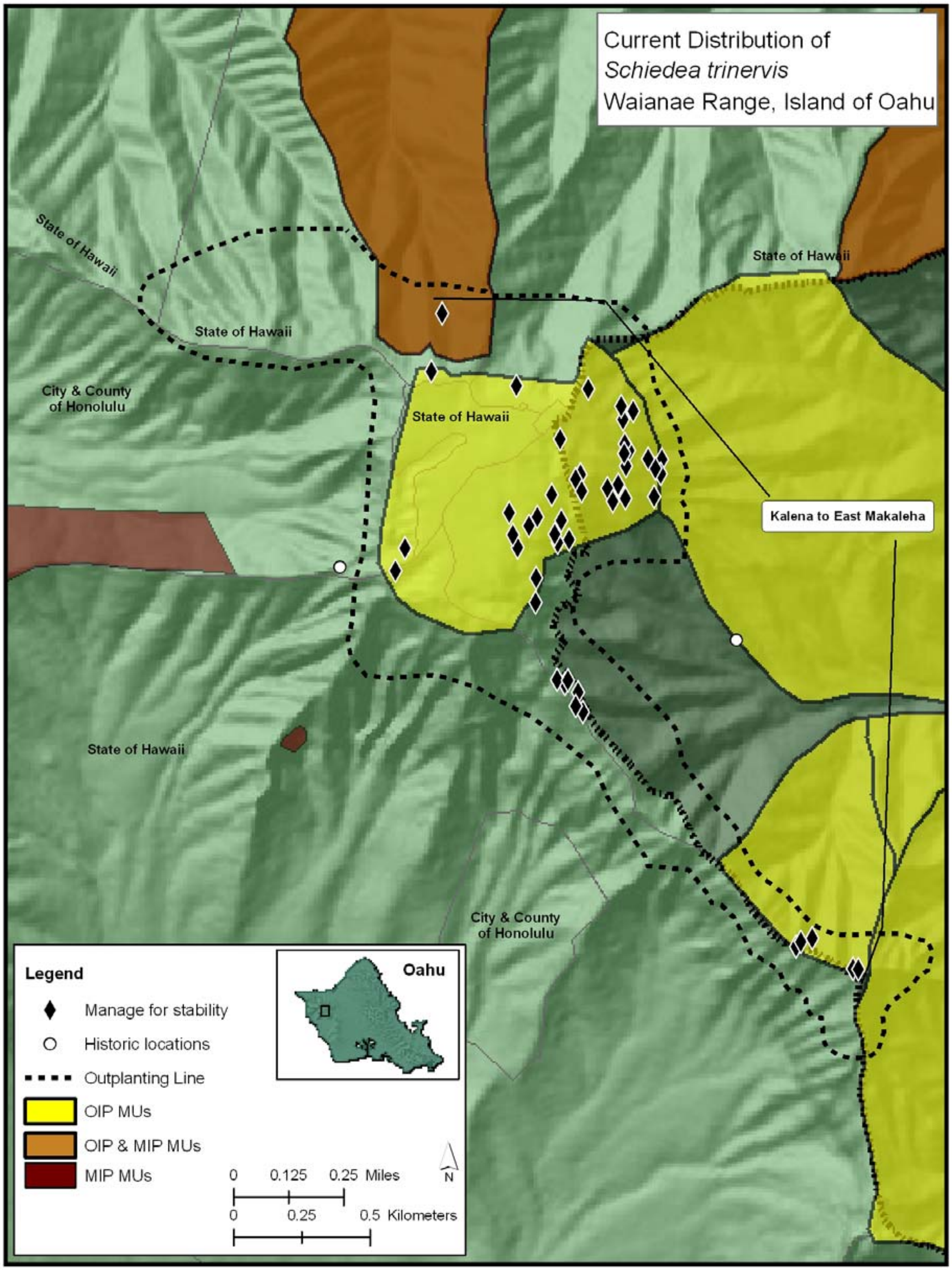


Figure 11.32 Current and historic distribution of *Schiedea trinervis* in the Waianae Mountains of Oahu with an outplanting line separating potential outplanting sites from any potential *S. obovata*.

Discussion of Management Designations

The center of distribution for this species is Mount Kaala in the Waianae Mountains. Stabilization for *Schiedea trinervis* involves the reestablishment of a somewhat continuous distribution of the species from Puu Kalena to East Makaleha. This continuous population will integrate individuals from various facing slopes of Kaala, minimizing the possibility of one stochastic event destroying the majority of the species. Genetic storage collections are required from at least 50 plants distributed across the range of the species in order to conserve sufficient genetic variation. This number was not increased to 150 because this is essentially a single population although stabilization target numbers are meant to reflect 3 PUs. Most of the known individuals will fall within the Kaala MU that will be protected by strategic fencing. There are also sub-populations within the East Makaleha and South Haleauau MUs. The number of known individuals has dramatically increased due to recent surveys. Additionally, the total number of known individuals is predicted to continue to increase with additional surveys. The Kaala area subpopulation appears to be stable and contains all age classes.

Propagation and Genetic Storage

Seeds are easy to collect *in situ* and plants are easily propagated from seed. Seed viability of this taxon is high. Seeds have a high potential for long-term storage longevity. Due to these propagation and seed characteristics, seed collected from wild plants will be stored long-term to maintain adequate genetic storage representation. Vegetative propagation has not been attempted and will likely not be necessary as seed is easily acquired *in situ*. This taxon will likely not need to be reintroduced, if this changes, seed collected *in situ* will be used to establish reintroductions.

Genetic Storage Summary

	# of Potential Founders			Partial Storage Status			Storage Goals Met
Population Unit Name	Current Mature	Current Imm.	NumWild Dead	# Plants >= 10 in Seedbank	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants that Met Goal
Schiedea trinervis							
Kalena to East Makaleha	169	206	15	36	1	0	35
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				36	1	0	35

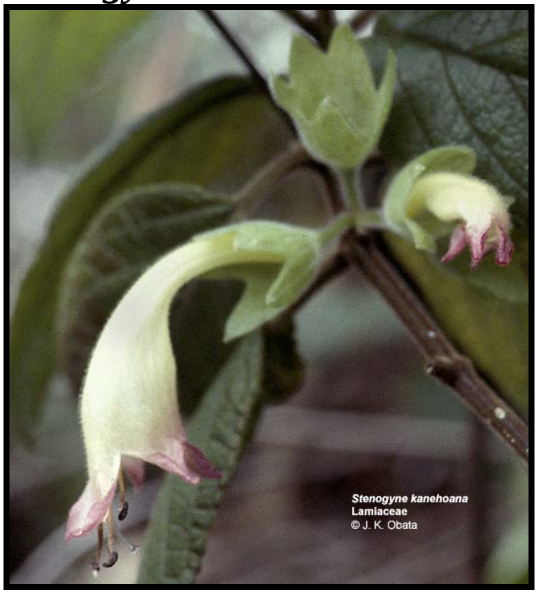
Management Notes

This species appears to be at stability target numbers. The numbers of individuals are expected to increase with MU management at Kaala, East Makaleha and South Haleauau MUs. Threats from pigs and goats need to be controlled. This species likely also benefits from weed control. The Army has nearly reached genetic storage collection goals of at least 50 seed from 50 individuals across the geographic range of the species. Representation of unprotected and outlying plants is a high priority. The target number for stability is 150 mature, reproducing individuals across the range of the species. The priority management actions are broken out by the three major geographic locations for this species. The target is higher than other species because there is just a single PU. The Army does not have plans to augment this species at this time though monitoring may dictate the need in the future.

Table 11.15 Priority Management Actions for *Schiedea trinervis.*

Geographic Area	Specific Management Actions	Partners/Concerns	Timeline
Kalena (South Haleauau MU)	• Construct South Haleauau MUs • Goat control in Makaleha and Waianae Kai • Collect propagules for genetic storage from this end of the range • Control priority weeds • Survey	• This MU needs an EA.	• Construct South Haleauau MU, OIP yr 3; 2010
Kaala (Kaala MU)	• Monitor and collect for genetic storage • Control priority weeds	• Kaala MU 90% complete • Work with the State to improve strategic fencing	• current
East Makaleha (East Makaleha MU)	• collect propagules for genetic storage from this end of the range • construct East Makaleha MU • control priority weeds	• Work with the State to complete East Makaleha MU (EA complete w/ FONSI)	• Construct East Makaleha MU MIP yr 7; 2010 •

11.15 Tier 1:
Stenogyne kanehoana: Taxon Summary and Stabilization Plan



Scientific name: *Stenogyne kanehoana* Degener & Sherff
Hawaiian name: None known
Family: Lamiaceae (Mint family)
Federal status: Listed endangered

Requirements for Stability

- 3 population units (PUs)
- 100 reproducing individuals (short-lived perennial; infrequent flowering)
- Threats controlled
- Genetic storage collection from all individuals
- Tier 1 stabilization priority

Description and biology: *Stenogyne kanehoana* is a scandent vine with tomentose stems 1-2 m (3.3-6.6 ft) long. The leaves are opposite, densely tomentose, narrowly ovate to oblong-ovate, and measure 6-14 cm (2.4-5.5 in) long and 2.5-4.8 cm (0.98-1.9 in) wide. The flowers are tubular and curved, and are arranged in clusters of 3-6 per node. The corolla tubes are white to pale yellow, and range from 27-42 mm (1.1-1.7 in) long. The lip of the corolla is pinkish purple. The nutlets are about 9 mm (0.35 in) long.

Little is known of *S. kanehoana*'s biology since this species has always been very rare, and has seldom been cultivated. It is likely that some percentage of the species' reproduction is asexual. As with other species of *Stenogyne, S. kanehoana* has long, rambling stems, which may root when contacting the ground, leading to the formation of additional plants.

There are no reports with respect to the species' pollinating agents, but the flower's long, curved corolla is suggestive of pollination by nectar feeding birds. Flowering and fruiting has been recorded from January through June. Dispersal agents for this species are unknown. The species is considered short-lived for the purposes of this implementation plan.

Known distribution: Until recently *S. kanehoana* had been known only from a few records from a small area south of Kolekole Pass. This area included only the Huliwai-Kaluaa Ridge and Kaluaa Gulch, both of which are within the Nature Conservancy's Honouliuli Preserve. In 2004 the species was discovered in Haleauau Gulch, which is north of Kolekole Pass, between Kaala and SBMR's West Range. The recorded elevations for this species range from 730-760 m (2,400-2,500 ft).

Population trends: The only plants known for decades are those that used to grow on the Huliwai-Kaluaa Ridge. The plants were growing alongside the major trail leading to Puukanehoa, and thus was often observed by hikers and botanists. In the late 1970's there was a patch of possibly three plants at this location. The last remaining plant died in 1996. The invasion of Koster's curse (*Clidemia hirta*) into the area in the 1980's and 1990's was probably a major factor contributing to the extirpation of this patch of *S. kanehoana*.

Current status: Only one naturally occurring individual of *S. kanehoana* is known to remain. The individual known from Central Kaluaa Gulch south of the SBMR action area recently died, leaving just one individual in Haleauau Gulch within the SBMR action area.

The population units are listed in the status table below and their sites are plotted on figure 11.25.

Habitat: *Stenogyne kanehoana* has been found in mesic forests, growing on ridge tops and on gulch slopes. Associated native plant species include koa (*Acacia koa*), uluhe (*Dicranopteris linearis*), and ohia lehua (*Metrosideros polymorpha*).

Taxonomic background: *Stenogyne* is an endemic Hawaiian genus of 20 species, only two of which occur on Oahu. The other Oahu *Stenogyne* is *S. kaalae*, which consists of two subspecies: subsp. *sherffii* in the Koolau Mountains, and subsp. *kaalae* in the Waianae Mountains.

Outplanting considerations: *Stenogyne kanehoana* and *S. kaalae* subsp. *kaalae* are both mesic forest plants that occur in the same drainages. *Stenogyne kaalae* subsp. *kaalae* is not considered rare. No apparent hybrids of the two species have been noticed, although elsewhere in Hawaii specimens of *Stenogyne* have been collected that probably represent hybrids (Wagner et al. 1990). Concerns with respect to outplanting *S. kanehoana* near *S. kaalae* subsp. *kaalae* are minimal since they are likely to have grown next to one another in the past.

Threats: Major threats to *S. kanehoana* include feral pigs and alien plants, fire, and potential effects from Army training. The most serious weed threats to *S. kanehoana* include Koster's curse (*Clidemia hirta*), lantana (*Lantana camara),* Hilo grass *(Paspalum conjugatum)* and Christmas berry (*Schinus terebinthifolius*).

Threats in the Action Area: Major threats to *Stenogyne kanehoana* due to army training include wild fire, trampling and the transport of non-native plant species from other training areas. Although, the threat of fire and trampling are both low. Additionally, this species is threatened throughout its range by habitat destruction from feral ungulates, competition with non-native plant species, and potential reduced reproductive vigor due to reproductive isolation and the low numbers of remaining individuals and the risk of extinction from naturally occurring stochastic events.

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Stenogyne kanehoana TaxonCode: SteKan

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Haleauau	Manage for stability	1	0	0	0	0	0	1	0	0	**1**	0	0	South Haleauau MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
SteKan.SBW-A	Haleauau	In situ	1		

	Total for Taxon:	1	0	0	0	0	0	1	0	0	1	0	0

Action Area: Out

TaxonName: Stenogyne kanehoana TaxonCode: SteKan

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Central Kaluaa (Gulch 2)	Manage for stability	0	0	0	0	26	0	0	0	0	**0**	26	0	Reintroduction with Kaluaa stock. Kaluaa and Waieli MU.

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
SteKan.KAL-C	Central Kaluaa (Gulch 2)	Reintro		3	
SteKan.KAL-D	Below Hapapa Summit LZ	Reintro		23	

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Central Kaluaa (South Fenceline)	Manage for stability	0	0	0	0	53	0	0	3	0	**0**	53	0	Reintroduction mixed Haleauau and Kaluaa stock. Kaluaa and Waieli MU.

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
SteKan.KAL-A	KAL-A	In situ	0	0	0
SteKan.KAL-B	Kalua'a Reintro	Reintro		53	

	Total for Taxon:	0	0	0	0	79	0	0	3	0	0	79	0

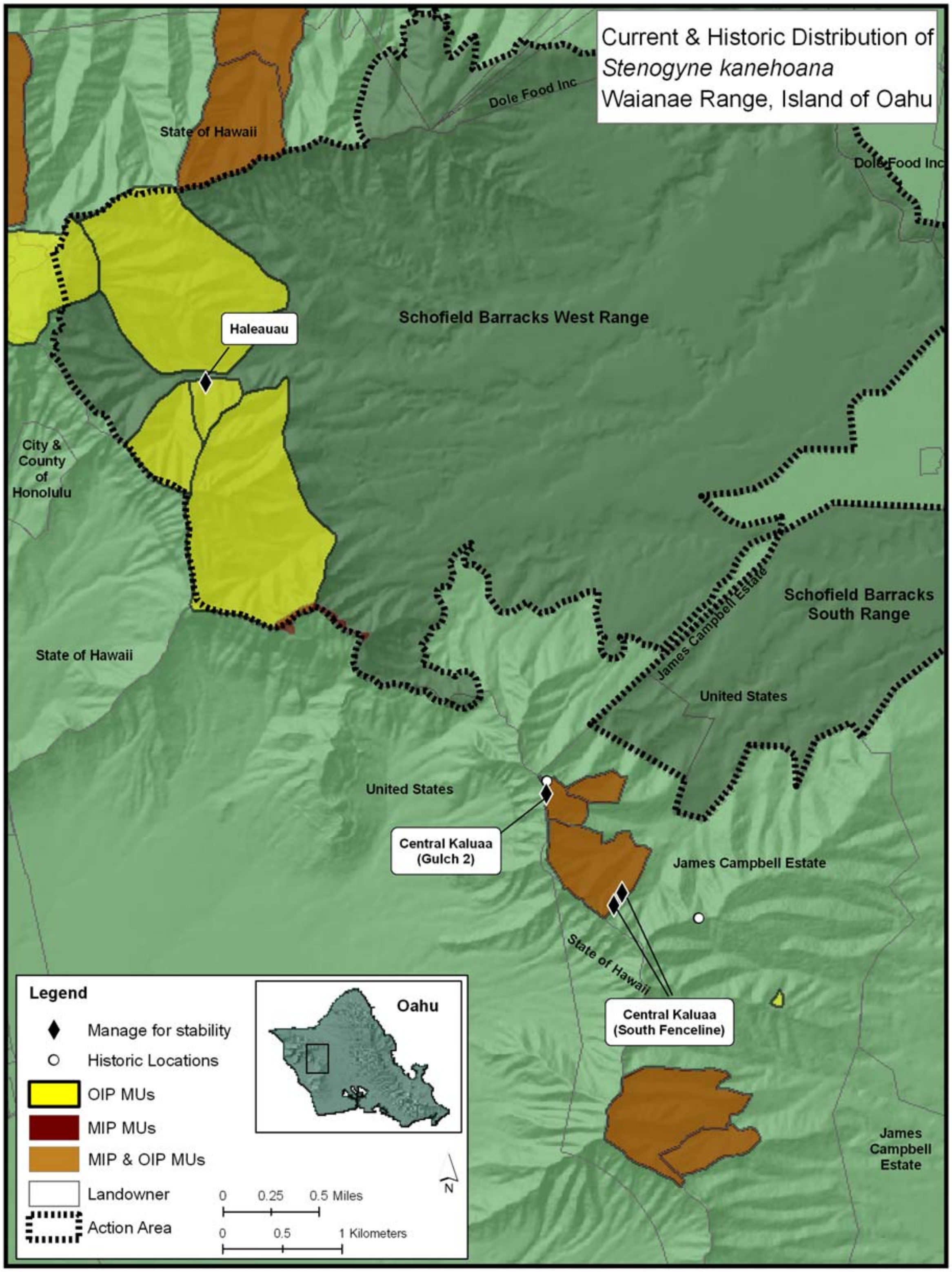


Figure 11.33 Current and historic distribution of *Stenogyne kanehoana* in the Waianae Mountains of Oahu.

Discussion of Management Designations

There are just two sites recently known for this species, Haleauau and Kaluaa. Therefore all three MFS PUs will rely heavily on reintroductions from these two source populations. The OIT has discussed having one mixed stock reintroduction and one pure site for each source population. At both original PU sites there were several clumps of vegetative plant material, with some clumps being separated by several meters. Therefore the number of source individuals at each site is not clear. Genetic testing has been suggested for the various clumps of vegetative material collected from the wild sites. This testing will be conducted within the first 2 years of the OIP.

Propagation and Genetic Storage

Clonal propagation via vegetative cuttings has been successful and effective in creating a living collection of this taxon in a nursery. Both wild populations are represented *ex situ* at Harold L. Lyon Arboretum Micropropagation Laboratory and in the Army Nursery. The utilization of vegetative cuttings to meet genetic storage requirements both in the nursery and the micropropagation facility will continue. One plant in the nursery has been observed flowering and phenology was closely observed. Flowers were pollinated (self-pollinated), but as immature fruit began to develop the branch died. Pollen is currently stored and viability will be assessed.

Reintroductions will initially be created with the clonal stock in the nursery. Any seeds (either naturally derived, or as a result of artificial crosses within PUs) may be used to create more genetically diverse reintroductions and may also be used to fulfill genetic storage requirements. Seeds produced at reintroductions may be collected, propagated *ex situ*, and planted back into the reintroduction site in order to increase the chance that these propagules will survive.

Management Notes

It is important to increase the *ex situ* stock through vegetative propagation of the two available PUs as well as the *in situ* stock via reintroductions.

The **Central Kaluaa South fork PU** (south fenceline) is a reintroduction composed of mixed stock from the two wild plants, Kaluaa and Haleauau PUs. The only wild plant in this population died in March 2005. The Army augmented this PU approximately 100 meters from the site of the original wild plant along the south Kaluaa fenceline with stock from both Kaluaa and Haleauau. Stock from this PU is represented in reintroductions, in the nursery and at the Lyon Micropropagation Lab.

The **Central Kaluaa North fork PU** (gulch 2) is a reintroduction meant to preserve the original Kaluaa PU stock. The first reintroduction at this PU was conducted in 2007. The Gulch 2 planting was established based on determinations by the Army and the IT that there should be a site where pure Kaluaa stock is represented. This site was selected because of the intact uluhe (*Dicranopteris linearis*) fern cover which reflects the natural habitat of this species. Planting operations involved clearing small openings in the uluhe.

The **Haleauau PU** was discovered in June 2004 and contained a few clumps of rooted plants but was assumed to be a single individual. Augmentations are needed at this site and will be with Haleauau stock. A 30 x 20 meter fence was constructed to protect it from pigs. This small PU fence will be encompassed by the larger South Haleauau MU. The Army has observed that the *S. kanehoana* canes do best when supported by other vegetation such as uluhe. *Acacia koa* growing within the fence will likely provide some shade for the *S. kanehoana* in the near future. Access restrictions have limited the number of visits to this population in the past although more access may be available in the next few years due to range construction. Clones of plants from this population have been reintroduced into Kaluaa and are represented in the nursery and micropropagation.

Table 11.16 Priority Management Actions for *Stenogyne kanehoana*

Population Unit	Specific Management Actions	Partners/Concerns	Timeline
Haleauau PU	• Collect seeds when available for propagation and genetic storage • Construct South Haleauau MU • Genetic testing in 2009 • Control priority weeds • Currently protected by a small fence	• Access is difficult to this part of SBMR. • South Haleauau MU needs an EA.	• Construct South Haleauau MU in OIP yr 2; 2009 • Genetic testing 2009
Central Kaluaa (South Fork) PU	• Collect seeds when available for propagation and genetic storage • Control priority weeds • Currently fenced.	• Work with new Honouliuli landowner.	• Genetic testing 2009
Central Kaluaa (North fork PU reintroduction)	• Build up additional greenhouse stock • Control priority weeds at reintro site • Within Kaluaa MU.	• Work with new Honouliuli landowner.	• currently building up stock

11.16 Tier 2:
Chamaesyce rockii: Taxon Summary and Stabilization Plan

Scientific name: *Chamaesyce rockii* (C. Forbes) Croizat & Degener
Hawaiian name: Akoko
Family: Euphorbiaceae (Spurge Family)
Federal status: Listed endangered

Requirements for Stability

- 3 population units (PUs)
- 50 reproducing individuals in each PU (Short-lived perennial)
- Threats controlled
- Genetic storage collections from all PUs
- Tier 2 stabilization priority

Description and biology: *Chamaesyce rockii* is a milky-sapped compact shrub or sometimes a small tree 0.5-2 m (1.6-6.6 ft) tall, although in protected sites may reach up to 4 m (13 ft) tall. The leathery leaves are opposite and narrowly oblong to narrowly oblong-elliptic or occasionally narrowly elliptic in shape, and measure 8-14 cm (3.1-5.5 in) long and 2-3.5 cm (0.8-1.4 in) wide. There are 3-10 cyathia (specialized flower-like inflorescences with a single central female flower surrounded by much-reduced male flowers) in branched, open to sometimes condensed, cymose inflorescences usually 2-6 cm (0.8-2.4 in) long. The capsules are three carpellate, globose, 14-25 mm (0.6-1.0 in) long, brilliant red in color, and contain seeds that are brown to grayish brown, globose or broadly obovoid in shape, and 3.5-4 mm (0.1-0.2 in) long.

Chamaesyce celastroides var. *lorifolia* on the south slope of Haleakala, Maui has been observed reproducing vegetatively by root suckers (Medeiros *et al.* 1986). With *C. rockii*, however, vegetative reproduction in such a manner has not been reported to date.

Little is known about the breeding system of *C. rockii*. However, the genus as a whole is usually monoecious (male and female flowers on different parts of the plant), or rarely dioecious (male and female flowers on separate plants). It is not known if the species is capable of self-fertilization. The species is presumed to be insect pollinated. It has been recorded flowering and fruiting at various times of the year. *Chamaesyce rockii* has by far the largest fruits and seeds of any of the Hawaiian species of *Chamaesyce*. Mature *Chamaesyce* capsules split open explosively upon drying, flinging the seeds for a short distance. The conspicuous red color of the ripe fruit is suggestive of seed dispersal by birds. For the purposes of the Implementation Plan, *C. rockii* is categorized as an intermediate to long-lived plant.

Known distribution: *Chamaesyce rockii* is recorded from scattered locations in the northern and central Koolau Mountains. The species has been found only as far south as the northern edge of Kalihi Valley. Most populations are on or near the Koolau summit ridge, although there are a few records of it up to 2.4 km (1.5 mi) to the lee of the summit ridge. The species has been documented from 564-847 m (1850-2780 ft) in elevation.

Population trends: The range of *C. rockii* has been diminishing as populations of the species are lost. Population numbers appear to declining as well (U.S. Army 2003). One colony of plants that has been observed in Waikakalaua Gulch, which is the gulch adjoining the southern boundary of the East Range of SBMR, was estimated to contain 40-50 plants when it was first recorded in 1989. When the colony was revisited in 2004 only seven plants could be found (Lau pers. comm. 2005).

Current Status: There are approximately 115 mature individuals known for this species. The majority of known plants are within the action area. The current numbers of individuals for this species is listed in the status table below and locations are plotted on figures 11.34-35 below.

Habitat: *Chamaesyce rockii* can be found on ridge crests, gulch sides, and in gulch bottoms in wet shrublands and forests. These habitats are often dominated by *ohia lehua* (*Metrosideros* spp.) and *uluhe* (*Dicranopteris linearis*). Common associated species include *mehame* (*Antidesma playtyphyllum*), *ohia ha* (*Syzygium sandwicensis*), *kokoolau* (*Bidens macrophylla*), *kanawao keokeo* (*Broussaisia arguta*), *hapuu* (*Cibotium* spp.), *pilo* (*Coprosma longifolia*), *uluhe lau nui* (*Diploterigium pinnatum*), *naenae* (*Dubautia laxa*), *manono* (*Hedyotis terminalis* and *H. fosbergii*), *uki* (*Machaerina angustifolia*), *alani* (*Melicope* spp.), *kolea* (*Myrsine* spp.), *kopiko* (*Psychotria* spp.), and *akia* (*Wikstroemia oahuensis*).

Taxonomic background: There are 16 native species of *Chamaesyce* in Hawaii; all are endemic. Several alien species of this genus are also found in Hawaii. The genus *Chamaesyce* is considered by some to be a subgenus of the large genus *Euphorbia* (Koutnik 1987). The elevation of *Chamaesyce* to the genus level leaves only a single Hawaiian *Euphorbia*, *E. haeleeleana*, which occurs only on Kauai and in the Waianae Mountains of Oahu.

Outplanting considerations: Hawaiian *Chamaesyce*s have been successfully crossed experimentally in many combinations, demonstrating that there is a lack of genetic barriers among the Hawaiian species (Koutnik 1987). There are several apparent cases of hybridization between co-occurring Hawaiian *Chamaesyce*s. Hybrid swarms between *C. rockii* and *C. clusiifolia* are found in KLOA at the head of Opaeula Gulch adjacent to the Peahinaia Trail, and on the ridge between Kawaiiki and Opaeula Gulches. The *Chamaesyce* populations at these two locations consist of very variable individuals, many of which are morphologically intermediate between *C. rockii* and *C. clusiifolia*. It is possible that the formation of hybrid populations between the two *Chamaesyce* species occurred naturally in pre-human times. Alternatively, it is also possible that the two species did not normally hybridize due to ecological reproductive barriers that effectively prevented hybridization of the two species. Alteration of the habitat of these plants resulting from the human presence in Hawaii could then have led to a breakdown of these reproductive barriers, allowing a higher level of hybridization than originally, and a blurring of species boundaries. Whether the hybridization represents a threat to *C. rockii* should be studied.

Chamaesyce clusiifolia is the only *Chamaesyce* whose range overlaps *C. rockii*'s range. It is endemic to the Koolau Mountains and is not considered to be a rare plant. If reintroductions or augmentations of *C. rockii* become necessary, they should be established away from *C. clusiifolia* populations to minimize the chances of hybridization between the two.

Threats: The primary threats to *C. rockii* are feral pigs, human impacts from trail clearing and hiking, and invasive alien plant species. The major alien plant threats to the species include Koster's curse (*Clidemia hirta*), *manuka* (*Leptospermum scoparium*), strawberry guava (*Psidium cattleianum*), kahili ginger (*Hedychium gardnerianum*), and *Pterolepis glomerata*. Rats represent a potential threat to the fruits of *C. rockii*.

Threats in the Action Area: Potential threats include trampling by foot traffic in the course of training maneuvers, habitat destruction by feral pigs, and competition from non-native plant species introduced by military personnel. The direct threat of trampling due to training maneuvers ranges from none to very low in the remote summit habitat occupied by *C. rockii.* There is no fire threat for this species due to its occurrence in montane wet forest and shrubland.

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Chamaesyce rockii   TaxonCode: ChaRoc

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Helemano	Manage for stability	7	1	0	0	0	0	300	0	0	**7**	**1**	**0**	estimated 300; Opaeula/Helemano MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
ChaRoc.KLO-D	Peahinaia, by KLO 12 #350	In situ	2	1	
ChaRoc.KLO-E	Helemano Drainage	In situ	5		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaluanui and Maakua	Genetic Storage	0	0	0	0	0	0	150		0	**0**	**0**	**0**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaukonahua to Kipapa	Genetic Storage	28	2	0	0	0	0	70	0	0	**28**	**2**	**0**	within South Kaukonahua MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
ChaRoc.KIP-A	S. Kipapa	In situ	7	1	
ChaRoc.KIP-B	Kipapa, 3 ridges south of OFNWR shelter	In situ	7		
ChaRoc.KLO-G	North Kaukonahua	In situ		1	
ChaRoc.KNA-A	Windward side Btwn SchWai Trail and Hakulei Ridge	In situ	4		
ChaRoc.SBE-A	Look in GIS and Name	In situ	10		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kawaiiki	Genetic Storage	48	2	0	0	0	0	50	0	0	**48**	**2**	**0**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
ChaRoc.KLO-B	Kawaiiki Stream	In situ	4	2	
ChaRoc.KLO-F	Freckle Tooth Ridge	In situ	1		
ChaRoc.KLO-H	Lower Alien Man	In situ	43		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kawainui to Koloa and Kaipapau	Manage for stability	48	25	4	0	0	0	50	24	0	**48**	**25**	**4**	to be managed within Koloa MU; needs more survey for better population estimates

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
ChaRoc.ELE-A	Puu Kainapuaa	In situ	5		
ChaRoc.ELE-B	Waiele Gulch	In situ		1	
ChaRoc.KLO-A	Kahuku Cabin	In situ	8	7	1
ChaRoc.KOL-A	Koloa near Kahuku Cabin	In situ	2	1	

Action Area: In

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
ChaRoc.KOL-B	Koloa Gulch	In situ	3	4	
ChaRoc.KOL-C	Koloa gulch east of middle ridge to eastern gulch bottom.	In situ	7	6	2
ChaRoc.KOL-D	Koloa gulch	In situ	6	1	
ChaRoc.KOL-E	Koloa- Kaipapa'u ridge	In situ	2		
ChaRoc.KOL-F	Off west side of proposed fenceline	In situ	3		
ChaRoc.KOL-G	Koloa north fenceline	In situ	4	1	
ChaRoc.KOL-H	Koloa north of HupNut	In situ	6	4	1
ChaRoc.KOL-I	Koloa- S. of Northern LZ	In situ	1		
ChaRoc.KOL-J	Main Northern drainage (below northern LZ)	In situ	1		
ChaRoc.PAP-A	Kaipapau paperbark gulch	In situ			
ChaRoc.PAP-B	Kaipapau L gulch	In situ			

	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling
Total for Taxon:	131	30	4	0	0	0	620	24	0	**131**	**30**	**4**

Action Area: Out

TaxonName: Chamaesyce rockii — TaxonCode: ChaRoc

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Halawa summit	Genetic Storage	0	0	0	0	0	0	1	0	0	**0**	**0**	**0**	Army has no current info for this PU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Waiawa and Waimano	Manage for stability	15	0	0	0	0	0	16	0	0	**15**	**0**	**0**	Waiawa MU (subunits I & II)

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
ChaRoc.AWA-A	Waiawa	In situ	15		

	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling
Total for Taxon:	15	0	0	0	0	0	17	0	0	**15**	**0**	**0**

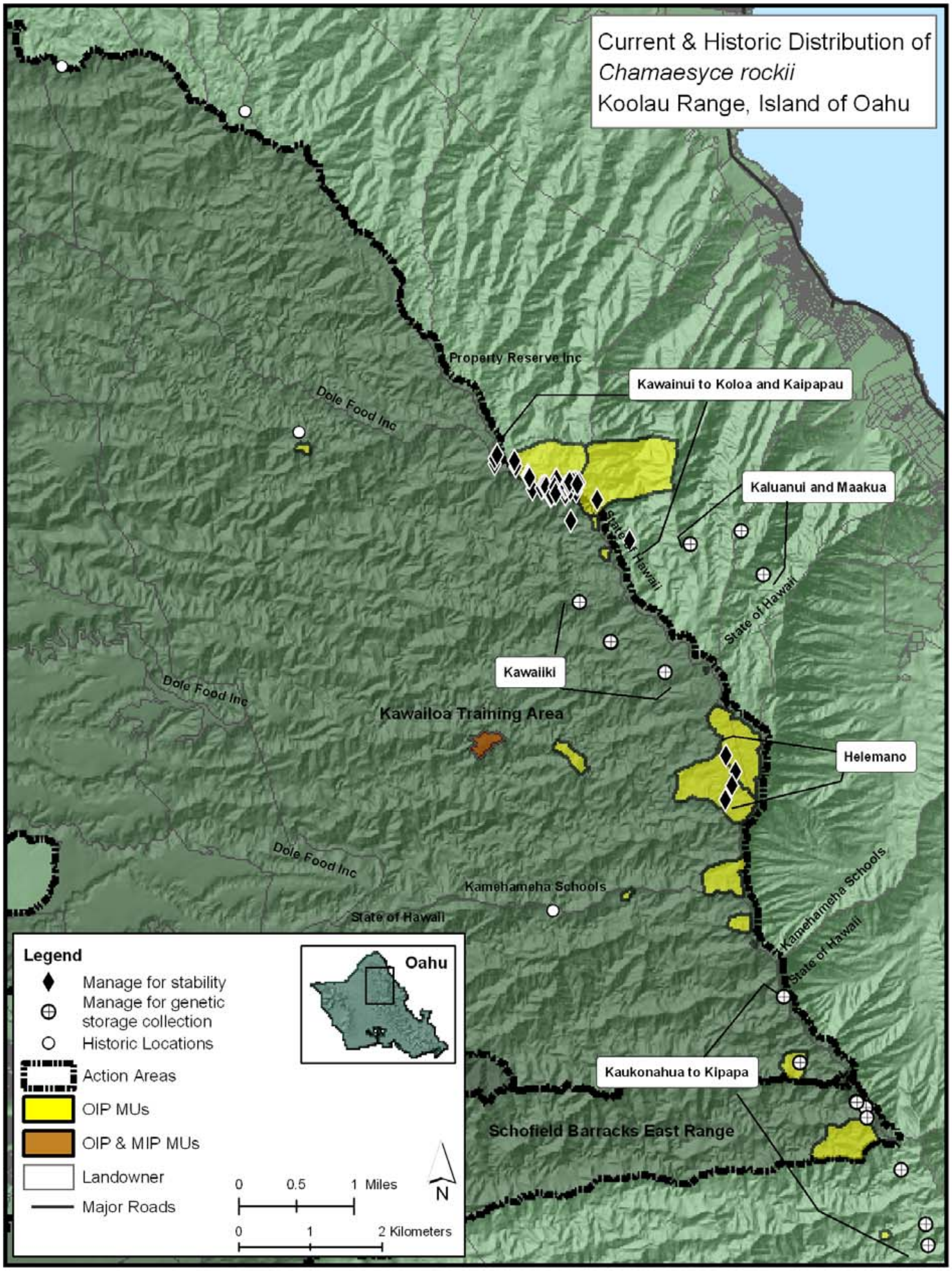


Figure 11.34 Current and historical distribution of *Chamaesyce rockii*, in the northern Koolau Mountains of Oahu.

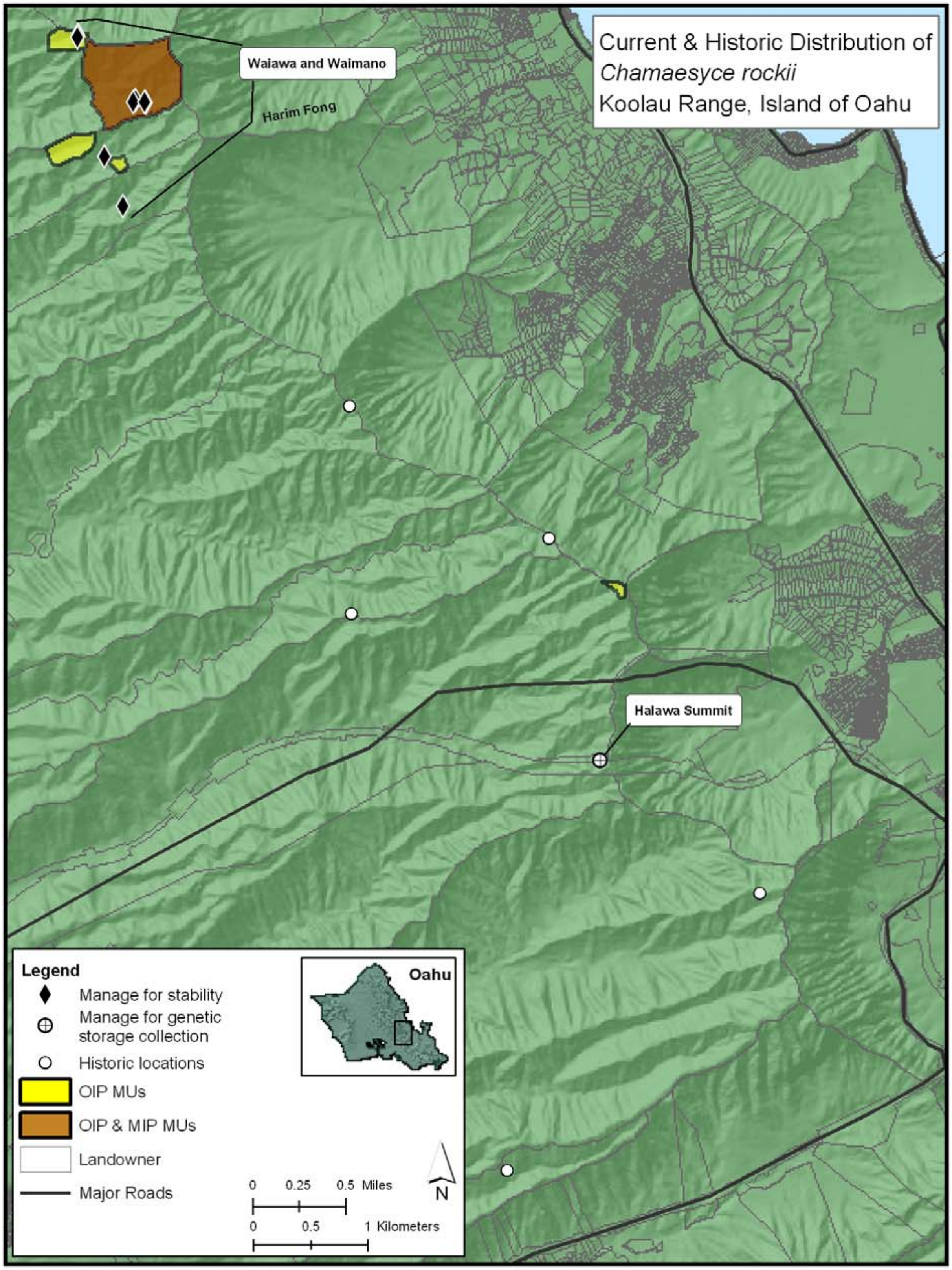


Figure 11.35 Current and historical distribution of *Chamaesyce rockii* in the central Koolau Mountains of Oahu.

Discussion of Management Designations

This species occurs in large clusters along the summit areas of the Koolau Mountains this makes it difficult to define PUs. The large Kaluanui to Maakua PU was not chosen for management due to the extremely steep terrain it encompasses. Similarly, the Kaukonahua to Kipapa PU was not chosen for stabilization because many of the plants are located on the steep windward slopes of the summit. The Kawaiiki PU was not chosen because of its remote location and the distance between the clumps of plants there. The PUs chosen for stabilization and management provide a significant representation of the range of this species from Kaipapau, Koloa, and Kawainui to Waiawa. There is a large population at Opaeula however these plants are considered hybrids. Field experts have determined that the Helemano PU is sufficiently distinct, both geographically and morphologically, from the Opaeula plants to be managed separately. Genetic testing may aid in this management decision. The Army is aware that the Kawaiiki PU has larger numbers of individuals than the Helemano PU. However, the Kawaiiki PU has not been monitored in several years and the Helemano PU is undersurveyed. Therefore, the Army will survey both sites and present the findings to the OIT.

Propagation & Genetic Storage

Little is known about the propagation methods or storage potential for this taxon. Vegetative propagation has not been attempted for this taxon. Seeds from fruit dehiscing post-harvest are viable. It is uncertain as to whether fruit should be collected pre-dehiscence or post-dehiscence for storage testing and genetic storage. Initial collections will be used to determine propagation methods, seed viability, and preferred genetic storage methods. Vegetative propagules may be collected from certain founders. This may be most appropriate for isolated, outlying, or non-reproductive individuals. Seed collected *in situ* will likely be used to establish reintroductions.

Management Notes

The **Helemano PU** is within the Opaeula/Helemano MU. There are approximately 150 hybrid individuals of *C. clusiifolia* X *C. rockii* in the northern end of the MU and will not be considered for management. Surveys of the extant of the pure and hybrid stock within the MU will be made so that management of the pure PU will be separate from the hybrid area. And genetic analyses underway will help to clarify this situation.

The **Kaipapau, Koloa, and Kawainui PU** will be managed within the Koloa MU. The highest priority for this PU is the construction of the MU fence. A thorough survey within the proposed fenced MU is also needed.

The **Waiawa and Waimano PU** will be managed within the Waiawa I and II MU. There are just 15 individuals known from this PU, however, there is some unsurveyed habitat within the MU. Therefore a survey of the general area and habitat should be made prior to the construction of the MU in order to capture as many individuals as possible. Genetic storage collections should begin opportunistically with a focus on the manage for stability PUs.

Table 11.17 Priority Management Actions for *Chamaesyce rockii* Army Stabilization PUs.

Population Unit	Specific Management Actions	Concerns/ Partners	Timeline
Kaipapau, Koloa, and Kawainui	• Continue surveys • Construct Koloa MU fence • Construct Kaipapau MU • Collect for genetic storage • Control priority weeds	• Koloa MU on Hawaii Reserves Inc. property requires license agreement. • Kaipapau MU on State Forest Reserve land. Requires State License Agreement. • MUs need an EA.	• Construct Koloa MU; OIP yr 4; 2011 • Construct Kaipapau MU; OIP yr 5; 2012 The Koloa MU continues to be a priority for construction. However, NRS are still awaiting a license agreement with the landowner.
Helemano	• Conduct thorough survey of PU • Collect for genetic storage • Control priority weeds	• MU completed in 2006.	• Conduct surveys in Helemano MU OIP yr 1 and 2
Waiawa and Waimano	• Survey • Construct Waiawa I and II MU fences • Collect for genetic storage • Control priority weeds	• Fence requires a license agreement with Kamehameha Schools. • MU has an EA w/ FONSI	• Collect for genetic storage • Construct Waiawa subunit I MU; OIP yr 10; 2017 • Construct Waiawa subunit II MU; OIP yr 12; 2019

11.17 Tier 2:
Cyanea crispa: Taxon Summary and Stabilization Plan

Scientific name: *Cyanea crispa* (Gaudich.) Lammers, Givnish & Sytsma
Hawaiian name: Haha
Family: Campanulaceae (Bellflower Family)
Federal status: Listed endangered (listed as *Rollandia crispa*)

Requirements for Stability

- 3 population units (PUs)
- 50 reproducing individuals (short-lived perennial)
- Threats controlled
- Genetic storage collections from all PUs
- Tier 2 stabilization priority

Description and biology: *Cyanea crispa* is an unbranched shrub up to 0.3-1.3 m (1-4.3 ft) tall, with broadly ovate leaves 30-75 cm (12-30 in) long and 9-16 cm (3.5-6.3 in) wide that are clustered at ends of the stems. The leaf margins are undulate, with upper surface glabrous and lower surface glabrous or pubescent. The inflorescences are axillary, and bear 3-8 flowers. The corollas are magenta, and measure 4-6 cm (1.6-2.4 in) long. The berries are orange, and are 1.0 cm (0.4 in) in length.

Flowering has been observed primarily from May through August, and fruiting from July through November. As with other *Cyanea*s with their long tubular flowers, this species is thought to have been pollinated by nectar-feeding birds. A study by Lammers and Freeman (1986) found that most Hawaiian lobelioids have a nectar sugar profile typical of bird-pollinated flowers. It is probably capable of self-pollination, as several other species of *Cyanea* are capable of selfing in cultivation. The species' orange berries are indicative of seed dispersal by fruit-eating birds. *Cyanea koolauensis* is categorized as a short-lived species for the purposes of the Implementation Plan.

Known distribution: *Cyanea crispa* has been recorded from both the windward and leeward sides of the Koolau Mountains. This species ranges from 229-707 m (750-2320 ft) in elevation.

Population trends: Population trends have not been well documented for most PUs of *C. crispa*.

Current status: *Cyanea crispa* is known from several PUs totaling approximately 110 individuals. Although, several populations have not been monitored for many years. One of the PUs is in the KLOA action area. It is in the Kawaiikii drainage and contains 17 individuals. The species' current population units and the number of plants they contain are given in the status table below and their locations are plotted on figures 11.36-38.

Habitat: *Cyanea crispa* occurs in gulch bottoms and on gulch slopes, in mesic to wet forests. Associated native plant species include *mehame* (*Antidesma platyphyllum*), *Boehmeria grandis*, *kanawao keokeo* (*Broussaisia arguta*), *Christella cyatheoides*, *hapuu* (*Cibotium chamissoi*), *haiwale* (*Cyrtandra* spp.), *lama* (*Diospyros* spp.), *naenae* (*Dubautia* spp.), *ohia lehua* (*Metrosideros polymorpha*), *olomea* (*Perrotettia sandwicensis*), *mamaki* (*Pipturus albidus*), *papala kepau* (*Pisonia umbellifera*), *kopiko* (*Psychotria* spp.), and *olona* (*Touchardia latifolia*).

Taxonomic background: There are approximately 60 species in the endemic Hawaiian genus *Cyanea*. *Cyanea crispa* was formerly included in the genus *Rollandia* (Lammers 1990). Studies have since indicated that *Rollandia* constitutes a subgroup within the genus *Cyanea* (Lammers, Givnish and Sytsma 1993).

Outplanting considerations: Extant *Cyanea* taxa potentially occurring with or near *C. crispa* are *C. calycina*, *C. acuminata*, *C. humboldtiana*, *C. lanceolata*, *C. st.-johnii*, *C. koolauensis*, and *C. angustifolia*. All except *C. angustifolia* are rare species. Another rare *Cyanea* potentially occurring with *C. crispa* in the northern Koolau Mountains is one that represents a possibly distinct, but currently unrecognized taxon. It was described as *Rollandia degeneriana* F. Wimmer (Wimmer 1956). It was considered a possible hybrid in the latest taxonomic treatment of *Rollandia* (Lammers 1990), but it was known only from the type specimen at that time. Field observations indicate that this *Cyanea* occurs in self reproducing populations not originating from recent or ongoing hybridization. There are also three possibly extinct *Cyanea* taxa that potentially occur with *C. crispa*, namely *C. longiflora*, *C. sessilifolia*, and *C. superba* subsp. *regina*. Hybridization concerns are minimal with respect to the aforementioned *Cyanea*s since they naturally co-occur with *C. crispa*.

Threats: Major threats to *C. crispa* include feral pigs, which degrade the species habitat and harm the plants through feeding on them, trampling them, or uprooting them when rooting for food. Rats pose a threat to the species through their predation on bark and fruit. Introduced slugs and snails threaten the species by feeding on its leaves, stems, and seedlings. The species is threatened by human impacts, such as trail clearing and hiking. Alien plants threaten *C. crispa* by altering the species habitat and competing with it for sunlight, moisture, nutrients, and growing space. Alien plant species that potentially threaten *C. crispa* include *Arthrostemma ciliatum, Clidemia hirta, Psidium cattleianum, Psidium guajava*, *Pterolepis glomerata*, *Rubus rosifolius, Schinus terebinthifolius, Setaria palmifolia,* and *Zingiber zerumbet.*

Long-billed, nectar-feeding native Hawaiian birds, which are the presumed original pollinators of *C. koolauensis*, have become extremely rare on Oahu. Although the species is probably capable of selfing, the loss of its normal pollinating vectors is likely to result in decreased genetic variability within its populations over successive generations.

Threats to the population units proposed to be managed for stability are identified in Table 11.39.

Threats in the Action area: Potential threats in the action area due to military training activities include trampling by foot traffic and competition with non-native plant species introduced via military training activities. The weed threat is low to moderate. The trampling threat is low but is primarily from various research scientists and hikers rather than from military activity. There is no fire threat to the onsite population. Additional threats include habitat degradation by feral ungulates and predation on seedlings and fruit by slugs and rats respectively.

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Cyanea crispa   TaxonCode: CyaCri

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kawaiiki	Manage for stability	2	4	0	0	0	0	5	0	0	**2**	**4**	**0**	To be managed within Kawaiiki MU; subunits I and II

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaCri.KLO-A	Crispa Rock	In situ	2	4	

	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling
Total for Taxon:	2	4	0	0	0	0	5	0	0	**2**	**4**	**0**

Action Area: Out

TaxonName: Cyanea crispa **TaxonCode: CyaCri**

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Aihualama	Genetic Storage	1	0	0	0	0	0	1	0	0	**1**	**0**	**0**	
Helemano	Manage reintroduction for storage	0	0	0	0	3	0	0	0	0	**0**	**3**	**0**	reintro of Kawaiiki PU for storage
Kahana and Makaua	Manage for stability	6	0	0	0	0	0	55	0	0	**6**	**0**	**0**	To be managed within Kahana MU
Kaipapau	Genetic Storage	0	1	0	0	0	0	3	0	0	**0**	**1**	**0**	Army has no current info for this PU
Kapakahi	Genetic Storage	0	0	0	0	0	0	1	0	0	**0**	**0**	**0**	Army has no current info for this PU
Kawaipapa	Genetic Storage	0	0	0	0	0	0	1	0	0	**0**	**0**	**0**	Army has no current info for this PU
Maakua	Genetic Storage	0	0	0	0	0	0	2	0	0	**0**	**0**	**0**	Army has no current info for this PU

Aihualama

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaCri.AIH-A	Aihualama	In situ	1		

Helemano

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaCri.KLO-B	Helemano REINTRO	Reintro		3	

Kahana and Makaua

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaCri.AKA-A	Makaua	In situ			
CyaCri.KNA-A	Kahana/Btw. Kahana and Makaua	In situ	6		

Kaipapau

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaCri.PAP-A	By Radio snail grid	In situ		1	

Kapakahi

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Kawaipapa

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Maakua

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Action Area: Out

Maunawili	Genetic Storage	0	0	0	0	0	0	1	0	0	**0**	**0**	**0**	Army has no current info for this PU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Pia	Genetic Storage	0	0	0	0	0	0	20	0	0	**0**	**0**	**0**	est>20

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Pukele	Genetic Storage	0	0	0	0	0	0	6	0	0	**0**	**0**	**0**	Army has no current info for this PU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Wailupe	Manage for stability	5	1	0	0	0	0	15	0	0	**5**	**1**	**0**	To be managed within Wailupe MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyaCri.UPE-A	Wailupe Gulch	In situ	5	1	

Total for Taxon:	12	2	0	0	3	0	105	0	0	**12**	**5**	**0**	

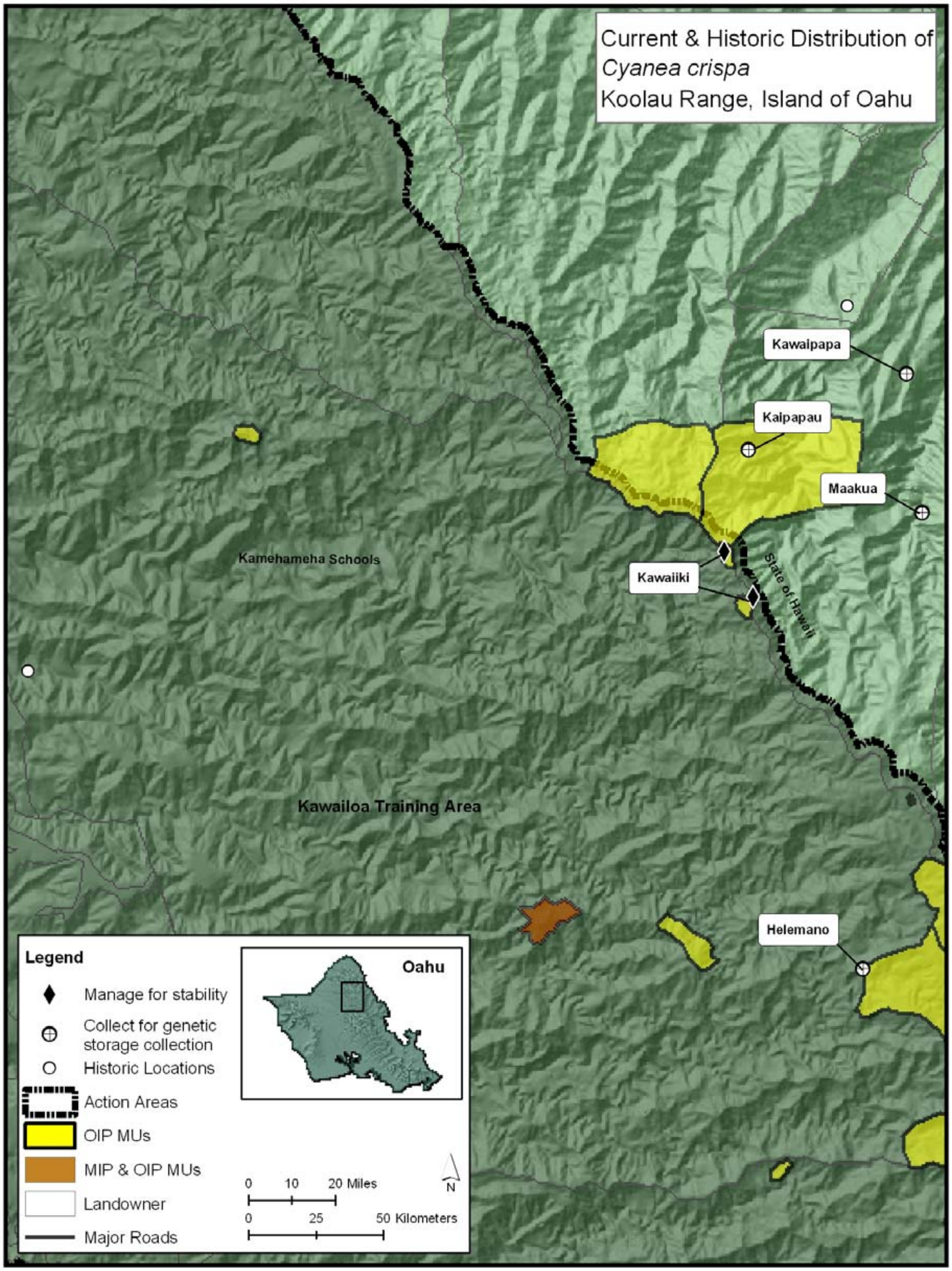


Figure 11.36 Current and historical distribution of *Cyanea crispa* in the northern Koolau Mountains of Oahu.

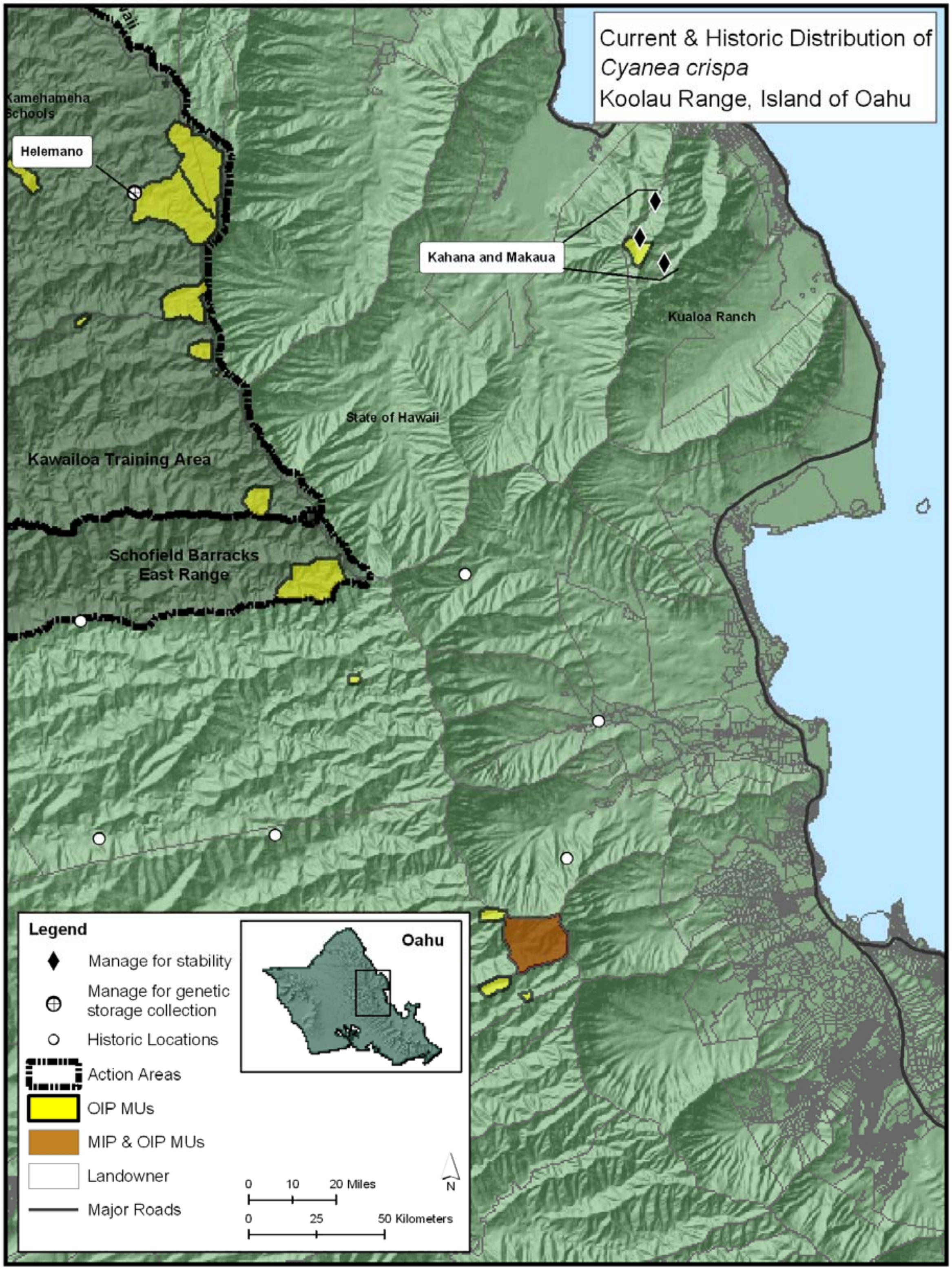


Figure 11.37 Current and historical distribution of *Cyanea crispa* in the central Koolau Mountains of Oahu.

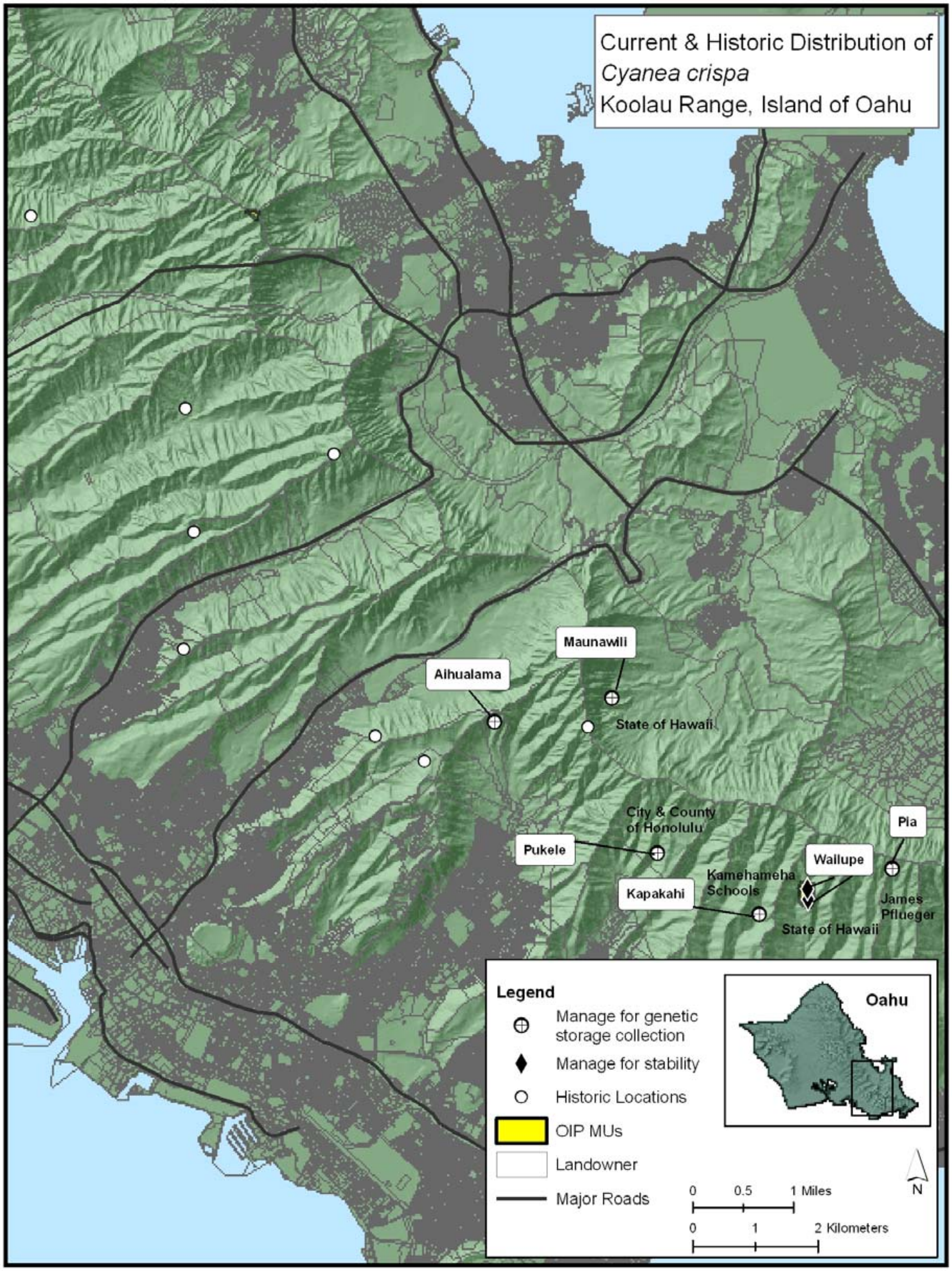


Figure 11.38 Current and historical distribution of *Cyanea crispa* in the southern Koolau Mountains of Oahu.

Discussion of Management Designations

Some populations of *Cyanea crispa* occur in gulches that may be less than 1000m apart, but have been designated as separate PUs because the preferred habitat is discontinuous. *Cyanea crispa* is known from 12 separate small PUs in mesic to wet habitat in both leeward and windward valleys in the Koolau Mountains. There are estimated to be around 110 mature plants throughout its geographical range and the three MFS PUs were chosen to cover this entire range and include the PU occurring within the action area. The Army has not monitored many of the offsite PUs for this species and therefore, the numbers in the table are compiled from a combination of Army, Hawaii Biodiversity and Mapping Program (HBMP) and Oahu PEP data. The Kahana MU will be built upon approval of the landowner. The Wailupe PU will be fenced within an MU specifically managed for this species. The Pia Valley PU was not chosen to be managed because of difficulty in getting permission from the current landowner. However, if the landowner agrees to implementing conservation efforts in the future this will be discussed with the OIT. The Aihualama, Kaipapau, Kapakahi, Kawaipapa, Maunawili, and Pukele PUs were not chosen to be managed for stability because of the low number of individuals and their distance from the action area.

Propagation and Genetic Storage

Vegetative propagules have been collected from wild individuals and successfully propagated in the nursery and reintroduced. Vegetative propagules will continue to be collected from all non-reproductive founders for living collection stock and reintroductions. Seed collected from different wild individuals display varying rates of initial (fresh) germination. Seedlings are slow-growing. Seed storage testing has indicated that seeds can be stored, but research is ongoing to determine the optimal conditions (specifically temperature and relative humidity) for long-term seed storage. Currently, all studied species of *Cyanea* exhibit unique storage requirements, consisting of an inability to tolerate frozen storage temperatures. Collaborative research at the USDA-ARS National Center for Genetic Resources Preservation aims to determine the cause of this anomaly, focusing on lipid composition of seeds of taxa of *Cyanea*. Seeds will be stored to meet genetic storage requirements for reproductive individuals. A living collection will be established for the founders represented by clonal propagules, with the hopes that this stock will flower in the nursery or at reintroductions. This would allow for genetic storage via seed for all founders. Both seed collected *in situ* as well as vegetative propagules will be used to establish reintroductions for this taxon.

Management Notes

The **Kawaiiki PU** at the northern site (Kawaiiki subunit I MU) may be clones of a single individual that spread as a result of trampling by pigs and humans. This PU was thought to be the only occurrence in the action area and is not considered to be within the expected distribution of the species. However, in recent surveys for *Achatinella livida* near Kawaiiki MU subunit II the Army found several new individuals. This population is at the edge of the species range and is considered important to manage. The Kawaiiki PU may need augmentation because of the low numbers of individuals to start with. This species has been difficult to store in the greenhouse and was outplanted in the Helemano MU to grow to maturity. This reintroduction will be managed for genetic storage.

The **Wailupe PU** will be managed within the Wailupe MU planned specifically for this species and may be augmented with propagules from the nearby Pia PU. A high priority for this PU is surveying prior to the construction of the MU fence so that all possible individuals will be included.

The **Kahana and Makaua PU** will be managed within the Kahana MU fence. There is an existing OPEP management unit in Kahana however, no *Cyanea crispa* are protected. The Army will work with the OPEP program to protect this species in this area both within the proposed Army fence and the existing OPEP fence. Genetic collections from this PU have been made by OPEP. Priority management actions are to survey prior to fence construction and work with OPEP to collect from unrepresented individuals for genetic storage.

Table 11.18 Priority Management Actions for *Cyanea crispa* Army Stabilization PUs.

Population Unit	Specific Management Actions	Partners/ Concerns	Timeline
Kawaiiki PU	• Construct Kawaiiki MU fences • Control priority weeds • Collect propagules for genetic storage • Outplant	• Requires KS license agreement • Requires EA.	• construct MUs OIP yr 12
Kahana and Makaua PU	• Construct Kahana MU fence • Control priority weeds • Collect propagules for genetic storage • Survey • Augment	• Requires EA. • Requires an agreement with the landowner, Kualoa Ranch.	• Construct MU OIP yr 13
Wailupe PU	• Construct Wailupe MU fence • Control priority weeds • Collect propagules for augmentation and genetic storage • Survey • Augment	• Requires EA. • State Forest Reserve	• Construct MU, OIP yr 16

11.18 Tier 2:
Cyrtandra viridiflora: Taxon Summary and Stabilization Plan

Scientific name: *Cyrtandra viridiflora* St. John & Storey
Hawaiian name: Haiwale, kanawao keokeo
Family: Gesneriaceae (African violet family)
Federal status: Listed endangered

Requirements for Stability
- 3 population units (PUs)
- 50 reproducing individuals (intermediate long-lived perennial)
- Threats controlled
- Genetic storage collections from all PUs
- Tier 2 stabilization priority

Description and biology: *Cyrtandra viridiflora* is shrub 0.5-2 m (1.6-7 ft) tall with opposite leaves clustered at the upper 1-3 nodes. The leaves are thick, fleshy, cordate in shape, 6-15 cm (2.4-5.9 in) long, and 3.5-7.7 cm (1.4-3.0 in) wide, with both surfaces densely covered with a velvety pubescence. The flowers are borne 1-5 in umbelliform cymes arising in the leaf axils. The corollas are green, and measure 17-22 mm (0.7-0.9 in) long. The berries are white, ovoid in shape, 1.3 cm (0.5 in) long, and contain numerous minute seeds.

Flowering and fruiting specimens of *C. viridiflora* have been collected at various times during the year. The reproductive biology of most Hawaiian *Cyrtandra*s, including *C. viridiflora*, has not been studied. However, a study of the reproductive biology of another Oahu *Cyrtandra*, *C. grandiflora*, showed that it is self-compatible and that both self-pollination and cross-pollination requires an unknown insect pollinator. It was also found that there is a strong tendency for a flower's pollen to be shed before the flower's stigma becomes receptive to pollen, thereby decreasing the likelihood of self-pollination (Roelofs 1979). *Cyrtandra viridiflora*'s dispersal agents are unknown, although its white berries suggest dispersal by fruit-eating birds. The species is presumed to be short lived.

Known distribution: *Cyrtandra viridiflora* has been recorded in the upper elevations of the Koolau Mountains from 443-867 m (1,450-2,840 ft) in elevation. Most records of this species are from the central and northern parts of the mountain range. There is only one historical record from the southern part of the Koolaus.

Population trends: All of the known *C. viridiflora* plants have been found within the last 15 years, too short a time for significant population trends to become evident.

Current status: The total number of known plants for the species is an estimated 68 individuals. More than 90% of these are within the KLOA action area. Only two plants have been found in the East Range part of the SBMR action area. The current population units and the number of plants they contain are given in the status table below and their locations are plotted on figure 11.39.

Habitat: *Cyrtandra viridiflora* is known from cloud covered, windswept wet shrubland often dominated by *ohia lehua* (*Metrosideros polymorpha*.) and *uluhe* (*Dicranopteris linearis*). Associated species include kanawao keokeo (*Broussaisia arguta*), *lapalapa* (*Cheirodendron platyphyllum*), *uluhe lau nui* (*Diplopterygium pinnatum*), *naenae* (*Dubautia* sp.), *ieie* (*Freycinetia arborea), manono* (*Hedyotis terminalis* and *H. fosbergii*), *uki* (*Machaerina angustifolia*), alani (*Melicope* spp.), lehua papa (*Metrosideros rugosa), kopiko* (*Psychotria* spp.), *ohia ha* (*Syzygium sandwicensis),* and *kolii* (*Trematolobelia macrostachys*).

Taxonomic background: *Cyrtandra* is one of the two largest genera in the native Hawaiian flora, including about 60 species, all of which are Hawaiian Endemics. Twenty-four of these species occur on Oahu.

Outplanting considerations: Hybridization between Hawaiian *Cyrtandra* species is very common. It is possible that the formation of hybrid populations between a given pair of *Cyrtandra* species occurred naturally in pre-human times. Alternatively, it is also possible that the two species did not normally hybridize due to ecological reproductive barriers that effectively prevented hybridization of the two species. Alteration of the habitat of these plants resulting from the human presence in Hawaii could then have led to a breakdown of these reproductive barriers, allowing a higher level of hybridization than originally, and a blurring of species boundaries. Whether the frequency of hybridization observed today represents a threat to Hawaiian *Cyrtandra species* should be studied.

Cyrtandra viridiflora potentially occurs alongside *C. hawaiiensis*, *C. paludosa*, *C. lessoniana*, and *C. waiolani*. Any area suitable for the outplanting of *C. viridiflora* would already contain one or more of these species of *Cyrtandra*. No hybrid combinations have yet been detected involving *C. viridiflora*. However, outplanted plants could be expected to hybridize to some extent with the *Cyrtandra* species already growing around the outplanting site.

The purity of the planting stock would be of concern in outplanting *C. viridiflora*, since there is a a chance that some seedlings raised from wild collected seeds are actually hybrids.

Threats: Major threats to *C. viridiflora* include feral pigs and alien plant species such as Koster's curse (*Clidemia hirta)* and strawberry guava (*Psidium cattleianum*). The species is potentially threatened by military activities, and predation by rats and slugs. Threats to the population units proposed to be managed for stability are identified in Table 11.41.

Threats in the Action Area: Potential threats in the action area due to military training activities include trampling by foot traffic and competition with non-native plant species introduced via military training activities. However, the threat from trampling varies from low to none due to the remote, wet forest shrubland habitat of this species. Additionally, all sites in the Kawailoa action area threats include habitat degradation by feral ungulates and competition from alien plant species.

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Cyrtandra viridiflora   TaxonCode: CyrVir

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Helemano and Opaeula	Manage for stability	45	15	6	0	0	0	41	13	0	**45**	**15**	**6**	To be managed within Opaeula/Helemano MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyrVir.KLO-B	Opaeula north of Goose Head	In situ			
CyrVir.KLO-E	Koolau Summit Trail, by Peahinaia	In situ	4	4	
CyrVir.KLO-F	Upper Peahinaia Trail, photo point pole	In situ	1		
CyrVir.KLO-G	Transect Ridge/Palm Grass	In situ	1		
CyrVir.KLO-H	Near CyaDeg-C	In situ	1		
CyrVir.KLO-I	Halemano proposed fence, 30m out of main drainage	In situ	1		
CyrVir.KLO-J	Sticherus Ridge	In situ	9	2	3
CyrVir.KLO-K	MB and VC's plants	In situ	2		
CyrVir.KLO-L	Near Hadfield site	In situ	1	3	
CyrVir.KLO-N	OWPP fence before drop into N. drainage stream crossing	In situ	2		
CyrVir.KLO-O	ITAM plot	In situ	1		
CyrVir.KLO-P	Frogman Ridge (S. Halemano fenceline)	In situ	8	3	1
CyrVir.KLO-R	Helemano/MK ridge	In situ	2	1	2
CyrVir.KLO-S	Helemano-Moku Haha	In situ	5		
CyrVir.KLO-T	Goosehead Ridge	In situ	2		
CyrVir.KLO-W	Helemano S. Fenceline	In situ	5	1	
CyrVir.KLO-X	Opaeula South of Waterfall crossing	In situ		1	

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kawainui and Koloa	Manage for stability	21	5	1	0	0	0	17	1	0	**21**	**5**	**1**	To be managed within Koloa MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyrVir.KLO-A	South of Crispa Rock	In situ	3		
CyrVir.KLO-U	Opaeula Waterfall	In situ		1	1
CyrVir.KLO-V	West of Radio LZ	In situ		1	
CyrVir.KOL-A	Koloa, One big ridge N. of Kahuku cabin	In situ	1		
CyrVir.KOL-B	Koloa-Kaipapa'u ridge	In situ	6	2	
CyrVir.KOL-C	Koloa	In situ	4	1	
CyrVir.KOL-D	North of Kahuku cabin (Dead)	In situ	1		

Action Area: In

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyrVir.KOL-E	North of Kahuku Cabin, Vince's patch	In situ	3		
CyrVir.KOL-F	South of Kahuku Cabin, leeward of trail	In situ	3		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
South Kaukonahua to Kipapa summit	Manage for stability	0	2	0	0	0	0	2	0	0	**0**	**2**	**0**	estimated >2 ind.; needs survey

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyrVir.SBE-A	Lower Kaaumakua "Y-Puu"	In situ		2	

Total for Taxon:	66	22	7	0	0	0	60	14	0	66	**22**	7

Action Area: Out

TaxonName: Cyrtandra viridiflora

TaxonCode: CyrVir

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaalaea	Genetic Storage	0	0	0	0	0	0	6	0	0	**0**	**0**	**0**	needs survey

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaluanui to Maakua Ridge	Genetic Storage	0	0	0	0	0	0	2	0	0	**0**	**0**	**0**	needs survey

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyrVir.NUI-A	Kaluanui to Maakua Ridge	In situ	0		

Total for Taxon:	0	0	0	0	0	0	8	0	0	0	0	0

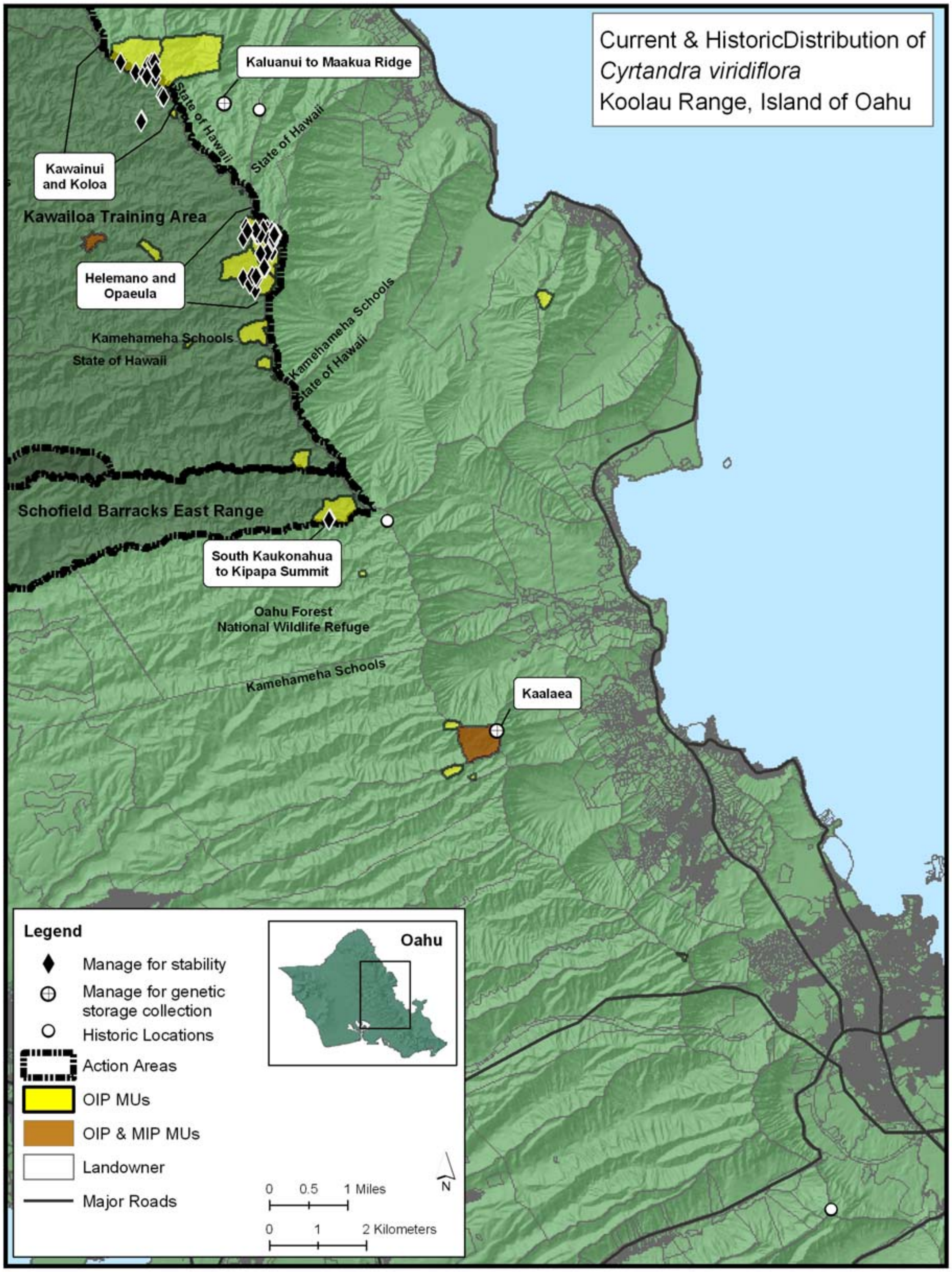


Figure 11.39 Current and historic distribution of *Cyrtandra viridiflora* in the Koolau Mountains of Oahu.

Discussion of Management Designation

All the PUs inside the action area will be managed for stability and represent the center of distribution for this species. However, some individuals in the Kawainui and Koloa PU do not fall within the proposed MU. In this case, outlying individuals will be managed as propagule sources for augmentation within the Koloa MU. Opaeula and Helemano populations will be managed together as one PU. More surveys are needed near South Kaukonahua II and Koloa MUs to determine the extent of the populations. The number of individuals is likely to increase with survey. The Kaalaea and Kaluanui to Maakua Ridge PUs were not chosen to be managed for stability due to the steep terrain characteristic of these areas and low numbers of individuals.

Propagation & Genetic Storage

Vegetative propagation has not been attempted for this taxon. Once methods are developed for *C. subumbellata*, clonal propagation may be used to represent founders that are susceptible to hybridization (other *Cyrtandra* taxa in area), non-reproductive, or outlying. Seeds are typically numerous within each fruit and have high viability. Plants of other *Cyrtandra* species are easily propagated from seed. Seeds store well and will maintain genetic storage goals. Storage longevity may not be as long as detected for other taxa. More frequent recollections from wild plants may be necessary to maintain genetic representation through seed storage. Research is targeting the storage temperatures that will prolong viability the longest. Seed collected *in situ* will be used to establish reintroductions.

Management Notes

The **Kawainui and Koloa PU** will be managed within the Koloa MU. Priority actions for this PU are the survey for individuals in the area and the construction of the MU fence to include all possible individuals.

The **Opaeula and Helemano PU** is currently being managed within the Opaeula/Helemano MU. This is the largest known population and it is anticipated that more individuals will recruit on their own inside the fence in the absence of ungulate pressure (although slugs may also be a threat to this species). A priority for this PU is genetic storage collections.

The **South Kaukonahua to Kipapa PU** contains just two known individuals and will be protected within the South Kaukonahua MU. Surveys of nearby historical locations should be made. Priorities for this PU are surveys, genetic storage collections, and the construction of the MU fence.

Table 11.19 Priority Management Actions for *Cyrtandra viridiflora* Army Stabilization PUs.

Population Unit	Specific Management Actions	Partners/Concerns	Timeline
Koloa	• Construct Koloa MU • Control priority weeds • Survey • Collect propagules for augmentation and genetic storage • Augment	• This MU needs an EA and license agreement with landowner, Hawaii Reserves Inc.	• Construct Koloa MU, OIP yr 4; 2011
Opaeula to Helemano	• Control priority weeds • @ stability target #s • Continue to collect propagules from unrepresented individuals for genetic storage	• MU Completed.	• Ongoing
South Kaukonahua	• Survey for more individuals • Control priority weeds • Construct South Kaukonahua II MU • Collect propagules for augmentation and genetic storage • Augment	• This MU needs an EA.	• Construct South Kaukonahua MU, OIP yr 5; 2012

11.19 Tier 2:
Myrsine juddii: Taxon Summary and Stabilization Plan

Scientific name: *Myrsine juddii* Hosaka
Hawaiian name: Kolea
Family: Myrsinaceae (Myrsine Family)
Federal status: Listed endangered

Requirements for Stability

- Maintain at least 75 reproducing individuals throughout the range of this species (from Kamananui and Koloa to South Kaukonahua) (Long lived perennial)
- Threats controlled
- Genetic storage collections for a general representation of the species
- Tier 2 stabilization priority

Description and biology: *Myrsine juddii* is a small shrub 1-2 m (3.3-6.6 ft) tall with alternate lanceolate to elliptic leaves 4-12 cm (1.6-4.7 in) long and 1.5-3.2 cm (0.59-1.3 in) wide. The upper leaf surface is glabrous and the lower surface is sparsely to moderately covered with short whitish to brownish hairs toward the base and along the midrib. The flowers are borne in tight clusters of 4-8 along the stems, and are perfect or unisexual (and then the plants are usually dioecious). The drupes are globose, and contain a single seed.

Known distribution: *Myrsine juddii* is narrowly endemic to a portion of the northern and central Koolau Mountains of Oahu. Its range extends from the main dividing ridge of the Koolaus to up to 1.9 km (1.2 mi) to the lee of the dividing ridge. Recorded elevations for the species range from 579-866 m (1,900-2,840 ft).

Population trends:
There are no historical records of this species outside of its current range. It apparently has long been restricted to where the plants are found today. Documentation of population trends in *M. juddii* is lacking.

Current status: Currently, only one extensive population of *M. juddii* is known between Puu Kainapuaa and N. Kaukonahua in the Koolau Mountains. All or almost all of the range of the species lies within the KLOA action area. In certain parts of its range the species is relatively common. The only population unit is included in the status table below and and the range of the species is shown on Map 11.40.

Habitat: *Myrsine juddii* occurs on ridge tops, on gulch slopes, and in gulch bottoms in wet forests and shrublands often dominated *ohia lehua* (*Metrosideros* spp.) and *uluhe* (*Dicranopteris linearis*). Other common associated species include *mehame* (*Antidesma platyphyllum*), *ohia ha* (*Syzygium sandwicensis*), *kokoolau* (*Bidens macrophylla*), *kanawao keokeo* (*Broussaisia arguta*), *hapuu* (*Cibotium* spp.), pilo (*Coprosma longifolia*), *uluhe lau nui* (*Diplopterygium pinnatum*), *naenae* (*Dubautia laxa*), *manono* (*Hedyotis terminalis* and *H. fosbergii*), *uki* (*Machaerina angustifolia*), alani (*Melicope* spp.), kolea (*Myrsine* spp.), *kopiko* (*Psychotria* spp.), and *akia* (*Wikstroemia oahuensis*).

