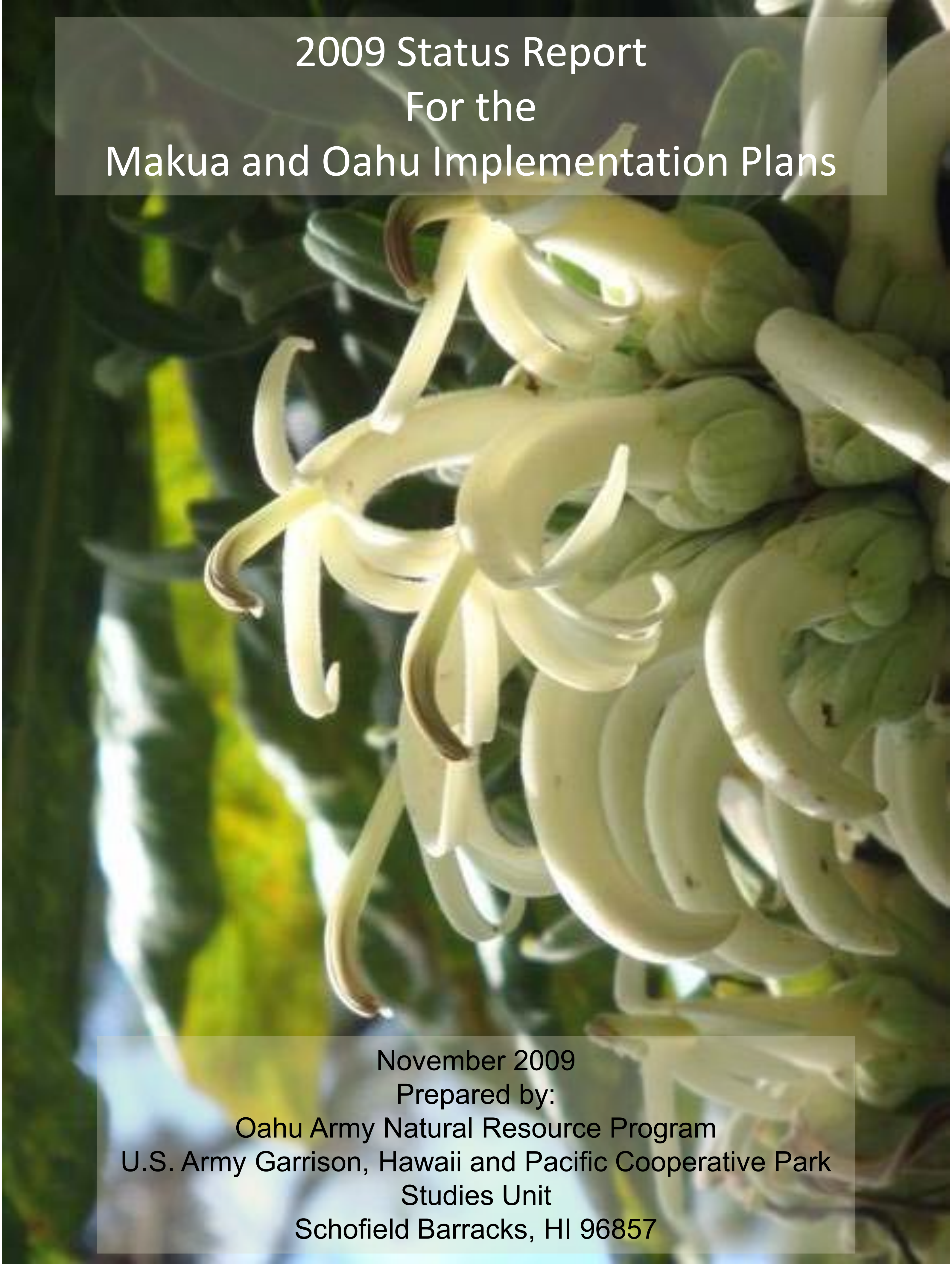
2009 Status Report For the Makua and Oahu Implementation Plans



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EXECUTIVE SUMMARY

The Oahu Army Natural Resources Program (OANRP) has just completed implementing its fifth year of the Makua Implementation Plan Addendum (2005) and the second year of the Oahu Implementation Plan (OIP) (OIP 2008, MIP 2005). The Makua Implementation Plan (MIP) was finalized in May 2003. In January 2005, the Army completed an Addendum which emphasized management of three population units (PUs) per plant taxon in the most intact habitat and 300 individuals of *Achatinella mustelina* in each genetically identified Evolutionarily Significant Unit (ESU). The 2007 Makua Biological Opinion (BO) issued by the U.S. Fish and Wildlife Service (USFWS) required that the Army provide threat control for all Oahu Elepaio pairs in the Makua action area (AA) and species stabilization for 29 species. An amended BO was issued in 2008 that covers additional minimizations measures necessary as a result of the 2007 Waialua fire that destroyed individuals and habitat for *Hibiscus brackenridgei* subsp. *mokuleianus*. This report serves as the annual status report to the Makua Implementation Team (MIT), and participating landowners on the MIP Year-5 actions and OIP Year-2 actions that occurred between 1 September 2008 and 31 August 2009 and also serves to report compliance to the USFWS. This report does not cover Oahu Elepaio. At the request of the USFWS, OANRP are analyzing many years of past data to produce a comprehensive report including population growth estimates. This analysis is taking longer than expected; therefore, Elepaio will be covered in a separate detailed report which will be transmitted early January 2010.

Year 2 of the Oahu Implementation Plan

Fence construction on OIP management units (MUs) is pending the preparation and approval of a programmatic Environmental Assessment. This document is being prepared and is scheduled to be approved by 31 March 2010. OANRP began construction on the Ekahanui Subunit III MU that will protect nine acres of habitat. This fence is covered by an Environmental Assessment prepared by The Nature Conservancy for management in the Honouliuli Preserve. One quarter of the high priority weeding areas designated in OIP MUs were weeded over the last year (20 acres out of 82 acres). Over this reporting period, OANRP reintroduced 8 individual plants of taxa covered in the OIP and 164 individuals of taxa that are OIP and MIP overlapping taxa. Genetic storage goals and *in situ* stabilization continued for all OIP target species.

Year 5 of the Makua Implementation Plan

Construction on MIP fences was stalled awaiting completion of Section 106 consultation in accordance with the National Historic Preservation Act. While awaiting completion of the 106 consultations, the program focused on fenceline clearing and materials distribution in preparation to secure 356 acres of essential habitat for MIP taxa. This includes Manuwai, Kaluaa and Waieli Subunit III and Napepeiauolelo fenceline preparation. These fences will be constructed in 2010. The Makaha Subunit I fence was declared pig free during this reporting period. Weed control was conducted over approximately 28% of the high priority weeding areas designated in MIP management units (57 acres out of 206 acres). Over this reporting period, OANRP outplanted 621 individuals of taxa covered in the MIP and 164 individuals of taxa that are OIP and MIP overlapping taxa. Genetic storage goals and *in situ* stabilization continued for all MIP target species. For *Achatinella mustelina*, six of the eight sites slated for management in the MIP have over 300 individuals. Vegetation monitoring belt transects were installed in three MIP MUs: Ekahanui, Kahanahaiki and Makaha.

Landowner/Agency Communications

The Army continues to work cooperatively under a Memorandum of Understanding (MOU) with both the Board of Water Supply (BWS) and The Nature Conservancy of Hawaiʻi (TNCH) for work in Makaha Valley and TNCH's Honouliuli Preserve.

The Honouliuli Preserve parcel was purchased by the Trust for Public Land (TPL) from the James Campbell Company. TPL intends to transfer ownership of the preserve to the State of Hawaii, Department of Land and Natural Resources, early 2010. A large portion of the purchase price was put

forward by the Army Compatible Use Buffer Program. Additional funding came from the State of Hawaii, Honolulu City and County and the USFWS. TNCH still has a conservation easement for management of Honouliuli which will end upon transfer to the State. TNCH ended their field program at Honouliuli in May 2009. Currently, the Army communicates with TNCH Honolulu Office for work conducted in the preserve.

OANRP is operating under a signed 3-year license agreement with Kamehameha Schools (KS) for work in the MUs on KS lands. KS staff are preparing a 15 year license agreement to include Army fencing projects on KS lands. This agreement is expected within the next six months and will pave the way for some OIP MU construction projects.

The Army is pursuing a six month right of entry for *Hibiscus brackenridgei* populations on Dole Food Company lands. In addition, the Army is also negotiating a license agreement with Hawaii Reserves Inc for work at the Koloa MU. OANRP allowed the ROE with Waikane Investment Corporation to lapse because O‘ahu ‘Elepaio management on the parcel has been discontinued.

Finally, the Army continues to work toward an agreement to continue conservation work on State of Hawaii lands. The Division of Forestry and Wildlife have conducted internal reviews of a draft MOU and are preparing to transmit a copy to Army Real Estate for review and comment. Once completed, the OANRP will continue to work closely with DLNR staff on all projects and decision making regarding natural resource management on these lands. The Army would like to work with the State to build the proposed East Makaleha and West Makaleha MU fences within the next two years.

Fire

The Army Wildland Fire program has moved from being directed by the Army Safety Office to the Directorate of Emergency Services. Approximately 1/3 of the 53 OANRP staff are trained and certified as wildland firefighters (type 2). Currently, the Research Corporation of the University of Hawai‘i (RCUH) Human Resources Department does not allow OANRP staff to fight fire. However, RCUH staff can assist with mop up operations under the direction of the Army Wildland Fire program and participate in an advisory capacity. RCUH and Army Wildland Fire staff are working to draft a Mutual Aid Agreement. Under this agreement, RCUH employees would become temporary federal employees in the event of a fire.

During this reporting period, OANRP helped coordinate fire fighting resources and funded helicopter support to extinguish the Kaena Point fire which occurred in July. In addition, OANRP surveyed a fire which occurred at Kaneana Cave on Farrington Highway to determine the need for Army Wildland Fire Program response and to assess the threat to rare resources. Fire reports are included as Appendix 2.

Greenhouse-introduced snails

Four alien snail species, *Zonitoides arboreus*, *Liardetia doliolum*, *Succinea tenella* and *Gonaxis kibweziensis* were identified in the OANRP greenhouse is November 2008, prior to the 2008-2009 reintroduction season. Many person hours were spent inspecting greenhouse plants. Overall, 4,000+ hours were devoted by non-greenhouse staff positions to control these pests. This number of hours is equivalent to two full time staff for the year. The genetic stock housed in the Army greenhouses are extremely valuable; therefore, infested plants had to be cleaned and could not be disposed of. OANRP suspect that these alien snails were obtained from cooperating nurseries on Oahu. These snails are not present in upland native habitat; therefore, the OANRP postponed and scaled back 2008-2009 reintroductions. A brochure about the alien snails and the intensive control methods employed by OANRP is included in the Environmental Outreach 2009 section (Appendix 1-1).

Research

OANRP worked in two new areas of research this year. First, a pilot rat control project was conducted that involved the installation of a large snap trap grid across the Kahanahaiki MU. This model is adopted from the New Zealand Department of Conservation. Along with grid installation, OANRP also conducted extensive pre-control monitoring. Results from this pilot project will be used to refine ongoing rat control efforts at other MUs and may be applied at other MUs if deemed successful and appropriate. For a detailed discussion about this project see Chapter 6. The second new pilot project involved working with dogs to detect *Euglandina rosea* in a field setting. OANRP contracted the group Working Dogs for Conservation to train their dogs for the task. This project is discussed in detail in Chapter 4. Both of these research projects are critical to threat control development but also time consuming for OANRP.

Funding and staffing levels

There are currently a total of 51 staff comprising three field crews, a fence crew, a greenhouse management crew and various foundational support staff; this is similar to last year's staffing. The Army received $3.4 million (M) for MIP and $2.8 M for OIP in FY2009. The OANRP is still increasing the number of staff to meet the necessities for implementing the current Makua and Oahu Implementation Plans and timelines. The major difficulties associated with increasing staff numbers are the lack of senior staff to orient new hires in the field, finding qualified hires, and the lack of space to house this large number of field crew and their field supplies.

In order to predict future MIP/OIP program budgets and determine staffing level requirements, OANRP developed a scheduling database. Over this year, OANRP staff populated a database with specific action items from the MIP and OIP totaling over 5,000 entries. This process was very time consuming but essential to analyzing project efficiency. In addition, administrative time was divided to better understand office task breakdown. OANRP will use this database to direct actions more efficiently in the next year.

The OANRP is now housed at two locations. Half the staff are located at East Range and the other half are located at the new facility on Schofield Barracks West Range. The new facility was provided and funded by the Army and includes an office building, a greenhouse, a flammable and pesticide storage, and a workshop. Office and base operations space was limited in years past. The West Base site has adequate space for further expansion to allow all staff to reside at one physical location. The move to West Base consumed substantial staff time. In addition, OANRP designed and installed an interpretive garden at West Base intended for use in outreach efforts.

Summary Tables

Table I. Status summary of MIP plant species for 2009

Bold = reached stabilization goal

Makua Implementation Plan				
Taxon Code	**Population Unit**	**Status mature/immature/ seedling (# mature goal)**	**Genetic Storage (> 50 seeds from 50 individuals, >3 clones in propagation from 50 individuals)**	**Ungulate free**
Alemacmac	Kahanahaiki to West Makaleha	36/6/0 (50)	0	partial
	Makua	22/0/0 (50)	1 (individuals represented by airlayers)	partial
	Central Kaluaa to Central Waieli	17/6/0 (50)	0 (individuals represented by airlayers)	partial
	Makaha	**63/5/2 (50)**	0	**yes**
Cenagragr	Kahanahaiki to Pahole	**331/31/39 (50)**	47 (clones + seed)	**yes**
	Central Ekahanui	**96/1/43 (50)**	15 (50 ind w/ clones)	**yes**
	Makaha and Waianae Kai	8/0/0 (50)	6 (ind w/ clones)	partial
Chacelkae	Makua	**118/16/0 (25)**	**59 (>50 seeds)**	**yes**
	Kaena to Keawaula	**300/0/0 (25)**	**55 (>50 seeds)**	**yes**

Makua Implementation Plan				
Taxon Code	**Population Unit**	**Status mature/immature/ seedling (# mature goal)**	**Genetic Storage (> 50 seeds from 50 individuals, >3 clones in propagation from 50 individuals)**	**Ungulate free**
	Kaena East of Alau	21/0/1 (50)	19 (>50 seeds)	**yes**
	Puaakanoa	**160/10/0 (25)**	3 (>50 seeds)	**yes**
Chaher	Kapuna to Pahole	**57/74/0 (25)**	10 (>50 seeds)	**yes**
	Makaha (reintro)	19/29/28 (25)	n/a	**yes**
	West Makaleha (reintro)	0/0/0	n/a	no
Cyagrioba	Pahole to W Makaleha	32/18/4 (100)	10 (>50 seeds)	**yes**
	Central Kaluaa	29/23/0 (100)	**1 (>50 seeds)**	**yes**
	Palikea (South Palawai)	92/37/0 (100)	13 (>50 seeds)	**yes**
	Makaha	1/0/0 (100)	**1 (>50 seeds)**	no
Cyalon	Kapuna to W Makaleha	39/18/0 (75)	18 (>50 seeds)	partial
	Pahole	56/49/2 (75)	41 (>50 seeds)	**yes**
	Makaha and Waianae Kai	3/6/0 (75)	2 (>50 seeds)	**yes**
Cyasupsup	Kahanahaiki	33/127/193(50)	3 of 3 available founders	**yes**
	Central and East Makaleha (reintro)	0/0/0 (50)	n/a	no
	Makaha (reintro)	0/42/0 (50)	n/a	**yes**
	Pahole to Kapuna (reintro)	**91/100/255 (50)**	n/a	**yes**
Cyrden	Pahole to Kapuna to West Makaleha	**577/615/238 (50)**	**50 (>50 seeds)**	partial
	Kawaiiki	15/31/39 (50)	0	no
	Opaeula	16/12/0 (50)	0	no
	Kahanahaiki	**156/57/27 (50)**	21 (>50 seeds)	**yes**
Delsub/wai	Kahanahaiki to Keawapilau	**156/28/0 (100)**	**11 (>50 seeds)**	**yes**
	Ekahanui	85/67/62 (100)	**6 (>50 seeds)**	**yes**
	Kaluaa	84/26/1 (100)	**5 (>50 seeds)**	**yes**
	Manuwai (reintro- Palikea gulch stock)	0	**6 (>50 seeds)**	no
Dubher	Ohikilolo Makai	**358/0/0 (50)**	0	**yes**
	Ohikilolo Mauka	**382/6/0 (50)**	1 (>3 clones)	**yes**
	Makaha	36/1/0 (50)	11 (>3 clones)	partial
Fluneo	Kahanahaiki to Kapuna	7/61/0 (50)	2 (>3 clones)	partial
	Central and East Makaleha	5/0/0 (50)	2 (>3 clones)	no
	Makaha	10/15/0 (50)	2 (>3 clones)	partial
	Manuwai	0/0/0 (50)	n/a	no
Gouvit	Keaau	**60/1/0 (50)**	36 (>50 seeds)	no
	Makaha (reintro- Waianae Kai stock)	0/0/0 (2 in Waianae Kai)	0	**yes**
	Makaleha or Manuwai (reintro)	0/0/0	n/a	no
Heddegdeg	Kahanahaiki to Pahole	**186/204/100 (50)**	30 (>50 seeds)	**yes**

Makua Implementation Plan				
Taxon Code	**Population Unit**	**Status mature/immature/ seedling (# mature goal)**	**Genetic Storage (> 50 seeds from 50 individuals, >3 clones in propagation from 50 individuals)**	**Ungulate free**
	Alaiheihe and Manuwai	27/6/0 (50)	25 (>50 seeds)	no
	Central Makaleha and West branch of East Makaleha	20/36/4 (50)	25 (>50 seeds)	no
Hedpar	Ohikilolo	**120/28/40 (50)**	**102 (>50 seeds)**	**yes**
	East Makaleha (reintro)	0/0/0 (50)	0	no
	Halona	**97/35/19 (50)**	**62 (>50 seeds)**	partial
Hesarbu	Waianae Kai	2/1/0 (75)	2 plants represented in nursery	**yes**
	Haleauau	0/1/0 (75)	0	**yes**
	Makaha	2/4/0 (75)	1 plant represented in nursery	**yes**
	North Palawai	1/0/0 (75)	3plants represented in nursery	**yes**
Hibbramok	Makua	**68/32/27 (50)**	29 (>3 clones)	**yes**
	Haili to Kawaiu	20/2/0 (50)	6 (>3 clones)	no
	Kaimuhole to Palikea Gulch	4/1141/10 (50)	12 (>3 clones)	no
	Keaau	5/2/0 (50)	3 (>3 clones)	no
Melten	Ohikilolo	**1233/0/0 (50)**	15 (>50 seeds)	**yes**
	Kamaileunu and Waianae Kai	**880/269/297 (50)**	0	no
	Mt. Kaala NAR	**300/0/0 (50)**	0	no
Nerang	Makua	28/83/3 (100)	20 (>3 clones)	**yes**
	Manuwai	0/0/0	**2 (>3 clones)**	no
	Waianae Kai Mauka	43/25/4 (100)	3 (>3 clones)	no
	Kaluakauila (reintro)	**113/24/1 (100)**	n/a	**yes**
Nothum	Kaluakauila	**198/35/0 (25)**	4 (>3 clones)	**yes**
	Makua (south side)	**66/1/0 (25)**	0	partial
	Kaimuhole and Palikea Gulch (Kihakapu)	**53/5/0 (25)**	20 (>3 clones)	no
	Waianae Kai	**199/105/0 (25)**	2 (>3 clones)	partial
Phykaa	Keawapilau to Kapuna	1/0/0 (50)	**1 (3 clones)**	**yes**
	Makaha (reintro)	0/0/0 (50)	**2 (3 clones; waianae kai)**	**yes**
	Manuwai (reintro)	0/0/ (50)	**3 (3 clones; palikea gulch)**	no
	Pahole	1/0/0 (50)	**2 (3 clones)**	**yes**
Plapripri	Ohikilolo	11/0/0 (50)	12 (>50 seeds)	**yes**
	Ekahanui	29/37/7 (50)	42 (>50 seeds)	**yes**
	North Mohiakea	10/16/2 (50)	12 (>50 seeds)	partial
	Halona	29/43/0 (50)	18 (>50 seeds)	partial
Prikaa	Ohikilolo	**76/1021/20 (25)**	18 (>50 seeds)	**yes**
	Ohikilolo East and West Makaleha (reintro)	0/122/0 (25)	n/a	**yes**
	Makaleha to Manuwai	**70/4/0 (25)**	15 (>50 seeds)	no
Sanmar	Ohikilolo	3/112/0 (100)	34 (>50 seeds)	**yes**