Taxonomic background: *Myrsine juddii* is one of 19 Hawaiian species of *Myrsine* (Wagner *et al*. 1999). Seven of these species occur on Oahu, six of which are known from the Koolau Mountains. Within *M. juddii*'s range, five other *Myrsine* species can be found: *M. degeneri*, *M. fosbergii*, *M. lessertiana*, *M. pukooensis*, and *M. sandwicensis*. Hybrids between various pairs of *Myrsine* species on Oahu are found occasionally (Lau pers. comm. 2005). Although no obvious hybrids involving *M. juddii* as a parent species have been reported to date, such a hybrid may be difficult to identify as such.

Outplanting considerations: No outplanting is currently planned in the conservation of *M. juddii*. However, if outplantings of *M. juddii* become necessary in the future, there is another *Myrsine* within *M. juddii*'s range that is of conservation concern whose distribution should be taken into account. This *Myrsine* is *M. fosbergii*, which is considered a "Species of Concern" by the Pacific Ecoregion office of the U.S. Fish and Wildlife Service.

If outplantings are to be established it would be best to restrict them to within the recorded current range of the species. The species has no historical range beyond its current range. Although there is much acreage of seemingly suitable habitat for *M. juddii* further south along the Koolau summit divide, the species cannot be considered native to these areas when there is no evidence that the species' range ever included these parts of the Koolau Mountains.

Threats: The primary threats to *M. juddii* include feral pigs and alien plants such as Koster's curse (*Clidemia hirta*), and strawberry guava (*Psidium cattleianum*). Threats to *M. juddii*'s single population unit are identified in Table 11.43.

Threats in the Action Area: Potential threats to *Myrsine juddii* caused by army training in the action area consist of trampling of seedlings during foot maneuvers, and the introduction of non-native plants via transport of personnel and equipment between training areas. However, the threat from trampling is low. Additionally, this species is threatened with habitat destruction by feral pigs.

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Myrsine juddii   TaxonCode: MyrJud

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaukonahua to Kamananui-Koloa	Manage for stability	455	0	0	0	0	0	3000	0	0	455	0	0	This is an estimate of Myrjud throughout its range in the Northern Koolaus. Three sites within MU fences (Koloa, Opaeula/Helemano, Poamoho) were selected below and estimates of plants are shown.
	Total for Taxon:	455	0	0	0	0	0	3000	0	0	**455**	**0**	**0**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
MyrJud.KLO-A	Poamoho Btw. summit and cabin	In situ	1		
MyrJud.KLO-B	Poamoho on KST south of Cabin	In situ	1		
MyrJud.KLO-C	Opeula Upper exclosure	In situ	300		
MyrJud.KLO-D	Helemano Upper Exclosure	In situ	100		
MyrJud.KLO-E	Poamoho	In situ	25		
MyrJud.KLO-F	Upper Kawaiki	In situ	3		
MyrJud.KOL-A	Koloa Upper gulch	In situ	25		

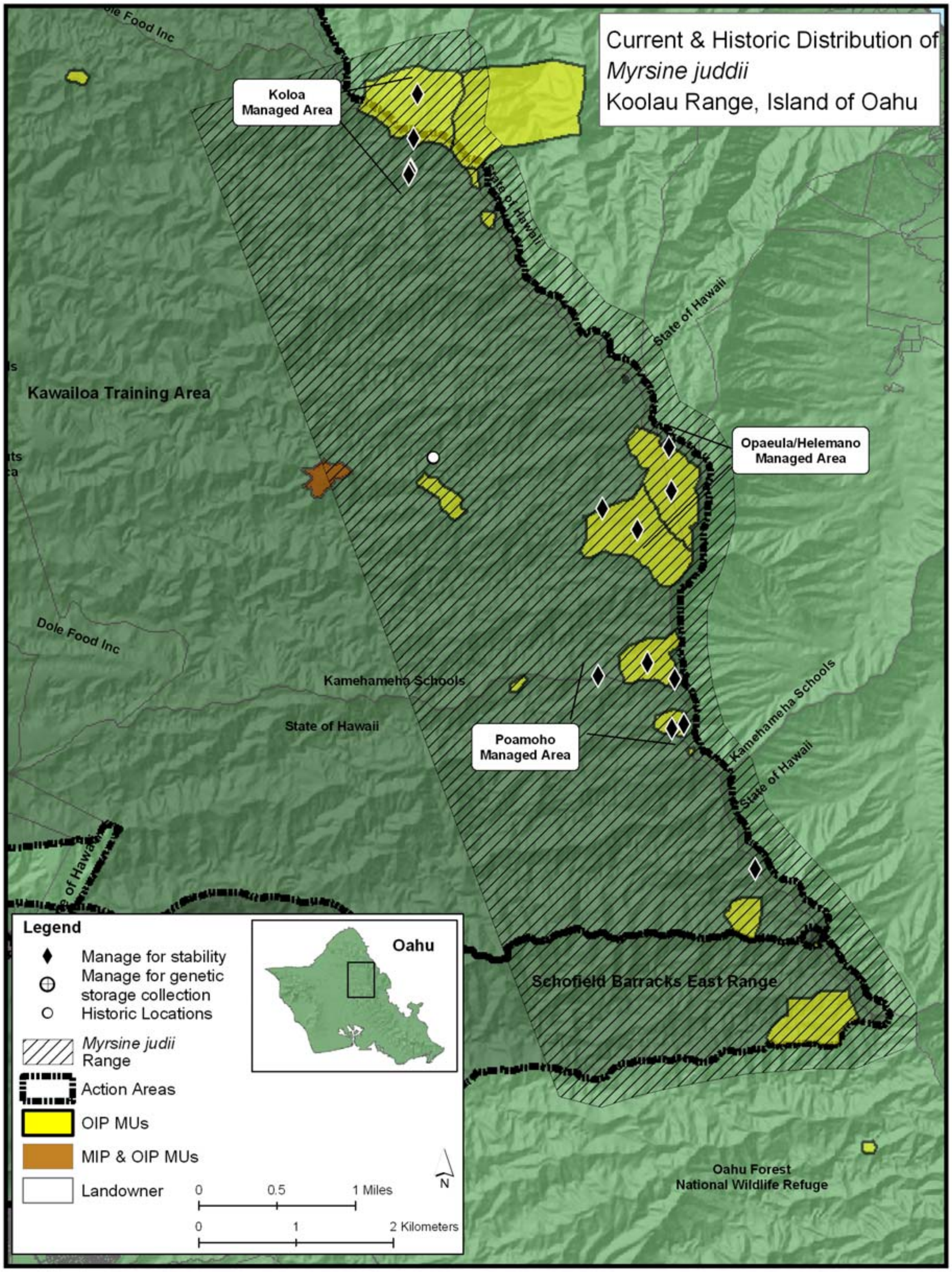


Figure 11.40 Current and historical distribution of *Myrsine juddii* in the Koolau Mountains, Oahu.

Discussion of Management Designations

This species occurs in a somewhat continuous pattern across the northern Koolaus and was not broken into population units. The Army is responsible for maintaining the target number of individuals representing 3 population units and will report on as many sites as possible. For the purposes of this plan three areas within proposed or existing MUs will be reported on.

Propagation & Genetic Storage

Vegetative propagation has not been attempted for this taxon and will likely not be necessary, due to the high numbers of plants and fruit. If seeds are not viable, or plants are close to other taxa of *Myrsine* so that hybridization is a concern, then vegetative propagation may be explored. Additionally, reintroductions are likely not necessary for this taxon, and propagules will not need to be produced for this purpose. Viability and germination requirements, however, are currently unknown for this taxon. Collections will be made to determine if seed storage is an appropriate action to maintain genetic storage requirements. Seeds of the congener, *M. lessertiana*, have been collected and have high rates of germination. Unfortunately, seeds appear not to be able to withstand desiccation and viable storage conditions have yet to be established. If seed of *M. juddii* have similar storage behavior, micropropagation techniques will be pursued, as they have been successful for other congeners. Genetic storage representation will hopefully be obtained from seed for storage or micropropagation.

Management Notes

This species is considered stable, however not all threats are removed. Monitoring of the number of individuals across the species' range will be challenging. Until more thorough monitoring is done for this species the Army will report on the numbers of individuals currently protected within proposed or existing MUs. This species is observed frequently within its known range although this is not reflected in the current GIS data. Priority management actions include protecting three subpopulations of target stable numbers within proposed or existing management units (Koloa, Opaeula/Helemano, and Poamoho), attempting to map/GPS known populations, and collecting seeds for testing and genetic storage.

11.20 Tier 2:
Sanicula purpurea: Taxon Summary and Stabilization Plan

Scientific name: *Sanicula purpurea* St. John & Hosaka
Hawaiian name: None known
Family: Apiaceae (Parsley family)
Federal status: Listed endangered

Requirements for Stability
- 3 population units (PUs)
- 100 reproducing individuals (short-lived perennial, inconsistent flowering)
- Threats controlled
- Genetic storage collections all PUs
- Tier 2 stabilization priority

Description and biology: *Sanicula purpurea* is a stout perennial herb up to 8-36 cm (3.1-14 in) tall with stems arising from a large tuberous base. The basal leaves are reniform or orbicular to ovate-cordate, 3-7-lobed, and 2-8 cm (0.8-3 in) wide. The flowers are borne in terminal inflorescences. Some flowers are perfect (possess male and female reproductive parts) and others are staminate (possess only male reproductive parts). The petals are purple or cream tinged with purple. The fruits are subglobose, 2-3.5 mm (0.1-0.14 in) long and 2-3 mm (ca. 0.1 in) wide, and are covered with slender, straight, or slightly curved prickles.

Little is known of the biology of *S. purpurea*. Plants have been found flowering and fruiting throughout the year. The species is presumably insect-pollinated. The bristles on the species' fruits indicate a potential for dispersal by birds. The species is presumed to be short-lived.

Known distribution: *Sanicula purpurea* is known from Oahu and West Maui. On Oahu it has been documented only from the summit ridge of the Koolau Mountains. Recorded elevations for the species on Oahu range from 700 to 957 m (2,300 to 3,140 ft). On West Maui the species has been recorded only in montane bogs from to 1,460-1,527 m (4,800-5,010 ft) in elevation. *Sanicula* pollen has been reported from prehistoric pollen deposits in Pepeopae Bog on Molokai (Selling 1948). It seems likely that this pollen is from *S. purpurea*, given the habitats in the general area of Pepeopae Bog, and Molokai's position right between Oahu and West Maui.

Population trends: All of the known population units of *S. purpurea* on Oahu were found in recent years, and clear population trends have not been documented. Also, this species is particularly difficult to census. The plants are small and often hidden in the vegetation. Also, it is difficult to know what constitutes a single individual, and there may be times when some plants lose their leaves and are not visible above ground. Because of these problems, changes in the numbers recorded in a given colony from year to year may not reflect actual changes.

Current status: Two population units of *S. purpurea* are known from the KLOA action area, and one is known from the East Range part of the SBMR action area. These total about 4 mature and 56 immature plants, while there are just 5 plants known south of the action area. On West Maui the species is thought to number a few hundred. The current population units and the number of plants they contain are given in the status table below and their locations are plotted on figure 11.41.

Habitat: In the Koolau Mountains, *S. purpurea* has only been found on or adjacent to the summit ridge of the mountain range, particularly on ridges exposed to the prevailing tradewinds. A bog-like type of vegetation is characteristic of such exposed ridges in the Koolau Mountains. This vegetation contains a number of plants that are usually bog species elsewhere in Hawaii (Fosberg and Hosaka 1938). In this vegetation much of the ground is covered by bryophytes (mosses and liverworts). The vegetation includes native shrubs, ferns, herbs, sedges, and grasses. One recorded *S. purpurea* site, on the windward side of the summit ridge between Kaipapau and Kawainui Gulches, has been described as being a sloping open bog very similar in physiognomy and species composition to the more familiar montane bogs on Kauai, Molokai, Maui, and Hawaii (Fosberg and Hosaka 1938). On West Maui, *S. purpurea* occurs in open montane bogs dominated by *ohia lehua* (*Metrosideros polymorpha*) and native sedges.

The *S. purpurea* sites in the Koolau Mountains have been invaded to various extents by the alien narrow-leaved carpetgrass (*Axonopus fissifolius*), and in some cases it is now a dominant species. Associated native plant species in the Koolaus include *ohia lehua* (*Metrosideros polymorpha*), *lehua papa* (*Metrosideros rugosa*), *kokoolau* (*Bidens macrocarpa*), *olapa* (*Cheirodendron trigynum*), *lapalapa* (*C. platyphyllum*), *Dichanthelium koolauense*, *pukiawe* (*Leptecophylla tameiameiae*), *uki* (*Machaerina angustifolia*), *Plantago pachyphylla*, *amau* (*Sadleria pallida*), and *ohelo* (*Vaccinium dentatum*).

Taxonomic background: *Sanicula purpurea* is one of four endemic Hawaiian species of *Sanicula*. It is the only species recorded from the Koolau Mountains.

Outplanting considerations: There are no hybridization concerns with respect to the outplanting of *S. purpurea* in the Koolau Mountains since no other species of *Sanicula* occur there.

Threats: Threats to *S. purpurea* on Oahu include feral pigs and alien plants. The most serious alien plant threat to the species is the narrow-leaved carpetgrass (*Axonopus fissifolius*), which has come to dominate some of the *S. purpurea* sites. Other alien plant threats to the Oahu plants include Koster's curse (*Clidemia hirta*), Glenwood grass (*Sacciolepis indica*), and *Pterolepis* *glomerata*. On West Maui, the bog habitat of *S. purpurea* is still relatively pristine, and almost completely native in composition. However, several alien plant species are found occasionally in the bogs. Perhaps the most serious weed threat among them is *Tibouchina herbacea*. Pigs also represent a threat to the plant and its bog habitats on West Maui, but to date, feral pig control has effectively kept the pig threat to a minimum.

Threats in the Action Area: Threats to *Sanicula purpurea* in the action area include trampling from foot traffic and the introduction of non-native plants via transport of personnel and equipment between training areas. There is no fire threat for this wet forest habitat. The trampling threat is also very low due to the steep windward slopes this species inhabits. Additional threats to this species throughout its range include habitat degradation by feral pigs, and competition from non-native plant species, such as *Axonopus fissifolius.*

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Sanicula purpurea — TaxonCode: SanPur

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
North of Puu Pauao	Manage for stability	0	21	0	0	0	0	0	21	0	**0**	**21**	**0**	Kaukonahua-Punaluu MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
SanPur.KLO-C	South of Poamoho Cabin, on KST	In situ		21	

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Opaeula-Punaluu Summit Ridge	Genetic Storage	0	0	0	1	2	1	0	0	0	**1**	**2**	**1**	Experimental reintroduction effort. Helemano and Opaeula MU.

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
SanPur.KLO-E	Opaeula Notch	Reintro	1	2	1

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Poamoho Trail Summit	Manage for stability	2	10	12	0	0	0	0	10	0	**2**	**10**	**12**	Poamoho MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
SanPur.KLO-A	Poamoho	In situ	2	10	12

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Schofield-Waikane Trail Summit	Manage for stability	2	25	0	0	0	0	0	21	0	**2**	**25**	**0**	South Kaukonahua MU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
SanPur.KLO-B	Schofield-Waikane Trail	In situ	2	25	

		NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling
	Total for Taxon:	4	56	12	1	2	1	0	52	0	5	**58**	**13**

Action Area: Out

TaxonName: Sanicula purpurea — TaxonCode: SanPur

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Wailupe-Waimanalo Summit Ridge	Genetic Storage	0	0	0	0	0	0	0	3	0	**0**	**0**	**0**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

		NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling
	Total for Taxon:	0	0	0	0	0	0	0	3	0	0	0	**0**

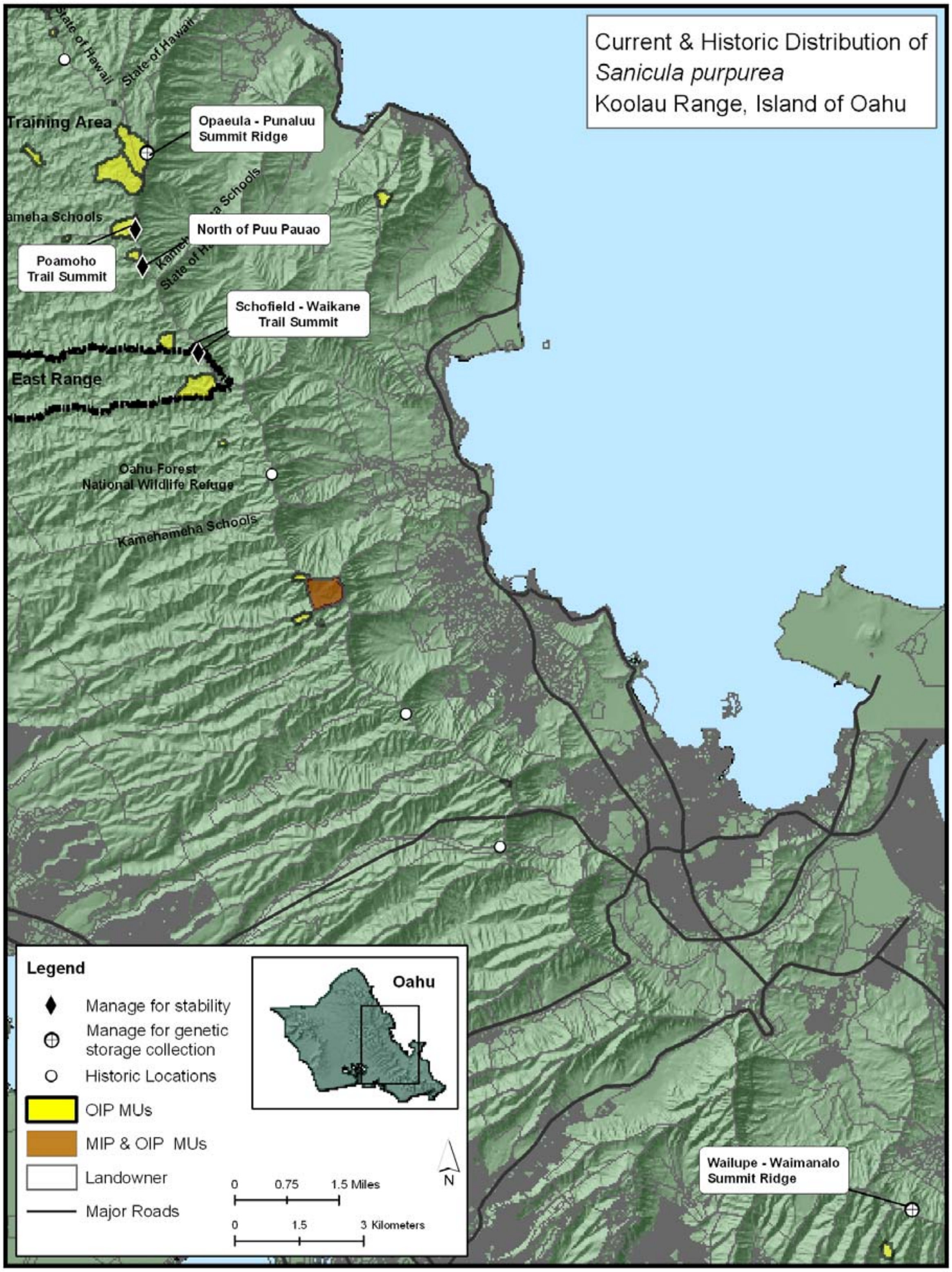


Figure 11.40 Current and historic distribution of *Sanicula purpurea* in the Koolau Mountains of Oahu.

Discussion of Management Designations

The largest PUs on Oahu were chosen for management. The Schofield-Waikane Trail Summit and North of Puu Pauao PUs are 878m apart, but are considered to be separate PUs due to the typically harsh summit habitat they occupy and the very small stature of the plants which makes cross pollination unlikely. The Oahu PUs outside the action area were not chosen for management due to the low numbers of individuals they contain.

Propagation and Genetic Storage

Seeds are slow to germinate and may present similar levels of dormancy as it cogener, *S. mariversa*. Plants can be propagated from seed. Seeds will be stored at conditions similar to *S. mariversa* until studies for this taxon indicate otherwise. Seeds will be collected from wild plants *in situ* to meet genetic storage requirements. Vegetative propagation will likely not be attempted as plants may only produce one apical meristem. This taxon has not been observed with multiple apical meristems. Reintroductions will be established with seed collected *in situ*.

Outplanting Issues

The Army outplanted four individuals grown from the Helemano-Punaluu Summit PU into a site at the Opaeula Summit in 2000 in order to work out reintroduction techniques for the taxon. Currently, all four of the reintroduced plants are still alive. One plant has reached reproductive maturity, and a new seedling was found near the mature plant. The Army did not have success outplanting *S. mariversa* and suspect this result was due to much drier conditions in the Waianae Mountains. The success of the first reintroduction attempt with this taxon may mean that *S. purpurea* may be easier to reintroduce than its congener.

Management Notes

Studies and observations on the phenology and longevity of individuals and populations on Oahu are greatly needed. Propagules should be collected whenever possible for genetic storage and testing. Due to a lack of knowledge about the biology of wild plants, research on both *S. mariversa* and *S. purpurea* should focus on determining seasonality. Propagules may be faster and better produced for storage testing in the greenhouse if a few plants can be maintained. This also reduces impact to wild plants.

These plants generally occur on steep slopes and may not be impacted by pigs as severely as other Koolau summit species in moderately sloped areas. A major weed threat to this species at all sites is the common carpet grass (*Axonopus fissifolius*). Priorities for management at all sites are seed collection for storage testing and propagation, fence construction, and weed control. The **Poamoho Trail Summit PU** will be protected within the Poamoho subunit I MU. The **North of Puu Pauao PU** will be protected within the Poamoho subunit III MU. The **Schofield-Waikane Trail Summit PU** will be protected within the South Kaukonahua subunit II MU. Thorough regular monitoring and collections for genetic storage testing and propagation are priorities for all manage for stability PUs.

Table 11.22 Priority Management Actions for *Sanicula purpurea* Army Stabilization PUs.

Population Unit	Specific Management Actions	Partners/Concerns	Timeline
Poamoho Trail Summit PU	• Construct fence • Control priority weeds • Collect propagules for augmentation and genetic storage	• This MU needs an EA. • Within State proposed Poamoho NAR	• Construct Poamoho MU, OIP yr 7; 2014
North of Puu Pauao PU	• Construct fence • Control priority weeds • Collect propagules for augmentation and genetic storage	• This MU needs an EA. • Within State proposed Poamoho NAR	• Construct Poamoho III MU, OIP 8; 2015
Schofield-Waikane Trail Summit PU	• Construct South Kaukonahua MU • Control priority weeds • Collect propagules for augmentation and genetic storage	• This MU needs an EA.	• Construct South Kaukonahua II MU, OIP yr 8; 2015
Opaeula reintroduction	• Monitor experimental reintroduction for longevity of individuals	• This reintroduction occurs on State land	• Monitoring continues yearly.

11.21 Tier 2:
Viola oahuensis: Taxon Summary and Stabilization Plan

Scientific name: *Viola oahuensis* C. Forbes
Hawaiian name: None known
Family: Violaceae (Violet Family)
Federal status: Listed endangered

Requirements for Stability

- 3 population units (PUs)
- 50 reproducing individuals in each PU (short-lived perennial)
- Threats controlled
- Genetic storage collections from PUs managed for stability
- Tier 2 stabilization priority

Description and biology: *Viola oahuensis* is an erect, usually unbranched subshrub 6-40 cm (2.4-16 in) tall. The alternately arranged elliptic leaves are clustered at the branch tips, hairless, and measure 3-12 cm (1.2-4.7 in) long by 2.5-5.8 cm (0.98-2.3 in) wide. The axillary inflorescences bear 1-2 flowers. The petals are pale yellow; the upper ones 8-13 mm (0.31-0.51 in) long, lateral ones 10-13.5 mm (0.39-0.53 in) long, and the lower one 12-16 mm (0.47-0.63 in) long. The capsules are 9-16 mm (0.35-0.63 in) long, and contain pale brown seeds 1.6-2.1 mm (0.06-0.8 in) long.

Little is known of *V. oahuensis*' biology. Flowering and fruiting can be observed year round. The species is presumed to be insect pollinated. Dispersal agents for *V. oahuensis* are unknown. *Viola oahuensis* is considered a short-lived species for the purposes of the Implementation Plan.

Known distribution: *Viola oahuensis* is endemic to the Koolau Mountains. The species occurs on or near the summit ridge of the Koolaus. It occurs primarily in the northern and central parts of the mountain range. There are only a few records of the species in the southern part of the

Koolau Mountains. Recorded elevations for the plant range from 415 to 960 m (1,360 to 3,150 ft).

Population trends: Population trends for this species are not known. This species occurs in the most remote parts of the Koolau Mountains, and its populations have not been well monitored.

Current status: Currently there are several populations units known from the KLOA action area and the Koolau portion of the SBMR action area. These plants total about one-fifth of the known wild individuals. The current population units and the number of plants they contain are given in the status table below and their locations are plotted on figures 11.42-43.

Habitat: *Viola oahuensis* is known mostly in wet, windswept situations. The vegetation in these locations is often shrubland, bog vegetation, or bog-like vegetation, or sometimes scrubby forest adjacent to such locations. The species' habitats are often dominated by *ohia lehua* (*Metrosideros* spp.) and *uluhe* (*Dicranopteris linearis*). Common associated species include *mehame* (*Antidesma platyphyllum*), *ohia ha* (*Syzygium sandwicensis*), *kokoolau* (*Bidens macrophylla*), *kanawao keokeo* (*Broussaisia arguta*), *hapuu* (*Cibotium* spp.), *pilo* (*Coprosma longifolia*), *uluhe lau nui* (*Diplopterygium pinnatum*), *naenae* (*Dubautia laxa*), *manono* (*Hedyotis terminalis* and *H. fosbergii*), *uki* (*Machaerina angustifolia*), *alani* (*Melicope* spp), *kolea* (*Myrsine* spp.), *kopiko* (*Psychotria* spp.), and *akia* (*Wikstroemia oahuensis*).

Taxonomic background: *Viola oahuensis* is one of seven native species of the genus *Viola* in Hawaii. All are endemic to Hawaii. Three species are native to the Koolau Mountains, namely *V. oahuensis*, *V. kauaiensis*, and *V. chamissoniana*.

Outplanting considerations: The only other *Viola* species that occurs naturally within *V. oahuensis*' range is *V. kauaiensis*. This species is endemic to Kauai and the Koolau Mountains on Oahu, where it has been recorded at only a few spots in the northern and central portions of the mountain range. The Oahu populations of *V. kauaiensis* may actually represent a taxon distinct from the Kauai plants, but during the preparation of the most recent taxonomic treatment of Hawaiian *Viola*, no herbarium specimens of the Oahu plants were available for study (Wagner *et al*. 1990). In addition to possibly representing a distinct taxon, the plants of the Oahu population of *V. kauaiensis* are extremely rare, as they are currently known from only a single small population containing perhaps only a few dozen individuals. This last known population is within KLOA, adjacent to the Koolau summit ridge between Poamoho Gulch and Punaluu Valley.

There is a case of putative hybridization between Hawaiian species of *Viola*, namely between *V. maviensis* and *V. chamissoniana* subsp. *robusta* at Pepeopae Bog on Molokai (Wagner *et al*. 1990). *Viola oahuensis* and *V. kauaiensis* have been recorded growing together in a small bog on the summit ridge between Kaipapau and Kawainui Gulches (Fosberg and Hosaka 1938). The potential for hybridization between *V. oahuensis* and *V. kauaiensis* is not known. In any case, given that the Oahu *V. kauaiensis* may actually represent an extremely rare taxon, if any reintroductions or augmentations of *V. oahuensis* are carried out, they should be located away from any *V. kauaiensis* populations to minimize the chance of unintended hybridization between the two species.

Threats: Major threats to *V. oahuensis* in the wild include feral pigs, trampling by humans, and invasive alien plants. The most serious alien plant species currently impacting populations of *V. oahuensis* are Koster's curse (*Clidemia hirta*), narrow-leaved carpetgrass (*Axonopus fissifolius)*, strawberry guava (*Psidium cattleianum*), and *Pterolepis glomerata*.

Threats in the Action Area: Within the action area *Viola oahuensis* is potentially threatened by trampling by foot maneuvers along summit trails and the introduction of non-native plant species via transport of personnel and equipment between training areas. However, the threat from trampling is low due to the remote summit habitat this species occupies. Currently this species is threatened throughout its range by habitat degradation by feral pigs and competition from non-native plant species such as *Axonopus fissifolius, Clidemia hirta,* and *Psidium cattleianum.*

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Viola oahuensis — TaxonCode: VioOah

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Helemano and Opaeula	Manage for stability	162	145	22	0	0	0	49	17	0	**162**	**145**	**22**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
VioOah.KLO-A	Upper Peahinaia Trail	In situ	22	1	
VioOah.KLO-D	KSTand Shelter Ridge junction	In situ	80	52	5
VioOah.KLO-F	Along Opaeula fenceline, on Peahinaia Trail	In situ	5	9	
VioOah.KLO-H	Moku Haha	In situ	39	63	8
VioOah.KLO-L	Upper Peahinaia-near Knotch	In situ	1		
VioOah.KLO-M	Opaeula Exclosure-Goose Ridge	In situ	11	16	7
VioOah.KLO-N	Halemano, Exonopus plot ridge	In situ	2		
VioOah.KLO-P	KLO/Opaeula Excl. Ridge north of Goose	In situ	1		
VioOah.KLO-S	Opaeula Exclosure southwest corner, near Cyacal	In situ	1		
VioOah.KLO-T	Opaeula south branch in stream	In situ		2	2
VioOah.KLO-U	Inside Opaeula WCA 1, near Cyacal pt	In situ		2	

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kamananui	Genetic Storage	1	0	0	0	0	0	0	0	0	**1**	**0**	**0**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
VioOah.KLO-I	Kamananui Gulch	In situ	1		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaneohe-Moanalua Summit Ridge	Genetic Storage	0	0	0	0	0	0	**1**		0	**0**	**0**	**0**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaukonahua	Manage for stability	25	0	0	0	0	0	20	0	0	**25**	**0**	**0**	Combined N and S Kaukonahua numbers from Draft OIP. North Kaukonahua MU and South Kaukonahua MU.

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
VioOah.KLO-J	Schofield-Waikane Trail	In situ	5		
VioOah.KLO-R	North Kaukonahua near Phynut	In situ	9		
VioOah.SBE-A	South Kaukonahua	In situ	11		

Action Area: In

Kawaiiki	Genetic Storage	13	9	11	0	0	0	8	0	0	**13**	**9**	**11**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
VioOah.KLO-B	Past bog	In situ	5		
VioOah.KLO-E	Kawaiiki Gulch	In situ	2	9	11
VioOah.KLO-G	Bloody Finger	In situ	1		
VioOah.KLO-O	Plants in Bog Fence, Upper Kawaiiki	In situ	5		

Koloa	Manage for stability	36	9	6	0	0	0	18	1	0	**36**	**9**	**6**	Koloa MU.

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
VioOah.ELE-A	Waiele Gulch by Kainapuaa	In situ	2	1	
VioOah.KLO-C	koloa	In situ	1		
VioOah.KLO-Q	Northern LZ	In situ	4	6	4
VioOah.KOL-A	Koloa near HupNut	In situ	2		
VioOah.KOL-B	Northern by baitstation #5	In situ	2		
VioOah.KOL-C	East side of middle ridge in upper Koloa to bottom of eastern gulch	In situ	2		
VioOah.KOL-D	Koloa, One big ridge N. of Kahuku cabin	In situ	9	1	2
VioOah.KOL-E	North of Kahuku Cabin	In situ	9		
VioOah.KOL-F	Koloa Gulch	In situ	5	1	

Poamoho	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

	Total for Taxon:	237	163	39	0	0	0	96	18	0	**237**	**163**	39

Action Area: Out

TaxonName: Viola oahuensis   TaxonCode: VioOah

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Ahuimanu-Halawa Summit Ridge	Genetic Storage	0	0	0	0	0	0	20	0	0	0	0	0	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Konahuanui	Genetic Storage	0	0	0	0	0	0	5	0	0	0	0	0	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling

Waiahole-Waiawa Summit Ridge	Genetic Storage	1	0	0	0	0	0	20	0	0	1	0	0	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
VioOah.AWA-A	Waiawa/Waiahole Summit	In situ	1		

Waimalu to Kahaluu Summit	Genetic Storage	50	0	0	0	0	0	50	0	0	50	0	0	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
VioOah.ALU-A	Waimalu Summit	In situ	50		

	Total for Taxon:	51	0	0	0	0	0	95	0	0	51	0	0	

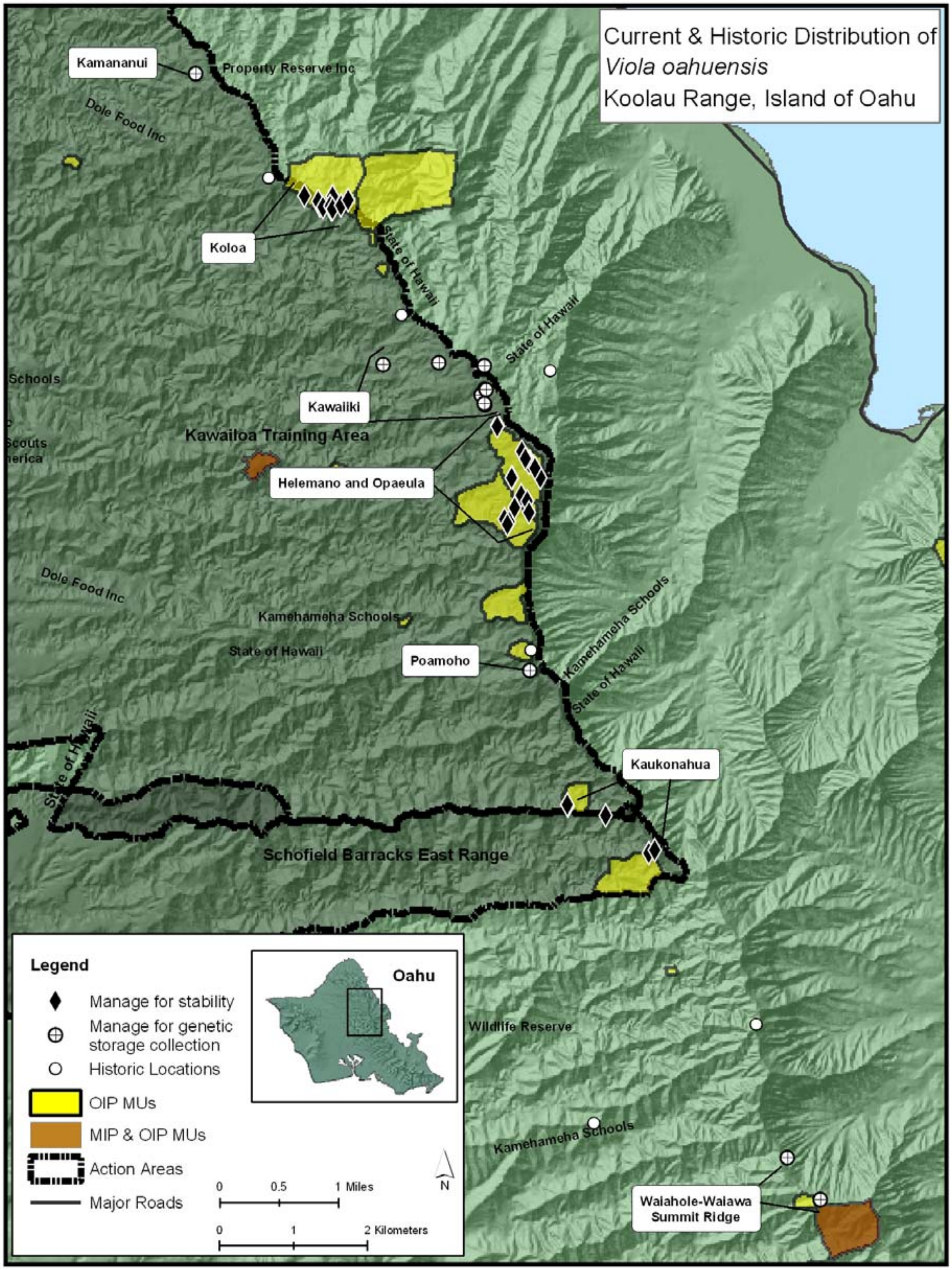


Figure 11.42 Current and historic distribution of *Viola oahuensis* in the Northern Koolau Mountains of Oahu.

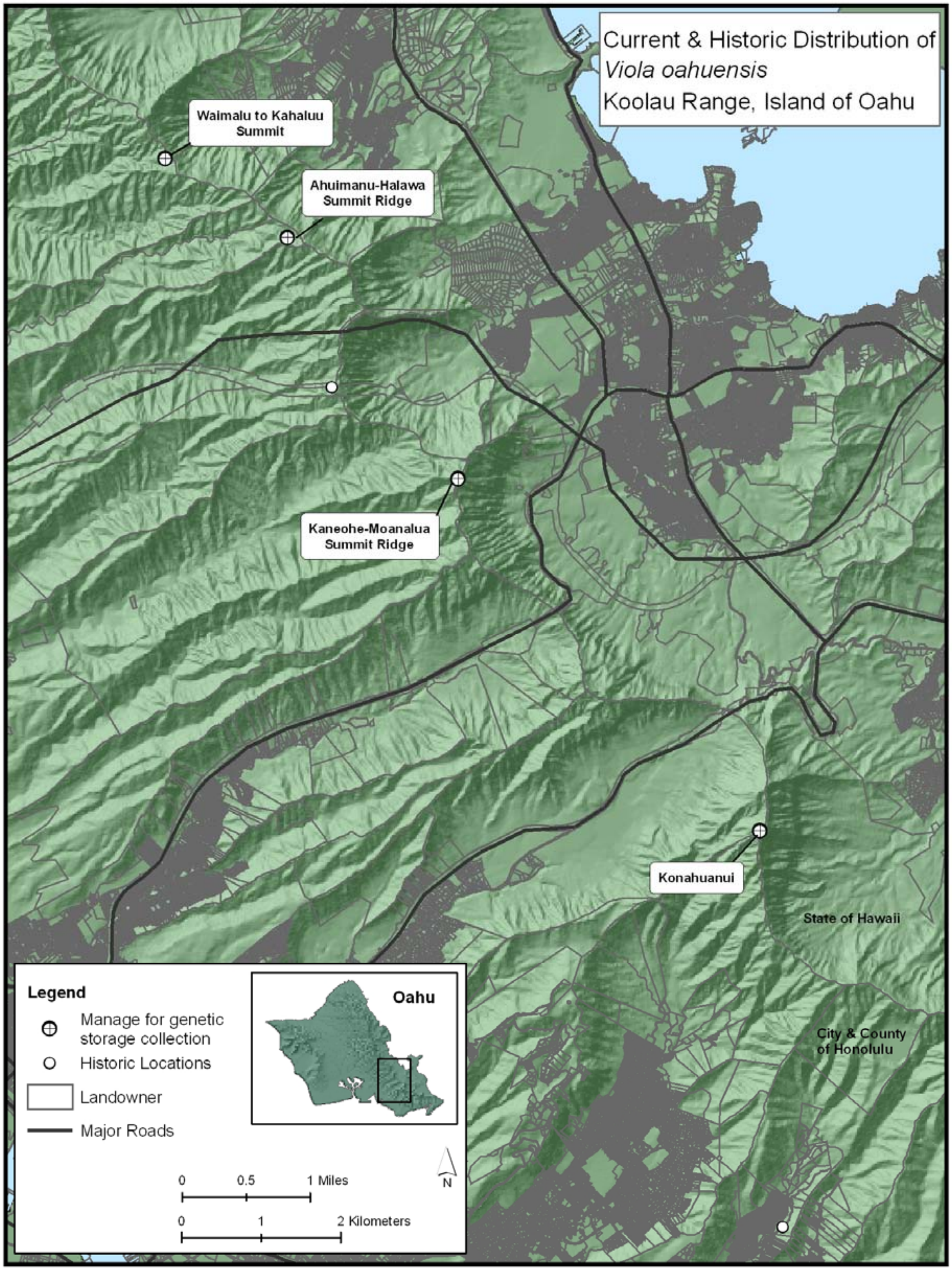


Figure 11.43 Current and historic distribution of *Viola oahuensis* in the Central and Southern Koolau Mountains of Oahu.

Discussion of Management Designations

This species is distributed in large sprawling populations that span sizeable geographic distances. The southern Koolau summit PUs were not chosen due to the difficulty in actively managing such large areas with relatively small numbers of individuals, in favor of managing PUs within the action area. PUs designated for stabilization were chosen to encompass the geographical range of the species within the action area. The Waimalu to Kahaluu Summit PU is the largest that was not chosen for management due to its distance from the action area. All other PUs were not chosen for management due to the small numbers of individuals and their distance to the action area.

Propagation & Genetic Storage

It has yet to be determined whether or not fruit should be collected pre-dehiscence or post-dehiscence. Germination studies have yet to be conducted. Seeds of this taxon may behave similarly to its cogener, *V. chamissoniana* subsp. *chamissoniana*, in both germination and storage potential. It has been observed that fruit of *V. chamissoniana* subsp. *chamissoniana* has low seed set in wild individuals and typically much higher seed set in living collection stock. Seeds of *V. chamissoniana* subsp. *chamissoniana* typically have high initial germination and can be stored using conventional methods in a dry, frozen environment. Storage studies will be conducted when collections are made, and other forms of propagule storage will be investigated if seeds are not able to be stored. Seeds will be collected *in situ* to meet genetic storage requirements. Seed will not need to be collected for propagation as reintroductions will likely not be necessary for this taxon.

Management Notes

Priorities for all MFS PUs are surveys to determine the extent of the PUs and begin collections for genetic storage testing. Surveys are needed to determine the extent of the PUs within the proposed MUs. The Army feels the numbers of known individuals will greatly increase with surveys. Recent surveys within the **Helemano and Opeaula PU** have greatly increased the numbers of individuals known from this area. Most of the known individuals are within the Opaeula and Helemano MU.

The **Koloa PU** will also likely have higher numbers of known individuals once more thorough surveys are conducted in the area. The Army will survey prior to the Koloa MU construction to capture as many individuals as possible within the fenced area. Currently, all the known individuals in this PU will be protected within the proposed Koloa MU.

The **Kaukonahua PU** will likely also have higher numbers of individuals following thorough surveys of the area prior to the South Kaukonahua MU construction. The Kaukonahua PU will not be fully included in a contiguous fence. Individuals that fall outside the proposed fencelines will be managed for genetic storage collections to be used for storage and augmentation within fenced areas if necessary.

Table 11.21 Priority Management Actions for *Viola oahuensis* Army Stabilization PUs.

Population Unit	Specific Management Actions	Partners/Concerns	Timeline
Koloa PU	• Survey • Control priority weeds • Collect seeds for genetic storage	• This MU needs an EA and license agreement with landowner.	• construct Koloa MU, OIP yr 4; 2011
Kaukonahua PU	• Survey • Control priority weeds • Collect seeds for genetic storage	• This MU needs an EA.	• Construct South Kaukonahua MU, OIP yr 5; 2012
Helemano and Opaeula PU	• Control priority weeds • Collect seeds for genetic storage	• MU fence completed. • Surveys and weed control ongoing	• ongoing

11.22 Tier 3:
Cyrtandra subumbellata: Taxon Summary and Stabilization Plan

Scientific name: *Cyrtandra subumbellata* (Hillebr.) St. John & Storey
Hawaiian name: Haiwale, kanawao keokeo
Family: Gesneriaceae (African violet family)
Federal status: Listed endangered

Requirements for Stability

- 3 population units (PUs)
- 50 reproducing individuals (short-lived perennial)
- Threats controlled
- Genetic storage collections from all PUs
- Tier 3 stabilization priority

Description and biology: *Cyrtandra subumbellata* is a perennial shrub 2-3 m (7-10 ft) tall. The leaves of this species are opposite, suborbicular to ovate, 12-39 cm (4.7-15.4 in) long, and 3-19 cm (1.2-7.5 in) wide. The upper leaf surface is rugose and glabrous, and the lower leaf surface has conspicuously raised veins. The flowers are borne 5-15 in dense umbelliform cymes arising in the leaf axils. The corollas are white, and are 18-20 mm (0.7-0.8 in) long. The berries are white, ovoid, measure 1-1.5 cm (0.4-0.6 in) long, and contain numerous minute seeds.

Flowering and fruiting specimens of *C. subumbellata* have been collected at various times during the year. The reproductive biology of most Hawaiian *Cyrtandra*s, including *C. subumbellata*, has not been studied. However, a study of the reproductive biology of another Oahu *Cyrtandra*, *C. grandiflora*, showed that it is self-compatible and that both self-pollination and cross-pollination requires an unknown insect pollinator. It was also found that there is a strong tendency for a flower's pollen to be shed before the flower's stigma becomes receptive to pollen, thereby decreasing the likelihood of self-pollination (Roelofs 1979). *Cyrtandra subumbellata*'s dispersal agents are unknown, although its white berries suggest dispersal by fruit-eating birds. The species is presumed to be short lived.

Known distribution: *Cyrtandra subumbellata* has been found in a small portion of the windward Koolau Mountains, and at a single location on the leeward side of the range. On the windward side of the range the species has been documented from the valleys of Waikane, Kahana, and Punaluu, and Kaluanui Gulch. The only leeward station for the species is in South Kaukonahua Gulch in SBMR East Range. Recorded elevations for the species range from 460 to 760 m (1,500 to 2,500 ft).

Population trends: Two of the three current population units were relatively recently found. The South Kaukonahua Gulch PU was found in 1994 on a biological survey of SBMR. The Punaluu plants were discovered only in 1995. Too little time has passed for population trends to be evident in these PUs. In contrast, the Kahana plants became known to botanists in the early 1900s when the Castle Trail was built through the *C. subumbellata* PU. In 1941 the species was described by the botanist Harold St. John as being "common" along the trail (St. John 1966). Now only one or two plants can be spotted from the trail (Lau. pers. comm. 2005).

Current status: A total of about 212 mature plants are known from the four PUs. The South Kaukonahua PU, which is the only one in an action area, contains about 6 mature plants. The current population units and the number of plants they contain are given in the status table below and their locations are plotted on figure 11.44.

Habitat: *Cyrtandra subumbellata* occurs in *ohia lehua* (*Metrosideros* spp.) wet forest or mixed *ohia lehua-uluhe-koa* (*M. polymorpha-Dicranopteris linearis-Acacia koa*) wet forest, in gulch bottoms or on gulch slopes. Common associated species include *Boehmeria grandis, kanawao keokeo (Broussaisia arguta*), *mehame (Antidesma platyphylla*), *manono* (*Hedyotis terminalis*), and *kopiko* (*Psychotria* spp.).

Taxonomic background: *Cyrtandra* is one of the two largest genera in the native Hawaiian flora, including about 60 species, all of which are Hawaiian Endemics. Twenty-four of these species occur on Oahu.

Outplanting considerations: Hybridization between Hawaiian *Cyrtandra* species is very common. It is possible that the formation of hybrid populations between a given pair of *Cyrtandra* species occurred naturally in pre-human times. Alternatively, it is also possible that the two species did not normally hybridize due to ecological reproductive barriers that effectively prevented hybridization of the two species. Alteration of the habitat of these plants resulting from the human presence in Hawaii could then have led to a breakdown of these reproductive barriers, allowing a higher level of hybridization than originally, and a blurring of species boundaries. Whether the frequency of hybridization observed today represents a threat to Hawaiian *Cyrtandra species* should be studied.

Cyrtandra subumbellata potentially occurs alongside *C. propinqua*, *C. hawaiiensis*, *C. paludosa*, *C. kalihii*, *C. calpidicarpa*, *C. rivularis*, *C. lessoniana*, *C. waiolani*, *C. sessilis*, and *C. laxiflora*. Any area suitable for the outplanting of *C. subumbellata* would already contain some of these species of *Cyrtandra*. Since hybridization frequently occurs in the wild populations of *C. subumbellata*, the outplanted plants would be expected to hybridize to some extent with the *Cyrtandra* species already growing around the outplanting site.

The purity of the planting stock would be of concern in outplanting *C. subumbellata*, since there is a good chance that some seedlings raised from wild collected seeds are actually hybrids.

Threats: Primary threats to *C. subumbellata* include pigs and invasive alien plants such as Koster's curse (*Clidemia hirta*), strawberry guava (*Psidium cattleianum*). The species is potentially threatened by military activities, and predation by rats and slugs.

Threats in the Action Area: Within the action area *Cyrtandra subumbellata* may be threatened by trampling and the introduction of non-native plant species due to army training maneuvers. However, the threat from this type of training is very low due to the very remote habitat and steep terrain this species inhabits. Added threats throughout the range of this species include, habitat degradation by feral pigs and competition from non-native plant species.

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Cyrtandra subumbellata TaxonCode: CyrSub

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaukonahua	Manage for stability	2	0	1	0	0	0	3	2	0	2	0	1	To be managed within the South Kaukonahua MU Subunit I;

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyrSub.SBE-A	South Kaukonahua Stream, south branch	In situ	2		1

Total for Taxon:	2	0	1	0	0	0	3	2	0	2	0	1	

Action Area: Out

TaxonName: Cyrtandra subumbellata TaxonCode: CyrSub

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kahana	Manage for stability	8	7	0	0	0	0	2	7	0	8	7	0	

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyrSub.KNA-A	Waikane Trail	In situ	6	7	
CyrSub.KNA-B	Windward side of Crash LZ	In situ	2		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Punaluu	Manage for stability	200	0	0	0	0	0	100	0	0	200	0	0	May not need fencing; need to survey extent of PU

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyrSub.UNA-A	Punaluu Valley back wall	In situ	200		

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Uwao	Genetic Storage	2	0	0	0	0	0	0		0	2	0	0	New PU; Needs survey to determine extent

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
CyrSub.UWA-A	UWA-A	In situ	2		

Total for Taxon:	210	7	0	0	0	0	102	7	0	210	7	0	

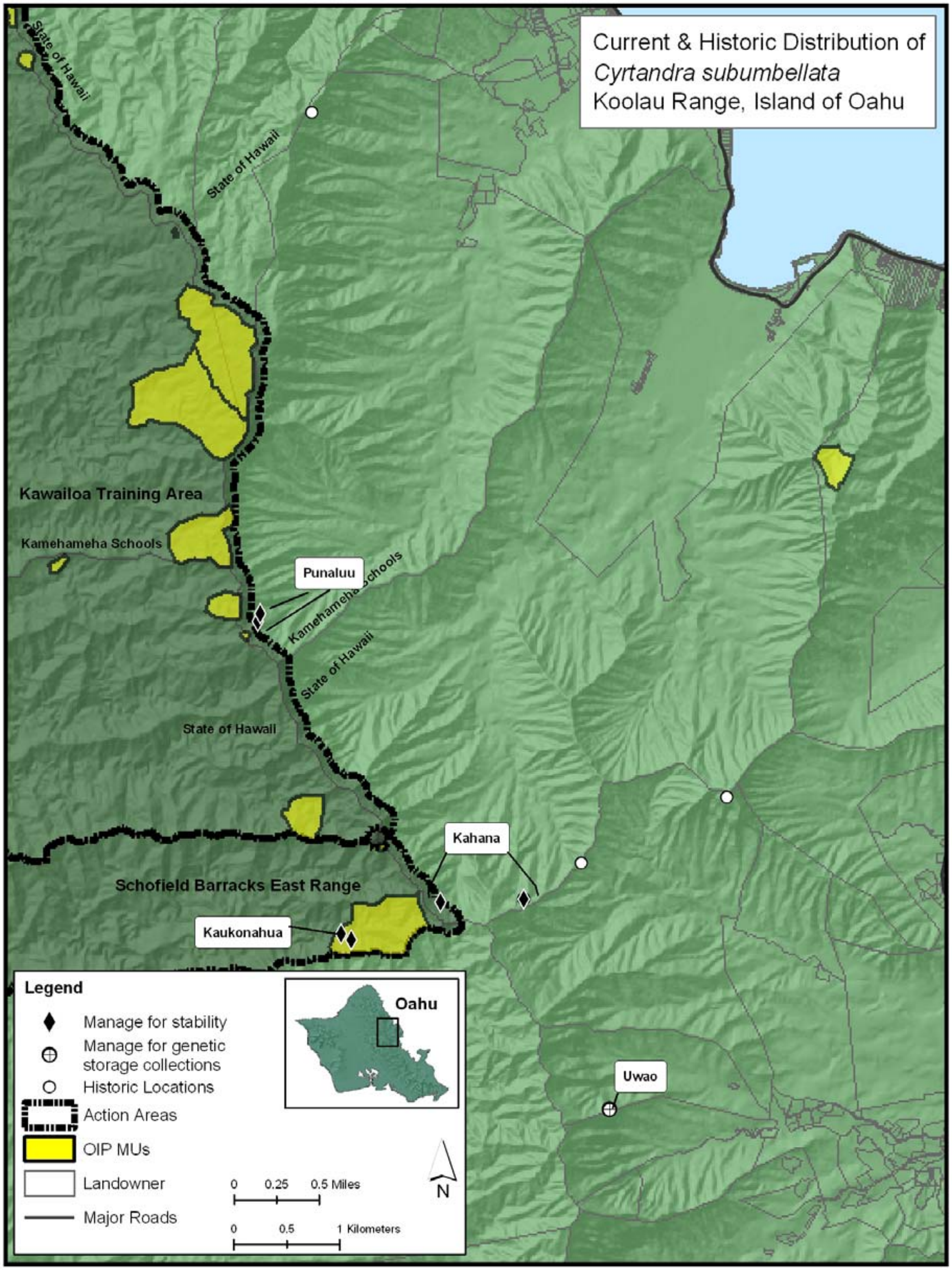


Figure 11.44 Current and historic distribution of *Cyrtandra subumbellata* in the Koolau Mountains of Oahu.

Discussion of Management Designation

Cyrtandra subumbellata can occur on steep windward cliff faces, a habitat that is vastly under surveyed. The Punaluu PU occurs predominately on the very steep windward cliff faces and may not need fencing. This population appears to be stable with an intact habitat and will be managed for stability. The Kahana PU was previously not chosen for management due to the steep terrain the plants inhabit and the degraded nature of the site. However, the Army has chosen to manage this PU instead of creating a reintroduction. The Kaukonahua PU occurs in moderate terrain near a gulch bottom, well within the action area and will be managed for stability. The Uwao PU was not chosen to be managed for stability because the two individuals observed appeared to be of hybrid origin. However, the location is significantly far away from the other known individuals that further surveys will likely reveal more pure individuals in the area.

Propagation and Genetic Storage

Vegetative propagation has not been attempted with this taxon. Due to the high likelihood that this taxon has and can hybridize with other taxa of *Cyrtandra* (Roelofs1979, Wagner, Herbst & Sohmer 1990, Smith, Burke & Wagner 1996), clonal propagation may be critical for maintaining pure representation of this taxon. Plants currently in the nursery will be used to develop successful cloning techniques. Once methods are developed, clonal propagation may occur for founders that are susceptible to hybridization (other *Cyrtandra* taxa in area), non-reproductive, or outlying. Viable seed has been collected from wild plants. Plants can be propagated from seed. Seedling stock propagated in the nursery flowered one year after germination. Seed storage studies are ongoing, and current results indicate that seeds will likely store similarly to other species of *Cyrtandra*. Collections will be made for additional storage testing designed to determine the optimal temperature for long term seed storage. Ongoing collaborative research on other species of *Cyrtandra* suggests that storage longevity may not be as long as detected for other genera. More frequent recollections from wild plants may be necessary to maintain genetic representation through seed storage. Seed collected *in situ* as well as cloned propagules will likely be used to establish reintroductions.

Roelofs, F. M. 1979 [1980]. The reproductive biology of *Cyrtandra grandiflora* (Gesneriaceae) on Oahu. Pacific Sci. 33:223-231.

Smith, J.F., C.C. Burke & W.L. Wagner. 1996. Interspecific hybridization in natural populations of *Cyrtandra* (Gesneriaceae) on the Hawaiian Islands: Evidence from RAPD markers. *Plant Systematics & Evolution* **200**: (1-2): 61-77.

Wagner, W. L., D. R. Herbst, and S. H. Sohmer. 1990. Manual of the flowering plants of Hawaii. Bishop Mus. Spec. Publ. 83:1-1853. Univ. of Hawaii Press and Bishop Mus. Press. Honolulu, HI.

Management Notes
The **Kaukonahua PU** is the only occurrence of this species on the leeward side of the Koolau Mountains. The PU is within the proposed South Kaukonahua subunit I MU. Augmentations may be necessary to reach stabilization target numbers. This action may take place prior to the initiation of Tier 3 stabilization as this fence will be constructed in OIP year 5; 2012.
The **Punaluu PU** has not been surveyed thoroughly and a determination on ungulate threat needs to be made. This should be done prior to the initiation of tier 3 so that if training changes occur the Army will know the status of this taxon.
The **Kahana PU** was monitored by the Army in the last 3 years and some genetic collections were made and plants from this collection are currently growing in the Army greenhouse. The Army needs to determine if this PU can be fenced.

Table 11.22 Priority Management Actions for *Cyrtandra subumbellata* Army Stabilization PUs.

Population Unit	Specific Management Actions	Concerns/Partners	Timeline
Punaluu PU	• Survey to determine the extent of the PU • Control priority weeds • Determine feasibility of fencing • Collect propagules for genetic storage	• Prior to surveys a license agreement with the landowner, Kamehameha Schools is needed.	• The license agreement is in process
Kaukonahua PU	• Construct South Kaukonahua I MU • Control priority weeds • Collect propagules for augmentation and genetic storage • Augment within the South Kaukonahua I MU	• This MU needs an EA.	• Construct S. Kaukonahua I MU, OIP yr 5; 2012
Kahana PU	• Re-monitor • Determine ungulate protection needs • Collect propagules for genetic storage	• A license agreement is needed with the State prior to further collections and or other management actions	• The license agreement is in process

11.23 Tier 3:
Lobelia gaudichaudii subsp. *koolauensis:* Taxon Summary and Stabilization Plan

Scientific name: *Lobelia gaudichaudii* subsp. *koolauensis* (Hosaka & Fosb.) Lammers
Hawaiian name: Haha
Family: Campanulaceae (Bellflower family)
Federal status: Listed endangered

Requirements for Stability
- 3 population units (PUs)
- 100 reproducing individuals (short-lived perennial; monocarpic; inconsistent flowering)
- Threats controlled
- Genetic storage collections from all PUs
- Tier 3 stabilization priority

Description and biology: *Lobelia gaudichaudii* subsp. *koolauensis* is an unbranched or sparingly branched shrub up to 1.5 m (4.9 ft) tall. Each stem bears a dense rosette of leaves. The leaves are glabrous and sessile, oblanceolate to oblong, 8-19 cm (3.1-7.5 in) long and 1.3-2.8 cm (0.51-1.1 in) wide. The flowers are borne in terminal racemes with 2-6 branches arising from the base of the raceme. The flower's corolla is greenish to yellowish white, and 50-75 mm (2.0-3.0 in) long. The fruit is a capsule that is ovoid in shape, and measures15-20 mm (0.59-0.79 in) long. The capsules dry on the inflorescence and split open to release numerous small brownish, ovoid, compressed, minutely winged seeds. The stem bearing the inflorescence dies after flowering and fruiting.

Lobelia gaudichaudii subsp. *koolauensis* has been seen flowering primarily from May through October, and fruiting from July through November. As with most other Hawaiian lobelioids with their long tubular flowers, this taxon is thought to have been pollinated by nectar-feeding birds. A study by Lammers and Freeman (1986) found that most Hawaiian lobelioids have a nectar sugar profile typical of bird-pollinated flowers. *Lobelia gaudichaudii* subsp. *koolauensis* is probably capable of self-pollination, as several other species of Hawaiian lobelioids have been found capable of selfing in cultivation. As the seeds of this taxon are extremely small and are winged, it is apparently wind-dispersed. For the purposes of this Implementation Plan, the taxon is categorized as a short-lived taxon.

Known distribution: *Lobelia gaudichaudii* subsp. *koolauensis* is endemic to the higher elevations of the northern and central portions of the Koolau Mountains on Oahu. Only four population units have been recorded to date. They are distributed from the type locality for the taxon on the Kaipapau-Kawainui summit ridge in the north, to Waiawa and Waimano in the central Koolau Mountains. Recorded elevations for the taxon range from 600-850 m (1,969-2,790 ft).

Population trends: There is little information on population trends for *L. gaudichaudii* subsp. *koolauensis*. The population units at the heads of South Kaukonahua and Kipapa Gulches were discovered too recently for population trends to be evident. The South Kaukonahua plants were found in 1997, and Kipapa plants were found in 2004. The third population unit, which covers an extensive area beginning in Waiawa Gulch and ending at Waimano Gulch, has been known for decades because the Manana Trail passes through the area, but the number of plants there has not been well documented through the years. The plants at the taxon's type locality at the head of Kaipapau Gulch reportedly contained about 15-20 mature plants when discovered in 1937 (Fosberg and Hosaka 1938). Since then, there have been no reported attempts to locate the plants again, and it is possible that the taxon still exists at this location. Recently, the Army discovered some individuals of this subspecies within the Lehua Makanoe Bog fence in the summit area of the Kawaiiki drainage. This PU along with the South Kaukonahua and Kipapa PU appear to have both *L. gaudichaudii* subsp. *koolauensis* and *L. gaudichaudii* subsp. *gaudichaudii*.

Current status: As discussed above, there are currently four known population units of this taxon. The population unit in Waiawa to Waimano Gulches, with an estimated 180 plants, contains the majority of the known plants of this taxon. The South Kaukonahua population unit is in the East Range of SBMR, and has approximately 3 mature and 42 immature plants. The Kipapa Gulch site is in the Oahu Forest National Wildlife Refuge. When observed in May 2005, at least 30-40 mature plants with inflorescences were observed (Bakutis pers. comm. 2005). Since this area has both subspecies of *L. gaudichaudii*, and the non-flowering plants could not be distinguished from one another at that time, the number of non-flowering mature plants and immature plants of subsp. *koolauensis* could not be determined. The identification of vegetative plants of *L. gaudichaudii* to the subspecies level in the field might be possible once one becomes familiar with vegetative differences between the two subspecies.

The current population units and the number of plants they contain are given in the status table below and their locations are plotted on figure 11.45.

Habitat: The habitat at the type locality of *L. gaudichaudii* subsp. *koolauensis* on the windward side of the summit ridge between Kaipapau and Kawainui Gulches has been described as being a sloping open bog very similar in physiognomy and species composition to the more familiar montane bogs on Kauai, Molokai, Maui, and Hawaii (Fosberg and Hosaka1938).

The only other records for this taxon are the three extant population units, which are located in bog-like vegetation on windswept ridges. In the wet, high elevation, parts of the Koolau Mountains this type of vegetation is characteristic of extremely exposed ridges. This vegetation contains a number of kinds of plants that are usually bog species elsewhere (Fosberg and Hosaka 1938. Plants occurring in Koolau bogs and bog-like habitats include *Metrosideros polymorpha*, including a prostrate form of the species in the most exposed situations, *Machaerina angustifolia*, *Sadleria pallida*, *Bidens macrocarpa*, *Broussaisia argutus*, *Dubautia laxa*, *Cibotium* spp., *Isachne* spp. *Rhynchospora* spp., and *Vaccinium* spp. Bryophytes (mosses and livorworts) constitute much of the groundcover in this vegetation type.

The Waiawa to Waimano population unit extends as far as 1 km (0.6 mi) leeward of the Koolau summit ridge, which is unusual for this taxon. This can be explained by the fact that the bog-like vegetation in which this taxon characteristically grows extends farther to the lee of the Koolau summit ridge here than anywhere else in the mountain range.

Taxonomic background: The genus *Lobelia* worldwide has over 350 species. There are 13 native species of *Lobelia* in Hawaii, all endemic to Hawaii, four of which occur in the Koolau Mountains. The four are *L. gaudichaudii, L. hypoleuca*, *L. monostachya* and *L. oahuensis*. *Lobelia hypoleuca* and *L. oahuensis* are closely related. They both belong to a group of Hawaiian *Lobelia* species whose flowers are blue. *Lobelia gaudichaudii* is closely related to *L. kauaensis* and *L. villosa* of Kauai, and *L. gloria-montis* of Molokai and Maui, all of which are characteristically bog species. *Lobelia monostachya* is closely related to *L. niihauensis.* Both are adapted to lower elevation, dry exposed cliffs. The species *L. gaudichaudii* consists of two subspecies, subsp. *koolauensis*, and subsp. *gaudichaudii*, both of which are endemic to the Koolau Mountains. Subsp. *gaudichaudii* has single-branched inflorescences with magenta colored flowers, whereas subsp. *koolauensis* has branched inflorescences with white flowers.

Outplanting considerations: Although more common than subsp. *koolauensis*, subsp. *gaudichaudii* is also a rare plant. As with subsp. *koolauensis*, it occurs only in the summit areas of the Koolau Mountains, and it can be found in habitats similar to subsp. *koolauensis*' habitats. At the Kipapa and Kawaiiki PUs subsp. *gaudichaudii* been observed growing with subsp. *koolauensis*. This co-occurrence of the two subspecies should be studied. Their growing side by side suggests that the two taxa may be reproductively isolated from one another, but until more is known about their potential for hybridizing, one subspecies should not be outplanted next to the other.

There are three additional species of *Lobelia* that occur in *L. gaudichaudii* subsp. *koolauensis*' habitat. One is *L. hypoleuca*, which is not considered rare, and occurs on most of the main islands of Hawaii. A second *Lobelia* species, *L. oahuensis*, is a rare, listed endangered plant endemic to the Koolau Mountains. Both of these species can occur in or near *L. gaudichaudii* habitat. However, no hybridization has been observed between either of these species and *L. gaudichaudii*. Hybridization concerns with respect to these two species are minimal. However, since *L. oahuensis* is a rare plant, its occurrences should be avoided if outplanting *L. g*. subsp. *koolauensis* becomes necessary. The third species, *L. monostachya*, is known only from a few plants in the Southern Koolaus and occurs on dry, exposed cliff habitat at lower elevations.

There are no hybridization concerns regarding *L. gaudichaudii* and *L. monostachya* due to their occupying distinctly different habitats and their non-overlapping geographical ranges.

Threats: The primary threats to *L. g*. subsp. *koolauensis* include feral pigs and alien plant species. Alien plant species that are potentially threatening include narrow-leaved carpetgrass (*Axonopus fissifolius)*, Koster's curse (*Clidemia hirta*), strawberry guava (*Psidium cattleianum*), *Pterolepis glomerata*, and Glenwood grass (*Sacciolepis indica*). Additional threats to the taxon include predation by slugs and rats, and trampling by hikers.

The long-billed, nectar-feeding native Hawaiian birds, which are the presumed original pollinators of *L. g*. subsp. *koolauensis*, have become extremely rare on Oahu. Although *L. g*. subsp. *koolauensis* is probably capable of selfing, the loss of its normal pollinating vectors is likely to result in decreased genetic variability within its populations over successive generations.

Threats in the Action Area: Potential threats to *Lobelia gaudichaudii* subsp. *koolauensis* caused by army training activities include trampling by foot maneuvers and the introduction of competing non-native plant species via transport of personnel and equipment between training areas. However, the due to the remote locations of this species, the threat from trampling is very low. There is no fire threat to PUs of this species in the action area. Throughout its range this species is also threatened by habitat destruction and trampling by feral pigs, and competition from non-native plant species such as *Axonopus fissifolius*.

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Lobelia gaudichaudii subsp. koolauensis   TaxonCode: LobGauKoo

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kaukonahua	Manage for stability	3	45	2	0	0	0	3	45	0	**3**	**45**	**2**	Within South Kaukonahua MU.

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
LobGauKoo.SBE-A	Hakulei Ridge	In situ	3	45	2

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kawaiiki	Genetic Storage	2	0	0	0	0	0	2	0	0	**2**	**0**	**0**	within Kawaiiki and Opaeula MU (Lehua Makanoe Bog fence); 89 plants total- not sure how many are subsp. koolauensis

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
LobGauKoo.KLO-A	Lehua Maka Noe Bog	In situ	2		

		NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling
	Total for Taxon:	5	45	2	0	0	0	5	45	0	**5**	**45**	**2**

Action Area: Out

TaxonName: Lobelia gaudichaudii subsp. koolauensis TaxonCode: LobGauKoo

Population Unit Name	Management Designation	NRS Current Mature (Wild)	NRS Current Immature (Wild)	NRS Current Seedling (Wild)	NRS Current Augmented Mature	NRS Current Augmented Immature	NRS Current Augmented Seedling	Draft OIP Mature 2005	Draft OIP Immature 2005	Draft OIP Seedling 2005	Total Mature	Total Immature	Total Seedling	Population Notes
Kipapa	Manage for stability	0	100	20	0	0	0	0	35	0	**0**	**100**	**20**	This population will be fenced via FWS and KMWP; NRS to assist if necessary.
Waiawa to Waimano	Manage for stability	0	200	0	0	0	0	0	180	0	**0**	**200**	**0**	partially protected within Waiawa, Manana, and Waimano MUs
	Total for Taxon:	0	300	20	0	0	0	0	215	0	**0**	**300**	**20**	

Kipapa:

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
LobGauKoo.KIP-A	Kipapa	In situ		100	20

Waiawa to Waimano:

TaxonCode PopRefSiteID	PopRefSiteName	InExsitu	Mature	Immature	Seedling
LobGauKoo.ANO-A	Waimano & Manana	In situ		100	
LobGauKoo.ANO-B	Inside Cyastj fence	In situ		10	
LobGauKoo.AWA-A	Manana Trail near summit	In situ		10	
LobGauKoo.AWA-B	Off Manana trail into Waiawa.	In situ		80	

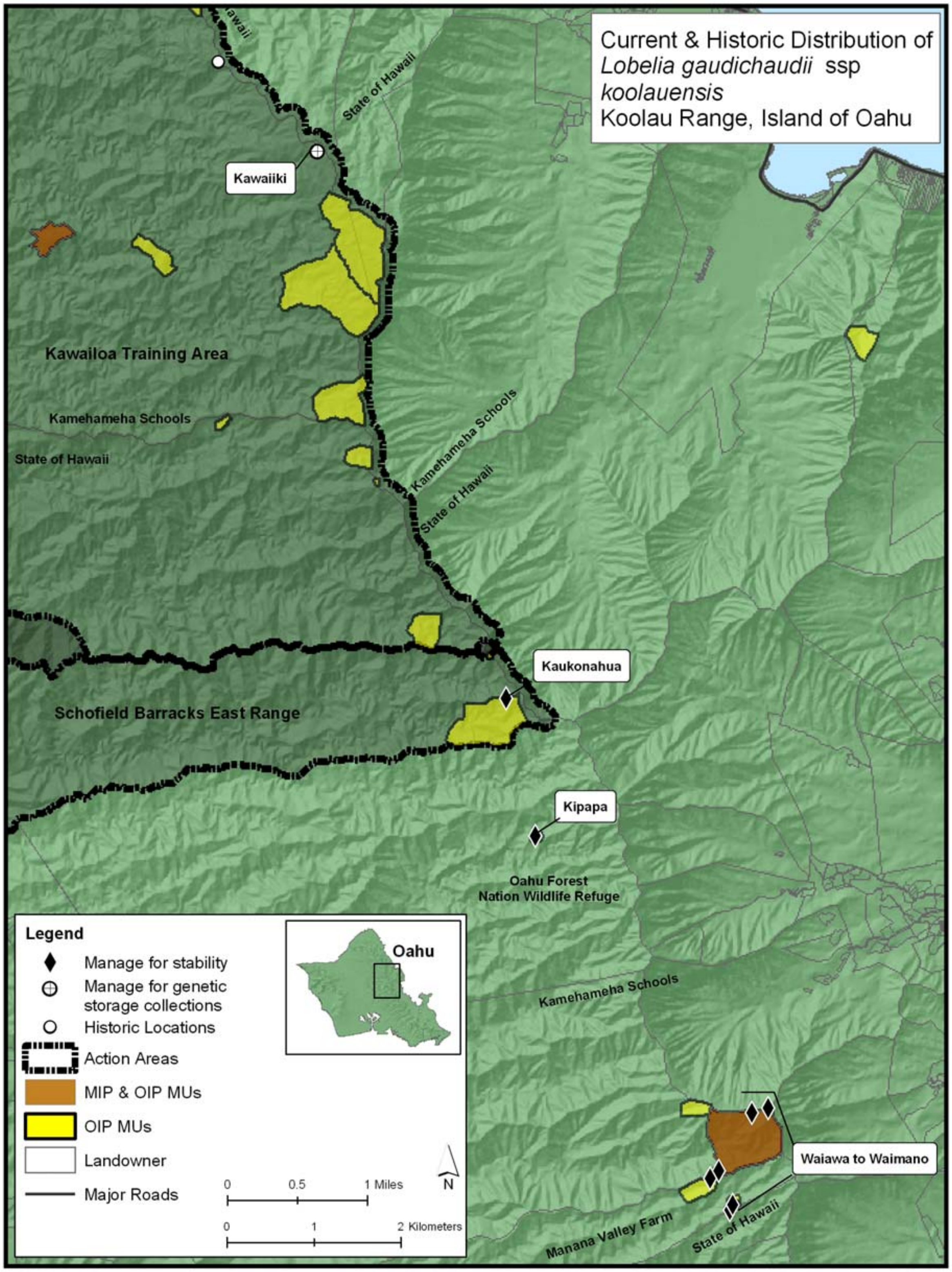


Figure 11.45 Current and historical distribution of *Lobelia gaudichaudii* subsp. *koolauensis* in the Koolau Mountains, Oahu.

Discussion of Management Designations

The PUs chosen for management are Kaukonahua, Kipapa, and Waiawa to Waimano. Individuals in the Waiawa to Waimano PU that fall outside the Waiawa MU will be managed for genetic storage collection.

Propagation and Genetic Storage

Since it appears difficult to distinguish this taxon from *L. gaudichaudii* subsp. *gaudichaudii* prior to flowering, vegetative propagation has not been and will likely not be attempted. This taxon has been successfully propagated from seed and this is the preferred propagation technique. Seed storage studies indicate storage characteristics similar to species of *Cyanea*. Currently, all studied species of *Cyanea* exhibit unique storage requirements, consisting of an inability to tolerate frozen storage temperatures. Research is ongoing with collaborators at the USDA-ARS National Center for Genetic Resources Preservation to determine the cause of this anomaly, focusing on lipid composition of seeds of taxa of *Cyanea*. Research is also targeting the storage temperatures that will prolong viability the longest. Seed collected *in situ* will be used to establish reintroductions.

Research Issues

Outstanding research issues include studies of possible hybridization between the two subspecies, development of techniques to differentiate immature plants of the subspecies from each other and life history research for *L. gaudichaudii* subsp. *koolauensis*.

Management Notes

The **Kaukonahua PU** will be managed within the South Kaukonahua I MU. A priority for this PU is the construction of the MU fence and genetic storage collections for testing and propagation.

The **Kipapa PU** is within the FWS Oahu Forest National Wildlife Refuge. This PU contains both subspecies growing sympatrically. A priority for this PU is monitoring to determine how many individuals are subspecies *koolauensis* and collection for genetic storage testing and propagation. This PU also needs to be fenced to protect it from ungulates. However, the Kipapa MU has a lower priority for construction than the other OIP MUs because it contains just one species (a Tier 3). Therefore, a priority for this PU is also working with the FWS and the Koolau Mountains Watershed Partnership (KMWP) to construct this fence prior to the projected date in the OIP.

The **Waiawa to Waimano PU** occurs along the ridges of these two valleys and portions of the PU will be protected within the Waiawa, Manana, and Waimano MUs. This PU currently has numerous individuals, however, fencing is still considered a high priority.

Monitoring phenology is important for all PUs as there are likely both *L. gaudichaudii* subsp. *gaudichaudii* and *L. gaudichaudii* subsp. *koolauensis* within some PUs. As mentioned there is a need to be able to distinguish between immature individuals of both subspecies. Currently, the primary distinguishing characters between the subspecies are found only on mature individuals. With sympatric subspecies that are also monocarpic it is difficult to determine population structure. Monitoring of individuals over time may provide additional vegetative distinguishing characters between the two subspecies.

Table 11.23 Priority Management Actions for *Lobelia gaudichaudii* subsp. *koolauensis*.

Population Unit	Specific Management Actions	Partners/Concerns	Timeline
Kaukonahua PU	• Construct South Kaukonahua MU • Control priority weeds • Collect propagules for augmentation and genetic storage • Outplant	• This MU needs an EA.	• Construct S. Kaukonahua MU I, OIP yr 6; 2013
Kipapa PU	• Construct Kipapa MU fence • Collect propagules for augmentation and genetic storage • Control priority weeds • Outplant	• This MU needs an EA.	• Construct Kipapa MU, OIP yr 12; 2019
Waiawa to Waimano PU	• Construct Waiawa I & II MU fences • Control priority weeds • Collect propagules for genetic storage	• Waiawa I has an EA w/ FONSI • Waiawa II and Manana MUs need an EA a finalized State Agreement	• Construct Waiawa I and II MUs, OIP yrs 10 and 12; 2017, 2019

12.0 Oahu Implementation Plan Management Units

The Oahu Implementation Plan (OIP) management units (MUs) are of the same intent as those designed for the Makua Implementation Plan (MIP), which is to provide a defined area that has active threat management for the rare species within. Active threat management assumes the area is ungulate free once the fence is constructed and that other threats such as weeds and/or invertebrates or pathogens are controlled to the greatest extent possible and is feasible for conservation of rare species. Each MU outlined here will be surrounded by an ungulate fence, and have major weeds controlled in the areas near sensitive target taxa. The MUs may also be the site of the reintroduction or augmentation of OIP target species. Some OIP MUs are the same or subunits of those described in the MIP Addendum (2004). By focusing on numerous target taxa within one MU, the Army natural resources staff will be able to conduct comprehensive ecosystem level restoration, to the benefit of both common and rare species (i.e. threat control, habitat restoration, etc). The OIP MUs occur on Army, State of Hawaii, and private lands, and require cooperation and memoranda of agreement with the landowners, as spelled out in scopes of work prior to initiation of management actions at these sites. Additionally, a Programmatic Environmental Assessment of all the OIP MUs is necessary prior to the construction of MU fences.

Each MU is designed to provide sufficient area for the stabilization of all *in situ* PUs designated as manage for stability and all reintroduced PUs within MUs. This resulted in the delineation of a number of larger area MUs, each containing numerous target taxa, and also in numerous smaller MUs that might contain only one or two target taxa. Because the MUs are sites of intensive management, it is important to repeat concerns about the harmful effects of human activities in natural areas, including inadvertent introductions of pests and pathogens, direct trampling damage to native vegetation, and genetic contamination of sensitive plant taxa. Detailed plans to be developed for specific management of each MU must include strategies to minimize such harm. See the MU summaries for the non-target rare taxa in and or near each MU.

Some OIP MUs are significantly smaller than most of those delineated for the MIP. These smaller MUs are a result of the larger geographical scope of the OIP, where target taxa may be spread over such a large area that it is not feasible to manage within a single fenceline. Therefore, several smaller MUs were developed for the stabilization of just one or a few target taxa.

MU designation

There are approximately 33 MUs designated based on locations of the *in situ* PUs of the target taxa and their potential reintroduction areas (see Table 12.2). Some of the 33 MUs include more than one fenced managed area, generally these are referred to as subunits, however some have distinct names depending on the proximity of the fences to each other or specific gulch names where the fences occur. Of these fenced managed units, 8 are in the Waianae Mountains, and the rest are in the Koolau Mountains. The MUs range from less than 1 acre up to 425.9 acres in size (see Table 12.2). The total acreage that will be managed for the OIP, including those MUs planned for the MIP, is approximately 1,997 acres. The total new acreage planned specifically for the stabilization of OIP species is 968 acres. These MUs include all of the target taxa PUs designated as manage for stability, as well as all selected reintroduction sites identified in the individual taxon stabilization plans (SPs). Additionally, some MUs also contain target taxa PUs that are designated as manage for genetic storage collections.

Larger MUs were designated to include: 1) relatively high densities of *in situ* PUs of target taxa, 2) large areas of relatively intact native-dominated vegetation which would provide habitat for *in situ* PUs as well as for reintroduction sites, and 3) as far as possible, locations in areas accessible for management (*e.g.*, near existing roads, trails, or helicopter landing areas).

Long-Term Threat Management Goals in Management Units (adapted from MIP)
The level of threat control varies according to the type of threat, the current methods of control and their efficacy, as well as the purpose of the threat control. It is feasible and necessary to eradicate ungulates within the entirety of fenced management units (MUs) to achieve adequate protection of target taxa and maintenance and improvement of their habitat. The level of weed control will be more intensive in the immediate vicinity of target taxa population units (PUs) but this level of weed control is not feasible or reasonable for the larger MUs for weeds that are not imminent threats to the maintenance and improvement of the habitat. While many invertebrates are serious pests to the target taxa and the component taxa of their habitat, broad-scale control methods for these taxa are unknown at this time. Goals for threat control vary according to the threat type, the size of the area being managed, and control method availability.

Three levels of threat management were developed: 1) the immediate vicinity of individuals of target taxa, 2) the entire area of a PU of a taxon, which may vary from a small cluster of individuals within a few square meters to a larger area containing hundreds of individuals, but considered a single PU, and 3) an entire MU or MU subunit. As may be expected, threat control can be exercised most fully within a small area and goals for threat control include total eradication of all weeds and control of all feasible pathogens and invertebrates within two meters of individuals of target taxa. In contrast, only incipient invasive weeds, invertebrates, or pathogens shall be eradicated at the scale of the PU (50 meter proximity). For other weed threats, the goals are expressed in terms of cover in the surrounding vegetation: surrounding PUs the goal is to have no more than 25% non native vegetation (although the Army would like to achieve %100 native cover within 50m of PUs), and across the MU or MU subunit the goal is no more than 50% non native vegetation. Cover percentage includes canopy and subcanopy layers as appropriate. Invertebrate pathogen pest goals are not delineated here due to the varied control methods and levels of control each method might effect.

Because threat management goals may take years to realize, they are characterized as long-term targets even though they will be initiated shortly after management has begun in a given MU or PU. Some threats are only controllable at the smallest scales and no goals are appropriate or applicable at larger ones. Where control is not applicable, the cell is filled "NA." Members of the OIT from the USFWS and the Army must approve the final decisions as to what level of control is acceptable in a given MU or MU subunit.

Table 12.1 Threat Management Goals at Three Scales of Management

	Proximity of Individuals (2 m radius)	Proximity of PUs (50 m buffer)	*Within the MU or MU subunit*
Threats:			
Fire**	zero incidence	zero incidence	zero incidence
Ungulates	total removal	total removal	total removal
Incipient invasive weeds	total removal	total removal	total removal
Percent cover of other weeds	0%	25%	50%
Small mammals*	total removal	total removal	NA
Euglandina rosea*	total removal	total removal	NA
Other invertebrates*	total removal	NA	NA
Pathogens	As feasible	As feasible	As feasible
Human impacts (other than management)	no impact	no impact	no impact

**Fire management plans will be created for each susceptible MU; * Control only if threatening target taxon

The target percentages for alien vegetation are viewed as a general guideline, and the OIT recognizes that modifications may be made upon development of the specific MU management plans. For example, certain native target taxa might be particularly sensitive to alien competition and alien-dominated habitat, while others might be able to tolerate high percentages of certain alien taxa. Taxon-specific weed target guidelines can be designated for each of the target taxa, and applied at the PU level upward. Assuming that MUs contain some large areas of alien-dominated vegetation, and a wide spectrum from completely non-native to mostly native-dominated areas, weed control will have to be defined by an average of weed frequency and cover over the entire MU. Alternately, the most important MU areas can be stratified according to habitat type and quality, and weed control can occur with greater intensity in those areas most appropriate for stabilization of the target taxa. For example these weed control goals need to be modified when working in elepaio areas as they nest and forage in both native and non native vegetation and require a certain forest structure. Therefore, when controlling canopy weeds in elepaio habitat within MUs, care must be taken to remove non native species slowly while replacing the canopy with native vegetation as much as possible. Any changes of this type recommended in MU threat management plans will be reviewed by members of the OIT and approved by the USFWS.

Due to the large geographic area covered in the OIP consultation, most of the MUs are not contiguous and are thus separated by large areas with no management. Some MUs are share adjacent fencelines. However, for the purposes of threat control management adjacent MUs will be treated separately.

Management actions to eliminate threats and encourage regeneration of target taxa are required within each MU. Although each taxon has specific threats and habitat needs, many of the threats apply to all or many of the taxa: feral ungulate browsing, competition with alien weeds, seed predation by rats, and the effects of alien pest insects are prominent among these. The management activities to be developed for each MU to counteract these threats, as needed, are briefly described below. The initial phases of MU management call for a survey and assessment of threats to justify the initiation of the management actions below. Subsequently, separate detailed MU management plans for each type of threat will be developed by the Army using the results of these MU surveys to identify specific management needs for each MU.

Prioritization

Management Units in the table below were prioritized based on the level of threat to the area and species (Tier), and the number of manage for stability PUs contained within the proposed units. One exception is Mohiakea MU, which is proposed to be constructed at a high priority because it is in SBMR and contains elepaio. It is hoped that by constructing this MU sooner aerial rat bait may be deployed. The construction priority is listed with the estimated construction year which is based on landowner agreements, NEPA documents, and size. The MIP MUs were not included in this prioritization, other than to denote the number of OIP species in each tier, as they are ranked for construction under that plan and will be funded via the MIP. It is assumed that the Army's in house fence crew can construct one large MIP and one large OIP fence per year and that smaller fences will be constructed as resources are available. Conservatively, all large Tier 1 OIP fences should be constructed within the first seven years. Tier 2 fences will be constructed prior to tier initiation as a proactive conservation measure. If additional training begins, threats will need to be reassessed and priorities may change. The OIT will be an integral part of the adaptive management process regarding the priority for MU construction. OIP MUs are listed in order of construction priority in Table 12.2 below. Fire threat is included in the table although it was not a factor in the prioritization process.

Threat management

Fencing and ungulate control

Using fences to create areas targeted for ungulate eradication is a well-established practice in other managed Hawaiian natural areas (Cory 2000). Perimeter fences for the MUs typically either follow the MU boundaries, or fall outside MU boundaries when topography forces the fence line to follow ridge tops or contours to avoid cliffs or other natural obstacles. Perimeter fences are typically not inside of the MU boundaries unless topographic or other features keep ungulates out of unfenced sections of the MU. In addition to perimeter fences, a number of fences are proposed to divide large MUs into more manageable subunits (subunit fences), or provide a strategic protective function, such as preventing movement of feral ungulates along ridges (strategic fences). All fence lines are depicted in the map for each MU, and include existing fences and proposed routes for additional fences. The fences are designed primarily to prevent further invasion of ungulates such as feral pigs, and goats. In very rare cases, perimeter fences are not recommended, for example, when MUs include areas that are considered self-protected (typically by vertical cliffs). In these situations, short, strategic fences might be the only fences proposed. **Placement and size of all MU fences will be refined based on landowner input.**

All proposed routes for additional MU fence lines are approximations only, and subject to a thorough fence line scoping to determine detailed on-the-ground placement that minimizes damage to habitat and rare taxa, and optimizes protection. In cases where little is known about an area, the need for and estimated placement of fences is uncertain, pending initial MU surveys.

Table 12.2 OIP Management Unit List. **MUs shared with the MIP. *fire threat; **Bold=existing fences.**
^W= Waianae Mountain Range, K= Koolau Mountain Range

#	Management Unit	# MFS PUs			Fire Threat*	Est. Year	Acres	Training Area	Region ^
		T1	T2	T3					
1	South Haleauau	5			Moderate	2009	425.7	SBMR	W
2	North Haleauau	5			Moderate	2010	123.6	SBMR	W
3	Mohiakea	2			Moderate	2010	425.9	SBMR	W
4	Koloa	4	2		Very low	2011	160	Offsite	K
5	Kaipapau Subunit I	4	1		Very low	2012	272	Offsite	K
6	South Kaukonahua Subunit I	3	3	1	Very low	2013	93.5	SBER	K
7	North Kaukonahua	3	1		Very low	2014	30.4	KLOA	K
8	Kamaili	1			Moderate	2010	6.3	Offsite	W
9	Manana	1			Very low	2012	18.1	Offsite	K
10	Waimano	1			Very low	2009	3.6	Offsite	K
11	Kawailoa	1			Very low	2011	6.49	KLOA	K
12	Poamoho Subunit I	1	4		Very low	2015	60.2	KLOA	K
13	Lower Poamoho	1			Very low	2014	<1	KLOA	K
14	Ekahanui extension + Huliwai (OIP); **Ekahanui Subunits I and II ***	2			Moderate	2013	1 + 202.25	Offsite	W
15	Lower Peahinaia II	1			Very low	2016	23.9	KLOA	K
16	North Halawa	1			Very low	2015	3.7	Offsite	K
17	Lower Peahinaia I* (syn: Lower Opaeula)	2	1		Very low	2011	25	KLOA	K
18	East Makaleha*	3			low	2010	231.1	Offsite	W
19	Manuwai*	1			Moderate	2008	322	Offsite	W
20	**Kaluaa** + Waieli*	**1**			moderate	2009	99 + 29	**Offsite**	W
21	**Kaala**	**3**			Very low	X	171.6	SBMR	W
22	**Kaunala, Pahipahialua, Oio**	1			moderate	X	25	KTA	K
23	**North Pualii**	1			moderate	X	19.1	**Offsite**	W
24	**Opaeula/Helemano**	1				X	234.5	KLOA	K
25	Poamoho Subunit II		2		Very low	2016	17.8	KLOA	K
26	Kaipapau Subunits II and III		2		Very low	2017	9.3	KLOA	K
27	South Kaukonahua Subunit II		2		Very low	2015	1	SBER	K
28	Poamoho Subunit III		1	1	Very low	2016	1.3	KLOA	K
29	Waiawa Subunit I		1	1	Very low	2017	124	Offsite	K
30	Kahana		1		Very low	2018	22.5	Offsite	K
31	Wailupe		1		low	2019	21.7	Offsite	K
32	Waiawa Subunit II		1		Very low	2019	12.7	Offsite	K
33	Kipapa			1	Very low	2019	3.7	KLOA	K
	Total acreage						3228		
	Total new OIP acreage						1870		

Within the MU fences, ungulates such as pigs, goats, and feral cattle must be removed until the MU is ungulate-free. Methods for ungulate control and removal are drawn from best available control techniques from natural resource managers at the Army Natural Resources Program, the National Park Service, U.S. Fish and Wildlife Service National Wildlife Refuges, State Natural Area Reserves, preserves of TNCH, and others. These techniques may include public hunting, staff hunting, trapping and snaring, or other methods (Cory 2000).

Weed assessment and control
Within the MUs, highest priority weeds will be identified and designated for one of two general levels of control. Incipient habitat modifying weeds are slated for complete removal, while other more established and persistent weeds are controlled in the vicinity of PUs and at the MU level to varying degrees. Some alien taxa that are less habitat modifying may be tolerated without much control effort being applied at present but warrant monitoring and periodic assessments to determine the need for control. A small number of known or potentially incipient habitat-modifying weeds have been and will continue to be assessed and mapped throughout the AA. The goal of this assessment is to monitor and identify the need to initiate management actions for taxa that may seriously threaten the MUs in the future. All of this information will be used to develop weed control plans for each MU.

The area for weed control typically lies within 50 meters or more of the polygon defined by the existing individuals of the PU for intensive management, with a lower level of control throughout the MU. Methods for weed control are continually being improved, so are not specified here, but the Army is expected to use the best available control techniques of natural area managers, as noted above for ungulates. In areas dominated by alien taxa, gradual, incremental weed control will be used to avoid rapid or major microhabitat changes.

Small mammal control
Where small mammals have been identified as a threat, small mammal control, in the form of trapping and the use of toxicants, will be implemented within MUs. Mammal control will be focused in the vicinity of PUs and proposed reintroductions/augmentations of target taxa shown to be sensitive to small mammal predation (*e.g.*, *Achatinella*, Elepaio, and plants eaten by rats). Small mammal assessments will be conducted within each MU to specify areas requiring control. Management should compensate for an edge effect in baiting (Nelson *et al*. 2002). Currently, the Army spends a large amount of staff time on small mammal control in the majority of completed MUs by restocking rat bait and setting snap traps around target taxa every six weeks. Therefore, when aerial rotenticides are approved for use in forested areas in Hawaii this will have a significant effect on the Army’s management practices for rare species.

Euglandina rosea and other snail predator control
Because the predatory alien snail *Euglandina rosea* is one of the main threats to *Achatinella,* monitoring and control measures for *E. rosea* are proposed in the *Achatinella* MUs wherever populations of *Achatinella* are present. Similar monitoring and control protocols are identified for slugs and *Platydemis manokwari*, an alien predatory flatworm. Methods have been developed for the control and exclusion of *E. rosea*, and are described in the *Achatinella*

stabilization plans. The Army is currently funding research on dog detection teams for the eradication of *E. rosea* within managed areas.

Other invertebrate control
Specific management tools are currently not available for invertebrate pests such as two-spotted leafhopper (*Sophonia rufofascia*), black twig borer (*Xylosandrus compactus*), Chinese rose beetle (*Adoretus sinicus*) and various species of slugs (*Limax* species, etc.). Research on specific control techniques for slugs, *X. compactus* and other insect pests, and the potential impacts of these control methodologies on native invertebrate taxa is urgently needed, since these threats are considered major factors in the decline of certain native plant taxa (particularly *Alectryon macrococcus* var. *macrococcus* and *Flueggea neowawraea*). The Army currently has a natural resource protection specialist position that researches new control methods for these significant pests.

Human impacts
The MUs will have to accommodate at least some level of human presence, including resource managers, volunteers, hikers, and hunters. Signage and some restrictions of human presence in the vicinity of *in situ* populations and reintroduction sites may be necessary.

Fire control
The goal of fire control in MUs is to bring fire threat to zero, or to minimize the threat in those areas where the threat cannot be removed entirely (*e.g*., some of the driest MUs adjacent to areas bearing significant fire histories). For all MUs with assessed high fire risk, fire planning and management programs are considered critical to ensure success of stabilization efforts. Fire is certainly the most devastating of the threats facing MUs and target taxa. Both taxa and habitat can be completely destroyed in a single, brief fire event. Fire pre-suppression and suppression plans should follow those established by other natural area managers. Perhaps the most experienced of these include the National Park Service, the Department of Land and Natural Resources, and TNCH. A fire management plan will be written to cover issues common to all MU areas by a fire management specialist. A Fire Management Unit (FMU) contains a grouping of MUs for which a similar fire management approach may be taken based on geographic proximity, fuel types, fire history and access routes (roads/trails). Fire management plans should assess and address fire threat attributed to both military and non-military ignition sources. The Army currently has a wildland fire crew that is the first response to all wildland fires within the Army training areas and which will also respond to any wildland fire that threatens any of the MIP or OIP MUs both in and out of the action area. Additionally, the Army Natural Resources Program has had approximately 1/3 of the staff trained in wildland fire techniques and will respond to fires and fire mop up in or near the MIP or OIP MUs. All Army Natural Resources fire response will be under the direction of the Army wildland fire crew.

Erosion control
It is important to manage erosion only when *in situ* target taxa are imminently threatened. There are limited erosion management options, but substrate stabilization in localized areas may help lower the risk of harm to target taxa. Additionally, it is expected that control of feral ungulates throughout all of the MUs will significantly reduce erosion in these areas.

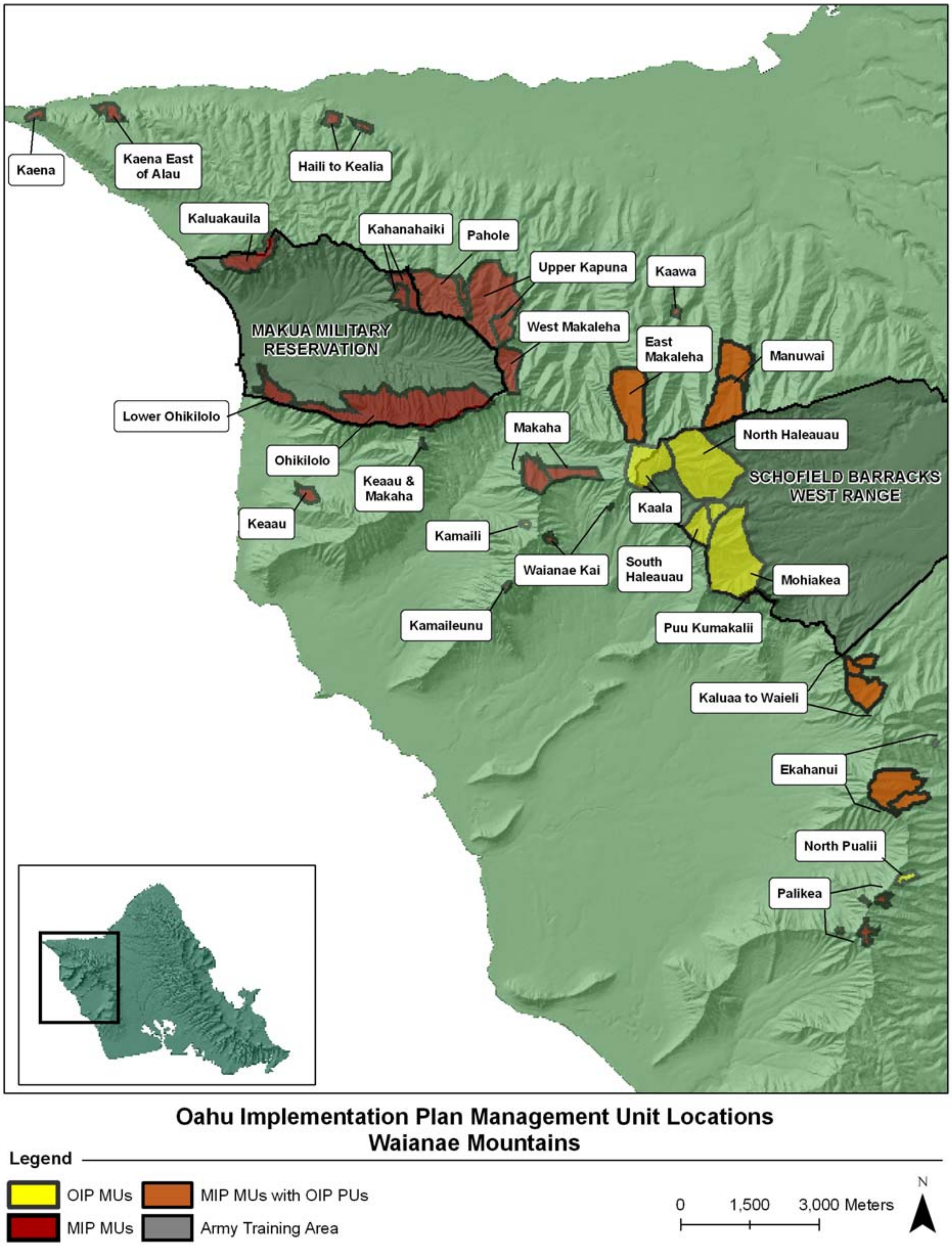


Figure 12.1 Oahu and Makua Management Units in the Waianae Mountain Range.

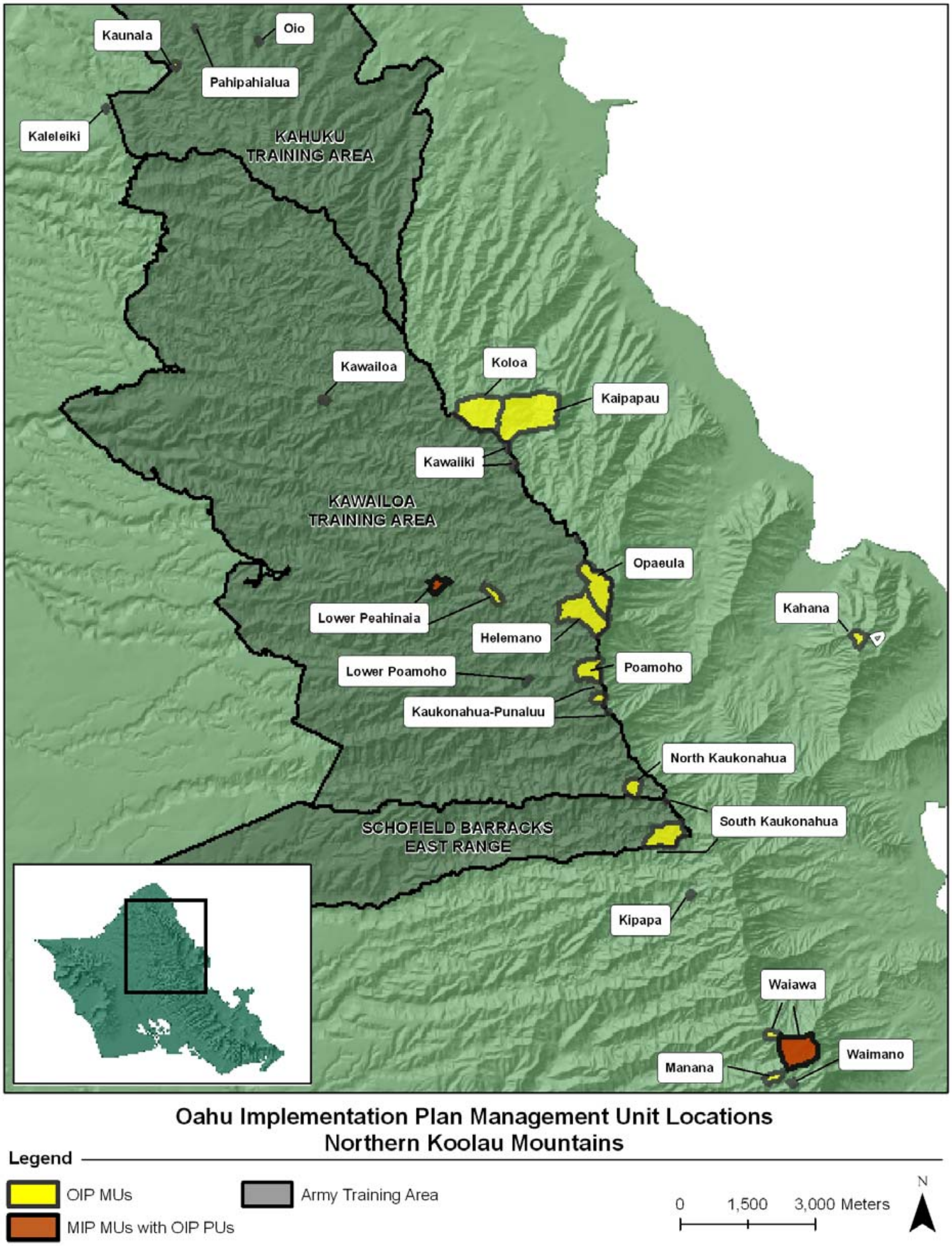


Figure 12.2 Oahu and Makua Management Units in the Northern Koolau Mountain Range.

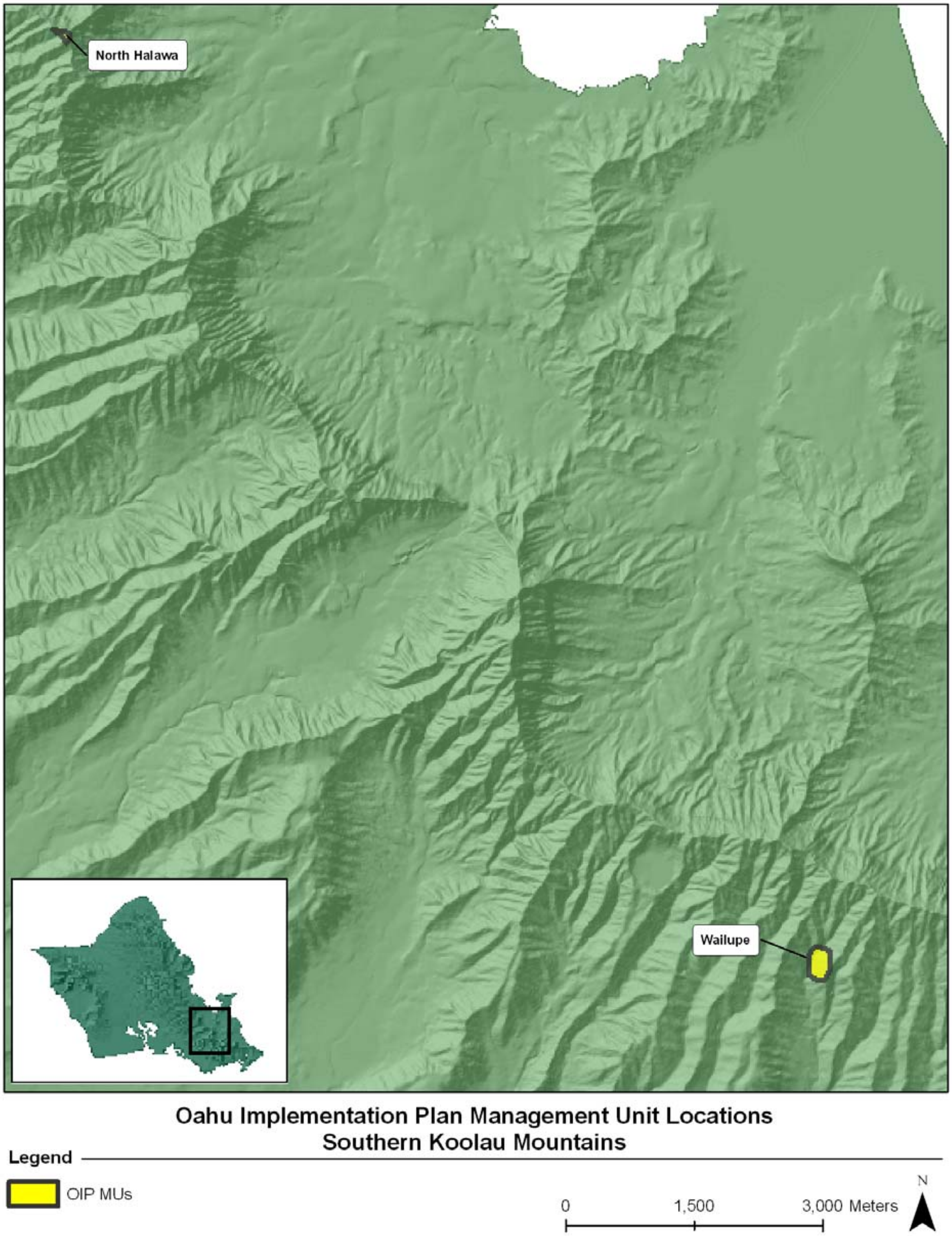


Figure 12.3 Oahu Management Units in the Southern Koolau Mountain Range.

Management Unit Plans

The MUs are presented with individual descriptions and maps in the following sections. The Table below can be found in each MU section and outlines: the MU name and subunits, acreage, a brief description of the topography, Fences planned (perimeter length, and completion status), target taxa PUs to be protected within the MU boundary (manage for stability PUs are in bold and indicate priority tiers) for the OIP, MIP and overlap species, any reintroductions planned are outlined by species, and any other significant rare Hawaiian species that are found within the MU are mentioned. A map of the MU boundary and rare species occurrences follows the table for each MU.

Tier 1:
12.4 Management Unit Summary: Koloa

Management Unit Name/Subunit Name		**Area (acres)**
Koloa (Koolaus, Oahu)		160 acres
Topography	Elevation range 2,000- 2,400 ft.;	
Ownership and acreage	Hawaii Reserves Inc., 160 acres.	
Existing land management	None. Army NRS do rat control on adjacent property.	
Natural communities	Ohia (*Metrosideros*)/ Olapa (*Cheirodendron*) wet native forest. Most of the terrain is moderate, gulches have moderate to steep slopes.	
Fire history	No fire history. There is no fire threat for this area.	
Human uses	Koolau Summit Trail runs along the southern perimeter.	
Fences	**Length (m)**	**Status- Tier 1**
MU perimeter fence	3,360 m	Construct in OIP year 2; 2009; This MU requires a license agreement with the landowner; This MU also requires an EA prior to fence construction.

***In situ* PUs:** species in bold are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

MU Name	**OIP Target Taxa**	**MIP Target Taxa**
Koloa	***Achatinella livida* T2** ***Chamaesyce rockii* T2** ***Cyanea koolauensis* T1** ***Cyrtandra viridiflora* T2** ***Hesperomannia arborescens* T1** ***Huperzia nutans* T1** ***Viola oahuensis* T2**	None

Reintroductions:

MU Name	**OIP Target Taxa**	**MIP Target Taxa**
N/A	***Phyllostegia hirsuta* T1**	None

Other significant Taxa:

Cyanea calycina
Cyanea humboltiana
Joinvillea ascendens subsp. *ascendends*
Zanthoxylum oahuense

Tier 1:
12.1 Management Unit Summary: South Haleauau

Management Unit/Subunit Name	**Area (acres)**
South Haleauau Subunit I (Waianaes, Oahu)	35 acres
South Haleauau Subunit II (Waianaes, Oahu)	88 acres

Topography	Elevation range 3,500-2,200 ft.; windward ridge and gulch systems running up to the Waianae summit crest. Moderate to steep-sided ridge slopes, gentle to moderate gulch bottoms, with steeper slopes near summit.
Ownership and acreage	US Army, 121 acres
Existing land management	Some conservation efforts and survey work by Army Natural Resources Staff. A high level of weed control is needed for this MU due to the high number of manage for stability taxa. Although access may be limited.
Natural communities	Ohia (*Metrosideros*) and Koa (*Acacia koa)* mesic to wet mixed native and introduced forest in the lower elevations; mostly Ohia (*Metrosideros*) native wet forest in the higher elevations.
Fire history	Some fires have occurred near the lower elevations of this MU. Because of the close proximity to the live fire range there is a high threat from fire to this MU.
Human use	Hunting trails

Fences	**Length (m)**	**Status- Tier 1**
Subunit I	1,698 m	This is the highest priority for construction for the OIP. This MU requires an EA.
Subunit II	1,123 m	

***In situ* PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

MU Name	**OIP Target Taxa**	**MIP Target Taxa**
Subunit I	***Chasiempis sandwicensis* subsp. *ibidis* T1** ***Stenogyne kanehoana* T1**	*Achatinella mustelina**
Subunit II	***Drosophila substenoptera*** ***Cyanea acuminata* T1** ***Gardenia mannii* T1** ***Phyllostegia hirsuta* T1** ***Schiedea trinervis* T1**	*Achatinella mustelina**

Reintroductions:

MU Name	**OIP Target Taxa**	**MIP Target Taxa**
Subunit I	None	none
Subunit II	None	

Other important taxa:

Cyanea calycina
Joinvellia ascendens subsp. *ascendens*
Lobelia oahuensis
Melicope christophersenii
Neraudia melastomifolia
Platydesma cornuta var. *decurrens*
Schiedea hookeri
Schiedea pentandra

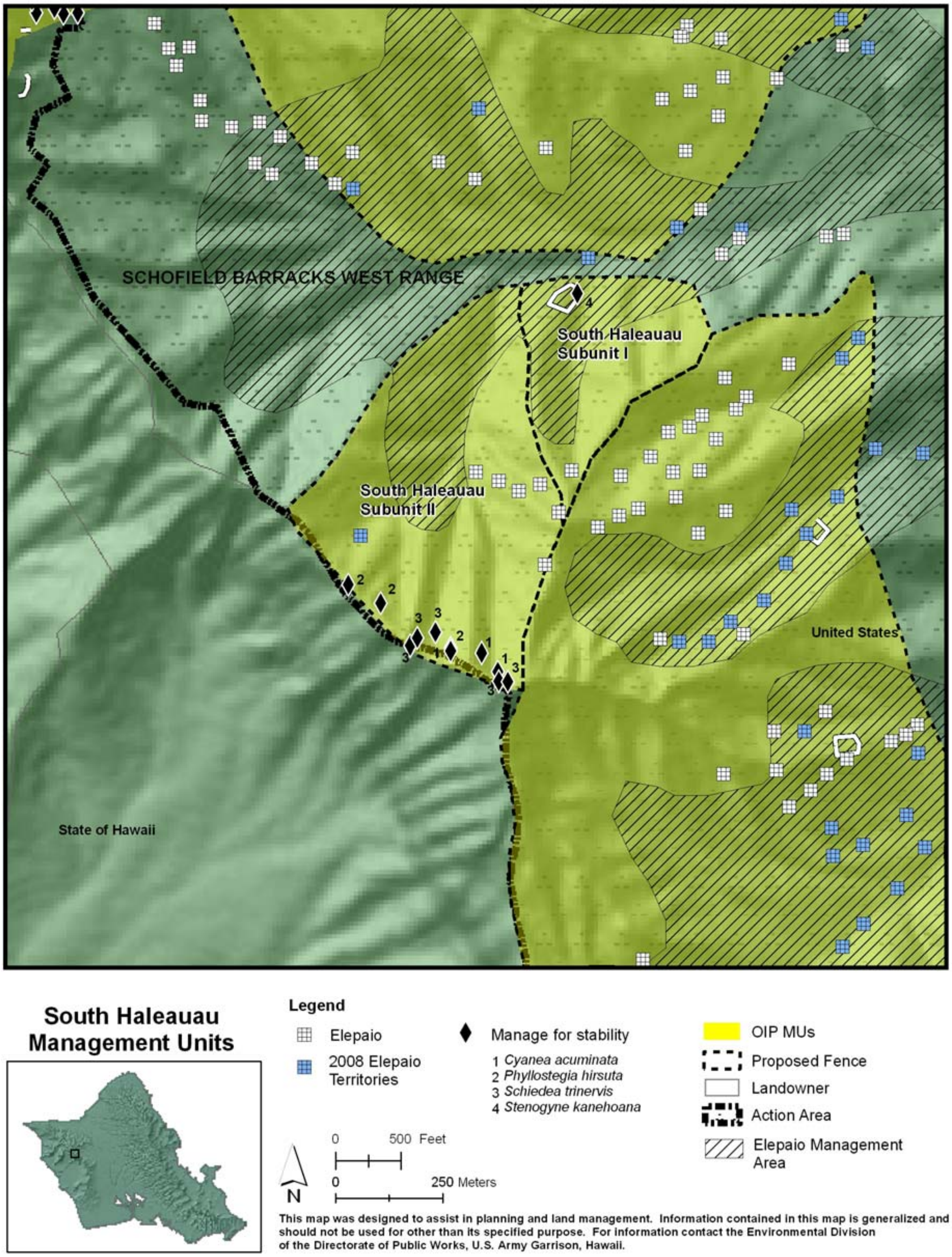


Figure 12.4 Proposed South Haleauau Management Unit in the Central Waianae Mountains, Oahu.

Tier 1:
12.2 Management Unit Summary: North Haleauau

Management Unit/Subunit Name		**Area (acres)**
North Haleauau (Waianaes, Oahu)		425.7 acres
Topography	Elevation range 3,400-2,000 ft.; windward ridge and gulch systems running up to the Kaala summit and northern ridges. Moderate to steep-sided ridges. Slopes gentle to moderate in gulch bottoms with steeper slopes near summit.	
Ownership and acreage	US Army, 425.7 acres	
Existing land management	Some conservation efforts and survey work by Army Natural Resources Staff. Small protective fences already exist within the proposed fence line. A low level of weed control is planned for this MU due to access issues and few manage for stability taxa.	
Natural communities	Ohia (*Metrosideros*) and Koa (*Acacia koa)* mesic to wet mixed native and introduced forest in the lower elevations; mostly Ohia (*Metrosideros*) native wet forest in the higher elevations.	
Fire history/Safety	Some fires have occurred near the lower elevations of this MU. Because of the close proximity to the live fire range there is a high fire threat to this MU.	
Human use	Hunting trails	
Fences	**Length (m)**	**Status- Tier 1**
MU perimeter fence	5,259 m	To be constructed in OIP year 2. This MU requires an EA.

***In situ* PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

MU Name	**OIP Target Taxa**	**MIP Target Taxa**
North Haleauau	***Chasiempis sandwicensis* subsp. *ibidis* T1** ***Gardenia mannii* T1** ***Labordia cyrtandrae* T1**	*Achatinella mustelina** *Alectryon macrococcus* var. *macrococcus** *Hesperomannia arbuscula**

Other important taxa:

Cyanea calycina *Eurya sandwicensis* *Labordia kaalae* *Nothocestrum longifolium* *Sicyos lanceoloidea*

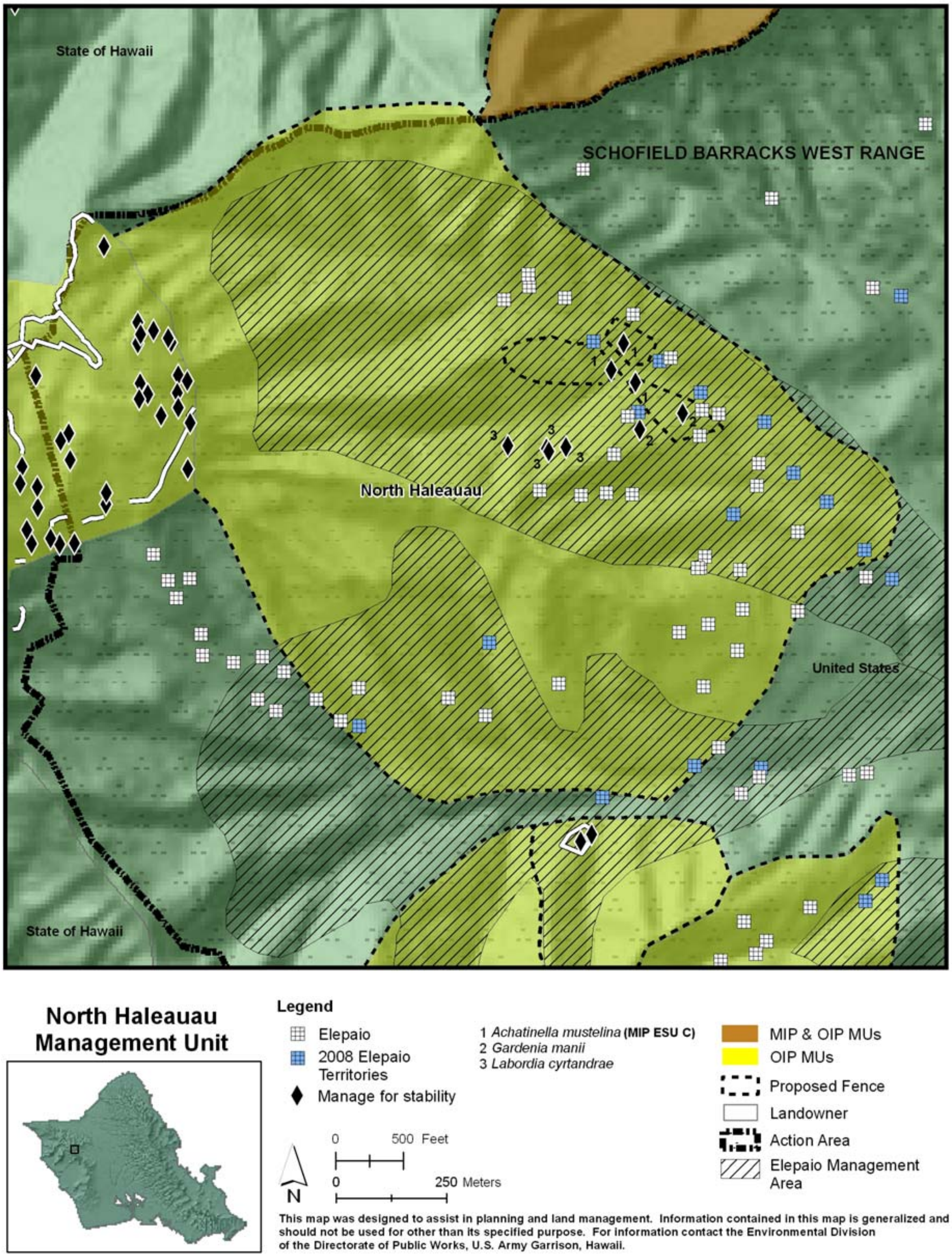


Figure 12.5 Proposed North Haleauau Management Unit in the Central Waianae Mountains, Oahu.

Tier 1:
12.3 Management Unit Summary: Mohiakea

Management Unit/Subunit Name			**Area (acres)**
Mohiakea (Waianaes, Oahu)			425.9 acres
Topography	Elevation range 2,860-2,000 ft.; windward ridge and gulch systems running up to the Waianae summit crest. Moderate to steep-sided ridge slopes, gentle to moderate gulch bottoms, with steeper slopes near summit.		
Ownership and acreage	US Army, 425.9 acres		
Existing land management	Some conservation efforts and survey work by Army Natural Resources Staff. A low level of weed control is planned for this MU due to limited access.		
Natural communities	Ohia (*Metrosideros*) and Koa (*Acacia koa)* mesic to wet mixed native and introduced forest in the lower elevations; mostly Ohia (*Metrosideros*) native wet forest in the higher elevations.		
Fire history	Some fires have occurred near the lower elevations of this MU. Because of the close proximity to the live fire range there is a high fire threat from fire to this MU.		
Human use	Hunting trails		
Fences		**Length (m)**	**Status- Tier 1**
MU perimeter fence		5,620 m (1,000 m shared with South Haleauau)	To be constructed in OIP year 3. This MU requires an EA.

***In situ* PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

MU Name	**OIP Target Taxa**	**MIP Target Taxa**
Mohiakea	***Chasiempis sandwicensis* subsp. *ibidis* T1** ***Phyllostegia hirsuta* T1** ***Phyllostegia mollis* T1** ***Labordia cyrtandrae* T1**	*Achatinella mustelina** *Alectryon macrococcus* var. *macrococcus** *Delissea subcordata** ***Plantago princeps* var. *princeps**** *Schiedea kaalae** ***Tetramalopium filiforme****

Other important taxa:

Dubautia sherfiana	*Neraudia melastomifolia*
Exocarpus gaudichaudii	*Schiedea hookeri*
Lepidium arbuscula	*Schiedea pentandra*
Lobelia oahuensis	*Sicyos lanceoloidea*
Lobelia hypoleuca	*Platydesma cornuta* var. *decurrens*
Melicope cinera	*Pteralyxia macrocarpus*

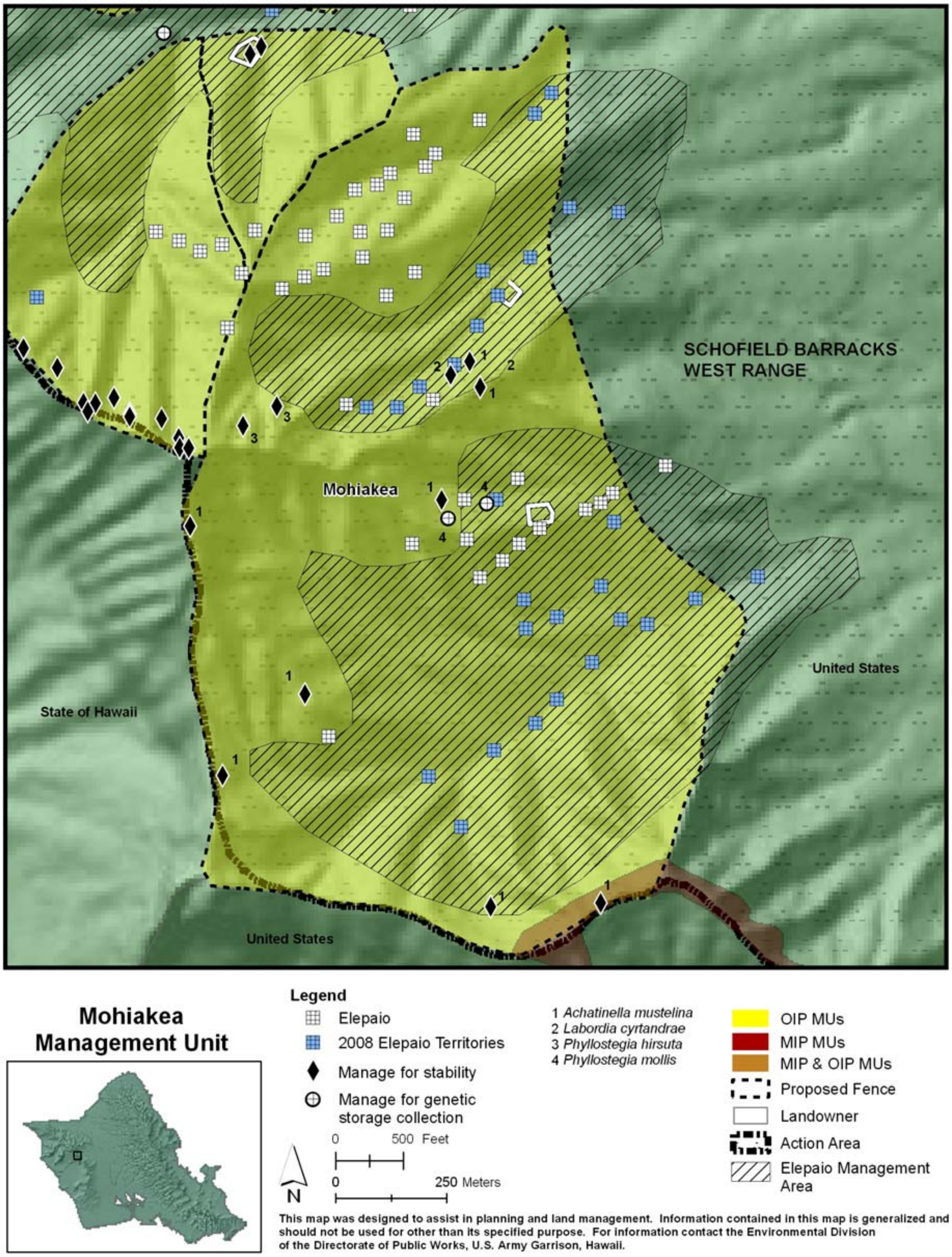


Figure 12.6 Proposed Mohiakea Management Unit in the Central Waianae Mountains, Oahu.

Tier 1:
12.4 Management Unit Summary: Koloa

Management Unit Name/Subunit Name		**Area (acres)**
Koloa (Koolaus, Oahu)		160 acres
Topography	Elevation range 2,000- 2,400 ft.;	
Ownership and acreage	Hawaii Reserves Inc., 160 acres.	
Existing land management	None. Army NRS do rat control on adjacent property. A moderate amount of weed control will be done in this MU.	
Natural communities	Ohia (*Metrosideros*)/ Olapa (*Cheirodendron*) wet native forest. Most of the terrain is moderate, gulches have moderate to steep slopes.	
Fire history	No fire history. There a very low fire threat for this area.	
Human uses	Koolau Summit Trail runs along the southern perimeter.	
Fences	**Length (m)**	**Status- Tier 1**
MU perimeter fence	3,360 m	Construct in OIP year 2; 2009; This MU requires a license agreement with the landowner; This MU also requires an EA prior to fence construction.

***In situ* PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

Subunit	**OIP Target Taxa**	**MIP Target Taxa**
N/A	***Achatinella livida* T2** ***Chamaesyce rockii* T2** ***Cyanea koolauensis* T1** ***Cyrtandra viridiflora* T2** ***Hesperomannia arborescens* T1** ***Huperzia nutans* T1** ***Viola oahuensis* T2**	None

Reintroductions:

Subunit	**OIP Target Taxa**	**MIP Target Taxa**
N/A	***Phyllostegia hirsuta* T1**	None

Other significant Taxa:

Cyanea calycina *Cyanea humboltiana* *Joinvillea ascendens* subsp. *ascendens* *Zanthoxylum oahuense*

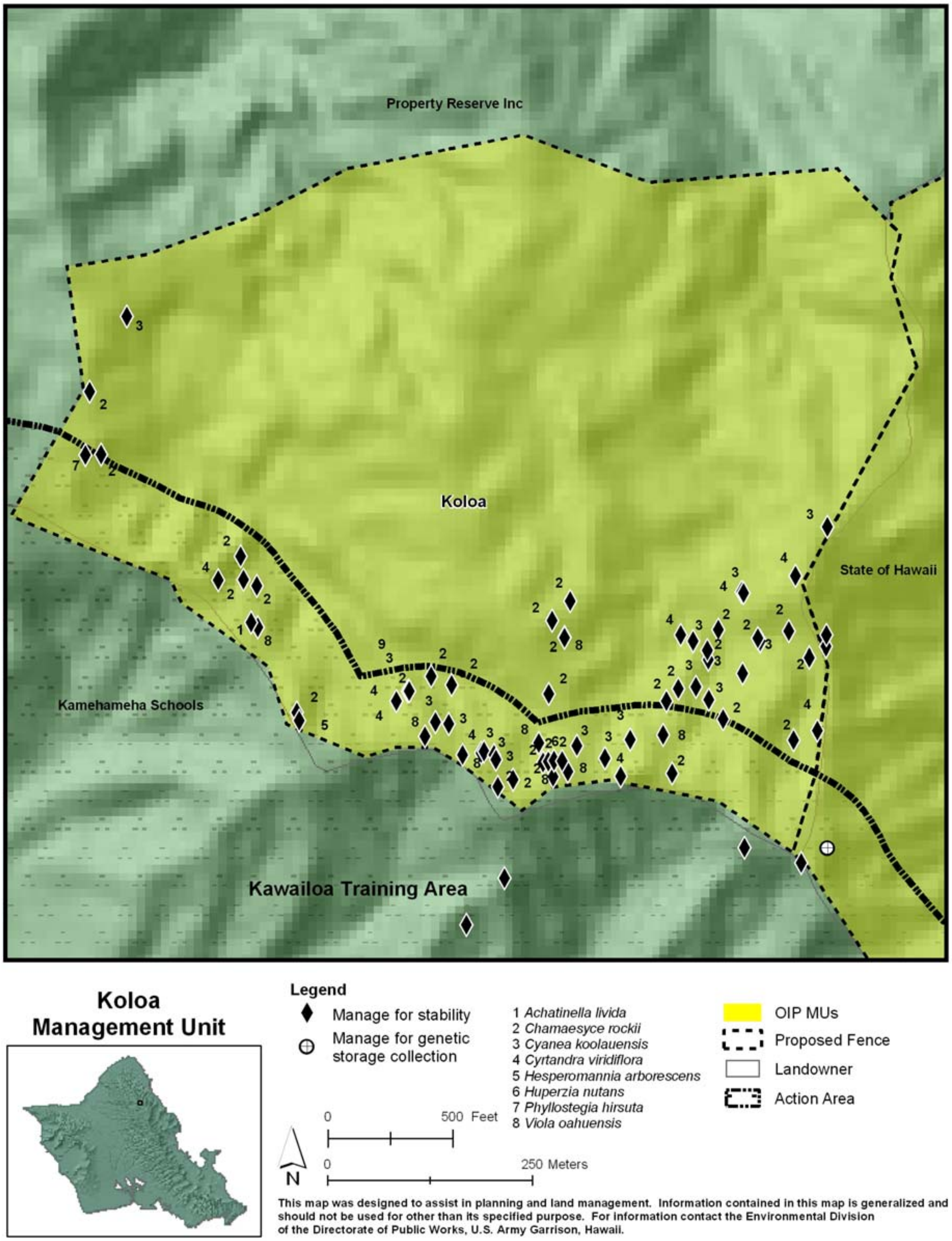


Figure 12.7 Proposed Koloa Management Unit in the Koolau Mountains, Oahu.

Tier 1:
12.5 Management Unit Summary: Kaipapau

Management Unit Name/Subunit Name		**Area (acres)**
Kaipapau subunit I (Koolaus, Oahu)		272 acres
Kaipapau subunit II (Koolaus, Oahu		4 acres
Kaipapau subunit III (Koolaus, Oahu		5.2 acres
Topography	Elevation range 1,000- 2,600 ft.;	
Ownership and acreage	State of Hawaii; Kaipapau Forest Reserve; 272 acres; Kamehameha Schools (Army Leased Kawailoa Training Area) 9.2 acres	
Existing land management	Army currently conducts rat control and rare plant/snail monitoring in subunits I and II. No existing fences. A moderate level of weed control is planned for this MU.	
Natural communities	Ohia (*Metrosideros*)/ Olapa (*Cheirodendron*) wet native forest. Most of the terrain steep slopes and ridges.	
Fire history	No fire history. Small fire burned on Laie Trail in 2008 approximately 2,400 meters to the north. There is a very low fire threat to this MU.	
Human uses	Koolau Summit Trail runs along the southern perimeter.	
Fences	**Length (m)**	**Status- Tier 1**
MU perimeter fence	4,405 m	Construct in OIP year 5; 2012; This MU requires a license agreement with the landowner; This MU also requires an EA prior to fence construction.

***In situ* PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1)

Subunit	**OIP Target Taxa**	**MIP Target Taxa**
Kaipapau I	***Chamaesyce rockii* T2** ***Cyanea acuminata* T1** ***Cyanea koolauensis* T1** *Gardenia mannii* ***Hesperomannia arborescens* T1** ***Huperzia nutans* T1** ***Phyllostegia hirsuta* T1**	*Schiedea kaalae** (historical)
Kaipapau II	***Achatinella livida* T2** ***Cyanea crispa* T2**	
Kaipapau III	***Achatinella livida* T2** ***Cyanea crispa* T2**	None

Reintroductions:

Subunit	**OIP Target Taxa**	**MIP Target Taxa**
N/A	N/A	N/A

Other significant Taxa:

Hedyotis fluviatilis *Pteralyxia macrocarpa* *Megalagrion oceanicum*

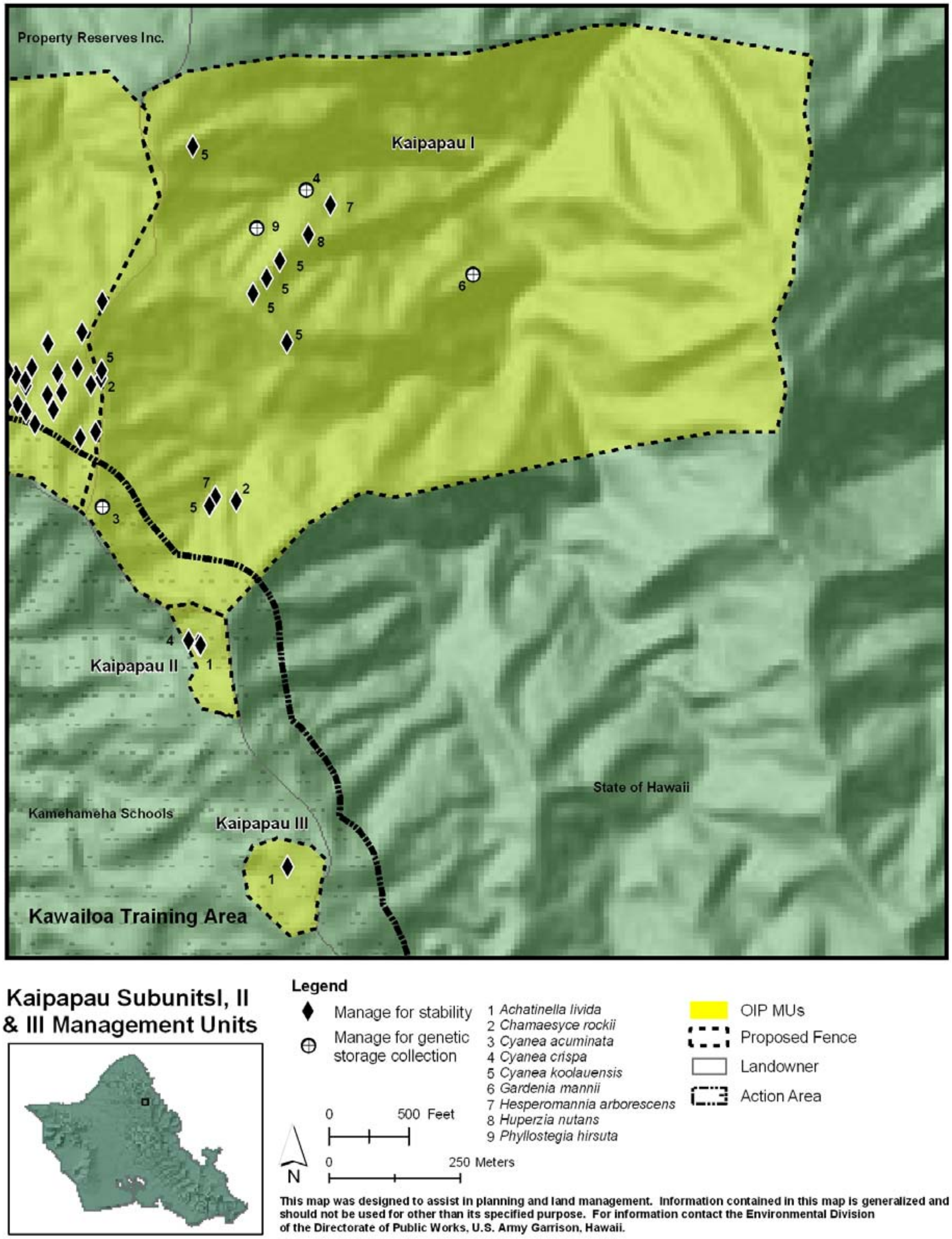


Figure 12.8 Proposed Kaipapau Management Unit in the Northern Koolau Mountains, Oahu.

Tier 1
12.6 Management Unit Summary: South Kaukonahua

Management Unit Name/Subunit Name		**Area (acres)**
South Kaukonahua (Koolaus, Oahu) Subunit I		93.5 acres
South Kaukonahua (Koolaus, Oahu) Subunit II		0.95 acres
Topography	Elevation range 1,800-2,400 ft.; moderate to steep gulches, encompassing the headwaters of both of north and south forks of South Kaukonahua stream.	
Ownership and acreage	United States of America; 94.45 acres	
Existing land management	Biological surveys and monitoring by Army Natural Resources Staff. There is a moderate level of weed control planned for this MU.	
Natural communities	Ohia (*Metrosideros*), Olapa (*Cheirodendron*) wet mixed native forest and windswept mixed shrubland along the summit areas.	
Fire history	No significant fire history; The Oahu Biological Assessment states there is no fire threat for the summit areas and low fire risk for areas below the summit. Overall there is a very low fire threat for this MU.	
Human use	Koolau Summit Trail follows the summit crestline.	
Fences	**Length (m)**	**Status**
Subunit I	2704 m	Tier 1, Construct in OIP year 6; 2013 This MU requires an EA.
Subunit II	253 m	Tier 2, Construct in OIP year 8; 2015 This MU requires an EA.

***In situ* PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

MU Name	**OIP Target Taxa**	**MIP Target Taxa**
South Kaukonahua Subunit I	***Achatinella byronii/decipiens*** ***Cyanea acuminata* (T1)** ***Cyanea koolauensis* T1** ***Cyrtandra viridiflora* T2** ***Cyrtandra subumbellata* (T3)** *Gardenia mannii* ***Hesperomannia arborescens* T1** ***Huperzia nutans* T1** ***Lobelia gaudichaudii* subsp. *koolauensis* T3** *Phyllostegia hirsuta* ***Viola oahuensis* T2**	None
South Kaukonahua Subunit II	***Sanicula purpurea* T2**	None

Reintroductions:

N/A

Other Significant Taxa In or Near the MU:

Isodendrion longifolium	*Platydesma cornuta* var. *cornuta*
Joivellea ascendens subsp. *ascendens*	*Zanthoxylum oahuense*
Labordia hosakana	

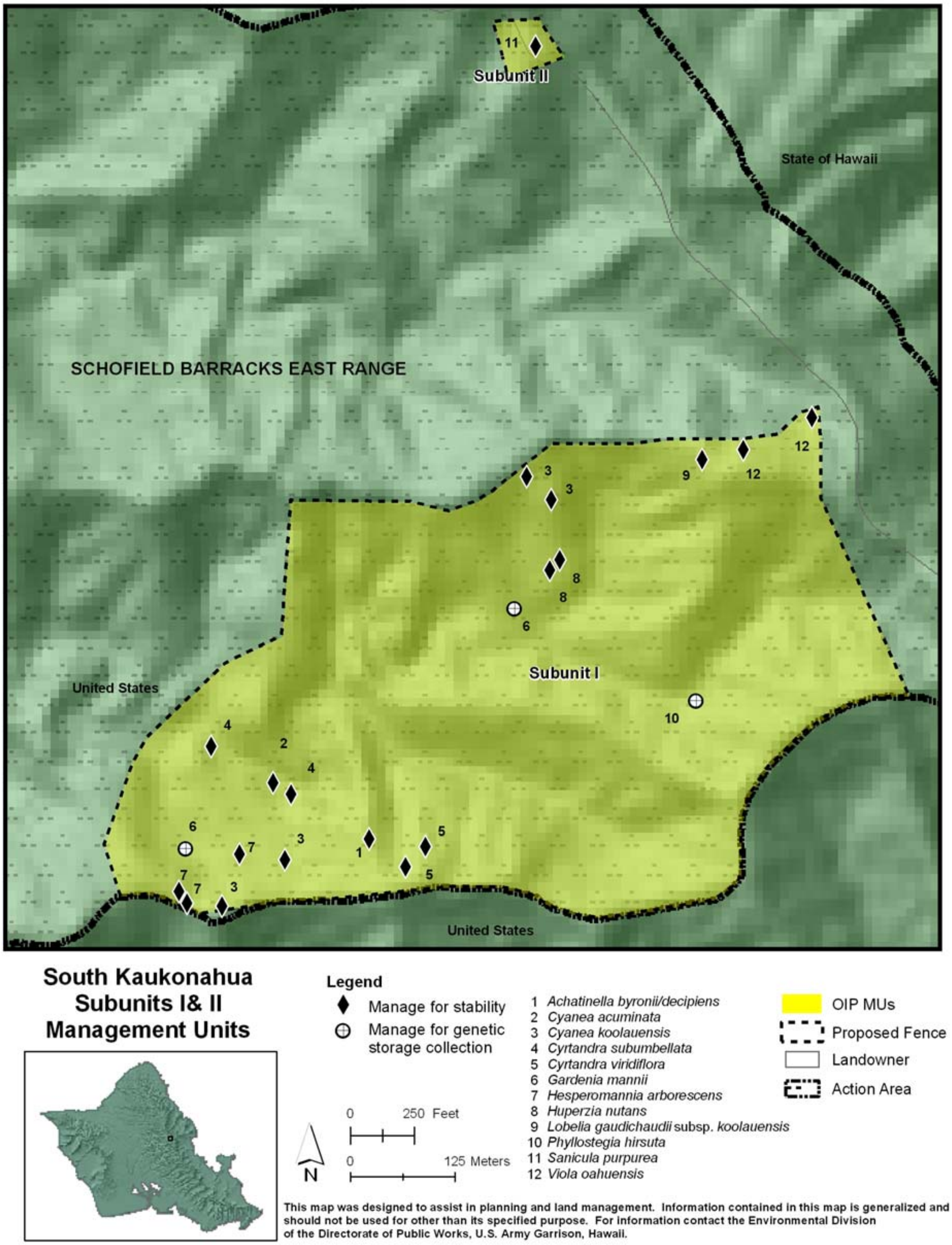


Figure 12.9 Proposed South Kaukonahua Management Unit in the Northern Koolaus, Oahu.

Tier 1
12.7 Management Unit Summary: North Kaukonahua

Management Unit Name/Subunit Name		**Area (acres)**
North Kaukonahua (Koolaus, Oahu)		30.4 acres
Topography	Elevation range 1,850 to 2,100 ft.; Moderate to steep sided gulch and ridge systems near the summit of North Kaukonahua Valley.	
Ownership and acreage	State of Hawaii; 30.4 acres	
Existing land management	Army NRS monitor rare plants and snails periodically. There is a moderate level of weed control planned for this MU.	
Natural communities	Ohia (*Metrosideros*), Olapa (*Cheirodendron*), and Uluhe (*Dicranopteris*) wet native forest.	
Fire history	No significant fire history. The fire threat for this area is considered very low.	
Human use	Restricted military training area, Schofield-Waikane hiking trail runs along the MUs Southern Boundary, unauthorized hunting.	
Fences	**Length (m)**	**Status-Tier 1**
MU boundary fences	1,362 m	Construct in OIP year 9 This MU requires a license agreement with the State; This MU also requires an EA.

***In situ* PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

Subunit	OIP Target Taxa	MIP Target Taxa
N/A	***Achatinella byronii/decipiens* T2** *Chamaesyce rockii* *Cyanea koolauensis* ***Hesperomannia arborescens* T1** ***Huperzia nutans* T1** ***Pteris lydgatei* T1** *Viola oahuensis*	None

Reintroductions

N/A

Other Significant Taxa

Doodia lyonii *Joinvillea ascendens* subsp. *ascendens* *Melicope hiiakae*

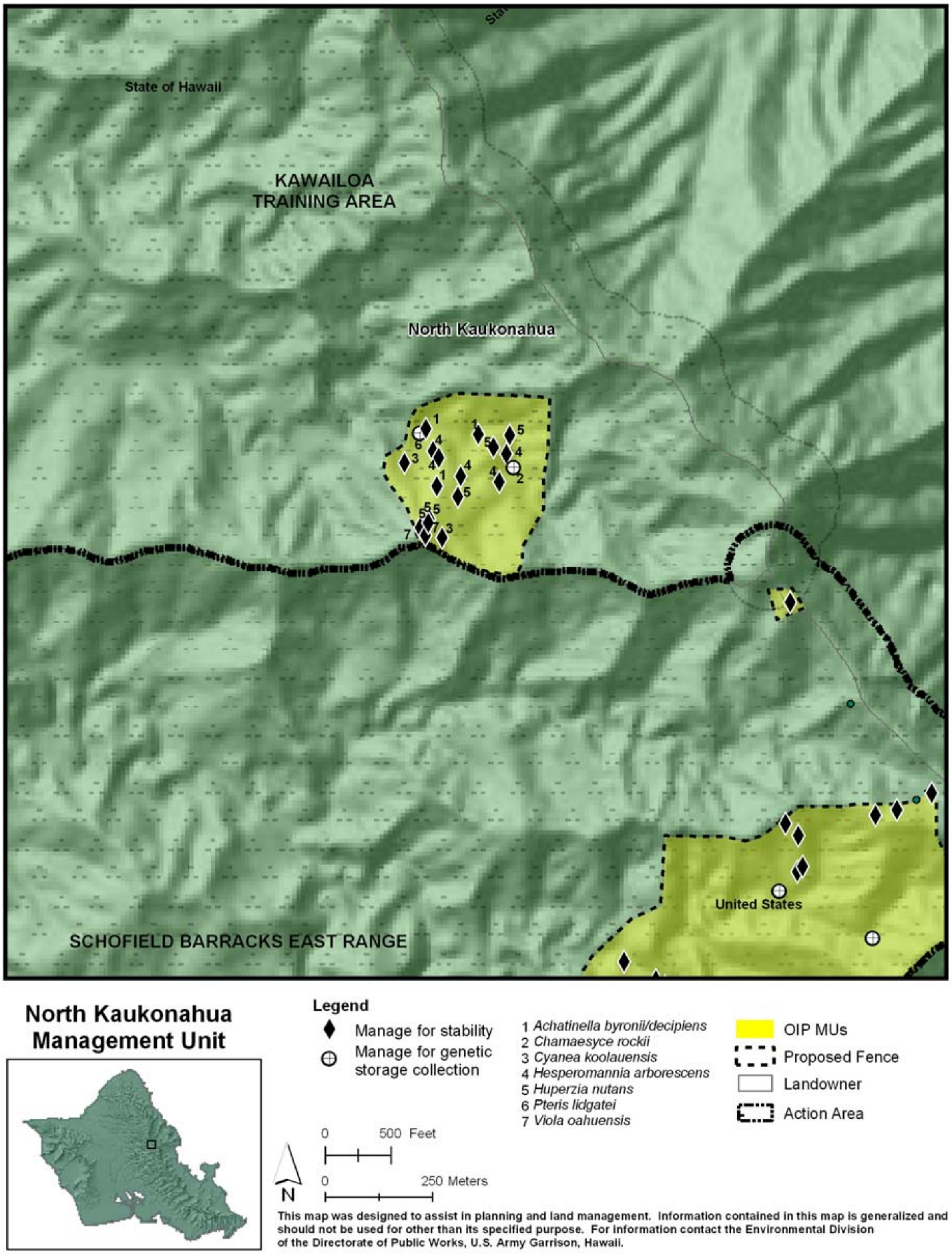


Figure 12.10 Proposed North Kaukonahua Management Unit in the Northern Koolau Mountains, Oahu.

Tier 1
12.8 Management Unit Summary: Kamaili

Management Unit Name/Subunit Name		**Area (acres)**
Kamaili (Waianaes, Oahu)		2.1 acres
Topography	Elevation range 1,500-1,800 ft.; rocky ridge and cliff face. Bottom of fence ties into cliff face.	
Ownership and acreage	Board of Water Supply, City and County of Honolulu; 2.1 acres	
Existing land management	None. There is a high level of weed control planned for this small MU.	
Natural communities	Mixed mesic alien forest and shrubland, some patches of native dominated areas. The bottom of this fence ties into a steep cliff face, the rest of the fenceline has moderate to steep and rocky slopes.	
Fire history	Close to Waianae Kai and lower Makaha Valley where there has been a significant fire history. There is a high fire threat for this MU.	
Human use	Hunting and hiking trails below the cliff area. Area around MU rarely visited.	
Fences	**Length (m)**	**Status- Tier 1**
Subunit I	2,890 m	MIP year 0
Subunit II	2,480 m	MIP year 5
Subunit III	417 m	Construct in OIP year 6; This MU requires an updated MOU with the landowner, BWS This MU also requires and EA.

***In situ* PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

MU Name	**OIP Target Taxa**	**MIP Target Taxa**
Kamaili	***Abutilon sandwicense* T1**	*Flueggea neowawraea**

Reintroductions:

N/A

Other Significant Taxa:

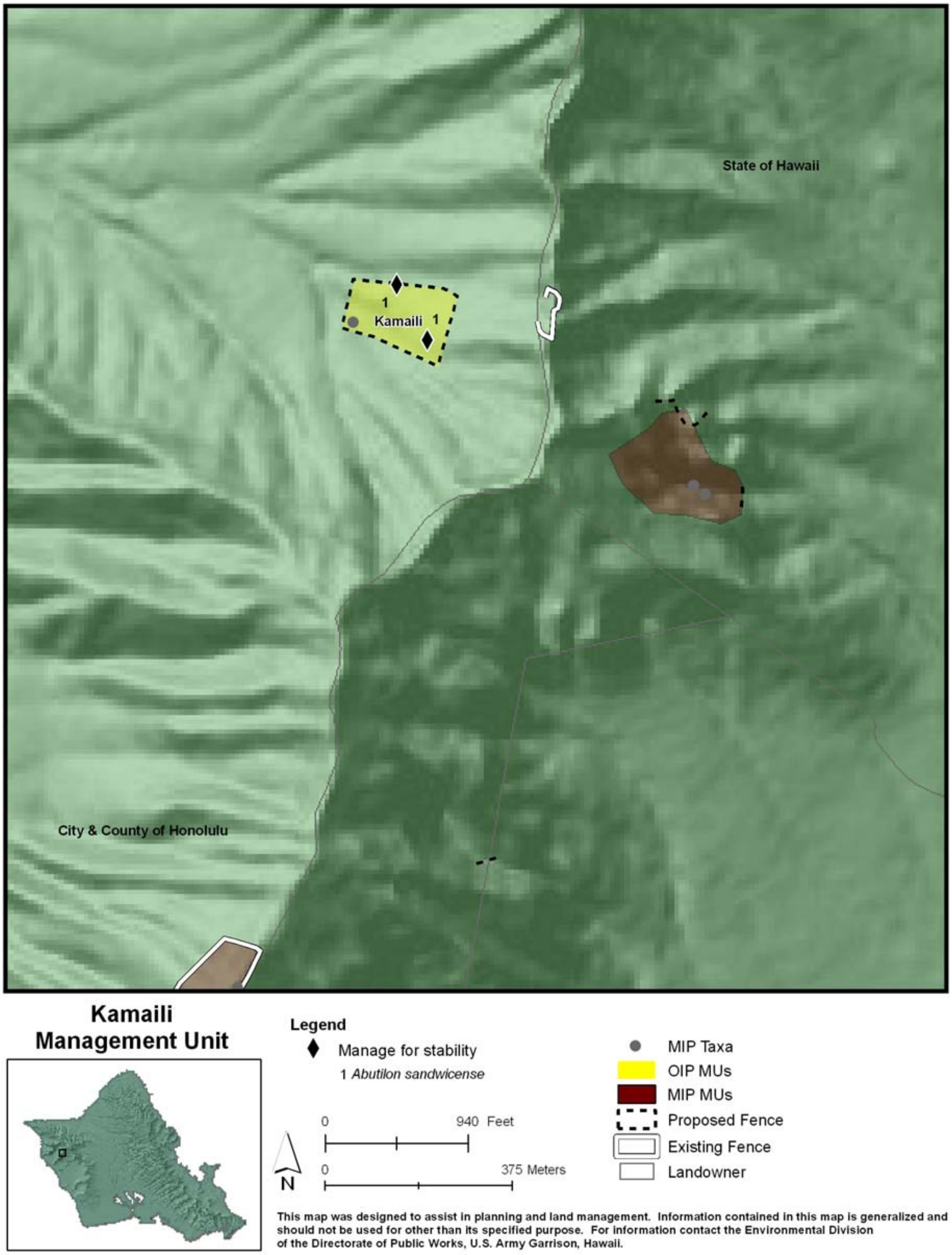


Figure 12.11 Proposed Kamaili Management Unit in the Central Waianae Mountains, Oahu.

Tier 1
12.9 Management Unit Summary: Manana

Management Unit Name/Subunit Name		**Area (acres)**
Manana (Koolaus, Oahu)		18.1 acres
Topography	Elevation range 1,950-2,200 ft.; moderate to steep-sided gulch, MU encompasses headwaters of Manana Valley Stream.	
Ownership and acreage	Manana Valley Farm	
Existing land management	None. Waiawa subunits I & II, in close proximity, will be actively managed by Army NRS. There is a low level of weed control planned for this MU.	
Natural communities	Ohia (*Metrosideros*)/Koa (*Acacia koa*)/ Uluhe (*Dicranopteris*) wet forest and shrubland. Moderate to steep slopes along the fenceline.	
Fire history	No significant fire history. Fire threat for this area is considered very low to none.	
Human use	Manana hiking trail on the southern boundary of the MU. However, the gulch where the fence is located is very rarely visited.	
Fences	**Length (m)**	**Status- Tier 1**
MU perimeter fence	1,155 m	Construct in OIP year 5 This MU requires a license agreement with the State; This MU also requires an EA.

***In situ* PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

Subunit	**OIP Target Taxa**	**MIP Target Taxa**
N/A	***Labordia cyrtandrae* T1** *Lobelia gaudichaudii* subsp. *koolauensis*	None

Reintroductions

N/A

Other Significant Taxa

Tetraplasandra gymnocarpa

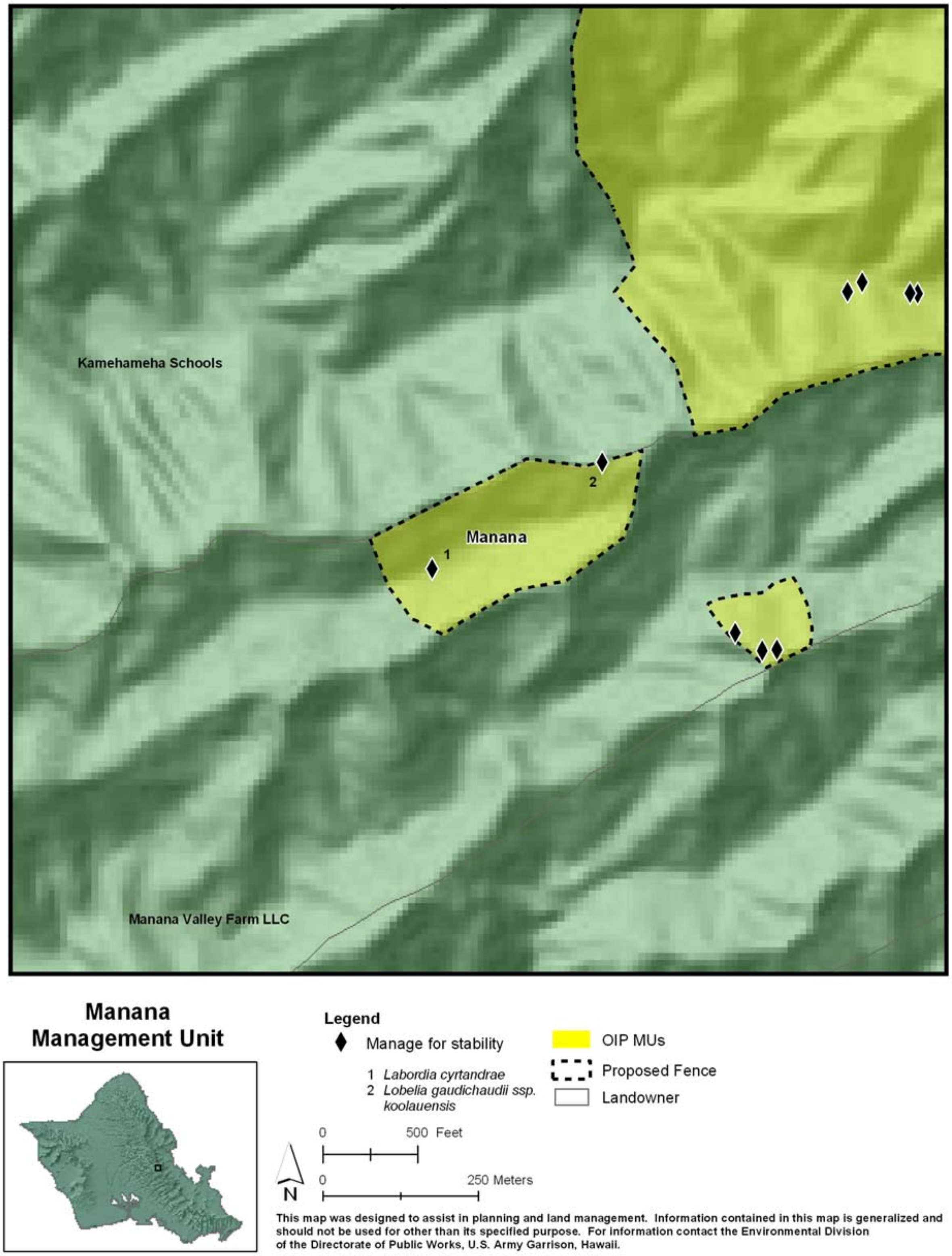


Figure 12.12 Proposed Manana Management Unit in the Central Koolau Mountains, Oahu.

Tier 1
12.9 Management Unit Summary: Waimano

Management Unit Name/Subunit Name		**Area (acres)**
North Waimano (Koolaus, Oahu)		3.6 acres
Topography	Elevation range 2,600-2,700 ft.; moderate sloping terrain.	
Ownership and acreage	State of Hawaii	
Existing land management	None. There is a low level of weed control planned for this MU.	
Natural communities	Windswept mixed wet shrubland; Dominated by Ohia (*Metrosideros*), Manono (*Hedyotis*), and *Axonopus fissifolius*. The fenceline follows relatively moderate terrain from the ridge crest to the gulch bottom.	
Fire history	No significant fire history. Very wet and remote site; there is a very low fire threat for this MU.	
Human use	Hiking trail along the summit area and along the Manana trail one ridge to the north. This ridge is rarely visited.	
Fences	**Length (m)**	**Status- Tier 1**
MU perimeter fence	483 m	Construct in OIP year 1, 2008. This MU requires a license agreement with the State;

***In situ* PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

MU Name	OIP Target Taxa	MIP Target Taxa
N/A	***Cyanea st.-johnii* T1** *Lobelia gaudichaudii* subsp. *koolauensis*	None

Reintroductions

N/A

Other Significant Taxa

N/A

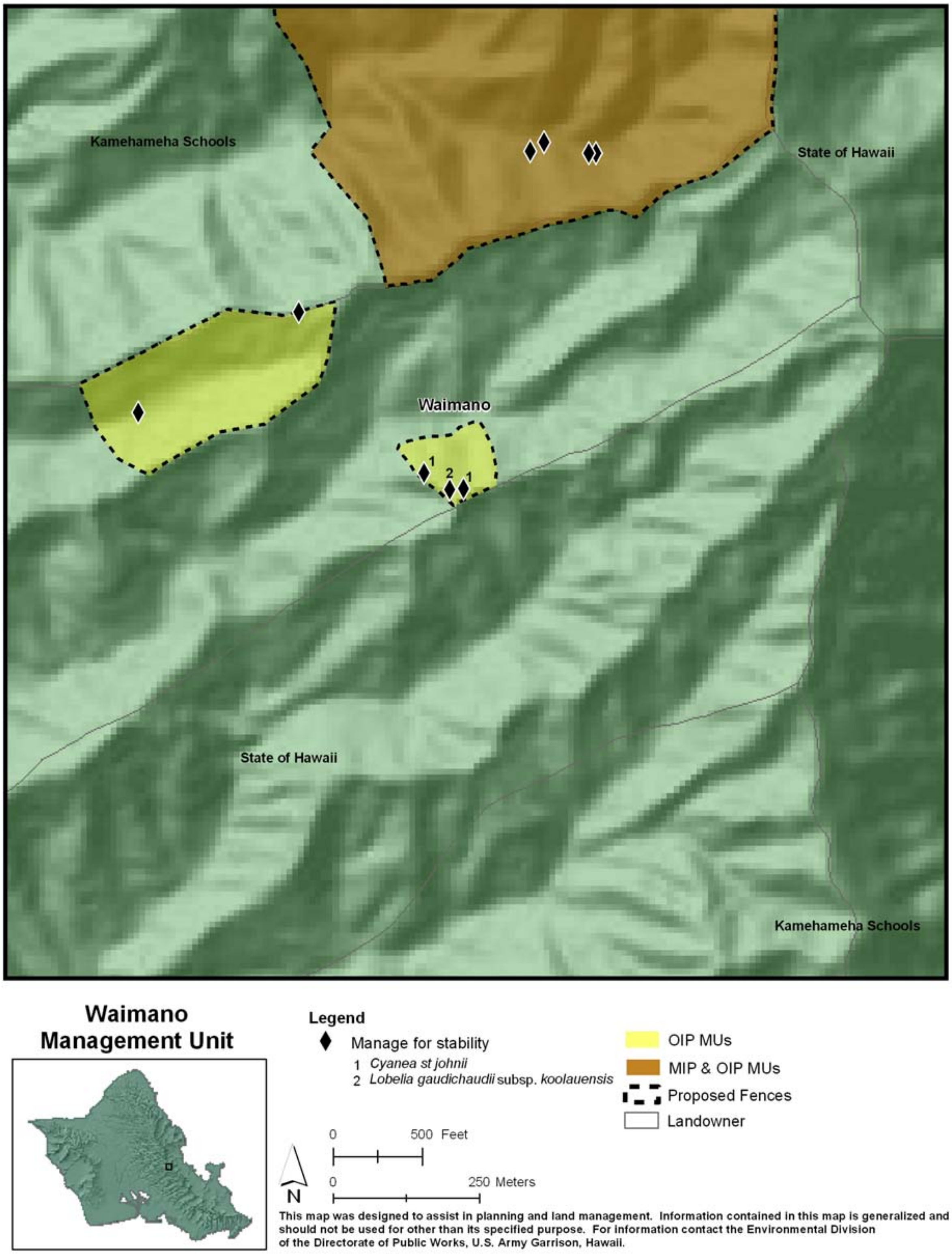


Figure 12.13 Proposed Waimano Management Unit in the Central Koolau Mountains, Oahu.

Tier 1
12.10 Management Unit Summary: Kawailoa

Management Unit Name/Subunit Name		**Area (acres)**
Kawailoa		6.5
Topography	Elevation range 2,400–2,600; northern end of the Koolau Mountains, on and near the summit crest. Moderate slopes and ridges.	
Ownership and acreage	Kamehameha Schools, US Army lease	
Existing land management	Surveys and monitoring, managed by Army Natural Resources Staff. There is a low level of weed control planned for this MU.	
Natural communities	Ohia (*Metrosideros*) wet native forest.	
Fire history	No fire history. There is a very low fire threat for this MU.	
Human use	Koolau Summit Trail runs just above proposed MU boundaries.	
Fences	**Length (m)**	**Status –Tier 1**
	641 m	This fence requires a license agreement with the landowner, Kamehameha Schools. This fence also requires an EA.

***In situ* PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

MU Name	**OIP Target Taxa**	**MIP Target Taxa**
N/A	***Melicope lydgatei* T1**	None

Reintroductions

Subunit	OIP Target Taxa	MIP Target Taxa
N/A	None	None

Other significant Taxa

Gardenia mannii

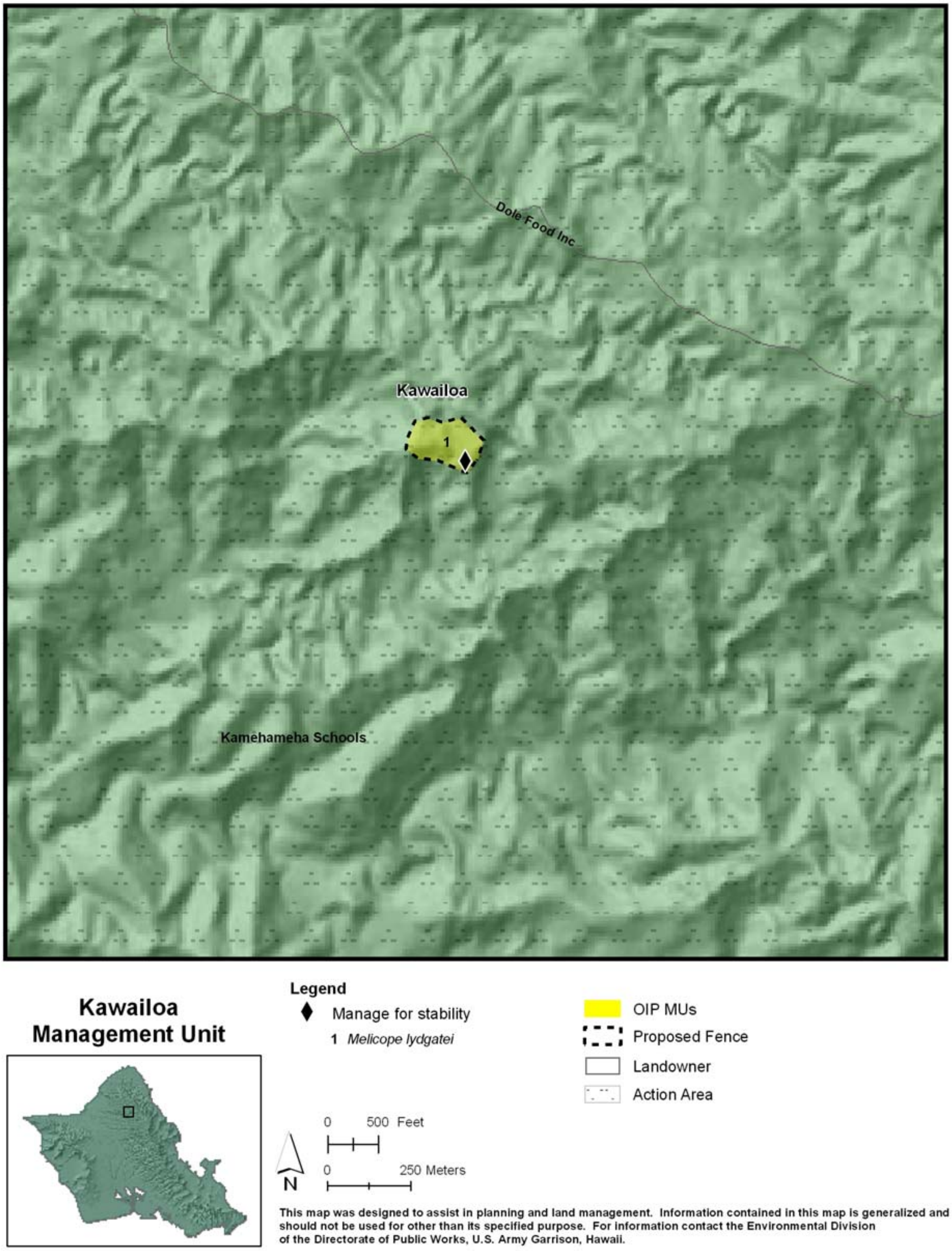


Figure 12.14 Proposed Kawailoa Management Unit in the Northern Koolau Mountains, Oahu.

Tier 1 and 2
12.12 Management Unit Summary: Poamoho

Management Unit Name/Subunit Name		**Area (acres)**
Poamoho I (Koolaus, Oahu) Tier 1		60.2 acres
Poamoho II (Koolaus, Oahu) Tier 2		17.8
Poamoho III (Koolaus, Oahu) Tier 2		1.3
Topography	Elevation range 2,200-2,600 ft.; Summit and headwaters of the south fork of Helemano stream, and the summit area above the North fork of North Kaukonahua stream, Koolau Mountains, moderate to steep gulch slopes and windswept summit areas.	
Ownership and acreage	Kamehameha Schools or State of Hawaii; U.S. Army lease	
Existing land management	Periodic natural resource management by Army Natural Resources Staff. There is a low level of weed control planned for this MU.	
Natural communities	Ohia/Olapa (*Metrosideros/Cheirodendron*) wet native forest; mixed native windswept shrubland along the summit.	
Fire history	No significant fire history, the Oahu Biological Assessment states there is no fire threat for areas along the summit within the action area of the Koolau Mountains inside the action area. There is a very low fire threat for this MU.	
Human use	Poamoho and Koolau Summit Trails, infrequent unauthorized hunting.	
Fences	**Length (m)**	**Status- Tier 1 and 2**
Subunit I (Poamoho Trail)	2223 m	**Tier 1:**Construct in OIP year 3 This MU requires a license agreement with the State; This MU also requires an EA.
Subunit II (Poamoho Pond)	1053 m	**Tier 2:** This subunit requires a license agreement with the State; This subunit also requires an EA.
Subunit III (Puu Pauao)	291 m	**Tier 2:** This subunit requires a license agreement with the State; This subunit also requires an EA.