Makua Implementation Plan				
Taxon Code	**Population Unit**	**Status mature/immature/ seedling (# mature goal)**	**Genetic Storage (> 50 seeds from 50 individuals, >3 clones in propagation from 50 individuals)**	**Ungulate free**
	Keaau	11/300/40 (100)	48 (>50 seeds)	no
	Kamaileunu	10/178/13 (100)	49 (>50 seeds)	**yes**
Schkaa	Pahole	42/12/0 (50)	2 (>50 seeds)	**yes**
	Maakua	10/0/0 (50)	4 (>50 seeds)	no
	South Ekahanui	35/7/0 (50)	13 (clones/seeds)	**yes**
	Kaluaa and Waieli (reintro)	**82/10/0 (50)**	n/a	**yes**
Schnut	Kahanahaiki to Pahole	**100/22/19 (50)**	35 (clones/seeds)	**yes**
	Kapuna-Keawapilau ridge	0/0/0	0 (no founders available)	no
	Makaha (reintro)	6/0/0 (50)	n/a	**yes**
Schobo	Kahanahaiki to Pahole	**144/110/15 (100)**	**6 (>50 seeds)**	**yes**
	Keawapilau to West Makaleha	**182/73/0 (100)**	**72 (>50 seeds)**	**yes**
	Makaha (reintro)	0/0/0	n/a	**yes**
Tetfil	Kalena	45/0/0 (50)	7 (>50 seeds)	**yes**
	Ohikilolo	**2542/582/21 (50)**	**51 (>50 seeds)**	**yes**
	Puhawai	1/2/0 (50)	5 (>50 seeds)	partial
	Waianae Kai	30/8/1 (50)	0	partial
Viochacha	Ohikilolo	**435/10/0 (50)**	2 (>50 seeds)	**yes**
	Puu Kumakalii	44/0/0 (5 0)	10 (>50 seeds)	partial
	Halona	41/3/0 (50)	1 (>50 seeds)	partial
	Makaha	37/2/0 (50)	0	**yes**

Table II. Status summary of OIP plant species for 2009

Bold = reached stabilization goal

Oahu Implementation Plan				
Taxon Name	**Population Unit**	**Status mature/immature/ seedling (# mature goal)**	**Genetic Storage (> 50 seeds from 50 individuals, >3 clones in propagation from 50 individuals)**	**Ungulate free**
Abusan	Kaawa to Puulu	31/77/5 (50)	0 (>50 seeds)	no
	Kaluakauila	0/19/0 (50)	0 (>50 seeds)	**yes**
	Ekahanui and Huliwai	16/28/0 (50)	6 (>50 seeds)	no
	Makaha Makai	**73/27/6 (50)**	8 (>50 seeds)	no
Charoc	Helemano	7/1/0 (50)	0 (>50 seeds)	**yes**
	Kawainui to Koloa and Kaipapau	43/16/3 (50)	0 (>50 seeds)	no
	Waiawa and Waimano	15/0/0 (50)	0 (>50 seeds)	no
Cyaacu	Helemano-Punaluu Summit Ridge to North Kaukonahua	**59/13/7 (50)**	4 (>50 seeds)	partial
	Kahana and South Kaukonahua	2/0/0 (50)	0 (>50 seeds)	no
	Makaleha to Mohiakea	**100/43/0 (50)**	0 (>50 seeds)	no
Cyacri	Kawaiiki	2/4/0 (50)	0 (>50 seeds)	no
	Kahana and Makaua	0/3/0 (50)	**3 (>50 seeds)**	no
	Wailupe	5/1/0 (50)	5 (>50 seeds)	no
Cyakoo	Kaipapau, Koloa and Kawainui	**57/25/6 (50)**	0 (>50 seeds)	no
	Kaukonahua	14/2/0 (50)	0 (>50 seeds)	no
	Opaeula to Helemano	14/5/0 (50)	0 (>50 seeds)	partial
Cyastj	Helemano	5/0/0 (50)	4 (>50 seeds)	**yes**
	Ahuimanu-Halawa Summit Ridge	11/3/1 (50)	3 (>50 seeds)	no
	Waimano	14/5/0 (50)	3 (>50 seeds)	no
Cyrsub	Kaukonahua	2/0/1(50)	0 (>50 seeds)	no
	Kahana	8/7/0 (50)	1 (>50 seeds)	no
	Punaluu	**200/0/0(50)**	0 (>50 seeds)	no
Cyrvir	Helemano and Opaeula	46/15/6 (50)	5 (>50 seeds)	**yes**
	Kawainui and Koloa	25/6/1 (50)	1 (>50 seeds)	no
	South Kaukonahua to Kipapa Summit	0/2/0 (50)	0 (>50 seeds)	no
Eugkoo	Kaunala	48/93/6 (50)	0 (>1 clone)	**yes**
	Oio	18/56/0 (50)	1 (>1 clone)	**yes**
	Pahipahialua	**57/234/1 (50)**	1(>1 clone)	**yes**
Garman	Haleauau	4/0/0 (50)	0	partial

Oahu Implementation Plan				
Taxon Name	**Population Unit**	**Status mature/immature/ seedling (# mature goal)**	**Genetic Storage (> 50 seeds from 50 individuals, >3 clones in propagation from 50 individuals)**	**Ungulate free**
	Helemano and Poamoho	14/0/0 (50)	0	no
	Lower Peahinaia	37/1/0 (50)	0	no
Hesarbo	Kamananui to Kaluanui	**56/46/14 (50)**	0	no
	Kaukonahua	**76/56/124**	0	**yes**
	Lower Opaeula	9/15/0	0	no
	Palikea Gulch	0/0/0	0	no
Hupnut	Kahana and North Kaukonahua	5/0/0 (50)	0	no
	Koloa and Kaipapau	3/2/0 (50)	0	no
	South Kaukonahua	1/0/0 (51)	0	no
Mellyd	Kawaiiki and Opaeula	42/0/0 (50)	0	no
	Kaiwikoele-Kawainui Ridge	3/0/0 (50)	1 (>3 clones)	no
Myrjud	Kaukonahua to Kamananui-Koloa	**455/0/0 (75)**	0	partial
Labcyr	East Makaleha to North Mohiakea	87/16/0 (100)	7 (>3 clones)	partial
	Manana	1/0/0 (100)	0	no
Lobgaukoo	Kaukonahua	1/35/1 (100)	3 (>50 seeds)	no
	Kipapa	0/100/20 (100)	0	no
	Waiawa to Waimano	0/200/0 (100)	0	no
Phyhir	Haleauau to Mohiakea	8/10/0 (100)	1 (>3 clones)	partial
	Laie and Puu Kainapuaa	0/0/0 (100)	0	no
	Hapapa to Kaluaa	3/11/3 (100)	2 (>3 clones)	**yes**
Phymol	Ekahanui	9/0/0 (100)	**1 (3 clones)**	**yes**
	Kaluaa	20/9/0 (100)	**2 (3 clones; waianae kai)**	**yes**
	Pualii	0/0/0 (100)	**3 (3 clones; palikea gulch)**	**yes**
Ptelid	Helemano	0/2/2 (50)	0	**yes**
	Kawaiiki	3/0/0	0	**yes**
	South Kaukonahua	6/0/0(50)	0	partial
Sanpur	North of Puu Pauao	0/21/0 (100)	0	no
	Poamoho Trail Summit	2/10/12 (100)	0	no
	Schofield-Waikane Trail Summit	2/25/0 (100)	0	no
Schtri	Kalena to East Makaleha	**179/198/318 (150)**	**51 (>50 seeds)**	partial

Oahu Implementation Plan				
Taxon Name	**Population Unit**	**Status mature/immature/ seedling (# mature goal)**	**Genetic Storage (> 50 seeds from 50 individuals, >3 clones in propagation from 50 individuals)**	**Ungulate free**
Stekan	Haleauau	1/0/0 (100)	**1 (>3 clones)**	**yes**
	Kaluaa	0/73/0 (100)	**1 (>3 clones)**	**yes**
	Makaha (reintro)	0/0/0 (100)	n/a	no
Viooah	Helemano and Opaeula	**163/146/22 (50)**	0	**yes**
	Kaukonahua	25/0/0 (50)	0	no
	Koloa	36/9/6 (50)	0	no

Table III. Status summary *Achatinella mustelina* for 2009.
Bold = reached stabilization goal. Goal for MIP snails is 300 total (all age classes) per ESU. No *ex situ* numerical goal defined so none are bolded.

Taxon Name	Evolutionarily Significant Unit (ESU)	Status adult/subadult/ juvenile (goal)	ex situ #s adult/subadult/juvenile (# of sites represented)	Ungulate free
Achmus	ESU A (Kahanahaiki/Pahole)	**248/45/43 (300)**	0/2/0 (1)	**yes**
	ESU B1 (Ohikilolo)	**279/33/36 (300)**	0/18/0 (2)	**yes**
	ESU B2 (East/Central Makaleha)	**263/135/66 (300)**	0/2/1 (1)	no
	ESU C (SBW/Alaiheihe/ Palikea)	29/12/3 (300)	1/60/2 (3)	partial
	ESU D1 (North Kaluaa to SBS, Kaala)	**387/76/67 (300)**	9/13/2 (2)	partial
	ESU D2 (Makaha)	79/20/17(300)	0/10/0 (1)	**yes**
	ESU E (Puu Kaua/Ekahanui)	**315/72/77 (300)**	0/6/0 (1)	**yes**
	ESU F (Puu Palikea/Mauna Kapu)	**229/58/29 (300)**	0/3/0 (1)	**yes**

Table IV. Status summary Koolau *Achatinella* spp. for 2009.
Bold = reached stabilization goal. Goal for OIP snails is 300 total (all age classes) per GU. No *ex situ* numerical goal defined so none are bolded.

Species	Geographic Unit (GU)	Status adult/subadult/ juvenile	*ex situ* #s adult/subadult/juvenile (# of sites represented)	Ungulate free
Achape	n/a	Lab (Poamoho Trail)	0/2/0 (1)	no
Achbul	n/a	Lab (Punaluu)	3/22/18 (1)	no
Achbyr/dec	GU A (East Range)	6	0	no
	GU B (Puu Pauao)	16	0	no
	GU C (Poamoho)	23	0	no
	GU D (Punaluu Cliffs)	5	0	no
	GU E (North Kaukonahua)	**445**	5/17/3 (1)	no
Achlil	GU A (Poamoho Summit)	39	118/363/175 (1)	no
	GU B (Peahinaia Summit)	2	0	partial
	GU C (Opaeula-Punaluu Summit)	45	0	no
Achliv	GU A (Crispa Rock)	86	0	no
	GU B (Northern)	9	0	no
	GU C (Radio)	7	17/51/17 (1)	no
Achsow	GU A (Kawainui Ridge)	2	0	no
	GU B (Kawaiiki Ridge)	3	0	no
	GU C (Opaeula-Helemano)	**344**	2/7/1 (1)	**yes**
	GU D (Poamoho Summit and Trail)	**302**	0	no
	GU E (Poamoho Pond)	90	0	no
	GU F (Poamoho-North Kaukonahua Ridge)	2	0	no
	GU G (Lower Peahinaia)	0	4/7/4 (1)	no

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CHAPTER 1: ECOSYSTEM MANAGEMENT

Notable projects from the 2008-2009 reporting year are discussed in the Project Highlights section of this chapter. The reporting year is defined as 1 September 2008 through 31 August 2009. Threat control efforts are summarized for each Management Unit (MU) or non-MU land division. Ungulate control, weed control, and outreach program data is presented with a minimum of discussion. For full explanations of project prioritization and field techniques, please refer to the 2007 Status Report for the MIP and Draft OIP.

Ecosystem Management Unit Restoration Plans (ERMUP) have been written for eight MUs: Palikea, Kahanahaiki, Ohikilolo (Upper), Ohikilolo (Lower Makua), Ekahanui, Helemano, Kaala, and Kaluakauila. All are included here, following Project Highlights. The ERMUPs detail all relevant threat control in the given MU over the next five years. The ERMUPs are working documents; OANRP will modify them as needed and re-submit to the Implementation Team.

1.1 PROJECT HIGHLIGHTS

1.1.1 Ungulate Control Program

Summary

- No fences were completed during the reporting year. OANRP had high expectations for the year to stay ahead of the projected goals. Unfortunately, 106 cultural surveys and the letters to the State Historic Preservation Office (SHPO) were not completed in a timely manner.
- At this time, all of the fences that were slated for construction in 2009 and several for 2010 have all been surveyed and letters of No Significant Impact have been received. This includes (MIP) Waianae Kai Slot Gulch and Mauka Nerang, Keaau and Makaha, Manuwai Subunit I/II. (OIP) Ekahanui Subunit III, Waimano. OANRP is awaiting a second letter from SHPO which includes Waieli Subunit III and Kaala extension to be concluded by mid December.
- Waianae Kai Slot Gulch, Keaau and Makaha, Manuwai Subunit I, Ekahanui Subunit III, Waimano and Waieli Subunit III have large portions of the lines cleared with materials on site.
- Manuwai Subunit I and Waianae Kai Mauka Nerang are awaiting Supplemental Environmental Assessments.
- Kaala and Waimano are included in the OIP EA which is projected to be finalized in March 2010.
- OANRP is projecting to complete the fences listed above and initiate construction at one or two of the following fences; East Makaleha, Keaau Subunit II, Makaha Subunit II, Kamaili, and Kahanahaiki Subunit II. All NEPA documents are being pursued at this time.
- The newly proposed Lihue MU fence, which will enclose Mohiakea and North and South Haleauau, will be started in April 2010.

MIP Management Unit Status

Management Unit	Fenced	Acreage Protected/ Proposed	Year Est.	# MFS PUs		Ungulate Control	Threats
				MIP	OIP		
ARMY MANAGED LANDS							
Kahanahaiki Subunit I/II	Partial	64/94	1998/ 2013	7/6	0/0	The 90 acre Subunit I is ungulate free. Subunit II is proposed for construction in 2013. Snaring is performed in this unit to keep pig pressure off of the Subunit I fence line and to protect the native resources in Subunit II.	Pigs
Kaluakauila	Yes	103/104	2002	2	0	This MU is fenced and ungulate free. Fence is in need of some modification but still tight.	None
Lower Ohikilolo	Yes	70/70	2000	3	0	The Ohikilolo ridge fence and the strategic fence are both complete. Since July 2006, 11 goats have been able to breach the fence. They have since been removed and the fence was modified to prevent more ingress.	Pigs Possibly
Lower Opaeula	No	0/26	2011	1	3	The Koolau Mountains Watershed Partnership has acquired partial funding for fence construction. A Final EA has been approved with a Finding of No Significant Impact. A 10-15 year license agreement still has to be obtained prior to construction of the fence.	Pigs
Ohikilolo	Partial	3/574	2002/ 2013	4	0	Ohikilolo ridge fence is complete along with six smaller PU fences and all have been ungulate free. Goats were eliminated from the MU in 2002. A large rock fall damaged the fence and goat scat was observed inside in 2009. OANRP are monitoring the situation and have scheduled the repairs. A route has yet to be determined for the closure of the Ohikilolo MU.	Pigs
Puu Kumakalii	No	-	-	2	0	None needed but will be included within the proposed Lihue fenced unit at Schofield Barracks West Range.	None
STATE OF HAWAII DEPARTMENT OF LAND AND NATURAL RESOURCES							
East Makaleha	No	0/231	2010	7	3	A 231 acre fence is proposed for construction. Limited goat control has been conducted in Central and East branches of Makaleha and Lower Kaala NAR under the direction of the NARS Specialist.	Pigs Goats Cattle
Haili to Kealia	No	-	-	1	0	In discussions with State NARS staff, it was determined that no fence was needed at this MU.	None
Kaena	No	-	-	1	0	None	None
Keaau Subunit I/II	No	0/29	2010	2	0	There are two proposed fences to protect *Gouania vitifolia* and *Hibiscus brackenridgei* subsp. *mokuleianus* for this area. A supplemental Environmental Assessment to the MIP needs to be completed to cover these fences and other updated management actions. Cultural 106 surveys also need to be completed.	Pigs Goats
Keaau and Makaha	No	0/3	2009	1	0	Construction has been delayed by the lack of a106 survey and proper rappel training for the fence crew. All is rectified, the line has been cleared and materials are in place.	Pigs Goats

Management Unit	Fenced	Acreage Protected/ Proposed	Year Est.	# MFS PUs		Ungulate Control	Threats
				MIP	OIP		
Manuwai Subunits I/II	No	0/321	2009	7	1	Construction has been delayed by the lack of an Environmental Assessment (EA) for Subunit II, lack of 106 surveys, and proper rappel training for the fence crew. Both units are proposed to be completed by February 2010. The EA for Subunit I is complete with a FONSI. Half of the line has been cleared and materials are on the ground.	Pigs Goats
Pahole	Yes	215/215	1998	15	0	In 2006, several small pigs breached the fence and were able to breed before detection. To date, a total of 23 pigs have been removed via snares. OANRP and NARS staff believe that there are no pigs left within the unit but continue to check the snares.	Pigs
Upper Kapuna Subunits I/II/III/IV	Yes	432/224	2007	10	0	NARS staff contracted the construction of these four separate subunits, all of which are completed. Subunits I, II, and III are pig free but IV is not. At this time, NARS staff are conducting volunteer hunts and running baited traps for pig control. When the volunteer hunter program is complete in November 2009, snares and more traps will be incorporated into the program. OANRP will assist at this point.	Pigs
Waianae Kai	Partial	.5/9	2008/ 2009	4	0	The *Hesperomannia arbuscula* and *Gouania vitifolia* PU fences are completed. There are two separate PU fences proposed for *Neraudia angulata* var. *angulata* and one for *Nototrichium humile*. Construction has been delayed by the lack of a106 survey and proper rappel training for the fence crew. Fences will protect about nine acres when completed. The Nerang WAI-A PU fence has been scoped and partially completed. The Nothum WAI-A PU has been scoped and partially completed. The upper line is cleared and materials are on site. The Nerang WAI-D PU has been scrapped due to no plants on site.	Pigs Goats
West Makaleha	Partial	7/93	2012	5	0	The *Schiedea obovata* and *Cyanea grimesiana obatae* PU fences are complete and pig free. A final EA was approved with a Finding of No Significant Impact. Limited ungulate control outside the fence has been done in the past in cooperation with NARS staff.	Pigs Goats
THE NATURE CONSERVANCY OF HAWAII							
Ekahanui Subunits I/II	Yes	203	2009	6/5	3/3	Both units are complete. Thirteen pigs were removed over 26 hunts. Possibly a few more may have been dispatched by the dogs before the hunters were able to locate them. Three more have been caught in snares. Snaring is continuing and baited traps are soon to be employed with on-line cameras. Several PU fences were constructed in 2004. Limited ungulate control to reduce populations outside the fence in Lualualei has been done in the past in cooperation with NARS staff.	Pigs

Management Unit	Fenced	Acreage Protected/ Proposed	Year Est.	# MFS PUs		Ungulate Control	Threats
				MIP	OIP		
Kaluaa and Waieli Subunits I/II/III	Partial	133/156	1999/ 2006/ 2009	5	1	Subunits I and II were completed by TNCH and have been ungulate free off and on. Unfortunately, there have been several breaches in Subunit I and a total of fifteen pigs have been removed from within. Skirting is being installed around the existing fence to deter incursions. Construction on Subunit III has been delayed by the lack of a106 survey and proper rappel training for the fence crew. Two-thirds of the line has been cleared and some of the materials are on site.	Pigs
Palikea Subunits I/II/III	Partial	36/45	2008/ 2009	6	0	Subunit I is complete and ungulate free. Subunit II has been postponed until further consultation with the IT. Subunit III (Napepeiauolelo) is partially completed, and with the new rappelling certification will be completed in 2009.	Pigs
BOARD OF WATER SUPPLY							
Kamaileunu Subunits I/II	Yes	5/2	2008	1	0	Both of the *Sanicula mariversa* PU fences are completed.	Pigs Goats
Makaha Subunits I/II/III	Partial	85/163	2007/ 2010	14	1	Subunit I is complete and ungulate free. Several community/staff hunts have been completed and 27 pigs have been removed since June 2007. Subunit II and Subunit III are slated for construction in 2010. Need to scope and amend BWS MOU to contain fencing language or get CDUP. OANRP has completed a small *Cyanea longiflora* PU fence within Subunit II.	Pigs Goats
DOLE FOOD COMPANY, INC.							
Kaimuhole	No	0/100	2010	4	0	An ROE is complete for rare plant monitoring. OANRP has scoped out a line and a 106 survey is complete. At this time, Castle and Cooke is unwilling to discuss any fencing and are looking to sell the land. OANRP is hopeful if there is a sale then the new landowner will be interested in working towards mutually beneficial goals.	Goats Pigs

Shading in the table above indicates that ungulate management is needed for the MU.