***In situ* PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

MU Name	**OIP Target Taxa**	**MIP Target Taxa**
Poamoho Subunit I	***Achatinella byronii/decipiens* T2** ***Achatinella lila* T2** ***Achatinella sowerbyana* T2** ***Cyanea acuminata* T1** *Phyllostegia hirsuta* ***Sanicula purpurea* T2**	None
Poamoho Subunit II	***Achatinella byronii* T2** ***Achatinella sowerbyana* T2** *Phyllostegia hirsuta*	None
Poamoho Subunit III	*Cyanea st.-johnii* ***Sanicula purpurea* T2**	None

Reintroductions:

N/A

Other Significant Taxa:

Cyanea humboldtiana *Joinvillea ascendens* subsp. *ascendens* *Megalagrion nigrohamatum* var. *nigrolineatum*	*Platydesma cornuta* var. *cornuta* *Zanthoxylum oahuensis* *Viola kauaiensis*

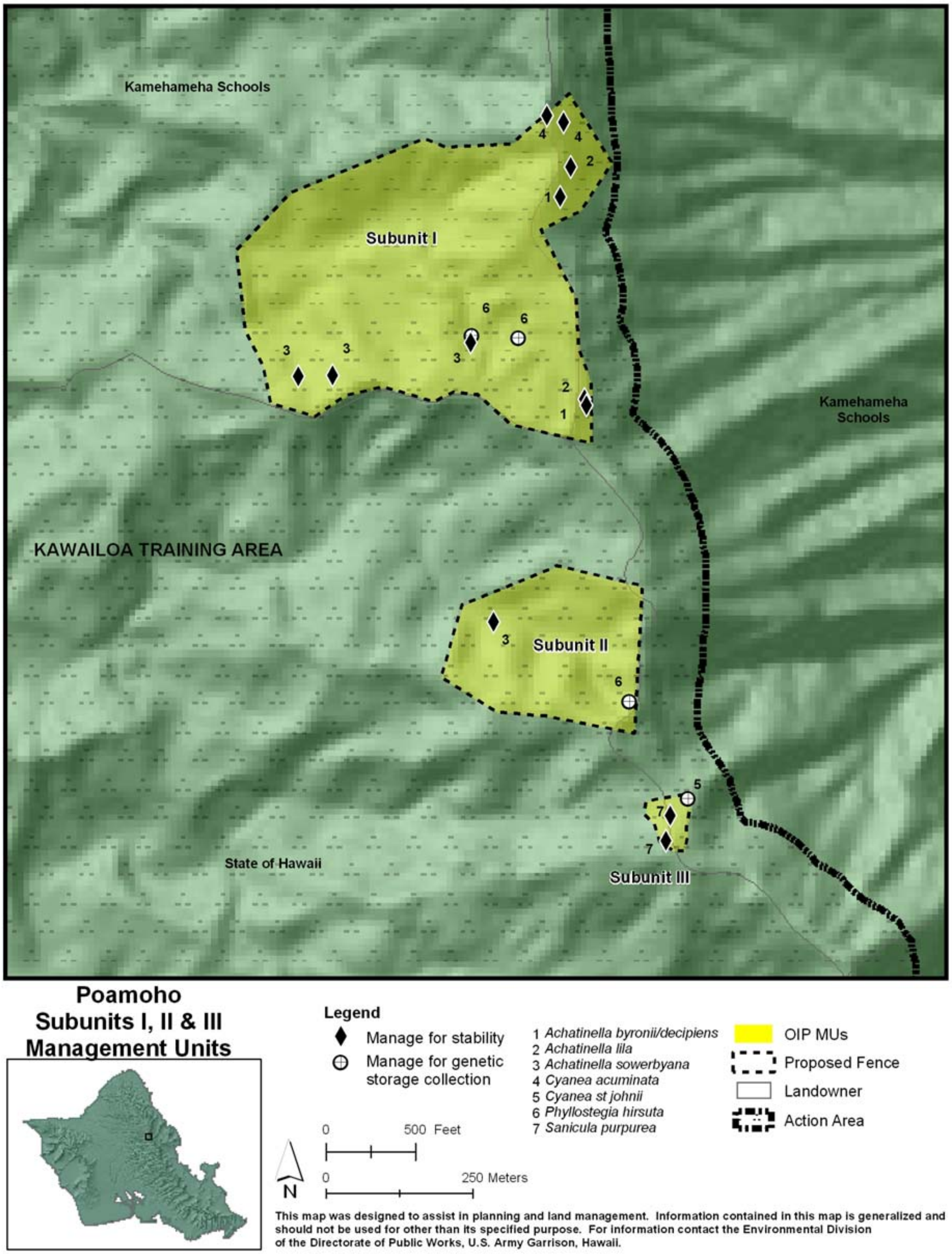


Figure 12.15 Proposed Poamoho Management Unit in the Northern Koolau Mountains, Oahu.

Tier 1
12.13 Management Unit Summary: Lower Poamoho

Management Unit Name/Subunit Name		**Area (acres)**
Lower Poamoho (Koolaus, Oahu)		4.2
Topography	Elevation range 1,800-1,860 ft.; moderately sloping gulch off the Poamoho Trail. Fence to be strategically tied into a vertical drop to the Poamoho stream on the south side of the MU.	
Ownership and acreage	State of Hawaii; U.S. Army lease	
Existing land management	Periodic natural resource management by Army Natural Resources Staff. There is a low level of weed control planned for this MU.	
Natural communities	Ohia/Koa (*Metrosideros/Cheirodendron*) wet native forest; mixed native windswept shrubland along the summit.	
Fire history	No significant fire history, the Oahu Biological Assessment states there is no fire threat for areas along the summit within the action area of the Koolau Mountains inside the action area. There is a very low fire threat for this MU.	
Human use	Poamoho and Koolau Summit Trails, infrequent unauthorized hunting.	
Fences	**Length (m)**	**Status- Tier 1**
Lower Poamoho	588 m	This MU requires a license agreement with the State. This MU also requires an EA.

***In situ* PUs:** species in bold are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

MU Name	**OIP Target Taxa**	**MIP Target Taxa**
Lower Poamoho	***Gardenia mannii* T1**	None

Reintroductions:

Gardenia mannii will be reintroduced into this MU.

Other Significant Taxa:

Lindsea repens var. *macraeana*

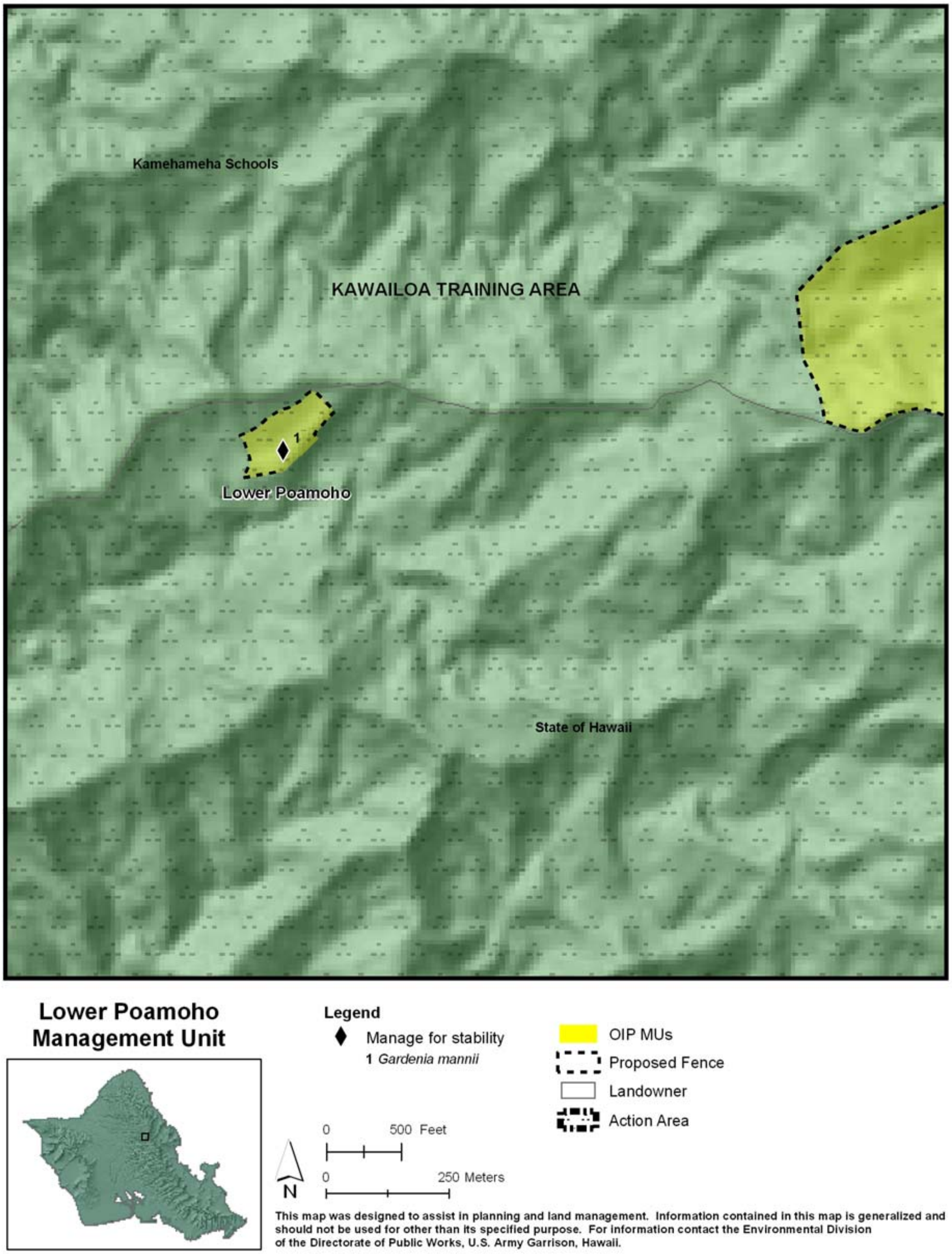


Figure 12.16 Proposed Lower Poamoho Management Unit in the Northern Koolau Mountains, Oahu.

Tier 1
12.14 Management Unit Summary: Ekahanui

Management Unit/Subunit Name	**Area (acres)**
Ekahanui (Waianaes, Oahu)	203 acres (total)
Subunit I	44 acres
Subunit II	159 acres

Topography	Elevation range 1,720-3,127 ft.; windward ridge and gulch systems running up to the Waianae summit crest. Moderate to steep-sided ridge slopes, gentle to moderate gulch bottoms and ridgetops, with steeper slopes near summit.
Ownership and acreage	Campbell Estate (leased to The Nature Conservancy of Hawaii).
Existing land management	Biodiversity Preserve. There is a high level of weed control currently conducted in this MU.
Natural communities	Mesic alien-dominated forest and shrublands, but with some mesic to wet native-dominated areas, including forest dominated by *Metrosideros* and *Acacia koa*; and *Metrosideros* shrubland.
Fire history	Recent fires occurred just below this MU. Therefore there is a high fire threat for this MU.
Human use	Hunting and hiking trails, including the Honouliuli Contour Trail.

Fences	**Length (m)**	**Status**
Subunit I	1,877 m	Existing; **extension to be constructed in OIP yr 6; 2013**
Subunit II	3,100 m	Existing (to be completed winter 2008)

***In situ* PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

MU Name	**OIP Target Taxa**	**MIP Target Taxa**
Ekahanui Subunit I	***Abutilon sandwicense* (T1)**	***Schiedea kaalae****
Ekahanui Subunit II	***Phyllostegia mollis* (T1)**	***Achatinella mustelina**** ***Cenchrus agrimonioides* var. *agrimonioides*** ***Delissea subcordata**** ***Plantago princeps* var. *princeps**** ***Schiedea kaalae****

Reintroductions:

Subunit	**OIP Target taxon**
I	None
II	None

Other important taxa:

Achatinella concavospira	*Pleomele forbesii*
Diellia unisora	*Phyllostegia parviflora* var. *lydgatei*
Labordia kaalae	*Pteralyxia macrocarpa*
Lobelia yuccoides	*Schiedea hookeri*
Melicope saint-johnii	*Tetramolopium lepidotum* subsp. *lepidotum*
Platydesma cornuta var. decurrens	Urera kaalae

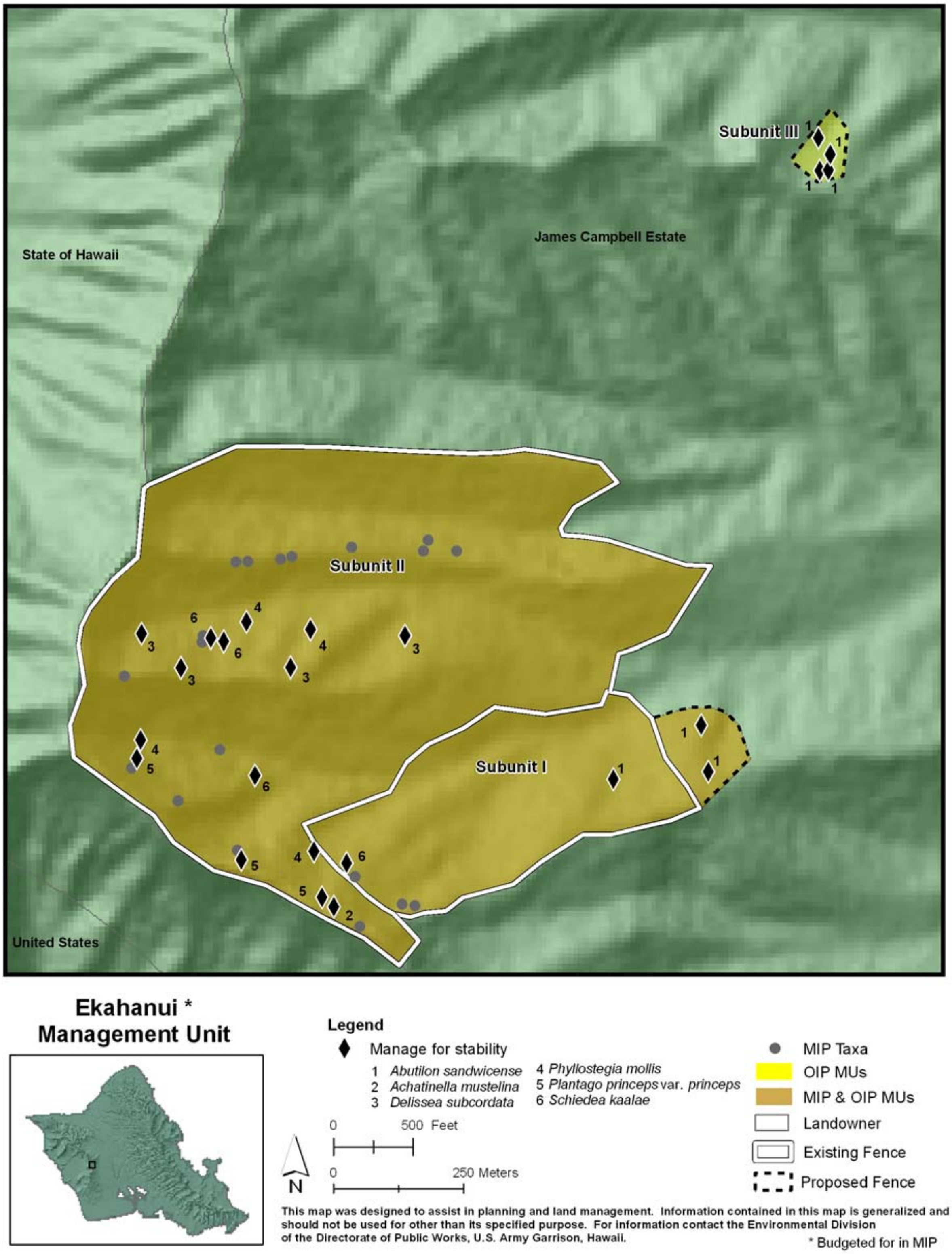


Figure 12.17 Proposed and Existing Ekahanui Management Unit fencelines in the Southern Waianae Mountains, Oahu.

Tier 1
12.15 Management Unit Summary: Lower Peahinaia (synonymous with Lower Opaeula)

Management Unit Name/Subunit Name		**Area (acres)**
Lower Peahinaia or Lower Opaeula Subunit I (Koolaus, Oahu)		25 acres
Lower Peahinaia or Lower Opaeula Subunit II (Koolaus, Oahu)		23.9 acres
Topography	Elevation range 2,100-2,500 ft.; moderate and steep-sided gulches. Complex gulch and ridge systems in the north-central Koolau Mountains.	
Ownership and acreage	Kamehameha Schools, US Army lease.	
Existing land management	Some natural resource management by Army NRS. There is a moderate level of weed control planned for this MU.	
Natural communities	Ohia (*Metrosideros*)/ Uluhe (*Dicranopteris*) wet native forest.	
Fire history	No significant fire history, but fires possible, especially during drought. Potentially affected by fires started by military training outside the management unit (MU). Fire risk is considered very low for this area.	
Human use	Military training area. Light training history in the MU, but frequent training in lower elevations west of the MU. Occasional hunters and hikers, but the area is rarely visited.	
Fences	**Length (m)**	**Status- Tier 1**
Lower Peahinaia Subunit I	1606 m	MIP year 1; This MU requires a license agreement with the landowner; This MU also requires an EA.
Lower Peahinaia Subunit II	1511 m	OIP year 8; 2016 This MU requires a license agreement with the landowner; This MU also requires an EA.

***In situ* PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

MU Name	**OIP Target Taxa**	**MIP Target Taxa**
Lower Peahinaia Subunit I	***Achatinella sowerbyana* T2** ***Gardenia mannii* T1** ***Melicope lydgatei* T1** *Phyllostegia hirsuta*	***Cyrtandra dentata***
Lower Peahinaia Subunit II	*Cyanea koolauensis* ***Hesperomannia arborescens* (T1)** *Phyllostegia hirsuta*	

Reintroductions:

N/A

Other Significant Taxa:

Lindsaea repens var. *macraeana* *Joinvillea ascendens* subsp. *ascendens* *Psychotria hexandra* var. *oahuensis*

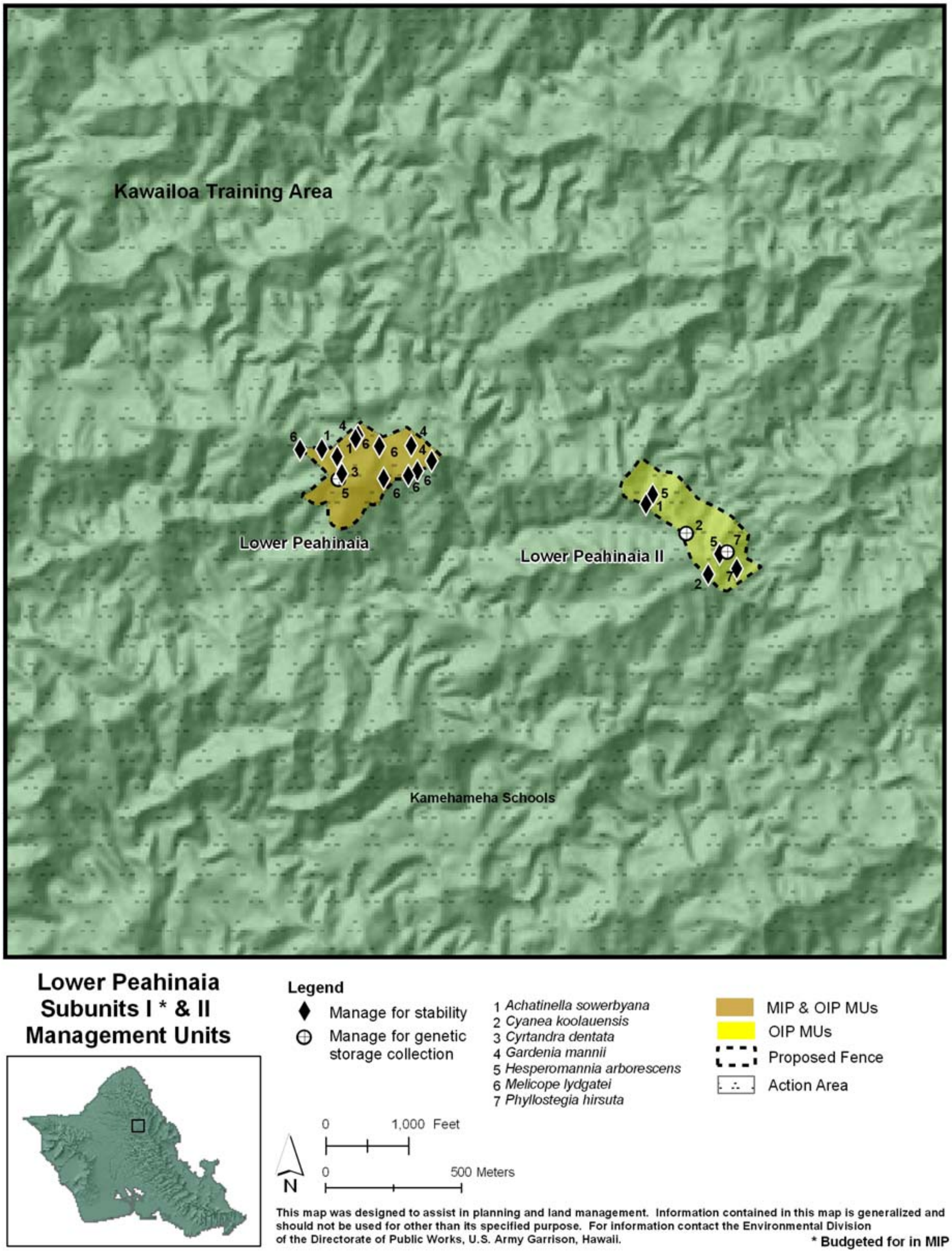


Figure 12.18 Proposed Lower Peahinaia (Lower Opaeula) Management Unit in the Northern Koolau Mountains, Oahu.

12.16 Management Unit Summary: North Halawa

Management Unit Name/Subunit Name		**Area (acres)**
North Halawa (Koolaus, Oahu)		3.6 acres
Topography	Elevation range 2,600-2,700 ft.; moderate sloping terrain.	
Ownership and acreage	Kamehameha Schools	
Existing land management	None. There is a high level of wed control planned for this MU.	
Natural communities	Windswept mixed wet shrubland; Dominated by Ohia (*Metrosideros*), Manono (*Hedyotis*), and *Axonopus fissifolius*. The area has been disturbed by feral pigs. The fenceline follows relatively moderate terrain.	
Fire history	No significant fire history. Very wet and remote site; there is a very low fire threat for this area.	
Human use	Hiking trail along the summit area, though used very infrequently. The area is rarely visited.	
Fences	**Length (m)**	**Status**
MU perimeter fence	607 m	Tier 1; This MU requires an EA and an agreement with the landowner (Hawaii State Department of Transportation) To be constructed in OIP year 8; 2015

***In situ* PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

MU Name	**OIP Target Taxa**	**MIP Target Taxa**
North Halawa	***Cyanea st.-johnii* T1** *Viola oahuensis* (no army data)	None

Reintroductions

N/A

Other Significant Taxa

N/A

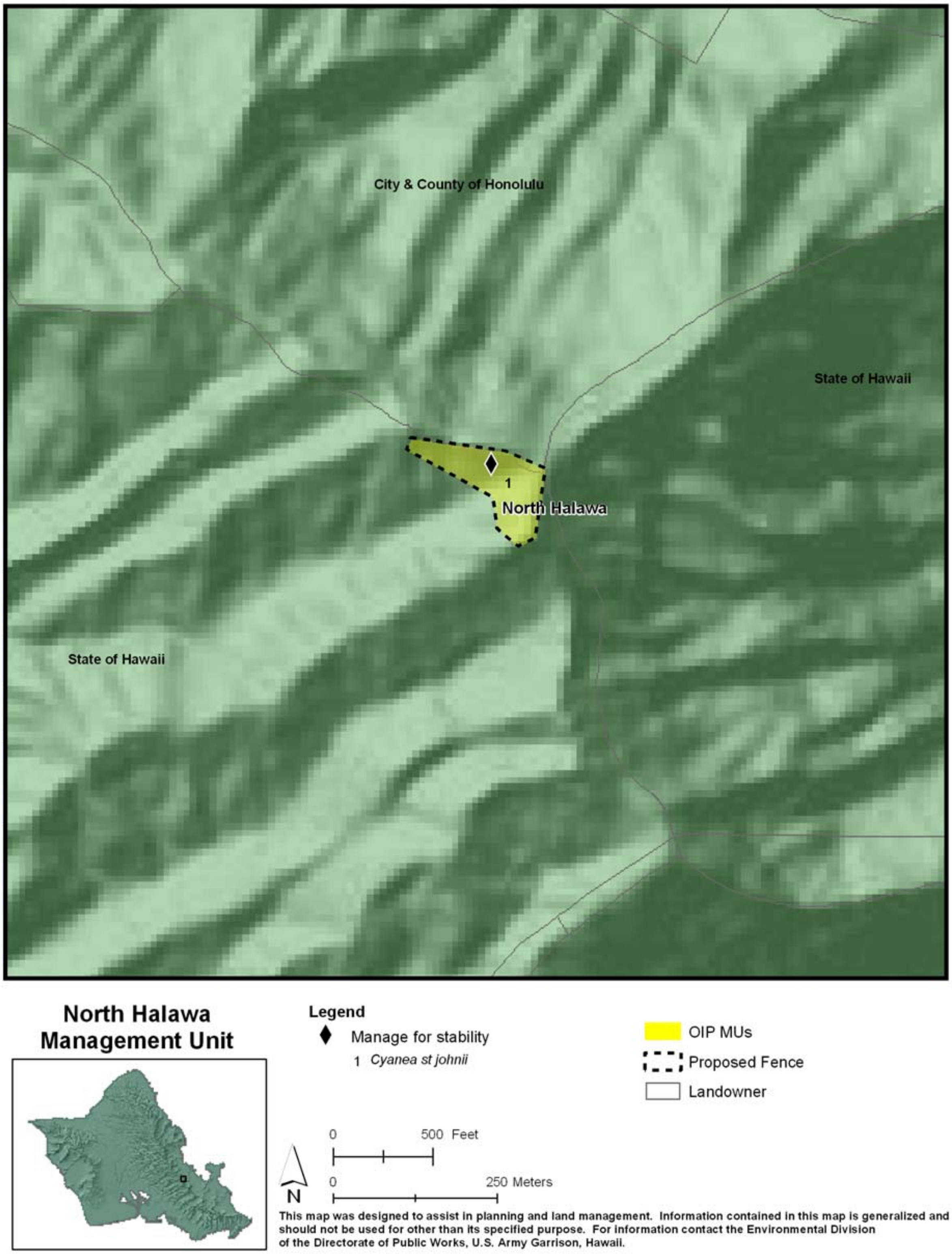


Figure 12.19 North Halawa Management Unit in the Central Koolau Mountains, Oahu.

Tier 1:
12.17 Management Unit Summary: East Makaleha

Management Unit/Subunit Name	**Area (acres)**
East Makaleha (Waianaes, Oahu)	231 acres

Topography	Elevation range 1,040-3,800 ft.; windward ridge and gulch systems running up to the Waianae summit crest. Moderate to steep-sided ridge slopes, gentle to moderate gulch bottoms, with steeper slopes near summit.
Ownership and acreage	State of Hawaii.
Existing land management	State Forest Reserve, State Public Hunting Area. There is a high level of weed control planned for this MU.
Natural communities	Dry-mesic to wet native forest and shrubland; alien-dominated dry-mesic to wet-mesic shrubland and forest.
Fire history	Only lower elevations with seasonal fire risk; mesic to wet-mesic sections considered low to medium fire risk.
Human use	Hunting trails, access to western and upper portions via a paved road.

Fences	**Length (m)**	**Status- Tier 1**
MU perimeter fence	4,360 m	Construct in Year 4 of MIP, 2008 This fence requires a license agreement with the State. An EA with a FONSI was completed for this fence in 2006.

***In situ* PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

Subunit	**OIP Target Taxa**	**MIP Target Taxa**
N/A	***Cyanea acuminata* T1** ***Labordia cyrtandrae* T1** ***Schiedea trinervis* T1**	***Achatinella mustelina**** ***Hedyotis degeneri* var. *degeneri*** ***Flueggea neowawraea**** ***Pritchardia kaalae***

Subunit	**OIP Target Taxa**	**MIP Target Taxa**
N/A	None	*Chamaesyce herbstii* *Cyanea superba* subsp. *superba*

Other important taxa:

Caesalpinia kavaiensis *Colubrina oppositifolia* *Delissea sinuata* (historical) *Gardenia brighamii* (historical) *Gouania vitifolia* (historical)	*Phyllostegia mollis* (historical) *Phyllostegia parviflora* var. *lydgatei* (historical) *Tetramolopium lepidotum* subsp. *lepidotum* (historical) *Vigna o-wahuensis* (historical)

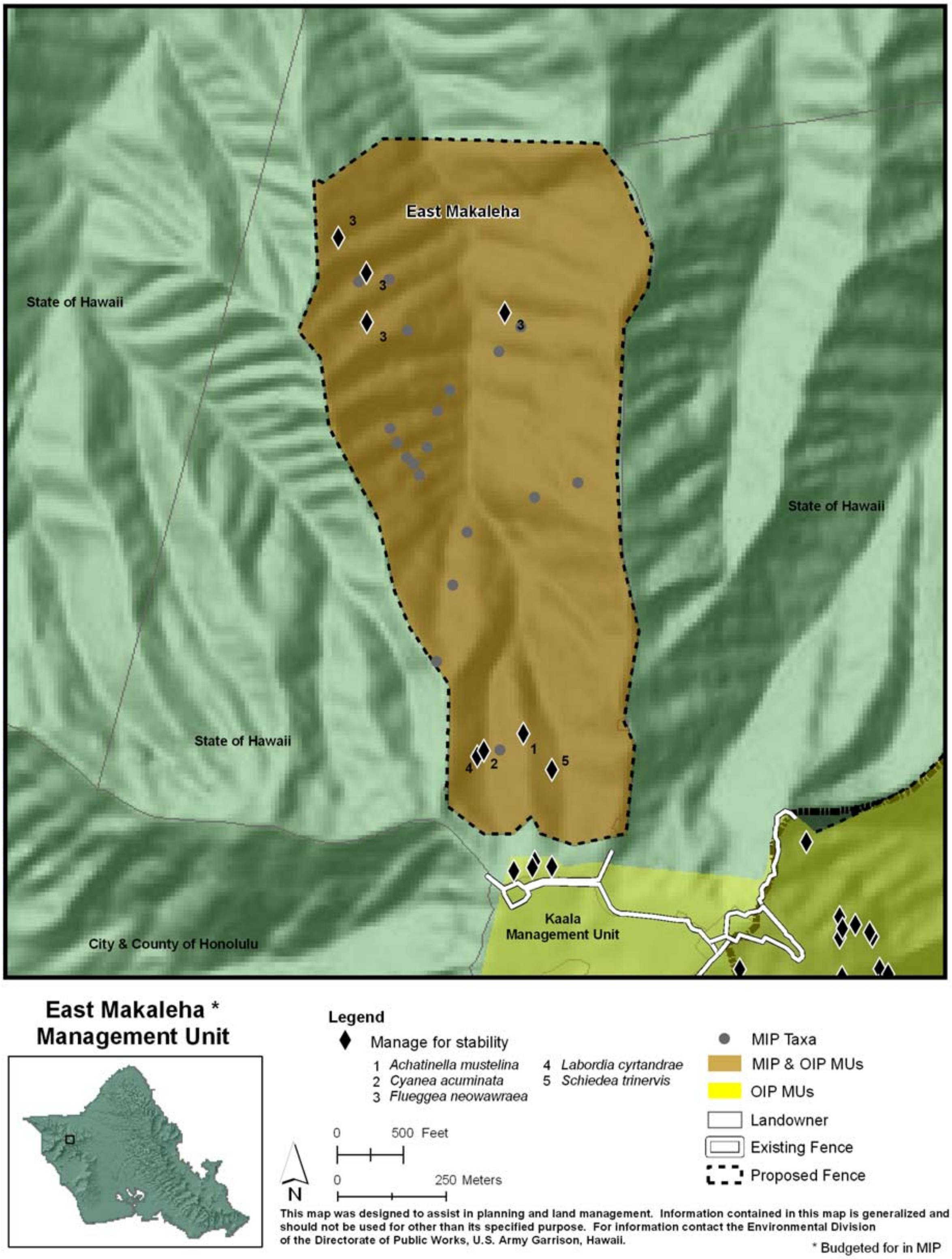


Figure 12.20 Proposed East Makaleha Management Unit in the Northern Waianae Mountains, Oahu.

Tier 1
12.18 Management Unit Summary: Manuwai

Management Unit/Subunit Name		**Area (acres)**
Manuwai (Waianaes, Oahu)		166 acres
Topography	Elevation range 1,400-2,600 ft.; windward ridge and gulch systems running up to ridge crest. Moderate to steep sided ridge slopes, gentle to moderate gulch bottoms, with steeper slopes near summit.	
Ownership	State of Hawaii.	
Existing land management	Natural Area Reserve. There is a high level of weed control planned for this MU.	
Natural communities	Dry-mesic to mesic alien forests and mesic native forests typically dominated by *Diospyros*, *Metrosideros*, *Acacia koa.* One rare natural community: *Sapindus oahuensis* Lowland Dry Forest.	
Fire history	No recent fires, but lower elevations seasonally dry and considered high risk. Overall there is a moderate threat from fire to this MU.	
Human use	Hunting trails.	

Fences	**Lenth (m)**	**Status- Tier 1**
MU perimeter fence	3,563 m	Construct in MIP Year 5, 2009. This MU has an EA with a FONSI since 2006. This fence will be built in cooperation with the State.

***In situ* PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

MU Name	**OIP Target Taxa**	**MIP Target Taxa**
Manuwai	***Abutilon sandwicense* T1**	***Hedyotis degeneri* var. *degeneri*** ***Melanthera tenuifolia*** ***Pritchardia kaalae***

Reintroductions:

MU Name	**Target taxon**
Manuwai	*Phyllostegia kaalaensis*

Other important taxa:

Caesalpinia kavaiensis	*Tetramolopium lepidotum* subsp. *lepidotum* (historical)
Colubrina oppositifolia (historical)	*Hedyotis degeneri* var. *coprosmifolia* (historical)

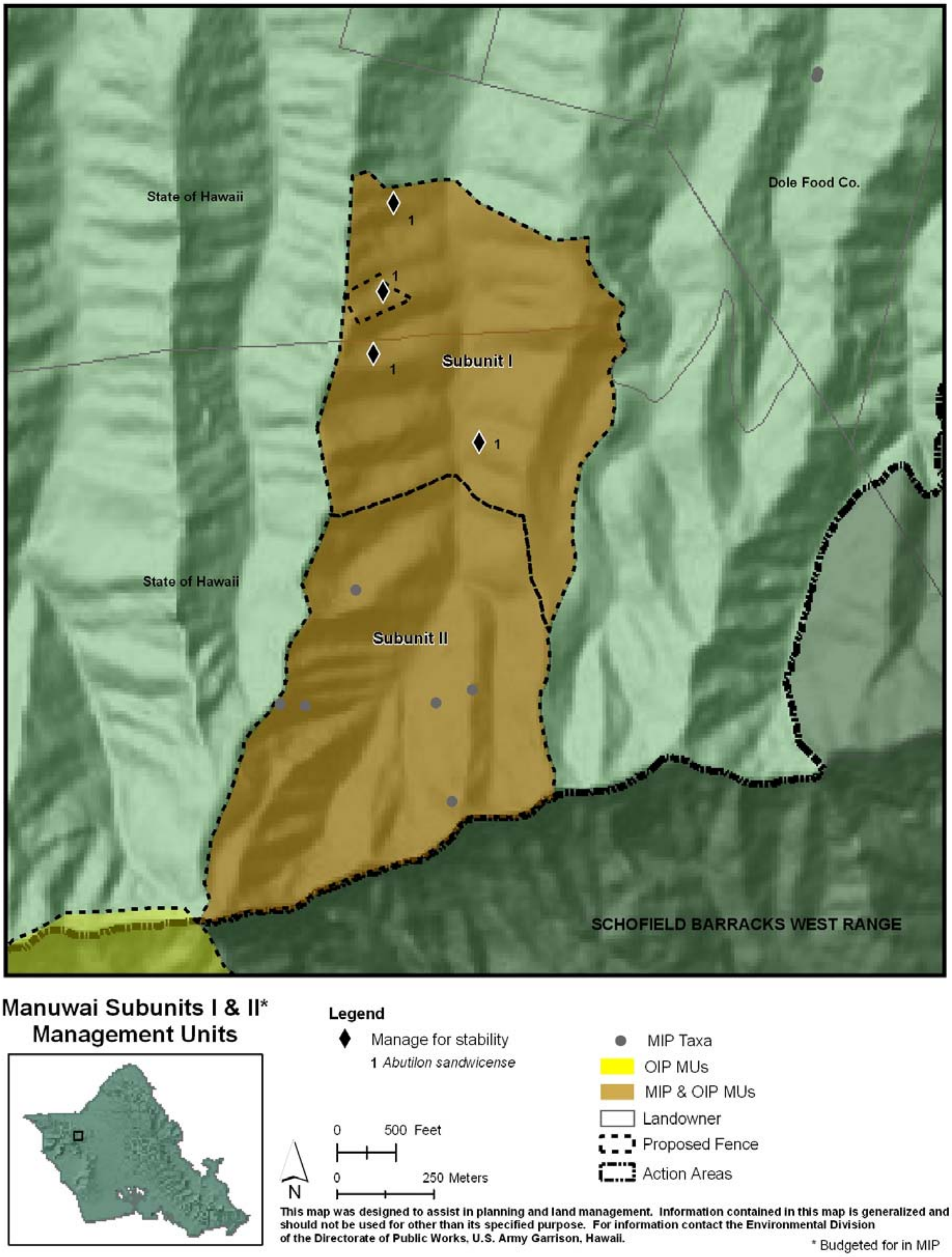


Figure 12.21 Proposed Manuwai Management Unit in the Northern Waianae Mountains, Oahu.

Tier 1
12.18 Management Unit Summary: Kaluaa and Waieli

Management Unit Name/Subunit Name		**Area (acres)**
Kaluaa and Waieli subunit I (Waianaes, Oahu)		128 acres
Kaluaa and Waieli subunit II (Waianaes, Oahu)		99 acres
Kaluaa and Waieli subunit III (Waianaes, Oahu)		29 acres
Topography	Elevation range 1,520-2,850 ft.; windward ridge and gulch systems running up to the Waianae summit crest. Moderate to steep-sided ridge slopes, gentle to moderate gulch bottoms and ridge tops below the summit.	
Ownership and acreage	The Estate of James Campbell (leased to The Nature Conservancy of Hawaii).	
Existing land management	Biodiversity Preserve. There is a high level of weed control currently conducted and planned for this MU.	
Natural communities	Alien-dominated forest and shrublands, but with some native-dominated areas, including forest dominated by *Metrosideros* and *Acacia koa*.	
Fire history	No significant fire history, however its proximity to fallow ag fields and mesic habitat mean there is a high fire threat for this MU.	
Human use	Hiking trails, including the Honouliuli Contour Trail.	
Fences	**Length (m)**	**Status- Tier 1**
Kaluaa and Waieli subunit I	2839.5 m	Existing
Kaluaa and Waieli subunit II	1,158.9 m	Existing
Kaluaa and Waieli subunit I	1008.7 m	Begin construction 2008 This MU has an EA with a FONSI, written by TNCH 2005. The Army will assist TNCH in the construction of this fence beginning in 2008

***In situ* PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

MU Name	**OIP Target Taxa**	**MIP Target Taxa**
Subunit I and II	***Phyllostegia hirsuta* T1** ***Phyllostegia mollis* T1** ***Stenogyne kanehoana* T1**	***Achatinella mustelina**** ***Alectryon macrococcus var. macrococcus**** ***Schiedea kaalae****
Subunit III		***Achatinella mustelina**** ***Alectryon macrococcus* var. *macrococcus* *** ***Cyanea grimesiana* subsp. *obatae**** ***Delissea subcordata****

Reintroductions:

MU Name	OIP Target Taxa	MIP Target Taxa
Kaluaa and Waieli subunit I and II	***Phyllostegia mollis* T1** ***Stenogyne kanehoana* T1**	***Scheidea kaalae****
Kaluaa and Waieli subunit III	None	***Alectryon macrococcus* var. *macrococcus****

Other Significant Taxa:

Cyanea pinnatifida (extirpated)	*Solanum sandwicense* (historical)
Cyanea calycina	*Tetramolopium lepidotum* subsp. *lepidotum* (historical)
Gardenia mannii	*Urera kaalae*
Schiedea pentandra	

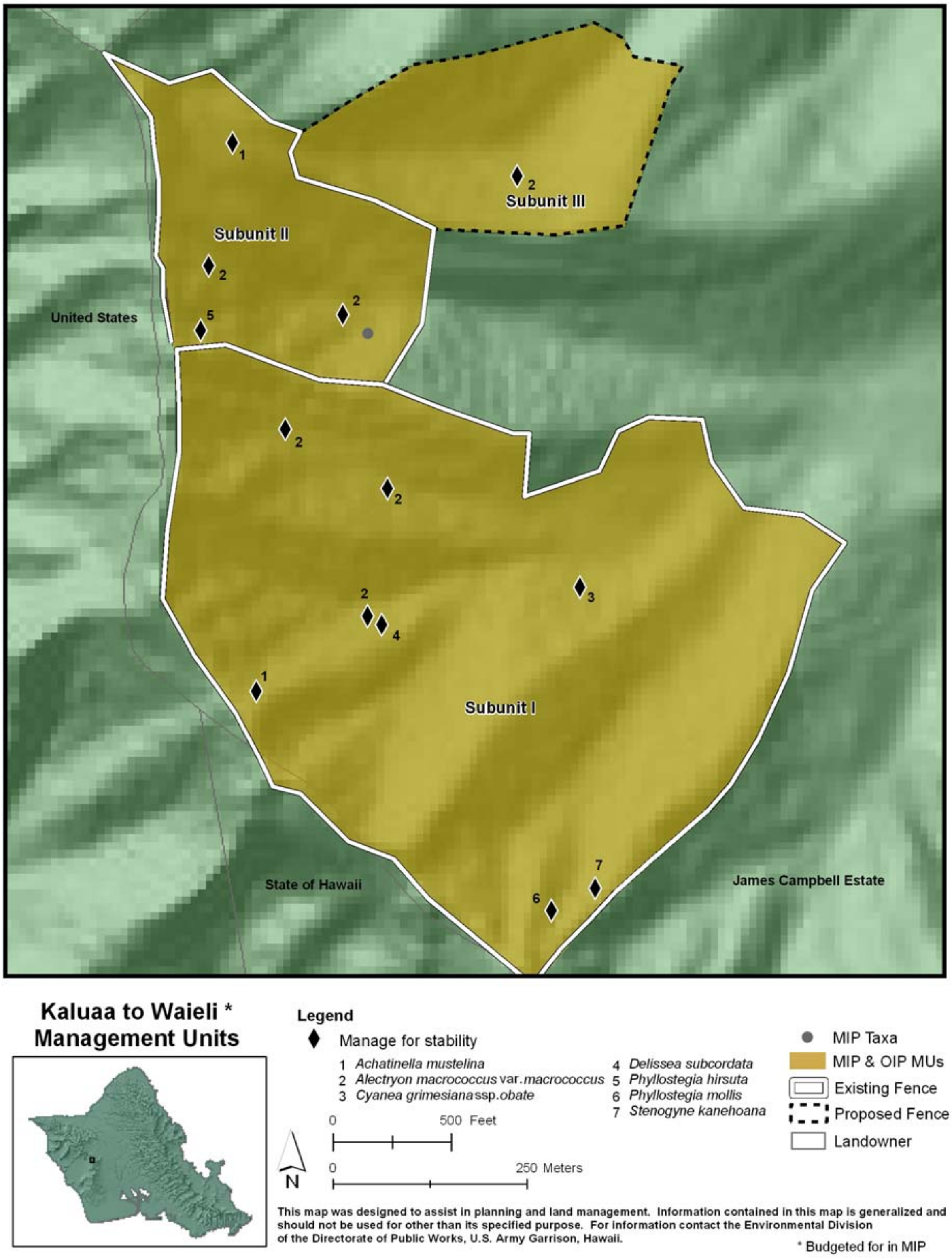


Figure 12.22 Proposed and Existing Kaluaa and Waieli Management Unit in the Central Waianae Mountains, Oahu.

Tier 1
12.19 Management Unit Summary: Kaala

Management Unit Name/Subunit Name		**Area (acres)**
Kaala (Waianaes, Oahu)		171.6 acres
Topography	Elevation range 3,400-4,020 ft.; Plateau and surrounding cliffs of Kaala peak in the Waianae Mountains. Bog and surrounding montane wet community. Moderate to steep slopes and cliffs	
Ownership and acreage	City and County of Honolulu- 12.9 acres, State of Hawaii-57 acres, and US Army 101.7	
Existing land management	Kaala Bog and surrounding upper gulches are actively managed by the Army Natural Resources. There is a moderate level of weed control conducted and planned for this area.	
Natural communities	Ohia (*Metrosideros*) montane wet mixed community	
Fire history	No significant fire history for the Kaala area. There is a very low fire threat.	
Human use	Kaala summit is jointly managed by the FAA and US Army National Guard. The Northern portion beyond the bog boardwalk is managed by the State as a Natural Area Reserves.	
Fences	**Length (m)**	**Status**
MU boundary fence	3573 m (strategic fence)	90% existing; some additional fencing may be necessary to exclude ungulates.

***In situ* PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

MU Name	**OIP Target Taxa**	**MIP Target Taxa**
Kaala	***Cyanea acuminata* T1** ***Labordia cyrtandrae* T1** ***Schiedea trinervis* T1**	None

Reintroductions

MU Name	**OIP Target Taxa**	**MIP Target Taxa**
Kaala	*Labordia cyrtandrae*	None

Other significant Taxa

Cyanea calycina *Gunnera petaloidea* *Melicope christophersenii* *Neraudia melastomafolia*

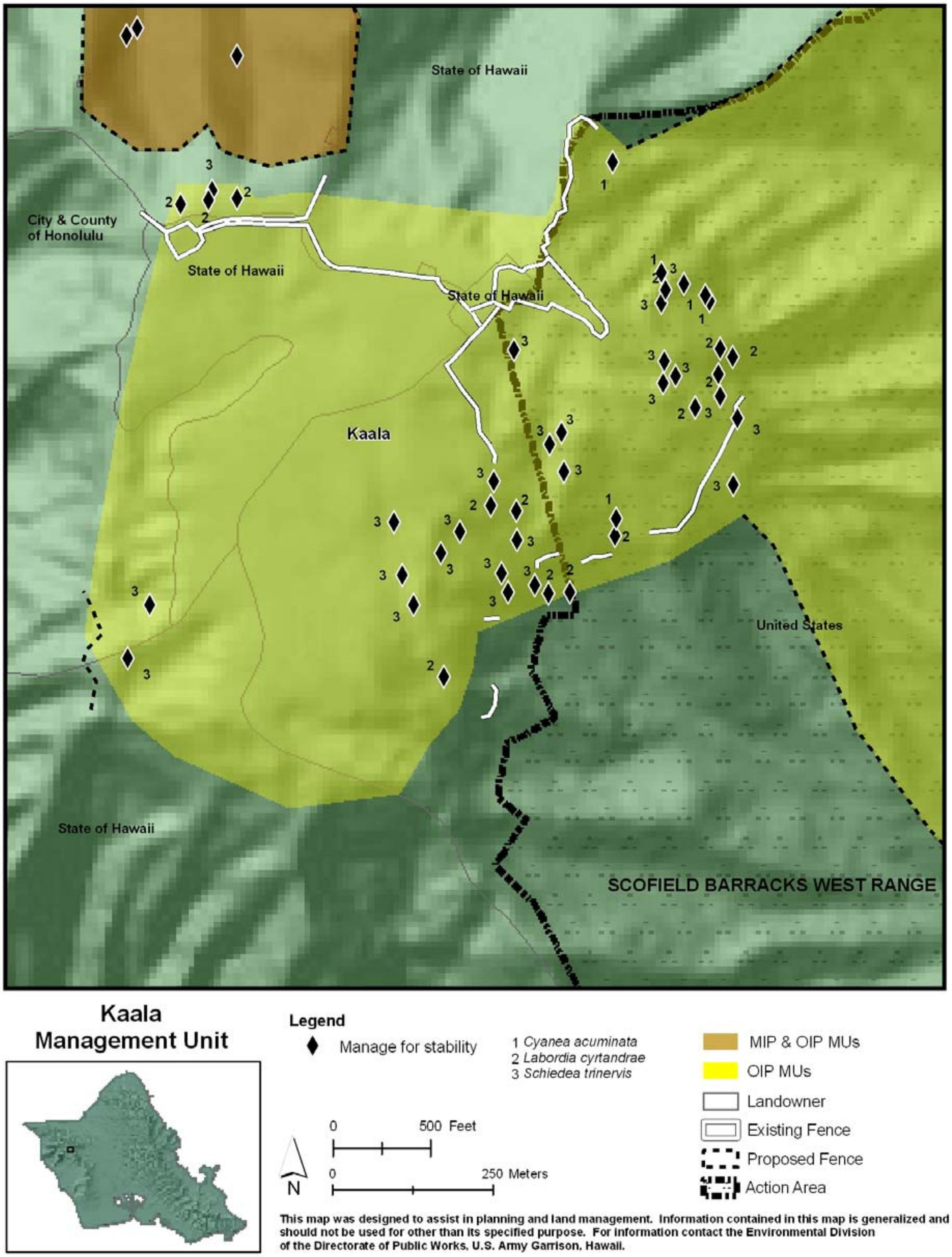


Figure 12.23 Kaala Management Unit in the Northern Waianae Mountains, Oahu.

12.21 Management Unit Summary: Kaunala, Pahipahialua, Oio

Management Unit Name/Subunit Name		Area (acres)
Kaunala (Koolaus, Oahu)		5.1 acres
Pahipahialua (Koolaus, Oahu)		17.1 acres
Oio (Koolaus, Oahu)		0.9 acres
Kaleleiki (Koolaus, Oahu)		1.9 acres
Topography	Elevation range 600-650 ft (Aimuu and Kaunala); 800-1,000 ft. (Pahipahialua and Kaleleiki). Moderate sloping gulches and ridges.	
Ownership and acreage	State of Hawaii (US Army Lease) 0.9; State of Hawaii (Kaleleiki-1.9 acres); United States of America (Pahipahialua-17.1 acres and Kaunala-5.1 acres)	
Existing land management	Natural resource management and monitoring by Army Natural Resources. There is a high level of weed control conducted and planned for these MUs.	
Natural Communities	Lowland mesic mixed native and introduced forest. Many areas dominated by Ironwood (*Casurina*) or Guava (*Psidium*), native species include Ohia and Papalakepau (*Metrosideros* and *Pisonia)*.	
Fire history	Recent fires have consumed small portions of the T & E natural resources in these areas. Fuel loads will need to be controlled to prevent potential future fire damage. The fire risk for this area is considered to be high.	
Human use	Military training area; motor cross trails throughout the lower elevations.	
Fences	**Length (m)**	**Status**
Kaunala	609 m	Complete
Pahipahialua	1144 m	Complete
Oio	247 m	Complete
Kaleleiki	355 m	Complete (Managed by the State)

***In situ* PUs:** species in bold are designated as manage for stability in this MU. MUs not containing manage for stability populations are part of a BO requirement to fence all *Eugenia koolauensis* populations and will be managed for genetic storage collections. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

Subunit	OIP Target Taxa	MIP Target Taxa
Kaunala	***Eugenia koolauensis* T1**	None
Pahipahialua	***Eugenia koolauensis* T1**	
Oio	***Eugenia koolauensis* T1**	
Kaleleiki	*Eugenia koolauensis*	

Reintroductions:

N/A

Other Significant Taxa:

Bobea timonioides (Kaunala)

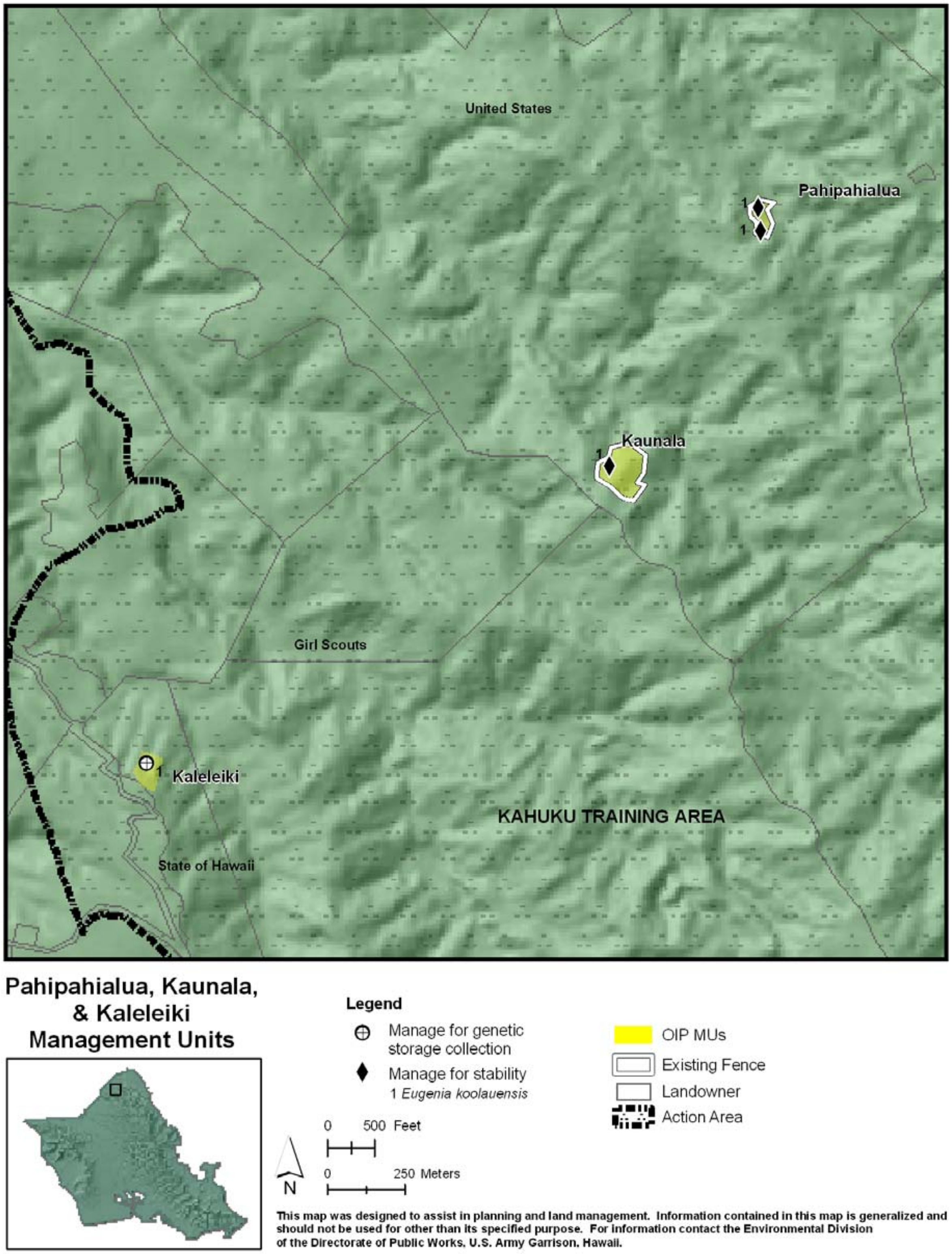


Figure 12.24 Kaunala, and Pahipahialua Management Units in the Northern Koolau Mountains, Oahu.

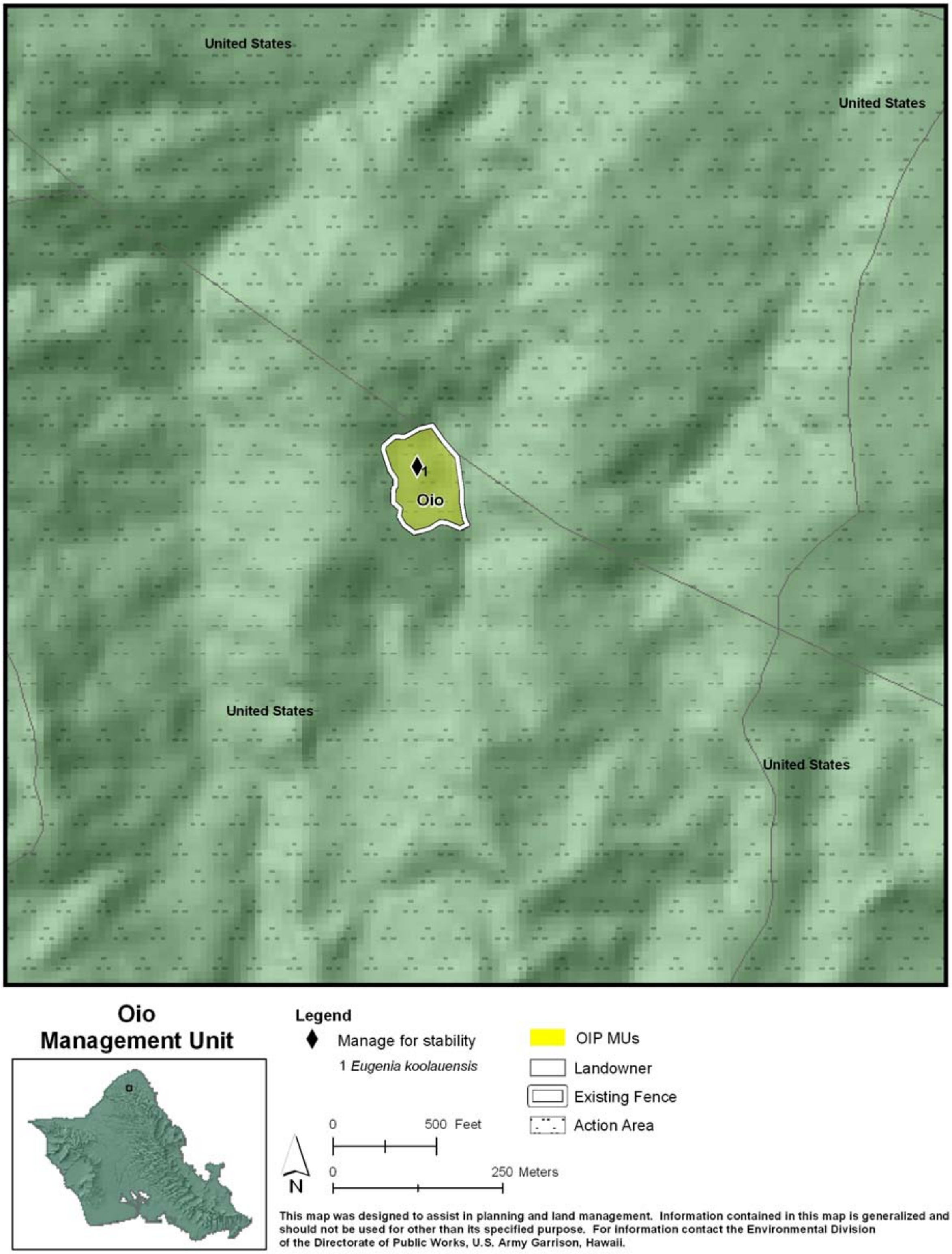


Figure 12.25 Oio Management Unit in the Northern Koolau Mountains, Oahu.

Tier 1
12.21 Management Unit Summary: North Pualii

Management Unit Name/Subunit Name		**Area (acres)**
North Pualii (Waianaes, Oahu)		10.1 acres
Topography	Elevation range 1,800-2,700 ft.; Steep ridges	
Ownership and acreage	Manana Valley Farm	
Existing land management	The Estate of James Campbell (leased to The Nature Conservancy of Hawaii). Biodiversity Preserve. There is a moderate level of weed control conducted and planned in this MU.	
Natural communities	Lower elevations are alien-dominated forest and shrublands, higher elevations have some native-dominated areas with Ohia (*Metrosideros*) and Koa (*Acacia koa*).	
Fire history	2004 fire burned 225 acres 1400 m north of this proposed exclosure, 125 acres of which were within the TNCH preserve. The fire risk for this are is considered high.	
Human use	Hiking trails, including the Honouliuli Contour Trail; some unauthorized hunting.	
Fences		**Status**
MU perimeter fence	1366 (m)	Existing (TNC constructed this fence in 2006)

***In situ* PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

MU Name	OIP Target Taxa	MIP Target Taxa
North Pualii	***Phyllostegia mollis* T1**	None

Reintroductions

Phyllostegia mollis will be reintroduced into this MU.

Other Significant Taxa

Chasiempis sandwichensis subsp. *ibidis* *Dissochondrus biflorus* *Labordia kaalae* *Urera kaalae*

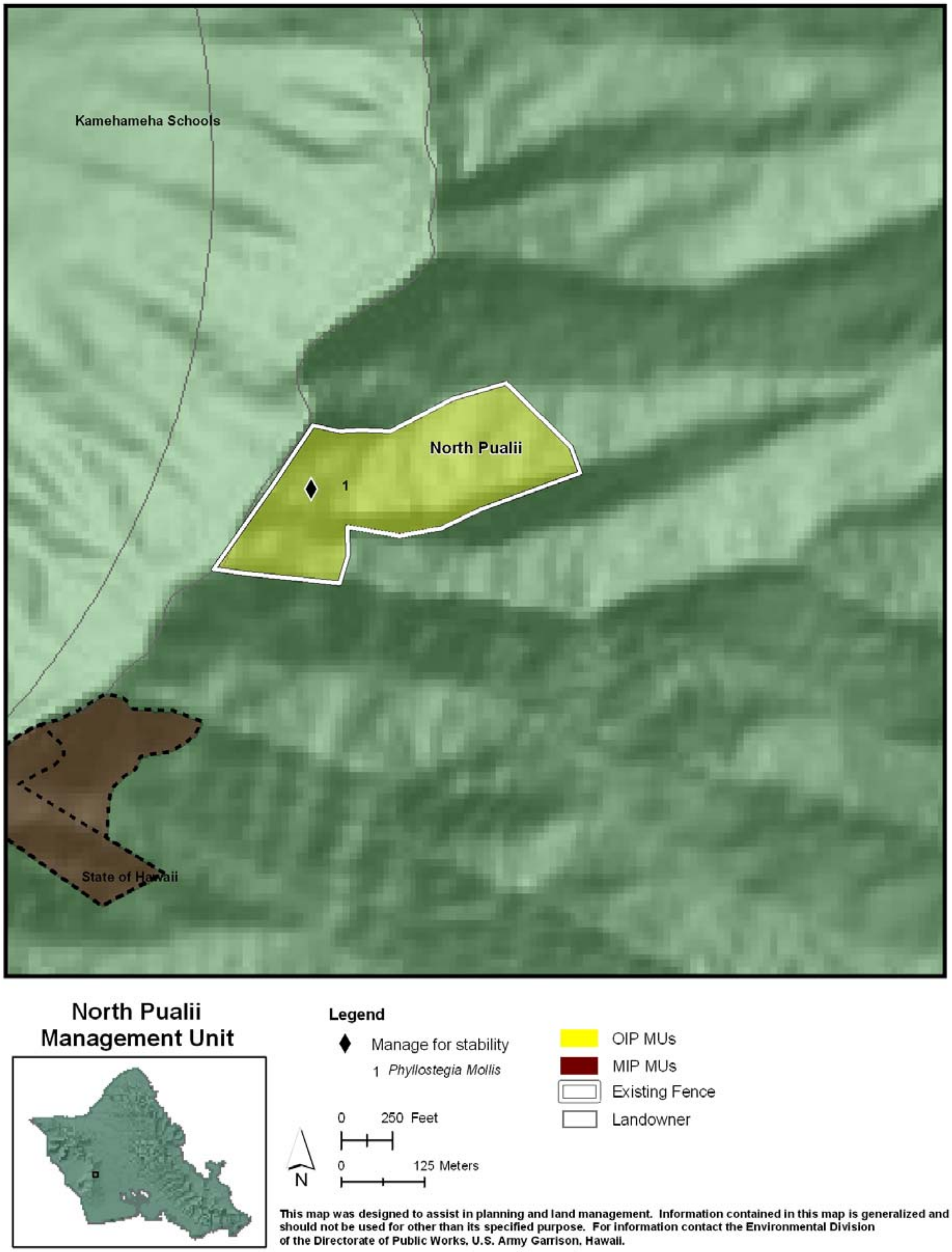


Figure 12.26 North Pualii Management Unit in the Southern Waianae Mountains, Oahu.

Tier 1
12.22 Management Unit Summary: Helemano and Opaeula

Management Unit Name/Subunit Name		**Area (acres)**
Helemano and Opaeula (Koolaus, Oahu)		234.6 acres
Opaeula		121.39 acres
Helemano		113.2 acres
Topography	Elevation range 2,400- 2,700 ft; summit and headwaters of Helemano and Opaeula Streams, Koolau Mountains, moderate gulch slopes.	
Ownership and acreage	Kamehameha Schools, US Army lease	
Existing land management	Existing fence and active natural resources management by the Army Natural Resources division within Opaeula fenceline. There is a low level of weed control conducted and planned for this MU.	
Natural communities	Ohia/Olapa (*Metrosideros/Cheirodendron*) wet native forest; mixed native windswept shrubland along the summit.	
Fire history	No significant fire history, the Oahu Biological Assessment states there is no fire threat for the summit area of the Koolau Mountains inside the action area. Therefore, the fire threat is considered very low.	
Human use	Koolau Summit Trail follows the summit fenceline. Opaeula trail follows the ridgeline on the leeward side of the summit, though this trail is used very infrequently.	
Fences	**Length (m)**	**Status**
Opaeula fence	3,490 m	Existing
Helemano fence	3,010 m	Existing

***In situ* PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

MU Name	**OIP Target Taxa**	**MIP Target Taxa**
Helemano and Opaeula	***Achatinella lila*** **T2** ***Achatinella sowerbyana*** **T2** ***Chamaesyce rockii*** **T2** ***Cyanea koolauensis*** **T1** ***Cyanea st.-johnii*** **T1** ***Cyrtandra viridiflora*** **T2** *Phyllostegia hirsuta* ***Viola oahuensis*** **T2**	None

Reintroductions:

Subunit	**OIP Target Taxa**	**MIP Target Taxa**
Opaeula	*Sanicula purpurea*	None
Helemano	None	None

Other Significant Taxa:

Arachnoides insularis *Anoectochilis sandvicensis* *Cyanea calycina* *Cyanea humboldtiana* *Joinvillea ascendens* subsp. *ascendens*	*Lobelia gaudichaudii* var. *gaudichaudii* *Megalagrion nigrohamatum* var. *nigrolineatum* *Zanthoxylum oahuensis*

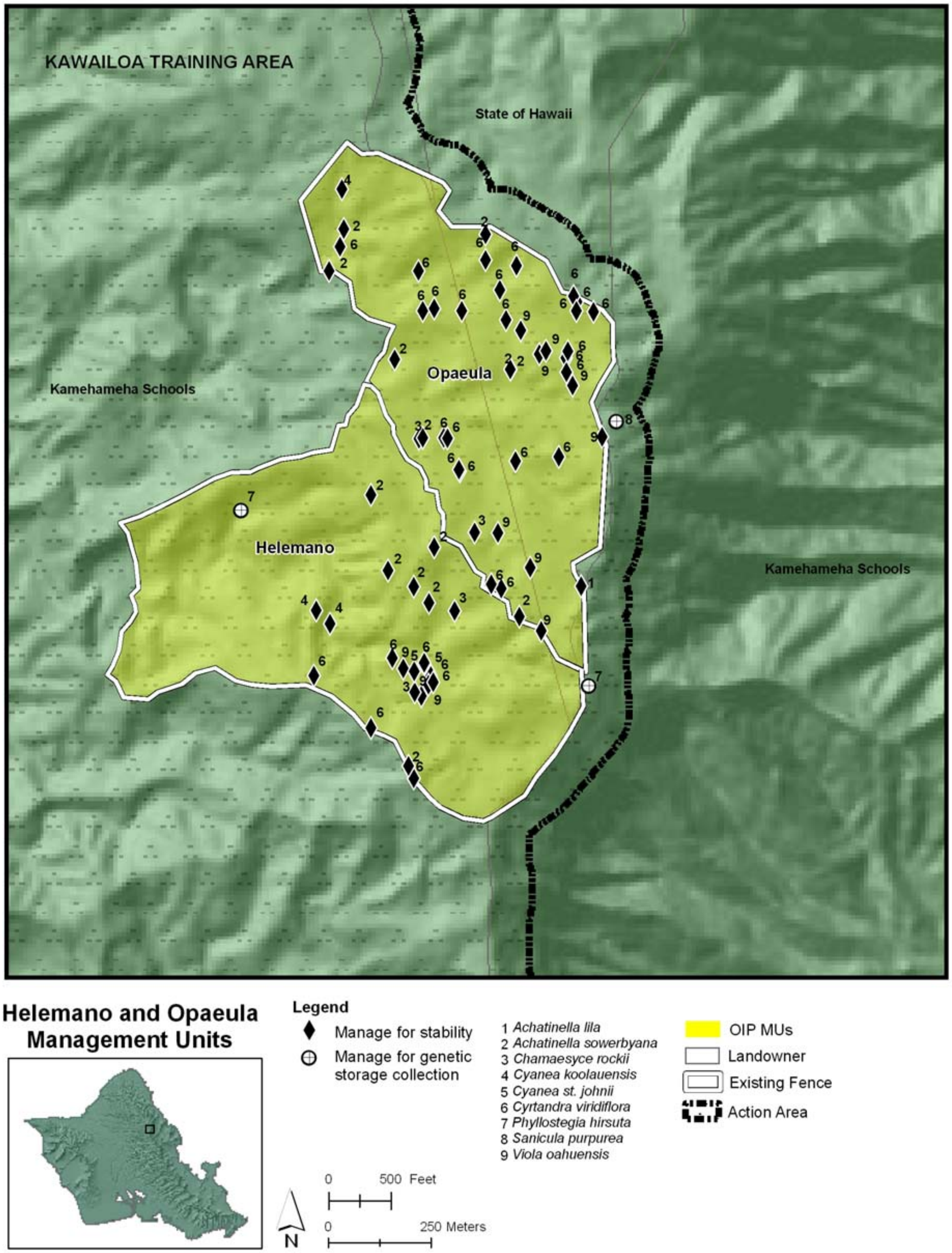


Figure 12.27 Helemano and Opaeula Management Unit in the Northern Koolau Mountains, Oahu.

Tier 2
12.23 Management Unit Summary: Waiawa

Management Unit/Subunit Name	**Area (acres)**
Waiawa (Koolaus, Oahu)	>124 acres
Subunit I	124 acres
Subunit II	12.7

Topography	Elevation range 1,800-2,725 ft.; complex gulch and ridge systems of the upper central Koolau Mountains. Moderate and steep-sided gulch sides.
Ownership and acreage	B. P. Bishop Estate Trustees, 136.7 total in MU
Existing land management	None. There is a low level of weed control planned for this MU.
Natural communities	Wet native forest and shrubland, including areas dominated by *Metrosideros*, *Dicranopteris*, and mixed fern and shrub assemblages.
Fire history	This habitat is very wet and is considered to be very low fire risk.
Human use	Hiking trail along the boundary; rest of area rarely visited.

Fences	**Length (m)**	**Status**
Subunit I	2,936 m	**Tier 2**, Construct in Year 9 of OIP This MU requires a license agreement with the landowner; This MU also requires an EA.
Subunit II	937 m	**Tier 2**, Construct in OIP year 15 This subunit requires a license agreement with the landowner; This subunit also requires an EA.

***In situ* PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

MU Name	**OIP Target Taxa**	**MIP Target Taxa**
I	***Chamaesyce rockii* T2** ***Lobelia gaudichaudii* subsp. *koolauensis*T3**	*Plantago princeps* var. *princeps**
II	***Chamaesyce rockii* T2** *Cyanea st.-johnii*	None

Reintroductions:

Subunit	**OIP Target Taxa**	**MIP Target Taxa**
I	None	None
II	None	None

Other important taxa:

Cyanea calycina *Cyanea humboldtiana* *Cyanea koolauensis* *Lobelia oahuensis*	*Tetraplasandra gymnocarpa* *Trematolobelia singularis*

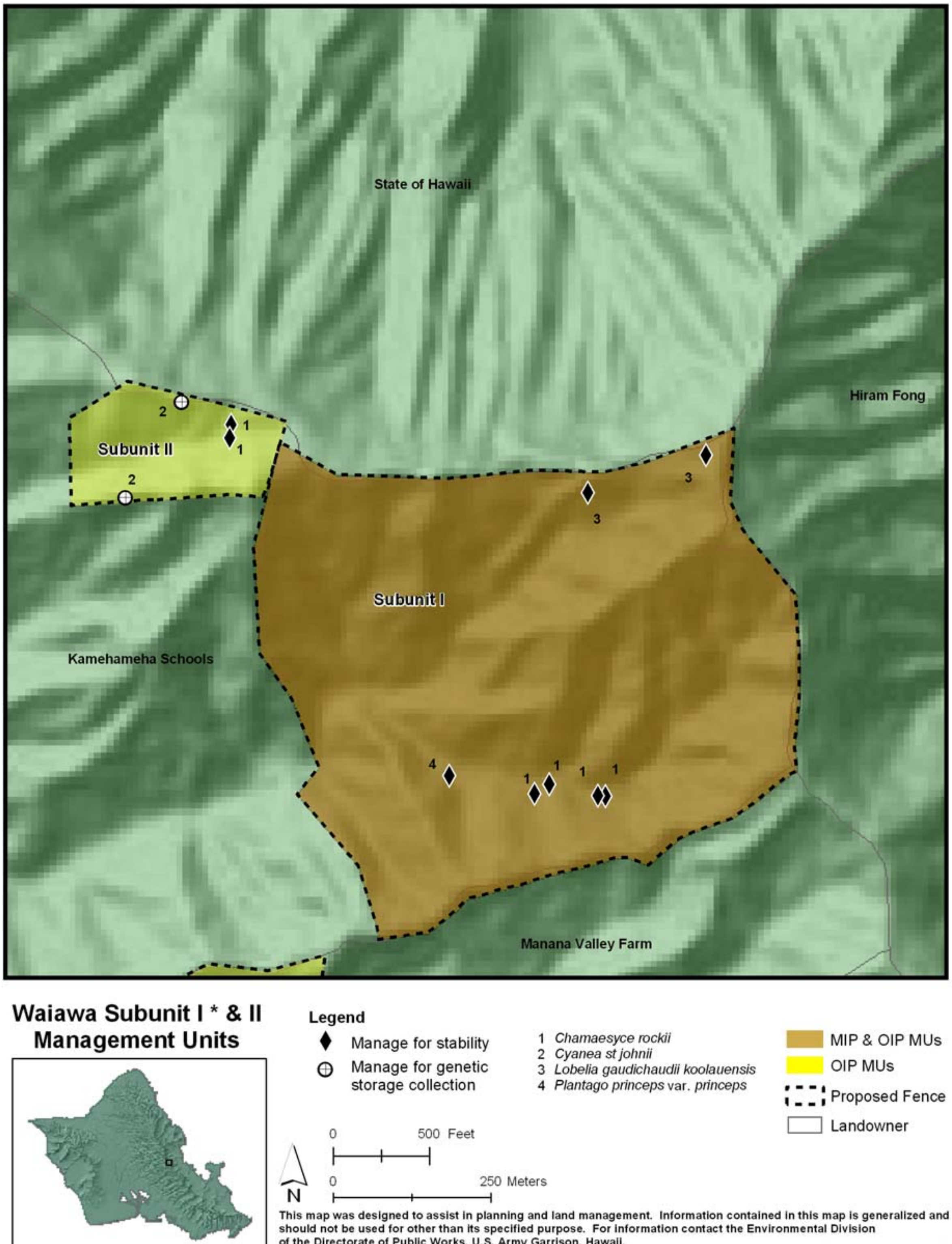


Figure 12.28 Proposed Waiawa Management Unit in the Central Koolau Mountains, Oahu.

Tier 2
12.24 Management Unit Summary: Kahana Subunit

Management Unit Name/Subunit Name		**Area (acres)**
Kahana (Koolaus, Oahu)		22.5 acres
Topography	Elevation range 1600-2000 ft.; steep ridges and gulch.	
Ownership and acreage	Kualoa Ranch Inc.	
Existing land management	Small fence around *Cyanea truncate* downstream from proposed fence. OPEP fence in Makaua valley to the east. There is a moderate level of weed control planned for this MU.	
Natural communities	Ohia (*Metrosideros*)/Uluhe (*Dicranopteris linnearis*)/Koa (*Acacia koa)* mesic to wet forest mixed with alien octopus tree (*Schefflera actinophylla*) and white moho (*Heliocarpus popayanensis*).	
Fire history	No significant fire history for the area. There is a very low fire threat.	
Human use	Hiking trails along the ridge tops, very little human use in the gulch.	
Fences	**Length (m)**	**Status- Tier 2**
	1234 m	Build in OIP year 13 This MU requires an EA and agreement with the landowner, Kualoa Ranch.

***In situ* PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

MU Name	**OIP Target Taxa**	**MIP Target Taxa**
Kahana	***Cyanea crispa* T2** *Gardenia mannii*	none

Reintroductions

N/A		

Other Significant Taxa

Cyanea truncata *Cyrtandra waiolani* *Schidea kaalae* (historical)		

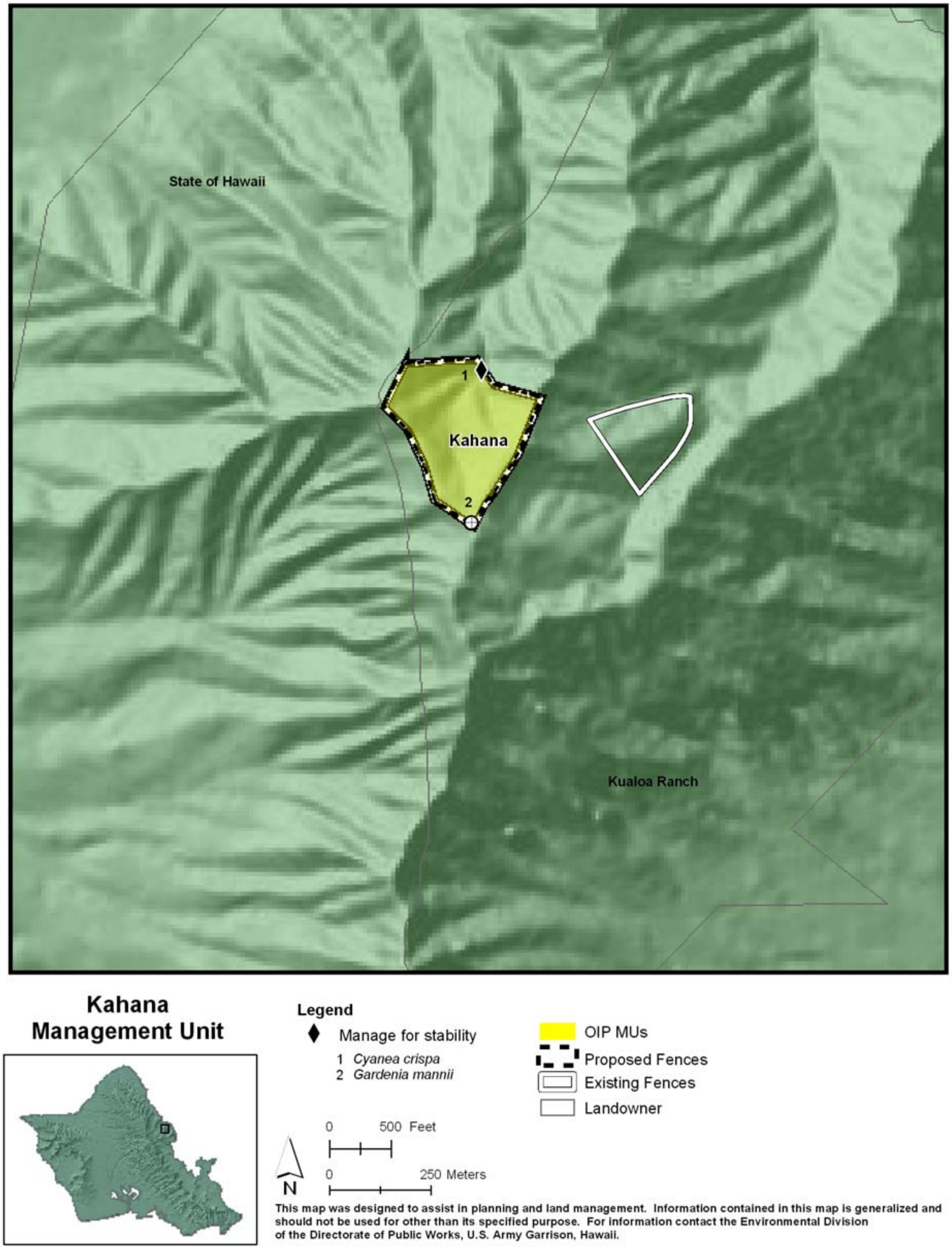


Figure 12.29 Proposed Kahana Management Unit in the Central Koolau Mountains, Oahu.

Tier 2
12.26 Management Unit Summary: Wailupe

Management Unit Name/Subunit Name		**Area (acres)**
Wailupe (Koolaus, Oahu)		21.2 acres
Topography	Elevation range 1,100-1,600 ft.; moderate to steep sided gulch.	
Ownership and acreage	State of Hawaii	
Existing land management	None. There is a moderate level of weed control planned for this MU.	
Natural communities	Mixed alien (*Psidium*) and native mesic to wet forest.	
Fire history	No significant fire history. Fire threat for this area is very low.	
Human use	Hiking trails, hunting.	
Fences	**Length (m)**	**Status- Tier 2**
MU perimeter fence	1123 m	Construct in OIP year 16 This MU requires an agreement with the landowner, State Forest Reserves. This MU also requires an EA.

***In situ* PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

MU Name	**OIP Target Taxa**	**MIP Target Taxa**
Wailupe	***Cyanea crispa* T2**	None

Reintroductions

N/A		

Other Significant Taxa

Cyanea lanceolata

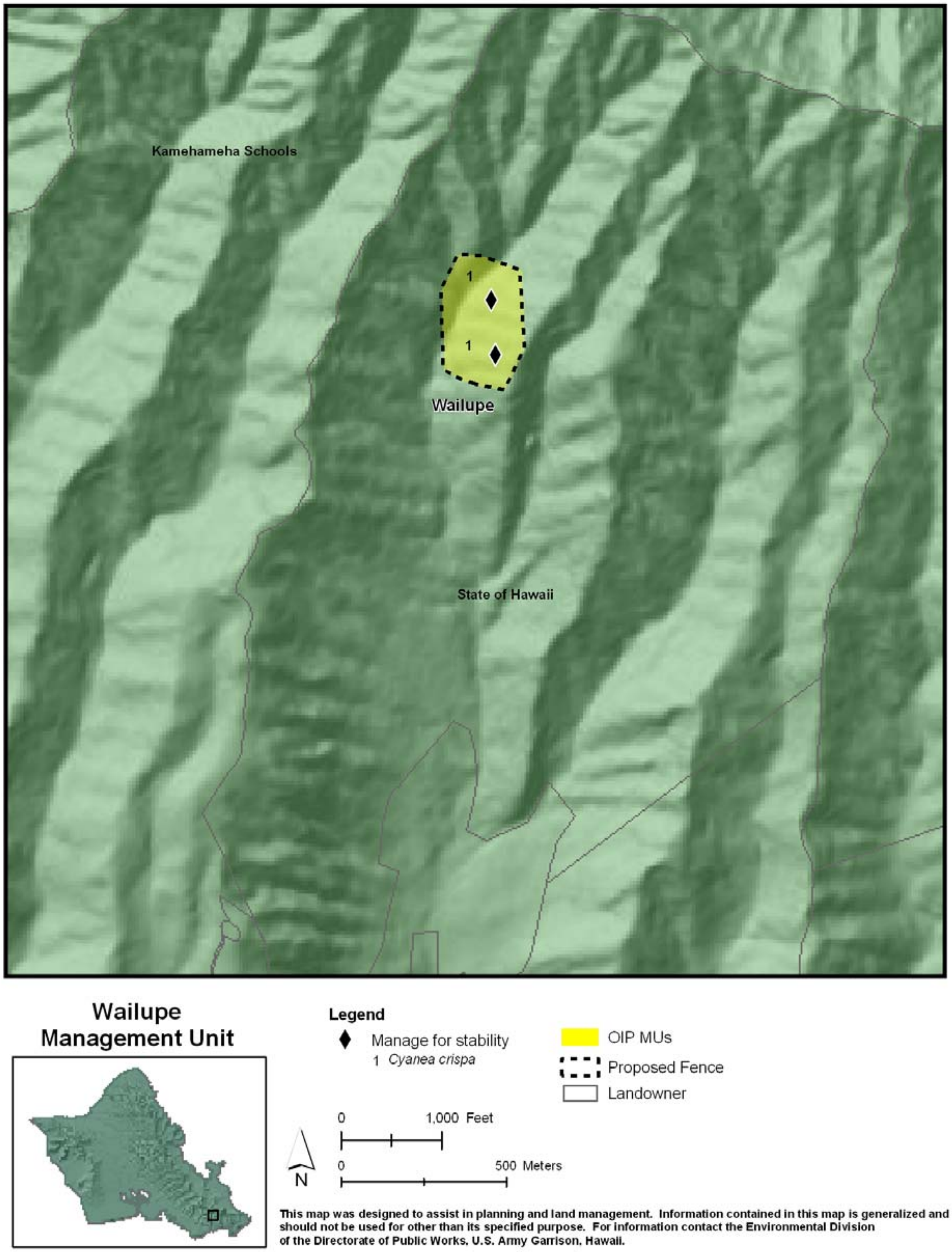


Figure 12.30 Proposed Wailupe Management Unit in the Southern Koolau Mountains, Oahu.

12.27 Management Unit Summary: Kipapa

Management Unit Name/Subunit Name		**Area (acres)**
Kipapa (Koolaus, Oahu)		3.7 acres
Topography	Elevation range 1850 – 2000 ft.; moderate sloping ridges	
Ownership and acreage	US Fish and Wildlife Refuge	
Existing land management	Oahu Wildlife Refuge. There is a low level of weed control planned for this MU.	
Natural communities	Mixed native wet shrubland including *Axonopus fissifolius*, *Metrosideros* sp., *Syzygium*, and *Sadleria*	
Fire history	No fire history for this area. Fire threat is considered very low.	
Human use	Rarely visited area. Unauthorized hunting in lower elevations.	
Fences	**Length (m)**	**Status**
MU perimeter fence	467 m	Tier 3, Construct in OIP year 12; 2019

In situ **PUs:** species in **bold** are designated as manage for stability in this MU. Stabilization priority tiers are indicated for manage for stability PUs (e.g T1 = Tier 1). *indicates OIP/MIP overlap sp.

MU Name	OIP Target Taxa	MIP Target Taxa
Kipapa	***Lobelia gaudichaudii*** **subsp. *koolauensis*** **(T3)**	None

Reintroductions:

N/A

Other Significant Taxa:

N/A

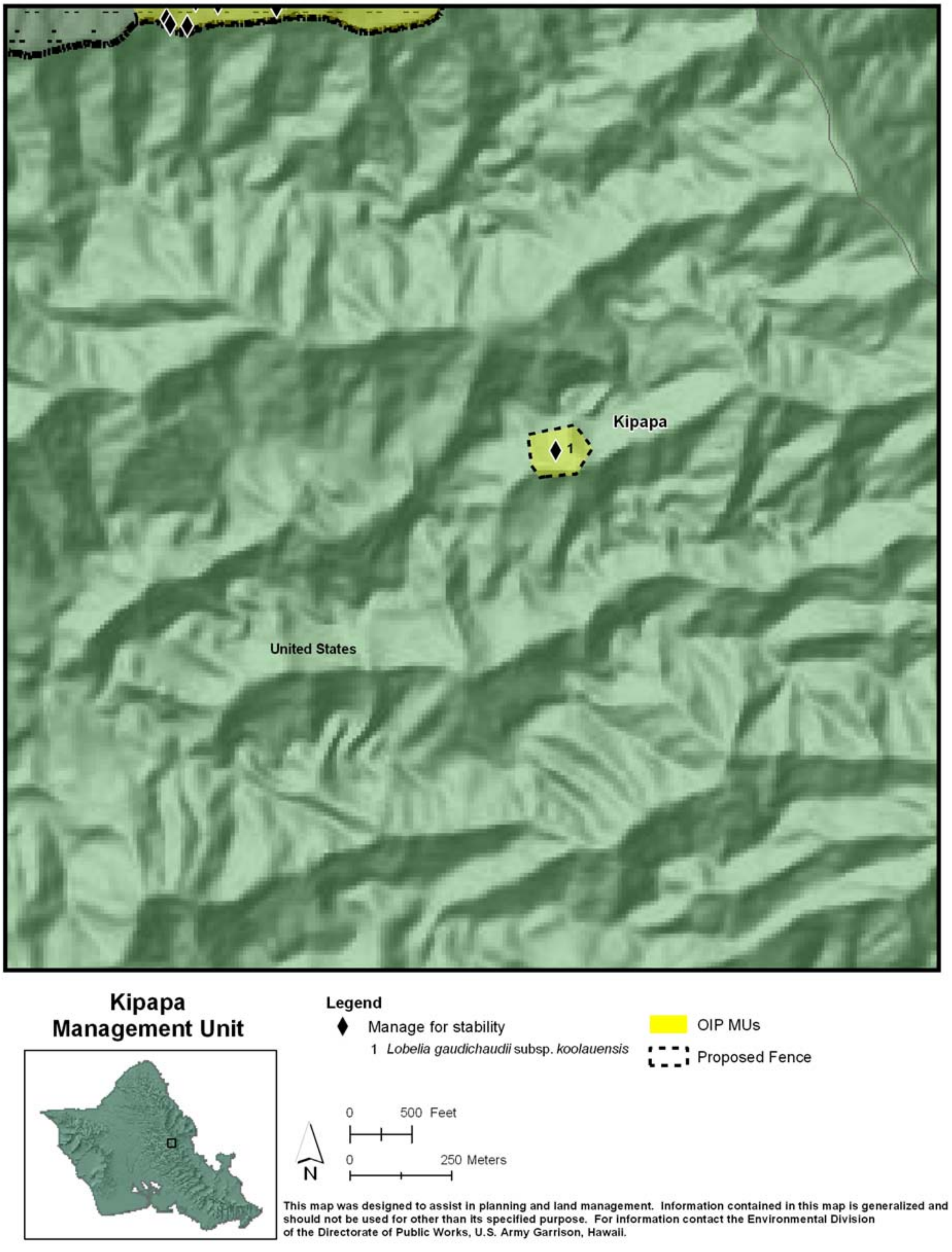


Figure 12.31 Proposed Kipapa Management Unit in the Central Koolau Mountains, Oahu.

Section 2: OIP Appendix

Appendix 1.1 Spelling of Hawaiian Place Names

Place Name	Hawaiian Spelling
Aihualama	‘Aihualama
Aimuu	Aimuu
Aiea	‘Aiea
Ekahanui	‘Ēkahanui
Eke	‘Eke
Haelelele	Hā‘ele‘ele
Halawa	Hālawa
Haleauau	Hale‘au‘au
Halona	Hālona
Hawaii	Hawai‘i
Hawaii loa	Hawai‘iloa
Helemano	Helemano
Honokohau	Honokōhau
Honolulu	Honolulu
Honouliuli	Honouliuli
Huliwai	Huliwai
Kaala	Ka‘ala
Kaawa	Ka‘awa
Kaena	Ka‘ena
Kahakuloa	Kahakuloa
Kahaluu	Kahalu‘u
Kahana	Kahana
Kahanahaiki	Kahanahāiki
Kaimuhole	Kaimuhole
Kainawaanui	Kainawa‘anui
Kaiwikoele	Kaiwiko‘ele
Kalena	Kalena
Kaluaa	Kalua‘ā
Kalauao	Kalauao
Kaleleliki	Kaleleiki
Kaluakauila	Kaluakauila
Kaluanui	Kaluanui
Kamaileunu	Kamaile‘unu
Kamananui	Kamananui
Kaipapau	Kaipapa‘u
Kapakahi	Kapakahi
Kapuna	Kapuna
Kauai	Kaua‘i
Kaukonahua	Kaukonahua
Kaunala	Kaunala
Kawaihapai	Kawaihāpai
Kawailoa	Kawailoa
Kawaiiki	Kawai Iki
Kawainui	Kawai Nui
Kawaipapa	Kawaipapa
Keaau	Kea‘au
Kealia	Keālia
Keawapilau	Keawapilau

Keawaula	Keawaʻula
Kihakapu	Kihakapu
Kipapa	Kīpapa
Koaie	Koaiʻe
Koiahi	Koʻiahi
Koloa	Koloa
Kona	Kona
Konahuanui	Kōnāhuanui
Koolau	Koʻolau
Kuaokala	Kuaokalā
Laie	Lāʻie
Lualualei	Lualualei
Lulumahu	Lulumahu
Maakua	Maʻakua
Maalaea	Māʻalaea
Mahanaloa	Mahanaloa
Makaha	Mākaha
Makaleha	Makaleha
Makolelau	Mākolelau
Makaua	Makaua
Makua	Mākua
Malaekahana	Mālaekahana
Manana	Mānana
Manoa	Mānoa
Manuka	Manukā
Manuwai	Manuwai
Maunawili	Maunawili
Maunauna	Maunauna
Maui	Maui
Mikilua	Mikilua
Moanalua	Moanalua
Mohiakea	Mohiākea
Molokai	Molokaʻi
Nanakuli	Nānākuli
Niu	Niu
Nuuanu	Nuʻuanu
Oahu	Oʻahu
Ohikilolo	ʻŌhikilolo
Ohiaai	ʻŌhiʻaʻai
Oio	ʻŌʻio
Opaeula	ʻŌpaeʻula
Paalaa Uka	Paʻalaʻa Uka
Pahipahialua	Pahipahiʻālua
Pahoa	Pāhoa
Pahole	Pahole
Palawai	Pālāwai
Palehua	Pālehua
Palikea	Palikea
Palolo	Pālolo
Pamalu	Pamalu
Papali	Papali
Peahinaia	Peahinaīʻa
Pia	Pia
Poamoho	Poamoho

Pohakea	Pōhākea
Pualii	Puali‘i
Puhawai	Pūhāwai
Pukele	Pūlele
Pulee	Pule‘ē
Puuhapapa	Pu‘u Hāpapa
Puukailio	Pu‘u Ka‘īlio
Puukaaumakua	Pu‘uka‘aumakua
Puukainapuaa	Pu‘uka‘inapua‘a
Puukaua	Pu‘ukaua
Puukawiwi	Pu‘ukawiwi
Puukumakalii	Pu‘ukūmakali‘i
Puupane	Pu‘upane
Puukanehoa	Pu‘ukānehoa
Puuokona	Pu‘uoKona
Puukeahiakahoe	Pu‘ukeahiaKahoe
Puulu	Puulu
Waahila	Wa‘ahila
Wahiawa	Wahiawā
Waialae Nui	Wai‘alae Nui
Waialua	Waialua
Waiawa	Waiawa
Waimalu	Waimalu
Waianae Kai	Wai‘anae Kai
Waieli	Wai‘eli
Waihee	Waihe‘e
Waikane	Waikapū
Wailupe	Wailupe
Waimano	Waimano
Waimea	Waimea
Wiliwilinui	Wiliwilinui

Appendix 1.2 HRPRG Reintroduction Guidelines

Reintroduction Guidelines
Hawaii Rare Plant Restoration Group
August 1999

These guidelines deal with the reintroduction of rare plants. Reintroduction should be a supplement to habitat management not a substitute. The final goal being not the success of an individual plant, but the establishment of a viable population where cross-pollination can occur and in which genetic variation is maintained. An intermediate goal may be to establish a population for field stock or research reasons. It is expected that derivatives of the material in such field stocks will be outplanted more widely once appropriate habitat is secured and stabilized. These plants can be maintained as sources of seeds, cuttings or transplants for reintroduction efforts. Research activities may be intended to identify what factors are causing mortality/decline, to test methods to overcome these factors, or validate planting techniques. Ideally, successful research efforts will be permanent outplantings in their own right. Regardless of the intent of the planting, the process of reintroduction should consider the following guidelines. Many of the guidelines require coordination with other committees within the Hawaii Rare Plant Restoration Group (HRPRG) as well as with agencies that may be collecting and propagating rare species. Included at the end of these guidelines is a list of contacts who may be contacted to consult on reintroductions. These guidelines have been broken into sections guiding actions before during and following the actual transplanting of a plant.

Prior

1. Prior to the reintroduction of a plant, there are some issues that must be considered to ensure the health of the species, the individual transplanted plant and the surrounding habitat. This must include considerations of the reproductive biology of the species to be outplanted.
    a) Genetic Stock: The agency or individual that is reintroducing a plant must coordinate with the agencies or individuals responsible for the collection, and propagation of the plant. This must be done to ensure a healthy and balanced genetic composition. In addition, a population geneticist may be consulted about strategies and alternatives when dealing with especially rare species or those with specific reproductive qualities. This is, of course, of special concern when dealing with depleted wild populations with remnant genetic stock. It should be the shared responsibility of all agencies and individuals involved to leave an easy-to-follow paper trail back to the source plant (*i.e.*, Rare Plant Monitoring Form (RPMF), greenhouse accession numbers). Reintroduction is the last chance to make sure what we are propagating and planting represents a sufficient amount of the genetic composition of the species. Recalcitrant seed-producing plants may be taken as cuttings and helped into seeding in a greenhouse to increase the overall genetic base of the outplantings. Plants used in reintroduction should be as close to the collected field stock as possible. Plants that have been in the greenhouse for multiple generations may have been selected for different conditions than the reintroduction site and may have high attrition rates when

planted. The pollination biology of each species must be researched and considered before reintroduction. Of special concern are pollen dispersal, autogamous (capable of self-pollination on a regular basis) and dioecious species, using propagules or plants from multiple year collections and mixing populations.

- When reintroducing a species that is an outcrosser, one must consider the method of pollen dispersal. For example, wind pollinated species need to be planted close enough to ensure successful cross-pollination and species which require a pollinator must be planted in an area where an appropriate pollinator is known to exist. In a situation where one needs to keep a reintroduced population distinct from a wild population the site must be far enough to not allow cross-pollination. How far is enough depends on the method of pollination (*i.e.*, wind, insects, and birds).
- One needs to determine if the species they intend to reintroduce is obligatively autogamous. Obligatively autogamous species tend to have genetically similar individuals due to their inability to outcross within a population. When collecting propagules for reintroducing an obligatively autogamous species, it is important to collect representatives from as many distinct populations as possible as opposed to getting representation from many individuals in one population as you would for an outcrossing species. If one intends to reintroduce an autogamous species it is important to maintain those distinct populations and not mix them when reintroducing. When reintroducing dioecious species one should plant equal numbers of male and female plants. If the plants are not yet mature and cannot be sexed, one should plant larger numbers of individuals to increase the effective population size.
- When selecting the plants to be used in reintroduction, one must consider the age and year the stock was collected. Using propagules or plants from multiple years ensures better age class representation and possible genetic variety of stock.
- Care should be taken not to mix gene pools that may be distinct and have local or microhabitat adaptations. A site with mixed stock should not be close to a population in which you seek to preserve representatives of geographically isolated subsets.

b) Maps: Prior to the reintroduction of a species, the area should be precisely mapped. Maps should include the historical and present range of the species, locations of known populations and proposed outplanting sites. A GIS database can also be used as a permanent record of the source of a particular population and to track the propagules. This will help ensure a genetic balance throughout the historical range.

c) Threat Abatement: Threats to a population should be noted on the RPMFs used to monitor rare species. An entity involved with reintroduction must obtain copies of the RPMF to track the genetic composition of their plants. As always consulting with anyone associated with the monitoring, collection and propagation of the species is necessary to get any other information. A management strategy addressing the threats compiled from the RPMFs should be in place before plants are reintroduced. Strategies should include measures to control the most likely threats of ungulates and competition with non-native plants. Management activities must be conducted carefully as to not further degrade the habitat for reintroduction. All threat control techniques can be pathways for pathogens and other contaminants and must be executed properly. Weeding around an outplanting site may only proceed after careful considerations of the intent. Changing light regimes and soil composition can negatively impact the habitat for reintroduced plants. In addition, threats to an outplanted population may be different from those affecting the wild populations. For example, a wild population from which propagules are collected may be fenced and weeded but an ideal outplanting site existing off site within historical range may not have any management. Reintroduction should only proceed once a management strategy for the site has been established.

d) Site Selection: Once the historical range of the species is known and a management strategy is established, a suitable site for outplanting within the range must be selected. Again coordination with the collectors and propagators is essential. A site should be chosen according to the biotic and abiotic elements that comprise the habitat for the newly transplanted population. A careful review of the RPMFs may provide all the information available on the source population. However, before outplanting, an agency or individuals should seek any additional information from anyone associated with the monitoring, collection, and propagation of the species. When interpreting historical range, one must consider that recent alterations of the habitats may have left the sites inhospitable for reintroduction. Invasion by alien species and other threats may have left the habitat within historical range unsuitable due to changes in moisture regimes and soil composition. In such cases reintroduction may be most successful in sites outside known historical locations that have maintained the critical biotic and abiotic elements necessary for successful reintroduction.

e) Reintroduction scenario: Sites for reintroduction can be placed in at least three categories each having special considerations.

   i) Reintroduction of a species within historical range: Agencies must consider what distinguishes populations from one another for each species that is to be outplanted. The site must be able to support a distinct population or one is only augmenting the adjacent population which may have different ramifications. Specific information about the habitat characteristics of the source population must be matched as close as possible with the outplanting site to provide the best chance for survival. This should be done by consulting anyone associated with the collection and propagation of the species and referring to the RPMFs.

   ii) Augmentations: This involves introducing propagules or plants into existing wild populations. This type of reintroduction must be considered on a case-by-case basis for each species. This reintroduction must be done carefully as to not harm the existing population with contaminants or physically altering the soil structure or existing roots. Augmentation may negatively alter the genetic composition of the population with propagules or plants from a single source or ones that have been raised through multiple generations in the greenhouse if not carried out strategically.

Alternative scenarios are preferred due to the difficulty in ensuring a successful reintroduction. The complex problems involved with preventing pathogens from invading the wild population lowers the desirability of this option. It is especially important to contact as many individuals or agencies as possible for comments before augmenting a population.

iii) Introduction of a species to a site outside the known historical range: Agencies or individuals considering this type of introduction need also to consider the possible negative effects on the species. Establishment of a healthy viable population may be hindered by loss of genetic variation being at a site away from other populations. Possible hybridization may occur when bringing a species outside its historical range and into the range of another related species. A site outside the known historical range may lack the habitat characteristics necessary for establishing a healthy population. Contrarily a site outside of the known historical range of the species may be the only place safe from the threats that brought the species to the remnant state we find them in today. In some cases, these sites may also offer the best management option for a particular species. It is also possible that the historical range is incomplete or no longer contain the most appropriate habitat including suitable moisture and soil composition.

f) Site Preparation: Once a proper site has been selected there are steps the agency or individuals can take to prepare it for reintroduction. In accordance with the management strategy for the species and site, it may be initially necessary to construct a small-scale exclosure and/or weed non-native competitors around the site. These actions should be taken in concurrence with protection of the greater habitat, which is critical to the success of an established population. The season in which to plant must be considered. Generally, mesic and dry plant species would face fewer challenges if planted during a wet season. If drought conditions persist for more than a year, it may be beneficial to wait for a better year if storage conditions allow. Techniques for preparing the soil to receive and support a new plant differ depending on the species. One should consider digging holes in advance and composting material on site to provide a favorable substrate. Composting materials should come from on-site and ideally be from native material. Soils may also be tested to guide soil preparation and future fertilization schemes. Coordination with the propagators is essential to ensure the fertilization and pesticide application schemes used in the greenhouse are adopted in the field. A catchment and watering system may also be considered.

During

2. The successful reintroduction from the greenhouse to the ground requires several issues to be taken into account.

a) Sanitation: Coordination with the propagator and collector is necessary to ensure that all aspects of rare plant handling are done with attention to sanitation. Collection should be done with sanitized tools and proper propagation techniques practiced to eliminate possible contaminants. Agencies and individuals involved with reintroduction need to coordinate with the propagator before the date of planting to make sure the propagules are prepared to go out. This may entail use of pesticides to ensure no foreign contaminants are transported to the site. The risk of spreading aliens via reintroduction activities must be adequately addressed and effectively eliminated. Seeds, slugs, disease, parasites, flatworms and other unintended inoculates must be prevented from being transported to the site by any aspect of the operation: protective management activities, materials, personnel and the plants themselves must all be completely free of contaminants. Care should be taken to clean all gear (boots, packs, planting tools, *etc.*) prior to arrival at the site to assure no contaminants are spread unknowingly.

b) Transport: Use caution when transporting fragile plants. Some species may need water or protection from the sun and wind during the transport. The most secure place in a vehicle for transporting plants is directly in back of the driver's seat.

c) Planting: Those involved in the planting of rare plants should be briefed before heading out to the site. Agencies and individuals directing reintroduction need to consider the techniques to be used in getting the plant from the container to the ground. Of special consideration is the decision to use a fertilizer in addition to any on site composting. In areas of low rainfall initial watering may be essential in easing the shock for the new plantings. Building up a pile of mulch around the base of a new plant can help to slow evaporation and keep water near the roots. A layer of cinder an inch thick placed around the base of a new planting can prevent slugs from reaching the plant.

Post

3. Following the reintroduction, monitoring is essential to maintain the health of the plant and the surrounding habitat.

a) Monitoring: Coordination with the agency or individual responsible for monitoring the existing populations may be necessary to see that a reintroduced population gets on a regular monitoring schedule. It is recommended that the site be monitored daily for a week after reintroduction. This close monitoring will insure that if there are problems with pests or other unforeseen threats such as drought, they can be addressed before they affect the plants. Use of the RPMF will give important information pertaining to the location, phenology, population structure, habitat characteristics and threats to the new population. Individual plants may be labeled or tagged and tracked using the RPMF. The goal of a successful reintroduction is the establishment of a viable population that maintains the genetic variability of the species and produces successful offspring. Recruitment in the wild is necessary for the reintroduction to be deemed successful. Monitoring a new population is essential to tracking the lineage of the population and to maintain local genotypes. A consistent monitoring schedule will also reduce the chance of a contaminant affecting the population or surrounding habitat. Recording the watering, fertilization and pesticide application schemes will help guide future reintroductions. Center for Plant Conservation (CPC) is currently working on a database to track safety net species including outplantings. Information on reintroduced populations should be transferred into the database.

b) Maintenance: Watering, fertilization and pesticide application may be necessary to ensure success. Supplemental watering especially in dry areas will greatly improve chances for a successful reintroduction.

c) Management: Actions after reintroduction must be taken in concurrence with a habitat management strategy. Reducing competition for resources with non-native plants by weeding may be necessary. A necessary ungulate exclosure may require maintenance.

List of Contacts

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Appendix 1.3 Plant Propagule Collection Protocols

Note: This document was written for the benefit of the Makua Implementation Plan (MIP) but is also applicable for the Oahu Implementation Plan (OIP). It has been reproduced here without major modification for those working with the OIP to reference. Two tables, reflecting the OIP taxa have been added below (see figures 2C-D).

I. Introduction: Benefits and costs of *ex situ* samples, and the context of collection

The ultimate goal of collecting seed or other samples for off site (*ex situ*) conservation purposes is to maximize the long-term survival prospects of these populations (or at least their genetic descendants) and species in their native habitats. *Ex situ* samples are thus a means to an end: continued survival of these rare and threatened species in the wild. They are also only one part of the total effort necessary to conserve these plant populations and species.

To the degree that samples can be maintained off site in good condition, they:

1. Reduce the chance that sampled individuals, populations and species will become irrecoverably lost, and
2. Provide material for use in reintroduction, research or other management options.

If done appropriately, off site samples can serve to reduce extinction risk. Collection does have a cost, however small or large, in terms of short-term survival prospects of sampled populations, and also in lost opportunities with management activities. These and other considerations must be weighed when sampling rare and endangered species for *ex situ* conservation attention.

II. Background : Center for Plant Conservation (CPC) genetic sampling guidelines for conservation collections of endangered plants and later developments

The Center for Plant Conservation's *Genetic Sampling for Conservation Collections of Endangered Plants* (CPC 1991) represent the first comprehensive attempt to create general guidelines for conservation collections. The Australian Network for Plant Conservation (ANPC) used the CPC guidelines as a basis for their own guidelines (Touchell *et al*.1997). The CPC collection guidelines are summarized below and are more thoroughly discussed in Guerrant and Pavlik (1998).

In short, the CPC guidelines provide a hierarchical series of questions to consider, and decisions to be made (Table 1). They are:

1. Which species should be collected?
2. How many populations should be sampled per species?
3. How many individuals should be sampled per population?
4. How many propagules should be collected from each individual?

When these four questions have been answered, there is another decision required: Is the desired collection level so great that it is harmful to the population, so that sampling should be distributed over two or more years?

Table 1. Summary of CPC (1991) Genetic Sampling Guidelines**

Questions/Decisions	CPC Recommended Range	Brown and Marshall 1995	Factors to Consider	Target level of biological organization	Key Considerations
Which species should be collected?	--	--	Degree of endangerment	Species	• Potential loss of unique genepool
How many populations should be sampled per species?	1-5	50	Degree of gene flow among populations	Ecotype and population	• Degree of genetic difference among populations • Population history
How many individuals should be sampled per population?	1-50	50	Diversity among individuals within each population	Individual	• 'Law of diminishing returns' on additional samples • Genetic communication within population
How many propagules should be collected from each individual?	1-20	50	Survivability of propagules	Allele	• Survivability of propagules • Long term use of collection

** One additional question/decision has been added (which community/habitat), along with alternative benchmark values recommended by Brown and Marshall (1995).

A growing consensus appears to be forming among those in the *ex situ* conservation community that, while the general framework is very useful, the recommended ranges for collection may seriously underestimate what is needed. There are two main reasons why this might be. One is that recent estimates of what constitutes a Minimum Viable Population are dramatically greater than earlier estimates, perhaps by an order of magnitude (Lande 1995, Lynch *et al*. 1995). The other stems from a combination of a greater appreciation of how difficult our basic tasks are, and how much uncertainty is involved in all steps of the process. From collecting a genetically representative sample, through maintaining it for long periods of time, and, finally, using those samples to establish new populations genetically comparable to those from which the propagules were collected are all more challenging than originally thought.

Brown and Marshall (1995) suggested that the objective should be to include in the sample at least one copy of 95% of the alleles that occurred in the large population at frequencies greater than 0.05 (5%). They note that either increasing certainty level over 95%, or dropping the critical allele frequency below 0.05 drastically increases sample size with only marginal gains. They provide what they call benchmark guidelines, which call for sampling 50 seeds each from 50 individuals per population, in 50 populations per ecogeographic portion of each species sampled. Clearly, this is far greater collection pressure than most if not all rare taxa can support, but it does provide a 'default' target to be adjusted for each species of interest, and the purposes for which collections are being made.

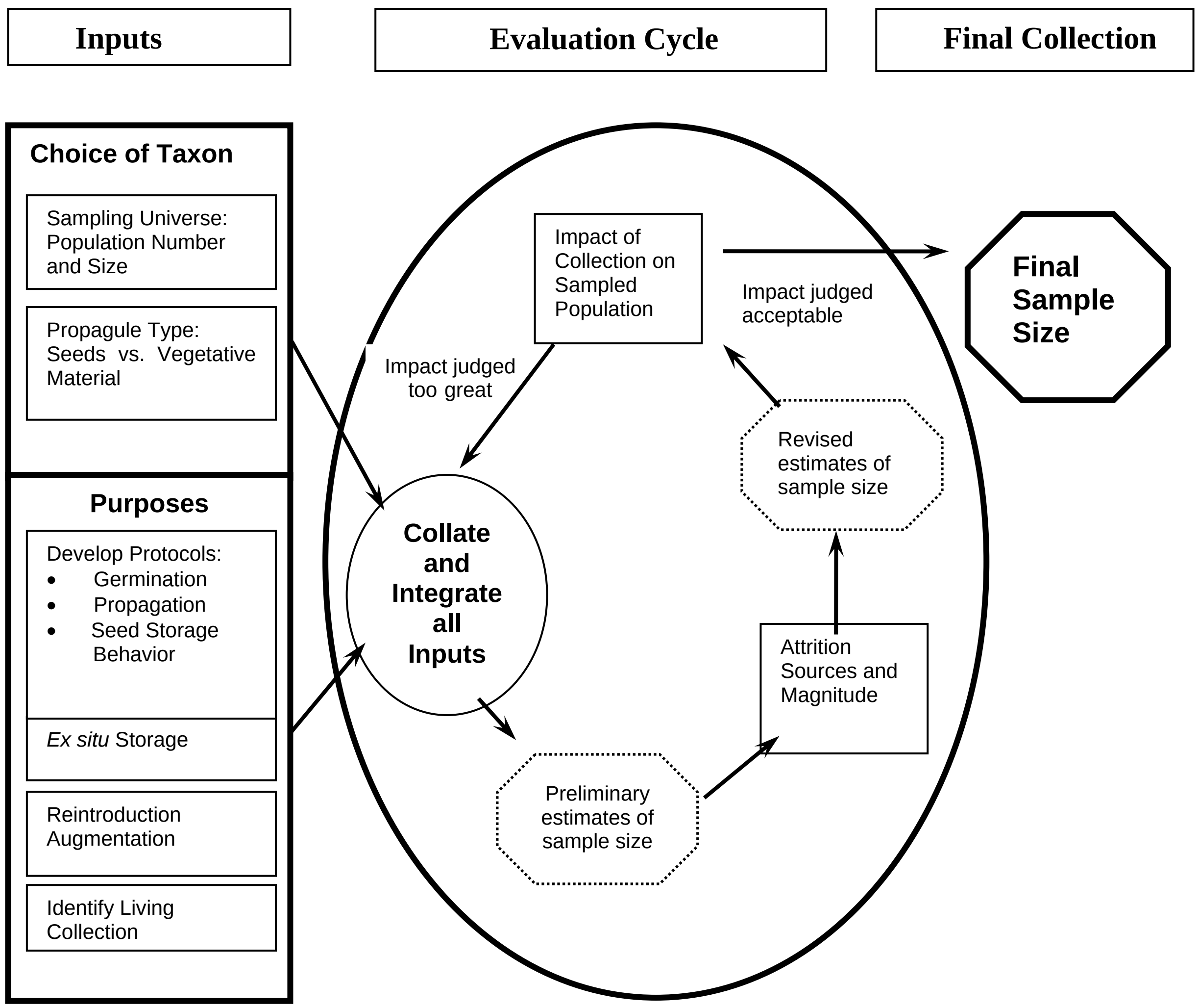
The original CPC recommended ranges were designed to describe how many propagules would be required to capture a genetic representative sample. It did not sufficiently reflect what additional material might be needed to learn how to germinate/propagate a species to compensate for possible attrition during storage, or losses during reintroduction itself. Thus, these are MINIMUM estimates of what should survive AFTER all these other factors are taken into consideration. Beyond that, the purpose for which a collection is being made will affect the appropriate sample size.

III. Overview: A process for arriving at an appropriate sample size

A complex and bewildering network of interconnected factors must be considered in the process of arriving at an appropriate sample size for a conservation collection of an endangered plant species. One way to organize the network is to view it as basically a two step process, which is driven by two independent classes of factors both of which feed into an evaluation cycle (Figure 1).

The major classes of input factors are, 1) the taxon being considered, and 2) the purposes for which samples are to be used. The choice of a taxon determines both the sampling universe (*i.e*. how many populations are known and how large are they?), and also strongly influences the type of propagules that can be used. The other major driver concerns the various purposes that an *ex situ* collection is intended to serve. With the taxon and purposes in place, initial sample size estimates can then be made. However, not all propagules collected can reasonably be expected to survive in good condition during the period of time between collection and successful use. Therefore, sufficient additional propagules will be needed to mitigate expected attrition and revised estimates made. Taking attrition into consideration, the revised sample size estimates are then evaluated for their potential impact on the sampled population. If the estimated impact is judged too great, then this additional factor is added to the sum of inputs, opportunities and constraints, and the process of evaluating needs and impact is repeated. Only when the perceived benefit of collection is judged to be sufficiently high, and the impact on the sampled population sufficiently low, is a final sample size determined.

Figure 1. Conceptual flow chart illustrating how collection size decisions might be made. Illustrated are two major input factors, the choice of taxa with which to work, and the purposes that collections are intended to serve. The information about taxa and purposes together are fed into an evaluation cycle that considers attrition to collections while off site, and the potential impact on sampled populations. If the impact is judged to be too great, then the evaluation cycle is repeated until the impact is judged acceptable.



A. Inputs

There are two main groups of factors that drive the process: The choice of taxa with which to work, and the purposes for which collections are intended to serve (Figure 1). Each of these two primary drivers has associated opportunities and constraints that flow from them.

1. Choice of taxa

The CPC guidelines focus attention on degree of endangerment, and the potential for loss of unique genepools as primary determinates of which taxa are chosen for *ex situ* treatment. The taxa for which *ex situ* treatment in the Makua and Oahu projects is considered necessary have already been chosen, so these guidelines will not address the choice of taxa as such.

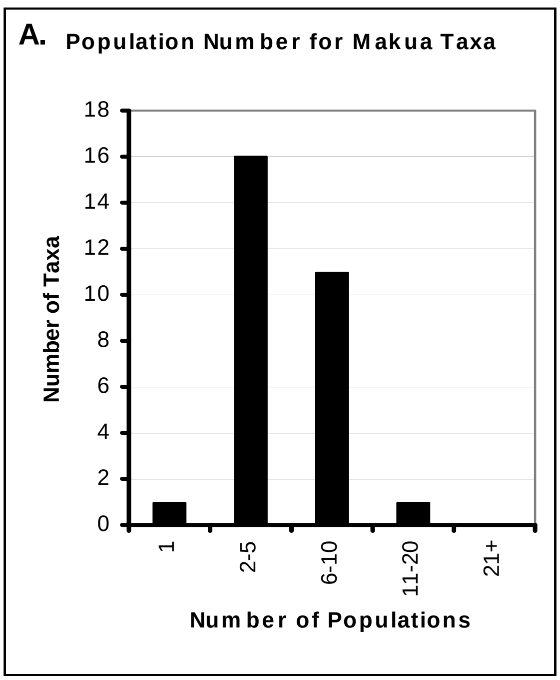
The choice of a taxon establishes two sets of opportunities and constraints. One is the sampling universe: how many populations of that taxon are known, and how large are they? The other concerns our ability to work with the taxon both horticulturally and for storage purposes: are seeds an option, and if so, how well and economically can they be stored for long periods of time, or must vegetative material be used?

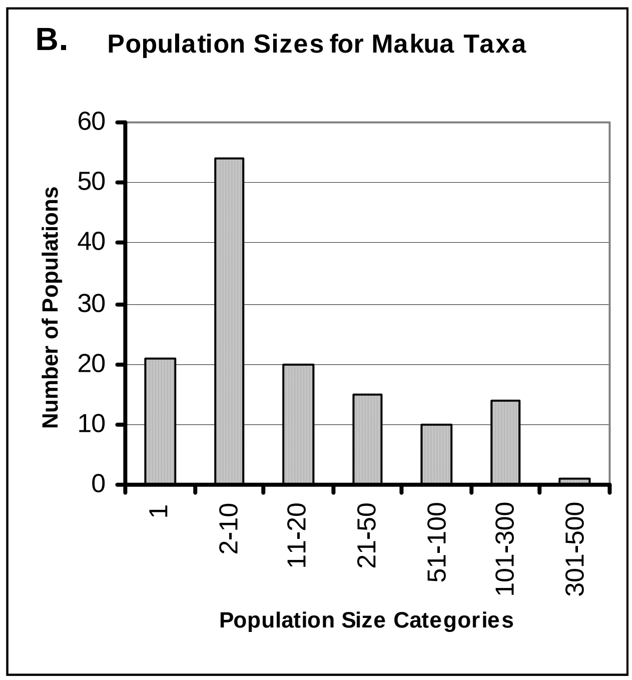
a) Sampling universe: How many populations are known, how large are they, and in what condition and management context are they found?

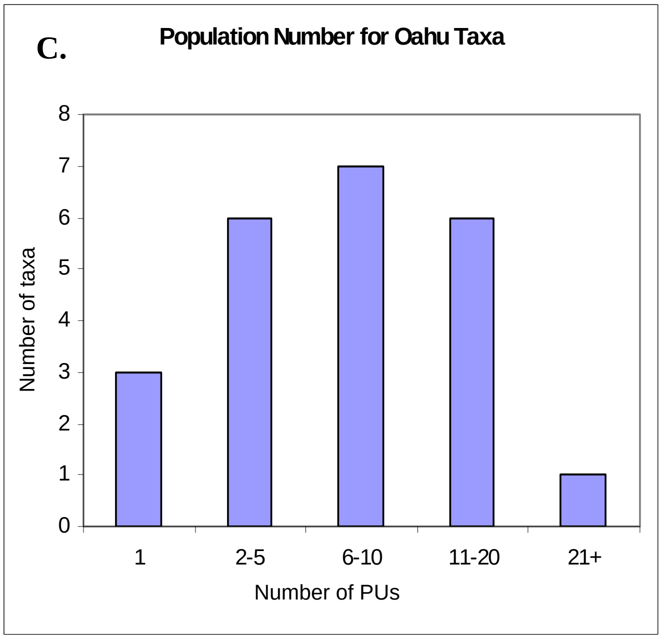
It is one thing to have an ideal target range for propagules to collect, but the actual optimal number to be taken is subject to many influences, such as population number, size and trend.

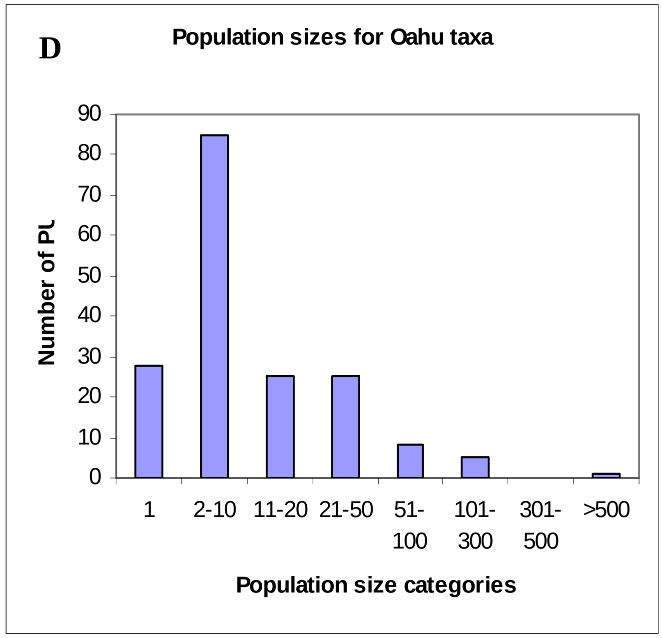
Figure 2 provides a comparison between the MIP and OIP population number and distribution based on the U.S. Fish and Wildlife Service (USFWS) categories of population number and size distributions.

Figure 2. Population number (A, C), and size (B, D) distributions (by USFWS size categories) for MIP and OIP taxa.









Clearly, the suite of taxa with which the Makua project is concerned are extremely rare, often comprised of very few occurrences of very few individuals. For the Makua target taxa the greatest number of species fall within the 2-5 PU category and the highest number of PUs fall within the 2-10 indiviudals sizecategory. Comparatively, the Oahu IP taxa appear to have a slightly different level of rarity. For the Oahu taxa many taxa also fall within the 2-5, and 6-10 PU categories, though there is also a large number of taxa with 11-20 PUs. This may be due to the higher percentage of intact habitat available to the OIP species. Though, some species in the OIP, particularly the Waianae taxa, are just as rare as many MIP taxa. Additionally, both the Makua and Oahu projects have several populations comprised of less than 20 individudals. With both the MIP and OIP taxa having the many populations with less than 10 individuals.

For as grim as these population size figures are, they may seriously over state the number of individuals from which seeds can be gathered. Seeds can only be gathered from successfully reproducing plants, and not all plants in a population are reproductive.
Recommendations: For species with 50 or fewer populations, collect from all known sites, or at least as many as is possible. For species with greater than 50 populations, collect from as many as possible, up to a total of 50. For populations with 50 or fewer individuals, collect from all known individuals; for populations with greater than 50 individuals, collect from 50.

The ultimate number of populations sampled per taxon is constrained by many factors: our ability to store them in good condition until they might be needed, the available resources, and the large number of other taxa that must be taken into consideration. Rather than get a 'complete' sample of any one species before moving on to the next, it is necessary to work with many species simultaneously. As a consequence, collection resources will probably spread strategically over many taxa simultaneously. The challenge becomes less of getting a fully adequate sample of one taxon before moving on, but getting as many samples as possible of the most critically endangered taxa first, and then gradually filling out the collections over time. Such a strategy of working with many taxa concurrently will spread collection pressure on any particular taxon over more time, which will help spread collection pressure on any one entity over more time.

b) Propagule types: Seeds and/or vegetative material?

Not only does the choice of taxa establish the sampling universe of populations and numbers of individuals with which there are to work, but also strongly influences the applicable range of horticultural and other options with which there are to work. With respect to long-term storage, those taxa with orthodox seeds offer the easiest, and most effective and economic options. For those species with recalcitrant seeds, off site samples may have to be maintained as growing collections. The relative impact on sampled populations is another factor to consider, and again, seeds are preferable to removing vegetative material.

Removal of seeds is considered less damaging demographically than removing vegetative plant parts. This conclusion is based on demographic modeling by Dr. Eric Menges (1992), in which he wrote, “The threat posed to population survival by environmental variation appeared almost entirely due to variation in mortality, growth and reproduction status and not to variation in reproductive output.” While seed collection increases environmental variation in reproductive output, taking cuttings increases the variation in growth rate and possibly mortality.

Thus, if there is a choice of propagule type (seeds vs. cuttings) – and seeds can be stored alive for long periods of time - it is generally better on the sampled plants and populations to take seeds. But, this is not always possible.

The seeds of the vast majority of species fall into one of two relatively discrete categories of seed storage behavior: orthodox or recalcitrant. Orthodox seeds can survive drying to such low moisture contents that there is no liquid water left to form ice crystals, and therefore, can be stored at temperatures below freezing without damage. Recalcitrant seeds cannot survive at such low moisture contents, and cannot, therefore, readily be stored at subfreezing temperatures.

Orthodox seeds can generally be stored alive for ‘long’ periods of time (decades or longer?) without suffering ‘significant’ ill effects. Recalcitrant seeds are generally very short lived, and cannot be stored off site without labor and resource intensive ‘heroic’ effort.

Recent work by Dr. Christina Walters (USDA National Seed Storage Laboratory, Ft. Collins, CO) and Alvin Yoshinaga (University of Hawaii) has shown that a large fraction of Hawaiian native plants have orthodox seeds. A summary for the Oahu target taxa tested and their results can be found in Appendix 1.3: CCRT Seed Storage Summary.

Recalcitrant seeded species, and those with other problems, pose greater challenges for off site storage. Unlike seed collection, cuttings reduce the photosynthetic capital of the plant to some degree, and subjects a plant to invasion by pathogens. Nevertheless, the material obtained can be maintained and proliferated in tissue culture, and can have significant conservation value.

In some cases, cuttings might be the only option. *Flueggea neowawrea*, for example, sets little seed and the few remaining plants suffer from chronic twig borer infestation; a problem for which there is currently no sure cure. *Flueggea* and other taxa threatened by twig borers might be good candidates for cryogenic storage of short segments of stem-with-a-bud. A relatively new technique has been developed for use with fruit trees in which a short segment of stem having a bud is maintained at liquid nitrogen temperatures. These samples are being used as an alternative to maintaining apple and pear varieties in an orchard setting. If borer-free shoots can be found, this might be a way to preserve these species off site until the invasive twig borers can be eliminated.

2. Purpose of collection

Along with the choice of taxa, the purposes for which a collection is being made is the second major determinant of sample size and density. At one extreme, some purposes, such as obtaining material to learn how to germinate and propagate plants or to determine their seed storage behavior, may require very little material to be gathered without much regard to its genetic make up. At another extreme, some purposes, such as salvaging what can be obtained from a doomed population for use in storage and reintroduction, may require that large samples be taken from every individual.

Note that it is not always necessary to collect additional material from the field. Suitable material (seeds, growing plants, or plant parts) may be available from other sources, such as existing samples in seed banks, *in vitro* cultures, or various cultivated sources. Where available and appropriate, material already stored off site should be used before new collections are made from wild populations, as long as the stored material is used for research or propagation/storage testing, or is not more than one generation removed from the wild population.

a) Develop protocols: Germination, propagation, seed-storage behavior, and/or reintroduction

Given the potential negative impact of collection on sampled populations, it is risky to collect material in volume before methods are available to use it well. In practice, there are taxa and situations, however, where the threat of extirpation in the wild is so high that more extreme measures might be justified. There appears to have been relatively little discussion in the conservation community of how to proceed in such extreme circumstances.

In general, there is rarely reason to think that different populations of a taxon would have significantly different germination, propagation requirements, and/or seed storage behavior. Therefore, there is no need for a statistically representative sample, as there is, for example, for storage or reintroduction. Thus, samples for these purposes should be taken from sources that will be least likely to harm survival prospects in the wild. In other words, obtain seeds (and/or cuttings) from the largest and/or most secure (or at least most dispensable) sources known. Seeds from properly identified and documented cultivated specimens are generally acceptable for these purposes. It may also be possible to minimize collection pressure by doing pilot work on closely related but more common congeners.

Absolute amounts will depend on whether standard horticultural or *in vitro* (tissue culture) techniques are used, or both.

Recommendation: For developing germination and propagation protocols, and determining seed storage behavior, begin with seeds derived from* ex situ *plants (whenever possible) or minimal collections from the most secure populations. Determine actual sample sizes in consultation with those who will be working with the material. Where possible and prudent, begin with very small samples, especially if the probability of early success is low.

Reintroduction, including augmentation, is not a simple one-size-fits-all procedure. Insofar as appropriate material is already being stored off site, it should where appropriate be used before new collections are made. Actual sample sizes will depend heavily on the questions being asked of the experiment(s), and other aspects of the reintroduction plan being considered.

Recommendation: For developing reintroduction protocols, begin with the smallest collections necessary to address the questions being posed in the experimental reintroductions.

Our ability to work with the species successfully will also influence sample size. Are seeds an option for storage, or must growing plants be used?

b) *Ex situ* conservation purposes

(1) Seed storage (in seed bank)

As a hedge against catastrophic loss in wild populations, and to provide material for reintroduction and other uses, collect and maintain off site as large and genetically representative and diverse an array of genotypes as possible without unduly compromising sampled populations. This is clearly easiest and most economical to do for taxa with long-lived orthodox seeds, which can be stored for long periods of time in standard (*i.e.*, –20ºC) seed bank facilities. The numbers and genetic diversity of these collections will, of course, be strongly influenced by the number and size of extant populations from which to collect.

The numbers required for storage depend greatly on what purposes the stored seeds are intended to serve. Should an off site collection be expected to support a single reintroduction attempt, two, or ten? Are there other purposes, such as unanticipated scientific research efforts, that an off site collection might be expected to support?

For those taxa with recalcitrant seeds, a few may be able to be stored under cryogenic conditions (*e.g.*, liquid nitrogen temperatures, approaching –200ºC). The expertise and facilities necessary to store recalcitrant seeds are much more limited than for orthodox seeds. As a practical matter, off site collections of many recalcitrant seeded species will need to be maintained as growing plants.

Recommendation: Begin calculations with generic Benchmark Guidelines for storage offsite of wild collected material (50 populations, 50 individuals/population, and 50 propagules/individual), and from that subtract or add depending on a variety of factors: purpose, sampling universe, our ability to germinate, grow and store seed, and to support and

sustain any intended reintroduction back into natural areas and sustain in the face of expected attrition.

(2) *Ex situ* storage using cultivation of growing plants

In certain cases where there is an immediate and severe risk of extirpation of a population (from fire, ungulate threat, *etc*.) and it isn't possible to collect enough seeds, living tissue may be collected to increase genetic diversity of *ex situ* stock. For small populations, there should be enough off-site plants in living collections or *inter-situ* populations to represent the genetic diversity of the wild populations, which may be used to provide adequate additional seed stock for reintroduction, augmentation, or storage.

A wide range of activities is encompassed by this category. At one extreme are small specimen collections maintained in botanic gardens, the conservation value of which, other than for education, is extremely limited. At the other extreme are medium to large-scale plantings maintained in semi-cultivated to semi-wild conditions. These have variously been called *inter situ* collections or field gene banks.

Relative to stored seed, the cost to maintain growing plants is much greater, and the probability of successfully perpetuating the genetic integrity of stored material is much less. Once the infrastructure is in place, large numbers of seed can be stored in a seed bank at relatively low actual cost, and very low marginal cost. The genetic integrity of stored samples is probably generally much greater than for population samples maintained as growing plants.

This is thought to be true for several reasons. The expected longevity of stored seed is generally much greater than for growing plants. Assuming proper seed storage facilities and techniques are available, both the absolute and relative cost of maintaining the original genetic array of a collection is much less for seeds than for growing plants. It is extremely difficult, if not impossible, to provide habitats off site that are sufficiently similar to those experienced in the wild, so as to avoid artificial selection. In addition to the deleterious genetic effects resulting from random genetic drift due to small population sizes, the genetic adaptiveness of growing samples is expected to deteriorate much faster than in dormant seed collections. Finally, there are phytosanitary and related considerations that need to be considered for growing plants, which do not affect stored seed.

Recommendation: For collections that must be maintained as growing plants, the limit is set more by the practical ability to handle a species, so numbers will generally be lower than for seed storage.

(3) Reintroduction, augmentation

Sample sizes necessary to support actual reintroductions and/or augmentations can vary widely. In general, the larger the founding population, the greater will be the chance of it surviving to become an established, self-sustaining population (Guerrant 1996). Not all reintroduction attempts will succeed, even for those species for which protocols have been established empirically. The number of reintroduction attempts and their geographic limitations that a collection is intended to support will also greatly affect the sample size required.

Recommendation: Collect from as large and diverse an array of suitable founders as seems prudent, given the sampling universe with which there is to work, and the ability to maintain the material off site between the time of collection and use.

(4) Other--including scientific research, education, interpretation, *etc*.

The sample sizes necessary to satisfy these uses are so idiosyncratic that no general recommendations seem possible.

Recommendation: Collection for these purposes should be evaluated in light of the estimated conservation or other value to the species, and the cumulative impact of all collection activities anticipated for those species and populations.

B. Evaluation cycle

Sample sizes indicated by the above factors need to be evaluated in light of the following potentially significant factors that may indicate sample sizes larger or smaller than originally indicated.

Recall that the ultimate purpose of *ex situ* collections is to enhance the survival of sampled populations, so a positive balance must be struck between the potential benefits and costs of collection. The next step in the process (Figure 1) is to reconcile the potential benefits and costs, to the benefit of the species.

With the choice of taxa and collection purposes, initial estimates of sample sizes can be made. Additional material must be added to these preliminary estimates to compensate for expected attrition between collection and use. If the potential impact of the total collection size on sampled populations is judged too great, then this information is added to the mix. The cycle of evaluation is repeated until a reasonable balance is found with what we think can be accomplished without unduly harming the sampled populations.

1. Sources of attrition in *ex situ* collections, between collection and successful establishment

It is one thing to collect a genetically representative population sample and quite another to have sufficient and appropriate material available to establish a new, genetically comparable population if and when it becomes necessary. There are many steps along the way in which mortality and other losses can occur, both in terms of sheer numbers and in genetic diversity. In this section, we will consider various sources of attrition, what it takes to monitor them, and how losses can be mitigated.

a) Survivorship and genetic change in collections

Perhaps the most basic source of loss is due to mortality during off site storage. There may be large differences in mortality rates among different propagule types and different taxa within a propagule type. Off site collections that must be stored as growing plants present a much more formidable challenge than those that can be stored as dried and frozen seed, and those stored as *in vitro* cultures are presumably somewhere in between.

There are several reasons why growing plants off site for conservation purposes is less desirable than storing them as seeds or as *in vitro* cultures, not the least of which are the resources required to maintain a given number of plants over a long period of time. First, to avoid the genetic losses and other changes that are likely to occur when population sizes are small, a large number of plants must be grown for, perhaps, many generations. The amount of space, man-power and other resources that must be expended to maintain just one population of one species is daunting indeed. If this were not problem enough, growing plants off site will inevitably subject them to a selective environment different than that in which they evolved, thus eroding their ability to survive when their descendants are used for reintroduction back into the wild. The most extreme illustration of this phenomenon is where plants grown off site under conditions sufficiently different than their native habitats cannot survive when returned to their native habitats. While this might seem fanciful to some, it or something close to it happened when the attempt was made to reintroduce to Tenerife, in the Canary Islands, a long established line of *Lotus berthelotii* that had been grown in Europe. The plants all died in the nursery on Gran Canaria, apparently as a result of the higher temperatures there than where they had been grown (Maunder and Bramwell pers. comm.). Another less extreme but still telling example is that of *Amsinckia grandiflora* (Pavlik *et al*. 1993, Pavlik 1995), in which plants were grown at the University of California at Davis in what would seem to be very similar conditions to, and within a few miles of, their native habitat. Electrophoretic analysis of seeds collected twenty years before and held in storage indicated relatively low genetic diversity, but seeds derived from plants grown off site for just a couple of generations showed even less. Although the plants were large and vigorous when grown off site, the pin/thrum ratio of this heterostylous plant was very different in cultivation than it was in the donor population. This suggests that plants derived from seeds grown off site might be less fit when reintroduced than those that had not. Finally, sanitation issues – keeping reintroductions from being a vehicle for introducing pests, pathogens, and weeds into the wild – are most acute when plants are grown off site; the danger of picking up pests and pathogens increases with time in off site cultivation.

Taxa with orthodox seeds are at the other extreme, where large samples can be in frozen storage for long periods of time with little maintenance and at a relatively low marginal cost. Seeds of some taxa can presumably be stored for decades, even centuries, with little mortality. We aren't aware of information about the degree to which mortality in seeds banks is selective or random.

Recommendation: Monitor survivorship and health of off site growing collections and respond appropriately. The emphasis should be on improving cultural conditions rather than additional collection.

b) Monitoring survival rates of stored seed

Although potential mortality rates appear to be quite low in stored seed, survival must nevertheless be monitored. The only sure way to do this is to attempt to germinate samples when they enter the seed bank, and periodically thereafter. This is not as simple as it might seem.

First, it is necessary to know how best to germinate the sampled population (Baskin and Baskin 1998). While germination requirements are often thought to be species specific, there are examples where germination requirements, at least of widespread species, may differ significantly among populations (*e.g.,* Meyer 1992). Once a suitable protocol is established, it is necessary to subject different seed batches to comparable conditions in order to assess changes in germinability over time. Otherwise, germination rate differences might be due to environmental causes. This will presumably require the use of controlled environment chambers, as ambient outdoor conditions are not sufficiently similar between years.

Interpreting the results of comparisons between different trials is the next hurdle to overcome. While the magnitude of what constitutes a significant decline is a subjective decision, it is possible to analyze sample sizes necessary to detect a given decline. In their Guidelines for the Maintenance of Orthodox Seeds, the CPC (Weiland 1995) suggest a 15% decline as a reasonable threshold to trigger action (either recollection, or a grow-out).

Ideally, the results of statistical tests on seed samples to determine if there has been germinability decline accurately reflect the true condition of the seed lot. However, it is possible, due to chance alone, that our tests will indicate a decline when, in fact, there is none. This is a Type I, or False Change Error, and the probability of making it can be considered the **significance of the test**. Designated α, this is the p-value commonly cited when a difference is found. Alternatively, and again due to chance alone, a test may fail to indicate a decline when, in fact there has been one. This is known as a Type II, or Missed Change Error, and our ability to avoid it is known as the **power of a test**. In other words, the power of a test is a measure of how likely our test is to detect a given decline, if there really is one. It is, of course, easier to detect a large decline than a small one, so it is necessary to designate the minimum detectable change when specifying the power of a test. There is no single sample size necessary to detect a given decline. Sample size varies, among other things, according to how tolerant you are of making the two kinds of errors. This is a subjective decision that involves tradeoffs. As the desired significance of a test increases, power declines.

The sample size necessary to detect a given decline also varies with the initial germinability of a seed lot. Figures 3-6 illustrate the differing relationships of statistical power as a function of sample size differences when initial germinability is either 90% or 50%, and the desired significance of the tests are either p=0.1 or p=0.01. There are three patterns to note. First, power increases dramatically as minimum detectable difference increases. Second, to detect a given decline for a given sample size, statistical power is greater if initial germination rate is 90% rather than 50%. Tests are least sensitive when the initial germinability is 50%, and more sensitive toward either extreme. Third, note the increase in statistical power associated with a greater tolerance for making a False Change Error (where α=p=0.1 versus α=p=0.01). Sample sizes refer to the number of seed used in each test, not the sum of two or more tests.

Fig. 3 Chi-square Test of Proportions (Two tailed test)
Higher = **0.9**, alpha or p = **0.01**

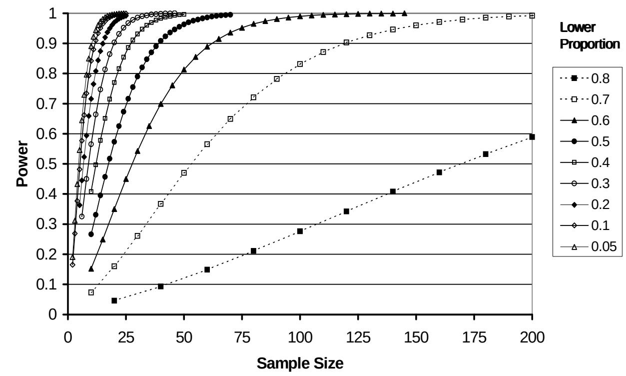


Fig. 4 Chi-square Test of Proportions (Two tailed test)
Higher = **0.9**, alpha or p = **0.1**

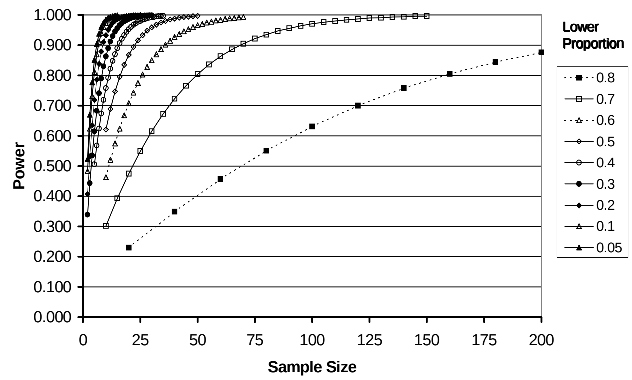


Fig 5. Chi-square Test of Proportions (Two tailed test)
Higher = **0.5**, alpha or p = **0.01**

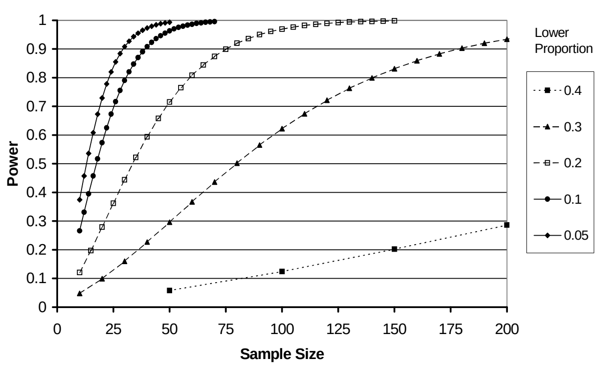
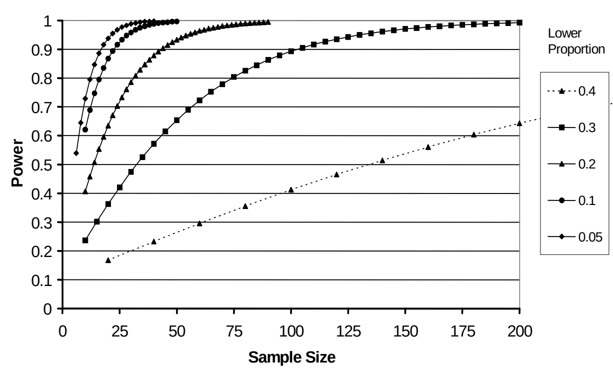


Fig. 6. Chi-square Test of Proportions (Two tailed test)
Higher = **0.5**, alpha or p = **0.10**



This method of analysis presents several dilemmas. One is that we must choose sample size before we know what the initial germination fraction is. Pilot studies are helpful, but use additional seed. Given the rather large sample sizes often needed to detect changes of a magnitude we might like, we simply will not have (or be willing to use) sufficient seed to be able to monitor a collection as closely as we might like. This sobering fact is especially true when seeds from each maternal parent are maintained separately – which is definitely preferred over bulk collections. This raises a policy choice about how precisely we can know the status of a collection. Resolution of this basic dilemma awaits further discussion in the conservation community. Nevertheless, even small samples can provide meaningful (if not very precise) information about the viability and longevity of a seed stock.

Recommendation: Unless very large samples are available, it is unlikely there will be sufficient seed to monitor viability with any high degree of precision.

c) Demographic costs of reintroduction: Modeling 'expected' attrition using empirical demographic data

Population size targets, often specifying numbers of mature plants, are indicated in reintroduction plans for each project. While it is not reasonable to expect that all propagules planted will survive to reproduce, what is a reasonable expectation? In order to estimate the range of post-planting decline in population size that might be expected during reintroduction, Guerrant and Fiedler (2003) used empirically derived stage-based transition matrices for a variety of life histories from the literature as a basis for stochastic modeling.

They found, not surprisingly, that the demographic cost during reintroduction can be substantial. In the most extreme case, an outplanting of 1,000 *Panax* seedlings would, on average, drop to just 15 individuals within three years before the simulated populations began to rise. But, of course, many simulated runs ended with extirpation before any increase could begin. If the newly established populations are to have anything like the genetic diversity of the ones from which the founders were collected, expected losses during reintroduction must be accounted for in the original collection. These data are, of course, simulated results based on wild populations with positive growth rates. One assumption of these models is that outplanted individuals will behave demographically identically to naturally occurring plants, which is probably optimistic. Another assumption of the models is that the series of years for which data were gathered in the field accurately reflect what will happen during a reintroduction. Presumably there will be many stochastic environmental effects that cannot be anticipated, but which will affect establishment. Using similar techniques and comparable seed supplies (planted in the field near where they were collected the year they were collected) a series of 27 field germination and seedling establishment trials of *Erythronium elegans* set out yearly with fresh seed each year over a 5-year period spanned the range from 0-94% establishment (Guerrant 1999). Clearly, attrition can be high, and vary greatly among different years.

The implications for collection guidelines to support even one reintroduction attempt are daunting. To compensate for expected losses of these magnitudes suggests that sample sizes might need to be one or two orders of magnitude greater than current suggestions. Unfortunately, such collections either may be too great for sampled populations to bear, or prohibitively expensive in time and other resources needed to collect, store and monitor. In addition to increased sample sizes, other ways to compensate for potential losses associated with reintroduction must be explored.

One such alternative is to use larger founding individuals, which might be expected to have greater survivorship than smaller founders. So, too, any post-planting care that can be provided to increase survivorship of the founding individuals should also reduce the sample size requirements.

Recommendations: Start with an estimate of desired numbers surviving to reproduction, and then account for expected losses during establishment. Maintaining backup clonal material can mitigate some of these losses.

2. What is the effect of collection on extinction risk of sampled population?

The ultimate purpose of *ex situ* collections is to enhance the long-term survival prospects of sampled populations. Thus, for collection itself to harm the sampled population in the short-term is generally to be avoided. However, even in the absence of collection, at what point does the short-term risk of extinction become so great that sampling at a rate that is harmful becomes justified?

a) General condition: Minimum risk to sampled population

The final question posed by the CPC genetic sampling guidelines was the least developed: What level of collection necessitates a multi-year collection strategy? Eric Menges, Samara Hamzé and Ed Guerrant have recently addressed this question with a computer simulation study.

The following paragraphs are the abstract for the manuscript, which is currently in review (and thus subject to change):

"Seeds are widely considered to be the propagule of choice for *ex situ* conservation collections elative to cuttings or transplants, seeds can easily be collected in large numbers and stored alive for long periods of time; their harvest is thought to be the least damaging to the sampled populations.

"Guidelines for amounts and timing of seed harvests, however, have not been grounded in demographic data or projections. We examined the demographic consequences of 36 patterns of seed harvests: 10, 50, and 100% of fecundity for 10, 50, and 90% of years, on populations of 10, 50, 100, and 500 plants. We compared these results to no-harvest scenarios with the same four initial population sizes. We used published projection matrices from about two dozen plant species encompassing a range of life forms. We modeled using stochastic simulations, alternating projection matrices representing different years and different harvesting intensities. For each species, we examined 40 combinations of conditions in 1,000 replicate simulations for 100 years each and we calculated the proportion of replicates becoming extinct.

"Species differed in sensitivity to seed harvest, with long-lived species, especially woody plants, being least sensitive. Populations of 500 or more were not harmed except by complete harvests for half or more of all years. Small populations of ten were harmed by less complete harvesting, but sensitivity varied widely by species.

"Our modeling suggests three seed harvest rules:

1. Harvesting 10% of seeds in 10% of years (or less) is generally safe.
2. Harvesting 50% of seeds in 50% of years (or more) is generally unsafe.
3. Less intense, frequent harvests are safer than more-intense, infrequent harvests.

Although these analyses encompass many mathematical, biological, and sociological assumptions, they suggest that prudent seed harvesting will not have significant short-term demographic effects."

Recommendation: Less intense, frequent harvests are expected to have less of an impact on sampled populations than more-intense, infrequent harvests. To the degree possible, spread collection out over two or more years, especially for small populations.

b) Special case: intentionally collect enough to cause short-term risk to sampled population

As stated in the first section, given the potential negative impact of collection on sampled populations, it is risky to collect material in volume before methods are available to use it well. In practice, there are taxa and situations, however, where the threat of extirpation in the wild is so high that more extreme measures might be justified; situations in which it might be necessary to act sooner rather than later.

The Makua IT must deal with many species that are so extremely rare and/or endangered that "we may not be able to safely wait until we get the propagation and genetic storage procedures worked out" (Bruegmann and Jacobi, pers. comm.). The same is true of some OIP species. However, the OIP target taxa have already benefited from the massive effort underway for the Makua IP. Through the MIP, collection effort the knowledge base regarding phenology, propagation, and germination of multiple genera and species has increased significantly.

Note that the minimum population size Menges *et al.* (2003) modeled was 10 individuals. Part of our reasoning is the belief that populations this small and especially smaller are inherently threatened with extinction, due simply to chance. In the manuscript, Menges *et al.* noted that declining populations represent special cases, where other considerations might become important. If a population is in decline and sliding toward extirpation anyway, collection did not affect the end result – extirpation - just the timing. In such cases, the potential benefits of collection must be weighed against the additional pressure of collection on extinction risk. Another area not covered directly in the models concerns very small and other populations where the probability of extirpation in the foreseeable future due to random factors is so high, that additional risk of 'rescue' collections might be of conservation value. Many of the very small populations managed through MIP and OIP probably fall into this category.

The question arises then of what to do with very small or other populations you have reason to think are particularly susceptible to extirpation in the near to medium term (say 5-25 years).

While it is always best to keep in mind the dictum – Do No Harm - it may be necessary in some situations to collect so much material that collection itself becomes a serious threat to the sampled wild population, at least in the short term. The effort to recover the California Condor – which is highly endangered even by Hawaii standards - is a case in point. ALL wild birds were captured, thus driving the species to 'extinction in the wild' – at least temporarily. These birds were and are being used in a captive-breeding program, and the goal is to release many more individuals into the wild (and in more areas than just the collection sites) than were removed. Thus, we may find ourselves in the uncomfortable position of 'destroying' something in order to save it.

Recommendation: For populations of species with low numbers overall, that have 10 or fewer reproductive individuals and a poor history of recruitment, or a population known to be in precipitous decline, collect 20-100% of seed at the discretion of the permitted collector. Such collection levels assume, of course, that adequate facilities and procedures are available to

care for the material, and that such collections are part of a more inclusive strategy. For those situations in which germination, propagation, or seed storage methods are not yet available, it may be necessary to collect some material to better ensure the continued existence of the species or populations in question.

C. Final collection guidelines considering the above factors

To determine the sample sizes that must be collected, use the accompanying worksheets (Tables 2 and 3) to clarify how much is needed for all purposes that are intended to be served, and how much suitable material is in off site collections already.

Genetic Sampling Guidelines Worksheet: Preliminary Estimates Taxon ___________________________________

Page __ of ___	**Population** For each population indicate name and number of mature and juveniles above preliminary target numbers for collection.														
Purpose of Collection	Mat		Juv	Mat		Juv	Mat		Juv	Mat		Juv	Mat		Juv
	Indiv	Prop /indiv	Tot Prop	Indiv	Prop /indiv	Tot Prop	Indiv	Prop /indiv	Tot Prop	Indiv	Prop /indiv	Tot Prop	Indiv	Prop /indiv	Tot Prop
To develop protocols															
Germination															
Propagation (standard Hort. proc.)															
Propagation (in vitro)															
Seed Storage Behavior															
Ex situ storage															
Orthodox Seed															
Attrition (rate)															
Recalcitrant Seed															
Attrition (rate)															
In vitro slow growth															
Attrition (rate)															
In Cultivation															
Attrition (rate)															
Reintroduction															
Attrition rate (inc. demog. cost)															
Augmentation															
Attrition rate (inc. demog. cost)															
Other															
Is multi-year collection plan indicated?															

2

Genetic Sampling Guidelines Worksheet: Page 2 Taxon ___________________________________

4

Sampling Universe by population		**Existing Collections**			**Final Targets for Collection**			Notes
	Pop size	Seeds	Growing Plants	In vitro	Indiv	Prop/ indiv	Multi-yr col.	

TABLE ABBREVIATIONS:					
col: collection	demog: demographic	Hort: Horticultural	inc: include (ing)	Indiv: Individual(s)	
Juv: Juvenile(s)	Mat: Matured	pop: population	proc: procedures	Prop: propagules	Tot: total

IV. Conclusions

The basic structure set out in the original Center for Plant Conservation Guidelines for Conservation Collections of Endangered Plants are sound, but the actual numbers need to be revised upward. In the most recent and thorough statistical treatment of sampling strategy, Brown and Marshall (1995) have a benchmark target of 50 individuals per population in each of 50 populations per ecogeographic region per taxon, which are here suggested as a benchmark against which actual sample sizes are determined.

All numbers are, of course, subject to change, and any collection strategy must be tempered with consideration for the purpose of collection, ability to maintain the samples in good condition off site, and any damage to wild populations done by collecting itself. After all, off site samples are part of a larger integrated conservation program; the ultimate purpose of which is to increase the long-term survival prospects of sampled populations in the wild.

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Appendix 1.3 Plant Propagule Collection Protocols

Note: This document was written for the benefit of the Makua Implementation Plan (MIP) but is also applicable for the Oahu Implementation Plan (OIP). It has been reproduced here without major modification for those working with the OIP to reference. Two tables, reflecting the OIP taxa have been added below (see figures 2C-D).

I. Introduction: Benefits and costs of *ex situ* samples, and the context of collection

The ultimate goal of collecting seed or other samples for off site (*ex situ*) conservation purposes is to maximize the long-term survival prospects of these populations (or at least their genetic descendants) and species in their native habitats. *Ex situ* samples are thus a means to an end: continued survival of these rare and threatened species in the wild. They are also only one part of the total effort necessary to conserve these plant populations and species.

To the degree that samples can be maintained off site in good condition, they:

1. Reduce the chance that sampled individuals, populations and species will become irrecoverably lost, and
2. Provide material for use in reintroduction, research or other management options.

If done appropriately, off site samples can serve to reduce extinction risk. Collection does have a cost, however small or large, in terms of short-term survival prospects of sampled populations, and also in lost opportunities with management activities. These and other considerations must be weighed when sampling rare and endangered species for *ex situ* conservation attention.

II. Background : Center for Plant Conservation (CPC) genetic sampling guidelines for conservation collections of endangered plants and later developments

The Center for Plant Conservation's *Genetic Sampling for Conservation Collections of Endangered Plants* (CPC 1991) represent the first comprehensive attempt to create general guidelines for conservation collections. The Australian Network for Plant Conservation (ANPC) used the CPC guidelines as a basis for their own guidelines (Touchell *et al*.1997). The CPC collection guidelines are summarized below and are more thoroughly discussed in Guerrant and Pavlik (1998).

In short, the CPC guidelines provide a hierarchical series of questions to consider, and decisions to be made (Table 1). They are:

1. Which species should be collected?
2. How many populations should be sampled per species?
3. How many individuals should be sampled per population?
4. How many propagules should be collected from each individual?

When these four questions have been answered, there is another decision required: Is the desired collection level so great that it is harmful to the population, so that sampling should be distributed over two or more years?

Table 1. Summary of CPC (1991) Genetic Sampling Guidelines**

Questions/Decisions	CPC Recommended Range	Brown and Marshall 1995	Factors to Consider	Target level of biological organization	Key Considerations
Which species should be collected?	--	--	Degree of endangerment	Species	• Potential loss of unique genepool
How many populations should be sampled per species?	1-5	50	Degree of gene flow among populations	Ecotype and population	• Degree of genetic difference among populations • Population history
How many individuals should be sampled per population?	1-50	50	Diversity among individuals within each population	Individual	• 'Law of diminishing returns' on additional samples • Genetic communication within population
How many propagules should be collected from each individual?	1-20	50	Survivability of propagules	Allele	• Survivability of propagules • Long term use of collection

** One additional question/decision has been added (which community/habitat), along with alternative benchmark values recommended by Brown and Marshall (1995).

A growing consensus appears to be forming among those in the *ex situ* conservation community that, while the general framework is very useful, the recommended ranges for collection may seriously underestimate what is needed. There are two main reasons why this might be. One is that recent estimates of what constitutes a Minimum Viable Population are dramatically greater than earlier estimates, perhaps by an order of magnitude (Lande 1995, Lynch *et al*. 1995). The other stems from a combination of a greater appreciation of how difficult our basic tasks are, and how much uncertainty is involved in all steps of the process. From collecting a genetically representative sample, through maintaining it for long periods of time, and, finally, using those samples to establish new populations genetically comparable to those from which the propagules were collected are all more challenging than originally thought.

Brown and Marshall (1995) suggested that the objective should be to include in the sample at least one copy of 95% of the alleles that occurred in the large population at frequencies greater than 0.05 (5%). They note that either increasing certainty level over 95%, or dropping the critical allele frequency below 0.05 drastically increases sample size with only marginal gains. They provide what they call benchmark guidelines, which call for sampling 50 seeds each from 50 individuals per population, in 50 populations per ecogeographic portion of each species sampled. Clearly, this is far greater collection pressure than most if not all rare taxa can support, but it does provide a 'default' target to be adjusted for each species of interest, and the purposes for which collections are being made.

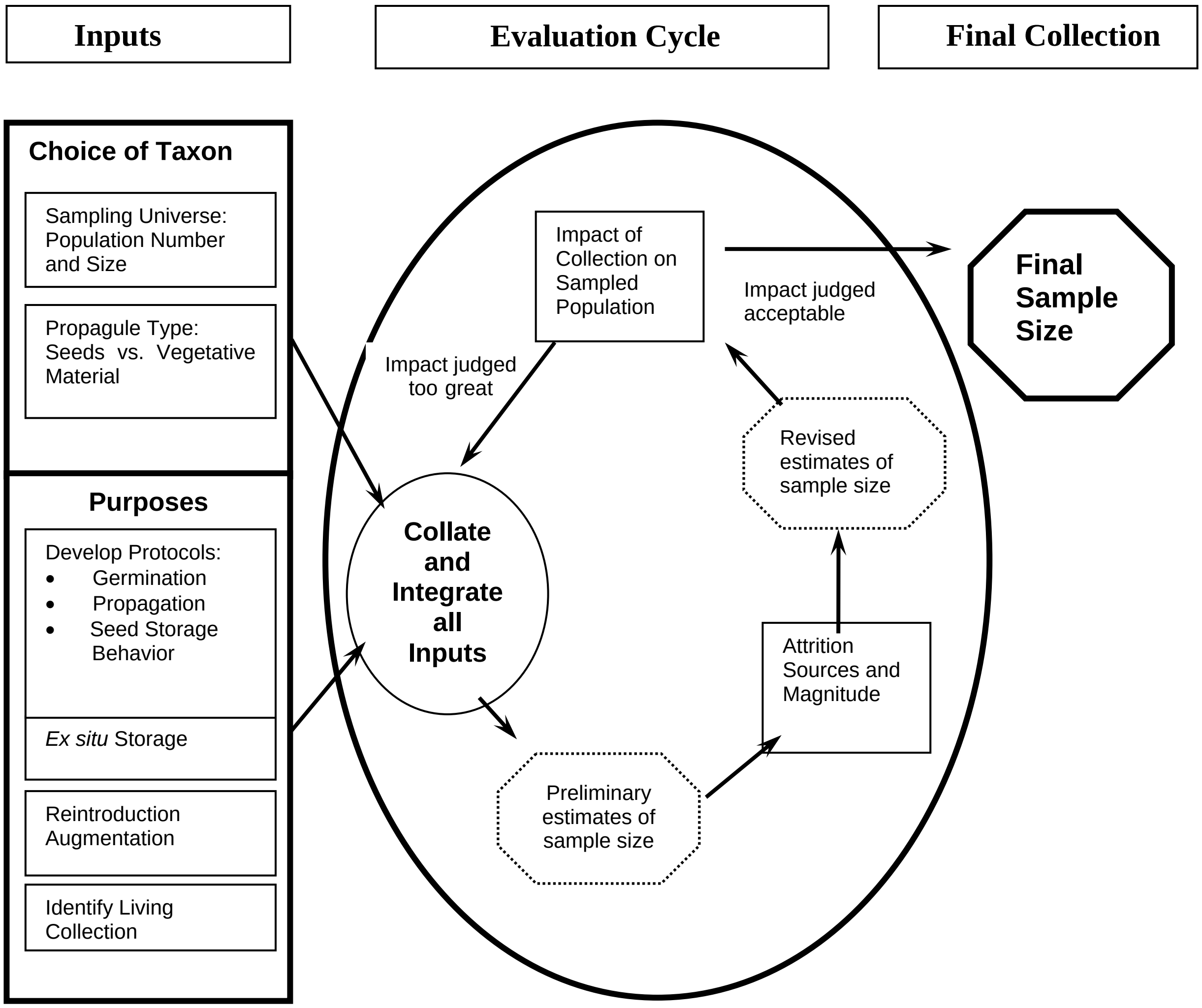
The original CPC recommended ranges were designed to describe how many propagules would be required to capture a genetic representative sample. It did not sufficiently reflect what additional material might be needed to learn how to germinate/propagate a species to compensate for possible attrition during storage, or losses during reintroduction itself. Thus, these are MINIMUM estimates of what should survive AFTER all these other factors are taken into consideration. Beyond that, the purpose for which a collection is being made will affect the appropriate sample size.

III. Overview: A process for arriving at an appropriate sample size

A complex and bewildering network of interconnected factors must be considered in the process of arriving at an appropriate sample size for a conservation collection of an endangered plant species. One way to organize the network is to view it as basically a two step process, which is driven by two independent classes of factors both of which feed into an evaluation cycle (Figure 1).

The major classes of input factors are, 1) the taxon being considered, and 2) the purposes for which samples are to be used. The choice of a taxon determines both the sampling universe (*i.e*. how many populations are known and how large are they?), and also strongly influences the type of propagules that can be used. The other major driver concerns the various purposes that an *ex situ* collection is intended to serve. With the taxon and purposes in place, initial sample size estimates can then be made. However, not all propagules collected can reasonably be expected to survive in good condition during the period of time between collection and successful use. Therefore, sufficient additional propagules will be needed to mitigate expected attrition and revised estimates made. Taking attrition into consideration, the revised sample size estimates are then evaluated for their potential impact on the sampled population. If the estimated impact is judged too great, then this additional factor is added to the sum of inputs, opportunities and constraints, and the process of evaluating needs and impact is repeated. Only when the perceived benefit of collection is judged to be sufficiently high, and the impact on the sampled population sufficiently low, is a final sample size determined.

Figure 1. Conceptual flow chart illustrating how collection size decisions might be made. Illustrated are two major input factors, the choice of taxa with which to work, and the purposes that collections are intended to serve. The information about taxa and purposes together are fed into an evaluation cycle that considers attrition to collections while off site, and the potential impact on sampled populations. If the impact is judged to be too great, then the evaluation cycle is repeated until the impact is judged acceptable.



A. Inputs

There are two main groups of factors that drive the process: The choice of taxa with which to work, and the purposes for which collections are intended to serve (Figure 1). Each of these two primary drivers has associated opportunities and constraints that flow from them.

1. Choice of taxa

The CPC guidelines focus attention on degree of endangerment, and the potential for loss of unique genepools as primary determinates of which taxa are chosen for *ex situ* treatment. The taxa for which *ex situ* treatment in the Makua and Oahu projects is considered necessary have already been chosen, so these guidelines will not address the choice of taxa as such.

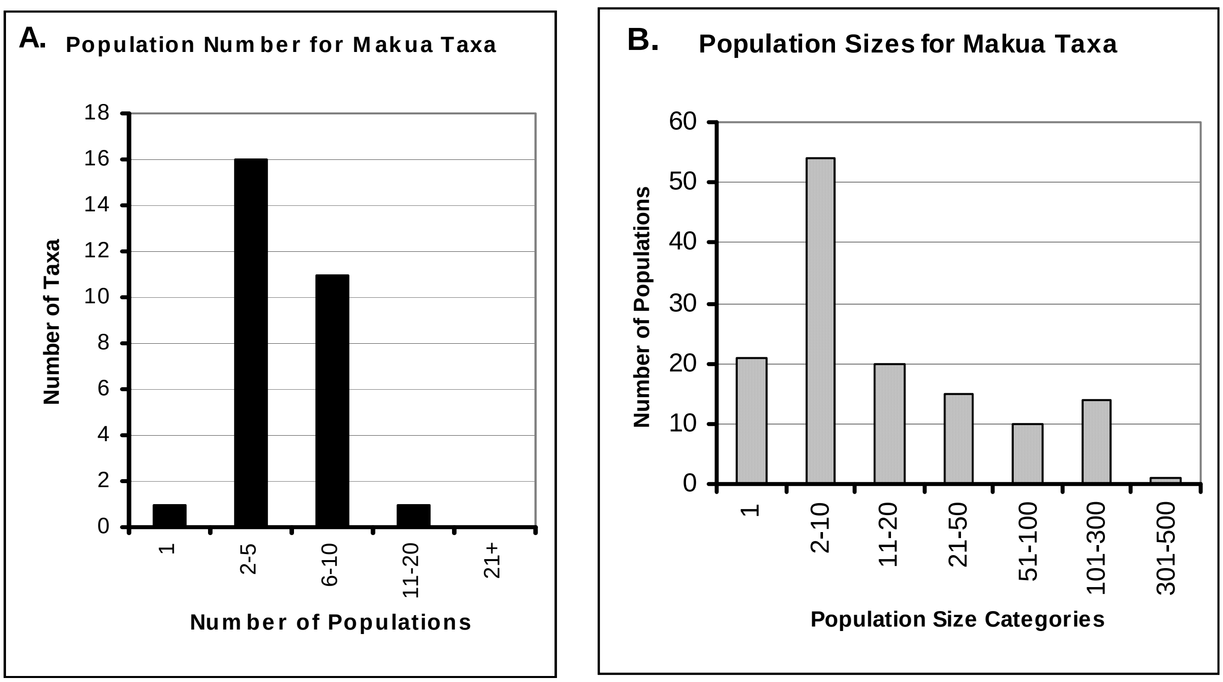
The choice of a taxon establishes two sets of opportunities and constraints. One is the sampling universe: how many populations of that taxon are known, and how large are they? The other concerns our ability to work with the taxon both horticulturally and for storage purposes: are seeds an option, and if so, how well and economically can they be stored for long periods of time, or must vegetative material be used?

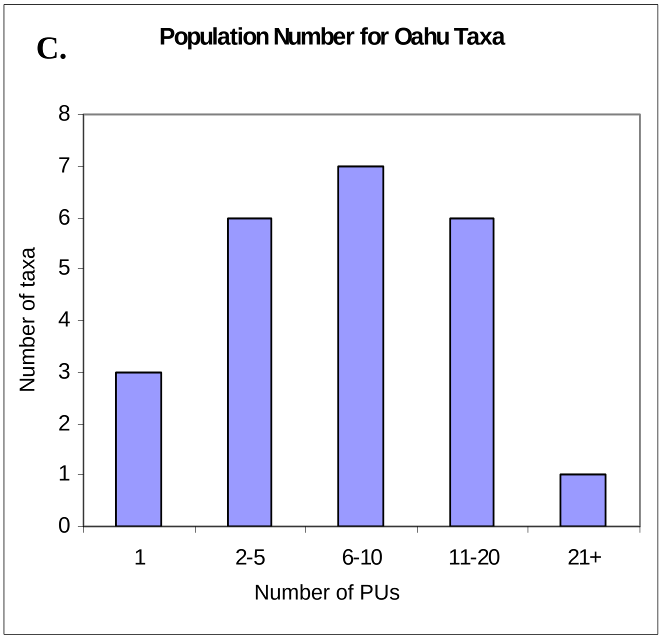
a) Sampling universe: How many populations are known, how large are they, and in what condition and management context are they found?

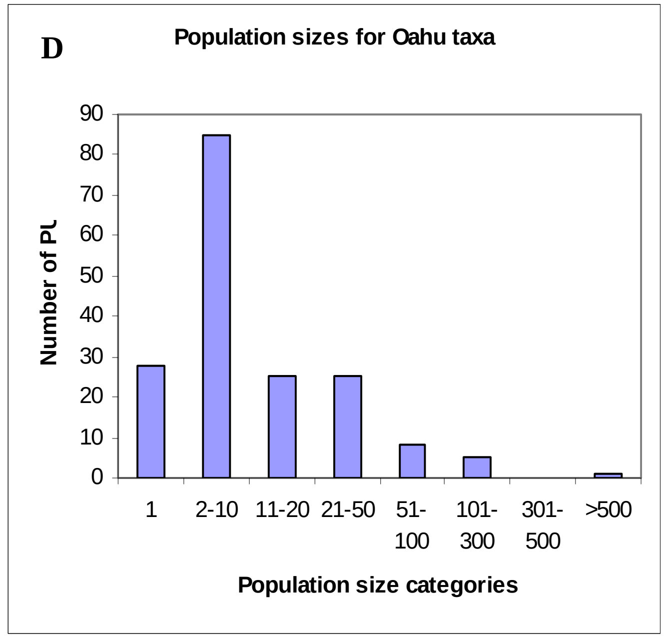
It is one thing to have an ideal target range for propagules to collect, but the actual optimal number to be taken is subject to many influences, such as population number, size and trend.