OIP Management Unit Status

Management Unit	Fenced	Acreage Protected/ Proposed	Est. Year	# MFS PUs			Ungulate Control	Threats
				T1	T2	T3		
ARMY MANAGED LANDS								
Kaala	Yes	183/183	2003	3			The Army controlled side of the MU is fenced. It is unclear as to whether all of the pigs have been eradicated from the fence and whether any animals can get up into the MU from the Waianae/ Makaha side. Five pigs have been removed this year. OANRP will work to examine possible gaps.	Pigs
Kaunala	Yes	5/5	2006	1			No animals were stuck inside	Pigs
Kawaiiki Subunit I/II	No	0/11	2017		2		OIP EA and 106 cultural surveys not completed. A 10-15 year license agreement still has to be obtained prior to construction of the fence.	Pigs
Kawailoa	No	0/7	2011	1			OIP EA and 106 cultural surveys not completed. A 10-15 year license agreement still has to be obtained prior to construction of the fence.	Pigs
Lower Peahinaia II	No	0/24	2016	1			OIP EA and 106 cultural surveys not completed. A 10-15 year license agreement still has to be obtained prior to construction of the fence.	Pigs
Mohiakea	Partial	1/522	2010	2			A new 1800 acre unit has been proposed by OANRP to encompass ~90% of the forested area above the firebreak road. NRS opted to do this instead of smaller discrete units due to the issue with unexploded ordnance. The Army has allocated funds to the project and 106 cultural surveys are complete. Construction is projected to start after March 2010 once the OIP EA and contracting is completed.	Pigs Goats
North Haleauau	Partial	2/423	2010	5			A new 1800 acre unit has been proposed by OANRP to encompass ~90% of the forested area above the firebreak road. NRS opted to do this instead of smaller discrete units due to the issue with unexploded ordnance. The Army has allocated funds to the project and 106 cultural surveys are complete. Construction is projected to start after March 2010 once the OIP EA and contracting is completed.	Pigs Goats
North Kaukonahua	No	0/31	2014	3	1		OIP EA and 106 cultural surveys not completed.	Pigs
Oio	Yes	4/4	2006	1			No animals were stuck inside.	Pigs
Opaeula / Helemano	Yes	273/273	2007	1			The fenced units remain ungulate free	Pigs
Pahipahialua	Yes	2/2	2006	1			No animals were stuck inside.	None

Management Unit	Fenced	Acreage Protected/ Proposed	Est. Year	# MFS PUs			Ungulate Control	Threats
				T1	T2	T3		
South Haleauau	Partial	1/125	2009	5			A new 1800 acre unit has been proposed by NRS to encompass ~90% of the forested area above the firebreak road. NRS opted to do this instead of smaller discrete units due to the issue with unexploded ordnance. The Army has allocated funds to the project and 106 cultural surveys are complete. Construction is projected to start after March 2010 once the OIP EA and contracting is completed.	Pigs Goats
South Kaukonahua Subunit I/II	No	0/95	2013/ 2015	3	3/ 2	1	OIP EA and 106 cultural surveys not completed.	Pigs
STATE OF HAWAII DEPARTMENT OF LAND AND NATURAL RESOURCES								
Kaipapau	No	0/273	2011	4	1		OIP EA and 106 cultural surveys not completed.	Pigs
Kaleleiki	Yes	2/2	1998	1			DLNR built this fence and no animals were stuck inside.	Pigs
Manana	No	0/19	2012	1			OIP EA and 106 cultural surveys not completed.	Pigs
Poamoho Subunit I/II/III/IV	No	0/63	2015/ 2016	1	4/ 2/ 1/ 1	1	OIP EA and 106 cultural surveys not completed.	Pigs
Wailupe	No	0/22	2019		1		OIP EA and 106 cultural surveys not completed.	Pigs
Waimano	No	0/4	2009	1			OIP EA not completed. The 106 cultural surveys are not complete, line is mostly cleared, materials are ready to be flown in.	Pigs
THE NATURE CONSERVANCY OF HAWAII								
Ekahanui Subunit III/IV	No	0/9	2013	2			Subunit III is cleared, materials are on the line, and the 106 consultation is complete. Subunit IV will come later.	Pigs
Pualii	Yes	20/20	2004	1			Ungulate free.	Pigs
BOARD OF WATER SUPPLY								
Kamaili	No	0/7	2010	1			OIP EA and 106 cultural surveys not completed. Need to scope and amend BWS MOU to contain fencing language or get CDUP.	Pigs Goats

Management Unit	Fenced	Acreage Protected/ Proposed	Est. Year	# MFS PUs			Ungulate Control	Threats
				T1	T2	T3		
HAWAII RESERVES INC.								
Koloa	No	0/160	2011	4	2		OIP EA and 106 cultural surveys not completed. Hawaii Reserves Inc. is a willing partner in the Koolau Mountains Watershed Partnership but wants a 10-15 year license agreement obtained prior to construction.	Pigs
KAMEHAMEHA SCHOOLS								
North Halawa	No	0/4	2015	1			OIP EA and 106 cultural surveys not completed. A 10-15 year license agreement still has to be obtained prior to construction of the fence.	Pigs
Waiawa Subunits I/II	No	0/136	2017/ 2019		1/ 1	1	OIP EA and 106 cultural surveys not completed. A 10-15 year license agreement must be obtained prior to construction of the fence.	Pigs
KUALOA RANCH INC.								
Kahana	No	0/23	2018		1		OIP EA and 106 cultural surveys not completed. Kualoa Ranch Inc. is a willing partner in the Koolau Mountains Watershed Partnership, and is accommodating to fence proposals.	Pigs
U. S. FISH AND WILDLIFE SERVICE								
Kipapa	No	0/4	2019			1	OIP EA and 106 cultural surveys not completed.	Pigs

Shading in the table above indicates that ungulate management is needed for the MU.

1.2 PUBLIC OUTREACH PROGRAM

1.2.1 Volunteers

Summary: Continued existing and developed additional volunteer-based projects at appropriate sites within OIP and MIP management areas, and at the two OANRP baseyards (September 1, 2008 – August 31, 2009).

- Total field volunteer hours = 5369
- Total field volunteer trips = 86

Volunteer field trips for FY 2009*

Management Unit	Projects	Total Number of Trips
Kahanahaiki	Invasive weed control	19
	Common native outplanting	3
	Common native plant monitoring	2
	Water catchment, step, and fence cross-over construction	1
	Common native seed collection	2
	Common native seed sowing	3
	Trail maintenance	1
	Common native transplanting	3
Kaala	Invasive weed control	10
	Incipient weed control	11
	Assist with *Sphagnum* research	2
Palikea	Incipient weed control	15
	Water catchment construction and repair	1
Makaha	Invasive weed control	7
West Makaleha	Invasive weed control	3
	Common native outplanting	1
	Rat control	1
Kaluakauila	Invasive weed control	1

*See Appendix I for photos of Volunteer Service Trips

- Total baseyard volunteer hours = 270
    - Baseyard projects:
        - Propagule processing
        - Nursery maintenance
        - Baseyard landscaping
        - Greenhouse snail monitoring
        - Herbarium organization
        - Outreach Material preparation and filing
- Maintained a volunteer database of 538 total volunteers, and communicated regularly with active volunteers on a daily basis.

1.2.2 Educational Materials

Developed and produced educational materials focused on natural resource issues specific to Oahu Army training areas (see Appendix 1-1 for examples).

- Brochures:
  - Oahu Army Natural Resource Program Outreach Activities
  - Oahu Army Natural Resource Program Volunteer Opportunities
- Displays:
  - Natural resource “Build A Forest” activity board for kids (used at Environmental Awareness Day, Operation Purple Camp presentation)
  - “Native Hawaiian Forest Monsters” – for the Bishop Museum’s “Backyard Monsters” family Sunday event
- Signage:
  - Interpretive signs about five habitat types for baseyard interpretive garden*
- Flyers:
  - “Alien Snails Found in Greenhouses – Can We Keep Them Out of Our Native Forests?”*
- Presentations:
  - OANRP presentation for the general public at the Hanauma Bay lecture series

*Examples of Educational Materials in Appendix 1-1

1.2.3 Internships

Developed internships at Army Natural Resources that were coordinated with cooperating agencies and organizations.

- Interns from Hawai`i Youth Conservation Corp (HYCC) contributed a total of 560 volunteer hours over the summer months of June and July.
- Three individuals gained valuable career skills and experience in the field of natural resource management through three-month paid OANRP internships.

1.2.4 Troop Education

Developed and produced educational materials and presentations for Army troops highlighting the relationship between troop training activities and the natural resources on Army training lands.

- Revised and implemented a 45 min. presentation for the eleven Environmental Compliance Officer (ECO) training courses held on Oahu in FY2009; Developed ECO Quiz Questions related to Natural Resources; approximate number of soldiers attending = 470
- Compiled and delivered a half-hour briefing to troops planning to resume live-fire training in Makua Valley; approximate number of soldiers attending = 100.

1.2.5 Outreach Events

Conducted outreach to disseminate information on natural resources specific to Army training lands at local schools, community events, and conferences.

- Total # of outreach activities = 20
- Total # of people served (approximated) = 3712

Outreach activities for FY 2009

Event	Approx. # of people served	Audience
Military Partnerships Conference	200	military community
Classroom presentation	60	middle school students
Classroom presentation	120	elementary students
Oahu Ag. & Environmental Awareness Day	600	elementary students
Classroom presentation	50	high school students
DPW Earth Day Event	250	general public - Schofield
Waikiki Aquarium Earth Day	200	general public
OANRP Earth Day Open House†*	50	general public & partners
Bishop Museum - Grow Hawaii Festival*	300	general public
Hanauma Bay presentation	40	general public
UH Botany Department pau hana presentation	40	UH students
Birding Hike - Volunteer Recognition event	6	general public
Schofield Homeschool Group - interpretive garden event	21	elementary through high school students - Schofield
Helemano M.R. - Grow You Green Festival	75	general public - Helemano
Operation Purple Camp presentations	75	elementary & middle school students, military
Bishop Museum - Family Sunday Event*	150	general public
2009 Conservation Conference - poster session, Sustainability Marketplace, Opportunities Fair	1100	attending participants
HCC Open House	75	conference participants & general public
ING Direct Café Conservation Fair	200	general public
Schofield Hoolaulea	100	general public - Schofield
†Coordinated an Earth Day Open House event celebrating the opening of the OANRP's new baseyard; receipt of the 2008 U.S. Fish & Wildlife Service's Military Conservation Partnership Award; and the partners (agencies, organizations, and volunteers) that helped the OANRP achieve the award (see Appendix for photos). *See Appendix 1-1 for photos of these events.		

1.2.6 Public Relations

Wrote articles, press-releases, and bulletins; provided coordination and accurate information to the local, state, regional, and national media and agencies.

- News Articles:
    - "Oahu volunteers to remove invasive weeds" Associated Press, Honolulu Advertiser and Hawaii News (B.I.), October 3, 2008.
    - "Groups aim to eradicate weed" Rosemarie Bernardo, Star Bulletin, Oct. 21, 2008.
    - "Averting Strawberry Guava Domination" Candace Russo, EMP Bulletin, November 2008.
    - "Tis the season for Hawaii Army environmentalists to plant" Kim Welch, OANRP, for Public Works Digest, November/December, 2008.
    - "Army Tree Program Enlists Hoala Student Planters" Kerry Miller, Central Oahu Islander, January 7, 2009.

  - "U.S. Army Garrison-Hawaii's Natural Resources Program Takes Home Award" Candace Russo, OANRP, for Natural Selections (March 2009), and also included in the EMP Bulletin, March 2009.
  - "Life Scouts Restore Native Forests on Path to Eagle Ranking" Kim Welch, OANRP, for Kui Ka Lono (DPW Newsletter) March 2009
  - "Cub Scouts help Army restore environment" Col. Wayne Shanks, U.S. Army Pacific Public Affairs. Hawaii Army Weekly, March 13, 2009.
  - "Plant, extinct in wild, returns" Will Hoover, Honolulu Advertiser, March 25, 2009.
  - "Hawaii's Natural Resources Program Takes Home Award" Stefanie Gardin & Candace Russo, DPW & OANRP, for Hawaii Army Weekly (Stefanie may have also submitted this to the Public Works Digest?). April, 2009.
  - "Garden shows visitors a slice of the island" Stefanie Gardin, DPW, for the Hawaii Army Weekly, April, 2009.
  - "Endangered Cyanea superba responds positively to the strategic management efforts of Oahu Army Natural Resource Program" Kim Welch, OANRP, for the Hawaii Army Weekly, April 2009.
  - "Environmentalists, Army join forces on preservation" Lea Hong, Mark Fox, & Blake McElheny, TPL, for the Honolulu Advertiser. May 21, 2009

- T.V. SPOTS:
  - KHNL Earth & Sea Series – "Plant Once Thought Extinct Makes Comeback"
  - KHNL Earth & Sea Series – "Rats! Army calls on kiwis to help with rodent problem" June 4 & 5, 2009*
  - KHON 2 – "Rebuilding a Forest," Ron Mizutani, reporter. March 24, 2009*
- Edited/produced/distributed the Ecosystem Management Program (EMP) Bulletin, a quarterly newsletter highlighting achievements made by the Army Environmental Division both on Oahu and the Big Island. The EMP is distributed to a comprehensive list of state, non-profit, federal, and educational institutions, and OANRP volunteers.*
- Contributed wildland fire and endangered species information to be featured in state-wide fire safety booklet (distributed at all DOE schools).

*Examples of Public Relation items are located in Appendix 1-1.

1.3 WEED CONTROL PROGRAM

1.3.1 MIP/OIP Goals

The stated MIP/OIP goals for weed control are:

- Within 2m of rare taxa: 0 percent alien vegetation cover
- Within 50m of rare taxa: 25 percent or less alien vegetation cover
- Throughout the remainder of the MU: 50 percent or less alien vegetation cover

Given the wide variety of habitat types, vegetation types, and weed levels encompassed in the MUs, these IP objectives sometimes seem inappropriate. The MIP does not specify whether these goals shall be met for canopy, understory, or both.

In particular, obtaining 0 percent alien vegetation cover within two meters of every rare plant is difficult, potentially harmful, and may not be worth the increased time/risk. At some locations, rare taxa are surrounded only by weeds; removing all aliens could lead to increased erosion, detrimental light levels, and changes in soil/air moisture. At other locations, maintaining 0 percent cover would mean frequent visitation and potential trampling of rare taxa/habitat. Achieving this 0 percent goal likely will not lead to improved health of every individual of every rare taxon. NRS would like to meet this 0 percent objective only in areas where appropriate. In the ERMUPs, NRS will discuss alternative goals.

NRS also seek additional guidance from the IT on the ‘50 percent or less alien vegetation across the MU’ goal. This goal is appropriate in some MUs. In others, however, the starting point is so degraded that achieving this goal seems unrealistic and a potential money/effort sink. While achieving the goal may be theoretically possible, it would require much more than the thirty years outlined in the IPs. In certain MUs elepaio presence further complicates weed control efforts, as replacing multi-leveled weedy elepaio forest habitat with multi-leveled native forest would require fifty-plus years at least. Different goals would be appropriate in these types of areas. NRS would like to modify this goal for certain MUs, and will discuss possible changes in the ERMUPs.

1.3.2 Management Unit WCA Summary

Only weed control efforts from Weed Control Areas (WCAs) are summarized in this table. Incipient control efforts are not included. The goal of all weed control is not necessarily to reach 100 percent coverage across all WCAs in a MU every year. Goals are further elucidated in the ERMUPs. Note that WCAs are not necessarily drawn to encompass all of a MU; rather, WCAs identify high priority weeding areas within the MU and serve to focus and direct effort in the most critical locations first. See Appendix 1-2, Weed Control Program Forms and Guidelines, for additional information on control techniques.

MU WCA Weed Control Summary, 2008/09/01 through 2009/08/31

Management Unit	Total WCA area (ha)	Area weeded (ha)	% of WCA weeded	Comments
DMR No MU	0.77	0.43	55.76%	NRS assisted the Army Wildland Fire Crew in creation of a firebreak to reduce the threat of fire to the *Hibiscus brackenridgei* subsp. *mokuleianus* at this site.
Ekahanui	13.89	1.89	13.58%	Much of the MU, especially the newly fenced Subunit II, is highly degraded forest; despite this it is home to a large and healthy elepaio population. Control efforts continue to target rare taxa and reintroduction sites. Efforts in these sites have been successful at reducing weed presence and frequency of follow-up trips. In the coming year, NRS will investigate new WCAs within the MU fence.
Ekahanui No MU	2.72	2.49	91.28%	Limited weed control is conducted outside the MU. This effort is along trails and roads to maintain/improve ease of access to the MU and minimize weed spread.

Management Unit	Total WCA area (ha)	Area weeded (ha)	% of WCA weeded	Comments
Helemano and Opaeula	38.19	6.36	16.66%	The Opaeula half of the MU has been weeded extensively in the past. NRS focused on gaps in previous sweeps this year. An unconfirmed *Toxicodendron* sp/*Spondias dulcis* tree was found during work at Opaeula. Final identification is pending. Weed control is beginning in the Helemano half of the MU.
Kaala	30.30	4.97	16.39%	*Hedychium gardnerianum* continues to be the primary weed target at Kaala. NRS swept a critical portion of the MU this year, focusing on areas with mature plants. 298 hours were spent working in a dense *Hedychium* infestation.
Kaena	2.42	1.02	42.15%	NRS weed control around *Chamaesyce celastroides* var. *kaenana* has been effective at removing woody weeds; only moderate effort is required directly around this rare taxa. NRS are beginning to target weeds between *C. celastroides* patches.
Kahanahaiki	23.31	11.37	48.78%	46 weed control trips were taken to Kahanahaiki this year. Many of these were volunteer trips. Volunteer efforts contribute significantly to weed management at this MU. Efforts continued to focus around rare taxa, reintroductions, and native forest patches.
Kaluaa and Waieli	15.29	1.39	9.12%	Weed control efforts focused around rare taxa and reintroductions, as well as along the proposed Waieli fence line. The Hapapa bench WCA, home to rare snails, plants and native forest remnants, was visited five times.
Kaluaa No MU	7692m²	5.46m²	0.071%	Limited weed control is conducted outside the MU. Control is targeted around rare taxa that fall outside the MU and the access road to the Kaluaa trailhead.
Kaluakauila	16.58	8.01	48.30%	Grass control continues to be a high priority in this MU. NRS re-cleared the ridgeline fuelbreak and controlled *Panicum maximum* in the forest patches. NRS also targeted weeds around reintroductions.
Keaau and Makaha	0.21	0.03	15.95%	In preparation for fence construction at the *Sanicula mariversa* population in this MU, NRS conducted some weed control along the scoped fence line.
Keawaula No MU	0.08	0.04	57.72%	Control efforts focused around rare taxa.
Lower Ohikilolo	5.77	5.58	96.68%	NRS visited the MU 24 times this year, maintaining low vegetation levels in the WCA/fuelbreaks throughout the year. This is a labor intensive project. Alternate control techniques are being investigated, but a high level of effort will likely always be required in this MU.
Lower Peahinaia II	36m²	29m²	82.13%	Extensive management will begin in this MU once the fence is completed in 2016.
Makaha	20.15	1.69	8.36%	Weeding efforts have focused around rare plant reintroductions in the southern side of the exclosure.
Makaha No MU	0.04	5011m²	10.02%	Limited weed control is conducted outside of the MU. This effort is along trails to improve ease of access and reduce potential weed spread.
Mohiakea	3.57	0.03	0.90%	Access to Mohiakea is limited (SBW). Weed control is targeted around rare taxa only.
North Haleauau	0.13	17m²	1.34%	Access to North Haleauau is limited (SBW). Weed control is targeted around rare taxa only, generally within small fences.
Ohikilolo	41.92	4.76	11.34%	In the Ohikilolo Ridge half of this MU, control efforts continued across native dominated forest and around rare taxa. In the Lower Makua half of this MU, NRS were successful in gaining access this year. Weed control was conducted in native dominated forest.

Management Unit	Total WCA area (ha)	Area weeded (ha)	% of WCA weeded	Comments
Pahole	22.07	4.21	19.05%	NRS conducted 22 weed control trips in Pahole this year. Efforts were spread across the MU, at almost every WCA. Weeds around rare taxa and reintroductions were targeted in particular.
Pahole No MU	15.76	7.90	50.12%	Control outside of the MU is limited to a reintroduction site, the Nike facility and the Pahole road. NRS continue to maintain the road for safety and ease of access.
Palawai	0.06	0.01	22.34%	Weed control in this MU was targeted around rare taxa.
Palikea	11.86	1.91	16.10%	The ERMU Plan for Palikea has helped direct weed control efforts. New WCAs were drawn to guide management. Control efforts have begun in several locations. The area directly around the *Cyanea grimesiana* is a primary weed control target.
Palikea No MU	1.52	1.20	78.57%	Some weed control is conducted outside the MU. Efforts focus along the Palikea trail, to maintain ease of access, and on certain *Sphaeopteris cooperi* infested areas bordering the exclosure
Puaakanoa No MU	0.35	0.30	87.12%	An MU will be drawn around this Manage for Stability *C. celastroides* population. Control efforts focus on reducing the fuel load below this cliff-side population.
Pualii	0.94	0.28	30.05%	Weed control efforts this year were restricted to proposed rare plant reintroduction sites.
Pualii No MU	6.87	6.87	100%	Limited weed control is conducted outside of the MU. This effort is along the contour road, to maintain access to the MU.
SBE No MU	0.15	0.05	36.18%	Control efforts focus on maintaining weed free areas at the East Baseyard, to reduce the potential for NRS to act as weed vectors.
SBW No MU	0.90	0.89	98.43%	Control efforts focus on maintaining weed free areas at the West Baseyard, to reduce the potential for NRS to act as weed vectors.
South Haleauau	0.26	0.26	100.00%	Access to South Haleauau is limited (SBW). Weed control is targeted around the *Stenogyne kanehoana* exclosure.
Upper Kapuna	3.75	0.47	12.55%	Control efforts this year focused primarily around rare plant reintroductions. A new reintroduction site was established for *Flueggea neowawraea*. In the coming year, NRS hope to develop an ERMU Plan for the Upper Kapuna, in conjunction with NARS, to direct future weeding efforts.
Waianae Kai	0.39	0.05	13.08%	Limited weed control is possible in this small MU, due to extremely steep terrain. Efforts this year focused on clearing fenceline.
Waianae Kai No MU	6.71	1.62	24.09%	NRS continued to assist BWS with work at the Kumaipo burn site this year. BWS funding for that project has since been used up. NRS will continue to assist with any future interagency efforts at this site. NRS began conducting control around the newly fenced *Gouania vitifolia* population.
West Makaleha	1.34	0.60	44.50%	Control efforts continue to focus within the Three Points Exclosure. Areas directly around rare taxa and reintroductions are targeted, but NRS spent significant time clearing weeds across the exclosure as well.
TOTAL	289	77.2	26.70%	A quarter of all WCA area was swept over the last year. Note that some WCAs are not intended to be controlled every year, particularly those in sensitive habitat. Others, like the ones in Lower Ohikilolo which facilitate fuel break maintenance, are maintained quarterly and are swept in their entirety. Via the ERMUPs, NRS hope to more accurately show how priorities are set for different WCAs.