Figure 2 provides a comparison between the MIP and OIP population number and distribution based on the U.S. Fish and Wildlife Service (USFWS) categories of population number and size distributions.

Figure 2. Population number (A, C), and size (B, D) distributions (by USFWS size categories) for MIP and OIP taxa.







Clearly, the suite of taxa with which the Makua project is concerned are extremely rare, often comprised of very few occurrences of very few individuals. For the Makua target taxa the greatest number of species fall within the 2-5 PU category and the highest number of PUs fall within the 2-10 indiviudals sizecategory. Comparatively, the Oahu IP taxa appear to have a slightly different level of rarity. For the Oahu taxa many taxa also fall within the 2-5, and 6-10 PU categories, though there is also a large number of taxa with 11-20 PUs. This may be due to the higher percentage of intact habitat available to the OIP species. Though, some species in the OIP, particularly the Waianae taxa, are just as rare as many MIP taxa. Additionally, both the Makua and Oahu projects have several populations comprised of less than 20 individudals. With both the MIP and OIP taxa having the many populations with less than 10 individuals.

For as grim as these population size figures are, they may seriously over state the number of individuals from which seeds can be gathered. Seeds can only be gathered from successfully reproducing plants, and not all plants in a population are reproductive.
Recommendations: For species with 50 or fewer populations, collect from all known sites, or at least as many as is possible. For species with greater than 50 populations, collect from as many as possible, up to a total of 50. For populations with 50 or fewer individuals, collect from all known individuals; for populations with greater than 50 individuals, collect from 50.

The ultimate number of populations sampled per taxon is constrained by many factors: our ability to store them in good condition until they might be needed, the available resources, and the large number of other taxa that must be taken into consideration. Rather than get a 'complete' sample of any one species before moving on to the next, it is necessary to work with many species simultaneously. As a consequence, collection resources will probably spread strategically over many taxa simultaneously. The challenge becomes less of getting a fully adequate sample of one taxon before moving on, but getting as many samples as possible of the most critically endangered taxa first, and then gradually filling out the collections over time. Such a strategy of working with many taxa concurrently will spread collection pressure on any particular taxon over more time, which will help spread collection pressure on any one entity over more time.

b) Propagule types: Seeds and/or vegetative material?

Not only does the choice of taxa establish the sampling universe of populations and numbers of individuals with which there are to work, but also strongly influences the applicable range of horticultural and other options with which there are to work. With respect to long-term storage, those taxa with orthodox seeds offer the easiest, and most effective and economic options. For those species with recalcitrant seeds, off site samples may have to be maintained as growing collections. The relative impact on sampled populations is another factor to consider, and again, seeds are preferable to removing vegetative material.

Removal of seeds is considered less damaging demographically than removing vegetative plant parts. This conclusion is based on demographic modeling by Dr. Eric Menges (1992), in which he wrote, “The threat posed to population survival by environmental variation appeared almost entirely due to variation in mortality, growth and reproduction status and not to variation in reproductive output.” While seed collection increases environmental variation in reproductive output, taking cuttings increases the variation in growth rate and possibly mortality.

Thus, if there is a choice of propagule type (seeds vs. cuttings) – and seeds can be stored alive for long periods of time - it is generally better on the sampled plants and populations to take seeds. But, this is not always possible.

The seeds of the vast majority of species fall into one of two relatively discrete categories of seed storage behavior: orthodox or recalcitrant. Orthodox seeds can survive drying to such low moisture contents that there is no liquid water left to form ice crystals, and therefore, can be stored at temperatures below freezing without damage. Recalcitrant seeds cannot survive at such low moisture contents, and cannot, therefore, readily be stored at subfreezing temperatures.

Orthodox seeds can generally be stored alive for ‘long’ periods of time (decades or longer?) without suffering ‘significant’ ill effects. Recalcitrant seeds are generally very short lived, and cannot be stored off site without labor and resource intensive ‘heroic’ effort.

Recent work by Dr. Christina Walters (USDA National Seed Storage Laboratory, Ft. Collins, CO) and Alvin Yoshinaga (University of Hawaii) has shown that a large fraction of Hawaiian native plants have orthodox seeds. A summary for the Oahu target taxa tested and their results can be found in Appendix 1.3: CCRT Seed Storage Summary.

Recalcitrant seeded species, and those with other problems, pose greater challenges for off site storage. Unlike seed collection, cuttings reduce the photosynthetic capital of the plant to some degree, and subjects a plant to invasion by pathogens. Nevertheless, the material obtained can be maintained and proliferated in tissue culture, and can have significant conservation value.

In some cases, cuttings might be the only option. *Flueggea neowawrea*, for example, sets little seed and the few remaining plants suffer from chronic twig borer infestation; a problem for which there is currently no sure cure. *Flueggea* and other taxa threatened by twig borers might be good candidates for cryogenic storage of short segments of stem-with-a-bud. A relatively new technique has been developed for use with fruit trees in which a short segment of stem having a bud is maintained at liquid nitrogen temperatures. These samples are being used as an alternative to maintaining apple and pear varieties in an orchard setting. If borer-free shoots can be found, this might be a way to preserve these species off site until the invasive twig borers can be eliminated.

2. Purpose of collection

Along with the choice of taxa, the purposes for which a collection is being made is the second major determinant of sample size and density. At one extreme, some purposes, such as obtaining material to learn how to germinate and propagate plants or to determine their seed storage behavior, may require very little material to be gathered without much regard to its genetic make up. At another extreme, some purposes, such as salvaging what can be obtained from a doomed population for use in storage and reintroduction, may require that large samples be taken from every individual.

Note that it is not always necessary to collect additional material from the field. Suitable material (seeds, growing plants, or plant parts) may be available from other sources, such as existing samples in seed banks, *in vitro* cultures, or various cultivated sources. Where available and appropriate, material already stored off site should be used before new collections are made from wild populations, as long as the stored material is used for research or propagation/storage testing, or is not more than one generation removed from the wild population.

a) Develop protocols: Germination, propagation, seed-storage behavior, and/or reintroduction

Given the potential negative impact of collection on sampled populations, it is risky to collect material in volume before methods are available to use it well. In practice, there are taxa and situations, however, where the threat of extirpation in the wild is so high that more extreme measures might be justified. There appears to have been relatively little discussion in the conservation community of how to proceed in such extreme circumstances.

In general, there is rarely reason to think that different populations of a taxon would have significantly different germination, propagation requirements, and/or seed storage behavior. Therefore, there is no need for a statistically representative sample, as there is, for example, for storage or reintroduction. Thus, samples for these purposes should be taken from sources that will be least likely to harm survival prospects in the wild. In other words, obtain seeds (and/or cuttings) from the largest and/or most secure (or at least most dispensable) sources known. Seeds from properly identified and documented cultivated specimens are generally acceptable for these purposes. It may also be possible to minimize collection pressure by doing pilot work on closely related but more common congeners.

Absolute amounts will depend on whether standard horticultural or *in vitro* (tissue culture) techniques are used, or both.

Recommendation: For developing germination and propagation protocols, and determining seed storage behavior, begin with seeds derived from* ex situ *plants (whenever possible) or minimal collections from the most secure populations. Determine actual sample sizes in consultation with those who will be working with the material. Where possible and prudent, begin with very small samples, especially if the probability of early success is low.

Reintroduction, including augmentation, is not a simple one-size-fits-all procedure. Insofar as appropriate material is already being stored off site, it should where appropriate be used before new collections are made. Actual sample sizes will depend heavily on the questions being asked of the experiment(s), and other aspects of the reintroduction plan being considered.

Recommendation: For developing reintroduction protocols, begin with the smallest collections necessary to address the questions being posed in the experimental reintroductions.

Our ability to work with the species successfully will also influence sample size. Are seeds an option for storage, or must growing plants be used?

b) *Ex situ* conservation purposes

(1) Seed storage (in seed bank)

As a hedge against catastrophic loss in wild populations, and to provide material for reintroduction and other uses, collect and maintain off site as large and genetically representative and diverse an array of genotypes as possible without unduly compromising sampled populations. This is clearly easiest and most economical to do for taxa with long-lived orthodox seeds, which can be stored for long periods of time in standard (*i.e.*, –20ºC) seed bank facilities. The numbers and genetic diversity of these collections will, of course, be strongly influenced by the number and size of extant populations from which to collect.

The numbers required for storage depend greatly on what purposes the stored seeds are intended to serve. Should an off site collection be expected to support a single reintroduction attempt, two, or ten? Are there other purposes, such as unanticipated scientific research efforts, that an off site collection might be expected to support?

For those taxa with recalcitrant seeds, a few may be able to be stored under cryogenic conditions (*e.g.*, liquid nitrogen temperatures, approaching –200ºC). The expertise and facilities necessary to store recalcitrant seeds are much more limited than for orthodox seeds. As a practical matter, off site collections of many recalcitrant seeded species will need to be maintained as growing plants.

Recommendation: Begin calculations with generic Benchmark Guidelines for storage offsite of wild collected material (50 populations, 50 individuals/population, and 50 propagules/individual), and from that subtract or add depending on a variety of factors: purpose, sampling universe, our ability to germinate, grow and store seed, and to support and

sustain any intended reintroduction back into natural areas and sustain in the face of expected attrition.

(2) *Ex situ* storage using cultivation of growing plants

In certain cases where there is an immediate and severe risk of extirpation of a population (from fire, ungulate threat, *etc*.) and it isn't possible to collect enough seeds, living tissue may be collected to increase genetic diversity of *ex situ* stock. For small populations, there should be enough off-site plants in living collections or *inter-situ* populations to represent the genetic diversity of the wild populations, which may be used to provide adequate additional seed stock for reintroduction, augmentation, or storage.

A wide range of activities is encompassed by this category. At one extreme are small specimen collections maintained in botanic gardens, the conservation value of which, other than for education, is extremely limited. At the other extreme are medium to large-scale plantings maintained in semi-cultivated to semi-wild conditions. These have variously been called *inter situ* collections or field gene banks.

Relative to stored seed, the cost to maintain growing plants is much greater, and the probability of successfully perpetuating the genetic integrity of stored material is much less. Once the infrastructure is in place, large numbers of seed can be stored in a seed bank at relatively low actual cost, and very low marginal cost. The genetic integrity of stored samples is probably generally much greater than for population samples maintained as growing plants.

This is thought to be true for several reasons. The expected longevity of stored seed is generally much greater than for growing plants. Assuming proper seed storage facilities and techniques are available, both the absolute and relative cost of maintaining the original genetic array of a collection is much less for seeds than for growing plants. It is extremely difficult, if not impossible, to provide habitats off site that are sufficiently similar to those experienced in the wild, so as to avoid artificial selection. In addition to the deleterious genetic effects resulting from random genetic drift due to small population sizes, the genetic adaptiveness of growing samples is expected to deteriorate much faster than in dormant seed collections. Finally, there are phytosanitary and related considerations that need to be considered for growing plants, which do not affect stored seed.

Recommendation: For collections that must be maintained as growing plants, the limit is set more by the practical ability to handle a species, so numbers will generally be lower than for seed storage.

(3) Reintroduction, augmentation

Sample sizes necessary to support actual reintroductions and/or augmentations can vary widely. In general, the larger the founding population, the greater will be the chance of it surviving to become an established, self-sustaining population (Guerrant 1996). Not all reintroduction attempts will succeed, even for those species for which protocols have been established empirically. The number of reintroduction attempts and their geographic limitations that a collection is intended to support will also greatly affect the sample size required.

Recommendation: Collect from as large and diverse an array of suitable founders as seems prudent, given the sampling universe with which there is to work, and the ability to maintain the material off site between the time of collection and use.

(4) Other--including scientific research, education, interpretation, *etc*.

The sample sizes necessary to satisfy these uses are so idiosyncratic that no general recommendations seem possible.

Recommendation: Collection for these purposes should be evaluated in light of the estimated conservation or other value to the species, and the cumulative impact of all collection activities anticipated for those species and populations.

B. Evaluation cycle

Sample sizes indicated by the above factors need to be evaluated in light of the following potentially significant factors that may indicate sample sizes larger or smaller than originally indicated.

Recall that the ultimate purpose of *ex situ* collections is to enhance the survival of sampled populations, so a positive balance must be struck between the potential benefits and costs of collection. The next step in the process (Figure 1) is to reconcile the potential benefits and costs, to the benefit of the species.

With the choice of taxa and collection purposes, initial estimates of sample sizes can be made. Additional material must be added to these preliminary estimates to compensate for expected attrition between collection and use. If the potential impact of the total collection size on sampled populations is judged too great, then this information is added to the mix. The cycle of evaluation is repeated until a reasonable balance is found with what we think can be accomplished without unduly harming the sampled populations.

1. Sources of attrition in *ex situ* collections, between collection and successful establishment

It is one thing to collect a genetically representative population sample and quite another to have sufficient and appropriate material available to establish a new, genetically comparable population if and when it becomes necessary. There are many steps along the way in which mortality and other losses can occur, both in terms of sheer numbers and in genetic diversity. In this section, we will consider various sources of attrition, what it takes to monitor them, and how losses can be mitigated.

a) Survivorship and genetic change in collections

Perhaps the most basic source of loss is due to mortality during off site storage. There may be large differences in mortality rates among different propagule types and different taxa within a propagule type. Off site collections that must be stored as growing plants present a much more formidable challenge than those that can be stored as dried and frozen seed, and those stored as *in vitro* cultures are presumably somewhere in between.

There are several reasons why growing plants off site for conservation purposes is less desirable than storing them as seeds or as *in vitro* cultures, not the least of which are the resources required to maintain a given number of plants over a long period of time. First, to avoid the genetic losses and other changes that are likely to occur when population sizes are small, a large number of plants must be grown for, perhaps, many generations. The amount of space, man-power and other resources that must be expended to maintain just one population of one species is daunting indeed. If this were not problem enough, growing plants off site will inevitably subject them to a selective environment different than that in which they evolved, thus eroding their ability to survive when their descendants are used for reintroduction back into the wild. The most extreme illustration of this phenomenon is where plants grown off site under conditions sufficiently different than their native habitats cannot survive when returned to their native habitats. While this might seem fanciful to some, it or something close to it happened when the attempt was made to reintroduce to Tenerife, in the Canary Islands, a long established line of *Lotus berthelotii* that had been grown in Europe. The plants all died in the nursery on Gran Canaria, apparently as a result of the higher temperatures there than where they had been grown (Maunder and Bramwell pers. comm.). Another less extreme but still telling example is that of *Amsinckia grandiflora* (Pavlik *et al*. 1993, Pavlik 1995), in which plants were grown at the University of California at Davis in what would seem to be very similar conditions to, and within a few miles of, their native habitat. Electrophoretic analysis of seeds collected twenty years before and held in storage indicated relatively low genetic diversity, but seeds derived from plants grown off site for just a couple of generations showed even less. Although the plants were large and vigorous when grown off site, the pin/thrum ratio of this heterostylous plant was very different in cultivation than it was in the donor population. This suggests that plants derived from seeds grown off site might be less fit when reintroduced than those that had not. Finally, sanitation issues – keeping reintroductions from being a vehicle for introducing pests, pathogens, and weeds into the wild – are most acute when plants are grown off site; the danger of picking up pests and pathogens increases with time in off site cultivation.

Taxa with orthodox seeds are at the other extreme, where large samples can be in frozen storage for long periods of time with little maintenance and at a relatively low marginal cost. Seeds of some taxa can presumably be stored for decades, even centuries, with little mortality. We aren't aware of information about the degree to which mortality in seeds banks is selective or random.

Recommendation: Monitor survivorship and health of off site growing collections and respond appropriately. The emphasis should be on improving cultural conditions rather than additional collection.

b) Monitoring survival rates of stored seed

Although potential mortality rates appear to be quite low in stored seed, survival must nevertheless be monitored. The only sure way to do this is to attempt to germinate samples when they enter the seed bank, and periodically thereafter. This is not as simple as it might seem.

First, it is necessary to know how best to germinate the sampled population (Baskin and Baskin 1998). While germination requirements are often thought to be species specific, there are examples where germination requirements, at least of widespread species, may differ significantly among populations (*e.g.,* Meyer 1992). Once a suitable protocol is established, it is necessary to subject different seed batches to comparable conditions in order to assess changes in germinability over time. Otherwise, germination rate differences might be due to environmental causes. This will presumably require the use of controlled environment chambers, as ambient outdoor conditions are not sufficiently similar between years.

Interpreting the results of comparisons between different trials is the next hurdle to overcome. While the magnitude of what constitutes a significant decline is a subjective decision, it is possible to analyze sample sizes necessary to detect a given decline. In their Guidelines for the Maintenance of Orthodox Seeds, the CPC (Weiland 1995) suggest a 15% decline as a reasonable threshold to trigger action (either recollection, or a grow-out).

Ideally, the results of statistical tests on seed samples to determine if there has been germinability decline accurately reflect the true condition of the seed lot. However, it is possible, due to chance alone, that our tests will indicate a decline when, in fact, there is none. This is a Type I, or False Change Error, and the probability of making it can be considered the **significance of the test**. Designated α, this is the p-value commonly cited when a difference is found. Alternatively, and again due to chance alone, a test may fail to indicate a decline when, in fact there has been one. This is known as a Type II, or Missed Change Error, and our ability to avoid it is known as the **power of a test**. In other words, the power of a test is a measure of how likely our test is to detect a given decline, if there really is one. It is, of course, easier to detect a large decline than a small one, so it is necessary to designate the minimum detectable change when specifying the power of a test. There is no single sample size necessary to detect a given decline. Sample size varies, among other things, according to how tolerant you are of making the two kinds of errors. This is a subjective decision that involves tradeoffs. As the desired significance of a test increases, power declines.

The sample size necessary to detect a given decline also varies with the initial germinability of a seed lot. Figures 3-6 illustrate the differing relationships of statistical power as a function of sample size differences when initial germinability is either 90% or 50%, and the desired significance of the tests are either p=0.1 or p=0.01. There are three patterns to note. First, power increases dramatically as minimum detectable difference increases. Second, to detect a given decline for a given sample size, statistical power is greater if initial germination rate is 90% rather than 50%. Tests are least sensitive when the initial germinability is 50%, and more sensitive toward either extreme. Third, note the increase in statistical power associated with a greater tolerance for making a False Change Error (where α=p=0.1 versus α=p=0.01). Sample sizes refer to the number of seed used in each test, not the sum of two or more tests.

Fig. 3 Chi-square Test of Proportions (Two tailed test)
Higher = **0.9**, alpha or p = **0.01**

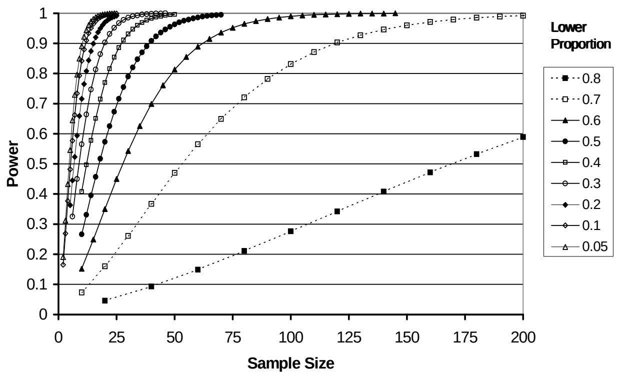


Fig. 4 Chi-square Test of Proportions (Two tailed test)
Higher = **0.9**, alpha or p = **0.1**

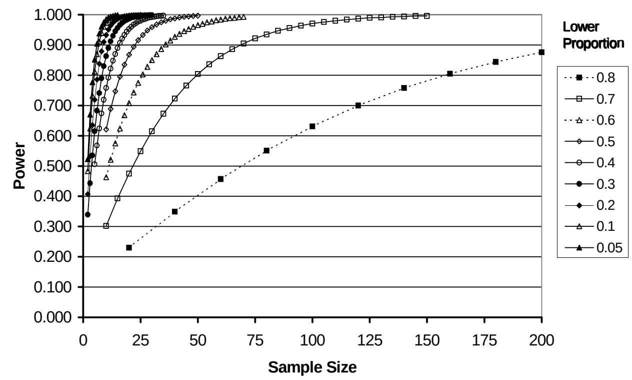


Fig 5. Chi-square Test of Proportions (Two tailed test)
Higher = **0.5**, alpha or p = **0.01**

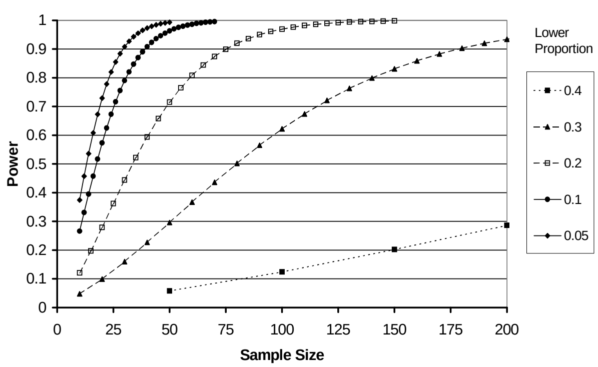
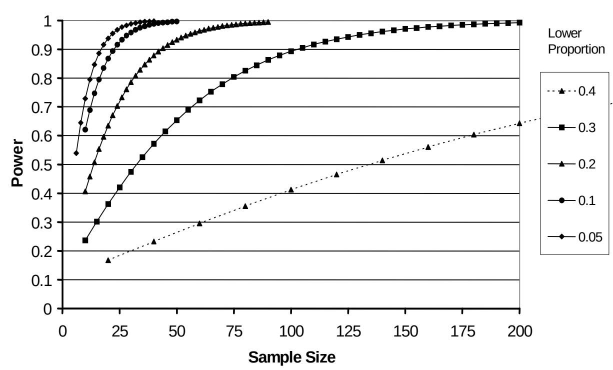


Fig. 6. Chi-square Test of Proportions (Two tailed test)
Higher = **0.5**, alpha or p = **0.10**



This method of analysis presents several dilemmas. One is that we must choose sample size before we know what the initial germination fraction is. Pilot studies are helpful, but use additional seed. Given the rather large sample sizes often needed to detect changes of a magnitude we might like, we simply will not have (or be willing to use) sufficient seed to be able to monitor a collection as closely as we might like. This sobering fact is especially true when seeds from each maternal parent are maintained separately – which is definitely preferred over bulk collections. This raises a policy choice about how precisely we can know the status of a collection. Resolution of this basic dilemma awaits further discussion in the conservation community. Nevertheless, even small samples can provide meaningful (if not very precise) information about the viability and longevity of a seed stock.

Recommendation: Unless very large samples are available, it is unlikely there will be sufficient seed to monitor viability with any high degree of precision.

c) Demographic costs of reintroduction: Modeling 'expected' attrition using empirical demographic data

Population size targets, often specifying numbers of mature plants, are indicated in reintroduction plans for each project. While it is not reasonable to expect that all propagules planted will survive to reproduce, what is a reasonable expectation? In order to estimate the range of post-planting decline in population size that might be expected during reintroduction, Guerrant and Fiedler (2003) used empirically derived stage-based transition matrices for a variety of life histories from the literature as a basis for stochastic modeling.

They found, not surprisingly, that the demographic cost during reintroduction can be substantial. In the most extreme case, an outplanting of 1,000 *Panax* seedlings would, on average, drop to just 15 individuals within three years before the simulated populations began to rise. But, of course, many simulated runs ended with extirpation before any increase could begin. If the newly established populations are to have anything like the genetic diversity of the ones from which the founders were collected, expected losses during reintroduction must be accounted for in the original collection. These data are, of course, simulated results based on wild populations with positive growth rates. One assumption of these models is that outplanted individuals will behave demographically identically to naturally occurring plants, which is probably optimistic. Another assumption of the models is that the series of years for which data were gathered in the field accurately reflect what will happen during a reintroduction. Presumably there will be many stochastic environmental effects that cannot be anticipated, but which will affect establishment. Using similar techniques and comparable seed supplies (planted in the field near where they were collected the year they were collected) a series of 27 field germination and seedling establishment trials of *Erythronium elegans* set out yearly with fresh seed each year over a 5-year period spanned the range from 0-94% establishment (Guerrant 1999). Clearly, attrition can be high, and vary greatly among different years.

The implications for collection guidelines to support even one reintroduction attempt are daunting. To compensate for expected losses of these magnitudes suggests that sample sizes might need to be one or two orders of magnitude greater than current suggestions. Unfortunately, such collections either may be too great for sampled populations to bear, or prohibitively expensive in time and other resources needed to collect, store and monitor. In addition to increased sample sizes, other ways to compensate for potential losses associated with reintroduction must be explored.

One such alternative is to use larger founding individuals, which might be expected to have greater survivorship than smaller founders. So, too, any post-planting care that can be provided to increase survivorship of the founding individuals should also reduce the sample size requirements.

Recommendations: Start with an estimate of desired numbers surviving to reproduction, and then account for expected losses during establishment. Maintaining backup clonal material can mitigate some of these losses.

2. What is the effect of collection on extinction risk of sampled population?

The ultimate purpose of *ex situ* collections is to enhance the long-term survival prospects of sampled populations. Thus, for collection itself to harm the sampled population in the short-term is generally to be avoided. However, even in the absence of collection, at what point does the short-term risk of extinction become so great that sampling at a rate that is harmful becomes justified?

a) General condition: Minimum risk to sampled population

The final question posed by the CPC genetic sampling guidelines was the least developed: What level of collection necessitates a multi-year collection strategy? Eric Menges, Samara Hamzé and Ed Guerrant have recently addressed this question with a computer simulation study.

The following paragraphs are the abstract for the manuscript, which is currently in review (and thus subject to change):

"Seeds are widely considered to be the propagule of choice for *ex situ* conservation collections elative to cuttings or transplants, seeds can easily be collected in large numbers and stored alive for long periods of time; their harvest is thought to be the least damaging to the sampled populations.

"Guidelines for amounts and timing of seed harvests, however, have not been grounded in demographic data or projections. We examined the demographic consequences of 36 patterns of seed harvests: 10, 50, and 100% of fecundity for 10, 50, and 90% of years, on populations of 10, 50, 100, and 500 plants. We compared these results to no-harvest scenarios with the same four initial population sizes. We used published projection matrices from about two dozen plant species encompassing a range of life forms. We modeled using stochastic simulations, alternating projection matrices representing different years and different harvesting intensities. For each species, we examined 40 combinations of conditions in 1,000 replicate simulations for 100 years each and we calculated the proportion of replicates becoming extinct.

"Species differed in sensitivity to seed harvest, with long-lived species, especially woody plants, being least sensitive. Populations of 500 or more were not harmed except by complete harvests for half or more of all years. Small populations of ten were harmed by less complete harvesting, but sensitivity varied widely by species.

"Our modeling suggests three seed harvest rules:

1. Harvesting 10% of seeds in 10% of years (or less) is generally safe.
2. Harvesting 50% of seeds in 50% of years (or more) is generally unsafe.
3. Less intense, frequent harvests are safer than more-intense, infrequent harvests.

Although these analyses encompass many mathematical, biological, and sociological assumptions, they suggest that prudent seed harvesting will not have significant short-term demographic effects."

Recommendation: Less intense, frequent harvests are expected to have less of an impact on sampled populations than more-intense, infrequent harvests. To the degree possible, spread collection out over two or more years, especially for small populations.

b) Special case: intentionally collect enough to cause short-term risk to sampled population

As stated in the first section, given the potential negative impact of collection on sampled populations, it is risky to collect material in volume before methods are available to use it well. In practice, there are taxa and situations, however, where the threat of extirpation in the wild is so high that more extreme measures might be justified; situations in which it might be necessary to act sooner rather than later.

The Makua IT must deal with many species that are so extremely rare and/or endangered that "we may not be able to safely wait until we get the propagation and genetic storage procedures worked out" (Bruegmann and Jacobi, pers. comm.). The same is true of some OIP species. However, the OIP target taxa have already benefited from the massive effort underway for the Makua IP. Through the MIP, collection effort the knowledge base regarding phenology, propagation, and germination of multiple genera and species has increased significantly.

Note that the minimum population size Menges *et al.* (2003) modeled was 10 individuals. Part of our reasoning is the belief that populations this small and especially smaller are inherently threatened with extinction, due simply to chance. In the manuscript, Menges *et al.* noted that declining populations represent special cases, where other considerations might become important. If a population is in decline and sliding toward extirpation anyway, collection did not affect the end result – extirpation - just the timing. In such cases, the potential benefits of collection must be weighed against the additional pressure of collection on extinction risk. Another area not covered directly in the models concerns very small and other populations where the probability of extirpation in the foreseeable future due to random factors is so high, that additional risk of 'rescue' collections might be of conservation value. Many of the very small populations managed through MIP and OIP probably fall into this category.

The question arises then of what to do with very small or other populations you have reason to think are particularly susceptible to extirpation in the near to medium term (say 5-25 years).

While it is always best to keep in mind the dictum – Do No Harm - it may be necessary in some situations to collect so much material that collection itself becomes a serious threat to the sampled wild population, at least in the short term. The effort to recover the California Condor – which is highly endangered even by Hawaii standards - is a case in point. ALL wild birds were captured, thus driving the species to 'extinction in the wild' – at least temporarily. These birds were and are being used in a captive-breeding program, and the goal is to release many more individuals into the wild (and in more areas than just the collection sites) than were removed. Thus, we may find ourselves in the uncomfortable position of 'destroying' something in order to save it.

Recommendation: For populations of species with low numbers overall, that have 10 or fewer reproductive individuals and a poor history of recruitment, or a population known to be in precipitous decline, collect 20-100% of seed at the discretion of the permitted collector. Such collection levels assume, of course, that adequate facilities and procedures are available to

care for the material, and that such collections are part of a more inclusive strategy. For those situations in which germination, propagation, or seed storage methods are not yet available, it may be necessary to collect some material to better ensure the continued existence of the species or populations in question.

C. Final collection guidelines considering the above factors

To determine the sample sizes that must be collected, use the accompanying worksheets (Tables 2 and 3) to clarify how much is needed for all purposes that are intended to be served, and how much suitable material is in off site collections already.

Genetic Sampling Guidelines Worksheet: Preliminary Estimates Taxon ___________________________________

Page __ of ___	**Population** For each population indicate name and number of mature and juveniles above preliminary target numbers for collection.														
Purpose of Collection	Mat		Juv	Mat		Juv	Mat		Juv	Mat		Juv	Mat		Juv
	Indiv	Prop /indiv	Tot Prop	Indiv	Prop /indiv	Tot Prop	Indiv	Prop /indiv	Tot Prop	Indiv	Prop /indiv	Tot Prop	Indiv	Prop /indiv	Tot Prop
To develop protocols															
Germination															
Propagation (standard Hort. proc.)															
Propagation (in vitro)															
Seed Storage Behavior															
Ex situ storage															
Orthodox Seed															
Attrition (rate)															
Recalcitrant Seed															
Attrition (rate)															
In vitro slow growth															
Attrition (rate)															
In Cultivation															
Attrition (rate)															
Reintroduction															
Attrition rate (inc. demog. cost)															
Augmentation															
Attrition rate (inc. demog. cost)															
Other															
Is multi-year collection plan indicated?															

2

Genetic Sampling Guidelines Worksheet: Page 2 Taxon ______________________________

4

Sampling Universe by population		**Existing Collections**			**Final Targets for Collection**			Notes
	Pop size	Seeds	Growing Plants	In vitro	Indiv	Prop/ indiv	Multi-yr col.	

TABLE ABBREVIATIONS:					
col: collection	demog: demographic	Hort: Horticultural	inc: include (ing)	Indiv: Individual(s)	
Juv: Juvenile(s)	Mat: Matured	pop: population	proc: procedures	Prop: propagules	Tot: total

IV. Conclusions

The basic structure set out in the original Center for Plant Conservation Guidelines for Conservation Collections of Endangered Plants are sound, but the actual numbers need to be revised upward. In the most recent and thorough statistical treatment of sampling strategy, Brown and Marshall (1995) have a benchmark target of 50 individuals per population in each of 50 populations per ecogeographic region per taxon, which are here suggested as a benchmark against which actual sample sizes are determined.

All numbers are, of course, subject to change, and any collection strategy must be tempered with consideration for the purpose of collection, ability to maintain the samples in good condition off site, and any damage to wild populations done by collecting itself. After all, off site samples are part of a larger integrated conservation program; the ultimate purpose of which is to increase the long-term survival prospects of sampled populations in the wild.

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Appendix 1.4 Phytosanitation Standards and Guidelines

This document was created to direct the phytosanitation of the Makua Implementation Plan (MIP) target taxa *ex situ* prior to any reintroduction or augmentation efforts. The standards and guidelines outlined in the original MIP document are reproduced here without modification (barring modifications to include the Oahu Implementation Plan (OIP) species).

The objective of this document is to state the level of sanitation that will be required during *ex situ* operations, and the transition into natural habitats via reintroduction or augmentation projects. Sanitation is a key factor in reintroductions or augmentations by preventing the introduction of foreign organisms into the wild. Plants grown for the U.S Army's (Army) Makua and Oahu Endangered Species Stabilization Plans must be visibly weed-free, pest-free, and pathogen-free. All plants to be used for reintroduction or augmentation projects in this plan will be rigorously checked for compliance with the requirements described in the narrative below. If the plants do not meet the standards stated in the guidelines at the time of inspection, they will not be used. The infected plants must be treated so that all alien plant species, pests and pathogens are eliminated before the plants can be reconsidered for Army projects. If any plants become infected with a virus that plant must be immediately removed from the growing area and destroyed. The surrounding plants should be monitored for signs of virus infection as well.

The phytosanitation checklist (see Attachment 1: Phytosanitation Checklist) outlines the range of threats that must be monitored and controlled in both in the nursery setting. The threats that are to be monitored and controlled are arthropods, alien plant species, nematodes, mollusks, pathogens, and small mammals and other pests. The Implementation Team (IT) feels that these threats are major problems that affect the overall health of the plants and can cause possible contamination to the environment if transported into the wild. The table below summarizes the threats and suggested actions to eliminate these problems.

Table 1. Summary of potential pest species or problems with *ex situ* propagation methods and facilities, and prevention and monitoring procedures identified in the Phytosanitation Standards and Guidelines section of the Makua Implementation Plan (U.S. Army Garrisson 1999).

Prevention or Monitoring Procedures	Potential Pest Species or Problem							
	Virus	Bacteria	Fungi	Nematodes	Arthropods	Slugs/Snails	Weeds	Small Vertebrates
1) DOA certification	X	X	X	X	X	X	X	
2) Nursery design					X	X	X	X
3) Media to use				X			X	
4) General sanitation	X	X	X	X			X	X

5) Threat control program	X	X	X	X	X	X	X	X
6) Nursery and plant inspection	X	X	X	X	X	X	X	X
7) Threat monitoring and control	X	X	X	X	X	X	X	X

REQUIREMENTS

1. Nursery Certification by Department of Agriculture (Plant Quarantine Branch)
The Department of Agriculture (DOA) developed this certification process for plant growers in Hawaii that want to export their goods out of state (see Attachment 4: Certification Requirements of Rooted Plants to Meet Burrowing Nematode Quarantine). The nursery certification encompasses various aspects of plant production ranging from general sanitation, to standards of nursery conditions, to pest control. Complying with the certification requirements will require the facilities and equipment to provide clean plants and the absence of nematodes in all plant pots. Examples of the DOA certification requirements as of 1999 are as follows. Plants or plant parts used must be:

1. Propagated from clean (nematode- and virus-free) seeds or cuttings taken at least 12 inches above the ground.
2. Planted in suitable material prepared or treated to assure freedom from burrowing nematodes.
3. Grown in sterilized pots, containers or beds.
4. Placed on sterilized benches or sterilized supports which are at least 18 inches above the ground or floor level.
5. Plants and growing media sampled using methods approved by the Department of Agriculture and found free of the burrowing nematode.
6. Protected from contamination until delivery.

For growers that are not yet certified contact DOA for more information regarding the certification requirements. (Department of Agriculture, Plant Quarantine Station, 701 Ilalo Street, Honolulu, HI 96813. Phone number 586-0844).

2. Nursery/ Growing area

- The nursery ground must be free from alien plant species, live roots and other plant material. The floor shall be paved, or covered with coarse gravel to insure that no dirt areas are exposed. The walkways must be paved with concrete, black top or gravel.
- A six feet buffer zone around the growing area must be free from any vegetation.
- The plants must be grown in an enclosed area to prevent weed seeds from blowing into pots.
- Plants and aerial roots shall not be grown lower than 18 inches from the ground level to top of benches.
- Water hoses must be kept off the ground.
- No plants are to be placed over the propagative stock (hanging containers or secondary benches), nor under the benches to prevent contamination to plant material.

3. Media

- See Attachment 3: Approved Growing Media for a list of IT approved growing media.
- Media must be stored on a concrete slab in an enclosed area (*i.e.*, in bins that are covered, or warehouse)

4. General Sanitation

- The grower must sterilize tools at least daily.
- The grower must keep growing area, benches, and work surfaces free from threats (*i.e.*, alien plant species, nematodes, pathogens).
- The workers shall also maintain the same requirements of cleanliness.
- Benches and plant boxes, used pots, flats and implements must be cleaned and washed free from soil prior to each planting. [There are no longer any nematocides that are registered for ornamental use to sterilize soil under benches. Chlorox cannot be used for soil sterilizing, but is okay for bench, pot and tool disinfecting. There is a fumigant (Vapam), which is registered for soil sterilizing, but is deadly to mammals and is impractical to use. (Murakami pers. comm. 1999)].
- All dead, diseased or infected material in or around the pots should be appropriately disposed of on a daily basis.
- Dead, diseased or decaying plant material should be pruned off with sterilized tools (and re-sterilized between cuts) to prevent further contamination. (*i.e.*, flaming tools)
- Adequate spacing between plants is necessary in order to have good air circulation between and around the plants to prevent pest problems.
- Propagules must be free from threats (*i.e.*, pathogen, nematode, *etc.*). Use appropriate methods to clean plants (*i.e.*, bleach solution). Do not use any propagules that were infested with a virus or nematodes.

5. Threat Control program

*NOTE: The use of pesticides is governed by state and federal regulations. Ensure pesticide use is in compliance with the law, and follow all label directions. If there are any questions, please contact the State of Hawaii, Department of Agriculture Pesticide Division for further information.

- It should be noted that if restricted pesticides are used, the applicator must be a certified pesticide applicator.
- The grower must have a monitoring and spraying program for each threat category.
- A copy of all the monitoring and spraying schedules, plant species treated, threat/pest treated, last time sprayed, and chemicals used will be submitted to the Army for review.
- See Attachment 2: Threat Monitoring and Control, for more information on specific threats.
    a) Look for signs and symptoms.
    b) Identify the target pests.
    c) Monitor for pests presence and their levels of abundance.
    d) Know their life cycle.
    e) Monitor on a weekly basis.
    f) Contact your local agriculture extension agent or DOA agent for proper identification, up-to-date chemicals and current control practices.

6. Nursery and Plant Inspections

- The nursery will be inspected by the DOA as part of the nursery certification process. All of the plants in the certified area are inspected. If the grower has areas that are not going to be covered under the certification, DOA agents will still factor in those areas as possible sources of inoculum and inspect a percentage of the total area.
- The plants are to be inspected at least three times in the greenhouse setting.
  a) The nursery will be inspected every six months by a DOA agent to see if they are in compliance with the DOA nursery certification requirements.
  b) The grower will monitor the plants on a regular basis in the nursery. The inspection can be done by doing a random spot check of 2-3% of the total growing area weekly or every two weeks (Murakami pers. comm. 1999).
  c) The plants will be inspected the day (or as close to the day) the plants are to be taken to the reintroduction site. The inspections will be performed by the DOA or the Army will contract an inspector.
- The plants should be periodically monitored post-planting to detect any weed seedlings (or other pests) emerging from the root ball area of the plants.
- Inspectors will inspect the nursery, outplanting sites, and/or quarantine house for arthropods, mollusks, nematodes, pathogens, and alien plant species.
- Use traps and baits (*i.e.*, sticky traps, ant traps, and slug bait) to monitor the presence of threats. Check on a weekly basis.

7. If plants fail inspection

- Remove the infected plant from the growing or quarantine area.
- Plants should be treated with the appropriate control method immediately to prevent further infestation.
- Check the surrounding plants to see if they are also infected.
- If the plant is infected with a virus, remove it from the nursery or quarantine area and destroy the plant. Make sure that no part of the plant (*i.e.*, leaves) is remaining. Infected plant material is a source for potential contamination to the surrounding plants. Be sure to wash your hands after handling the plant with the virus and disinfect any tools that were used.
- Once the plant is treated and no threats are detected, it can be used for reintroduction or augmentation projects.

QUARANTINE FACILITY

In order for a facility to be used as a quarantine facility, it must meet the requirements stated in the sanitation guidelines above as well as the following requirements:

- The quarantine facility must have insect screening on all walls and roof of the greenhouse. The recommended height for the roof is 12-20 feet. This is to prevent heat build up close to the plants.
- A daily walk-through of the facility is required to inspect the quarantined plants for possible threat problems.
- Inspection of plant material will be done prior to outplanting by a qualified inspector (*i.e.*, DOA, University of Hawaii Agriculture extension agent).

- Length of time in quarantine: At least two weeks, three weeks if the plants show susceptibility particularly to disease (note: at least 10 days is required to detect insects, 3 weeks to detect fungal diseases).

OPERATING PROCEDURES

Transportation

The Army is responsible for the transportation of plants from nursery to quarantine site or outplanting site. This is to reduce the amount of handling of the plants, and to prevent “sitting” time for the plants in a less desirable holding area which would increase the chances of contamination. This is especially the case for plants obtained from contracted nurseries.
The Army is required to do the following:

- Use a vehicle free from threats (*i.e*., arthropods, mollusks, pathogens) to transport plants. The storage area of the vehicle shall be enclosed to protect the plants from wind damage and potential threat problems. Follow the Army Environmental vehicle sanitation protocol.

OUTPLANTING

- Clothes, gear, tools, *etc.*, should be free from foreign substances.
- Use on site mulch if needed instead of bringing in to site.

Attachment 1: Phytosanitation Checklist

This checklist must be followed by all growers and will be used by the Army to ensure compliance prior to the acceptance of any plant material.

- ☐ **Nursery Facility** Certified by the State DOA (see "Certification Requirements of Rooted Plants to Meet Burrowing Nematode Quarantine")
- ☐ Growing area, walls and roof, must be enclosed
- ☐ Walkways covered with coarse gravel or paved with good drainage
- ☐ No vegetation within six feet of growing area
- ☐ No plants over or under growing area
- ☐ Plastic/metal benches at least 18" above ground
- ☐ Water hoses kept off ground
- ☐ Adequate storage for media (concrete/paved floor and enclosed on all sides)
- ☐ Adequate mixing and pouring and storage areas for pesticides
- ☐ Adequate facility for washing and disinfecting pots
- ☐ At least weekly inspections by greenhouse staff
- ☐ Six (6) month inspections by DOA to ensure compliance

Quarantine Facility

- ☐ Certified by the State DOA (see "Certification Requirements of Rooted Plants to Meet Burrowing Nematode Quarantine")
- ☐ Facility must be enclosed with insect screening, and vents (if applicable) must be covered with insect screening. Have roof 12-20 feet high
- ☐ No vegetation within six feet of growing area
- ☐ No plants over or under growing area
- ☐ Plastic/metal benches at least 18" above ground
- ☐ Water hoses kept off ground
- ☐ Adequate mixing and pouring and storage areas for pesticides
- ☐ Use of yellow and blue sticky traps to detect infestations early
- ☐ Daily inspections by greenhouse staff
- ☐ Six (6) month inspection by DOA to ensure compliance
- ☐ Workers wearing clean clothing and shoes

Equipment

- ☐ Use of only State DOA approved growing media
- ☐ Use of sterilized tools and benches, disinfected pots and trays (if reused)
- ☐ Use of yellow and blue sticky traps to detect infestations early
- ☐ Clean transportation vehicle to pick up and drop plants at other sites (see "Army Environmental vehicle sanitation protocol")
- ☐ Be prepared to detect and control pests, and have proper equipment and training available to conduct daily inspections (*i.e.*, loop, insect ID)

- ☐ Adequate chemical application equipment and Personal Protective Equipment

Chemical

- ☐ Compliance with State DOA regulation regarding use of all pesticides
- ☐ Completion of State Restricted Use Pesticide Applicator Certification if restricted chemicals are the only means of pest control
- ☐ Prepared to apply broad and narrow spectrum fungicides for prevention and control
- ☐ Prepared to spray broad and narrow spectrum herbicides for prevention and control
- ☐ Prepared to spray broad and narrow spectrum insecticides for prevention and control
- ☐ Prepared to spray greenhouse disinfectant (contact DOA for a list of approved chemicals)
- ☐ Must be prepared to provide a spray schedule and history

Cultural

- ☐ Benches cleaned when rotating crops at least every other month
- ☐ Appropriate watering schedule to prevent pests (*i.e.*, not too wet)
- ☐ Watering/irrigation done to prevent splash-over into adjacent pots
- ☐ Dying/dead material removed daily
- ☐ Plants spaced on benches to allow for adequate air movement and drying
- ☐ Propagules inspected and cleaned before planting

Attachment 2: Threat Monitoring and Control

This reference is provided for the nursery grower to help identify threats, their signs and symptoms and suggested methods for their control. This is just a general summary of threats, for more information contact your local agriculture extension agent, Department of Agriculture personnel, or the University of Hawaii Diagnostic Laboratory or Agricultural extension agent.

1. Arthropod Monitoring and Control

- Look for signs and symptoms.
- Identify the target pest.
- Monitor for pests presence and their levels of abundance.
- Know their life cycle.
- Monitor on a weekly basis.
- Contact your local agriculture extension agent or DOA agent for proper identification, current control practices, and up-to-date chemicals to use.

a) **Ants**:

- DESCRIPTION: There are many types of ants that affect plants in the nursery as well as in the wild. They have six legs and have a chewing mouthpart. They can range in color and size. They live in colonies and the queen lays thousands of eggs in individual sacs.
- SIGNS AND SYMPTOMS: Ants are usually found on plants that have scale, mealy bug or any other insect that produces honeydew. The ants farm these insects for the honeydew they produce. They can be seen crawling all over the plant and/or pot. "Tunnels" built by ants that are made out of potting media from the pot can be found on the stems protecting insects that produce honeydew.
- CONTROL: There are two distinct types of ants to control. One type is sugar loving and the other prefers an oil-based food. Bait for ants at first sign of presence. If population increases, find and destroy the nest.

b) **Aphids**:

- DESCRIPTION: There are many types of aphids that attack plants; however, all of them are soft-bodied and have piercing sucking mouthparts. Their bodies are pear-shaped and can range in colors from yellow to green to black. Aphids secrete a sweet, sticky substance, which is called honeydew. Ants farm aphids for a constant source of honeydew, which is the ant's source of food. The females bear live young. Once they reproduce, aphids can have many generations a year.
- SIGNS AND SYMPTOMS: When aphids are present on the plant, pale yellow spots are visible on the foliage. Also, leaves may be curled, puckered or stunted. Presence of sticky honeydew is also a good indicator of aphids. Sooty mold may be visible growing on the honeydew. Check under leaves and at growing points for aphid infestation.
- CONTROL: Be aware that there are several beneficial insects that prey on aphids. If population numbers increase, spray insecticide as directed on the chemical label. Just a note: aphids are usually attracted to plants over-fertilized with nitrogen.

c) **Beetles**:

- DESCRIPTION: Beetles range in size, shape and color; however all have hard bodies and wings (Ball and Ball 1990). They have chewing mouthparts.
- SIGNS AND SYMPTOMS: Check for chewed up plant parts such as leaves and flowers. If left unattended, the beetle can totally denude the plant.
- CONTROL: Manually pick beetles from the plant by hand. Remove leaf litter around the plant to eliminate suitable habitat.

d) **Black Twig Borer**:

- DESCRIPTION: Adult females are twice a big as the males at about 1/16 inch long and are shiny black in color. The males are reddish-brown in color and can't fly. The entire life cycle can take about a month to complete (Tenbrink and Hara 1994). They have chewing mouthparts.
- SIGNS AND SYMPTOMS: Stems become weakened and breakage often occurs. Look for small round holes. The twig borers will create holes in the branches and create a living area. Die back of the plant is not caused by the borers feeding on the plant. Instead, it is caused by the physical infestation and the introduction of pathogens (Tenbrink and Hara 1994).
- CONTROL: Remove and destroy infested parts. There may be some biological control insects, but more information is needed. Not too much is known about control methods.

e) **(True) Bugs**:

- DESCRIPTION: True bugs range in body shape, size and color. Typically, the body is shield shaped and about 1/6-1/2 in long (Ball and Ball 1990). When smashed, they often exude a distinct odor. They have piercing-sucking mouthparts.
- SIGNS AND SYMPTOMS: The infested plant may have disfigured growth such as discolored spots, stunted growth, or wilted shoot tips (Ball and Ball 1990).
- CONTROL: If infestation is low, hand pick the insects. Clean the area surrounding the plant of leaf litter to decrease suitable habitat.

f) **Cutworms**:

- DESCRIPTION: Cutworms are soft-bodied caterpillars that are dull gray or brown in color, and are 1 to 2 inches in length. They are nocturnal feeders that find refuge in the soil or leaf litter during the day. As adults, they change into moths. The females lay the eggs in the soil, and they can produce an average of 5 generations a year. (Ball and Ball 1990).
- SIGNS AND SYPTOMS: If seedlings are mowed down or chomped down near the soil line, that's a good indicator of cutworm damage. Some cutworms also attack the seedlings from below the soil line, damaging the roots and causing the plants to wilt. (Ball and Ball 1990). Damage look similar to mollusk damage.
- CONTROL: Put up biological, chemical or physical barriers around the seedlings to deter the cutworms. There may be some beneficial biological control.

g) **Leafhoppers**:

- DESCRIPTION: Leafhoppers have wedge-shaped bodies that are 1/8-1/4in long. They have a hunched look to them since their folded wings are slightly protruding from their bodies. (Ball and Ball 1990, Kessing and Mau 1993a). They range in colors from green, brown or yellow. They are not very active, however, when disturbed, they can jump suddenly or move sideways with agility. They have piercing-sucking mouthparts and can spread virus (Ball and Ball 1990).
- SIGNS AND SYMPTOMS: They feed on all part of the plant (except the roots). As they feed, toxins are released into the plant causing yellowing or discoloration. Leaves will turn yellow and fall off. Leafhoppers excrete honeydew, so ants and sooty mold may be present. (Ball and Ball 1990)
- CONTROL: There may be some beneficial biological control (*e.g.* mymarid wasp) (Kessing and Mau 1993b). Keep area around plants clear of leaf litter and alien plant species.

h) **Mealy bugs:**

- DESCRIPTION: Mealy bugs have piercing-sucking mouthparts, and can attack either the foliage or the root system, depending on the species. They are mobile throughout their lifecycle. Depending of the species, males are relatively short-lived, living an average of 27 days, while the females can live around 115 days (Martin and Mau 1992). Their bodies are covered with a white waxy substance that gives it a “mealy” look (Tenbrink and Hara 1993).
- SIGNS AND SYMPTOMS: Leaves will look droopy and the areas they feed on will be yellow and discolored. They excrete honeydew, which can cover portions of the plant. Look for sooty mold, which grows on honeydew. If ants are present, that’s a good indicator that mealy bugs are there. They can be vectors of pathogens.
- CONTROL: There may be some beneficial biological control (*e.g.*, parasitic wasps). Mixing white oil with the chemical will aid in smothering the scale.

i) **Scale insects:**

- DESCRIPTION: Scales are related to mealy bugs and aphids, and have bodies that range from 1/12 inch to 1/5 inch (Ball and Ball 1990). Most scales are only mobile during the first stage of their lifecycle. Usually, after their first instar, the female scales become immobile attaching themselves to the plant and form a protective coat. This protective coat can vary from cottony white masses to waxy shells. Males, if present, are not able to feed since they don’t have mouthparts. The females either lay eggs or bear live young under the protective scale (Mau and Kessing 1992). Several generations can be produced per year. (Ball and Ball 1990)
- SIGNS AND SYMPTOMS: Areas where they are feeding on will turn yellow and may drop. They excrete honeydew can cover portions of the plant. Look for sooty mold, which grows on honeydew. If ants are present, that’s a good indicator that scales are there. They can be vectors of pathogens.
- CONTROL: There may be some beneficial biological control (*e.g.*, parasitic wasps). Spraying the scale during their mobile stage is the most effective chemical practice. The dead scales are persistent on the plant, so check the scale population prior to

spraying (it may just be dead scale shells). Just a note: Over use of nitrogen fertilizer can encourage growth of scale attracted to succulent new growth.

j) **Spider mites:**

- DESCRIPTION: Spider mites are extremely tiny. Adult females, which are larger than the males, are not any bigger than 1/20 inch (UCDANR 1995). They have piercing-sucking mouthparts that they use to feed on the underside of leaves and flowers. As they feed, toxins are injected into the plant that result in distorted growth and discoloration of the plant. New generations can be produced as quickly as 2 weeks if the conditions are right (Ball and Ball 1990).
- SIGNS AND SYMPTOMS: Check the underside of leaves and on flowers for webbing and tiny excrement pellets as this will indicate the presence of spider mites. Also, if the foliage begins to turn yellow and develop a dry, sandpapery texture, or become distorted in growth that is a good indicator of spider mites. To check whether the spider mites are still on the plant, use a hand lens and examine the underside of leaves. Tap the branch tip or leaves while holding a white paper underneath to catch the spider mites. (Ball and Ball 1990, UCDANR 1995)
- CONTROL: There may be some beneficial biological control (*e.g*., parasitic mites and ladybird beetles). Spider mites thrive in hot, dry, dusty conditions. The warmer the conditions, the faster they reproduce. Make sure the plants have adequate water because when plants are water-stressed, they are more susceptible to spider mite damage. Be aware that some chemicals such as carbaryl and pyrethroids can actually increase spider mite production (UCDANR 1995).

k) **Thrips:**

- DESCRIPTION: The adult thrips are winged and are less than 1/25 inch long. They are shiny and usually black or yellow in color and have a rasping mouthpart. Thrips can produce approximately 8 generations per year. They thrive in dry environments so make sure the plants are adequately misted and watered (Ball and Ball 1990).
- SIGNS AND SYMPTOMS: Check the new growing tips or buds for thrips. If the leaves are curled, or if tiny, black excrement on the leaves is visible, that's good indicator that thrips are present. Also, if there is dried tissue on the leaves, or discoloration or disfiguration of the leaves or flowers, that can be another indication of thrips (Ball and Ball 1990 UCDANR 1996).
- CONTROL: There may be some beneficial biological control (*e.g.*, predatory mites). Prune affected flowers and foliage, and dispose of properly. Use sticky traps to monitor. Keep plants adequately watered, and do not let it become water-stressed (Ball and Ball 1990, UCDANR 1996).

l) **Whitefly**:

- DESCRIPTION: Whiteflies are white, tiny moth-like four-winged insects with piercing-sucking mouthparts. The immature whiteflies resemble aphids, however they are legless and not very mobile once they start feeding (Ball and Ball 1990, Flint and Parrella 1995). They produce many generations per year, sometimes one generation in less than three weeks depending on the temperature. They thrive in warmer climates (Flint and Parrella 1995).

- SIGNS AND SYMPTOMS: Check the underside of the leaves for whiteflies. If present, the leaves will prematurely turn yellow and then fall off. The plant growth will also be stunted. Whiteflies produce honeydew, so check for presence of sooty mold or ants.
- CONTROL: There may be some beneficial biological control (*e.g*., parasitic wasp). Use sticky traps to monitor the whitefly population on a weekly basis in conjunction with a weekly foliage inspection (Flint 1995). Horticultural soaps and other insecticides can be effective in controlling the population. "Try to time treatments when your monitoring results indicate that most of the population is in the first, second, or third instar stage" (Flint 1995). When spraying, make sure there is good coverage of insecticides to the underside of the leaves.

2. Weed Monitoring and Control

- Any plant (alien or native) in the pot other than the designated plant is considered a weed.
- Monitor on a weekly basis.
- Install weed mat in and around the growing area.
- Have a buffer area around the growing area/nursery of at least 6 feet
- Enclose growing area to prevent weed seeds from blowing in to pots.
- Pull alien plant species from pots and growing area as they come up. Do not let them go to seed.
- If weed problem gets out of hand, apply herbicide.
- Contact your local agriculture extension agent or DOA agent for proper identification, up-to-date chemicals and current control practices.

3. Nematode Monitoring and Control

- Look for signs and symptoms.
- Identify the target pests (make sure it is a nematode).
- Know their life cycle.
- Monitor on a weekly basis.
- Due to the fact that there are many different nematodes, contact your local agriculture extension agent or DOA agent for proper identification, up-to-date chemicals and current control practices.

- DESCRIPTION: Nematodes are tiny, microscopic, worm-like organisms that are usually translucent with a white hue, and have bodies that are covered by a tough cuticle (Ball and Ball 1990).
- SIGNS AND SYMPTOMS: In general, plants affected by nematodes look unhealthy or stunted. It is difficult to identify nematode damage, but damage from a root-knot nematodes can be seen as galls on the roots. Look for plants that look sickly for no apparent reason. Chlorotic leaves or yellow patches on the plant, wilting, and stunting are the main symptoms to look out for. For a positive identification, a dissection of the root is necessary. If nematodes are present, roots will be reduced and have galls (Holtsmann and McSorley 1993, Ferreira and Boley 1991).
- CONTROL: There are a few cultural control steps that can be implemented to prevent the spread of nematodes. Have good sanitation practices like removing and destroying infected parts or plants from the growing area and disposing of them

properly. Do not dispose of in the compost piles. There are some nematocides that are no longer recommended for control. It would be best to contact DOA, or a UH Agriculture specialist to check on the species of nematodes, and chemicals to use for controlling nematodes.

4. Mollusk Monitoring and Control

- Look for signs and symptoms.
- Identify the target pests (make sure it is a pest and not a beneficial insect).
- Monitor for pests presence and their levels of abundance.
- Know their life cycle
- Monitor on a daily basis, usually early morning is best.
- Contact your local agriculture extension agent or DOA agent for proper identification, up-to-date chemicals and current control practices.

a) Slug

- DESCRIPTION: Slugs are terrestrial mollusks that do not have shells. They have slimy bodies, are usually 1 to 2 inches (some can even reach 8 inches) long and travel on a foot that leaves a trail of slime behind. The colors range from white, yellow to black. They have a rasping mouthpiece. The eggs are in translucent-white, individual sacs, which form a cluster, and are usually found in dark, cool, moist areas or underground. Slugs can produce about 6 generations per year and take about a year to mature. (Deputy and Murakami 2000).
- SIGNS AND SYMPTOMS: Look for the slime trail, which is usually silver in color. Damage to the plant, such as large ragged holes in leaves, flowers, and stems, is done by the slug. They can quickly defoliate the plant if not controlled. Check the undersides of pots and in drainage hole of the pot to see if they are present. Slugs begin feeding at the bottom of plants and work their way up (Ball and Ball 1990).
- CONTROL: Keep area around plant and in pot clear of leaf litter. Manually dispose of any slugs in growing area. Set up traps to lure slugs and then dispose of them. Set up a physical or chemical barrier to deter slugs. Use baits to kill slugs (Deputy and Murakami 2000).

b) Snails

- DESCRIPTION: Snails are soft-bodied mollusks that are protected in a shell. They can range in color from cream, pink to gray. The markings on the shell vary from species to species. They can be found in moist, dark areas, usually coming out at night to feed with their rasping mouthpiece (Ball and Ball 1990). They produce about 80 eggs at a time, and can lay eggs up to 6 times a year. The eggs are rounded and white in color, and can be found in the upper layer of the soil. The snails mature in two years (Deputy and Murakami 2000).
- SIGNS AND SYMPTOMS: Look for the slime trail, which is usually silver in color. Damage to the plant, such as large ragged holes in leaves, flowers, and stems, is done by the snail. They can quickly defoliate the plant if not controlled. Check the undersides of pots to see if they are present (Ball and Ball 1990).

- CONTROL: Keep area around plant and in pot clear of leaf litter. Manually dispose of any snails in growing area. Set up traps to lure snails and then dispose of them. Set up a physical or chemical barrier to deter snails. Use baits to kill snails (Deputy and Murakami 2000).

5. Pathogen Monitoring and Control

- Look for signs and symptoms.
- Identify the pathogen.
- Know their life cycle.
- Monitor on a daily basis.
- Contact your local agriculture extension agent or DOA agent for proper identification, up-to-date chemicals and current control practices.

a) Bacterial disease

- SIGNS AND SYMPTOMS: Infected plants often have rotted leaves, stems, branches, or tubers, which have a foul odor. When cutting into an infected area, a small amount of whitish or yellowish ooze will seep out. Other symptoms include wilted leaves or stems, or odd shaped galls on the stem or on the roots near the soil line. Symptoms can spread quite quickly by splashing water (such as irrigation or rain) or by infected soil. They can enter a plant either through wounds or through the stomata (Ball and Ball 1990).
- CONTROL: Besides chemical control methods, also remove all infected plants, and wash hands and sterilize tools after handling infected plants. Provide ample spacing between plants to encourage good air circulation. Clean up and remove diseased plant parts and dispose of them by placing in plastic bag or sealed container right away.

b) Fungal diseases

- SIGNS AND SYMPTOMS: Look for rust-colored or powdery-white looking spots on either side of leaves. These spots will eventually make the leaf chlorotic and will eventually kill the leaf tissue. Also, look out for water soaked spots, greasy looking areas, or black streaks or blotches on the leaves or stems (Ball and Ball 1990).
- CONTROL: Besides using fungicide control methods, remove affected areas and dispose of in a plastic bag or a sealed container. Be sure to wash hands and sterilize tools after handling infected plants. Provide ample spacing between plants to encourage good air circulation (Ball and Ball 1990).

c) Viral Diseases

- DESCRIPTION: “Viruses are basically parasites, multiplying inside their hosts or if no host is available, lying inactive but viable in dead plant material for up to 50 years while waiting for a new victim” (Ball and Ball 1990).
- SIGNS AND SYMPTOMS: Be aware of plants that have poor overall growth (like stunted leaves, and flowers). There may be yellowish mottling patterns on the leaves, stems or blossoms that make the plant look sickly (Ball and Ball 1990).

- CONTROL: Viruses are spread by insects with piercing-sucking mouthparts such as aphids and leafhoppers. Garden tools and humans are other vectors of viruses. Do not take cuttings from infected plants as the cuttings will also have the virus. Remove and destroy (not in the compost pile) the infected plants, and wash hands and sterilize tools after use (Ball and Ball 1990).

6. Small Mammals and other pest monitoring and control

- Look for signs and symptoms.
- Identify the target pests.
- Monitor for pests presence and their levels of abundance.
- Know their life cycle
- Monitor on a daily basis.
- Contact your local agriculture extension agent or DOA agent for up-to-date chemicals and current control practices.

a) Rats/Mice

- SIGNS AND SYMPTOMS: Look for seedlings and/or seeds dug up, uprooted and eaten. Droppings and tracks.
- CONTROL: Traditional mousetrap and bait. Use good sanitation practices by cleaning up all possible food sources, using rodent-proof containers of metal or glass, and removing tall grass, alien plant species and shrubby growth.

b) Birds

- SIGNS AND SYMPTOMS: Young seedlings and/or buds may be nipped off. Look for droppings and feathers.
- CONTROL: Barriers and deterrents like metallic ribbon and owl figures.

c) Toads and Frogs

- SIGNS AND SYMPTOMS: Look for evidence of nestling in pots such as vegetation in pots that are smashed or pushed to the side of the pot. Toads and frogs are potential carrier of nematodes.
- CONTROL: Do not have standing water anywhere that would make it favorable to toads or frogs. Capture manually and dispose/release in favorable habitat far away from the growing area.

Attachment 3: Approved Growing Media

This list of approved growing media was modified from the Department of Agriculture's Approved Growing Media for Japan-Hawaii Burrowing Nematode Certification Program.

1) Peat
2) Bark
3) Bark charcoal
4) Perlite
5) Vermicultie
6) Rock wool
7) Pumice
8) Volcanic cinder*
9) Coir

*If volcanic cinder is used, it must be from a cinder pit where the cinder source is certified. This is a voluntary compliance with the Department of Agriculture.

Note: Compost is NOT allowed in the growing media at any time. It can carry pathogens, weed seeds/spores, and other pests.

Attachment 4: Certification Requirements of Rooted Plants to Meet Burrowing Nematode Quarantine

REVISED 8/82

State of Hawaii
DEPARTMENT OF AGRICULTURE
Plant Quarantine Branch
Honolulu, Hawaii

CERTIFICATION REQUIREMENTS OF ROOTED PLANTS TO MEET BURROWING NEMATODE QUARANTINE

1. QUARANTINE

The states of Claifornia, Louisiana, and Texas have established a quarantine against the nematode, *Radopholus similis*. The commodities covered by this quarantine are:

A. All earths including sand and soil, **except** industrial sand and clay.

B. All plants and plant parts with roots, including aerial roots, **except**:

1. Air plants, including certain orchids and other plants produced epiphytically, if growing exclusively in or on soil-free material such as osmunda fiber, tree trunk, or bark.
2. Aquatic plants if free from soil.
3. Plants secured by air layering if roots are established and enclosed in the original soil-free moss wrappings.
4. Root and soil-free cuttings of Ti *(cordyline* subsp.*).*

C. All parts of plants produced below the ground or soil level **except:**

1. Dormant bulbs and corms for propagation, if free from roots and soil, **but not including taro** corms for propagative purposes.
2. All fleshy roots, corms, tubers and rhizomes for edible or medicinal purposes if washed or otherwise free of soil.

D. All plant cuttings for propagation.

II. CERTIFICATION REQUIREMENTS
(Based on California's Quarantine 25, the most restrictive of the three states involved.)

All commodities covered by this quarantine are prohibitive entry into these states unless each shipment or lot is accompanied by a certificate issued by a State Plant Quarantine Inspector, establishing that all material contained in the shipment meets **one** of the following conditions:

A. It has been determined through survey by methods approved by the California, Louisiana and Texas Departments of Agriculture, at six month intervals that the burrowing nematode does not exist on the property or premise or facility used to grow the nursery stock, and that the seed or plant parts used for production of the plants were determined by the certifying officer to be free from burrowing nematodes, or

B. The plants or plant parts being shipped to these states were protected from burrowing nematode infestation by all the following sanitation methods:

1. Propagated from clean seed or from cuttings taken at least 12 inches above the ground.

2. Planted in suitable material prepared or treated to assure freedom from burrowing nematodes.

3. Retained in sterilized pots, containers or beds.

4. Placed on sterilized benches or sterilized supports at least 18 inches or above from the ground or floor level.

5. Area beneath the benches or supports holding plants treated at six month intervals with a registered nematocide or other material having nematocidal value and approved by Department of Agriculture officials, **except** when smooth, clean flooring of concrete is present.

6. Plants and growing media sampled using methods approved by these states and found free of the burrowing nematode.

7. Protected from contamination until shipped.

C. The shipment consists of only unrooted plant cuttings of plants, which are not prime hosts, and the cuttings were taken at least 12 inches above ground level and were protected from contamination until shipped.

*Root-free and soil-free cuttings

Ill. PRODUCTION OF NEMATODE-FREE PLANTS OFF THE GROUND UNDER CONDITION 11-B
(Including terrestrial or ground orchids such as *Arundina*, *Bletia*, *Cymbidium Phaius*, *Spathoglottis*, *etc.*, grown in soil)

A. Growing Ground or Nursery Area.

1. The nursery growing ground must be free from alien plant species, live roots and other plant growth (cleaned by bulldozing, hoeing or weed killers).

2. The soil floor shall be paved, covered with plastic covering, gravel, black sand, cinders or similar materials. (Saw dust is not recommended because of its tendency to retain moisture which is favorable for the development and increase of burrowing nematodes.)

3.Walkways must be paved with concrete, black top or gravel.

4. The grounds shall be fumigated or treated with nematocides at dosages specified under III-C-1a-f.

B. Benches, Watering System, *etc.*

1. The benches shall not be closer than 3 feet from the nearest shrubbery or plants or overhanging tree branches.

2. Plants and aerial roots shall not be grown lower than 18 inches from the ground level to top of benches.

3. Overhead sprinklers are recommended for watering but hoses may be used if they are kept off the ground.

4. Benches and plant boxes, containers, flats and implements must be washed free from soil and treated with 5% formaldehyde, Vapam or similar nematocides prior to each planting.

C. Preparation of Planting Media and Treatment of Infested Grounds

1. Sand, cinders or used peat fern fiber or moss, *etc.*, must be sterilized or treated with nematocide.
(Clean new peat, *etc.*, need not be treated.)

   a. Steam sterilization 1600 ºF. - 2000 ºF. at center of media for 30 minutes.

   b. Methyl bromide (98%) 1-4 lbs. per 1,000 cu. ft. or 100 sq. ft. for 24 hours at 70 ºF. or above. (Under gas-tight cover-aerate 2-3 days.)

   c. DD Mixture 20-40 gals. per acre or 5 ml (1 tsp. per cu. ft. (No cover or water seal-aerate 1 week for every 10 gals./acre.)

d. EDB (40% by wt.) 20-40 gals. per acre or 1.7 ml (1/3 tsp.) to 5 ml (1 tsp./cu.ft.) (No cover or water seal-aerate 10-14 days.)

e. Vapam: 1 qt. Vapam in water per 100 sq. ft. for 5 days (water seal-aerate 14 days or more).

f. V-C 13 nemacide 1 pt.: 50 gals. water per 100 sq. ft. - 1/2 pt.: 9 gals. per 1 1/3 cu. yd. (1 tsp.: qt. water/per cu. ft.) (Drench-aerate 14 days.)

NOTE: Contact Hawaii Department of Agriculture, Pesticide Section for Pesticide Use Requirements.

D. Planting Materials, Seeds.

1. Clean seeds, rootless cuttings, aerial cuttings, crowns, or suckers taken well off the ground may be planted in clean or treated media under supervision.
   (The above materials must not contact the ground or soil at any time.)

2. Rooted plants, off-shoots, suckers, corms and rhizomes (except benchgrown epiphytic orchids in moss) - each plant or propagative part must be determined as free from burrowing nematode before planting under supervision.
   (Laboratory inspection fee - charged at the rate of $2.00 for 1-6 "plants.")

3. No plants are to be placed over the propagative stock (hanging containers or secondary benches).

E. Cost of Inspection for Commercial Nurseries Upon Request.

1. Nurseries carrying less than 10,000 plants of varieties covered by burrowing-nematode quarantines…

   $20.00 - each field inspection

2. Nurseries carrying more than 10,000 plants of varieties covered by burrowing-nematode quarantines...

   $40.00 - each field inspection

3. Mileage charge: For travel to and from the Department's offices, additional charges of 20 cents per mile.

IV. PRODUCTION OF EPIPHYTIC ORCHID PLANTS GROWN OFF THE GROUND.

In the quarantines, air plants include "certain orchids produced epiphytically if growing exclusively in or on soil-free material such as osmunda fern and bark." The phrase "if growing exclusively" apparently is the criterion to reject or release the orchid plant upon arrival. The theory is that if an orchid plant arrives on the mainland with the roots imbedded in the soil-free media, the inspector can be reasonably sure the plant was grown epiphytically off the ground and free from *Randopholus similis.* If not, the plant may be rejected. Certification in Hawaii is guided by the above and discretion of the inspector at the time of examination.

Exceptions to the above interpretation can be expected from some counties. San Luis Obispo County, California, has refused all rooted orchid plants regardless of the potting material unless certified with a special burrowing-nematode certificate. To eliminate the uncertainty of rejections, commercial orchid growers should have their nurseries approved. The following requirements must be met to qualify for special burrowing-nematode certificates.

A. All epiphytic orchid plants must have originated in soil-free media, kept off the ground and the premises inspected at six month intervals.

1. Recommended height of benches, *etc.*, at least 18 inches or higher from ground.
2. Aerial roots must not touch the ground.
3. Premises or greenhouses must be relatively free from alien plant species, live roots and other plant growths.
4. Orchid plants growing on approved premises should be kept free from injurious insects, pests and diseases at all times.
5. Overhanging tree branches.

B. Owners of approved nurseries must agree to ship clean plants, bench-grown in soil-free media only.

C. Cost of Inspection for Approval of Orchid Nurseries.

1. Nurseries carrying less than 10,000 plants of varieties covered by burrowing-nematode quarantines…

   $20.00 - each field inspection

2. Nurseries carrying more than 10,000 plants of varieties covered by burrowing-nematode quarantines...

   $40.00 - each field inspection

3. Mileage charge: For travel to and from the Department's offices, additional charges of 20 cents per mile.

V. SHIPPERS OF SMALL LOTS OF ROOTED PLANTS (COMMERCIAL AND NON-COMMERCIAL)

A. Certification of small lots (1-6 plants) to California, Louisiana and Texas.

(Large lots of 100 or more plants - inspection by special arrangements only.)

Small lots of rooted materials or plant cuttings may be tested for the presence of the burrowing-nematode by subjecting the root or cutting samples to the Baermann funnel method of detecting nematodes as outlined in "Standard Procedures for County Plant Nematology Work" (PI. Path. B-61-6).

B. Places of Inspection.

Plant Quarantine Station
701 Ilalo Street
Honolulu, Hawaii 96813
(Phone: 586-0844)

Plant Inspection Office
Lihue, Kauai, 96766
(Phone: 274-3071)

Plant Inspection Office
635 Mua Street
Kahului, Maui 96732
(Phone: 873-3556)

Plant Inspection Office
Kilauea and Lanikaula Streets
Hilo, Hawaii 96720
(Phone: 974-4141)

C. Time Required.

Owners must agree to leave plants at their own risk for about 5 working days pending examination.

D. Sample Preparation.

Sufficient roots or part of the cutting will have to be removed for examination.

E. Conditions, *etc.*, of Materials.

Plants must be washed and may be repacked in spagnum moss, peat moss or vermiculite by the owner before submitting for inspection.

Rhizomes, flowering ginger rhizomes, Heliconia, coconut plants, *etc.*, should be brought in with roots and rootlets attached or be refused for testing.

It is recommended that antheriums, philodendrons, *etc.*, be limited to young suckers, top cuttings or plants originating in moss and grown off the ground.

Plant quarantine supervision of plants cut 12 inches above the ground level or collecting of rooted aerial growths of red ginger, papyrus on private premises for export certification is available on an appointment basis. Charges for this service will be in accordance to Regulation 6.

F. Charges.

$2.00 for 1-6 plants brought to Quarantine Station or Inspection Office. (Charges will not be refunded regardless whether or not plants are found to be infested with burrowing-nematodes.)

NOTE: Requirements and conditions stated are subject to change as the concerned state's quarantine regulations are amended from time to time.

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Appendix 1.5 HRPRG Guidelines for Rare Plant Inventory, Monitoring and Collecting

Instructions and Methods

Hawaii Rare Plant Restoration Group

This document, provided by *Hawaii Rare Plant Restoration Group* (HRPRG) and the *Center for Plant Conservation Hawaii* (CPC), serves as guidance when observing, inventorying, monitoring and collecting rare plant populations in Hawaii. Attached are two forms the HRPRG recommends for use: the *Rare Plant Background Data Form,* and the *Rare Plant Field Data Form*.

Rare Plant Background Data Form

This form is to be used in the office and does not need to be taken into the field. Information can be obtained from the Field Data Form or from other reference sources.

CPC Population Reference : This code is assigned by the CPC office staff to be consistent with national CPC standards. It is cross-referenced with individual agency population reference designations. For example, the first individual marked in the first population of *Cenchrus agrimonioides agrimonioides* would have the reference code Cenagragr-A-01.

All other requested information is self-explanatory.

Rare Plant Field Data Form

This form is designed for use in the field. It has an introductory section where general population tracking information can be recorded (*i.e.,* species, population #, observers, location, *etc*.). It has an *Individual Plants* section for use when conducting a detailed population inventory or monitoring, or when collecting material for taxonomic, genetic, or propagation purposes. It has a *Population Structure* section for tracking the age class within a population and a *Population Information* section for tracking phenology, vigor, and environmental characteristics such as canopy height and closure, topography, and edaphic conditions. Instructions for filling out each of these sections are listed below.

Scientific Name: Genus and species.

Agency Ref. Code: Provide the population number assigned by the observer, or the observer's agency. An abbreviation of the population location can be included in the code. For example a *Cenchrus agriminoiodes agriminoiodes* in Makua

Military Reservation would have an Agency Reference Code of Cenagragr-MMR-A-01.

Observers: Name all observers present.

Agency: Identify the observer's agency affiliation.

Location/Directions/
Flagging scheme: Record any and all information that could assist in relocating the population, including geographical coordinates (UTM or Lat.-Long. or GPS coordinates). Also indicate if a GPS file exists, if it was sent to CPC and if it was entered into a GIS database. Further descriptive directions could be included which would help to locate the population such as landmarks, trails and transect stations.

Photo Taken (Y/N)
Notes: Record whether or not photographs were taken this visit. If so, record photo record number, type and speed of film and other pertinent information that could aide in tracking-down previously taken photographs. If fixed photo points were used, describe their location(s). A point of contact who is in possession of the negatives and other information about the photograph should be included.

Elevation: Record the elevation of the population in feet or meters (use the "~" symbol to indicate "approximate").

Date: Record date of field visit.

Individual Plants: This section must be completed when collecting fruit, optional when not.

Plant Number: Record existing plant number or assign one. Must sketch a map and/or use a tag to indicate plant number.

Tagged: Indicate whether or not the population is marked (including your own numbered tag, flagging or label).

Sex: For plants with perfect flowers indicate P (perfect). Indicate sex of only plants with imperfect flowers (having only male or female reproductive parts within a flower). Indicate in this column M (male); F (female), B (both) if male and female flowers exist on the same plant. Mark Unk (unknown) if sex can not be determined.

Height: Measure or estimate height or length of plant. Height is measured from the substrate to the point on the plant furthest from the substrate. Length is used for prostrate or climbing plants such as vines and grasses.

Basal Diameter: Record estimated diameter at 1 decimeter (dm) above root crown. If you choose to use diameter at breast height (DBH), then indicate so in the header of this column. Indicate N/A for plants with impossible situations such as Bunchy grass.

Age Class: Use definitions from the ***Population Structure*** section below.

Reproductive Status: Indicate the reproductive status of the individual [*i.e.*, in a vegetative state, in bud, in flower, possessing immature fruit, possessing mature fruit, or in a dormant (post reproduction) stage].

Vigor: Assess the vigor of the individual plant; use your best judgment.

Material Collected:

immature fruit/seed: Record number taken (indicate fruit or seed)
mature fruit/seed: Record number taken(indicate fruit or seed)
cuttings: Record number taken
Propagule destination: Identify where the propagules will be sent
Plan for Propagules Collected: Identify the intended fate of propagules collected

Population Structure: This table must be completed for all site visits. This table is designed to track the age structure of the population. If an actual count is performed, fill out column titled "counted number of individuals". If only an estimate is performed, fill out column titled "estimated number of individuals." Identify the age class of the individual and define your age classes (Examples of age class definitions could be: Mature = Indication that the plant has reproduced at some point in it's life, Immature = > 1 dm, but no indication of previous reproduction, Seedling = < 1 dm, no evidence of previous reproduction).

Population Information: These boxes are intended for use in *all* population visits.

Accuracy level: Indicate whether data is an actual count of all individuals or an estimate of the population. Circle % or actual count.

Phenology: Designate phenological state for all plants recorded as mature in population structure section. Record actual numbers of individuals in each category or estimate % of population that falls into each category by circling % or actual count. Could exceed 100% because any given plant could be fruiting and flowering at the same time.

Condition: Indicate the "health" condition of the population by recording the number of individuals in each category or by estimating the % of the population that falls into each category. Circle % or actual count.

Light level: Indicate the light level in the immediate environment of the plant. Full sun, >95% of the day in direct sunlight, partial sun 50-95% of the day in direct sun, partial shade 5-50% of the day in direct sun, deep shade 0-5% of the day in direct sun. Indicate % or actual count for each category.

Habitat Characteristics: These boxes are intended for use in *all* population visits. For the following categories, mark only one choice or indicate *why* more than one choice was marked.

Overstory Closure: Circle the appropriate overstory closure class which defines the habitat of the plant. Overstory is defined as the vegetation above 2 meters.

Overstory height: Indicate overstory height which defines the habitat of the plant. Choose all that apply.

Understory Closure: Circle the appropriate understory closure class which define the habitat of the plant. Understory is defined as the vegetation below 2 meters.

Soil Drainage: Circle the appropriate soil drainage descriptor. Well = No standing water high oxide content. Moderate = wet with medium oxide content. Poor = Reducing conditions show green or gray colored soils. Hydric = standing water at or just below surface.

Topography: Circle appropriate topographic position of plants.

Moisture class: Circle the appropriate estimated moisture regime. (This may not be possible from field observations and should be confirmed through weather station data or other sources.) If you mark more than one, explain.

Slope: Circle the estimated slope of the ground at the population.

Aspect: Indicate the aspect if there is a slope at the location (N, NW, NNW, *etc.*). Write in N/A for flat sites.

Associated Species:

Overstory: In order of abundance, record the most abundant associated overstory taxa (>2 meters) in the vicinity of the plant including those which define that type of habitat. Indicate genus/species, can use 6-letter abbreviations. If the rare plant population is very scattered and associated species vary over its distribution, list the associated species but indicate they are in no particular order.

Understory/
Ground Cover: In order of abundance, record the most abundant associated Understory taxa (<2 meters) in the vicinity of the plant including those which define the habitat of that plant.. Indicate genus/species, can use 6-letter abbreviations. If the rare plant population is very scattered and associated species vary over its distribution, list the associated species but indicate they are in no particular order.

Substrate: Identify the substrate (*i.e.*, type of soil, cinder, sand, pahoehoe, *etc.*).

Threats and Management: Identify any observed or perceived threats (*i.e.*, weed species, ungulates, rodents, invertebrates, disease, fire, erosion, poor health). Identify necessary or suggested management actions or list other comments. Also indicate any management actions taken on the visit.

Sketch map: Please draw, to the best of your ability, a map of the site that could be used to relocate the population by persons who have never been there. Indicate individual plant locations on map if fruit collected.

Attachment 1: HRPRG Rare Plant Field Data Form

Hawaii Rare Plant Restoration Group

Rare Plant Field Data

Scientific Name ____ Date __________________

Agency ________________________________ Observers _________________________________

Agency Population Reference ________________ Island _____________ Elevation ___________ft/m

Location/Directions/Flagging Scheme/GPS Notes ____

____

____

Photo taken? Y/N ___ Notes ____

Individual Plant Information

								Material Collected			
Plant #	Tag ? Y/N	Sex P or M/F Both or Unk	Ht. (m)	Basal Diam (cm) or N/A	Age Class: mature, immat, seedling	Reproduct. Status: veg, bud, flwr, imm frt, mat frt, dormant	Vigor: healthy mod, poor, dead	# Imm. Fruit or seed	# Mat. Fruit or seed	# Cut-tings	Propagule Destination & Purpose (*i.e.*, Lyon for prop and reintro @ SB)

Population Structure

Age Class	Observer Definition of Age Class (Define criteria for seedling, immature, and mature, *e.g.*, height, reproductive status, *etc.*).	Counted # of Individuals	Estimated # of Individuals
Seedling			
Immature			
Mature			
Total			

Population Information (If multiple categories chosen, explain in comments section below.)

Accuracy level (circle)	Phenology (for mature	Indicate % or	Condition	Indicate % or	Light Level	Indicate % or actual

	plants)	count		count		
Actual count	Vegetative		Healthy		Full sun >95%	
Estimate	Bud		Moderate		Partial sun 50-95%	
	Flower		Poor		Partial shade 5-50%	
	Imm Fruit		Dead		Deep shade 0-5%	
	Mat Fruit					
	Dormant					

Habitat Characteristics (circle)

Overstory Closure >2m	Overstory height (All that apply)	Understory Closure <2m	Soil Drainage	Topography	Moisture Class	Slope (degrees)
Closed75-100%	2-5m	Closed 75-100%	Well	crest	Dry <25"/yr	flat 0-10°
Intermediate25-75%	5-10m	Intermediate 25-75%	Moderate	upper slope	Dry-Mesic 25-50"/yr	moderate 10-45°
Open 0-25%	>10m	Open 0-25%	Poor	mid slope	Mesic 50-75"/yr	steep 45-70°
			Hydric	lower slope	Wet-Mesic 75-100"/yr	vertical 70-90°
				gulch bottom	Wet >100"/yr	
				plateau-flat		

Aspect (*e.g.*, N,NNW,N/A)______________________

Associated species in order of abundance
Overstory >2m____

____

Understory/Ground Cover <2m(woody and herbaceous)______________________________

____

Substrate (*e.g.*, soil, pahoehoe, rock, sand, *etc.*) ___________________________________

Comments on threats (alien plant species, ungulates, arthropods), management suggestions and actions

____

____

____

Sketch Map

Appendix 1.6 HRPRG Collecting and Handling Protocols

Hawaii Rare Plant Recovery Group - Collecting and Handling Protocols

General Information

What do I need to provide to the propagation facilities when I submit my samples?