1.3.3 Invasive Species Updates: Tibouchina herbacea and Corynocarpus laevigatus

1.3.3.1 Tibouchina herbacea, Cane Tibouchina

- On 6 August 2008, *Tibouchina herbacea* was discovered on the Koolau Summit Trail in the Poamoho region. Only one plant was found. Oahu Early Detection (OED) staff at Bishop Museum provided species identification. As of 31 August 2009, no other plants have been found in the area. Note: in October 2009, outside of this reporting period, two immature plants were found at the site by State staff.
- On 8 September 2008, an aerial survey was conducted on the windward side of Poamoho plant, across the back of Punaluu. No flowering *T. herbacea* were seen. Some suspicious plants were seen colonizing landslides; these were marked with a GPS for further investigation. When visited on the ground, these suspicious plants turned out to be *Buddleia asiatica*.
- In February 2009, an interagency group conducted a ground survey around the known *T. herbacea* site. Due to a safety incident, NRS did not participate, and the Oahu Invasive Species Committee (OISC) led the group. The ground survey focused on the leeward side of the summit; no plants were found. Surveys were halted, to resume during the next flowering season (October – December 2009).
- Additional aerial and ground surveys will be conducted in winter of 2010. The OANRP still plan to survey a 2km buffer around the known *T. herbacea* site. Natural Resource Staff (NRS) will continue to coordinate with OISC, Dept. of Fish and Wildlife (DOFAW), and the Natural Area Reserve System (NARS) on control efforts.
- The *T. herbacea* information flyer, which was publicized widely, resulted in only one call. A woman reported seeing a plant that matched the description of *T. herbacea* approximately 10 minutes up the Poamoho trail. This area has been walked by NRS many times, and no plants were found. However, NRS will conduct a more thorough survey in this area, as *T. herbacea* can be difficult to spot.

1.3.3.2 Corynocarpus laevigatus, Karaka Nut

- On 9 March 2009, *Corynocarpus laevigatus* was found in Palehua, during ‘elepaio monitoring. Several stands of trees were found, and ‘elepaio were observed nesting and feeding on insects in them. Positive identification was provided by Bishop Museum. This is the only known naturalized *C. laevigatus* site on Oahu.
- There are no records of *C. laevigatus* plantings at Palehua, so the method of introduction is unknown. Palehua is part of the James Campbell Company, and the infestation sites are located between cabins. It is possible that trees were planted by former residents.
- Widely naturalized on Kauai, *C. laevigatus* is considered a major threat to native plants. It produces deep shade and appears to lower species diversity. It produces many fruit; fortunately the fruit are large and are not bird or wind dispersed. However, ungulates are known to eat the fruit and have been reported on as a vector on Kauai (Katie Cassel, Kauai Resource Conservation Program, pers. com.). *C. laevigatus* is native to New Zealand, however, its range is the northern part of the nation; it has been observed naturalizing from plantings in the south (Costall et al, 2006).
- The forest at Palehua is highly degraded, dominated by *Psidium cattleianum*, *Eucalyptus robusta*, and other weeds. However, it is home to a very productive ‘elepaio population, and the ‘elepaio appear to favor *C. laevigatus*. This poses some difficulties in determining how to proceed in controlling *C. laevigatus*.

- In May 2009, NRS and OISC conducted a thorough survey of Palehua. *C. laevigatus* is limited to two gulches, and appears to favor gulch bottoms. Both gulches include large areas with a few scattered karaka nut, as well as smaller areas with very dense stands; the dense stands hold hundreds of trees of all size classes. Staff observed mature fruit and germinating seedlings, as well as 8-10m tall mature trees. Based on the distribution of the plants, it appears that it is spreading slowly, via water ways. It does not appear to be naturalizing along pig trails at this time. The overall area of the infestation is small, 5.16 acres.
- In June 2009, NRS and Dr. Eric VanderWerf visited the site to discuss options for weed control, given the high usage of the area by ‘elepaio. Both infested gulches were surveyed and control options discussed. In areas with very scattered *C. laevigatus* (low canopy coverage), it was determined that the trees could be killed. In areas with dense *C. laevigatus* and ‘elepaio territory overlap (four territories), individual trees were marked for control with orange flagging. Each tree was hand-selected; creating large light gaps or otherwise drastically changing the area would be detrimental to the ‘elepaio. Timing of control was also discussed; control between breeding seasons, in late summer, early fall, would impact ‘elepaio least. Also, control will have to be carried out over multiple years. Removing all of the *C. laevigatus* at one time will undoubtedly have a negative impact on ‘elepaio. Gradual removal will need to be supplemented by outplanting of substitute species, such as *Pisonia brunoniana*, or else it too will harm elepaio. There is no doubt that removing *C. laevigatus* will require much thoughtful effort.
- No control was conducted this year. Due to the slow spread exhibited, NRS felt that there was no rush to begin control. NRS will begin control in the coming year. All control efforts will be discussed with Dr. VanderWerf prior to implementation.

1.3.4 Weed Survey Updates: New Finds

No new significant weed pests were discovered on LZs, along weed transects, or at camp sites.

Several new alien species were discovered on Road Surveys this year. This is due in part to vigilant staff, as well as to species identification services provided by the Bishop Museum.

- Kaala Road Survey: Two incipient alien species were discovered along the Kaala road, *Pterolepis glomerata* and *Anthoxanthum odoratum*. Both are now being targeted for control. The *P. glomerata* was found at about 1800ft; it is widespread in the Koolau Mountains, but is currently unknown from Kaala. NRS are concerned that it would thrive at the summit of Kaala, and have begun control efforts. The *A. odoratum* was found at two locations at the summit of Kaala; this is a new island record for Oahu. This taxa is a documented invasive on the Big Island, where it thrives in pastures. NRS are controlling *A. odoratum* to prevent its spread around the disturbed portions of Kaala.
- Kaena Road Survey: Two incipient alien species were found along the Kaena road, *Emex spinosa* and *Trianthema portulacastrum*. NRS do not know how widely spread either species is on Oahu. In the coming year, NRS will determine if either species poses a high enough threat to merit targeted control.
- Palehua Road Survey: NRS conducted a survey along the Palehua road for the first time this year. This survey was deemed a high priority given that two concerning weeds were noted along it by NRS (*Corynocarpus laevigatus* and *Olea europa*). NRS observed a number of unfamiliar species, but few which turned out to have significant potential as pests. Two species, *Melaleuca ericifolia* and *Melaleuca styphelioides* (ids yet to be confirmed), merit further research, as they are closely related to the widespread weed *Melaleuca quinqueveria*.

1.3.5 Weed Control Techniques: Biodiesel Surfactant Trials

Much of the weed control conducted by NRS involves the use herbicides. See Appendix 3, Weed Control Program and Forms, for further information. In previous trials and through field experience, NRS found that a 20% solution of Garlon 4 in a surfactant/carrier of Forestry Crop Oil (FCO) is effective on a wide range of target weeds. This herbicide mix is used extensively by NRS. In the last year, FCO has become increasingly difficult to find, and increasingly expensive. At the beginning of 2009, NRS installed trials to locate a possible substitute for FCO. See Appendix 1-3, Oil-Based Carrier Herbicide Trials, for a complete project description. Four different surfactant/carriers (MSO, Phase, FCO, and Biodiesel) were tested on four different alien plants (*Clidemia hirta, Leucaena leucocephala, Psidium cattleianum*, and *Schinus terebinthifolius*). Results of the trials indicate:

- No difference in control was observed among the four surfactants in trials with *C. hirta*.
- No difference in control was observed among the four surfactants in trials with *L. leucocephala*.
- *P. cattleianum* control levels varied slightly with surfactant, but not enough to indicate the one surfactant was far superior to another. Biodiesel performed as well as FCO.
- Trials with *S. terebinthifolius* exhibited the greatest variation. While both Biodiesel and FCO resulted in consistent control, neither Phase nor MSO appeared effective.
- Biodiesel would be an effective substitute for FCO. In addition, it is several times cheaper than FCO, more readily available, and more environmentally friendly. Over the next year, NRS will switch to using Biodiesel as the primary surfactant in herbicide solutions with Garlon 4.

1.3.6 Restoration Techniques: Common Native Reintroduction

Sanitation issues continue to plague both the rare plant and common native plant reintroduction programs. Tiny, invasive snails were found in the OANRP greenhouses, as well as in facilities used by growers contracted by OANRP to grow common natives. Multiple species of invasive snails were discovered. As a result, OANRP decided to halt all common native reintroductions until protocols for ensuring plants are invasive snail free are developed, tested, and established. Developing these protocols is a priority, particularly for rare plant management. Depending on what these protocols involve, OANRP will decide how to proceed with common native plantings in the future. Some options include:

- *Working with contractors/growers to implement invasive snail protocols.* NRS are particularly interested in working with Laau Hawaii, a nursery specializing in native ferns, on this. At Laau Hawaii’s greenhouses, only low numbers of one snail (*Liardetia* sp.) have been found in the past. Management is open to learning more about invasive snail sanitation protocols.
- *Growing common natives with OANRP staff.* This may be a viable option depending on staffing and cleanliness of the SBE greenhouse.
- *Experimenting with field nurseries.* Plans are in place to set up a small field nursery in Kahanahaiki and compare the ease of growing *Acacia koa* in the field nursery with the ease of growing koa at the Nike site greenhouse. This comparison will help identify time requirements, potential stumbling blocks, and logistics required for field nurseries. While field nurseries have the potential to eliminate some sanitation issues, such as invasive greenhouse snails, they bring up others, such as media and equipment cleanliness. The field nursery trial would be set up in June/July of 2010, with the resulting *A. koa* scheduled for outplanting in the winter of 2010.
- *Sowing appropriate native seed.* Seed sowing is attractive in that in requires minimal effort. However, not all species are well suited to produce high germination from seed sows. This year, NRS experimented with *Bidens torta* at Kahanahaiki. Preliminary results indicate that *B. torta* does germinate well in some settings, and that this species is worth further investigation. NRS will continue to monitor *B. torta* trials over the coming year, and will consider testing other species.
- *Transplanting wild seedlings from large, natural clumps of seedlings to open areas.* Taking advantage of locally abundant common native seedlings, transplanting allows NRS to introduce

common natives into degraded areas. NRS are experimenting with species, size class, and planting techniques to determine how effective of a tool this can be. Some transplanted *A. koa* in Kahanahaiki are thriving. Other transplanted *A. koa* in Makaha experienced high mortality.

OANRP are currently investigating all of these options. The common native program will likely involve a mosaic of these different methods.

- Hot Water treatment. In previous years, OANRP used a hot water treatment to kill invasive greenhouse snails. This was effective on the target *Liardetia* sp. However, this year, several other species of invasive snail were discovered in the OANRP greenhouses, including *Succinea tenella*. This species proved very resistant to the hot water treatment.

1.3.7 Stryker Transformation Projects

1.3.7.1 Drum Road

- Continue to consult with US Army Corp of Engineers (USACE) and contractors to ensure that construction work on Drum Road did not and will not negatively impact any listed taxa or promote the spread of any noxious weeds.
- NRS regularly review Drum Road construction updates from USACE.
- Construction of Drum Road is 80-85 percent complete. Estimated completion date is February 2010.
- OANRP will prioritize surveying the newly completed Drum Road in the coming year, with particular focus on incipient invasive weeds.
- The *Melochia umbellata* infestation in the Kahuku Training Area (KTA) section of Drum Road continues to be the focus of OANRP outreach to USACE and its contractors. While construction did limit visitation (and control trips) to the infestation site, contractors were accommodating in providing some access. Additional control trips to the *Melochia* sites will be scheduled in the coming year and staff will conduct surveys to ensure that *Melochia* was not transported to new locations during construction.
- Positive communication established with USACE last year has continued this year. USACE managers have been proactive in seeking NRS input in some projects including washrack facility construction at KTA, and Combined Arms Collective Training Facility (CACTF) construction pre-planning discussions at KTA
- The Department of Transportation (DOT) has developed invasive species savvy contract language. NRS was not able to review it last year, as hoped, but look forward to reviewing it in the coming year, and encouraging the Army to adopt similar such language.
- NRS reviewed several proposed seed mixes for hydro mulching for Drum Road and other projects. NRS are working to ensure that no potentially significant weeds are planted in the course of Army-related road work.

1.3.7.2 Vehicle Wash Racks

- OARNP received permission to use the Schofield Barracks East Range (SBE) vehicle Wash Rack to clean work vehicles. The wash rack, which has high pressure hoses, allows for thorough cleaning of undercarriages and tires, reducing the potential for staff to spread weeds during the course of normal field work. Also, all dirt and debris is washed into a holding tank, instead of the parking lot at the OANRP baseyard, further reducing risk of weed spread.
- OANRP monitor the disposal site for the debris from the SBE Wash Rack during annual road surveys.

- The wash rack at Schofield Barracks West Range (SBW) is currently non-functional, but is being brought on line by the Department of Logistics (DOL). OANRP are in communication with DOL and will monitor disposal of dirt/debris from the wash rack when it becomes necessary.

1.3.8 Interagency Coordination

1.3.8.1 Oahu Early Detection (OED)

- In August 2009, OED completed road surveys of both Schofield Barracks and Wheeler Army Airfield. NRS accompanied OED on a couple of the survey trips. Focusing on non-restricted roads (no training area roads), OED identified a number of unique species, including some species more commonly found in botanical gardens than military bases. Results of the survey are included in Appendix 1-4.
- Of the 30 significant species found, 11 taxa are known on Oahu only from Schofield and Wheeler, 1 taxon was recommended for removal, and 12 are potential control targets.
- The species recommended for removal is *Albizia niopoides*. Little is currently known about the invasive status of this taxon worldwide; a preliminary reference search did not turn up any documentation of invasiveness. However, certain characteristics make it a good target candidate: the Schofield location is the only known location in Hawaii, it is naturalizing at Schofield, the infestation site is small, it is a nitrogen fixer, other closely related taxa are highly invasive, seeds have high viability and germination, fruit and seeds are likely dispersed in part by wind. NRS will further investigate this taxon before beginning control.
- NRS will use OED's survey results to guide additional incipient species monitoring and control efforts in the coming year. Removing trees (if deemed necessary) from non-training areas on Schofield will require additional coordination with the Garrison.
- OED also provides species identification services to OANRP. Over the past year, NRS have submitted 66 samples to OED. Several of these have turned out to be new island records. By being able to get identification for unknown species, NRS have greatly improved weed survey results.

1.3.8.2 Oahu Invasive Species Committee (OISC)

- Due to major budget cutbacks, OISC has prioritized working on *Miconia calvescens*, *Rubus discolor*, and a few other targets. OANRP continues to assist OISC by providing data and updates on other incipient species of interest found on Army land, such as *Melochia umbellata, Buddleia madagascariensis,* and *Acacia mangium*. OANRP also has donated some helicopter time to OISC. OANRP continues to participate in the strategy, planning, and control meetings held by OISC.
- OANRP and OISC operate together (via PCSU) under an Aviation Management Directorate (AMD) contract for helicopter use.
- In spring of 2010, OANRP and OISC will share results of the successful *Eleuthrodactyls coqui* control efforts at SBE at the Island Invasives Eradication and Management conference in Auckland, New Zealand. OANRP will present a talk at the conference. A jointly written paper will be published in the conference proceedings. This is a unique opportunity to share the success of coqui control on Oahu with the international conservation community.

1.3.8.3 College of Tropical Agriculture and Human Resources, CTAHR, Dr. James Leary, Invasive Weed Management

- OARNP are continuing to collaborate with Dr. James Leary on the development of Herbicide Ballistic Technology, HBT. This method, currently being researched and tested by Dr. Leary, involves focused delivery of small amounts of herbicide to target plants via paintball equipment.

- Trials of HBT are ongoing at KTA. Several species have been tested, with mixed results. Species that showed susceptibility to the active ingredient in the paintballs, imazapyr, include *Schinus terebinthifolius*, and *Leptospermum scoparium*. Species that did not show susceptibility to imazapyr include *Schefflera actinophylla*, *Grevillea robusta,* and *Ardesia elliptica*. These results suggest that multiple chemistries will be required to obtain successful results on a variety of species.
- Dr. Leary submitted a proposal to the DOD Legacy office to further research HBT. If he is successful in obtaining funding, NRS will work intensively with him to conduct field trials of HBT, determine logistical considerations, identify safety concerns and draft SOPs. Field trials would include both ground and aerial operations. NRS will work with partner agencies (with trained ACETA staff) to facilitate aerial operations.

1.4 ECOSYSTEM RESTORATION MANAGEMENT UNIT PLANS

1.4.1 Ekahanui Ecosystem Restoration Management Plan

MIP Year 6-10, Oct. 2009 – Sept. 2014

OIP Year 3-7, Sept. 2009 - Sept. 2014

MU: Ekahanui Subunit I, II, III, IV and Ekahanui No MU

1.4.1.1 Overall MIP/OIP Management Goals:

- Form a stable, native-dominated matrix of plant communities which support stable populations of IP taxa.
- Control ungulate, rodent, arthropod, slug, snail, fire, and weed threats to support stable populations of IP taxa. Implement control methods by 2013.

1.4.1.2 Background Information

Location: Southern Waianae Mountains

Land Owner: State of Hawaii

Land Manager: DOFAW (State Forest Reserve)

Acreage: 3100 acres

Elevation Range: 1800-3100 ft

Description: Ekahanui MU is located in the Southern Windward Waianae Mountains. Puu Kaua is at the apex of many sub drainages that make up Ekahanui. The summit of Puu Kaua is 3127 ft high. Three major drainages are encompassed in the MU. Overall the area is characterized by steep vegetated slopes and cliff especially at higher elevations. Much of the MU is dominated by alien vegetation. There are only small pockets of native vegetation worth intensive management. The alien dominated areas were included in the MU boundary to ensure management options for Elepaio. Most of this alien dominated area fenced for Elepaio management falls into the Subunit II fence. The MU is accessed via the Kunia road through the Kunia village.

Native Vegetation Types

Waianae Vegetation Types
Mesic mixed forest
Canopy includes: *Acacia koa*, *Metrosideros polymorpha, Nestegis sandwicensis, Diospyros* spp., *Pouteria sandwicensis, Charpentiera* spp., *Pisonia* spp., *Psychotria* spp., *Antidesma platyphylum*, *Bobea* spp. and *Santalum freycinetianum*. Understory includes: *Alyxia oliviformis, Bidens torta, Coprosma* spp., and *Microlepia strigosa*
Mesic-Wet forest
Canopy includes: Metrosideros polymorpha polymorpha. Typical to see Cheirodendron trigynum, Cibotium spp., Melicope spp., Antidesma platyphyllum, and Ilex anomala. Understory includes: Cibotium chamissoi, Broussasia arguta, Dianella sandwicensis, Dubautia spp. Less common subcanopy components of this zone include Clermontia and Cyanea spp.

Vegetation Types at Ekahanui

Mesic Mixed Forest

Mesic-Wet Forest

MIP/OIP Rare Resources

Organism Type	Species	Pop. Ref. Code	Population Unit	Management Designation	Wild/ Reintroduction
Plant	*Abutilon sandwicense*	EKA-A, B HUL-A	Ekahanui and Huliwai	MFS (OIP)	Both
Plant	*Alectryon macrococcus* var *macrococcus*	EKA-A, B, C, D, E, F	Ekahanui	N/A	Wild
Plant	*Cenchrus agrimonioides* var. *agrimonioides*	EKA-A, B, C, D†	Central Ekahanui	MFS	Both
Plant	*Cyanea grimesiana* subsp. *obatae*	EKA-A*	North Branch of South Ekahanui	N/A	Wild
Plant	*Cyanea grimesiana* subsp. *obatae*	EKA-B, C	North Branch of South Ekahanui	Genetic Storage	Reintroduction
Plant	*Delissea subcordata*	EKA-A, B*, C*, D	Ekahanui	MFS	Both
Plant	*Phyllostegia mollis*	EKA-A*, B*, C	Ekahanui	N/A	Wild
Plant	*Phyllostegia mollis*	EKA-C	Ekahanui	MFS (OIP)	Reintroduction
Plant	*Plantago princeps* var *princeps*	EKA-A, B, C	Ekahanui	MFS (OIP)	Wild
Plant	*Schiedea kaalae*	EKA-A, B, C*, D	South Ekahanui	MFS	Both
Snail	*Achatinella mustelina*	EKA-A, B, C,D,E,F,G	ESU-E	MFS	Wild
Bird	*Chasiempis sandwichensis ibidis*	N/A	Ekahanui	None	Wild

MFS= Manage for Stability *= Population Dead GSC= Genetic Storage Collection †=Reintroduction not yet done

Other Rare Taxa at Ekahanui MU

Organism Type	Species	Status	Comments
Plant	*Chamaecyce herbstii*	Endangered	Population gone (2001)
Plant	*Diellia falcata*	Endangered	Scattered individuals
Plant	*Diellia unisora*	Endangered	Hybridizing w/ *D. falcata*
Plant	*Phyllostegia hirsuta*	Endangered	Population gone (2000)
Plant	*Phyllostegia kaalaensis*	Endangered	Population gone (2000)
Plant	*Platydesma cornuta* var *decurrens*	Candidate	
Plant	*Schiedea hookeri*	Endangered	Small wild population in Subunit I, larger TNC reintroduction elsewhere in Subunit I.
Plant	*Schiedea pentandra*	Candidate	
Plant	*Urera kaalae*	Endangered	Wild plants in Subunit II, reintroduction established by TNC in Subunit I.
Plant	*Tetramolopium lepidotum var. lepidotum*	Endangered	Small wild location at crestline, Subunit I
Plant	*Solanum sandwicense*	Endangered	Reintroduction established by TNC in Subunit I. Founder from Palawai
Plant	*Cyanea pinnatifida*	Endangered	Reintroduction established by TNC in Subunit I. Founder from Kaluaa.
Plant	*Dissochondrus biflorus*	Species of Concern	One location
Plant	*Pleomele forbesii*	Candidate	Scattered individuals
Plant	*Pteralyxia macrocarpa*	Species of Concern	Scattered clusters
Plant	*Zanthoxylum dipetalum var. dipetalum*	Species of Concern	Scattered individuals
Fly	*Drosophila montgomeryi*	Endangered	One location, Subunit II
Snail	*Philonesia sp.*	Species of Concern	
Snail	*Amastra spirizona*	Species of Concern	Subunit I

Locations of Rare Resources at Ekahanui

Map removed,
available upon request

Rare Resources at Ekahanui


Mature *Cyanea grimesiana subsp. obatae* at reintroduction


D. subcordata recruitment under reintroduced plants


Abutilon Sandwicense flower


Wild *Schiedea kaalae* patch


Plantago princeps var. princeps with infructescense

MU Threats to MIP/OIP MFS Taxa

Threat	Taxa Affected	Localized Control Sufficient?	MU scale Control required?	Control Method Available?
Pigs	All	No	Yes	MU fenced
Rats	All	Yes for Elepaio, Unknown for plants and snails	Yes	MU-wide snap trap grid to be tested
Predatory snails	*Achatinella mustelina*	Unknown	Unknown	No. Limited to hand-removal and physical barriers
Slugs	*C. grimesiana* subsp. *obatae, D. subcordata, P. princeps* var *princeps, S.kaalae, P. mollis*	Yes	No	Currently under development
Ants	Potential threat to *Drosophila montgomeryi*	Unknown	Unknown	Some available, depends on species
Weeds	All	Yes	Yes	Yes
Fire	All	Yes	Yes	Yes

Management History

- 1998-2002: Biological surveys by TNC Staff and Joel Lau.
- 1999: Elepaio management begins with banding and rodent control of about 6 pairs. By 2006, the number of territories protected is about 20. By 2009, over 25 pairs are known and protected by rat control efforts.
- 2000: Subunit I fence completed (40 acres). TNC eradicated the last pigs through the use of volunteer and staff hunters.
- 2001-2006: Catchment tanks and field nursery installed. Other common native restoration efforts done by TNC/Army staff.
- 2002: *Achatinella mustelina* surveys by Army Staff and Joel Lau.
- 2005: 120 acre fire burns into the forest, well into the adjacent gulch to the south of Ekahanui as well as into the lower reaches of Ekahanui Gulch itself.
- 2007: Most restoration and active management by TNC stops due to staff reductions.
- 2008: Subunit II fence completed.
- 2009: James Campbell Co. sells Honouliuli Preserve to The Trust for Public Land with goal of eventual transfer to the State of Hawaii.

1.4.1.3 Ungulate Control

Identified Ungulate Threats: Pigs

Threat Level: High

Primary Objective:

- Maintain Subunit I and II as pig free.
- Complete the construction of Subunit III and IV.

Strategy:

- Maintain Subunit I and II as pig free by maintaining fences.
- Volunteer hunters were used initially to eliminate the majority of the pigs.
- Snares are now employed in Subunit II to get the last of the animals and trapping will soon commence.

Monitoring Objectives:

- Conduct fence checks and read transects quarterly. GPS and mark the fence at ten meter intervals so that the fence will be one large transect.
- Monitor for pig sign while conducting other management actions in the fence.

Management Responses:

- If any pig activity is detected within the fenced unit, implement hunting and/or trapping/snaring program.
- When DOFAW takes over the management of Honouliuli, OANRP will fully support the institution of a hunting program to help reduce the amount of pressure from pigs on fences.

Fence Completions:

- Subunits III and IV are scheduled to be completed in 2013, but III should be completed by 2010.

Maintenance Issues:

- There is a perimeter fence around Subunit I and II. The major threats to the perimeter fence include fallen trees and vandalism. There are no “major” gulch crossings but rather three smaller crossings that have potential to carry a large amount of debris. Special emphasis will be placed on checking the fence after extreme weather events. There have been relatively few incidences of vandalism in the past.

Ungulate Control Actions:

Year	Action	Quarter
MIP YEAR 6 Oct 2009-Sept 2010	• Check MU fence for breaches, maintain integrity of fence • Install two 500m transects within the fence • Clear and herbicide grassy sections of fence to maintain ability to monitor	• 1-4 • 1 • 1, 3
MIP YEAR 7 Oct 2010- Sept 2011 through MIP YEAR 10 Oct 2013-Sept 2014	• Check MU fence for breaches, maintain integrity of fence • Read ungulate transects quarterly • Clear and herbicide grassy sections of fence to maintain ability to monitor • Subunit III construction to be completed by 2010 , Subunit IV by 2013	• 1-4 • 1-4 • 1, 3 • 1-4

1.4.1.4 Weed Control

Weed Control actions are divided into 4 subcategories:

1. Vegetation Monitoring
2. Surveys
3. Incipient Taxa Control (Incipient Control Area - ICAs)
4. Ecosystem Management Weed Control (Weed Control Areas - WCAs)

These designations facilitate different aspects of MIP/OIP requirements.

Vegetation Monitoring Objectives

- Conduct MU vegetation monitoring every five years to measure the effectiveness of current weeding efforts within the MU.
- Make a current vegetation map.
- Conduct vegetation monitoring throughout the area that is being managed for rare plant species.

MU Vegetation Monitoring

From October - November of 2008 vegetation monitoring was conducted for the Ekahanui management unit. The total effort including commute time was 450 hours. MU monitoring will be conducted every five years and will provide OANRP with trend analyses on vegetation cover and species diversity.

MU Monitoring Transects

Vegetation Monitoring Analyses

The mean alien vegetation cover in the understory was 33% across the MU. The 90% confidence interval for the mean was 28% to 37%. This percentage meets the management goal of 50% or less non-native cover in the understory. The mean alien canopy cover was 56% with 90% confidence that the mean was 50% to 62% (refer to MU Vegetation Monitoring table).

Pimenta dioica and *Fraxinus uhdei* are non-native species which OANRP is interested in tracking over time in order to learn more about the potential threat of these species. From the data collected for the 2008 MU vegetation monitoring *Pimdio* occurred in one out of 115 plots and *Frauhd* in six.

A large portion of the MU was fenced for the protection of Elepaio and will be weeded on a gradual basis. In areas around rare plant taxa OANRP will take a more aggressive approach to weed management (refer to Ecosystem Management Weed Control section). In 2010 OANRP will map out all areas that are suitable habitat for rare plant taxa. Once this is complete, vegetation monitoring will be conducted for these specific areas in order to set realistic vegetation percent cover goals.

MU Vegetation Monitoring Analyses

Variable	Count	Mean	StDev	*lower limit	*upper limit
NF	115	5.4	15.4	3.1	7.8
NS	115	9.5	15.6	7.1	11.9
NG	115	1.6	4.4	1	2.3
XF	115	3.8	12.4	1.9	5.7
XS	115	18.8	21.1	15.5	22
XG	115	11.2	21.1	8	14.5
Bryo	115	3	6.6	2	4
NoVegUS	115	53.6	34.5	48.3	59
NativeUS	115	15.2	21.7	11.8	18.5
AlienUS	115	32.9	29.3	28.4	37.4
NativeCanopy	115	15.9	25.3	12	19.9
AlienCanopy	115	56.3	38.1	50.5	62.2
TotalCanopy	115	68	31	63.2	72.8
*90% probability interval					

With the exclusion of the cliff and wet-mesic communities Ekahanui is a mixed mesic forest. The majority of management falls within this vegetation type and was analyzed separately to aid in setting WCA vegetation percent cover goals. A large portion of the mesic forest was dominated by well established monotypic Psidium cattleianum stands. This is the main reason for the low percentage of alien vegetation cover and low species diversity in the understory. The mixed mesic vegetation community's mean alien cover in the understory was 33% and 75% in the canopy. The mean native vegetation cover for the understory was 7.2% and 9.4% for the canopy (refer to the Mixed Mesic Vegetation Type Monitoring Analysis table).

Mixed Mesic Vegetation Type Monitoring Analysis

Variable	Count	Mean	StDev	*lower limit	*upper limit
Native US	86	7.2	12	5	9.3
Alien US	86	33.3	30.2	27.8	38.7
Nonveg	86	63.1	32.4	57.3	68.9
Native canopy	86	9.4	17.4	6.3	12.5
Alien canopy	86	74.8	24	70.5	79.1
*90% Confidence Level					

For the MU the alien species mean in the understory was 6.5 and 1.9 in the canopy. The native understory species mean was 6.2 and 1.5 in the canopy (Refer to MU Species Count Table). For the mixed mesic vegetation type the alien species mean in the understory was 4.7 and 2.3 in the canopy. The native understory species mean was 3.7 and 1.2 in the canopy (refer to the Mixed Mesic Vegetation Type Species Count table). This baseline data will be used to track species diversity of the MU over time.

MU Species Count

Variable	Count	Mean	StDev	*lower limit	*upper limit
Native US	115	6.2	6.3	5.2	7.1
Alien US	115	6.5	4.4	5.8	7.2
Native Canopy	115	1.5	2	1.2	1.8
Alien Canopy	115	1.9	1.3	1.7	2.1
*90% Confidence Level					

Mixed Mesic Vegetation Type Species Count

Variable	Count	Mean	StDev	*lower limit	*upper limit
Native US	86	3.7	3.8	3	4
Alien US	86	4.7	2.9	4.1	5.2
Native canopy	86	1.2	1.4	0.9	1.4
Alien canopy	86	2.3	1.17	2.1	2.5
*90% Confidence Level					

Vegetation Monitoring Response:

- Increase weeding efforts if the non-native vegetation goals are not being met in the MU.

Vegetation Monitoring Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2008- Sept.2009	• Create a current vegetation map	• 1-4
MIP YEAR 7 Oct.2010- Sept.2011 through MIP YEAR 10 Oct.2013- Sept.2014	• Conduct WCA based vegetation monitoring • Conduct MU vegetation monitoring in 2013	• 1-4

Surveys

Army Training?: No

Other Potential Sources of Introduction: NRS, pigs, public hikers

Survey Locations: Roads, Landing Zones, Fencelines, High Potential Traffic Areas.

Management Objective:

- Prevent the establishment of any new invasive alien plant or animal species through regular surveys along roads, landing zones, camp sites, fencelines, trails, and other high traffic areas (as applicable.

Monitoring Objectives:

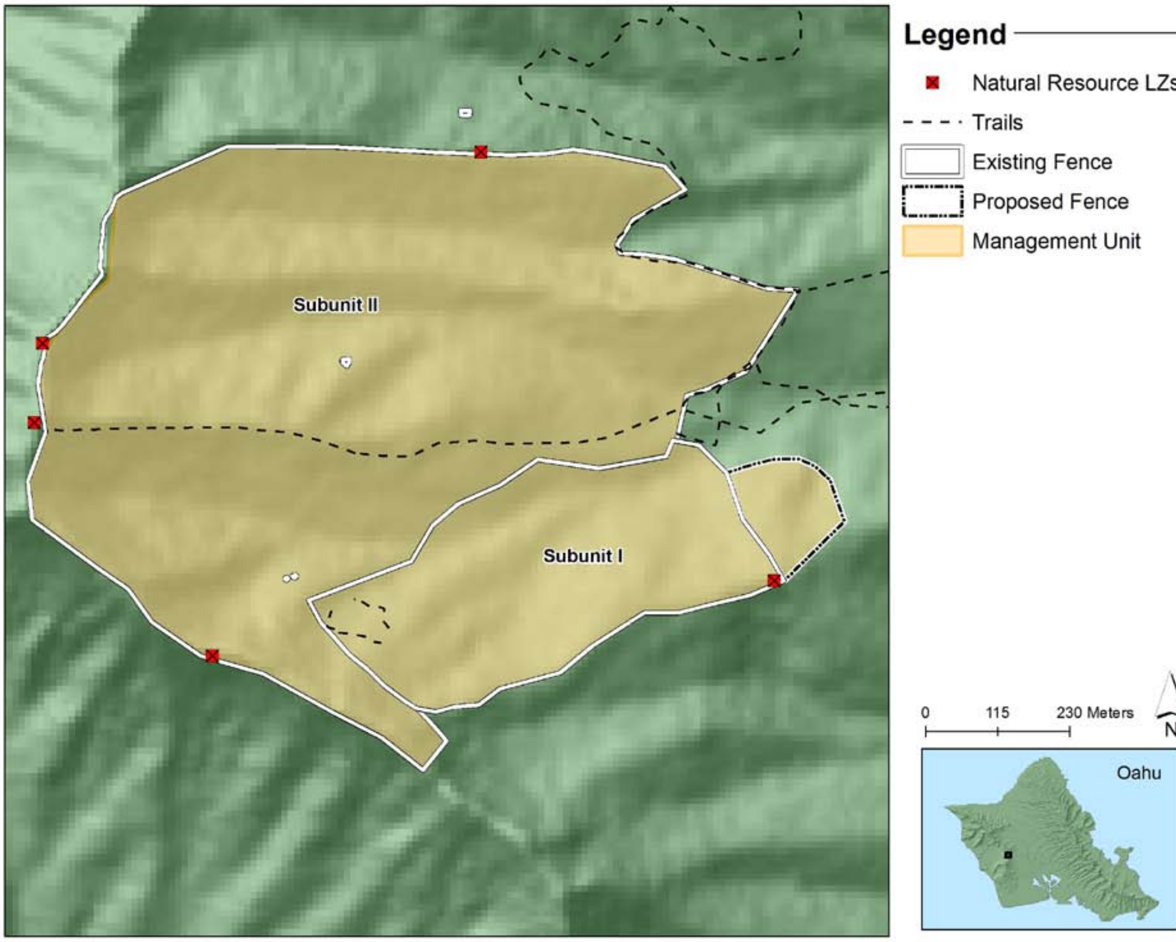
- Survey transects for weeds; this includes fencelines used as ungulate transects.
- Quarterly surveys of LZs (if used).
- Note unusual, significant or incipient alien taxa during the course of regular field work.

Surveys are designed to be the first line of defense in locating and identifying potential new weed species. At Ekahanui, landing zones are checked when used (not exceeding once per quarter). LZs within the MU include the following: 132, 136, Crestline (106), and the Ekahanui Trailhead (99). There are currently no weed surveys along transects, however will be established when ungulate transects are created along fences in the coming year. There are no road surveys established for the MU.

Weed Survey Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Survey LZs once per quarter (no use, no survey) • Create weed surveys along ungulate transects	• 1-4 • 1-4
MIP YEAR 7 Oct.2011- Sept.2012 through MIP YEAR 10 Oct.2013-Sept.2014	• Survey LZs once per quarter (no use, no survey) • Read weed surveys along ungulate transects quarterly	• 1-4 • 1-4

Survey Locations at Ekahanui



Incipient Taxa Control (ICAs)

Management Objectives:

- As feasible, eradicate high priority species identified as incipient invasive aliens in the MU by 2014.
- Conduct seed dormancy trials for all high priority incipients by 2014.

Monitoring Objectives:

Visit ICAs at stated re-visitation intervals. Control all mature plants at ICAs and prevent any immature or seedling plants from reaching maturity.

Management Responses:

- If unsuccessful in preventing immature plants from maturing, increase ICA re-visitation interval.

Incipient Control Areas, or ICAs, are drawn around each discrete infestation of an incipient invasive weed. ICAs are designed to facilitate data gathering and control. For each ICA, the management goal is to achieve complete eradication of the invasive taxa. Frequent visitation is often necessary to achieve eradication. Seed bed life/dormancy and life cycle information is important in determining when eradication may be reached; much of this information needs to be researched and parameters for determining eradication defined. NRS will compile this information for each ICA species as needed. Currently, there are no ICAs designated for Ekahanui MU.

The table below summarizes incipient invasive taxa at Ekahanui. Appendix 3.1 of the MIP lists significant alien species and ranks their potential invasiveness and distribution. Each species was given a weed management code: 0 = not reported from MU, 1 = incipient (goal: eradicate), 2 = control locally. While the list is by no means exhaustive, it provides a good starting point for discussing which taxa should be targeted for eradication in an MU. In many cases, the weed management code assigned by the MIP has been revised to reflect field observations.

While there are many species that were initially given a code 1, very few of these have been treated thus far as incipient with the goal of eradication. Those that are currently, or planned to be targeted for eradication within the MU are bolded and underlined. Subunit II has the majority of these weeds, and is the area least surveyed for the extent and potential for eradication of many of the species listed in the table below. These weeds will be evaluated in the next couple of years to determine status, and until then, will be targeted for removal during weed sweeps.

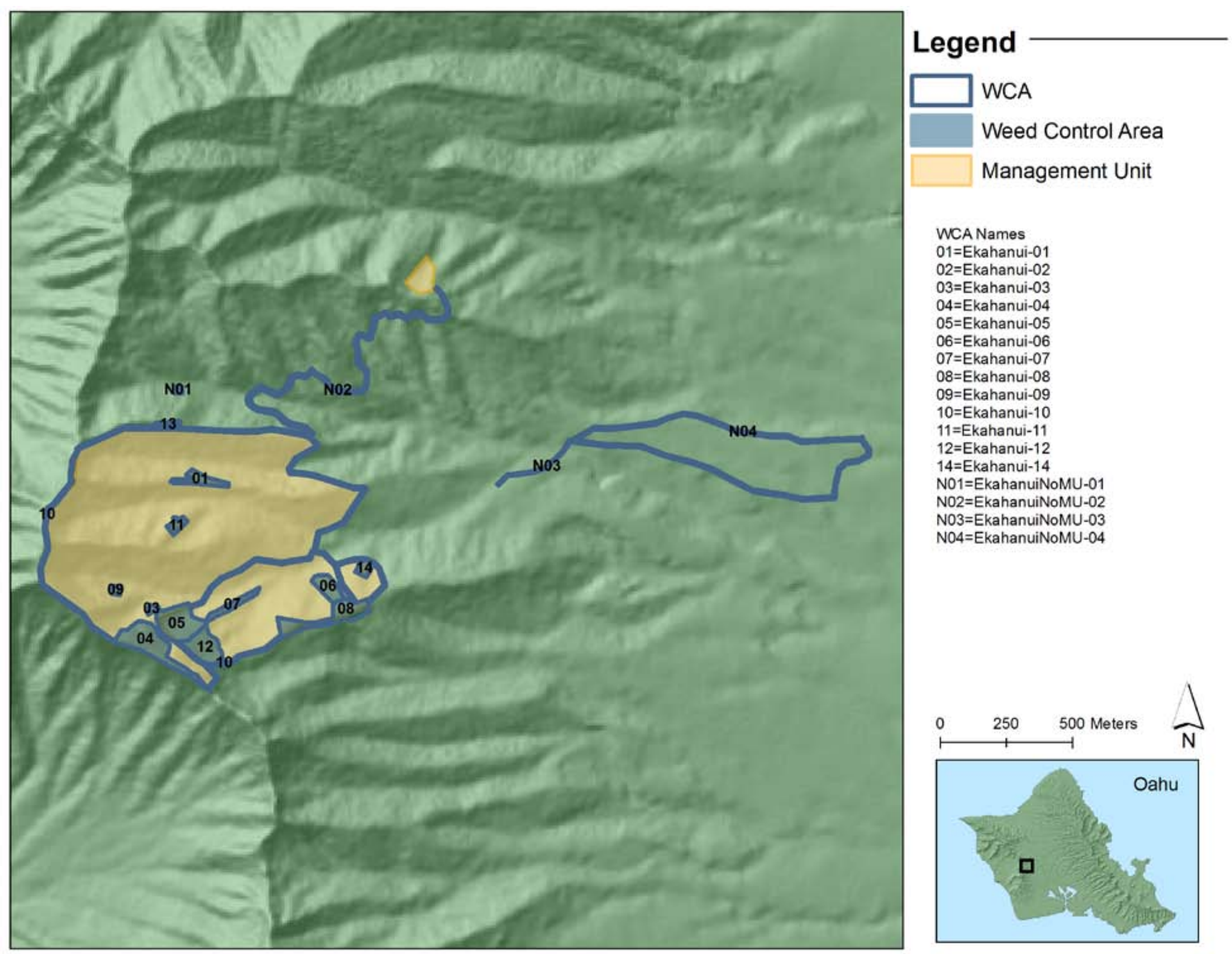
Summary of Potential ICA Target Taxa

Taxa	MIP weed man. code		Notes	No. of ICAs
	Original	Revised		
Chrysophyllum oliviforme	1	2	Further evaluation of this weed necessary; map individuals/groups of plants within the MU.	0
Dicliptera chinensis	1	2	Further evaluation of this weed necessary; map individuals/groups of plants within the MU.	0
<u>Ficus macrophylla</u>	**<u>1</u>**	**<u>1</u>**	**<u>Map individuals/groups of plants within the MU and create ICAs for this species. All trees should be targeted for removal.</u>**	**<u>0</u>**
Heliocarpus popayanensis	1	2	Further evaluation of this weed necessary; map individuals/groups of plants within the MU.	
Kalanchoe pinnata	1	2	Further evaluation of this weed necessary; map individuals/groups of plants within the MU.	0
Melaleuca quinquenervia	1	2	Further evaluation of this weed necessary; map individuals/groups of plants within the MU.	
<u>Panicum maximum</u>	**<u>1</u>**	**<u>1</u>**	**<u>Two *P. maximum* patches are within two different WCAs and are targeted with other grasses. However, *P. maximum* is targeted for eradication within the fence. *P. maximum* is widespread below the MU.</u>**	**<u>0</u>**
Pimenta dioica	1	2	Further evaluation of this weed necessary; map individuals/groups of plants within the MU.	0
Schefflera actinophylla	1	2	Further evaluation of this weed necessary; map individuals/groups of plants within the MU.	0
<u>Setaria palmifolia</u>	**<u>1</u>**	**<u>1</u>**	**<u>Several unmapped populations of this weed occur within the MU, however most is found along access trails. *S. palmifolia* will be treated along these trails to prevent further spread into MU. Populations found within the MU will be treated as ICAs.</u>**	**<u>0</u>**
Spathodea campanulata	1	2	Further evaluation of this weed necessary; map individuals/groups of plants within the MU.	0
<u>Sphaeropteris cooperi</u>	**<u>1</u>**	**<u>1</u>**	**<u>Further evaluation of this weed necessary: map individuals/groups of plants within the MU and create ICAs. This weedy fern should be targeted for eradication. .</u>**	**<u>0</u>**