1. Provide whenever possible the Rare Plant Field Data Form. If not, include with plant material sample descriptors such as:

    - Genus, species, subspecies, *etc.*
    - Collection organization
    - Collector
    - Date of collection
    - Collection site
    - Collection number
    - Type of material
    - Purpose of collection

    This is to ensure accurate documentation of the plant samples.

2. Label all samples legibly and unambiguously. Make sure all samples are tagged.

3. If any special or significant sampling methods were used, note what was done.

4. Note any pest problems associated with the parent plant at the time of collection.

5. If possible, make arrangements with the propagation facility before sample collection.

6. Submit samples to the propagation facilities **as soon as possible**! Delays may have deleterious effects on sample viability.

How do I handle my plant samples after I collect them?

1. Insulate from heat. Keep at ambient to cool temperatures but do not freeze.

2. Try to cushion material so it won't be crushed.

3. Do not pack samples with excessive moisture or allow samples to sweat in the bags for an extended period of time. This promotes fungal and bacterial growth and accelerates the decline to sample quality.

4. Send to propagative facilities as soon as possible.

<u>Collecting and Handling of Seed Propagules</u>

Seed quality is primarily dependent upon the seed collector's methods and post harvest handling of material. Knowledge of timing and habit of natural seed dispersal is helpful (though not always available) in seed collection. Attention to inflorescence structure and their seed maturity patterns are also important in determining what to harvest.

Loss of seed viability is due to:

1. Excessive temperature.

2. Development of anaerobic conditions around the seeds caused by their own respiration. This is due to storing in plastic bags or tight packing.

3. Prolonged time interval from collection of samples to propagative facilities under conditions conducive to fungal and bacterial growth. Samples of fleshy fruit stored in plastic bags should be aerated intermittently in immediate delivery is not possible.

Dry dehiscent	Only available before it disperses. Try to harvest just before dehiscing.
Dry Indehiscent	Dependent upon when and how dispersed. For example, wind dispersed, by animals or insects, *etc.*
Fleshy fruits	Need to know if recalcitrant (desiccation intolerant) or orthodox (desiccation tolerant).

Recalcitrant Seed

Recalcitrant seeds cannot withstand any drying. Some have seed coats adapted to prevent excessive water loss while others have no such adaptation and are prone to rapid water loss post harvest.

In fleshy fruits, high seed moisture can be maintained by keeping the fruit intact. Seeds can be stored in impermeable plastic bags, but must be aerated by opening the bag intermittently to compensate for the restrictive gas exchange environment.

Insulate against heat and temperature extremes. Try to maintain a temperature as close to ambient as possible.

In mature fruit, indicate if picked off the ground or parent plant. Try not to collect from the ground if possible, unless it is known that they have recently fallen.

Orthodox Seed

In general, the desiccation tolerance of orthodox seed varies throughout its development. They tend to be intolerant of drying during early development and become more tolerant as the seeds mature.

If the fruits are immature, leave the seed within the fruit. Treat in the same manner as recalcitrant seeds.

Mature seeds from dry indehiscent or dehiscent fruits can be kept in permeable containers such as paper or cloth bags.

Collecting and Handling of Vegetative Propagules

Successful propagation of vegetative propagules is dependent upon many different factors such as the vigor of the parent, the collection date and even the environmental conditions at the time of collection. Correct handling of vegetative material is also important.

1. Vegetative materials deteriorate quickly post harvest and quick transfer from field to the propagative facility is imperative to ensure maximum viability.
2. Additional care must be taken during transport since they are easily damaged.
3. Place under cool conditions, such as a cooler with ice packs, as soon as possible after collecting and during transport to the propagation facility.
4. Try to collect samples that are insect and disease free.
5. Minimize damage during harvesting and transport.
6. In the case of vegetative cuttings, cut ends can be wrapped in damp towels or newspaper.

Vegetative Cuttings (Herbaceous)

The shoots harvested should be from the last mature flush of the plant. Cuttings should be long enough to allow for trimming and possible division.

If the plant species is known to be hard to propagate, small rooted plant suckers with some of the soil surrounding the roots could be taken if possible. Whole plants should not be removed at any time.

Vegetative Cuttings (Woody)

Propagation of mature trees is more difficult in general than their juvenile counterparts; but in many cases, juvenile forms are not available for collection. Whenever possible, the best material for propagation is the juvenile form. If only mature forms are available, material from their juvenile gradients may have a better chance of success.

Roots and Tubers

Timing of collection is important. The collection of immature or sprouting storage organs can result in significant losses in viability. In the case of plants that possess a dormant stage, a two-visit strategy may be required. One to identify individual clones and mark their location and another to collect the tubers or rhizomes once the top of the plant has died.

Fern Fronds

Fern fronds should be kept in plastic bags and not allowed to dry out during transport. If immediate delivery to the laboratory is difficult, place frond between 2 sheets of paper and allow to air dry flat within a plastic bag propped open. Spores will fall off frond as it dries. Seal the bag shut when completely dry and maintain a flat position to keep the spores on the paper surface.

Flowering Shoots

Some flowering shoots contain vegetative buds that do not develop but remain dormant. Sometimes the dormancy can be broken to produce juvenile vegetative shoots. Also, the immature flowers of a few tree species have been known to form adventitious shoots.

Root Cuttings

When lateral shoots are not available, such as in palms and other monocots, it is sometimes possible to produce vegetative shoots from root cuttings. Roots are often considered to be more juvenile in age than most of the tree. A juvenile gradient exists for roots, with the most juvenile material being closest to the trunk. Sprouts arising naturally from the roots of trees generally are juvenile in form. Store root cuttings in a moist sterile medium, such as peat moss.

Decontamination of Collecting Tools

Many of the Hawaiian endemic species have limited or non-existing *ex situ* collections, which necessitates the need for active *in situ* collecting. It is imperative that precautions be taken to keep the natural populations as disease free as possible. This is not only to maintain clean propagative stock material during collections, but also to ensure the integrity and overall health of the existing population and the surrounding flora. While absolute elimination of all pathogens is impractical and impossible, procedures should be directed toward preventing the introduction of serious foreign pathogens.

The risk of disease transmission of viral, fungal, or bacterial origin is a realistic possibility through the cutting implements used in collection of plant samples. Whenever possible, plant cuttings should be made with a new, unused blade. This can be accomplished by using an implement such as a box knife fitted with a disposable razor blade. The used blade can be changed before cutting the next sample.

Dr. Stephen Ferreira at UH Plant Pathology has also suggested that any cutting of plant propagules performed post collection should be done with disinfected tools. This is to prevent any disease contamination of the propagules before it goes to the propagation facility.

Decontaminate tools:

> Make a 5 % to 10% solution of household bleach (such as Clorox manufactured by The Clorox Co.) and soak tools. Let sit for 2-3 minutes then rinse well with water. Always use a fresh batch of bleach solution.

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Draft Monitoring Protocol 1.2.1
Belt Plot Sampling for Understory, Weeds, and Canopy

22 September 2008

INTRODUCTION

The U.S. Army is currently involved in a major conservation effort to stabilize populations of endangered plant and animal species within lands they manage on the island of O‘ahu. These actions are conducted by the Army’s Environmental Division (AED) following strategies described in the Makua Implementation Plan (MIP) (Gon et al. 2001, Makua Implementation Team et al. 2003) and the O‘ahu Implementation Plan (OIP) (In Prep.). Both of these plans specify that monitoring will be conducted as part of the species stabilization efforts to evaluate the response of both the target species and their habitats to conservation management actions.

To meet this requirement, monitoring protocols are developed for each management unit (MU) and target species population unit (PU) to assess changes in distribution and abundance of populations of native and alien plant species, as well as changes in distribution, structure, and composition of the dominant plant communities. The monitoring protocol described in this document focuses on monitoring both overstory and understory components of the plant communities within the U.S. Army’s Makua and O`ahu natural resource management units. This protocol includes collecting data on vegetation structure, species composition, and species cover for both native and alien plant species, which can be used to track changes in these parameters relative to ongoing and future management actions in this area.

Monitoring Objectives

Primary Objectives

1. Assess the cover of alien plant species within a specific MU to determine if it is less than 50% across the sampled unit or continuing to decrease to ultimately meet that threshold requirement (Makua Implementation Team et al. 2003).

2. If alien species cover is not below the 50% threshold, determine if this value is decreasing significantly toward that goal based on repeat monitoring of the MU.

Secondary Objectives

1. Monitor the status of native plant species within the MU and determine if their cover changes relative to management actions conducted within the unit.

2. Assess the status and changes in bare ground (not vegetated areas) within the MU relative to management actions conducted within the unit.

3. Determine if any ungulates (feral pigs or goats) are detected within the fenced portion of a MU.

Statistical Thresholds

All of the sampling and analysis methods addressed in this protocol are based on the following assumptions:

- The probability of making a Type I error (detecting change or difference when none exists) is <10% (Alpha = .10)

- The probability of making a Type II error (missing change or difference that does exist) is <20%.

- Minimum detected change or difference between two samples being compared is 20% over the sampling period. This threshold may be revised in cases where the resulting needed sample size is too large to be practical.

Sample Size Considerations

An optimal sample size will be calculated following the collection of the initial set of data at a particular MU. Sampling effort will be stratified by the major plant communities within the unit, but may be pooled for analysis. For the first sampling effort within each MU, at least 100 sample plots will be established with no less than 10 plots per each plant community stratum. The results of this baseline survey will be used to assess the total sample size needed to monitor changes in species cover for the unit.

FIELD SAMPLING

Sampling Framework

Vegetation sampling within the MUs is conducted using both transects and rectangular plots that are are established throughout the area using a systematic sampling scheme with a random start for the initial point. Since several different vegetation units may be found within each MU, the sample plots will be post-stratified into the different communities for analysis. It was decided that pre-stratification was not practical since the plant communities are closely interdigitated within the MU,(e.g., transects crossing both ridges and gulches), and some of the units may change significantly in plant species distribution, composition, or vegetation structure as a result of management actions within the unit, particularly following removal of ungulates and weeding.

Transect and Plot Layout

Using ArcMap a base line is selected running across the long axis of the MU. Along this base a series of points at 10 m intervals are plotted to serve as potential starting points for the first transect. One of these points is selected using a random numbers table and used to establish the first transect in the MU, running perpendicular to the base line. Additional transects are then placed at 500 m intervals parallel to the initial transect, extending to encompass the entire MU. Transects within a MU are numbered from north to south, with the zero point established at the end with highest elevation on the initial reference transect. All other transects within the MU then follow this numbering orientation. Initial location coordinates and for the start points for each transect are obtained from the GIS and used to locate the sampling points in the field. Compass bearings for transects are also generated using the GIS. When transects and plots are sampled for the first time, location coordinates are taken using a field GPS unit. Both the GIS and GPS should be setup using UTM Zone 4 projection and NAD 83 datum base.

Sampling plots are located along each transect. Each plot is 5 m wide (extending 2.5 m to each side of the transect line), and 10 m long. The distance between the end of a plot and the start of the next plot should be 20 m. However, for small MUs, this distance may be reduced (even down to zero) to allow for the establishment of at least 100 plots within the unit.

The start point for the first plot on each transect within a MU is located using the GIS-generated coordinates. From this point a meter tape or pull-line marked with 5 m intervals is fixed and extended along the GIS-generated azimuth for the transect. The start and end points for each plot are marked using yellow and blue colored flagging tape tied to a woody stem within 30 cm of the actual point. If there is not a suitable place to tie the flagging within this distance, it is tied to a PVC pipe that is pounded into the ground. An aluminum tag with the transect number and distance is also tied to this point.

If it is impossible (due to terrain) or inappropriate (due to sensitivity of the area) to continue the transect along the specified bearing, the compass heading should be changed by 45 degrees away from the impediment. As soon as the terrain permits, complete the sampling plot, then return to the original compass heading prior to delineating a new plot. (NEEDS FIGURE).

Data Collection

Within each plot, data are recorded on cover in several pre-defined plant species associations, as well as the presence and cover of each species by specified vegetation layers, using the Belt Plot Sampling Field Form (Appendix A) or this form loaded onto a field PDA unit or data logger. In addition to recording plant data, information is recorded on when the plot was sampled and by whom, data on the plot location (GPS coordinates), plant community type, if photographs were taken, and other comments on the site or conditions. Value tables for the major data variables are provided in Appendix B.

Understory vegetation is considered to be all live foliage up to 2 m from the surface of the ground; canopy vegetation is foliage that is greater than 2 m above the ground. Dead foliage on the ground is considered to be litter and is not recorded. Bare ground is defined as areas from 0 – 10 cm above the ground surface that are not directly covered by live foliage. Cover values for both species and species associations are estimated in 10% cover classes, except for values less than 10% cover which are estimated at finer resolution (Table 1). When estimating cover values it is best to have two people independently come up with a value, then discuss the results to arrive at the consensus value that is recorded on the data form.

Species are recorded on the form using the standard 3x3 species field code. For any species that cannot be determined in the field, enter the three letter code for the genus followed by "sp" (e.g., MelSp). Indicate in the comments section if a specimen was collected to help with identification. If this is the case, make sure that the determined name is added to the field form as soon as possible. For plants that you cannot determine to genus, enter UNKSP1 (for unknown species 1), and indicate that a collection was made for final determination.

DATA MANAGEMENT

Database Description

A relational database has been designed in MS Access to allow for data entry and management prior to analysis. This database consists of a set of linked tables, queries that are used to join fields together, a data entry form and related subforms, as well as several data report forms.

Data Entry and QA/QC

If data were collected using a paper field form, all of the information is entered into the monitoring database using the main data entry form (Belt_Plot_Main) (see Appendix B). This form allows for several functions including initial data entry and update, creation of new entries for the Observers and Plant Communities fields, as well as running reports used to check the data. If data are entered into the database manually, it is important that a subset (at least 10%) of the entered records is randomly selected and all entries checked for accuracy against the data on the original field sheets. If >10% of these records contain errors in fields other than the Comments field, all records will need to be verified and corrected prior to doing another quality check.

DATA ANALYSIS

Data will be analyzed utilizing both parametric and non-parametric methods, depending on how well they meet the assumptions needed for the various tests. Data analysis for each MU will consist of two steps: baseline analyses following collection of the initial set of data, and analyzing changes in variables over time after the completion of each new sampling effort at the MU.

Baseline Data Analysis

Descriptive statistics will be calculated for all variables following collection of the initial baseline data for each MU and this information will be used to assess current conditions of the variables relative to the monitoring objectives and to help decide what analysis strategies will be appropriate. Additionally, the baseline data will be used to assess the adequacy of sample sizes for the most important variables.

Trend Analysis

After data are collected following the completion of a new monitoring cycle, analyses will be performed to assess trends of selected variables relative to the thresholds identified in the monitoring objectives for this protocol. These analyses will include paired tests (to compare changes in variables between two specific points in time), trend analysis (e.g., regression analysis), and repeat measures ANOVA.

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APPENDIX A

Field Data Form

MIP/OIP NATURAL RESOURCES MONITORING PROGRAM

Protocol 1.2.1 - Belt Plot Sampling for Understory, Weeds, and Canopy

Area or MU: ______________________ **Date:** _________________ **Obs1:** __________

Obs2: __________

Transect: ________ **Plot Start:** ________ **Bearing:** ________ **Others:** __________

UTM Coordinates X: ________________ **Y:** ________________ **Err:** ______ **Datum:** ________

Ungulate Sign? Y N **Describe:** ____________ **Photos:** __________

Veg Type: Alien Gulch Gulch Zone Wet Crest Uluhe Dom Other __________

Comments:

SP. ASSOCIATIONS				**COVER VALUES**	
NS:		**XS:**		**<1 %**	**>40 - 50 %**
NF:		**XF:**		**1 - 5 %**	**>50 - 60 %**
NG:		**XG:**		**>5 - 10 %**	**>60 - 70 %**
Other :		**:**		**>10 - 20 %**	**>70 - 80 %**
Bryophytes:		**Not Veg:**		**>20 - 30 %**	**>80 - 90 %**
UNDERSTORY ∑ Native:		**∑ Alien:**		**>30 - 40 %**	**>90 - 100 %**

Sp Assn. or Layer	Species Code	% Cover	Notes	Sp Assn. or Layer	Species Code	% Cover	Notes

Native Canopy __________

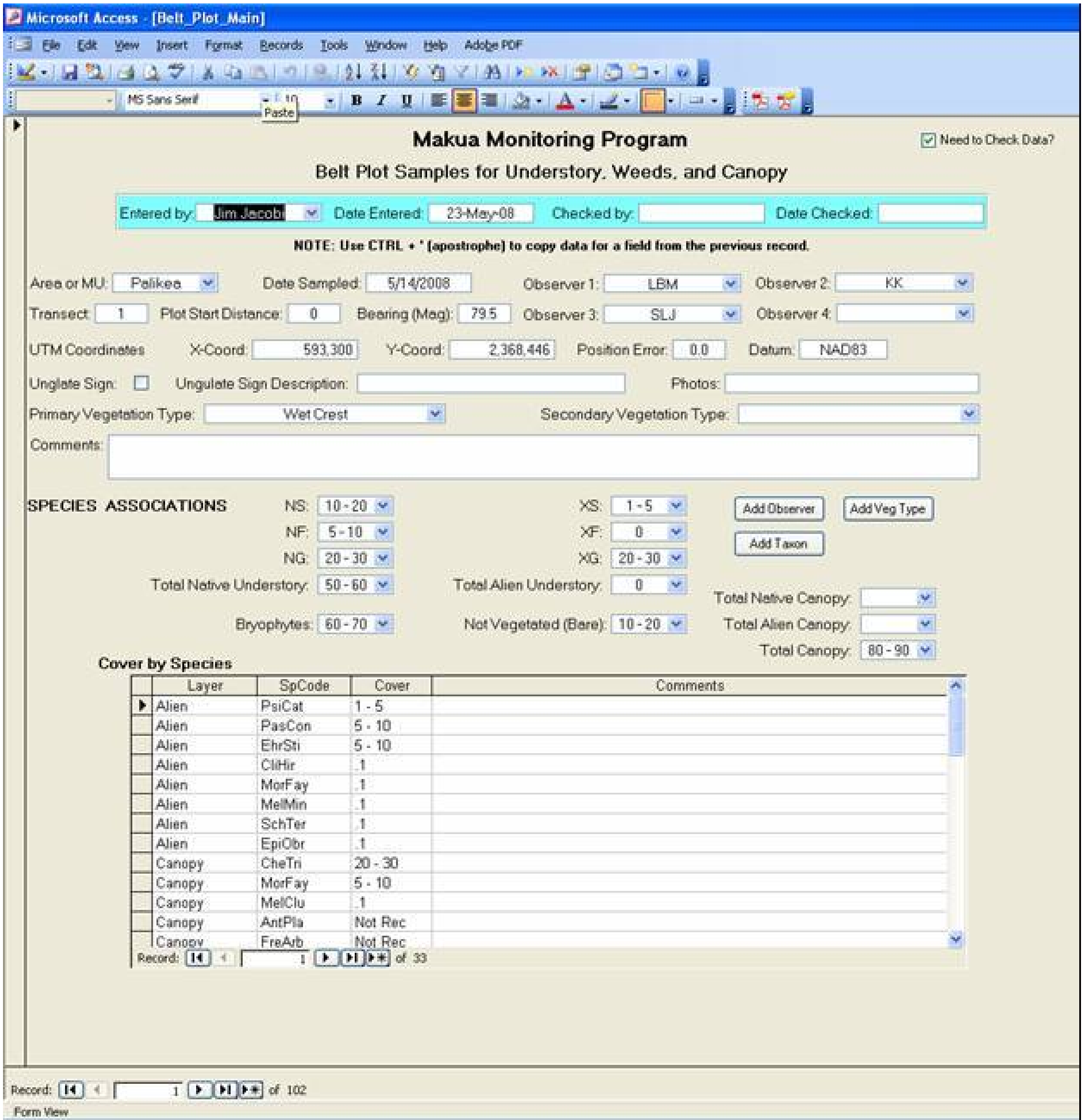
LAYERS: **Native Understory; Alien Understory; Tree Canopy** **Alien Canopy** __________

Total Canopy __________

DATA ENTRY	**Entered by:**	**Date:**
DATA CHECK	**Checked by:**	**Date:**

APPENDIX B

Data Entry Form for Database



Microsoft Access - [Belt_Plot_Main]

File Edit View Insert Format Records Tools Window Help Adobe PDF

Makua Monitoring Program

Need to Check Data? ☑

Belt Plot Samples for Understory, Weeds, and Canopy

Entered by: Jim Jacobi | Date Entered: 23-May-08 | Checked by: | Date Checked:

NOTE: Use CTRL + ' (apostrophe) to copy data for a field from the previous record.

Area or MU: Palikea | Date Sampled: 5/14/2008 | Observer 1: LBM | Observer 2: KK

Transect: 1 | Plot Start Distance: 0 | Bearing (Mag): 79.5 | Observer 3: SLJ | Observer 4:

UTM Coordinates | X-Coord: 593,300 | Y-Coord: 2,368,446 | Position Error: 0.0 | Datum: NAD83

Unglate Sign: ☐ | Ungulate Sign Description: | Photos:

Primary Vegetation Type: Wet Crest | Secondary Vegetation Type:

Comments:

SPECIES ASSOCIATIONS

NS: 10 - 20 | XS: 1 - 5

NF: 5 - 10 | XF: 0

NG: 20 - 30 | XG: 20 - 30

Total Native Understory: 50 - 60 | Total Alien Understory: 0

Bryophytes: 60 - 70 | Not Vegetated (Bare): 10 - 20

Total Native Canopy: | Total Alien Canopy: | Total Canopy: 80 - 90

Add Observer | Add Veg Type | Add Taxon

Cover by Species

Layer	SpCode	Cover	Comments
Alien	PsiCat	1 - 5	
Alien	PasCon	5 - 10	
Alien	EhrSti	5 - 10	
Alien	CliHir	.1	
Alien	MorFay	.1	
Alien	MelMin	.1	
Alien	SchTer	.1	
Alien	EpiObr	.1	
Canopy	CheTri	20 - 30	
Canopy	MorFay	5 - 10	
Canopy	MelClu	.1	
Canopy	AntPla	Not Rec	
Canopy	FreArb	Not Rec	

Record: 1 of 33

Record: 1 of 102

Form View

Appendix 1.8 Captive Propagation Protocols for *Achatinella* species

Incubators

Models- We currently have three environmental chambers in our captive propagation facility at the University of Hawaii, Manoa. The model names and numbers are as follows: Revco Scientific (gray two-door) (Model # RI-50-555A), American Scientific Products (tan one-door) (Model # I-22-LTPA), and Precision (white one-door) (Model # 818). All of the environmental chambers run on 120 volts. They are all capable of programmable day/night temperatures, programmable photoperiods, and are equipped with alarm set points in the event that the temperature within the incubator becomes too hot or cold.

Temperature- For upper-elevation snails (2,500+ ft.), temperature should be maintained at 20°C during the day (light) cycle (12 hrs.) and 16°C during the night (dark) cycle (12 hrs.). Ambient room temperature should be approximately 25°C. The closer to 20° the ambient air is, the less the environmental chambers need to work, therefore increasing their lifespan.

Water Spray- Plumbing within incubators is designed to provide simulated rainfall (one minute duration) three times per day, except for one day per week (simulating dry periods). The spraying times are currently set at 12:00am, 8:00am, and 4:00pm. Monitor rainfall frequently to catch any leaks or other problems. Terraria will dry out quickly if they don't receive water each day. Drier terraria should be identified and hand-sprayed until better rainfall can be provided to them.

Plumbing system- The plumbing system has been custom installed in each of our environmental chambers. Two small holes (~2.54 cm diameter) have been bored into the incubators (one at the top, one near the bottom). The top hole provides entry for the latex water tube; the lower hole provides for a drainage hose. Hoses are connected to a water faucet in the lab; an electric Rain Bird yard-watering timer is hooked up to these hoses. It is on this timer that the programming is done (*i.e.*, a one minute duration, three times a day). From the timer, the water-supply hose goes up to a manifold (near the top of the incubator). This manifold splits the water from one garden hose to eight smaller latex tubes. Black latex tubing (3 mm internal diameter X 1.6 mm wall size) is used. It is important that the latex tubing is black, as this occludes light and prevents algae from growing within the tube and clogging it. The ends of the tubes are equipped with Drip Mist (or equivalent) spray/mist nozzles. These sit on a frame above the terraria.

Drainage- This is accomplished with water collection pans and drainage tubes. Terraria sit high above these pans on a screen "shelf" to prevent flooding (and drowning) of the snails. Connected to each collection pan is a tube that drains the water from it. If a floor drain is provided, these drain tubes can simply be converged and emptied out into the floor drain. If no floor drain is provided, some ingenuity may be needed to get the water up and out into a sink drain. (*e.g.*, in our lab, a "toilet type" float switch and an underwater pump are used to pump the water up to our sink drain.)

Regular maintenance- Incubators should be checked regularly (if possible every day) for normal functioning. Temperature should be checked to assure that it is being properly maintained, and clocks should be checked to make sure they have not been reset. As mentioned above, the plumbing system should also be regularly checked for leaks, overflows, or clogged nozzles or drains.

Troubleshooting- Power outages are probably the most important problem to address here. A back-up power supply (generator) is the preferable means of avoiding this problem. If no back-up power exists, one must always be wary of power outages. Intentional power outages should be avoided. If they cannot be avoided, they should be no longer than 3 hours. If the doors to the incubators remain shut during the outages, then they should be able to maintain a reasonable temperature for this length of time. For any longer, unexpected outages, a generator capable of running the incubators should be rented and utilized until city power is returned. When power returns, the incubators need to be checked to insure that the proper settings (temperature and photoperiod) have come back. Clocks should be reset.

Snail terraria

Snail terraria can be made from clear plastic aquaria (*e.g*., "Critter Cages," available at pet stores) or tupperware containers. The lids of Critter Cages are fitted with plastic window screen, glued in place with a hot glue gun. Drainage holes are cut in the bottom of the cage and fitted with more screen (glued in place). Tupperware containers can also be modified similarly, making sure there are plenty of mesh-covered openings for water to come through at the top, and drain out through the bottom. **It is essential that terraria be designed so that there is complete drainage, with no pooling of water. A small pool of standing water will drown snails.** To give an idea of size requirements: we currently house about 15 adult snails in a terrarium of the following dimensions: length = 22.9 cm, width =15.2 cm, depth =17.8 cm.

Terraria should be regularly checked for leaks, holes and cracks, which generally can be repaired with a glue gun. Keiki snails can escape through the tiniest holes, so watch out! See section below for details on cleaning of snail terraria.

Food

Leaf Collection- Achatinelline tree snails do best when maintained on glabrous (shiny, round leaves) *Ohia lehua* (*Metrosideros polymorpha*) leaves. Branches can be searched out and cut using a tree trimmer. Hand clippers may also be useful. It is best to keep the branches as whole as possible, so that they will stay fresh. *Freycinetia arborea* (*ie ie*) is another snail favorite. Leaves can easily be acquired in the field. Pull them off the plant at the bases, instead of clipping them. They will stay fresher longer this way. Back in the lab, spray them down with water and refrigerate in a closed plastic trash bag. Leaf collection is done biweekly no more than a couple of days before cleaning and changing leaves in the terraria.

Fungus culture- Cultured fungus is an essential supplement to the snails' diet. After snails acclimate to eating the fungus (usually 4-6 weeks), they will generally thrive on it. Currently we are maintaining a single line of *Cladosporium cladosporioides* that we feed to all of our snails. The Potato Dextrose Agar (Difco) medium on which the fungus grows is supplemented with calcium carbonate to help with shell maintenance and growth. See fungus culture protocol below.

Fungus protocol-

1. Autoclave Pyrex petri dishes: 25 minutes gravity cycle, 15 minutes steam (these are standard autoclave cycles). Autoclave 35 petri dishes (100 X 15mm size). Alternately, sterile, disposable plastic petri dishes can be used.

2. Mix agar: 3.9g Difco Potato Dextrose agar, 0.02g calcium carbonate to 100ml water. We make 1,100ml for ~33 plates; therefore use 43 grams of Potato Dextrose Agar and 0.22 grams calcium carbonate in 1,100ml of water. Use graduated cylinder to measure water. Mix agar in by swirling and agitating by hand. Cover Erlenmeyer flask with foil.

3. Autoclave agar: 24 minutes liquid cycle. Always use metal pan to catch overflow.

4. Swirl agar until cooled: After medium is removed from autoclave, vortex by swirling flask. Do this periodically until the medium cools enough to pour (~every ten minutes for an hour). This should keep the medium homogenous and allow it to cool evenly. If a magnetic stirrer is used, be sure to autoclave medium with stir bar. Stir on low after autoclaving until medium is cool enough to pour (rule of thumb: pour when the medium still feels hot, but you can hold the flask without insulated gloves).

5. Lift cover, pour agar in dish to a depth of 6-7 mm, replace cover, allow agar to harden and cool; then place upside-down in refrigerator (if fungus is not going to be inoculated the next day). Agar-filled petri dishes can be stored in the refrigerator for a couple of weeks like this.

6. Inoculate plates using a contamination-free source plate. Work in the hood, sterilize wire between every plate, and minimize exposure to air. Fungus cultures take approximately a week to mature in the fungus incubator (24^{o}C). Inoculate stock plates separately and label. (Also maintain "*Ohia* Leaf 1, 2 and 3" cultures once per month. These are stock fungus cultures with fungus inoculum taken directly from wild *ohia* leaves.)

Petri Dishes-

Glass petri dishes are used not only for culturing fungus but also as holding containers for snails while their terraria are being cleaned. They should be deep enough to allow the largest snails adequate crawling room (those shells can be tall…). Large-diameter petri dishes (150 X 25mm size) are handy for holding 10 or more snails at a time.

Cleaning- All petri dishes should be regularly cleaned using a scrub pad and 70% EtOH followed by a thorough rinse with water. Do not reuse a petri dish for more than one population of snails: wash before reusing. Note that for fungus culture (above), petri dishes are autoclaved.

<u>Population monitoring</u>

Snail populations are monitored for growth and decline. All births and deaths are recorded, and measurements taken of these individuals. This enables us to produce summary statistics of population growth rates or declines, so that we can monitor the captive propagation program accordingly. It will also help contribute to our knowledge of the life histories of these rare snails. Without these data, we would have no scientific foundation on which to build a strong captive rearing program. Data are recorded separately for each population (see sample data sheet attached). All snails should be accounted for each time the snails are transferred to clear terraria with fresh leaves.

Terraria cleaning procedure (every 2 weeks):
The following is the stepwise procedure for cleaning an individual snail terrarium. Strict adherence to these steps is essential to the maintenance of healthy, growing populations of achatinelline tree snails (**read**: this really works!).

1. Wipe working counter clean using 70% EtOH (ethyl alcohol) and paper towels. Make sure area is dry.
2. Set out ample supplies of clean petri dishes and fungus (and fungus cutter). Make sure leaves are ready (and pruning shears), and that water spray bottle is out. Open current population logbook to the appropriate page.
3. Remove a terrarium from an incubator and set terrarium on counter. Carefully remove terrarium cover (some snails tend to stick in the corners between the cover and the terrarium, where moisture collects – some snails could dislodge and fall, or get crushed accidentally).
4. Carefully remove some of the vegetation and start removing snails. [The goal here is to minimize handling, thereby minimizing snail stress! Constantly stressed snail populations will not maintain population growth over the long-term.] Place snails in petri dish (use large-diameter petri dish if you have approx. 10 or more snails to unload from terrarium). If snails are stuck to the sides of the terrarium, carefully dislodge them by gently scooping them with an *ohia* leaf. If snails are already stuck to leaves, it is best to carefully remove the leaf with the snail on it, rather than disturbing the snail.
5. Continue process of searching **every** branch and **every** single leaf (front and back). Those keiki (and even the adults) can really hide. You may find a snail in the most curled and dried leaf in the terrarium, or in a crevice in the terrarium top. It is best to not unload all the vegetation from the terrarium at once, since snails may crawl away while you are searching; believe it or not, they can really move (especially the keiki)!
6. Place the cover on the petri dish when you have collected all or most of the snails. Count them carefully. Be certain not to crush any snails on the edges. Snails can be gently prodded or moved using an *ohia* leaf.
7. Check how much fungus was eaten and record percentage. Check fungus for snails (sometimes they hide there). Remove fungus from side of terrarium and discard.
8. Check the terrarium and cover for snails once more.
9. Take the terrarium and cover to the sink and spray them with 70% EtOH.
10. Count the snails again.
11. Search any remaining leaves for keiki. Look over branches again. If you are working with a partner, switch branches with her/him and check for snails again. Yes, this job takes patience! When you are confident that all snails have been found and that there are no newborns, discard old leaves in trash and make sure snails are in a covered dish. Spray table with 70% EtOH and wipe with paper towels.
12. Fill in data sheet (Date, % fungus eaten, amount fungus fed, Births, Deaths, # snails now in population, Notes)
13. <u>Record births</u>- Births are assumed to be the smallest snails in the dish. Measure these as accurately as possible using calipers. It is important not to squeeze or damage the young snails, so you may need to just place the calipers next to the snail and estimate the length.

Length equals the furthest distance from the apex (pointy part) to the opposite end of the shell. We generally don't measure the width of the newborns.

14. Record deaths- Dead snails are also measured (length x width; width equals the widest distance across the shell, measured with the aperture towards you, and the apex pointing up directly in the middle of the two sides of the caliper). *Be sure that the snail is dead*; this is sometimes obvious, since the body may have already liquefied and oozed out of the shell. However it may not be so obvious, and some live snails may be retracted and appear to be dead. A dissection scope can sometimes assist in determining whether or not snails are alive (smelling the snail at the shell's aperture may also help—dead snails typically do not smell very good!). (Also, spraying water on a live snail can sometimes make them come out of their shell.) If you are still uncertain, make a note and put the snail back in the terrarium until next time. Place the dead snail in 90% EtOH in a glass or plastic vial. Label vial with date the death was discovered, population and species i.d., and shell measurements. Write on tape on outside of vial using pencil or permanent ink and/or include a label inside vial. Do not simply write on the glass or plastic, since this easily wipes off (even with permanent inks). Thoroughly clean caliper edges with ethanol to prevent potential transmission of bacteria/disease from dead snail to future measured snails.

15. Scrub terrarium with a scrub pad.. Make sure there are no traces of slime or snail feces left. Rinse thoroughly with water. Spray terrarium with 70% EtOH. Rinse, rinse, rinse. Make sure there are no traces of alcohol left on the terrarium. Alcohol is very poisonous to snails. Let drain upside down for a minute or two.

16. Bring terrarium back to working counter and begin clipping fresh branches for the clean snail home. Try to keep branches as whole as will fit in the terrarium – they will last longer. Give the snails ample amounts of leafy branches, but don't pack the terrarium too full. Try to arrange the branches upright and as "naturally" as possible.

17. Cut the appropriate amount of fungus and stick it to the side of the terrarium in quarters or halves. Make sure the fungus sticks and that there are no air pockets.

18. Once everything is assembled, spray the whole terrarium with water.

19. Place the snails back in their home by scooping them with *ohia* leaves. It's a good idea to count them again as they go back in, as one last double-check.

20. Make sure all snails are in the terrarium, and none have escaped from the petri dish or started to crawl down the sides of the terrarium.

21. Carefully place the cover back on the terrarium, taking care not to crush any snails. Make sure the cover fits snugly and there are no openings for escapes.

22. Place the terrarium back in the incubator, making sure plumbing is properly aligned to assure good rain exposure. Now it's time for the next one…

23. When all of the terraria have been cleaned, it is a good idea to go through each data sheet in the log book and double check that nothing was missed.

Oahu Rare Snail Working Group Reintroduction Guidelines

April 2007 DRAFT

These guidelines address issues regarding the reintroduction of rare snails. Reintroduction should be a supplement to habitat management not a substitute. The final goal of a reintroduction being not the success of an individual snail, but the establishment of a viable population where natural reproduction can occur and in which genetic variation is maintained. Any process of rare snail reintroduction should consider the following guidelines. Many steps in these guidelines require coordination with species experts, land managers and snail propagation facilities. Included at the end of these guidelines is a list of resources who may be contacted to consult on reintroductions. These guidelines have been broken into sections guiding actions before, during, and following the actual reintroduction of a snail.

Considerations Prior to a Reintroduction

Prior to the initiation of a snail reintroduction project, there are some issues that should be considered to ensure the health of the species, the individual reintroduced snail, any other snails existing in the reintroduction location, and the surrounding habitat.

1) Purpose: Determining the purpose and anticipated end result of a reintroduction effort is the most essential first step in any rare snail reintroduction project. For example, the purpose of a reintroduction may be to reintroduce surplus snails to relieve over-crowding issues at snail captive propagation facilities. Another goal may be to stabilize a population which has been greatly reduced in number by any number of factors such as stochastic environmental occurrence, predation, or disease (Hadfield, Miller, and Carwile 1993; Coote et al. 2004). Different goals will result in different management strategies, objectives, and expectations. Regardless of the purpose, it should be stated clearly and made clear to all participants and cooperating agencies so that no misunderstandings occur.

2) Reintroduction scenarios: Sites for reintroduction can be placed in at least three categories each having special considerations.

- *Reintroduction of a species within historical range.* This involves the reintroduction of a species back into a site where it had been previously observed but where it is not close enough to any wild sites for there to be genetic communication between the new reintroduction and the existing population.
- *Augmentations of an existing wild population.* This involves introducing snails into existing wild populations. This type of reintroduction must be considered on a case-by-case basis for each species, utilizing all available genetic data. This type of reintroduction must be done with extreme caution and special attention to sanitation so as to not harm the existing population genetically or via the inadvertent introduction of pathogens from the lab. Augmentation may negatively alter the genetic composition of a population if snails from a single parent or snails from lab selected populations are used.

- *Introduction of a species to a site outside the known historical range.* Agencies or individuals considering this type of introduction need also to consider the possible negative effects on the species. Establishment of a healthy viable population may be hindered by loss of genetic variation being at a site away from other populations. Possible hybridization may occur when bringing a species outside its historical range and into the range of another related species. A site outside the known historical range may lack the habitat characteristics necessary for establishing a healthy population. Contrarily a site outside of the known historical range of the species may be the only place safe from the threats that brought the species to the remnant state we find them in today. In some cases, these sites may also offer the best management option for a particular species.
- *Relocation of snails into a predator free site*. Threat control is difficult to conduct across a population with scattered few individuals. A management option for managers is to construct a predator exclosure and relocate snails into this protected site. If using this management option, genetic issues should be considered. The genetic relatedness of relocated individuals should be similar to individuals at destination site.

3) Contacting Federal and State Agencies: The USFWS and the State Department of Land and Natural Resources must be contacted once the purpose of a reintroduction has been determined. Obtaining the required permits should be a consideration in any reintroduction effort. Federal and State permit should be submitted 3-6 months prior to doing a reintroduction. For a list of snail reintroduction contacts see the table below.

4) Genetic Stock: The agency or individual that is reintroducing snails should coordinate with the agencies or individuals responsible for the collection and propagation of that snail to ensure a healthy and balanced genetic composition. It must be determined if the reintroduction of snails will be augmenting numbers at an existing population or creating a new one. In addition, a population geneticist may be consulted about strategies and alternatives when dealing with especially rare species. For example, if numbers of snails available to begin a new population are limited and stock is available from a number of wild sites, the decision may be made to mix these stocks. Detrimental effects of mixing should be considered closely and may require the use of genetic analyses in making a determination. This is, of course, of special concern when dealing with depleted wild populations with remnant genetic stock. Snails used in reintroductions should be from geographically close sites to the destination site. Genetic investigations may be used to determine Evolutionary Significant Units (ESUs) to identify diversity within a species (Holland and Hadfield 2002) or develop a genetic strategy in establishing new populations. Reintroductions should be conducted using only surplus lab stock. In special cases it may be necessary to move small numbers of remnant snails into a protected area. Back up collections essential to preventing population or species' extinctions should never be used as reintroduction stock. It should be the shared responsibility of all agencies and individuals involved to leave an easy-to-follow paper trail back to the source population (*i.e.*, Rare Snail Monitoring Form (RSMF) (Enclosure 1), captive propagation inventory records). Snails that have been in the lab for multiple

generations may be adapted for different conditions than the reintroduction site and may have high attrition rates when reintroduced. Care should be taken not to mix gene pools that may be distinct and have local or microhabitat adaptations. A site with mixed stock should not be close to a population in which the goal is to preserve representatives of geographically isolated subsets.

5) <u>Mapping</u>: Prior to the reintroduction of a species, the area should be precisely mapped. Maps should include the historical and present range of the species, locations of known populations and proposed reintroduction sites. A GIS database should be used to establish a permanent record of snail reintroduction efforts. A copy of this data should be deposited at the U.H. Tree Snail Laboratory. Copies of reintroduction data should be provided to the U.S. Fish and Wildlife Service and the State of Hawaii, Division of Forestry and Wildlife if a project involves endangered snails.

6) <u>Site Selection</u>: Once the historical range of the species is known and a management strategy is established, a suitable site must be selected. A site should be chosen according to the biotic and abiotic elements that comprise appropriate habitat. A careful review of the RSMFs may provide a great deal of information on habitat of the source population but experts should also be consulted. Important characteristics to consider include potential host tree species, substrate type, elevation, aspect, slope, humidity, rainfall, canopy, and understory species cover. It may also be important to note the presence or absence of other native snail species (i.e. *Auriculella*, *Philonesia*, *Amastra*, *Succinea*) that can be used as indicators of a habitat able to support other snail species. The size of the reintroduction site must be considered. Specifically, adequate number of host trees must be present to support the proposed population number. In this, consideration should be given to the natural density of snails in particular habitats. For example, the population at the Pahole site which was dominated by *Pisonia sandwichensis* was approximately 300 total snails in a 5x5 meter area (Hadfield et al., 1993). Prior to reintroduction, weather monitoring stations may be utilized to confirm the suitability of selected sites.

7) <u>Site Preparation</u>: Once a proper site has been selected there are steps that should be taken to prepare it for reintroduction. This preparation includes essential actions such as removal of rats and *Euglandina rosea*. Ideal threat abatement would also include control of feral ungulates, and weeds. Common native plantings may be conducted in combination with weed control as needed. Diphacinone rat bait deployment in tamper proof bait stations can effect good rat control. Rat control should be underway at the site for at least three months prior to release of snails. A complementary method for controlling rats and *Euglandina* is to construct a predator exclosure. Two such exclosures currently exist on Oahu. The design for such exclosures can vary and is still somewhat experimental. In general, terrain at a field site must be relatively flat to construct such an exclosure. The feasibility of constructing a predator exclosure at a proposed reintroduction site should be assessed in early planning stages as these exclosures are both time-consuming and costly to design and construct. If it is not feasible to construct a predator exclosure, the reintroduction site should be exhaustively searched under favorable weather conditions.

8) Lab Preparation: The propagation lab should know well in advance prior to reintroduction, snails should be maintained on leaves from plants at the proposed reintroduction site so they can adjust to the new food supply for at least a month. Fungus plates provided normally in the lab will be removed during this same period. To ensure adequate food supply, snails will be kept at lower densities in terraria. Environmental conditions in the chamber should be set to mimic destination field site conditions as determined by on site weather data collection. All snails destined for reintroduction should be marked with unique alpha-numeric codes in order to track the survivorship of individual snails. Only snails larger than 10 mm can be marked using the hole-punch and superglue tagging technique. The lab should know well in advance of a planned reintroduction. Additionally, to increase lab populations, wild snails can be brought into the lab for short periods of time to promote births (Hadfield pers comm. 2007) and then returned to the wild.

When selecting the snails to be used in reintroduction, one must consider the age of the individual snails and year lab population was collected. The age class of snails proposed for reintroduction should be carefully considered. Considerations should include the survivorship of different age classes in prior reintroduction efforts and lab survivorship trends. In the lab, the sub-adult age class is the most robust (Hadfield pers comm. 2007). It is recommended that no fewer than ten snails be used to start a new population. The number of snails to reintroduce should be based on the total snails available of appropriate stock and the available habitat in the reintroduction. Reintroductions should be conducted conservatively at first until methods are refined.

Considerations During a Reintroduction

The successful reintroduction of snails from the lab to the wild or translocation of wild snails requires several issues to be taken into account.

1) Sanitation: Coordination with the propagator is necessary to ensure that all aspects of rare snail handling are done with attention to sanitation to prevent the inadvertent transfer of pathogens. The Best Management Practices (BMPs) (Appendix 2-5) should be followed at rare snail propagation facilities. BMPs should be revised based on any new research/information. Agencies and individuals involved with reintroduction need to coordinate with the lab staff before the reintroduction date. A quarantine chamber will be used to isolate snails slated for reintroduction from others in the lab. Snails will be isolated in this chamber for at least three to four months prior to release.

2) Transport: Use caution when transporting snails to field sites. Snails should be transported in terrarium/Tupperware that is kept in a small hard-walled cooler to maintain stable environmental conditions (temperature not to exceed 80°F), see photo below of possible transport set up. Containers will be adequately ventilated during transport. No more than ten snails should be kept in a container the size of the one in the photo below (approximately 4”x 6”x 3”). Stabilize the terrarium in the cooler to avoid shifting. Snails can be kept overnight at a staging site as stable temperatures are maintained. Snails may be flown in the passenger compartment of a helicopter and secured.

Snail transport container

3) Release: Reintroductions should be conducted during periods of ample rainfall to minimize the chance of snail desiccation from extended dry periods. For example, in the Waianae Mountains, releases may be conducted during high rainfall months between December and March, but for the Koolau Mountains may be more flexible. If crawling, snails will be placed directly on the leaves of an appropriate host tree. Otherwise, snails will be placed in small screened baskets (see photo below) hung in host trees and containing leaves. In order to encourage the movement of snails from these containers into host trees, squirt bottles will be used to wet the container and vegetation. Snails will be released in close proximity to one another.

Screened snail release basket

When planning a reintroduction that will exceed 25 snails then you should begin the reintroduction effort with a test release of 25 snails to ensure site suitability. See monitoring section below to determine when to supplement these numbers.

Considerations after a Reintroduction

Following a reintroduction, monitoring is essential to maintain the health of the snails and the surrounding habitat, and to determine the level of success. A yearly evaluation of reintroduction activities will be included in year end reports and submitted to permitting agencies.

1) Monitoring: Following a reintroduction, the snails must monitored with mark and recapture methods monthly for the first six months. Data on the size length of shell and lipped condition of each snail will be recorded. Attached at Enclosure 1 is a Rare Snail Reintroduction Form. In addition, ground shell plots will be established within the reintroduction site to track mortality of snails. If survivorship declines more than 50% during this six month period if observed survivorship is <50% the release site will be reevaluated. Supplemental reintroduction will be postponed until further investigations are conducted. If survivorship is more than 50% then supplemental reintroductions may proceed. After the initial six month period, monitoring will continue on a quarterly basis.

2) Maintenance: Ground shell plot data will be used to guide threat control. Threat abatement efforts must continue following reintroduction and should be adapted based on monitoring data and site observations. Threat abatement will include predator exclosure maintenance at least quarterly if applicable.

List of Contacts	Affiliation	Phone	Email
Gagne, Betsy	DLNR, DOFAW invertebrate permits	587-0063	betsy.h.gagne@hawaii.gov
Liesemeyer, Brent	Oahu NARS Manager	973-9783	brent.r.liesemeyer@hawaii.gov
Beachy, Jane	Army Natural Resources	656-8341	beachyjr@schofield.army.mil
Saufler, Jen	UH Snail Lab	956-6176	saufler@hawaii.edu
Rohrer, Joby	Army Natural Resources	656-8341	rohrerjl@schofield.army.mil
Hiromasa, Joy	USFWS, Invertebrate Program	792-9400	Joy_Hiromasa@fws.gov
Kawelo, Kapua	Army Natural Resources	656-7641	kawelok@schofield.army.mil
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References

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Rare Snail Observation Form **Enclosure 1**

Scientific Name: ____ Date: _________________
Pop Ref Code: _______________________ Range: ______________________________
Elevation: _____________ft/m Observers: _________________________ Aspect: ___________

Location/Flagging Scheme (orange/blue):
____
____
____
____
____
_____

Weather: _________________________ Effort (people hours):
____
GPS? Y / N Coordinates: __________________ Photo Y / N?

Predation: Ground search conducted for fresh shells? Y / N Area searched: ________________m^2
People Hours: ______________ # intact___________ #rat damaged_____________
Empty shells collected for reference? Y / N

Population Structure:

Small	Medium	Large

Achatinella mustelina: small ≤ 8 mm, medium 8-18 mm, large ≥ 18 mm
Koolau *Achatinella*: small ≤ 7 mm, medium 7-15 mm large ≥15 mm

Threats/Management Recommendations/Actions Taken/Notes:
____
____
__
____
_
____
____
__

C**ount/Density**: ___________SNAILS __________________SNAILS/HOUR

SKETCH MAP OF SITE (indicate area ground searched):

Section 3: Cost and Staffing Estimates

November 2008

Introduction

This section provides an outline for the budgetary and staffing requirements to carry out the actions in the Oahu Implementation Plan (OIP). The Army recognizes that the OIP cannot be implemented without staff and a budget. Therefore, this section was created to reflect the most current staffing needs, salaries schemes, contract costs, and support systems costs needed. This section was based largely on the cost estimates created for the Makua Implementation Plan (MIP).

Manage for stability PU actions		one year one time costs		Tier 2 specific actions
MU action costs		staffing estimates by action		Tier 3 specific actions
inflation costs (salary only- 4%/yr)		subtracting non-rollover costs each year		gear/general
alternative estimates (large west range fences +/-)		Year Totals		

Cost Estimates Assumptions (CEA) – Reference List

General caveats:

- Cost estimates are based on the current requirements of the Oahu Biological Opinion (USFWS 2003) addressing 23 plant species, ten snail species, and one avian species, and may change according to future assessments.
- Cost estimates were developed to carry out the Oahu Implementation Plan over 20 years. Although these estimates terminate at year 20, the actions themselves are not terminated but continue as long as determined necessary through the Oahu Implementation Team (OIT) review process to maintain stable populations.
- Through monitoring and adaptive management, new information will continually be fed back into the plan and actions will be adjusted accordingly. For this reason, actions and cost estimates will be re-evaluated every 3 to 5 years for the purposes of budgeting for the coming year(s) and will likely differ from the current projections.
- For many actions, the cost required to implement the action will be affected by a multitude of factors (e.g., population unit size/distribution, topography, degree of threats in the area, habitat quality, geographic distribution of actions). The ability to determine an accurate estimate is limited by current knowledge of a geographic site, the fact that some of these factors are variable over time, and the unprecedented scale of this project. All estimates were based on best available knowledge and derived with input from Implementation Team members and persons knowledgeable and experienced in the relevant subject. Estimates were assigned as *averages*, in anticipation that due to unforeseen factors some population units or sites will require less, while others will require more, than the allotted funds.
- Salary estimates for all positions include benefits and overhead typical of contracted positions; including trainings. Each year a %4 salary increase is included to account for inflation.
- Budget items beyond salaries do not include any inflationary factors. Attempting to account for inflation on the cost of commercial items would be too speculative over the course of the proposed implementation schedule.
- Cost Estimate Assumption numbers are not always consecutive because some costs have been absorbed by others and numbers are already assigned taks/values in the Army’s Scheduling Database. Changing these numbers would be problematic for the database tracking system.

#	Description	Assumptions
1	**Implementation Senior Coordinator** Includes management and coordination of implementation actions, supervision of Natural Resource Managers and multiple field crews. *Annual cost:* Implementation coordinator : **Implementation Plan Project Manager** Includes management of the implementation plan and writing and coordinating of annual reports. *Annual cost:* Implementation plan project manager:	**41.5k=** (50% FTE)(83 k/yr w/ benefits/ overhead) **41.5k=** (50% FTE)(83 k/yr w/ benefits/ overhead)
2	**Administrative Assistants** Manage human resources aspects, including benefits (vacation, medical insurance, sick leave), and training certifications. *Annual Cost:* Administrative Assistant:	Assume 1 assistant for every 20 personnel (administrators, support staff and natural resource staff). **50 k/yr** (w/ benefits and overhead)
3	**Army Environmental Field Staff** Natural Resource Management Coordinator (NRMC): Natural Resource Management Technician (NRMT): (NRMT3): (NRMT2): (NRMT1):	RCUH staff will be hired and trained. **71.5 k/yr = 0.344 k/day** (w/benefits & overhead) **54 k/yr = 0.259 k/ day** (w/benefits & overhead) **51k/yr = 0.245 k/ day** (w/benefits & overhead) **42 k/yr = 0.202 k/day** (w/benefits & overhead) Where: 1 year = 208 work days Although NRS salaries will range from NRS1 to NRS3, the salary for an NRS2 was used as an average for all actions requiring an NRS.

#	Description	Assumptions
4	**Fence Crew** Fence Crew Supervisor: Fence Crew Worker: Fence crew will initially have 3 worker positions (2 will be funded by the MIP)	RCUH staff will be hired and trained. Assuming an NRW(1) @ 29 k/yr can clear 46 ft/day: (34 k/208 days) (1 day/ 46ft) = $3.54/ ft. **71.5 k/yr =0.343 k/day** (w/ benefits & overhead) **59 k/yr = 0.284 k/day** (w/benefits & overhead) Where: 1 year = 208 work days
5	**Preparation of Programmatic NEPA Document** Programmatic NEPA document:	Assumes preparation of a single programmatic NEPA document. Cultural surveys and Section 106 consultation will be completed by Army archaeologists. A separate NEPA document will not be prepared for urgent actions. Supplemental NEPA documents will be prepared for individual MUs if necessary. Assumes NEPA document will be prepared by the implementation plan coordinator at no additional cost.
7	**Development of MU Alien Species Control Strategies** Includes development of MU- and population-level alien species control strategies for each MU (excluding ungulates). Data to be updated annually and included in the annual report. *Annual cost:* Ecosystem Manager	Calculated for each MU allowing 1 Ecosystem Restoration Manager. Assumes data needed to develop and update the control strategy will be gathered and provided by the Natural Resource staff conducting population-level management and monitoring. **83 k/yr** (w/ benefits & overhead)
9	**Development of Fire Management Plans (FMPs)** Includes fuels studies. Excludes costs associated with implementation of the FMP (pre-suppression and suppression actions).	Based on FMP estimates. A single Fire Management Plan will be written for areas involved in the Oahu Implementation Plan that are threatened by fire. Fire Management Units (FMUs) contain a grouping of MUs for which a similar fire management approach may be taken based on geographic proximity, fuel types, fire history and access

#	Description	Assumptions
	One-time cost: Overall FMP:	routes (roads/trails). See Section 1 Chapter 12. **35 K**
10	**Implementation of FMP Actions** Includes pre-suppression actions (development of dip ponds, helicopter support, wildfire training of Natural Resource staff, development and maintenance of fuel breaks).	Assumes the Army will assist landowners in maintaining existing roads that serve as fuel breaks, and other fire break maintenance. **Cost to be determined by Fire Management Plans (FMP).**
11	**Fence Contracts** ***Annual Cost depends on fence***	Assumes that large fences in SBMR need to be contracted for construction and clearing in order to be completed within the available time frame. Cost based on $40/foot including clearing and construction and materials. Total for 3 SBMR fences to be constructed by 2011. **South Haleauau** 123.6 acres, perimeter 3,595 meters = 11,794 ft * $40/ft= $471,760 + (*30 EOD days @ $1000/day = $30,000) **North Haleauau** 426 acres, perimeter 5,259 meters = 17,253 ft * $40/ft = $690,120 + (*42 EOD days= $42,000) **Mohiakea** 426 acres, perimeter 4,620 meters = 15,157 ft * $40/ft = $606,280 + (38 EOD days= $38,000) Total perimeter is 13,474 meters linear distance to construct. Equals 44,206 feet. At $40/foot including materials, construction and clearing = 1.768 EOD support for these fences; incl. scoping and constructions= 110 days* $1000/day= $110,000

#	Description	Assumptions
12	**Fence Construction, Repair and Replacement (in house)** Labor for fence monitoring and maintenance to be covered by NRS's as part of ungulate monitoring/control. *Annual cost:*	Assume small fence repairs will be ongoing. Materials for fence repair and maintenance = **5.5 k/yr** for all OIP fences. The fence repair amount will increase over the first 10 years of fence construction. Cost of fence materials for new construction of MUs: $15/meter. Based on current costs of materials. Approximately 1 large OIP fence will be constructed each year.
13	**Manage for Stability for species requiring a high level of work** All actions needed to increase population levels to achieve stabilization criteria, including monitoring of populations, management of aggressive weeds (<25% cover over 50 m radius beyond PU perimeter), control of other threats (rodents, slugs, human, etc.) as needed for population stability, collection for genetic storage and propagation, and augmentation. *Annual Cost:* NRMC (0.57 mos/yr): NRMT2 (3.43 mos/yr):	While the need for augmentation is based on monitoring results, for the purposes of cost estimates, it is anticipated that all populations requiring a **high** level of work will require augmentation. A proportion of the MU acreage around these populations will also be managed. See CEA #16 - MU Threat Management. Assumes 4 months of NR effort, of which ~ 1/7 of the effort is a NRMC's time and ~ 6/7 of the effort is a NRMT2's time: 3.4 k/yr = (1/12) (71.5 k/yr)(0.57 mos) 14.58 k/yr = (1/12) (51 k/yr) (3.43 mos) **17.98 k/yr**

#	Description	Assumptions
14	**Manage for Stability for species requiring a medium level of work** All actions needed to increase population levels to achieve stabilization criteria, including monitoring of populations, management of aggressive weeds (<25% cover over 50 m radius beyond PU perimeter), control of other threats (rodents, slugs, human, etc.) as needed for population stability, collection for genetic storage and propagation, and augmentation. *Annual Cost:* NRM (0.29 mo/yr): NRS2 (1.71 mo/yr):	While the need for augmentation is based on monitoring results, for the purposes of cost estimates, it is anticipated that all populations requiring a **medium** level of work will require some level of augmentation. A proportion of the MU acreage around these populations will also be managed. See CEA #16 - MU Threat Management. Assumes 2 months of NR effort, of which ~ 1/7 of the effort is a NRM's time and ~ 6/7 of the effort is a NRS2's time: 1.73 k/yr = (1/12) (71.5 k/yr) (0.29 mos) <u>7.3 k/yr = (1/12) (51 k/yr) (1.71 mos)</u> **9.03 k/yr**
15	**Manage for Stability for species requiring a low level of work** All actions needed to maintain populations levels, includes monitoring of populations, management of aggressive weeds (<25% cover over 50 m radius beyond PU perimeter), control of other threats (rodents, slugs, human, etc., as needed), and collection for genetic storage and propagation. *Annual Cost:* NRM (0.14 months/yr): NRS2 (0.86 months/yr):	While the need for augmentation is based on monitoring results, for the purposes of cost estimates, it is anticipated that populations requiring a **low** level of work will not require augmentation. A proportion of the MU acreage around these populations will also be managed. See CEA #16 - MU Threat Management. Assumes 1 month of NR effort, of which ~ 1/7 of the effort is a NRM's time and ~ 6/7 of the effort is a NRS2's time: 0.83 k/yr = (1/12) (71.5 k/yr) (0.14 mos) <u>3.65 k/yr = (1/12) (51 k/yr) (0.86 mos)</u> **4.48 k/yr**

#	Description	Assumptions
16	**MU Threat Management** Includes ecosystem-wide threat control of all alien species. Includes assisting with ungulate control, weed control, fenceline monitoring and minor fence repairs. *Intensive Alien Species Threat Management:* NRMC (0.1 days/yr per acre): NRMT (.4 days/yr per acre): High Level of Threat Control NRMC (.07 days/yr per acre) NRMT (.26 days/yr per acre) Medium level of Threat Control NRMC (.033 days/yr per acre) NRMT (.13 days/yr per acre) Low Level of Threat Control	Total MU acreage subject to ecosystem-level threat control excludes the total area within a 50m radius of all manage for stability *in situ* populations and reintroductions (this area will be managed on the PU-level). Assumes that for a high level of weed control in 300 acres, 12 months of NR effort, of which ~1/7 is an NRM's time, ~4/7 is an NRS2's time: 10.0 k/yr = (70.5 k/yr)(1 yr/12 mos)(1.71 mos) 28.6 k/yr = (50 k/yr)(1 yr/12 mos)(6.86 mos) 48.6 k/ yr per 300 acres = **0.128 k /acre per year High** 6.7 k/yr= (1.14 mos)(1yr/12mos)(70.5k/yr) 19.04 k/yr (4.57 mos)(1yr/12mos)(50 k/yr) **=0.085 k/acre Medium** =(2/3)(0.128k/acre) 3.35 k/yr =(0.57 mos)(1 yr/12 mos)(70.5k/yr) 9.5 k/yr =(2.28 mos)(1yr/12mos)(50k/yr) **=0.043 k/acre Low** =(1/3)(0.128k/acre)
17	**MU Ungulate Control Specialist** Ungulate control specialist will coordinate hunting and snaring operations in MUs with fences. Will also conduct fenceline monitoring and minor fence repairs. *Annual cost:*	MU ungulate control will begin upon construction of the MU. Intensive ungulate control efforts will be conducted for one year inside new fences, after which time ungulate monitoring and smaller-scale control efforts will take place. Intensive ungulate control is not needed in MUs that have existing fences (e.g., Pahole, Kahanahaiki – subunit I, etc.). **83 k/yr** (w/benefits & overhead)
18	**Research Specialist** Research Specialist will coordinate research projects on various issues such as slug control, black twig borer control, etc. *Annual cost:*	There will be 2 research specialists 1 funded via the OIP and the other funded via the MIP. **28.7 k/yr =(**57.4 k/yr w/ benefits & overhead)/2 **5 k/yr** Research budget for supplies

#	Description	Assumptions
19	**MU Monitoring** Includes ecosystem-wide monitoring of at least 4 MUs >10 acres or subunits as scheduled. The monitoring team will provide information for development of MU plans and threat control strategies, and will assist in conducting ungulate control maintenance in MUs as needed. Excludes population-level monitoring of *Manage for Stability* plant populations. LZ surveys: NRMC (6 days): NRMT2 (6 days): Road surveys: NRMT2 (1.16 mos/yr): MU monitoring: NRMC: NRMT2:	MU-level monitoring will be conducted over the entire MU or subunit at the time fenceline clearing begins. Monitoring Specialist cost will come out of MIP budget. Assumes 30 days of monitoring/yr/MU >10acres for 4 MUs/yr with 1 NRMC and 2 NRMTs. NRS's conducting monitoring will be supervised by the monitoring specialist (see MIP CEAs). Includes road surveys and corridor monitoring. Assume 4 NRS days per 20 km of road per year. There are approximately 50 km of road monitored biannually. LZ surveys are necessary for all military used LZs. Surveys for infrequently used LZs can be done once a year. **2.034 k/yr** = (6 survey days/yr)(.339k/day) **1.44 k/yr** = (6 days/yr)(.240k/day) **3.474 k/yr** **4.83 k/yr per 20km road** = (50 k/hr)(1 yr/12 mos)(1.16 mos) 6.78k/yr=(70.5k/yr)(20days/208days/yr) 24/yr=(50k/yr)(100days/208days/yr) **30.8 k/yr to monitor 4 MUs/yr w/ 1 NRMC and 2 NRMTs**
19.1	**Non-MU ICAs** Control efforts: NRMCs (60 days) NRMTs(2 people, 60 days)	Assumes that NRS will survey for and manage any incipient populations/infestations of new invasive species that are potential threats to any of the target taxa or ecosystems required for their survival over the long term. This work will be done in cooperation with the Oahu Invasive Species Committee (OISC) and the Oahu Early Detection (OED) programs. 20.34 k/yr =(60 days)(.339k/day) 28.8 k/yr =(2 NRMTs)(60 days)(.240k/day) **49.14 k/yr**

#	Description	Assumptions
20	***Achatinella* Genetics Analysis** Includes sampling time in the field. *One-time cost:* Sampling for genetics analysis: Genetics testing:	NRS2 (2) will each sample 3 days / population. Testing estimates are based on the cost for microsatellites genetics analysis already conducted (@ 29 k/16 populations = 1.81 k/population). **1.1 k/population** = (0.183 k/day)(6 days/ population) **40 k total** (assumes 16 populations will be tested)
21	**Tier 2: *Achatinella* Exclosure Construction** Includes labor and materials for an average 60m x 80m = 4800 sq. meter exclosure. *One-time construction cost:* Each exclosure (4800 sq. m): Exclosure Maintenance supplies:	Based on average construction cost of existing Pahole and Kahanahaiki exclosures of 4 k/ 1200 sq. meters (30m x 40m). Assumes dimensions of new exclosures will be approximately twice that of existing exclosures and of improved construction. Contractors will be hired to construct exclosures and will work under the supervision of an NRM. A maximum of 6 exclosures per species will be constructed (6x4=24). **10 k** per exclosure. (One new exclosure per year will be constructed.) Exclosure repair and maintenance (of the solar battery, salt trough, etc.) will be included in NRS time (see OIP CEA #3). **1 k** per year per exclosure

#	Description	Assumptions
22	**Tier 2: *Achatinella* Management for Stability** Includes monitoring, threat management, collection, exclosure maintenance and mark-recapture studies (1 time/yr) for populations designated for management. *Annual cost:* NRMC (28 days/yr): NRMT (28 days/yr): Surveys for species with no known extant populations. *Annual cost:* NRMC (10 days/yr): NRMT (10 days/yr):	Assumes two (2) NR personnel will make monthly monitoring, threat management, and exclosure maintenance visits (1 day each/month), and 1 mark-recapture study per year (2 days each/yr) for a total of 14 days/yr per population for each NR (28 person days/yr total). Assume ~1/7 of the effort will be conducted by an NRM and ~6/7 of the effort by an NRS2. 1.37 k/yr **=** (1/7) (28 days/year) (0.343 k/day) <u>5.88 k/yr= (6/7) (28 days/year) (0.245 k/day)</u> **7.25 k/yr** per population or exclosure Assumes an NRM and a NRS will conduct 2 survey days per species per year (for five species, *A. apexfulva, A. bulimoides, A. curta, A. leucorraphe, A. pulcherrima*). Some of these surveys may be combined as some of the historical ranges overlap. 3.43 k/yr =(10 days/yr)(0.343 k/day) <u>2.45 k/yr =(10 days/yr)(0.245 k/day)</u> **5.88 k/yr** for 10 days survey
23	***Achatinella* Captive Propagation Collection** Collection from *Manage for Stability* populations. *One-time cost:* Captive propagation collection:	For each of 2 NRMs: Allow 3 days/population per year for each of two years with some allowance for helicopter support. 16 extant GUs for Koolau *Achatinella* species. 1/5 collected each yr. (16*(1/5))=3.2 **2.03 k/yr per GU** = (0.339 k/day) (6 days/population)
24	**Oahu Elepaio Threat Control and Monitoring Contracts** Assumes Elepaio stabilization efforts involving threat control may be conducted through contracts for offsite populations. *Annual cost:* Elepaio Contract:	Elepaio threat control contracts will be awarded on a yearly basis. Assumes rat control and monitoring will be overseen by NRS and field experts. Cost will cover all rat bait, bait stations, snap traps, etc., and labor. **75 k/yr** = (approximately 25 k/population) (3 populations)

#	Description	Assumptions
25	**Oahu Elepaio Threat Control and Monitoring in House** Assumes onsite threat control and monitoring will be done by NRMC. *Annual Cost:*	Onsite threat control and monitoring will be done in consultation with field experts. Assumes 3 populations will have threat control in House. Cost will cover all rat bait, bait stations, snap traps, etc., and labor. **75 k/yr** = (25 k/population)(3 populations)
26	**Genetic Storage: Collections (Plants)** Excludes collections from *Manage for Stability*, *in situ* populations (will be conducted by staff doing management of these populations). *Annual cost:* NRM (1): NRS2 (1):	Assumes two (2) NR personnel (1 NRM and 1 NRS2) will visit each population 2 times/year to refresh the collection stock. (15 Tier 1 species)(~2 GSC PUs/species)= ~30 GSC PUs 0.68 k/yr = (0.339 k/day)(1 days/trip)(2 trips/yr) 0.45 k/yr = (0.212 k/day) (1 day/trip)(2 trips/yr) **1.13 k/yr per population**
27	**Genetic Storage: Seed Storage** Includes genetic storage of seed, genetic storage via live plants and testing of alternative storage methods (pollen, tissue culture or cuttings). Supplies and Equipment *One time Cost*: 1 refrigerator, 1 freezer, etc.: Propagule Management Specialist (1/2 cost covered via MIP): Full-time Technician (0.5):	Based on estimates from Army seed storage specialist. Based on Army Seed Storage Specialist medium-term seed storage facility estimate: (1 refrigerator: 0.5 k; freezer: 0.576 k; etc.) **5 k** 28.7 =(57.4 k/yr total w/ MIP)(0.5) 25.5=(51 k/yr with benefits and overhead)(0.5) **54.2 k/ yr**
28	**Genetic Storage: Tissue Culture** Includes tissue culture testing as recommended in the Implementation Plan and for target taxa found to have seeds that are not orthodox. Includes annual storage and maintenance of plants stored in tissue culture and	Assumes tissue culture facility will be housed in the newly constructed Lyon Arboretum genetic storage and tissue culture facility. Based on estimates from Lyon Arboretum

#	Description	Assumptions
	germination of immature seeds. *Annual cost:* Tissue Culture materials+ Tissue Culture Assistant (1):	Tissue Culture Specialist: **22 k/yr**
29	**Genetic Storage via Living Collections** Collect from unique populations (geographically isolated, morphologically distinct or located in unique habitat) with fewer than 5 mature individuals and establish living collections *(ex situ* or *inter situ)*, from seeds or cuttings from each individual. *Annual cost:* Maintain *ex situ* or *inter situ* collection:	Assumes additional visits by an NRM (1) and an NRS2 (1) to unique populations will be made. Time required to collect from unique populations is taxon-specific. Assumes each living collection will consist of a maximum of 12 individuals (3 representatives of each wild individual) and will be maintained annually by a botanic garden (National Tropical Botanic Garden, Waimea or Lyon Arboretum) at a cost of 0.5 k / yr. **0.5 k / year** per living collection (12 plants)
31	**Plant Propagation: Facility and Staff** *One-time cost:* Electrostatic sprayer(1) + protective gear + shadehouse benches, watering system, etc.: *Annual costs:* Supplies: Systemic and conventional pesticides: Pots, potting media: Permanent labels: Horticulturalist (1/2 per OIP, 1/2 per MIP): 2 Horticultural Assistants for the OIP Assistant (46 k/yr):	 **18.50k** Estimates for supplies are based on current Nike Site usage per plant/year. Assume an average of 2000 plants outplanted (reintroduction/augmentation) each year. $10 per plant/year $ 4 per plant/year $ 2 per plant /year **$16 per plant/year** For 2000 plants/year, annual greenhouse supplies cost: **32 k** **28.2** =(57.4k/yr)(0.5) **92 k/ yr** (46k/yr*2) (includes overhead)

#	Description	Assumptions
32	***Achatinella* Captive Propagation: Facility and Staff** Includes estimates for environmental chambers, supplies and a facility assistant. *One-time costs:* Chambers (2): *Annual costs:* Full-time Lab Manager (1.5): Supplies: Utilities:	Assumes an existing space can be found to house the expanded facility; MIP will cover cost of *Achatinella mustelina* propagation and genetic analyses; currently Dr. Brendon Holland is responsible for the maintenance and propagation and research for the Army regarding *Achatinella* species. **16.0 k** = (8.0 k/chamber)(2 chambers) 76.0 k 1.0 k 1.5 k **78.5 k/yr**
34	**Office Furniture, Machines and Supplies** Includes desks and chairs for all administrative staff. NRMs will be provided desks and chairs; NRSs will share desks. *One-time cost:* Administrative staff: Office furniture (6 desks and chairs): Fax machine (Canon Laser Class 9000S): Telephone system (for 30): Printer (HP Color Laser Jet 4550DN): Copier (lease) **Office furniture** Tier 1= 8 desks + chairs: Tier 2= 11 desks + chairs: Tier 3= 14 desks + chairs: Office furniture initial purchase: *Annual Costs:* Copier for Administrative Facility (lease includes maintenance & supplies): Office supplies (Administrative staff):	Assumes the administrative facility will have a high-level copier (leased), fax machine, laser-jet printer and telephone system. Excludes computer and field technology (see CEAs #42-43). 4.2 k = (0.7 k) (6) 4 k 10 k 4 k (see below under annual costs) 4 k = (0.5 k)(8) **.7 k/admin staff** 8 k/yr 10 k/yr

#	Description	Assumptions
	Office supplies (field staff):	3 k/yr **21 k/yr**
35	**Helicopter Support** *Annual cost:* Includes helicopter support for all implementation actions except fence contracts:	Based on AMD contract for 400 flight hours/yr; (50 hrs for KMWP/OISC) @ $850/hr. Cost split between MIP and OIP 297.5 k/yr =(350 hrs)(.850 k/hr) **148.75 k/yr=** 297.5/2 (1/2 MIP; OIP) (allows 6 hours flight time/week)
36	**Vehicles** Includes fuel, maintenance and mud tires. No insurance needed (government is self-insuring). *Annual cost:* Vehicle maintenance and fuel: *One time cost:* Vehicle purchase (4WD truck/SUV):	Four-wheel drive vehicles will be purchased through the contracting agency. Estimate 1 vehicle to transport every 4 NR field crew. Estimate 1 vehicle for other staff (IP coordinator, administrative assistant, horticultural assistant). Purchase one new 4WD vehicle per year until needs are met (3 vehicles needed for Tier 1; 4 vehicles for Tier 2; 4 vehicles for Tier 3). Estimate $3k/ year per vehicle. Annual cost will vary with the number of vehicles. Estimate vehicles will need to be replaced every 8 years. **55k/year**
37	**Computer Systems for Administrators and Field Staff AND GIS Specialist** Includes office computers (software and hardware).	Computer systems: Assumes 1 computer system for each administrative/support position: 1 computer will be provided per NRMC (2-4). Additional computers will be shared amongst NRS staff. One-third of the computers purchased will be GIS-compatible. Replace all computers every 5 years. Approx 4

#	Description	Assumptions
	Annual costs: Replacement costs:	computers each year. ArcView software upgrade every other year (approximately 0.8 k each) for GIS computer. **6.4k/yr**=(4)(1.5k/computer) + (0.4k/yr software)
	GIS Specialist and assistant GIS specialist: GIS assistant:	Assumes 1 GIS specialist and 1 assistant will be sufficient for the whole program. Therefore, ½ of the cost of these 2 positions will be covered in the OIP and ½ in the MIP. (1/2)(83k) = 41.5k/yr (1/2)(40.5) = 20.25 k/yr **=61.75k/yr**
38	**Technological Support Systems for Field Staff** Includes global positioning systems (GPSs), personal data assistants (PDAs) and digital cameras. GPS Devices: PDAs: Field-hardened digital cameras:	Assumes field systems will be provided for 1/3 of total number of field staff (NRMCs and NRMTs). 3.0 k/yr =(1.0 k/ system)(3/yr) 1k/yr=(0.5k/PDA)(2/yr) 1k/yr=(0.5 k/camera)(2/yr) **5 k/yr (Tier 1)** **7.5 k/yr =(5k/yr) (1.5) Tier 2)** **8.75 k/yr =(5k/yr)(1.75) (Tier 3)**
	GIS software *Initial cost:* *Annual cost:*	 **7.695k =**7.295k Arc Info + 0.4k arcpad **3.173k=**2.528k ArcInfo maintenance+ 0.5k ArcInfo upgrades+ 0.145k arcpad upgrades
39	**Field Equipment and Supplies** *One-time costs:* Threat control: Weed, ungulate control (includes firearms only) and vegetation-clearing equipment (handsaws, chainsaws, weed eaters, backpack sprayers, clippers):	Assumes field crew (NRMC, NRMT, etc) will *not* be able to sign out battle dress uniform (BDU) from Central Issues Facility to use as daily field wear. Initial purchases for all Tiers will be: Tier 1 = 33 people Tier 2 = 36.4 people Tier 3 = 37 people **.9k/person**

#	Description	Assumptions
	Camping gear (includes backpacks [day and overnight packs]):	Assumes day and overnight packs will be provided for each field staff member. Camping gear will be shared 0.3 k per person for camping gear 0.275 k per person for packs 0.200 k per person for rain gear **0.775 k per person**
	Miscellaneous field gear (includes rappelling gear, compasses, binoculars, etc.):	Assumes hand radios will be provided by the Army, and cell phones will be free with activation. **0.5 k per person**
	Annual costs:	
	Replacement of miscellaneous field gear (year 2 below)	Assume 1/5 of the equipment will need to be replaced each year:
	Replacement of threat control equipment:	Assume 1/5 of the equipment will need to be replaced each year.
	Annual replacement of camping gear and backpacks	Assumes approximately 1/5 of the camping gear and packs will need to be replaced annually due to wear-and-tear:
	Pesticides, herbicides, rat control (traps and diphacinone bait), salt, batteries, flagging, safety equipment (respirators, Tyvek suits, gloves) and snares.	Based on current Army Environmental estimates of 15k /year for 10 staff. **1.5 k/ person**
	Cell phone service:	Assumes cell phone service all NRMCs and NRMTs at the rate of $700/yr for phone service:
	Annual allowance of $400/field person to be used toward footwear and raingear, assumes administrative assistant does not require field gear.	Based on current allowance of **0.40 k/ yr** per person.

#	Description	Assumptions
41	**Summer Internship Program** The intent of this program is to provide early experience for college undergraduate students such that they may transition into full time Natural Resource positions in the future. Annual summer interns:	Summer interns will be hired in addition to (not in replacement of) the required Natural Resource staff. Three summer interns will be hired per year, at the rate of $12.50/hr ($14.75/hr with overhead) @ 40 hrs/week for 12 weeks/year. 7.08 k/intern = ($14.75/hr)(40hrs/wk)(12 weeks) **21.24 k** = (3 interns)(7.08 k/intern)
42	**IT Annual Review** Includes 3 days of IT time: *Annual cost:*	**7.2 k/yr=** (~3 OIT member daily cost)(0.1k/hr)(8 hrs)(3 days) **~2**k/yr for IT travel **=9.2k/yr**
43	**Production of Annual Progress Reports for IT Review** *Annual cost:* Annual report (30 copies):	Assumes reports will be prepared by Implementation Plan coordinators at no additional cost. Reproduction costs: 30 copies of the annual report will be produced: **1.98 k /yr** = (0.066 k/annual report) (30 copies)
44	**Explosive Ordinance Disposal (EOD)** For Unexploded Ordinance (UXO) *Annual cost:* 1 EOD tech II/ field day in AA w/ required EOD:	Assumes EOD support for field staff will be required on all visits to Schofield Barracks West Range and Lower Makua. EOD support will be needed for all fence scoping/clearing projects and elepaio threat management/monitoring projects. = (1k/day for tech II EOD w/ overhead)(# of field days needed)
46	**Outreach Specialist/Volunteer Coordinator** *Annual Cost:*	Assumes that NR program will need to conduct environmental outreach and coordinate with community volunteers. 2 needed; 1 coordinator for the OIP and 1 for the MIP. This cost covers only the OIP coordinator.

#	Description	Assumptions
	1 NR Environmental Outreach/ Volunteer Coordinators:	**61k** w/ overhead and benefits
47	**Development of rare plant management plans** *Annual Cost:* 1 rare plant program manager (cost split between MIP and OIP): **Rare Species Monitoring and Data Management** Includes monitoring of target and non-target rare species within each MU. Data to be updated and included in the annual status report. *Annual cost:* NRM (1 sp/day):	Assumes some office time is necessary for the development of rare plant management plans, includes meetings with other agencies, database development, etc. =(50%)(83k/yr w/ overhead and benefits) =**41.5k** Calculated for each MU allowing 1 NRM to report on the status of 1 target taxon per day. **6.85 k** = (1/12)(0.05mos/species)(71.5k/yr)(23 species)
48	**Development of rare snail management plans** *Annual Cost:* 1 rare snail specialist (cost split between MIP and OIP):	Assumes some office time for the development of management plans, includes meetings, etc. =(50%)(83k w/ overhead and benefits) =**41.5K**
49	**Development of Elepaio management plans** *Annual Cost:* 1 Elepaio program manager	Assumes office time is necessary for the development of Elepaio management plans. Meetings, reporting, planning, contractor auditing, data entry. Assumes a full time manager is needed to for these actions to be completed. May not be filled by one particular staff but several staff working part time. =**83 k** w/ overhead and benefits
50	**Rare Species Surveys (Plants, invertebrates, vertebrates).** *Annual Cost:*	Includes field time, mapping of survey and rare species locations, collection of specimens, taxonomic determination and completion of field data forms.

#	Description	Assumptions
	20 days NRM: 20 days NRS2:	6.86k =(20 days survey)(.343k/day) 4.9k =(20 days survey)(.245k/day) **11.76k** yearly

Section 3. Table 1. Cost and Staff Summary by Tiers 1,2,3 and by year.