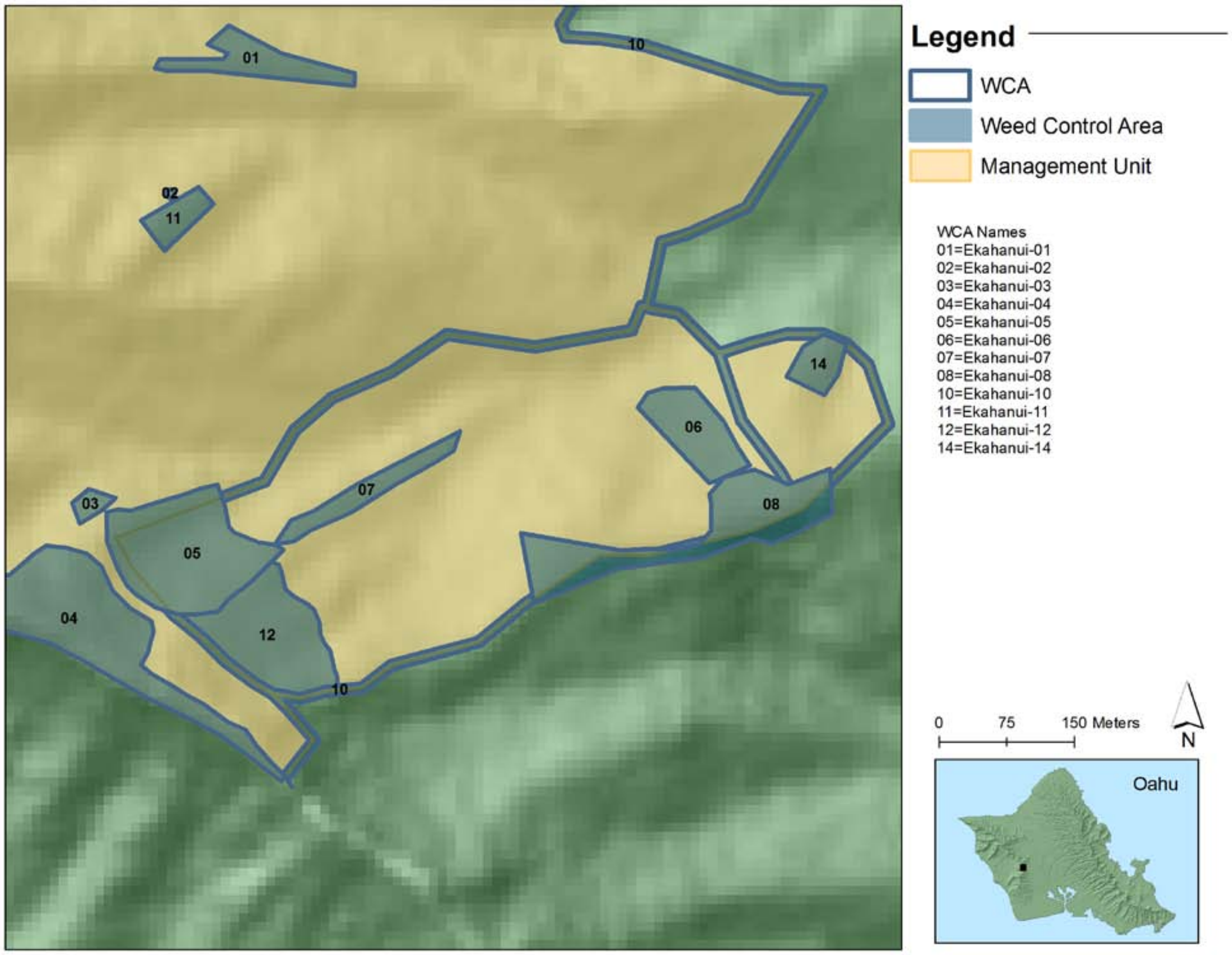
ICA Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Evaluate list of revised species (see table above) to assess control/eradication potential. Review monitoring weed presence data to aid in evaluation. • Conduct surveys and create ICAs for species designated, but not yet targeted for eradication (Table above)	• 1-4 • 1-4
MIP YEAR 7 Oct.2011-Sept.2012 through MIP YEAR 10 Oct.2013- Sept.2014	• Treat any new ICAs quarterly until frequency of re-visitation is reduced or no longer needed	• 1,3

Weed Control Areas at Ekahanui



Weed Control Areas at Ekahanui



Ecosystem Management Weed Control (WCAs)

MIP Goals:

- Within 2m of rare taxa: 0% alien vegetation cover
- Within 50m of rare taxa: 25% or less alien vegetation cover
- Throughout the remainder of the MU: 50% or less alien vegetation cover

Management Objectives:

- Maintain 50% or less alien vegetation cover in the understory across the MU.
- Reach 50% or less alien canopy cover across the MU in the next 5 years.

Management Responses:

- Increase/expand weeding efforts if MU vegetation monitoring (conducted every 3 years) indicates that goals are not being met.

Weed control began in Ekahanui with the efforts of The Nature Conservancy (TNC). Most of this effort has taken place in Subunit I. *Passiflora suberosa,* which is pervasive throughout the MU, was cleared out of the many *Pisonia* dominated gulches, and *Psidium cattleianum* was thinned from native canopy. Hundreds of endangered plants were planted in this MU by TNC, and many more followed by Army

Natural Resources Staff (NRS). Reintroductions of common natives were also used by TNC to restore habitat within the MU. Much of the weed control conducted by NRS in Subunit I follows the actions set-forth by TNC staff.

The Ekahanui Subunit II fence was completed in 2009. There are a few WCAs within this subunit, but for the most part they are small and were targeted for weed control only as needed around several rare plant species. Further assessment on the ground and vegetation monitoring data will be used to create new larger WCAs around native forest patches that will be more comprehensive and improve more habitat for rare plants. The entire Subunit II will not be broken up into WCAs as is the case with some other MUs, due to the fact that most of Subunit II is highly degraded.

A large concern with weed control in Ekahanui MU is its potential impacts on Oahu Elepaio. The MU has one of the largest breeding populations of Elepaio, and impacts of weed control during breeding season are not well understood. It is reasonable to assume that killing potential foraging and nest trees during breeding season has the potential to be at the very least disruptive to the endangered bird. It is also reasonable to assume that Elepaio have evolved with native forest components and would persist better within restored habitat.

Elepaio territories are surveyed and mapped each year and within these territories canopy weed control is prohibited during breeding. Restricted canopy control may be conducted during ‘off’ season, with the guidance of the Elepaio specialists.

General WCA Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 7 Oct.2010-Sept.2011	• Evaluate WCAs in Subunit II. Use geographical and vegetation data; change and create new if necessary. • GPS boundaries of all WCAs. Use landmarks to mark in field • GPS and maintain trails	• 2 • 3 • 1

WCA: Ekahanui-01 Airplane Ridge

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native cover

Targets: *P. cattleianum* and *S. terebinthifolius* is targeted for gradual removal from the overstory. *P. suberosa* densities are surprisingly low in this WCA given high densities elsewhere in the MU. Therefore it is targeted on all weed sweeps.

Notes: This WCA occurs around a wild population of *C. agrimonioides* var. *agrimonioides.* Weed control is currently conducted across the north facing slope on a large ridge around the many small patches of this rare grass. Overstory canopy consists mostly of *P. cattleianum* and *S. terebinthifolius* is gradually removed to reduce large light gaps. Alien grass species are handcleared around the wild *C. agrimonioides* var. *agrimonioides.* Grass specific herbicides may be used to treat alien grass across the ridge in the future, but only after thorough surveys have been conducted to identify all individuals. After all these small patches are thoroughly weeded, larger sweeps between all these patches will begin thus creating continuous habitat across the slope.

G. robusta is prevalent throughout the ridge and is controlled during weed sweeps. It is also sometimes treated as the sole target, and is girdled with chainsaws and treated with herbicide (a more efficient way to treat large numbers in a day).

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013-Sept.2014	• Conduct weed control around all Cenagr A groups annually. Control both understory and canopy weeds; remove canopy weeds gradually. • Evaluate need for alien grass control; control if necessary	• 2,4 • 4

WCA: Ekahanui-03 Small *S. kaalae* fences

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native cover

Targets: Understory weeds such as *C. parsitica* and *R. rosifolius*

Notes: This is a very small WCA in Subunit II around a small population of *S. kaalae* individuals.

Weed control is conducted directly around the plants, and in the surrounding area. Mostly understory weeds are targeted to improve habitat for the wild plants.

This WCA may be included in another WCA or expanded dramatically in the future as the Subunit II WCAs are further developed. Regardless of this action, weed control will continue annually around the *S. kaalae.*

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013-Sept.2014	• Conduct weed control directly around *S. kaalae* and in surrounding area	• 3

WCA: Ekahanui-04 Upper Cliffs to Crestline

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native cover

Targets: Understory and canopy weeds, targeting *P. cattleianum* and *S. terebinthifolius* for gradual removal.

Notes: Weed control is focused in this area around *P. princeps* var. *princeps, T. lepidotum,* and *A. mustelina.* The area is steep, and weed control is therefore conducted in smaller patches between cliff areas. Removal of alien vegetation is targeted for slow removal as there is a mix of native and non-native plants throughout the WCA. Because there are snails in the area, alien trees and shrubs will be girdled, and not cut down. Grass control is important in maintaining native habitat for the cliff-dwelling rare plants. However, grass sprays are difficult given the steep terrain. Grass control will be conducted only after thorough surveys of grass locations are completed, thereby facilitating safer sprays.

Actions:

Year	Action	Quarter
MIP YEAR 5 Oct.2008-Sept.2009	• Conduct weed control through WCA annually • Control grasses throughout WCA as needed annually	• 1,3 • 1
MIP YEAR 6 Oct.2009- Sept.2010	• Conduct weed control through WCA annually • Control grasses throughout WCA as needed annually	• 1,3 • 1
MIP YEAR 7 Oct.2010- Sept.2011	• Conduct weed control through WCA annually • Control grasses throughout WCA as needed annually	• 1,3 • 1
MIP YEAR 8 Oct.2011- Sept.2012	• Conduct weed control through WCA annually • Control grasses throughout WCA as needed annually	• 1,3 • 1
MIP YEAR 9 Oct.2012- Sept.2013	• Conduct weed control through WCA annually • Control grasses throughout WCA as needed annually	• 1,3 • 1

WCA: Ekahanui-05 Reintroduction Zone

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native cover

Targets: Understory weeds are currently the largest target in this WCA, however overstory *P. cattelianum* and *S. terebinthifolius* is targeted for gradual removal where it is found in mostly native areas. There is also a small stand of *Ricinus communis* (Castor Bean) within the WCA that is targeted for removal from the WCA.

Notes: Due to the long history of weeding by The Nature Conservancy and later by NRS in this area, there is a high density of native cover. Given this, along with the appropriate habitat for many rare species in this WCA, many reintroductions are established here. These species include: *C. agrimonioides* var. *agrimonioides, C. grimesiana* subsp. *obatae*, *C. pinnatifida* (TNC reintroduction), *D. subcordata, P. mollis, S. kaalae*. There are also wild *S. kaalae* and an *A. macrococcus* var. *macrococcus* individual within the WCA.

While the areas around the rare plants are the most native, there are still a few larger stands of *P. cattleianum* throughout the WCA. These weeds are targeted for gradual removal during weed sweeps, although there is growing interest to remove some of these monotypic stands using the aid of the chipper. Removal should not affect the rare plants established there as very few are directly under the *P. cattleianum* stands. The potential for chipper use in this WCA will be further evaluated, with particular consideration of Elepaio.

Large scale grass control has not yet been necessary in this WCA as most of it is gulch terrain. However, there is a fair amount of *M. minutiflora* growing with the *C. agrimonioides* var. *agrimonioides* reintroduction ridge. Grass is hand pulled directly around the rare grass, because the common herbicide used in sensitive areas is a grass specific herbicide. There is still potential for using this herbicide within the WCA, but only after all the *C. agrimonioides* var. *agrimonioides* individuals have been identified and it is sprayed far enough away to prevent the effects of drift.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009- Sept.2010	• Sweep entire WCA annually • Evaluate potential for chipper use within WCA • Control *P. cattleianum* with chipper as needed	• 3 • 1 • 3
MIP YEAR 7 Oct.2010- Sept.2011 through MIP YEAR 10 Oct.2013- Sept.2014	• Sweep entire WCA annually • Handpull/treat *M. minutiflora* around *C. agrimonioides* var. *agrimonioides* as needed	• 3 • 3

WCA: Ekahanui-06 Palai Gulch

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native cover

Targets: Understory weeds include: *R. rosifolius* and *Christella paracitica. P. suberosa* is also controlled.

Notes: Nicknamed Palai Gulch for its many native ferns, this WCA occurs around reintroduced *C. grimesiana* subsp. *obatae, U. kaalae* (TNC planting) and *S. kaalae* *A. sandwicense* is also proposed for reintroduction in the WCA. Understory weeds such as *Rubus rosifolius* and *Christella paracitica* compete with native ferns, and are the most common weeds controlled during weed sweeps. There is a significant amount of *P. cattleianum* that circles about half way around the WCA, however, control to push these dense stands back is limited by the fact that the WCA is within an Elepaio territory. Canopy weed control will not be conducted during Elepaio breeding season to avoid disrupting foraging and nesting behavior. Canopy weed control, if any, will only be conducted outside of Elepaio breeding season, and in consultation with the Elepaio specialist.

Weed control has expanded in this WCA further up the gulch over the years. Recent efforts have focused on clearing understory weeds and *P. suberosa* in a more open area where A. sandwicense are planned for reintroduction. This type of habitat continues further up the gulch, and will continue to be cleared.

Due to the shady canopy, the weedy grass *Oplismenus hirtellius*, thrives in the gulch and throughout the WCA. Annual grass sprays will be conducted to control this grass.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009- Sept.2010 through MIP YEAR 10 Oct.2013-Sept.2014	• Conduct weed control through WCA biannually. • Spray grasses annually as needed	• 2,4 • 3

WCA: Ekahanui-07 Silk Oak Ridge

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 50% non-native cover

Targets: *G. robusta* because the ridge is a seed source for the rest of the MU.

Notes: This WCA encompasses a ridge that was forested with *G. robusta*. The mid canopy below the *G. robusta* canopy consists of *P. cattleianum*, and the understory is mostly open, with patches of *M. strigosa*. TNC planted hundreds of small *A. koa* along this ridge, however likely due to the overstory canopy of *G. robusta,* the survival rate was variable. No large scale removal of any canopy has yet been conducted. Removal of anything on this ridge will be very gradual, especially the *G. robusta*. Elepaio also inhabit the gulch adjacent to this ridge and therefore no control of any canopy weeds will be conducted during Elepaio breeding season. Assessment of strategies to reduce numbers of G. robusta, encourage *A. koa* to thrive, and restore the ridge still needs to be made.

Actions:

Year	Action	Quarter
MIP YEAR 8 Oct.2011- Sept.2012 through MIP YEAR 10 Oct.2013-Sept.2014	• Assess potential for *G. robusta* removal. *P. cattleianum* may be removed too.	• 2

WCA: Ekahanui-08 South Fenceline

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 50% non-native cover

Targets: Primary target in this WCA is *Panicum maximum.*

Notes: This WCA was created mostly to control the alien, *P. maximum* inside the fence, but also where it occurs up to about 25 meters outside of the fence. *P. maximum* is a fire fuel, and elimination from within the fence as well as creating a buffer on the outside of the fence is desired. Maintenance such as clearing shrubs and trees of a camp DZ, and an LZ also fall into and are reported in this WCA. The majority of this WCA is alien dominated and is not slated for further ecosystem restoration.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 9 Oct.2013-Sept.2014	• Treat *P. maximum* biannually. • Maintain camp DZ and LZ as needed so functional	• 1,3 • 1

WCA: Ekahanui-09 Alectryon

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native

Targets: *S. terebinthifolius*

Notes: Not much weed control has taken place in this WCA. Weeding has been conducted to do some small scale clearing around *A. macrococcus* var. *macrococcus* to allow more light for the canopy tree. Snails are also found in the area. This WCA will be evaluated annually and weed control will follow if necessary. This WCA may be lumped in to new WCAs or expanded in the future, as subunit II is divided into WCAs to facilitate weed control tracking.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013-Sept.2014	• Conduct weed control annually around Alemac D, Achmus trees, native forest patch	• 2

WCA: Ekahanui-10 Fenceline

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native

Targets: Target fallen trees that may affect integrity of fence, and thick understory along fenceline that may obscure view of bottom of fence.

Notes: This WCA accounts for all weed control that takes place in order to maintain the fenceline and facilitate fence checks. Actions for this WCA may include: removing downed trees, treating thick understory, and spraying grass as needed along perimeter fences of subunit I and II. Weed control needs for this WCA will be assessed and conducted quarterly as needed in conjunction with fence checks.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013-Sept.2014	• Assess/control weeds along perimeter fences of Subunit I and II as needed	• 1-4

WCA: Ekahanui-11 Cenagragr Eka-C Site

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native cover

Targets: Understory weeds directly around remaining reintroduced *C. agrimonioides* var. *agrimonioides.*

Notes: Weed control is conducted in this area because of a reintroduction of *C. agrimonioides* var. *agrimonioides*. However, the site has since been determined not suitable to establish the reintroduction necessary, and no more plants will be planted here. Understory weed control will continue directly around the remaining plants (many have died), but greater habitat restoration here will not be conducted.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013-Sept.2014	• Conduct weed control around remaining *C. agrimonioides* var. *agrimonioides*	• 3

WCA: Ekahanui-12

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native cover

Targets: Control all understory weeds and *P. suberosa*, and gradually treat *P. cattleianum* and *S. terebinthifolius.*

Notes: There are *A. mustelina* and several TNC rare plant reintroductions in this newly expanded WCA. Overall, this WCA is similar in species composition and range of topography to its neighbor adjacent on the same contour, WCA-05. WCA-12 still has quite a few weedier patches, but will be weeded through to eventually have one continuous contour of suitable habitat for a number of rare taxa along the top of Subunit I. Since much of this WCA has not been weeded, *P. suberosa* is a major weed to target on weed sweeps through new areas. Once initial treatment of huge clumps and clusters that grow in to the canopy are treated, control thereafter is much easier and impact to native canopy is sustained.

P. cattleianum in the gulches, and *S. terebinthifolius* on the ridges will be targeted for gradual removal. Grass sprays will be conducted annually.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013-Sept.2014	• Conduct weed sweep across WCA annually. • Spray grass annually	• 2 • 2

WCA: Ekahanui-13 New Cenagragr Eka-D Site

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native

Targets: Understory weeds, gradual removal of *P. cattleianum* and *S. terebinthifolius* from canopy.

Notes: Weed control has only been conducted once at this site, and began in preparation for a reintroduction of *C. agrimonioides* var. *agrimonioides* that will be planted in quarter 3, 2009. Additional weed sweeps will be conducted annually across the slope for understory weeds through native patches of forest. Canopy weeds of *P. cattleianum* and *S. terebinthifolius* will be removed gradually. All *G. robusta* will be treated during weed sweeps.

There is a small patch of *P. maximum* that was noted during the last weed control effort, but has not yet been treated. Treatment will begin in quarter 1 of 2010, and will be set for a biannual schedule until eradicated. Other grasses throughout the WCA may call for control as well, and will be paired with the *P. maximum* effort.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013-Sept.2014	• Sweep through WCA annually • Spray *P. maximum* and other grasses and throughout WCA biannually as needed	• 4 • 2,4

WCA: Ekahanui-14 Abutilon

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native

Targets: Understory weeds such as *Lantana camara*

Notes: This WCA is highly degraded, and minimal weed control is conducted around a small wild population of *A. sandwicense.* The slope that the plants are on is somewhat steep and has soft soil. Heavy foot traffic around the plants is not desired. Weed control of nearby *L. camara* patches and thinning of *S. terebinthifolius* will be conducted annually along with rare plant monitoring to reduce impact to the population. Common reintroductions of *A. koa* or *S. oahuensis* may be considered for the ridge next to the plants to aid in stabilization of soil and to improve overall habitat.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013-Sept.2014	• Weed around *A. sandwicense* population during annual rare plant monitoring	• 2

WCA: Ekahanui NoMU-01

Veg Type: Mesic Mixed Forest

MIP Goal: Weed 2m around *D.subcordata* individuals

Targets: *S. terebinthifolius.*

Notes: This WCA occurs outside of the MU, however is still within Ekahanui drainage. Weed control is conducted primarily around a small wild, fenced population of *D. subcordata*. Weeding is done only directly around the plant to keep it alive for genetic storage collection. Understory weeds and grasses are treated. No canopy is weeded; however *S. terebinthifolius* will be cleared if fallen on the fence.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013-Sept.2014	• Conduct understory weed control within small fence; maintain fence free of fallen debris	• 2

WCA: Ekahanui NoMU-02

Veg Type: N/A

MIP Goal: N/A

Targets: *P. maximum* and *S. terebinthifolius*

Notes: This WCA was created along the contour trail north of the Ekahanui fence. Weed control is conducted to facilitate access to the trail, particularly for potential fire response. Weed control along this trail was a regular TNC action, but has not yet been maintained regularly by NRS. NRS need to assess the importance of maintaining this section of trail, and discuss responsibility with the new land owners.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013-Sept.2014	• Discuss trail clearing with new land owners. • Clear trail (use volunteer groups when available) as needed.	• 4 • 4

WCA: Ekahanui NoMU-03

Veg Type: N/A

MIP Goal: N/A

Targets: *P. maximum* and *S. palmifolia*

Notes: Similar to NoMU-02, this WCA is also maintained along a trail for access into Ekahanui MU. Unlike the contour trail, the access trail to Ekahanui is used very regularly by NRS. Therefore, there has been more regular maintenance in this WCA. The trail is sprayed to prevent the spread of *P. maximum* and *S. palmifolia* further along the trail, ultimately preventing its spread into the MU. *S. terebinthifolius* and various shrubs will also be trimmed off the trail if necessary. Responsibility for maintaining this WCA will be discussed with the new land owners.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013-Sept.2014	• Spray grass along Ekahanui Access trail	• 3

WCA: Ekahanui NoMU-04

Veg Type: N/A

MIP Goal: N/A

Targets: *P. maximum*

Notes: This WCA is maintained to facilitate safety along the Ekahanui Access Road, and the trailhead LZ. Most of the maintenance for this WCA involves spraying *P. maximum* continual maintenance of the road will also need to be worked out with the future landowners.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013-Sept.2014	• Discuss maintenance schedule with new land owners • Spray grass along Ekahanui Access Road and around LZ.	• 3 • 3

1.4.1.5 Rodent Control

Threat level: High

Control method: Bait station & Snap trap grids (Current) / Trap Out grid (Winter 2010)

Seasonality: Plants & Snails: Year-Round / Elepaio: Breeding Season (January – June)

Number of bait grids: 5 (29 bait stations, 58 snap traps)

Elepaio territories: 25 (70 bait stations, 120 snap traps)

Primary Objective:

- To maintain rat/mouse populations to a level that facilitates stabilized or increasing plant, snail, and Elepaio populations across the MU by the most effective means possible.

Management Objective:

- Continue to maintain bait station and snap trap grids (localized control) around individual *Achatinella mustelina*, rare plant, and Elepaio pair territories/populations in the short term.
- Establish a large scale trapping grid (MU control) for the control of rats over the entire MU in winter 2010.
- Less than 10% activity levels in rat tracking tunnels.

Monitoring Objectives:

- Monitor tracking tunnels to determine rat activity within the trapping grid twice a quarter.
- Monitor ground shell plots for predation of *A. mustelina* by rats.
- Monitor *Cyanea grimesiana* subsp. *obatae* and *Plantago princeps* var. *princeps* as a focal species to determine the occurrence of fruit/plant predation by rats.

Monitoring Issues:

- An acceptable level of rat activity, which promotes stable or increasing *A. mustelina* and *C. grimesiana* subsp. *obatae*, *P. princeps* var. *princeps*, and Elepaio populations, has not been clearly identified. It could be very low, less than 2%, or very high, 40%; in New Zealand, studies have shown that rat activity levels of 10% are low enough to maintain certain rare bird populations. A 10% activity level may also be the most achievable level using a large scale trapping grid. In order to determine this acceptable level, more intensive monitoring of rare resources is required.

Localized Rodent Control:

- Localized control consists of bait station and snap trap grids deployed around discrete populations of *A. mustelina*, *Plantago princeps* var. *princeps*, and *C. grimesiana* subsp. *obatae* throughout the year at four to six week intervals. Rat control efforts for Elepaio management are focused on individual breeding pair territories only during the breeding season (January through June) and maintained at two week intervals. These small scale control areas consist of bait stations and snap traps are over areas less than .25 ha each.

Localized Rodent Control Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Plapripri EKA-A, C grid restock, every 4 weeks • Achmus EKA-A-C, E-F grid restocks, every 4 weeks • Cyagrioba EKA-B grid restock, every 4 weeks • Elepaio territory rat control, every 2 weeks • Monitor ground shell plots 1x per year • Phase out localized bait grids	• 1-4 • 1-4 • 1-4 • 1-2 • 4 • 2

MU Rodent Control:

- To protect the ecosystem as a whole, MU wide rat control will be initiated in the winter of 2010 through the use of a large scale trapping grid. The large scale trapping grid of snap trap boxes will follow the New Zealand Department of Conservation's current Best Practices for rat trapping. If the trap out grid proves to be insufficient, other methods will be considered (hand broadcast of rodenticide). This pilot project will be designed to run for several years. Monitoring of rat activity via tracking tunnels will be vital in determining whether control is having the desired effect, as will intensive monitoring of rare snails, plants, and Elepaio populations.

MU Rodent Control Actions:

Year	Action	Quarter
MIP YEAR 6 Oct. 2009-Sept.2010	• Install and monitor tracking tunnels 2x a quarter • Install/deploy wooden snap trap box grid across MU • Run snap trap grid daily during initial knockdown phase • Run snap trap grid 2x month once initial knockdown complete; this frequency will in part be determined by the acceptable level of rat activity. • Run snap trap grid 1x month outside of the Elepaio breeding season • Monitor ground shell plots 1x per year • Monitor Cyagri & Plapripri for rat predation • Evaluate efficacy of MU-wide grid, decide how to modify actions and continue project	• 1-4 • 1 • 1 • 2 • 1-2 • 3-4 • 1-4 • 4
MIP YEAR 7 Oct.2010-Sept.2011 Through MIP YEAR 9 Oct.2012-Sept.2013	• Run snap trap grid 2x month during Elepaio breeding season • Run snap trap grid 1x month outside of the Elepaio breeding season • Monitor tracking tunnels, 6x a year • Monitor ground shell plots 1x per year • Monitor Cyagri & Plapripri for rat predation • Evaluate efficacy of MU-wide grid, decide how to modify actions and continue project	• 1-2 • 3-4 • 1-2 • 1-4 • 4

1.4.1.6 Slug Control

Species: *Limax maximus, Deroceras leave*

Threat level: High

Control level: Localized

Seasonality: Wet season (September-May)

Number of sites: 2 (*Cyanea grimesiana* subsp. *obatae* populations)

Primary Objective: Reduce slug population to levels where germination and survivorship of rare plant taxa are optimal.

Management Objective:

- Begin a pilot slug control program in the fall of 2011 using Sluggo around the *Cyanea grimesiana* subsp. *obatae* populations if additional Special Local Needs labeling is approved by USFWS and HDOA.
- By 2013, reduce slugs by at least 50% of estimated baseline densities around the *Cyanea grimesiana* subsp. *obatae* populations through a pilot control program.

Monitoring Objectives:

- Determine slug species present and estimate baseline densities using traps baited with beer in the fall of 2010.
- Annual census monitoring of *Cyanea grimesiana* subsp. *obatae* seedling recruitment following fruiting events.
- Annual census monitoring of slug densities during wet season

Effective molluscicides have been identified (Sluggo) and initial control programs are ongoing in Kahanahaiki. A pilot slug control program using Sluggo could begin at Ekahanui in the fall of 2011 should slug and *Cyanea grimesiana* subsp. *obatae* monitoring reveal slug damage to plants. If large-scale rat control is implemented, plots to monitor the effect of predator removal on slug population (if not already determined in other areas) may be considered.

Slug Control Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Monitor slug activity at *Cyanea grimesiana* subsp. *obatae* via traps baited with beer	• 1-4
MIP YEAR 7 Oct.2010-Sept.2011	• Deploy slug bait around *Cyanea grimesiana* subsp. *obatae* frequency to be determined during research phase.	• 1-4
MIP YEAR 8 Oct.2012-Sept.2013	• Maintain slug bait around *Cyanea grimesiana* subsp. *obatae*	• 1-4

1.4.1.7 Predatory Snail Control

Species: *Euglandina rosea* (rosy wolf snail), *Oxychilus alliarus* (garlic snail)

Threat level: High

Control level: Localized

Seasonality: Year-Round

Number of sites: 7 *Achatinella mustelina* sites

Acceptable Level of Activity: Unknown

Primary Objective: Reduce predatory snail populations to a level optimal for *A. mustelina* survival.

Management Objective:

- Continue to develop better methods to control predatory snails.
- Keep sensitive snail populations safe from predatory snails via currently accepted methods (such as hand removal of alien snails, construction of barriers which prevent incursion from alien snails).

Monitoring Objectives:

- Annual or every other year census monitoring of *A. mustelina* population(s) to determine population trend.
- Annual searches for predatory snails to confirm their absence or presence in proximity to *A. mustelina.*

No baits have been developed for the control of predatory snails. Little is known regarding their distribution and prey preference. Control is limited to hand removal. Visual searches are time-consuming, difficult, and not feasible over large areas and in steep terrain. It is also unknown whether predatory snail populations are reduced by hand removal. High numbers of *E. rosea* have been found in this MU at elevations between 1000 and 2000 feet. No searches for *O. alliarus* have been completed.

Field trials using detector dogs (Working Dogs for Conservation, MT), to find and eliminate *E. rosea* took place in this unit from February – March 2009. Results were presented as a poster at the 2009 Hawaii Conservation Conference. This poster may be viewed online at: http://www.botany.hawaii.edu/faculty/duffy/DPW/HCC-2009/Dog_Poster.pdf

Preliminary observations suggest that dogs are unable to outperform humans in detecting snail presence.

Predatory Snail Control Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009-Sept.2010	• Determine if any *E. rosea* or *O. alliarus* snails are present at the *A. mustelina* sites	• 1-4
OIP YEAR 4-6 Oct.2010- Sept.2013	• Implement control as improved tools become available	• 1-4

1.4.1.8 Ant Control

Species: *Solenopsis papuana, Plagiolepis alludi*

Threat level: Low

Control level: Only for new incipient species

Seasonality: Varies by species, but nest expansion observed in late summer, early fall

Number of sites: 3 (Mamane Gulch, *Amastra* Site and *Drosophila montgomeryi* location Subunit II)

Acceptable Level of Ant Activity: Current level acceptable

Primary Objective: Eradicate incipient ant invasions and control established populations when densities are high enough to threaten rare resources.

Management Objective:

- If incipient species are found and deemed to be a high threat and/or easily eradicated locally (<0.5 acre infestation) begin control using a bait containing Hydramethylnon (Amdro, Maxforce or Seige).

Monitoring Objective:

- Continue to sample ants at human entry points (landing zones, fence line, trails) a minimum of once a year. Use samples to track changes in existing ant densities and to alert OANRP to any new introductions.
- Sample ants at *Drosophila montgomeryi* site annually, as these may pose a threat to immature larvae.

Ants have been documented to pose threats to a variety of resources, including native arthropods, plants (via farming of Hemipterian pests), and birds. The distribution and diversity of ant species in upland areas on Oahu, Ekahanui, has only begun to be studied and changes over time. Impacts to the rare species present in Ekahanui remain unknown, but it is likely they are having some type of effect on the ecosystem at large. The OANRP has already conducted some surveys across Ekahanui to determine which ant species are present and where they are located. Surveys were conducted using a standardized sampling method (see Appendix 6 Invasive Ant Monitoring Protocol). *Solenopsis papuana* were found at high elevations (>2000 ft.) in low densities.

Ant Control Actions:

Year	Action	Quarter
OIP YEAR 6 Oct.2009-Sept.2010	• Conduct additional surveys for ants as needed • Analyze results of surveys, develop management plan	• 1, 2 • 3,4
OIP YEAR 6 Oct.2009-Sept.2010 through OIP YEAR 9 Oct.2012-Sept.2013	• Implement control if deemed necessary • Conduct arthropod survey along transects in anticipation of rat trap out project.	• 1-4

1.4.1.9 Fire Control

Management Objective:

- To prevent fire from burning any portion of the MU at any time.

Threat Level:

- Low

Available Tools:

- Fuelbreaks, Visual Markers, Helicopter Drops, Wildland Fire Crew, Red Carded Staff

Actions:

- Grass control in the MU is discussed in the Weed Control section of the plan. Appropriate WCAs include the following: Ekahanui-08 and NoMU-03. Fallow agricultural fields run below the management unit. Since there are no active crops on these lands, the fields have begun to fill in with *P. maximum* and a variety of other weeds. This fuel load below the MU is concerning and NRS would like to begin a dialogue with land managers of these fields. Additionally, a fire management plan and this issue of *P. maximum* loads should be addressed with the new Honouliuli land owner when land acquisition is finalized.

Preventative Actions

There is little infrastructure/construction which would be helpful to reduce fire threat. NRS will focus on maintaining good communication with the Wildland Fire Working Group to facilitate positive on-the-ground fire response. NRS will maintain red-carded staff to assist with fire response.

1.4.2 Helemano Ecosystem Restoration Management Plan

OIP Year 3-7, Oct. 2009 - Sept. 2014

MU: Helemano

1.4.2.1 Overall OIP Management Goals:

- Ensure the plant communities within the MU form a stable, native-dominated matrix which will be able to support stable populations of the OIP rare species.
- Control ungulate, rodent, invertebrate, and weed threats to support stable populations of IP taxa. Implement control methods by 2014.

1.4.2.2 Background Information

Location: Northern Leeward Koolau Mountains; Helemano summit

Land Owner: Kamehameha Schools, US Army lease

Land Manager: Army Natural Resources

Acreage: 113.2 acres

Elevation range: 2,400-2,700 ft.

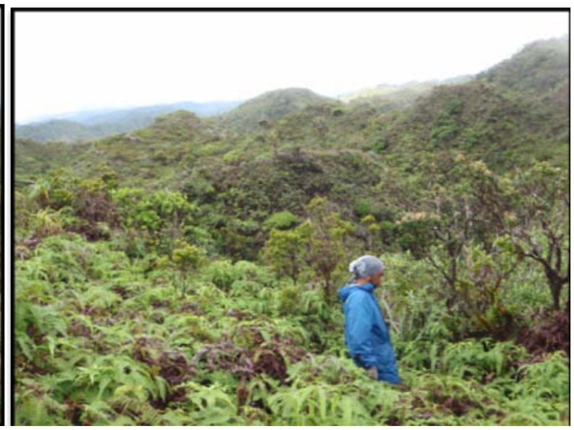
Description: The Helemano MU is located on the leeward side of the Northern Koolau Mountains. The MU contains a windswept summit area with gentle terrain leading into moderately steep slopes. Helemano is comprised of two main drainage systems, the southern and northern drainages. The southern drainage contains the headwaters of Helemano stream. This drainage gets deeper with steep sides as one travels further from the summit. In contrast, the northern drainage is shallow with gradual slopes.

The 2008 OIP places the Opaeula and Helemano areas into the same Management Unit (MU). This management plan focuses on the Helemano portion of the MU.

Native Vegetation Types

Koolau Vegetation Types
Wet forest
Canopy includes: *Metrosideros* spp., *Cheirodendron* spp., *Cibotium* spp, *Ilex anomala*, *Myrsine sandwicensis*, and *Perrottetia sandwicensis*. Understory includes: Typically covered by a variety of ferns and moss; may include *Dicranopteris linearis, Melicope* spp., *Cibotium chamissoi, Machaerina angustifolia*, *Nertera granadensis, Hedyotis centranthoides*, *Nothoperanema rubiginosa*,, *Sadleria sp.* and *Broussaisia arguta*.
NOTE: For MU monitoring purposes vegetation type is mapped based on theoretical pre-disturbance vegetation. Alien species are not noted.
NOTE: For MU monitoring purposes, vegetation types were subdivided using topography (gulch, mid-slope, ridge). Topography influences vegetation composition to a degree. Combining vegetation type and topography is useful for guiding management in certain instances.

Primary Vegetation Types at Helemano

Helemano windswept summit, and gentle terrain in the northern Helemano drainage

OIP Rare Resources

Organism Type	Species	Pop. Ref. Code	Population Unit	Management Designation	Wild/ Reintroduction
Snail	*Achatinella sowerbyana*	KLO-BB,CC,D, E, EE, F, G, HH, II, JJ, KK, NN	GU-C Opaeula/ Helemano	MFS/T2	Wild
Plant	*Chamaesyce rockii*	KLO-E	Helemano	MFS/T2	Wild
Plant	*Cyanea crispa*	KLO-B	Helemano	MRS/T2	Reintroduction
Plant	*Cyanea koolauensis*	KLO-G,J,P,Q	Helemano	MFS/T1	Wild
Plant	*Cyanea st.-johnii*	KLO-A	Helemano	MFS/T1	Wild
Plant	*Cyrtandra viridiflora*	KLO- I,R-T, W	Opaeula/ Helemano	MFS/T2	Wild
Plant	*Gardenia mannii*		Opaeula/ Helemano	MFS/T1	Wild
Plant	*Phyllostegia hirsuta*	KLO-C	Opaeula/ Helemano	GSC/T1	Wild
Plant	*Myrsine juddii*	KLO-D	Helemano	MFS/T2	Wild
Plant	*Pteris lidgatii*	KLO-C	Helemano	MFS/T1	Wild
Plant	*Viola oahuensis*	KLO-H, N	Opaeula/ Helemano	MFS/T2	Wild

MFS= Manage for Stability
GSC= Genetic Storage Collection
MRS = Manage Reintroduction for Genetic Storage
*= Population Dead
†=Reintroduction not yet done
T1 = Tier 1
T2 = Tier 2

Other Rare Taxa in the Helemano MU:

Organism Type	Species	Federal Status	Notes
Plant	*Cyanea calycina*	Candidate	
Plant	*Cyanea humboldtiana*	Endangered	
Plant	*Joinvillea ascendens* subsp. *ascendens*	Species of Concern	
Insect	*Megalagrion oceanicum*	Endangered	Rare on leeward side of Koolau slopes
Plant	*Zanthoxylum oahuensis*	Candidate	

Rare Resources at Helemano:

Cyanea st. johnii

Achatinella sowerbyana

Locations of Rare Resources at Helemano

MU Threats to OIP MFS Taxa

Threat	Taxa Affected	Localized Control Sufficient?	MU scale Control required?	Control Method Available?
Pigs	All	No	Yes	Yes
Euglandina rosea	*Achatinella sowerbyana*	Unknown	Unknown	No, limited to hand-removal and physical barriers
Slugs	*Cyanea crispa*, *C. koolauensis, C. st.-johnii*	Yes	No	Currently being developed
Ants	Unknown	Unknown	Unknown	Some available, depends on species
Weeds	All	Yes	Yes	Yes
Fire	N/A	N/A	No (very low threat)	Yes
Rats	All	Unknown	Yes	Currently being Developed

Management History:

- 1995 OANRP staff began survey work in adjacent Opaeula MU
- 2000 OANRP staff started survey work in Helemano MU
- 2001 Opaeula fence construction complete, Koolau Mountain Watershed Partnership formed.
- 2005 *Setaria palmifolia* control initiated, Helemano fence line cleared.
- 2006 Helemano fence construction began by Southwest Fence
- 2007 Helemano fence construction complete, ungulate control in fence begun
- 2008 Helemano declared pig free, strawberry guava sweeps initiated in Helemano

Cyrtandra viridiflora

1.4.2.3 Ungulate Control

Identified Ungulate Threats: Pigs

Threat Level: High

Primary Objectives:

- Maintain MU fence as ungulate free.

Strategy:

- Maintain the fenced area as ungulate-free by maintaining fence and using transects to monitor for sign

Monitoring Objectives:

- Conduct fence checks and read transects quarterly. GPS and mark the fence at ten meter intervals so that the fence will be one large transect.
- Monitor for pig sign while conducting other management actions in the fence.

Management Responses:

- If any pig activity detected in the fence area, implement snaring program. Snares still remain within the MU. If ungulate sign is detected they will be reset.

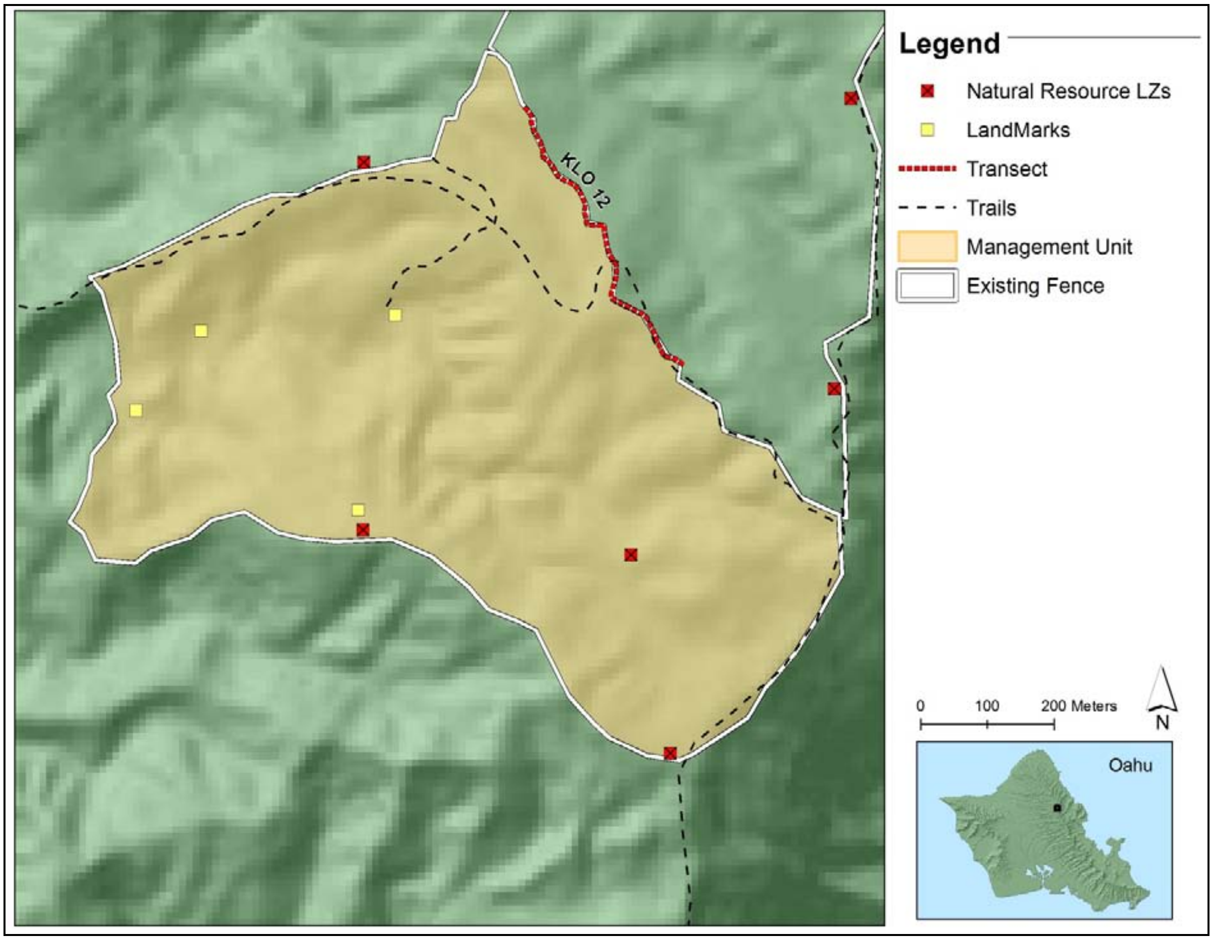
Maintenance Issues:

There is a perimeter fence around the MU. The MU fence is relatively small (64 acres). The major threats to the perimeter fence include fallen trees and vandalism; there is one major gulch crossing. The stream crossing was strategically placed at the base of a large waterfall to avoid weather related issues. There have been no incidences of vandalism in the past. Special emphasis will be placed on checking the fence after extreme weather events. Monitoring for ungulate sign will occur during the course of other field activities. The fence will be kept clear of vegetation (especially grasses) to facilitate quarterly monitoring. This weed control is discussed in the Weed Control section.