Estimated cost by year including large West Range fences																			
	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10	year 11	year 12	year 13	year 14	year 15	year 16	year 17	year 18	year 19	year 20
Tier 1 cost $	3329.5	4190.8	2787	2844.1	3027.0	3009.4	3115.2	3208.4	3305.4	3406.2	3511.1	3620.1	3730.3	3845.0	3964.2	4088.2	4220.3	4357.7	4500.7
Tier 1 people #	31.5	31.8	32.0	32.6	32.8	32.8	32.8	32.8	32.8	32.8	32.8	32.8	32.8	32.8	32.8	32.8	32.8	32.8	32.8
Tier 2 cost $	3600.5	4451.7	3121	3178.4	3167.6	3095	3115	3196	3338.9	3417	3396.2	3504.4	3613.8	3727.5	3845.8	3968.9	4100	4236.4	4378.2
Tier 2 people #	35.0	35.3	35.5	36.1	36.3	36.3	36.3	36.3	36.3	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4
Tier 3 cost $	3618.3	4478.2	3148	3204.8	3194	3121.4	3141.4	3222.4	3365.3	3443	3422.5	3530.7	3640.1	3753.8	3872.1	3995.1	4126.2	4262.6	4404.4
Tier 3 people #	35.7	35.997	36.18	36.774	36.944	36.967	36.984	36.991	37.016	37.05	37.053	37.053	37.053	37.053	37.053	37.053	37.053	37.053	37.053

Without WR fences		
	year 2	year 3
Tier 1 cost $	2769.4	2722.5
Tier 1 people #	31.5	31.5
Tier 2 cost $	3040.4	2990.9
Tier 2 people #	34.8	34.816
Tier 3 cost $	3031.3	2990.7
Tier 3 people #	34.8	34.808

year	Tier year	Trigger Action Description	Trigger Actio	Taxon	Assumptior	Unit	Number of Units	Unit Cost (1,000s)	Cost (subtotal) (1,000s)	One-Time Prorated Costs (1,000s)	Annual Costs (1,000s)	No. of NRM per Year	No. of NRS2 per Year	other personnel
2	1	Administrative Assistants	administrative		CEA 2	1 person					50			1
2	1	Army Implementation Senior Coordinator	administrative		CEA 1	1 person	0.5	83	41.5		41.5			0.5
2	1	Army Implementation Plan Project Manager	administrative		CEA 1	1 person	0.5	83	41.5		41.5			0.5
2	1	Research Specialist	research	multiple	CEA 18	1 person	0.50	57.4	28.7		33.7			0.5
2	1	Ungulate control specialist, to conduct management-unit level ungulate control.	personnel		CEA 17	1 person	0.5	83	41.5		41.5			0.5
2	1	Fence Crew Coordinator	Fence Crew		CEA 4	1 person	1	71.5	70.5		70.5			1
2	1	Fence crew worker	Fence Crew		CEA 4	1 person	3	59	177		177			3
2	1	Fence maintenance for OIP MU fences	fence	multiple	CEA 12	1 MU	5	1	5		5			
2	1	Cell phone (for field communication only)	equipment and supplies		CEA 39	1	29	0.83	24.07		24.07			
2	1	Equipment (theat management gear, telecommuncations gear - annual replacement)	equipment and supplies		CEA 39	0.9k / persor	29	0.9	26.1		26.1			
2	1	Field supplies, annual supplies purchase (Pesticides, herbicides, rat control (traps and diphacinone bait), salt, batteries, flagging, safety equipment (respirators, Tyvek suits, gloves and snares).	equipment and supplies		CEA 39	1.5 k/ persor	29	1.5	43.5		43.5			
2	1	Personal gear for field crew (annual allowance for footwear and rain gear)	equipment and supplies		CEA 39	$400/person	29	0.4	11.6		11.6			
2	1	Field supplies, initial purchase (camping gear.)	equipment and supplies		CEA 39	.775/person + annual replacemen	29	0.775	22.48		22.48			
2	1	Office furniture for Admin and NRMs	equipment and supplies		CEA 39	.7/person	6	0.7		4.20	4.20			
2	1	Communications equipment, initial purchase (includes rappelling gear, compasses binoculars.)	equipment and supplies		CEA 39	.5 k/person + annual replacemen	29	0.5	14.50		14.5			
2	1	Development of fire management plans = one time cost	fire management		CEA 9	FMP	1	35	35	35				
2	1	Annual Office copy machine rental and supplies costs	equipment and supplies		CEA 34				21.0		21.0			
2	1	Manage for stability, Abutilon sandwicense, Kaluakauila (reintro)	Manage for stability	Abusan	CEA 14	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Abutilon sandwicense, Ekahanui and Huliwai	Manage for stability	Abusan	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Abutilon sandwicense, Kaimuhole	Manage for stability	Abusan	CEA 15	1 population	1	4.48	4.48		4.48	0.011	0.074	

Chapter 2:		Detailed Cost Estimates and Time Schedule													
year	Tier year	Trigger Action Description	Trigger Actio	Taxon	Assumption	Unit	Number of Units	Unit Cost (1,000s)	Cost (subtotal) (1,000s)	One-Time Prorated Costs (1,000s)	Annual Costs (1,000s)	No. of NRM per Year	No. of NRS2 per Year	other personnel
2	1	Manage for stability, Abutilon sandwicense, Makaha	Manage for stability	Abusan	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Schidea trinervis, Kalena to Kaala	Manage for stability	Schtri	CEA 15	1 population	1	4.48	4.48		4.48	0.011	0.074	
2	1	Manage for stability, Schiedea trinervis, East Makaleha	Manage for stability	Schtri	CEA 13	1 population	2	17.93	35.86		35.86	0.090	0.590	
2	1	Manage for stability, Cyanea acuminata, Kaala	Manage for stability	Cyaacu	CEA 14	1 population	1	9.03	9.03		7.94	0.020	0.131	
2	1	Manage for stability, Cyanea acuminata, Poamoho	Manage for stability	Cyaacu	CEA 14	1 population	1	9.03	9.03		9.03	0.023	0.149	
2	1	Manage for stability, Cyanea acuminata, South Kaukonahua	Manage for stability	Cyaacu	CEA 14	1 population	1	9.03	9.03		9.03	0.023	0.149	
2	1	Manage for stability, Cyanea koolauensis, Koloa	Manage for stability	Cyakoo	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Cyanea koolauensis, North Kaukonahua	Manage for stability	Cyakoo	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Cyanea koolauensis, Opaeula/Helemano	Manage for stability	Cyakoo	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Cyanea st.-johnii, Helemano	Manage for stability	Cyastj	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Cyanea st.-johnii, Waimano	Manage for stability	Cyastj	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Cyanea st.-johnii, Waiawa	Manage for stability	Cyastj	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Eugenia koolauensis, Oio	Manage for stability	Eugkoo	CEA 13	1 population	1	4.48	4.48		4.48	0.011	0.074	
2	1	Manage for stability, Eugenia koolauensis, Kaunala	Manage for stability	Eugkoo	CEA 13	1 population	1	4.48	4.48		4.48	0.011	0.074	

Chapter 2:		Detailed Cost Estimates and Time Schedule													
year	Tier year	Trigger Action Description	Trigger Actio	Taxon	Assumptior	Unit	Number of Units	Unit Cost (1,000s)	Cost (subtotal) (1,000s)	One-Time Prorated Costs (1,000s)	Annual Costs (1,000s)	No. of NRM per Year	No. of NRS2 per Year	other personnel
2	1	Manage for stability, Eugenia koolauensis, Pahipahialua	Manage for stability	Eugkoo	CEA 13	1 population	1	4.48	4.48		4.48	0.011	0.074	
2	1	Manage for stability, Gardenia mannii, Haleauau	Manage for stability	Garman	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Gardenia mannii, Opaeula	Manage for stability	Garman	CEA 14	1 population	1	9.03	9.03		9.03	0.023	0.149	
2	1	Manage for stability, Gardenia mannii, Poamoho	Manage for stability	Garman	CEA 14	1 population	1	9.03	9.03		9.03	0.023	0.149	
2	1	Manage for stability, Hesperomannia arborescens, Koloa	Manage for stability	Hesarbo	CEA 14	1 population	1	9.03	9.03		9.03	0.023	0.149	
2	1	Manage for stability, Hesperomannia arborescens, North and South Kaukonahua	Manage for stability	Hesarbo	CEA 15	1 population	1	4.48	4.48		4.48	0.011	0.074	
2	1	Manage for stability, Hesperomannia arborescens, Palikea gulch	Manage for stability	Hesarbo	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Huperzia nutans, North Kaukonahua	Manage for stability	Hupnut	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Huperzia nutans, South Kaukonahua	Manage for stability	Hupnut	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Huperzia nutans, Koloa	Manage for stability	Hupnut	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage fot stability, Labordia cyrtandrae, East Makaleha to Kaala	Manage for stability	Labcyr	CEA 13	1 population	2	17.93	35.86		35.86	0.090	0.590	
2	1	Manage for stability, Labordia cyrtandrae, Manana	Manage for stability	Labcyr	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Melicope lydgatei, Kawailoa	Manage for stability	Mellyd	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Melicope lydgatei, Lower Opaeula	Manage for stability	Mellyd	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Melicope lydgatei, reintro.	Manage for stability	Mellyd	no reintro.	1 population	0	17.93	0		0	0.000	0.000	
2	1	Manage for stability, Phyllostegia hirsuta, Koloa	Manage for stability	Phyhir	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Phyllostegia hirsuta, Kaala to Kalena	Manage for stability	Phyhir	CEA 15	1 population	1	4.48	4.48		4.48	0.011	0.074	
2	1	Manage for stability, Phyllostegia hirsuta, Kaluaa	Manage for stability	Phyhir	CEA 14	1 population	1	9.03	9.03		9.03	0.023	0.149	
2	1	Manage for stability, Phyllostegia mollis, Ekahanui	Manage for stability	Phymol	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Phyllostegia mollis, Kaluaa	Manage for stability	Phymol	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Phyllostegia mollis, Pualii	Manage for stability	Phymol	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	

Chapter 2:		Detailed Cost Estimates and Time Schedule												
year	Tier year	Trigger Action Description	Trigger Actio	Taxon	Assumptior	Unit	Number of Units	Unit Cost (1,000s)	Cost (subtotal) (1,000s)	One-Time Prorated Costs (1,000s)	Annual Costs (1,000s)	No. of NRM per Year	No. of NRS2 per Year	other personnel
2	1	Manage for stability, Pteris lidgatei, Kawaiiki	Manage for stability	Ptelid	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Pteris lidgatei, North Kaukonahua	Manage for stability	Ptelid	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Pteris lidgatei, South Kaukonahua	Manage for stability	Ptelid	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Stenogyne kanehoana, Kaluaa	Manage for stability	Stekan	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Stenogyne kanehoana, Haleauau	Manage for stability	Stekan	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Stenogyne kanehoana, South Kaluaa	Manage for stability	Stekan	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Genetic Storage Collections- non MFS PUs	Genetic Storage	multiple	CEA 26	1 PU	1.13	30	33.9		33.9	0.085	0.558	
2	1	Survey for five Achatinella species	Relocate species	*Ach* sp.	CEA 22	1 survey day	10	0.588	5.88		5.9	0.042	0.059	
2	1	Construct South Haleauau MU: materials cost	Threat Management	multiple	CEA 11	1 foot	0.04	11794	471.76	471.76				
2	1	EOD for South Haleauau MU: Tech II EOD	EOD	multiple	CEA 11	1 day	1	30	30	30				
2	1	Helicopter support for South Haleauau: X hours	transportation		CEA 35	1 hr	50	0.85	42.5	42.5				
2	1-2009	MU Threat Management, Waimano (LOW)	Threat Management	multiple	CEA 16	1 acre Low	3.60	0.043	0.155		0.155	0.000	0.001	
2	1-2009	Construct Waimano MU; matertials cost	Threat Management	Cyastj	CEA 12	1 meter	0.02	483.5	7.253	7.253				
2	1	MU Threat Management, Helemano (LOW)	Threat Management	multiple	CEA 16	1 acre Low	113.17	0.043	4.866		4.866	0.003	0.018	
2	1	MU Threat Management, Opaeula (LOW)	Threat Management	multiple	CEA 16	1 acre Low	121.39	0.043	5.220		5.220	0.003	0.020	
2	1	MU Threat Management, Kaala (MED)	Threat Management	multiple	CEA 16	1 acre Med	171.60	0.085	14.586		14.586	0.020	0.055	
2	1	MU Threat Management, Kaunala to Kaleleiki (HIGH)	Threat Management	multiple	CEA 16	1 acre High	25.20	0.128	3.226		3.226	0.007	0.037	
2	1	MU Threat Management, South Haleauau (HIGH)	Threat Management	multiple	CEA 16	1 acre High	123.60	0.128	15.821		15.821	0.032	0.181	
2	1	Elepaio Threat Control Contracts	Management	Elepaio	CEA 24	1 population	3.00	25	75		75.0			
2	1	Elepaio Threat Control by NRS	Management	Elepaio	CEA 25	1 population	3.00	25	75		75.0	0.266	1.13	
2	1	Helicopter support	transportation		CEA 35	hrs/yr	175	0.85	148.8		148.8			
2	1	Vehicle purchase for NR field staff	transportation		CEA 36	1 vehicle	1	55	55.0	55				

Chapter 2: Detailed Cost Estimates and Time Schedule

year	Tier year	Trigger Action Description	Trigger Actio	Taxon	Assumption	Unit	Number of Units	Unit Cost (1,000s)	Cost (subtotal) (1,000s)	One-Time Prorated Costs (1,000s)	Annual Costs (1,000s)	No. of NRM per Year	No. of NRS2 per Year	other personnel
2	1	Annual vehicle maintenance. Includes fuel, maintenance, mud tires; (government vehicles are self-insured).	transportation		CEA 36	1 vehicle	4	3	12.0		12.0			
2	1	MU monitoring, road, LZ, and corridor surveys	monitoring		CEA 19	1 NRS2	2		4.8		4.8	0.017	0.004	
2	1	MU and MU subunit monitoring, ecosystem level monitoring	monitoring		CEA 19	1 MU	4	7.7	30.8		30.8	0.042	0.296	
2	1	Non-MU ICA monitoring	monitoring		CEA 19	1 day	60	0.819	49.1		49.1	0.195	0.56	
2	1	Achatinella captive propagation collections- 3.2 populations each year	Manage for st	Achatinel	CEA 23	1 PU	2.03	3.2	6.5		6.5	0.023		
2	1	Achatinella spp. captive propagation program + annual utilities cost	captive propagation	*Achatinel*	CEA 32	1.5 assistants + supplies +			83.2	16	83.2			
2	1	Achatinella Genetics Analyses= one years testing only.	Genetic Samples	*Achatinel*	CEA 20	1 PU	1.1	16	17.6	56				
2	1	Horticulturalist: 1/2 cost covered by MIP	greenhouse	*multiple*	CEA 31	1 person	0.5	57.4			28.7			0.5
2	1	Horticultural assistant (1) for propagation of endangered plants, in compliance with sanitation protocols	greenhouse	multiple	CEA 31	1 person	2	46	92.0		92.0			2
2	1	Seed storage testing and seed storage - annual storage maintenance costs and staffing.	seed storage	multiple	CEA 27	1 person + supplies	1		54.2	5	54.2			1
2	1	Genetic Storage: Tissue Culture	Tissue Culture	multiple	CEA 28	1 person	22				22.0			
2	1	Genetic Storage: Living collections	Living collectio	multiple	CEA 29	1 species	0.5	12	6.0		6.0			
2	1	Annual greenhouse supplies (pesticides, pots, fertilizer, etc.)	greenhouse	multiple	CEA 31	1 plant	2,000	0.016	32.00	18.5	32.0			
2	1	Summer Internship Program			CEA 41	1 person	3	7.08	21.24		21.24			
2	1	Annual progress report for IT review (production	report printing		CEA 43	1 report	30	0.066	1.98		1.98			
2	1	Implementation Team (IT) Annual Review	reporting	multiple	CEA 42				9.20		9.20			
2	1	Outreach/Volunteer coordinator	outreach	multiple	CEA 46	1 person	1	61			61.00			1
2	1	Develop MU alien species control plan and include status update in annual report	report writing	multiple	CEA 7	1 person	1	83	83.00		83.00			1
2	1	Technological support for field staff, GPS and digital cameras - every year replacement cost			CEA 38	3GPS/2PDA/2 Camera/yr	1.0	5.0	5.00		5.00			
2	1	GIS Software			CEA 38	GIS Software	1.0	3.2	3.17	7.695	3.17			
2	1	GIS specialist and GIS Assistant			CEA 37	1 person	1.0	61.8	61.75		61.75			1
2	1	Technological support for Army Environmental staff - in office (general office computers			CEA 37	1 computer	4	1.5	6.00		6.40			

year	Tier year	Chapter 2: Detailed Cost Estimates and Time Schedule Trigger Action Description	Trigger Actio	Taxon	Assumptior	Unit	Number of Units	Unit Cost (1,000s)	Cost (subtotal) (1,000s)	One-Time Prorated Costs (1,000s)	Annual Costs (1,000s)	No. of NRM per Year	No. of NRS2 per Year	other personnel
2	1	Rare species Monitoring and Data Management	monitoring	multiple	CEA 47	1 species	23	0.297	6.83		6.83	0.024		
2	1	Development of rare plant management plans	report writing	multiple	CEA 47	1 person	0.5	83	41.50		41.50			0.5
2	1	Development of rare snail management plans	report writing	multiple	CEA 48	1 person	0.5	83	41.50		41.50			0.5
2	1	Development of Elepaio management plans	report writing	Elepaio	CEA 49	1 person	1	83	83.00		83.00			1
2	1	Surveying for rare species	surveys	multiple	CEA 50	1 day	20		11.76		11.76	0.016	0.023	
2	1	EOD Contract	EOD		CEA 44	1 EOD day	62	1	62.00		62.00			
X		Year 2 costs at tier 1								748.9	2580.6	2.4	13.6	15.5
X		Year 2 costs at tier 1---no South Haleauau MU								204.6	2564.7	2.4	13.6	15.5
3	1-2010	no fire management plan or Genetics Testing costs + other one time costs								-122.2				
3	1-2010	no construct south haleauau: -materials, EOD, helicopter								-544.3				
2	1-2010	no initial purchase CEA 39	equipment and supplies		CEA 39						-67.28			
2	1	annual replacement of misc. field gear = 1/5 cost of initial purchase each year	equipment and supplies		CEA 39	1/5 of initial cost			13.46		13.46			
3	1-2010	Construct North Haleauau MU: materials cost	Threat Management	multiple	CEA 11	1 foot	0.04	17253	690.12	690.12				
3	Jan-10	EOD for North Haleauau MU: tech II	EOD	multiple	CEA 11	1 day	1	42		42				
3	1-2010	Helicopter support for North Haleauau MU: X hours	transportation		CEA 35	1 hr	50	0.85	42.5	42.5				
3	1-2010	MU Threat Management, North Haleauau	Threat Management	multiple	CEA 16	1 acre High	123.60	0.128	15.821		15.821	0.032	0.181	
3	1-2010	Construct Mohiakea MU: materials cost	Threat Management	multiple	CEA 11	1 foot	0.04	15157	606.28	606.28				
3	1-2010	EOD for Mohiakea MU: tech II	EOD	multiple	CEA 11	1 day	1	38		38				
3	1-2010	Helicopter support for Mohiakea; X hours	transportation		CEA 35	1 hr	50	0.85	42.5	42.5				
3	1-2010	MU Threat Management, Mohiakea	Threat Management	multiple	CEA 16	1 acre low	426.00	0.043	18.318		18.318	0.012	0.070	
3	1-2010	Construct Mahaka III MU; Materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	411.6	6.174	6.174				
3	1-2010	MU Threat Management, Kamaili	Threat Management	multiple	CEA 16	1 acre high	6.30	0.128	0.806		0.806	0.002	0.009	
3	1-2010	%4 inflation increase each year on salaries									79.063			
X		Year 3 costs at tier 1								1550.0	2640.7	2.5	13.9	15.5
X		Year 3 costs at tier 1--no North Haleauau or Mohiakea								210.8	2511.7	2.4	13.6	15.5
4	1-2011	no construct North Haleauau and Mohiakea								-1467.6				
4	1-2011	Construct Koloa MU: materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	3356.1	50.3415	50.3415				

Chapter 2:		Detailed Cost Estimates and Time Schedule												
year	Tier year	Trigger Action Description	Trigger Actio	Taxon	Assumption	Unit	Number of Units	Unit Cost (1,000s)	Cost (subtotal) (1,000s)	One-Time Prorated Costs (1,000s)	Annual Costs (1,000s)	No. of NRM per Year	No. of NRS2 per Year	other personnel
4	1-2011	MU Threat Management, Koloa	Threat Management	multiple	CEA 16	1 acre Med	160.00	0.085	13.600		13.600	0.028	0.155	
4	1-2011	%4 inflation increase each year on salaries									81.078			
X	Year 4 costs at tier 1									132.8	2654.3	2.5	14.0	15.5
	no construct Koloa MU									-50.3				
5	1-2012	Construct Kaipapau MU: materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	4405	66.075	66.075				
5	1-2012	MU Threat Management, Kaipapau	Threat Management	multiple	CEA 16	1 acre Med	272.00	0.085	23.120		23.120	0.062	0.271	
5	1-2012	Construct Manana MU: materials cost	Threat Management	Cyastj	CEA 12	1 meter	0.015	1152	17.280	17.280		0.046	0.203	
5	1-2012	MU Threat Management, Manana	Threat Management	Cyastj	CEA 16	1 acre low	18.100	0.048	0.869		0.869	0.002	0.010	
5	1-2012	%4 inflation increase each year on salaries									79.682			
X	Year 5 costs at tier 1									165.8	2678.3	2.6	14.5	15.5
	no construct Koloa MU and no vehicles									-121.1				
6	1-2013	Construct South Kaukonahua MU: materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	2701.3	40.5195	40.5195				
6	1-2013	MU Threat Management, South Kaukonahua	Threat Management	multiple	CEA 16	1 acre med	93.50	0.085	7.948		7.948	0.011	0.061	
6	1-2013	Construct Ekahanui extension + Huliwai	Threat Management	Abusan	CEA 12	1 meter	0.015	447	6.705		6.705	0.018	0.079	
6	1-2013	MU Threat Management, Eka extension + Huliwai	Threat Management	Abusan	CEA 16	1 acre High	1.00	0.128	0.128		0.128	0.000	0.002	
6	1-2013	%4 inflation increase each year on salaries									82.869			
X	Year 6 costs at tier 1									251.1	2776.0	2.6	14.7	15.5
	no construct South Kaukonahua MU									-40.5				
7	1-2014	Construct North Kaukonahua MU: materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	1352	20.28	20.28				
7	1-2014	MU Threat Management, North Kaukonahua	Threat Management	multiple	CEA 16	1 acre Med	30.40	0.085	2.584		2.584	0.003	0.020	
7	1-2014	Construct Lower Poamoho: materials	Threat Management	Garman	CEA 12	1 meter	0.015		0.000		0.000	0.000	0.000	
7	1-2014	MU Threat Management: Lower Poamoho	Threat Management	Garman	CEA 16	1 acre low	1.00	0.048	0.048		0.048	0.000	0.000	
7	1-2014	%4 inflation increase each year on salaries									86.184			
X	Year 7 costs at tier 1									230.8	2778.6	2.6	14.7	15.5
	no construct North Kaukonahua MU									-20.3				
8	1-2015	Construct Poamoho Subunit I MU: materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	2210	33.15	33.15				

Chapter 2:		Detailed Cost Estimates and Time Schedule												
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8	1-2015	MU Threat Management, Poamoho Subunit I	Threat Management	multiple	CEA 16	1 acre low	30.40	0.043	1.307		1.307	0.001	0.005	
8	1-2015	Construct Lower Peahinaia II: materials cost	Threat Management	multiple	CEA 12	1 meter	0.015							
8	1-2015	MU Threat Management, Lower Peahinaia II	Threat Management	multiple	CEA 16	1 acre med	23.900	0.085	2.032		2.032	0.003	0.008	
8	1-2015	%4 inflation increase each year on salaries									89.631			
X	Year 8 costs at tier 1									243.7	2871.5	2.6	14.7	15.5
9	1-2016	%4 inflation increase each year on salaries									93.216			
X	Year 9 costs at tier 1									243.7	2964.8	2.6	14.7	15.5
10	1-2017	%4 inflation increase each year on salaries									96.945			
X	Year 10 costs at tier 1									243.7	3061.7	2.6	14.7	15.5
11	1-2018	%4 inflation increase each year on salaries									100.823			
X	Year 11 costs at tier 1									243.7	3162.5	2.6	14.7	15.5
12	1-2019	%4 inflation increase each year on salaries									104.856			
X	Year 12 costs at tier 1									243.7	3267.4	2.6	14.7	15.5
13	1-2020	%4 inflation increase each year on salaries									109.050			
X	Year 13 costs at tier 1									243.7	3376.4	2.6	14.7	15.5
14	1-2021	%4 inflation increase each year on salaries									110.225			
X	Year 14 costs at tier 1									243.7	3486.7	2.6	14.7	15.5
15	1-2022	%4 inflation increase each year on salaries									114.634			
X	Year 15 costs at tier 1									243.7	3601.3	2.6	14.7	15.5
16	1-2023	%4 inflation increase each year on salaries									119.219			
X	Year 16 costs at tier 1									243.7	3720.5	2.6	14.7	15.5
17	1-2024	%4 inflation increase each year on salaries									123.988			
X	Year 17 costs at tier 1									243.7	3844.5	2.6	14.7	15.5
18	1-2025	%4 inflation increase each year on salaries									132.134			
X	Year 18 costs at tier 1									243.7	3976.6	2.6	14.7	15.5
19	1-2026	%4 inflation increase each year on salaries									137.420			
X	Year 19 costs at tier 1									243.7	4114.0	2.6	14.7	15.5
20	1-2027	%4 inflation increase each year on salaries									142.917			
X	Year 20 costs at tier 1									243.7	4257.0	2.6	14.7	15.5

Chapter 2:		Detailed Cost Estimates and Time Schedule												
year	Tier year	Trigger Action Description	Trigger Action	Taxon	Assumptions	Unit	Number of Units	Unit Cost (1,000s)	Cost (subtotal) (1,000s)	One-Time Prorated Costs (1,000s)	Annual Costs (1,000s)	No. of NRM per Year	No. of NRS2 per Year	other personnel
2	1	Administrative Assistants	administrative		CEA 2	1 person					50			1
2	1	Army Implementation Senior Coordinator	administrative		CEA 1	1 person	0.50	83	41.5		41.5			0.5
2	1	Army Implementation Plan Project Manager	administrative		CEA 1	1 person	0.50	83	41.5		41.5			0.5
2	1	Research Specialist	research	multiple	CEA 18	1 person	0.50	56.4	28.2		33.2			0.5
2	1	Ungulate control specialist, to conduct management-unit level ungulate control.	personnel		CEA 17	1 person	0.5	83	41.5		41.5			0.5
2	1	Fence Crew Coordinator	Fence Crew		CEA 4	1 person	1	71.5	70.5		70.5			1
2	1	Fence crew worker	Fence Crew		CEA 4	1 person	3	59	177		177			3
2	1	Fence maintenance for OIP MU fences	fence	multiple	CEA 12	1 MU	5	1	5		5			
2	1	Cell phone and pager service (for field communication only)	equipment and supplies		CEA 39	1	31	0.83	25.73		25.73			
2	1	Equipment (theat management gear, telecommuncations gear - annual replacement)	equipment and supplies		CEA 39	0.9k / person	31	0.9	27.9		27.9			
2	1	Field supplies, annual supplies purchase (Pesticides, herbicides, rat control (traps and diphacinone bait), salt, batteries, flagging, safety equipment (respirators, Tyvek suits, gloves and snares).	equipment and supplies		CEA 39	1.5 k/ person	31	1.5	46.5		46.5			
2	1	Personal gear for field crew (annual allowance for footwear and rain gear)	equipment and supplies		CEA 39	$400/person	31	0.4	12.4		12.4			
2	1	Field supplies, initial purchase (camping gear.)	equipment and supplies		CEA 39	.775/person + annual replacement	31	0.775	24.03		24.03			
2	1	Office furniture for Admin and NRMs	equipment and supplies		CEA 39	.7/person	6	0.7		4.20	4.20			
2	1	Communications equipment, initial purchase (includes rappelling gear, compasses binoculars.)	equipment and supplies		CEA 39	.5 k/person + annual replacement	29	0.5	14.50		14.5			
2	1	Development of fire management plans = one time cost	fire management		CEA 9	FMP	1	35	35	35				
2	1	Annual Office copy machine rental and supplies costs	equipment and supplies		CEA 34				21.0		21.0			
2	1	Manage for stability, Abutilon sandwicense, Kaluakauila (reintro)	Manage for stability	Abusan	CEA 14	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Abutilon sandwicense, Ekahanui and Huliwai	Manage for stability	Abusan	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	

Chapter 2:		Detailed Cost Estimates and Time Schedule												
year	Tier year	Trigger Action Description	Trigger Action	Taxon	Assumptions	Unit	Number of Units	Unit Cost (1,000s)	Cost (subtotal) (1,000s)	One-Time Prorated Costs (1,000s)	Annual Costs (1,000s)	No. of NRM per Year	No. of NRS2 per Year	other personnel
2	1	Manage for stability, Abutilon sandwicense, Kaimuhole	Manage for stability	Abusan	CEA 15	1 population	1	4.48	4.48		4.48	0.011	0.074	
2	1	Manage for stability, Abutilon sandwicense, Makaha	Manage for stability	Abusan	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Schidea trinervis, Kalena to Kaala	Manage for stability	Schtri	CEA 15	1 population	1	4.48	4.48		4.48	0.011	0.074	
2	1	Manage for stability, Schiedea trinervis, East Makaleha	Manage for stability	Schtri	CEA 13	1 population	2	17.93	35.86		35.86	0.090	0.590	
2	1	Manage for stability, Cyanea acuminata, Kaala	Manage for stability	Cyaacu	CEA 14	1 population	1	9.03	9.03		7.94	0.020	0.131	
2	1	Manage for stability, Cyanea acuminata, Poamoho	Manage for stability	Cyaacu	CEA 14	1 population	1	9.03	9.03		9.03	0.023	0.149	
2	1	Manage for stability, Cyanea acuminata, South Kaukonahua	Manage for stability	Cyaacu	CEA 14	1 population	1	9.03	9.03		9.03	0.023	0.149	
2	1	Manage for stability, Cyanea koolauensis, Koloa	Manage for stability	Cyakoo	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Cyanea koolauensis, North Kaukonahua	Manage for stability	Cyakoo	CEA 13	2 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Cyanea koolauensis, Opaeula/Helemano	Manage for stability	Cyakoo	CEA 13	3 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Cyanea st.-johnii, Helemano	Manage for stability	Cyastj	CEA 13	4 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Cyanea st.-johnii, Waimano	Manage for stability	Cyastj	CEA 13	5 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Cyanea st.-johnii, Waiawa	Manage for stability	Cyastj	CEA 13	6 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Eugenia koolauensis, Oio	Manage for stability	Eugkoo	CEA 13	1 population	1	4.48	4.48		4.48	0.011	0.074	
2	1	Manage for stability, Eugenia koolauensis, Kaunala	Manage for stability	Eugkoo	CEA 13	1 population	1	4.48	4.48		4.48	0.011	0.074	
2	1	Manage for stability, Eugenia koolauensis, Pahipahialua	Manage for stability	Eugkoo	CEA 13	1 population	1	4.48	4.48		4.48	0.011	0.074	
2	1	Manage for stability, Gardenia mannii, Haleauau	Manage for stability	Garman	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Gardenia mannii, Opaeula	Manage for stability	Garman	CEA 14	1 population	1	9.03	9.03		9.03	0.023	0.149	

Chapter 2:		Detailed Cost Estimates and Time Schedule													
year	Tier year	Trigger Action Description	Trigger Action	Taxon	Assumptions	Unit	Number of Units	Unit Cost (1,000s)	Cost (subtotal) (1,000s)	One-Time Prorated Costs (1,000s)	Annual Costs (1,000s)	No. of NRM per Year	No. of NRS2 per Year	other personnel
2	1	Manage for stability, Gardenia mannii, Poamoho	Manage for stability	Garman	CEA 14	1 population	1	9.03	9.03		9.03	0.023	0.149	
2	1	Manage for stability, Hesperomannia arborescens, Koloa	Manage for stability	Hesarbo	CEA 14	1 population	1	9.03	9.03		9.03	0.023	0.149	
2	1	Manage for stability, Hesperomannia arborescens, North and South Kaukonahua	Manage for stability	Hesarbo	CEA 15	1 population	1	4.48	4.48		4.48	0.011	0.074	
2	1	Manage for stability, Hesperomannia arborescens, Palikea gulch	Manage for stability	Hesarbo	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Huperzia nutans, North Kaukonahua	Manage for stability	Hupnut	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Huperzia nutans, South Kaukonahua	Manage for stability	Hupnut	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Huperzia nutans, Koloa	Manage for stability	Hupnut	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage fot stability, Labordia cyrtandrae, East Makaleha to Kaala	Manage for stability	Labcyr	CEA 13	1 population	2	17.93	35.86		35.86	0.090	0.590	
2	1	Manage for stability, Labordia cyrtandrae, Manana	Manage for stability	Labcyr	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Melicope lydgatei, Kawailoa	Manage for stability	Mellyd	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Melicope lydgatei, Lower Opaeula	Manage for stability	Mellyd	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Melicope lydgatei, reintro.	Manage for stability	Mellyd	reintro. Yr. 1	1 population	0	17.93	0		0	0.000	0.000	
2	1	Manage for stability, Phyllostegia hirsuta, Koloa	Manage for stability	Phyhir	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Phyllostegia hirsuta, Kaala to Kalena	Manage for stability	Phyhir	CEA 15	1 population	1	4.48	4.48		4.48	0.011	0.074	
2	1	Manage for stability, Phyllostegia hirsuta, Kaluaa	Manage for stability	Phyhir	CEA 14	1 population	1	9.03	9.03		9.03	0.023	0.149	
2	1	Manage for stability, Phyllostegia mollis, Ekahanui	Manage for stability	Phymol	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Phyllostegia mollis, Kaluaa	Manage for stability	Phymol	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Phyllostegia mollis, Pualii	Manage for stability	Phymol	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Pteris lidgatei, Kawaiiki	Manage for stability	Ptelid	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	

Chapter 2:		Detailed Cost Estimates and Time Schedule												
year	Tier year	Trigger Action Description	Trigger Action	Taxon	Assumptions	Unit	Number of Units	Unit Cost (1,000s)	Cost (subtotal) (1,000s)	One-Time Prorated Costs (1,000s)	Annual Costs (1,000s)	No. of NRM per Year	No. of NRS2 per Year	other personnel
2	1	Manage for stability, Pteris lidgatei, North Kaukonahua	Manage for stability	Ptelid	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Pteris lidgatei, South Kaukonahua	Manage for stability	Ptelid	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Stenogyne kanehoana, Kaluaa	Manage for stability	Stekan	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Stenogyne kanehoana, Haleauau	Manage for stability	Stekan	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Stenogyne kanehoana, South Kaluaa	Manage for stability	Stekan	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Genetic Storage Collections- non MFS PUs	Genetic Storage Collections	multiple	CEA 26	1 PU	1.13	42	47.46		47.46	0.119	0.781	
2	1	Survey for five Achatinella species	Relocate species	*Ach* sp.	CEA 22	1 survey day	10	0.588	5.88		5.9	0.042	0.059	
2	1	Construct South Haleauau MU: materials cost	Threat Management	multiple	CEA 11	1 foot	0.04	11794	471.76	471.76				
2	1	EOD for South Haleauau MU: Tech II EOD	EOD	multiple	CEA 11	1 day	1	30	30	30				
2	1	Helicopter support for South Haleauau: X hours	transportation		CEA 35	1 hr	50	0.85	42.5	42.5				
2	1-2009	MU Threat Management, Waimano (LOW)	Threat Management	multiple	CEA 16	1 acre Low	3.60	0.043	0.155		0.155	0.000	0.00	
2	1-2009	Construct Waimano MU; matertials cost	Threat Management	Cyastj	CEA 12	1 meter	0.02	483.5	7.253	7.253				
2	1	MU Threat Management, Helemano (LOW)	Threat Management	multiple	CEA 16	1 acre Low	113.2	0.043	4.866		4.866	0.003	0.02	
2	1	MU Threat Management, Opaeula (LOW)	Threat Management	multiple	CEA 16	1 acre Low	121.4	0.043	5.220		5.220	0.003	0.02	
2	1	MU Threat Management, Kaala (MED)	Threat Management	multiple	CEA 16	1 acre Med	171.6	0.085	14.583		14.583	0.020	0.06	
2	1	MU Threat Management, Kaunala to Kaleleiki (HIGH)	Threat Management	multiple	CEA 16	1 acre High	25.2	0.128	3.226		3.226	0.007	0.04	
2	1	MU Threat Management, South Haleauau (HIGH)	Threat Management	multiple	CEA 16	1 acre High	123.6	0.128	15.821		15.821	0.032	0.18	
2	1	Elepaio Threat Control Contracts	Threat Management	Elepaio	CEA 24	1 population	3.00	25	75		75.0			
2	1	Elepaio Threat Control by NRS	Threat Management	Elepaio	CEA 25	1 population	3.00	25	75		75.0	0.266	1.13	
2	1	Helicopter support	transportation		CEA 35	hrs/yr	175	0.85	148.8		148.8			

Chapter 2:		Detailed Cost Estimates and Time Schedule												
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2	1	Vehicle purchase for NR field staff	transportation		CEA 36	1 vehicle	1	55	55.0	55				
2	1	Annual vehicle maintenance. Includes fuel, maintenance, mud tires; (government vehicles are	transportation		CEA 36	1 vehicle	4	3	12.0		12.0			
2	1	MU monitoring, road, LZ, and corridor surveys	monitoring		CEA 19	1 NRS2	2		4.8		4.8	0.017	0.004	
2	1	MU and MU subunit monitoring, ecosystem level monitoring	monitoring		CEA 19	1 MU	4	7.7	30.8		30.8	0.042	0.296	
2	1	Non-MU ICA monitoring	monitoring		CEA 19.1	1 day	60	0.819	49.1		49.1	0.195	0.56	
2	1	Achatinella captive propagation collections- 3.2 populations each year	Manage for stabili	Achatinella	CEA 23	1 PU	2.03	3.2	6.5	6.5		0.023		
2	1	Achatinella spp. captive propagation program + annual utilities cost	captive propagation	*Achatinella*	CEA 32	1.5 assistants + supplies + utilities			78.5	16	78.5			
2	1	Achatinella Genetics Analyses= one years testing only.	Genetic Samples	*Achatinella*	CEA 20	1 PU	1.1	16	17.6	56				
2	1	Horticulturalist: 1/2 cost covered by MIP	greenhouse	*multiple*	CEA 31	1 person	0.5	57.4			28.7			0.5
2	1	Horticultural assistant (1) for propagation of endangered plants, in compliance with sanitation protocols	greenhouse	multiple	CEA 31	1 person	2	46	92.0		92.0			2
2	1	Seed storage testing and seed storage - annual storage maintenance costs and staffing.	seed storage	multiple	CEA 27	1 person	1		54.2	5	54.2			1
2	1	Genetic Storage: Tissue Culture	Tissue Culture	multiple	CEA 28	1 person	22				22.0			
2	1	Genetic Storage: Living collections	Living collections	multiple	CEA 29	1 species	0.5	12	6.0		6.0			
2	1	Annual greenhouse supplies (pesticides, pots, fertilizer, etc.)	greenhouse	multiple	CEA 31	1 plant	2,000	0.016	32.00	18.5	32.0			
2	1	Summer Internship Program			CEA 41	1 person	3	7.08	21.24		21.24			
2	1	Annual progress report for IT review (production	report printing		CEA 43	1 report	30	0.066	1.98		1.98			
2	1	Implementation Team (IT) Annual Review	reporting	multiple	CEA 42				9.20		9.20			
2	1	Outreach/Volunteer coordinator	outreach	multiple	CEA 46	1 person	1	61			61.00			1
2	1	Develop MU alien species control plan and include status update in annual report	report writing	multiple	CEA 7	1 MU	5	1.71	8.55		8.55	0.104		
2	1	Technological support for field staff, GPS and digital cameras - every year replacement cost			CEA 38	GPS/PDA/Camera	1.0	7.500	7.50		7.50			

Chapter 2: Detailed Cost Estimates and Time Schedule

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2	1	GIS specialist and GIS Assistant			CEA 37	1 person	1.0	61.8	61.75		61.75			1
2	1	GIS Software			CEA 38	GIS Software	1.0	3.2	3.17	7.695	3.17			
2	1	Technological support for Army Environmental staff - in office (general office computers			CEA 37	1 computer	4	1.5	6.00		6.40			
2	1	Rare species Monitoring and Data Management	monitoring	multiple	CEA 47	1 species	23	0.298	6.85		6.85	0.024		
2	1	Development of rare plant management plans	report writing	multiple	CEA 47	1 person	0.5	83	41.50		41.50			0.5
2	1	Development of rare snail management plans	report writing	multiple	CEA 48	1 person	0.5	83	41.50		41.50			0.5
2	1	Development of Elepaio management plans	report writing	Elepaio	CEA 49	1 person	1	83	83.00		83.00			1
2	1	Surveying for rare species	surveys	multiple	CEA 50	1 day	20		11.76		11.76	0.016	0.02	
2	1	EOD Contract	EOD		CEA 44	1 EOD day	62	1	62.00		62.00			
2	**2**	**Construct exclosure, Achatinella byronnii, (6 total)**	**construct exclosure**	**Achbyr/dec**	**CEA 21**	**1 exclosure**	**6**	**10.0**						
2	**2**	**Construct exclosure, Achatinella lila (6 total)**	**construct exclosure**	**Achlil**	**CEA 21**	**1 exclosure**	**6**	**10.0**						
2	**2**	**Construct exclosure, Achatinella livida (6 total)**	**construct exclosure**	**Achliv**	**CEA 21**	**1 exclosure**	**6**	**10.0**		**10.0**				
2	**2**	**Construct exclosure, Achatinella sowerbyana (6 total)**	**construct exclosure**	**Achsow**	**CEA 21**	**1 exclosure**	**6**	**10.0**		**10.0**				
2	**2**	**Collect Achatinella species individuals for captive propagation**	**Ach captive propagation**	**Achatinella**	**CEA 23**	**1 PU**	**8**	**1.916**	**15.3**		**15.3**	**0.156**	**0.202**	
2	**2**	**Annual exclosure maintenance for exclosures, Achantinella sp.**	**maintenance**	**Achatinella**	**CEA 21**	**1 exclosure**	**4**	**1**	**4**		**4**			
2	**2**	**Manage for stability, Achatinella byronnii/decipiens**	**Manage for stability**	**Achbyr/dec**	**CEA 22**	**1 population**	**4**	**7.25**	**29**		**29**	**0.019**	**0.115**	
2	**2**	**Manage for stability, Achatinella lila**	**Manage for stability**	**Achlil**	**CEA 22**	**1 population**	**3**	**7.25**	**21.75**		**21.75**	**0.019**	**0.115**	
2	**2**	**Manage for stability, Achatinella livida**	**Manage for stability**	**Achliv**	**CEA 22**	**1 population**	**3**	**7.25**	**21.75**		**21.75**	**0.019**	**0.115**	
2	**2**	**Manage for stability, Achatinella sowerbyana**	**Manage for stability**	**Achsow**	**CEA 22**	**1 population**	**6**	**7.25**	**43.5**		**43.5**	**0.019**	**0.115**	
2	**2**	**Manage for stability, Chamaesyce rockii, Koloa**	**Manage for stability**	**Charoc**	**CEA 15**	**1 population**	**1**	**4.48**	**4.48**		**4.48**	**0.011**	**0.074**	
2	**2**	**Manage for stability, Chamaesyce rockii, Opaeula/Helemano**	**Manage for stability**	**Charoc**	**CEA 15**	**1 population**	**1**	**4.48**	**4.48**		**4.48**	**0.011**	**0.074**	
2	**2**	**Manage for stability, Chamaesyce rockii, Waiawa Subunit II**	**Manage for stability**	**Charoc**	**CEA 15**	**1 population**	**1**	**4.48**	**4.48**		**4.48**	**0.011**	**0.074**	
2	**2**	**Manage for stability, Cyanea crispa, Upper Kawaiiki**	**Manage for stability**	**Cyacri**	**CEA 13**	**1 population**	**1**	**17.93**	**17.93**		**17.93**	**0.045**	**0.295**	

Chapter 2:		Detailed Cost Estimates and Time Schedule												
year	Tier year	Trigger Action Description	Trigger Action	Taxon	Assumptions	Unit	Number of Units	Unit Cost (1,000s)	Cost (subtotal) (1,000s)	One-Time Prorated Costs (1,000s)	Annual Costs (1,000s)	No. of NRM per Year	No. of NRS2 per Year	other personnel
2	2	Manage for stability, Cyanea crispa, Kahana	Manage for stability	Cyacri	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	2	Manage for stability, Cyanea crispa, Wailupe	stability	Cyacri	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	2	Manage for stability, Cyrandra viridiflora, Koloa	Manage for stability	Cyrvir	CEA 14	1 population	1	9.03	9.03		9.03	0.023	0.149	
2	2	Manage for stability, Cyrtandra viridiflora, Opaeula/Helemano	Manage for stability	Cyrvir	CEA 15	1 population	1	4.48	4.48		4.48	0.011	0.074	
2	2	Manage for stability, Cyratandra viridiflora, South Kaukonahua	Manage for stability	Cyrvir	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	2	Manage for stability, Myrsine juddii, metapopulation	Manage for stability	Myrjud	CEA 15	1 population	3	4.48	13.44		13.44	0.034	0.221	
2	2	Manage for stability, Sanicula purpurea, Sanicula	Manage for stability	Sanpur	CEA 14	1 population	1	9.03	9.03		9.03	0.023	0.149	
2	2	Kaukonahua	stability	Sanpur	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	2	Manage for stability, Sanicula purpurea, Poamoho	Manage for stability	Sanpur	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	2	Manage for stability, Viola oahuensis, Koloa	Manage for stability	Viooah	CEA 15	1 population	1	4.48	4.48		4.48	0.011	0.074	
2	2	Manage for stability, Viola oahuensis, Opaeula/Helemano	Manage for stability	Viooah	CEA 15	1 population	1	4.48	4.48		4.48	0.011	0.074	
2	2	Manage for stability, Viola oahuensis, North Kaukonahua	Manage for stability	Viooah	CEA 15	1 population	1	4.48	4.48		4.48	0.011	0.074	
X	Year 2 costs at tier 2									775.4	2825.1	3.204	17.3	14.5
X	Year 2 costs at tier 2---no South Haleauau MU									231.1	2809.2	3.172	17.1	14.5
3	1-2010	no fire management plan or genetics tests								-122.2				
3	1-2010	no construct south haleauau: -materials, EOD, helicopter								-544.3				
2	1-2010	no initial purchase CEA 39	uipment and supplies		CEA 39						-70.63			
2	1	annual replacement of misc. field gear = 1/5 cost of initial purchase each year	equipment and supplies		CEA 39	1/5 of initial cost			14.13		14.13			
3	1-2010	Construct North Haleauau MU: materials cost	Threat Management	multiple	CEA 11	1 foot	0.04	17253	690.12	690.12				
3	Jan-10	EOD for North Haleauau MU: tech II	EOD	multiple	CEA 11	1 day	1	42		42				
3	1-2010	Helicopter support for North Haleauau MU: X hours	transportation		CEA 35	1 hr	50	0.85	42.5	42.5				
3	1-2010	MU Threat Management, North Haleauau	Threat Management	multiple	CEA 16	1 acre High	123.6	0.128	15.821		15.821	0.032	0.18	

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Chapter 2:		**Detailed Cost Estimates and Time Schedule**												
3	1-2010	Construct Mohiakea MU: materials cost	Threat Management	multiple	CEA 11	1 foot	0.0	15157	606.28	606.28				
3	1-2010	EOD for Mohiakea MU: tech II	EOD	multiple	CEA 11	1 day	1.0	38		38				
3	1-2010	Helicopter support for Mohiakea; X hours	transportation		CEA 35	1 hr	50.0	0.85	42.5	42.5				
3	1-2010	MU Threat Management, Mohiakea	Threat Management	multiple	CEA 16	1 acre low	426.0	0.043	18.318		18.318	0.012	0.07	
3	1-2010	Construct Mahaka III MU; Materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	411.6	6.174	6.174				
3	1-2010	MU Threat Management, Kamaili	Threat	multiple	CEA 16	1 acre high	6.30	0.128	0.806		0.806	0.002	0.01	
3	1-2010	%4 inflation increase each year on salaries									71.622			
X	Year 3 costs at Tier 2									1576.5	2875.1	3.250	17.6	14.5
X	Year 3 costs at Tier 2--no North Haleauau or Mohiakea									237.3	2753.6	3.173	17.1	14.5
		no construct North Haleauau and Mohiakea								-1467.6				
4	1-2011	Construct Koloa MU: materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	3356.1	50.3415	50.3415				
4	1-2011	MU Threat Management, Koloa	Threat Management	multiple	CEA 16	1 acre Med	160.0	0.085	13.600		13.600	0.028	0.16	
4	1-2011	%4 inflation increase each year on salaries									73.339			
X	Year 4 costs at Tier 2									159.3	2962.1	3.277	17.7	14.5
		no construct Koloa MU								-50.3				
5	1-2012	Construct Kaipapau MU: materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	4405	66.075	66.075				
5	1-2012	MU Threat Management, Kaipapau	Threat Management	multiple	CEA 16	1 acre Med	272.0	0.085	23.120		23.120	0.062	0.27	
5	1-2012	Construct Manana MU: materials cost	Threat Management	Cyastj	CEA 12	1 meter	0.02	1152	17.280	17.280		0.046	0.20	
5	1-2012	MU Threat Management, Manana	Threat Management	Cyastj	CEA 16	1 acre low	18.1	0.048	0.869		0.869	0.002	0.01	
5	1-2012	%4 inflation increase each year on salaries									79.074			
X	Year 5 costs at Tier 2									192.3	2986.1	3.388	18.2	14.5
		no construct Koloa MU								-66.1				
6	1-2013	Construct South Kaukonahua MU: materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	2701.3	40.5195	40.5195				

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6	1-2013	MU Threat Management, South Kaukonahua	Threat Management	multiple	CEA 16	1 acre med	93.50	0.085	7.948		7.948	0.011	0.06	
6	1-2013	Construct Ekahanui extension + Huliwai	Threat Management	Abusan	CEA 12	1 meter	0.015	447	6.705		6.705	0.018	0.08	
6	1-2013	MU Threat Management, Eka extension + Huliwai	Threat Management	Abusan	CEA 16	1 acre High	1.00	0.128	0.128		0.128	0.000	0.00	
6	1-2013	%4 inflation increase each year on salaries									82.237			
X	Year 6 costs at Tier 2									166.7	3000.8	3.417	18.4	14.5
		no construct South Kaukonahua MU and no vehicles								-95.5				
7	1-2014	Construct North Kaukonahua MU: materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	1352	20.28	20.28				
7	1-2014	MU Threat Management, North Kaukonahua	Threat Management	multiple	CEA 16	1 acre Med	30.40	0.085	2.584		2.584	0.003	0.02	
7	1-2014	Construct Lower Poamoho: materials	Threat Management	Garman	CEA 12	1 meter	0.015		0.000		0.000	0.000	0.00	
7	1-2014	MU Threat Management: Lower Poamoho	Threat Management	Garman	CEA 16	1 acre low	1.00	0.048	0.048		0.048	0.000	0.00	
7	1-2014	%4 inflation increase each year on salaries									85.527			
X	Year 7 costs at Tier 2									91.5	3003.5	3.421	18.4	14.5
		no construct North Kaukonahua MU								-20.3				
8	1-2015	Construct Poamoho Subunit I MU:	Management	multiple	CEA 12	1 meter	0.015	2210	33.15	33.15				
8	1-2015	Subunit I	Management	multiple	CEA 16	1 acre low	30.40	0.043	1.307		1.307	0.001	0.00	
8	1-2015	cost	Management	multiple	CEA 12	1 meter	0.015							
8	1-2015	MU Threat Management, Lower Peahinaia II	Threat Management	multiple	CEA 16	1 acre med	23.90	0.085	2.032		2.032	0.003	0.01	
8	1-2016	Tier 2: Construct South Kaukonahua II MU; materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	252	3.78	3.78				
8	1-2016	Tier 2: MU threat management, south kaukonahua II	Threat Management	multiple	CEA 16	1 acre low	1.30	0.043	0.056		0.056	0.000	0.000	
8	1-2015	%4 inflation increase each year on salaries									88.948			
X	Year 8 costs at Tier 2									108.2	3006.9	3.424	18.4	14.5
		no construct Poamoho subunit I								-33.2				
9	1-2016	Tier 2:Construct Poamoho Subunit II; materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	1052	15.78	15.78				
9	1-2016	Tier 2: MU Threat management, Poamoho Subunit II	Threat Management	multiple	CEA 16	1 acre low	30.40	0.048	1.459		1.459	0.001	0.006	

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9	1-2016	Tier 2: Construct Poamoho Subunit III, Materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	289	4.335	4.335				
9	1-2016	Tier 2: MU threat management, Poamoho subunit I	Threat Management	multiple	CEA 16	1 acre low	1.30	0.048	0.062		0.062	0.000	0.000	
9	1-2016	%4 inflation increase each year on salaries									92.506			
X	Year 9 costs at Tier 2									95.1	3100.9	3.425	18.4	14.5
10		no construct Poamoho subunit II, III, South Kaukonahua II								-20.1				
10	1-2017	Tier 2: Construct Waiawa subunit I; materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	2933	43.995	43.995				
10	1-2017	Tier 2: MU Threat management, Waiawa Subunit I	Threat Management	multiple	CEA 16	1 acre low	124.00	0.043	5.332		5.332	0.004	0.020	
10	1-2017	Tier 2: Construct Kawaiiki subunits I and II; materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	1140	17.1	17.1				
10	1-2017	Tier 2: MU Threat Management, Kawaiiki subunits	Threat Management	multiple	CEA 16	1 acre low	9.30	0.043	0.400		0.400	0.000	0.002	
10	1-2017	%4 inflation increase each year on salaries									96.206			
X	Year 10 costs at Tier 2									136.1	3202.8	3.429	18.4	14.5
11		no construct waiawa I, kahana								-61.1				
11	1-2018	Tier 2:Construct Kahana MU; Materials Cost	Threat Management	multiple	CEA 12	1 meter	0.015	1234	18.51	18.51				
11	1-2018	Tier 2: MU Threat management, Kahana	Threat Management	multiple	CEA 16	1 acre Med	22.50	0.085	1.913		1.913	0.003	0.015	
11	1-2018	Tier 2: Construct Wailupe MU; Materials Cost	Threat Management	multiple	CEA 12	1 meter	0.015	1123	16.845	16.845				
11	1-2018	Tier 2: MU Threat management, Wailupe	Threat Management	multiple	CEA 16	1 acre Med	21.70	0.085	1.845		1.845	0.002	0.014	
11	1-2018	%4 inflation increase each year on salaries									100.054			
X	Year 11 costs at Tier 2									110.4	3306.6	3.434	18.4	14.5
	no MU construction from this year on; maintenance is covered under other CEA#									-35.4				
12	1-2019	Tier 2: Construct Waiawa II; materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	931.2	13.968	14.0				
12	1-2019	MU Threat Management, Waiawa II	Threat Management	multiple	CEA 16	1 acre low	12.7	0.043	0.5461		0.5	0.000	0.002	
12	1-2019	%4 inflation increase each year on salaries									104.057			
X	Year 12 costs at Tier 2									89.0	3307.2	3.435	18.4	14.5
13	1-2020	%4 inflation increase each year on salaries									108.219			
X	Year 13 costs at Tier 2									89.0	3415.4	3.435	18.4	14.5
14	1-2021	%4 inflation increase each year on salaries									109.385			

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X		Year 14 costs at Tier 2								89.0	3524.8	3.435	18.4	14.5
15	1-2022	%4 inflation increase each year on salaries									113.760			
X		Year 15 costs at Tier 2								89.0	3638.6	3.435	18.4	14.5
16	1-2023	%4 inflation increase each year on salaries									118.310			
X		Year 16 costs at Tier 2								89.0	3756.9	3.435	18.4	14.5
17	1-2024	%4 inflation increase each year on salaries									123.043			
X		Year 17 costs at Tier 2								89.0	3879.9	3.435	18.4	14.5
18	1-2025	%4 inflation increase each year on salaries									131.128			
X		Year 18 costs at Tier 2								89.0	4011.0	3.435	18.4	14.5
19	1-2026	%4 inflation increase each year on salaries									136.373			
X		Year 19 costs at Tier 2								89.0	4147.4	3.435	18.4	14.5
20	1-2027	%4 inflation increase each year on salaries									141.828			
X		Year 20 costs at Tier 2								89.0	4289.2	3.435	18.4	14.5

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2	1	Administrative Assistants	administrative		CEA 2	1 person					49			1
2	1	Army Implementation Senior Coordinator	administrative		CEA 1	1 person	0.50	83	41.5		41.5			0.5
2	1	Army Implementation Plan Project Manager	administrative		CEA 1	1 person	0.50	83	41.5		41.5			0.5
2	1	Research Specialist	research	multiple	CEA 18	1 person	0.50	56.4	28.2		33.2			0.5
2	1	Ungulate control specialist, to conduct management-unit level ungulate control.	personnel		CEA 17	1 person	0.5	83	41.5		41.5			0.5
2	1	Fence Crew Coordinator	Fence Crew		CEA 4	1 person	1	71.5	70.5		70.5			1
2	1	Fence crew worker	Fence Crew		CEA 4	1 person	3	59	177		177			3
2	1	Fence maintenance for OIP MU fences	fence	multiple	CEA 12	1 MU	5	1	5		5			
2	1	Cell phone and pager service (for field communication only)	equipment and supplies		CEA 39	1	33	0.83	27.39		27.39			
2	1	Equipment (theat management gear, telecommuncations gear - annual replacement)	equipment and supplies		CEA 39	0.9k / person	33	0.9	29.7		29.7			
2	1	Field supplies, annual supplies purchase (Pesticides, herbicides, rat control (traps and diphacinone bait), salt, batteries, flagging, safety equipment (respirators, Tyvek suits, gloves and snares).	equipment and supplies		CEA 39	1.5 k/ person	33	1.5	49.5		49.5			
2	1	Personal gear for field crew (annual allowance for footwear and rain gear)	equipment and supplies		CEA 39	$400/person	33	0.4	13.2		13.2			
2	1	Field supplies, initial purchase (camping gear.)	equipment and supplies		CEA 39	.775/person + annual replacement	33	0.775	25.58		25.58			
2	1	Office furniture for Admin and NRMs	equipment and supplies		CEA 39	.7/person	6	0.7		4.20	4.20			
2	1	Development of fire management plans = one time cost	fire management		CEA 9	FMP	1	35	35	35				
2	1	Annual Office copy machine rental and supplies costs	equipment and supplies		CEA 34				21.0		21.0			
2	1	Manage for stability, Abutilon sandwicense, Kaluakauila (reintro)	Manage for stability	Abusan	CEA 14	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Abutilon sandwicense, Ekahanui and Huliwai	Manage for stability	Abusan	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Abutilon sandwicense, Kaimuhole	Manage for stability	Abusan	CEA 15	1 population	1	4.48	4.48		4.48	0.011	0.074	
2	1	Manage for stability, Abutilon sandwicense, Makaha	Manage for stability	Abusan	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	

Chapter 2: Detailed Cost Estimates and Time Schedule

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2	1	Manage for stability, Schidea trinervis, Kalena to Kaala	Manage for stability	Schtri	CEA 15	1 population	1	4.48	4.48		4.48	0.011	0.074	
2	1	Manage for stability, Schiedea trinervis, East Makaleha	Manage for stability	Schtri	CEA 13	1 population	2	17.93	35.86		35.86	0.090	0.590	
2	1	Manage for stability, Cyanea acuminata, Kaala	Manage for stability	Cyaacu	CEA 14	1 population	1	9.03	9.03		7.94	0.020	0.131	
2	1	Manage for stability, Cyanea acuminata, Poamoho	Manage for stability	Cyaacu	CEA 14	1 population	1	9.03	9.03		9.03	0.023	0.149	
2	1	Manage for stability, Cyanea acuminata, South Kaukonahua	Manage for stability	Cyaacu	CEA 14	1 population	1	9.03	9.03		9.03	0.023	0.149	
2	1	Manage for stability, Cyanea koolauensis, Koloa	Manage for stability	Cyakoo	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Cyanea koolauensis, North Kaukonahua	Manage for stability	Cyakoo	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Cyanea koolauensis, Opaeula/Helemano	Manage for stability	Cyakoo	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Cyanea st.-johnii, Helemano	Manage for stability	Cyastj	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Cyanea st.-johnii, Waimano	Manage for stability	Cyastj	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Cyanea st.-johnii, Waiawa	Manage for stability	Cyastj	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Eugenia koolauensis, Oio	Manage for stability	Eugkoo	CEA 13	1 population	1	4.48	4.48		4.48	0.011	0.074	
2	1	Manage for stability, Eugenia koolauensis, Kaunala	Manage for stability	Eugkoo	CEA 13	1 population	1	4.48	4.48		4.48	0.011	0.074	
2	1	Manage for stability, Eugenia koolauensis, Pahipahialua	Manage for stability	Eugkoo	CEA 13	1 population	1	4.48	4.48		4.48	0.011	0.074	
2	1	Manage for stability, Gardenia mannii, Haleauau	Manage for stability	Garman	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Gardenia mannii, Opaeula	Manage for stability	Garman	CEA 14	1 population	1	9.03	9.03		9.03	0.023	0.149	
2	1	Manage for stability, Gardenia mannii, Poamoho	Manage for stability	Garman	CEA 14	1 population	1	9.03	9.03		9.03	0.023	0.149	
2	1	Manage for stability, Hesperomannia arborescens, Koloa	Manage for stability	Hesarbo	CEA 14	1 population	1	9.03	9.03		9.03	0.023	0.149	

Chapter 2: Detailed Cost Estimates and Time Schedule

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2	1	Manage for stability, Hesperomannia arborescens, North and South Kaukonahua	Manage for stability	Hesarbo	CEA 15	1 population	1	4.48	4.48		4.48	0.011	0.074	
2	1	Manage for stability, Hesperomannia arborescens, Palikea gulch	Manage for stability	Hesarbo	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Huperzia nutans, North Kaukonahua	Manage for stability	Hupnut	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Huperzia nutans, South Kaukonahua	Manage for stability	Hupnut	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Huperzia nutans, Koloa	Manage for stability	Hupnut	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage fot stability, Labordia cyrtandrae, East Makaleha to Kaala	Manage for stability	Labcyr	CEA 13	1 population	2	17.93	35.86		35.86	0.090	0.590	
2	1	Manage for stability, Labordia cyrtandrae, Manana	Manage for stability	Labcyr	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Melicope lydgatei, Kawailoa	Manage for stability	Mellyd	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Melicope lydgatei, Lower Opaeula	Manage for stability	Mellyd	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Melicope lydgatei, reintro.	Manage for stability	Mellyd	no reintro. Yr. 1	1 population	0	17.93	0		0	0.000	0.000	
2	1	Manage for stability, Phyllostegia hirsuta, Koloa	Manage for stability	Phyhir	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Phyllostegia hirsuta, Kaala to Kalena	Manage for stability	Phyhir	CEA 15	1 population	1	4.48	4.48		4.48	0.011	0.074	
2	1	Manage for stability, Phyllostegia hirsuta, Kaluaa	Manage for stability	Phyhir	CEA 14	1 population	1	9.03	9.03		9.03	0.023	0.149	
2	1	Manage for stability, Phyllostegia mollis, Ekahanui	Manage for stability	Phymol	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Phyllostegia mollis, Kaluaa	Manage for stability	Phymol	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Phyllostegia mollis, Pualii	Manage for stability	Phymol	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Pteris lidgatei, Kawaiiki	Manage for stability	Ptelid	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Pteris lidgatei, North Kaukonahua	Manage for stability	Ptelid	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Pteris lidgatei, South Kaukonahua	Manage for stability	Ptelid	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	

Chapter 2: Detailed Cost Estimates and Time Schedule

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2	1	Manage for stability, Stenogyne kanehoana, Kaluaa	Manage for stability	Stekan	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Stenogyne kanehoana, Haleauau	Manage for stability	Stekan	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Manage for stability, Stenogyne kanehoana, South Kaluaa	Manage for stability	Stekan	CEA 13	1 population	1	17.93	17.93		17.93	0.045	0.295	
2	1	Genetic Storage Collections- non MFS PUs	Genetic Storage	multiple	CEA 26	1 PU	1.13	46	51.98		51.98	0.131	0.856	
2	1	Survey for five Achatinella species	Relocate species	*Ach* sp.	CEA 22	1 survey day	10	0.588	5.88		5.9	0.042	0.059	
2	1	Construct South Haleauau MU: materials cost	Threat Management	multiple	CEA 11	1 foot	0.04	11794	471.76	471.76				
2	1	EOD for South Haleauau MU: Tech II EOD	EOD	multiple	CEA 11	1 day	1	30	30	30				
2	1	Helicopter support for South Haleauau: X hours	transportation		CEA 35	1 hr	50	0.85	42.5	42.5				
2	1-2009	MU Threat Management, Waimano (LOW)	Threat Management	multiple	CEA 16	1 acre Low	3.60	0.043	0.155		0.155	0.000	0.001	
2	1-2009	Construct Waimano MU; matertials cost	Threat Management	Cyastj	CEA 12	1 meter	0.02	483.5	7.253	7.253				
2	1	MU Threat Management, Helemano (LOW)	Threat Management	multiple	CEA 16	1 acre Low	113.17	0.043	4.866		4.866	0.003	0.018	
2	1	MU Threat Management, Opaeula (LOW)	Threat Management	multiple	CEA 16	1 acre Low	121.39	0.043	5.220		5.220	0.003	0.020	
2	1	MU Threat Management, Kaala (MED)	Threat Management	multiple	CEA 16	1 acre Med	171.60	0.085	14.586		14.586	0.020	0.055	
2	1	MU Threat Management, Kaunala to Kaleleiki (HIGH)	Threat Management	multiple	CEA 16	1 acre High	25.20	0.128	3.226		3.226	0.007	0.037	
2	1	MU Threat Management, South Haleauau (HIGH)	Threat Management	multiple	CEA 16	1 acre High	123.60	0.128	15.821		15.821	0.032	0.181	
2	1	Elepaio Threat Control Contracts	Threat Management	Elepaio	CEA 24	1 population	3.00	25	75		75.0			
2	1	Elepaio Threat Control by NRS	Threat Management	Elepaio	CEA 25	1 population	3.00	25	75		75.0	0.266	1.13	
2	1	Helicopter support	transportation		CEA 35	hrs/yr	175	0.85	148.8		148.8			
2	1	Vehicle purchase for NR field staff	transportation		CEA 36	1 vehicle	1	55	55.0	55				
2	1	Annual vehicle maintenance. Includes fuel, maintenance, mud tires; (government vehicles are self-insured).	transportation		CEA 36	1 vehicle	4	3	12.0		12.0			

Chapter 2: Detailed Cost Estimates and Time Schedule

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2	1	MU monitoring, road, LZ, and corridor surveys	monitoring		CEA 19	1 NRS2	2		4.8		4.8	0.017	0.0037	
2	1	MU and MU subunit monitoring, ecosystem level monitoring	monitoring		CEA 19	1 MU	4	7.7	30.8		30.8	0.042	0.2957	
2	1	Non-MU ICA monitoring	monitoring		CEA 19.1	1 day	61	0.819	50.0		50.0	0.198	0.5695	
2	1	Achatinella captive propagation collections- 3.2 populations each year	Manage for stal	Achatinella	CEA 23	1 PU	2.03	3.2	6.5	6.5		0.023		
2	1	Achatinella spp. captive propagation program + annual utilities cost	captive propagation	*Achatinella*	CEA 32	+ supplies + utilities			78.5	16	78.5			
2	1	Achatinella Genetics Analyses= one years testing only.	Genetic Samples	*Achatinella*	CEA 20	1 PU	1.1	16	17.6	56				
2	1	Horticulturalist: 1/2 cost covered by MIP	greenhouse	*multiple*	CEA 31	1 person	0.5	57.4			28.7			0.5
2	1	Horticultural assistant (1) for propagation of endangered plants, in compliance with sanitation	greenhouse	multiple	CEA 31	1 person	2	46	92.0		92.0			2
2	1	Seed storage testing and seed storage - annual storage maintenance costs and staffing.	seed storage	multiple	CEA 27	1 person	1		54.2	5	54.2			1
2	1	Genetic Storage: Tissue Culture	Tissue Culture	multiple	CEA 28	1 person	22				22.0			
2	1	Genetic Storage: Living collections	Living collectior	multiple	CEA 29	1 species	0.5	12	6.0		6.0			
2	1	Annual greenhouse supplies (pesticides, pots, fertilizer, etc.)	greenhouse	multiple	CEA 31	1 plant	2,000	0.016	32.00	18.5	32.0			
2	1	Summer Internship Program			CEA 41	1 person	3	7.08	21.24		21.24			
2	1	Annual progress report for IT review (production costs)	report printing		CEA 43	1 report	30	0.066	1.98		1.98			
2	1	Implementation Team (IT) Annual Review	reporting	multiple	CEA 42				9.20		9.20			
2	1	Outreach/Volunteer coordinator	outreach	multiple	CEA 46	1 person	1	61			61.00			1
2	1	GIS specialist and GIS Assistant			CEA 37	1 person	1.0	61.750	61.75		61.75			1
2	1	Technological support for field staff, GPS and digital cameras - every year replacement cost			CEA 38	GPS/PDA/camera	1	8.8	8.75		8.75			
2	1	GIS Software			CEA 38	GIS Software	1.0	3.2	3.17	7.695	3.17			
2	1	Technological support for Army Environmental staff - in office (general office computers [hardware and software]), initial purchase			CEA 37	1 computer	4	1.5	6.00		6.40			
2	1	Rare species Monitoring and Data Management	monitoring	multiple	CEA 47	1 species	23	0.298	6.85		6.85	0.024		
2	1	Development of rare plant management plans	report writing	multiple	CEA 47	1 person	0.5	83	41.50		41.50			0.5
2	1	Development of rare snail management plans	report writing	multiple	CEA 48	1 person	0.5	83	41.50		41.50			0.5

Chapter 2: Detailed Cost Estimates and Time Schedule

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2	1	Development of Elepaio management plans	report writing	Elepaio	CEA 49	1 person	1	83	83.00		83.00			1
2	1	Surveying for rare species	surveys	multiple	CEA 50	1 day	20		11.30		11.30	0.015	0.0217	
2	1	EOD Contract	EOD		CEA 44	1 EOD day	62	1	62.00		62.00			
2	**2**	**Construct exclosure, Achatinella byronnii, (6 total)**	**construct exclosure**	**Achbyr/dec**	**CEA 21**	**1 exclosure**	**6**	**10.0**						
2	**2**	**Construct exclosure, Achatinella lila (6 total)**	**construct exclosure**	**Achlil**	**CEA 21**	**1 exclosure**	**6**	**10.0**						
2	**2**	**Construct exclosure, Achatinella livida (6 total)**	**construct exclosure**	**Achliv**	**CEA 21**	**1 exclosure**	**6**	**10.0**		**10.0**				
2	**2**	**Construct exclosure, Achatinella sowerbyana (6 total)**	**construct exclosure**	**Achsow**	**CEA 21**	**1 exclosure**	**6**	**10.0**		**10.0**				
2	**2**	**Collect Achatinella species individuals for captive propagation**	**Ach captive propagation**	**Achatinella**	**CEA 23**	**1 PU**	**8**	**1.916**	**15.3**		**15.3**	**0.156**	**0.202**	
2	**2**	**Annual exclosure maintenance for exclosures, Achantinella sp.**	**maintenance**	**Achatinella**	**CEA 21**	**1 exclosure**	**4**	**1**	**4**		**4**			
2	**2**	**Manage for stability, Achatinella byronnii/decipiens**	**Manage for stability**	**Achbyr/dec**	**CEA 22**	**1 population**	**4**	**7.25**	**29**		**29**	**0.019**	**0.115**	
2	**2**	**Manage for stability, Achatinella lila**	**Manage for stability**	**Achlil**	**CEA 22**	**1 population**	**3**	**7.25**	**21.75**		**21.75**	**0.019**	**0.115**	
2	**2**	**Manage for stability, Achatinella livida**	**Manage for stability**	**Achliv**	**CEA 22**	**1 population**	**3**	**7.25**	**21.75**		**21.75**	**0.019**	**0.115**	
2	**2**	**Manage for stability, Achatinella sowerbyana**	**Manage for stability**	**Achsow**	**CEA 22**	**1 population**	**6**	**7.25**	**43.5**		**43.5**	**0.019**	**0.115**	
2	**2**	**Manage for stability, Chamaesyce rockii, Koloa**	**stability**	**Charoc**	**CEA 15**	**1 population**	**1**	**4.48**	**4.48**		**4.48**	**0.011**	**0.074**	
2	**2**	**Manage for stability, Chamaesyce rockii, Opaeula/Helemano**	**Manage for stability**	**Charoc**	**CEA 15**	**1 population**	**1**	**4.48**	**4.48**		**4.48**	**0.011**	**0.074**	
2	**2**	**Manage for stability, Chamaesyce rockii, Waiawa Subunit II**	**Manage for stability**	**Charoc**	**CEA 15**	**1 population**	**1**	**4.48**	**4.48**		**4.48**	**0.011**	**0.074**	
2	**2**	**Manage for stability, Cyanea crispa, Upper Kawaiiki**	**Manage for stability**	**Cyacri**	**CEA 13**	**1 population**	**1**	**17.93**	**17.93**		**17.93**	**0.045**	**0.295**	
2	**2**	**Manage for stability, Cyanea crispa, Kahana**	**Manage for stability**	**Cyacri**	**CEA 13**	**1 population**	**1**	**17.93**	**17.93**		**17.93**	**0.045**	**0.295**	
2	**2**	**Manage for stability, Cyanea crispa, Wailupe**	**Manage for stability**	**Cyacri**	**CEA 13**	**1 population**	**1**	**17.93**	**17.93**		**17.93**	**0.045**	**0.295**	
2	**2**	**Koloa**	**stability**	**Cyrvir**	**CEA 14**	**1 population**	**1**	**9.03**	**9.03**		**9.03**	**0.023**	**0.149**	
2	**2**	**Manage for stability, Cyrtandra viridiflora, Opaeula/Helemano**	**Manage for stability**	**Cyrvir**	**CEA 15**	**1 population**	**1**	**4.48**	**4.48**		**4.48**	**0.011**	**0.074**	
2	**2**	**Manage for stability, Cyratandra viridiflora, South Kaukonahua**	**Manage for stability**	**Cyrvir**	**CEA 13**	**1 population**	**1**	**17.93**	**17.93**		**17.93**	**0.045**	**0.295**	

Chapter 2: Detailed Cost Estimates and Time Schedule

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2	2	**Manage for stability, Myrsine juddii, metapopulation**	**Manage for stability**	**Myrjud**	**CEA 15**	**1 population**	**3**	**4.48**	**13.44**		**13.44**	**0.034**	**0.221**	
2	2	**Manage for stability, Sanicula purpurea, Sanicula**	**Manage for stability**	**Sanpur**	**CEA 14**	**1 population**	**1**	**9.03**	**9.03**		**9.03**	**0.023**	**0.149**	
2	2	**Manage for stability, Sanicula purpurea, South Kaukonahua**	**Manage for stability**	**Sanpur**	**CEA 13**	**1 population**	**1**	**17.93**	**17.93**		**17.93**	**0.045**	**0.295**	
2	2	**Manage for stability, Sanicula purpurea, Poamoho**	**Manage for stability**	**Sanpur**	**CEA 13**	**1 population**	**1**	**17.93**	**17.93**		**17.93**	**0.045**	**0.295**	
2	2	**Manage for stability, Viola oahuensis, Koloa**	**Manage for stability**	**Viooah**	**CEA 15**	**1 population**	**1**	**4.48**	**4.48**		**4.48**	**0.011**	**0.074**	
2	2	**Manage for stability, Viola oahuensis, Opaeula/Helemano**	**Manage for stability**	**Viooah**	**CEA 15**	**1 population**	**1**	**4.48**	**4.48**		**4.48**	**0.011**	**0.074**	
2	2	**Manage for stability, Viola oahuensis, North Kaukonahua**	**Manage for stability**	**Viooah**	**CEA 15**	**1 population**	**1**	**4.48**	**4.48**		**4.48**	**0.011**	**0.074**	
2	3	Manage for stability, Cyrtandra subumbellata, South Kaukonahua	Manage for stability	Cyrsub	CEA 14	1 population	1	9.03	9.03		9.03	0.033	0.196	
2	3	Manage for stability, Cyrtandra subumbellata, Punaluu rim	Manage for stability	Cyrsub	CEA 15	1 population	1	4.48	4.48		4.48	0.016	0.097	
2	3	Manage for stability, Cyrtandra subumbellata, reintro.	Manage for stability	Cyrsub	CEA 13	1 population	0	17.93	0		0	0.000	0.000	
2	3	Manage for stability, Lobelia gaudichaudii koolauensis, South Kaukonahua	Manage for stability	Lobgaukoo	CEA 15	1 population	1	4.48	4.48		4.48	0.016	0.097	
2	3	koolauensis, Kipapa	stability	Lobgaukoo	CEA 15	1 population	1	4.48	4.48		4.48	0.016	0.097	
2	3	Manage for stability, Lobelia gaudichaudii koolauensis, Waiawa	Manage for stability	Lobgaukoo	CEA 15	1 population	1	4.48	4.48		4.48	0.016	0.097	
X	Year 2 costs at tier 3---no South Haleauau MU									775.4	2842.9	3.2	18.0	14.5
X	Year 2 costs at tier 3---no South Haleauau MU									231.1	2800.1	3.1	17.2	14.5
3	1-2010	no fire management plan or genetic tests								-122.2				
3	1-2010	no construct south haleauau: -materials, EOD, helicopter								-544.3				
2	1-2010	no initial purchase CEA 39	ipment and supplies		CEA 39					-59.48				
2	1	annual replacement of misc. field gear = 1/5 cost of initial purchase each year	equipment and supplies		CEA 39	1/5 of initial cost			11.90		11.90			
3	1-2010	Construct North Haleauau MU: materials cost	Threat Management	multiple	CEA 11	1 foot	0.04	17253	690.12	690.12				
3	Jan-10	EOD for North Haleauau MU: tech II	EOD	multiple	CEA 11	1 day	1	42		42				
3	1-2010	Helicopter support for North Haleauau MU: X hours	transportation		CEA 35	1 hr	50	0.85	42.5	42.5				

Chapter 2: Detailed Cost Estimates and Time Schedule

year	Tier year	Trigger Action Description	Trigger Action	Taxon	Assumptions	Unit	Number of Units	Unit Cost (1,000s)	Cost (subtotal) (1,000s)	One-Time Prorated Costs (1,000s)	Annual Costs (1,000s)	No. of NRM per Year	No. of NRS2 per Year	other personnel
3	1-2010	MU Threat Management, North Haleauau	Threat Management	multiple	CEA 16	1 acre High	123.60	0.128	15.821		15.821	0.032	0.181	
3	1-2010	Construct Mohiakea MU: materials cost	Threat Management	multiple	CEA 11	1 foot	0.04	15157	606.28	606.28				
3	1-2010	EOD for Mohiakea MU: tech II	EOD	multiple	CEA 11	1 day	1	38		38				
3	1-2010	Helicopter support for Mohiakea; X hours	transportation		CEA 35	1 hr	50	0.85	42.5	42.5				
3	1-2010	MU Threat Management, Mohiakea	Threat Management	multiple	CEA 16	1 acre low	426.00	0.043	18.318		18.318	0.012	0.070	
3	1-2010	Construct Mahaka III MU; Materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	411.6	6.174	6.174				
3	1-2010	MU Threat Management, Kamaili	Threat Management	multiple	CEA 16	1 acre high	6.30	0.128	0.806		0.806	0.002	0.009	
3	1-2010	%4 inflation increase each year on salaries									71.435			
X	Year 3 costs at Tier 3									1576.5	2901.7	3.3	18.2	14.5
X	Year 3 costs at tier 1--no North Haleauau or Mohiakea									237.3	2753.4	3.1	17.2	14.5
		no construct North Haleauau and Mohiakea								-1467.6				
4	1-2011	Construct Koloa MU: materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	3356.1	50.3415	50.3415				
4	1-2011	MU Threat Management, Koloa	Threat Management	multiple	CEA 16	1 acre Med	160.00	0.085	13.600		13.600	0.028	0.155	
4	1-2011	%4 inflation increase each year on salaries									73.145			
X	Year 4 costs at Tier 3									159.3	2988.5	3.3	18.4	14.5
		no construct Koloa MU								-50.3				
5	1-2012	Construct Kaipapau MU: materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	4405	66.075	66.075				
5	1-2012	MU Threat Management, Kaipapau	Threat Management	multiple	CEA 16	1 acre Med	272.00	0.085	23.120		23.120	0.062	0.271	
5	1-2012	Construct Manana MU: materials cost	Threat Management	Cyastj	CEA 12	1 meter	0.015	1152	17.280	17.280		0.046	0.203	
5	1-2012	MU Threat Management, Manana	Threat Management	Cyastj	CEA 16	1 acre low	18.100	0.048	0.869		0.869	0.002	0.010	
5	1-2012	%4 inflation increase each year on salaries									79.059			
X	Year 5 costs at Tier 3									192.3	3012.4	3.4	18.9	14.5
		no construct Koloa MU								-66.1				
6	1-2013	Construct South Kaukonahua MU: materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	2701.3	40.5195	40.5195				
6	1-2013	MU Threat Management, South Kaukonahua	Threat Management	multiple	CEA 16	1 acre med	93.50	0.085	7.948		7.948	0.011	0.061	

Chapter 2: Detailed Cost Estimates and Time Schedule

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6	1-2013	Construct Ekahanui extension + Huliwai	Management	Abusan	CEA 12	1 meter	0.015	447	6.705		6.705	0.018	0.079	
6	1-2013	MU Threat Management, Eka extension + Huliwai	Threat Management	Abusan	CEA 16	1 acre High	1.00	0.128	0.128		0.128	0.000	0.002	
6	1-2013	%4 inflation increase each year on salaries									82.222			
X		Year 6 costs at Tier 3								166.7	3027.2	3.4	19.0	14.5
		no construct South Kaukonahua MU and no vehicles								-95.5				
7	1-2014	Construct North Kaukonahua MU: materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	1352	20.28	20.28				
7	1-2014	MU Threat Management, North Kaukonahua	Threat Management	multiple	CEA 16	1 acre Med	30.40	0.085	2.584		2.584	0.003	0.020	
7	1-2014	Construct Lower Poamoho: materials	Threat Management	Garman	CEA 12	1 meter	0.015		0.000		0.000	0.000	0.000	
7	1-2014	MU Threat Management: Lower Poamoho	Threat Management	Garman	CEA 16	1 acre low	1.00	0.048	0.048		0.048	0.000	0.000	
7	1-2014	%4 inflation increase each year on salaries									85.510			
X		Year 7 costs at Tier 3								91.5	3029.9	3.4	19.0	14.5
		no construct North Kaukonahua MU								-20.3				
8	1-2015	Construct Poamoho Subunit I MU: materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	2210	33.15	33.15				
8	1-2015	MU Threat Management, Poamoho Subunit I	Threat Manageme	multiple	CEA 16	1 acre low	30.40	0.043	1.307		1.307	0.001	0.00	
8	1-2015	Construct Lower Peahinaia II: materials cost	Threat Manageme	multiple	CEA 12	1 meter	0.015							
8	1-2015	MU Threat Management, Lower Peahinaia II	Threat Manageme	multiple	CEA 16	1 acre med	23.90	0.085	2.032		2.032	0.003	0.01	
8	1-2016	Tier 2: Construct South Kaukonahua II MU; materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	252	3.78	3.78				
8	1-2016	Tier 2: MU threat management, south kaukonahua II	Threat Management	multiple	CEA 16	1 acre low	1.30	0.043	0.056		0.056	0.000	0.000	
8	1-2015	%4 inflation increase each year on salaries									88.931			
X		Year 8 costs at Tier 3								108.2	3033.3	3.4	19.1	14.5
		no construct Poamoho subunit I								-33.2				
9	1-2016	Tier 2:Construct Poamoho Subunit II; materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	1052	15.78	15.78				
9	1-2016	Tier 2: MU Threat management, Poamoho Subunit II	Threat Management	multiple	CEA 16	1 acre low	30.40	0.048	1.459		1.459	0.001	0.006	

Chapter 2: Detailed Cost Estimates and Time Schedule

year	Tier year	Trigger Action Description	Trigger Action	Taxon	Assumptions	Unit	Number of Units	Unit Cost (1,000s)	Cost (subtotal) (1,000s)	One-Time Prorated Costs (1,000s)	Annual Costs (1,000s)	No. of NRM per Year	No. of NRS2 per Year	other personnel
9	1-2016	Tier 2: Construct Poamoho Subunit III, Materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	289	4.335	4.335				
9	1-2016	Tier 2: MU threat management, Poamoho subunit I	Threat Management	multiple	CEA 16	1 acre low	1.30	0.048	0.062		0.062	0.000	0.000	
9	1-2016	%4 inflation increase each year on salaries									92.488			
X	Year 9 costs at Tier 3									95.1	3127.3	3.4	19.1	14.5
10	no construct Poamoho subunit II, III, South Kaukonahua II									-20.1				
10	1-2017	Tier 2: Construct Waiawa subunit I; materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	2933	43.995	43.995				
10	1-2017	Tier 2: MU Threat management, Waiawa Subunit I	Threat Management	multiple	CEA 16	1 acre low	124.00	0.043	5.332		5.332	0.004	0.020	
10	1-2017	Tier 2: Construct Kawaiiki subunits I and II; materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	1140	17.1	17.1				
10	1-2017	Tier 2: MU Threat Management, Kawaiiki subunits	Threat Management	multiple	CEA 16	1 acre low	9.30	0.043	0.400		0.400	0.000	0.002	
10	1-2017	%4 inflation increase each year on salaries									96.188			
X	Year 10 costs at Tier 3									136.1	3229.2	3.4	19.1	14.5
		no construct waiawa I, kahana								-61.1				
11	1-2018	Tier 2:Construct Kahana MU; Materials Cost	Threat Management	multiple	CEA 12	1 meter	0.015	1234	18.51	18.51				
11	1-2018	Tier 2: MU Threat management, Kahana	Threat Management	multiple	CEA 16	1 acre Med	22.50	0.085	1.913		1.913	0.003	0.015	
11	1-2018	Tier 2: Construct Wailupe MU; Materials Cost	Threat Management	multiple	CEA 12	1 meter	0.015	1123	16.845	16.845				
11	1-2018	Tier 2: MU Threat management, Wailupe	Threat Management	multiple	CEA 16	1 acre Med	21.70	0.085	1.845		1.845	0.002	0.014	
11	1-2018	%4 inflation increase each year on salaries									100.035			
X	Year 11 costs at Tier 3									110.4	3333.0	3.4	19.1	14.5
no MU construction from this year on; maintenance is covered under other CEA#										-35.4				
12	1-2019	Tier 2: Construct Waiawa II; materials cost	Threat Management	multiple	CEA 12	1 meter	0.015	931.2	13.968	14.0				
12	1-2019	MU Threat Management, Waiawa II	Threat Management	multiple	CEA 16	1 acre low	12.7	0.043	0.5461		0.5	0.000	0.002	
12	1-2019	Tier 3: Construct Kipapa MU; materials cost	Threat Management	Lobgaukoo	CEA 12	1 meter	0.015	467	7.005	7.0				
12	1-2019	MU Threat Management, Kipapa	Threat Management	Lobgaukoo	CEA 16	1 acre low	2.7	0.043	0.1161		0.1	0.000	0.000	
12	1-2019	%4 inflation increase each year on salaries									104.037			
X	Year 12 costs at Tier 3									89.0	3333.5	3.4	19.1	14.5

Chapter 2: Detailed Cost Estimates and Time Schedule

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13	1-2020	%4 inflation increase each year on salaries									108.198			
X		Year 13 costs at Tier 3								89.0	3441.7	3.4	19.1	14.5
14	1-2021	%4 inflation increase each year on salaries									109.364			
X		Year 14 costs at Tier 3								89.0	3551.1	3.4	19.1	14.5
15	1-2022	%4 inflation increase each year on salaries									113.738			
X		Year 15 costs at Tier 3								89.0	3664.8	3.4	19.1	14.5
16	1-2023	%4 inflation increase each year on salaries									118.288			
X		Year 16 costs at Tier 3								89.0	3783.1	3.4	19.1	14.5
17	1-2024	%4 inflation increase each year on salaries									123.019			
X		Year 17 costs at Tier 3								89.0	3906.1	3.4	19.1	14.5
18	1-2025	%4 inflation increase each year on salaries									131.102			
X		Year 18 costs at Tier 3								89.0	4037.2	3.4	19.1	14.5
19	1-2026	%4 inflation increase each year on salaries									136.346			
X		Year 19 costs at Tier 3								89.0	4173.6	3.4	19.1	14.5
20	1-2027	%4 inflation increase each year on salaries									141.800			
X		Year 20 costs at Tier 3								89.0	4315.4	3.4	19.1	14.5