Ungulate Control Actions:

Year	Action	Quarter
OIP YEAR 3 Oct. 2009-Sept.2010	• Check MU fence for breaches • Identify and scope high probability ungulate usage areas • Decide whether or not to install transects • GPS and tag stations on entire fence line at 10 meter intervals	• 1-4 • 1-4 • 1
OIP Year 4 Oct. 2010 – Sept. 2011 through OIP Year 7 Oct. 2013- Sept. 2014	• Check MU fence for breaches (quarterly) • Monitor transects quarterly	• 1-4 • 1-4

Ungulate Management and Survey Locations at Helemano



Helemano fence

1.4.2.4 Weed Control

Weed Control actions are divided into 4 subcategories:

1. Vegetation Monitoring
2. Surveys
3. Incipient Taxa Control (Incipient Control Area - ICAs)
4. Ecosystem Management Weed Control (Weed Control Areas - WCAs)

These designations facilitate different aspects of OIP requirements.

Vegetation Monitoring

Objectives:

- Develop vegetation monitoring protocol for Helemano MU.
- Conduct vegetation monitoring for Helemano MU every three years.
- Produce vegetation map every three years for comparative analysis of weeding efforts.

MU Vegetation Monitoring:

Vegetation monitoring protocols used in other MUs may not be feasible in Helemano MU. Due to the relatively intact condition of the Northern Koolau summit region, current monitoring practices would increase traffic through the MU and may negatively impact the area by introducing weedy species normally found in the fence corridors to the interior. Possible alternatives to transect monitoring may be aerial monitoring surveys, remote vegetation mapping, or a combination of both. Utilizing new technologies and methodologies to develop vegetation monitoring protocols is a priority for this MU.

Vegetation Monitoring Response:

- Produce, refine and modify the vegetation map every three years in conjunction with MU vegetation monitoring efforts.
- Analyze vegetation monitoring data to determine efficacy of weeding efforts in the MU.

Surveys

Army Training?: No.

Other Potential Sources of Introduction: NRS, pigs, public hikers

Survey Locations: Landing zones, camp sites, fence lines, high potential traffic areas.

Management Objective:

- Prevent the establishment of any new invasive alien plant or animal species through regular surveys along fencelines, trails, on landing zones, around camp sites, and other high traffic areas.

Monitoring Objectives:

- Annual surveys of fencelines and main access trails to Camp Sites and LZs.
- Quarterly surveys of LZs and Camp sites.

Management Responses:

- Any significant alien taxa found will be researched and evaluated for distribution and life history. If found to pose a major threat, control will begin and will be tracked via Incipient Control Areas (ICAs)

Surveys are designed to be the first line of defense in locating and identifying potential new weed species. Landing zones, camp sites, fence lines, and other highly trafficked areas are inventoried regularly; Army LZs are surveyed annually and all other sites are surveyed quarterly or as they are used. Only currently used LZs and campsites are currently surveyed. No weed transects have been established along fence lines or other possible high traffic areas, such as trails and staging areas. NRS will consider whether such transects are a valuable tool at Helemano in the coming year. See the Ungulate Management and Survey Locations at Helemano map above.

Incipient Taxa Control (ICAs)

Management Objectives:

- As feasible, eradicate high priority species identified as incipient invasive aliens in the MU by 2014.
- Conduct seed dormancy trials for all high priority incipients by 2014.
- Identify potential paths of contamination and develop strategies to decontaminate gear when working in densely infested incipient areas.

Monitoring Objective:

- Visit ICAs at stated revisitation intervals. Control all mature plants at ICAs and prevent any immature or seedling plants from reaching maturity.

Management Responses:

- If unsuccessful in preventing immature plants from maturing, increase ICA revisitation interval.

ICAs are drawn around each discrete infestation of an incipient invasive weed. ICAs are designed to facilitate data gathering and control. For each ICA, the management goal is to achieve complete eradication of the invasive taxa. Frequent visitation is often necessary to achieve eradication. Seed bed life/dormancy and life cycle information is important in determining when eradication may be reached; much of this information needs to be researched and parameters for determining eradication defined. NRS will compile this information for each ICA species.

The table below summarizes incipient invasive taxa at Helemano. While the list is by no means exhaustive, it provides a good starting point for discussing which taxa should be targeted for eradication in an MU. ICAs are not designated for every species in the table below; however, occurrences of all species in the table should be noted by field staff. All current ICAs are mapped. Three management designations are possible: Incipient (small populations, eradicable), Control Locally (significant threat posed, may or may not be widespread, control feasible at WCA level), and Widespread (common weed, may or may not pose significant threat, control feasible at WCA level).

Summary of Potential ICA Target Taxa

Taxa	Management Designation	Notes	No. of ICAs
Angiopteris evecta	Incipient	Localized population in Helemano stream. One large mature plant found. Invasiveness in similar habitats creates potential for invasiveness in MU. Survey to determine if recruitment taking place. Control high priority. Control any plants found outside the MU, if near the fence.	1
Erigeron karvinskianus	Control locally	Established populations along summit create potential for invasiveness. Much of the windward cliff habitat just east of the MU fence has been invaded by *E. karvinskianus*. It poses a threat to rare taxa found in this area, particularly *Lobelia gaudichaudii*. Eradication not feasible. Emphasize control around rare taxa. Prevent *E. karvinskianus* from crossing onto leeward side. Control of one small population on east fence line high priority due to wind dispersed seeds and location. Reevaluate ICA status.	1
Clidemia hirta	Widespread	*C. hirta* is a well established part of the Koolau vegetation type. NRS do not currently target it for control, except in the vicinity of rare taxa	0
Pterolepis glomerata	Widespread	This Melastome is ubiquitous across the Koolaus. It thrives in disturbed areas, particularly pig wallows. NRS do not currently target it for control.	0
Psidium cattleianum	Widespread	Patches scattered across Helemano. Primary target of WCA sweeps. The largest and thickest stands tend to be in gulches and draws.	0
Schefflera actinophylla	Control locally	One individual outside of the southern fence line, high priority for control. Established populations on the windward side of the summit create potential for invasiveness. If found, control as part of WCA sweeps. Consider creating ICAs if find mature plants. Control plants found outside the MU, if near the fence.	0
Setaria palmifolia	Control locally	Several stable populations known in low lying stream areas and fence lines. It appears that the eastern section of the MU does not have *S. palmifolia*, while the western section does. Taxon likely moving via NRS activities and waterways. ICAs drawn both in and out of subunit. Control technique needs to be evaluated due to proximity to waterways. Improved NRS decontamination practices need implementation to minimize seed dispersal. NRS will target plants along trails and fencelines.	7
Sphaeropter-is cooperii	Control locally	No plants found in MU, but large numbers of plants observed south along the Koolau summit. If found, target during WCA sweeps	0

Helemano ICA target taxa

Setaria palmifolia

Angiopteris evecta

Helemano ICA target taxa

Erigeron karvinskianus

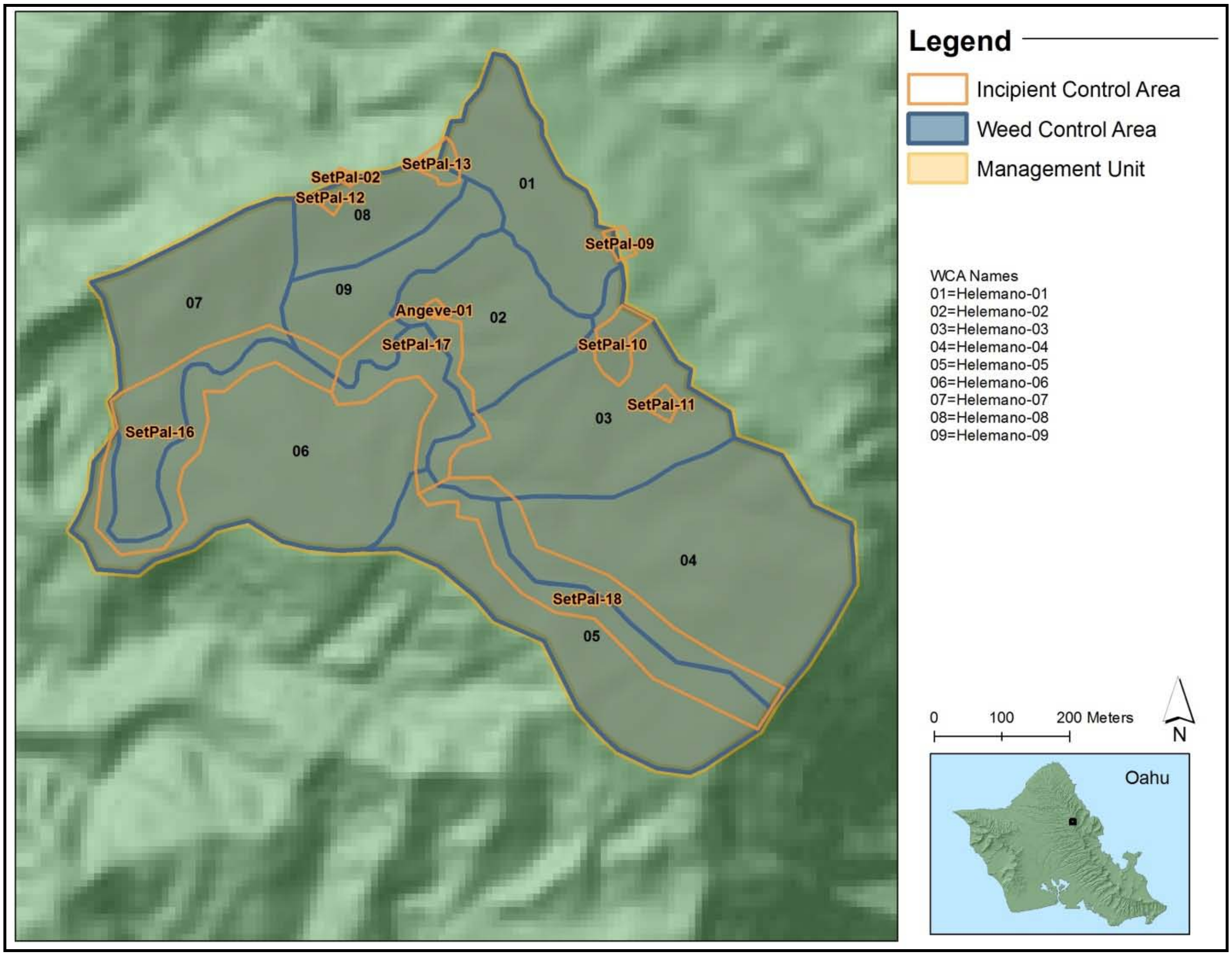
Schefflera actinophylla

ICA Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009-Sept.2010	• KLOA-Angeve -01 control • Survey and determine Schact ICAs. • Evaluate Erikar control possibilities. • Begin Setpal control, as feasible.	• 1, 3* • 1,3* • 1,3* • 1-4
OIP YEAR 4 Oct.2010-Sept.2011 through OIP YEAR 7 Oct.2013-Sept.2014	• KLOA-Angeve -01 control • Schact control • Erikar control • KLOA-Setpal-01 control • KLOA-Setpal -02 control • KLOA-Setpal -03 control • KLOA-Setpal -04 control • KLOA-Setpal -05 control • KLOA-Setpal -06 control • KLOA-Setpal -07 control • KLOA-Setpal -08 control • KLOA-Setpal -09control • KLOA-Setpal -10 control • KLOA-Setpal -11 control • KLOA-Setpal -12 control • KLOA-Setpal -13 control • KLOA-Setpal -14 control • KLOA-Setpal -15 control • KLOA-Setpal -16 control • KLOA-Setpal -17 control • KLOA-Setpal -18 control	• 1, 3* • 1,3* • 1,3* • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1* • 1,3* • 1,3* • 1* • 1-4 • 1* • 1*

*= doesn't matter in which quarter control conducted

Incipient and Proposed Weed Control Areas at Helemano MU



Ecosystem Management Weed Control (WCAs)

OIP Goals:

- Within 2m of rare taxa: 0% alien vegetation cover
- Within 50m of rare taxa: 25% or less alien vegetation cover
- Throughout the remainder of the MU: 50% or less alien vegetation cover

Management Objectives:

- Maintain 50% or less alien vegetation cover in the understory across the MU.
- Reach 50% or less alien canopy cover across the MU in the next 5 years.
- In WCAs within 50m of rare taxa, work towards achieving 25% or less alien vegetation cover in understory and canopy.

Management Responses:

- Increase/expand weeding efforts if MU vegetation monitoring (conducted every 3 years) indicates that goals are not being met.

WCAs are weeded on a rotational basis given the difficulty of access, terrain, and limited staff resources. Use aerial and ground surveys to guide control efforts for *P. cattleianum, S. palmifolia*, and other target weeds.

General WCA Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009-Sept.2010	• GPS trails • Conduct aerial surveys • Weed control WCAs Helemano-01 and Helemano-03	2-3
OIP YEAR 4 Oct.2010-Sept.2011	• Conduct aerial surveys • Weed control WCAs Helemano-04 and Helemano-05	1-4*
OIP YEAR 5 Oct.2011-Sept.2012	• Conduct aerial surveys • Weed control WCAs Helemano-07 and Helemano-08	1-4*
OIP YEAR 6 Oct.2012-Sept.2013	• Conduct aerial surveys • Weed control WCAs Helemano-02 and Helemano-09	1-4*
OIP YEAR 7 Oct.2013-Sept.2014	• Conduct aerial surveys • Weed control WCAs Helemano-06	1-4*

*Exact quarter doesn't matter; to be finalized by Coordinators

WCA: Helemano-01

Vegetation Type: Wet Montane

OIP Goal: 25% or less alien cover (rare taxa in WCA).

Target: *P. cattleianum*, tree weeds

Notes: OIP rare plants: Cyacal and Viooah present. Area predominantly native. To minimize impact to area, sweeps are done via Spot-and-treat method: spotting from open ridges with binoculars and directing other staff to plants for treatment.

Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009-Sept.2010	• Conduct Psicat sweeps. • GPS WCA to define boundaries.	• 1-4
OIP YEAR 4 Oct.2010-Sept.2011	• Binocular survey and monitor for new Psicat and other incipient weed populations. Treat as necessary and feasible.	• 1-4
OIP YEAR 5 Oct.2011-Sept.2012	• Binocular survey and monitor for new Psicat and other incipient weed populations. Treat as necessary and feasible.	• 1-4
OIP YEAR 6 Oct.2012-Sept.2013	• Re-sweep WCA for Psicat	• 1-4

WCA: Helemano-02

Vegetation Type: Wet Montane

OIP Goal: 25% or less alien cover (rare taxa in WCA).

Target: *P. cattleianum*, tree weeds

Notes: Many steep areas make complete sweep coverage unfeasible. Weed control will be conducted so as not to compromise staff safety. To minimize impact to area, sweeps are done via Spot-and-treat method: spotting from open ridges with binoculars and directing other staff to plants for treatment.

Actions:

Year	Action	Quarter
OIP YEAR 5 Oct.2011-Sept.2012	• Heli survey • Explore weed control options for steep areas. • Determine weed control strategy for this WCA.	• 3-4
OIP YEAR 6 Oct.2012-Sept.2013	• Conduct Psicat sweeps. • GPS WCA to define boundaries.	• 1-4
OIP YEAR 7 Oct.2013-Sept.2014	• Binocular survey and monitor for new Psicat and other incipient weed populations. Treat as necessary and feasible.	• 1-4

WCA: Helemano-03

Vegetation Type: Wet Montane

OIP Goal: 25% or less alien cover (rare taxa in WCA).

Target: *P. cattleianum*, tree weeds

Notes: OIP rare plants: Charoc and Viooah. To minimize impact to area, sweeps are done via Spot-and-treat method: spotting from open ridges with binoculars and directing other staff to plants for treatment.

Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009-Sept.2010	• Conduct Psicat sweeps. • GPS WCA to define boundaries.	• 1-4
OIP YEAR 4 Oct.2010-Sept.2011	• Binocular survey and monitor for new Psicat and other incipient weed populations. Treat as necessary and feasible.	• 1-4
OIP YEAR 5 Oct.2011-Sept.2012	• Binocular survey and monitor for new Psicat and other incipient weed populations. Treat as necessary and feasible.	• 1-4
OIP YEAR 6 Oct.2012-Sept.2013	• Re-sweep WCA for Psicat	• 1-4

WCA: Helemano-04

Vegetation Type: Wet Montane

OIP Goal: 25% or less alien cover (rare taxa in WCA).

Target: *P. cattleianum*, tree weeds

Notes: OIP rare plants: Cyastj, Charoc, Cyrvir, Viooah. OIP rare snails: Achsow, Achlil. To minimize impact to area, sweeps are done via Spot-and-treat method: spotting from open ridges with binoculars and directing other staff to plants for treatment. Due to sensitivity of this area, all weed control will be done in a manner that minimizes impact to rare plant and snail populations.

Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009-Sept.2010	• Heli survey • Explore weed control options for steep areas. • Determine weed control strategy for this WCA.	• 3-4
OIP YEAR 4 Oct.2010-Sept.2011	• Conduct Psicat sweeps. • GPS WCA to define boundaries.	• 1-4
OIP YEAR 5 Oct.2011-Sept.2012	• Binocular survey and monitor for new Psicat and other incipient weed populations. Treat as necessary and feasible.	• 1-4
OIP YEAR 6 Oct.2012-Sept.2013	• Binocular survey and monitor for new Psicat and other incipient weed populations. Treat as necessary and feasible.	• 1-4
OIP YEAR 7 Oct.2013-Sept.2014	• Re-sweep WCA for Psicat	• 1-4

WCA: Helemano-05

Vegetation Type: Wet Montane

OIP Goal: 25% or less alien cover (rare taxa in WCA).

Target: *P. cattleianum*, tree weeds

Notes: OIP rare plants: Cyacal, Cyahum, Cyrvir. To minimize impact to area, sweeps are done via Spot-and-treat method: spotting from open ridges with binoculars and directing other staff to plants for treatment.

Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009-Sept.2010	• Heli survey • Explore weed control options for steep areas. • Determine weed control strategy for this WCA.	• 3-4
OIP YEAR 4 Oct.2010-Sept.2011	• Conduct Psicat sweeps. • GPS WCA to define boundaries.	• 1-4
OIP YEAR 5 Oct.2011-Sept.2012	• Binocular survey and monitor for new Psicat and other incipient weed populations. Treat as necessary and feasible.	• 1-4
OIP YEAR 6 Oct.2012-Sept.2013	• Binocular survey and monitor for new Psicat and other incipient weed populations. Treat as necessary and feasible.	• 1-4
OIP YEAR 7 Oct.2013-Sept.2014	• Re-sweep WCA for Psicat	• 1-4

WCA: Helemano-06

Vegetation Type: Wet Montane

OIP Goal: 25% or less alien cover (rare taxa in WCA).

Target: *P. cattleianum*, tree weeds

Notes: OIP rare plants: CyaKoo, Cyrvir and Joiascasc. To minimize impact to area, sweeps are done via Spot-and-treat method: spotting from open ridges with binoculars and directing other staff to plants for treatment.

Actions:

Year	Action	Quarter
OIP YEAR 6 Oct.2012-Sept.2013	• Heli survey • Explore weed control options for steep areas. • Determine weed control strategy for this WCA.	• 3-4
OIP YEAR 7 Oct.2013-Sept.2014	• Conduct Psicat sweeps. • GPS WCA to define boundaries.	• 1-4

WCA: Helemano-07

Vegetation Type: Wet Montane

OIP Goal: 25% or less alien cover (rare taxa in WCA).

Target: *P. cattleianum*, tree weeds

Notes: OIP rare plants: CyaKoo, Cyacri, Garman, Myrjud, Phyhir and Zanoah. To minimize impact to area, sweeps are done via Spot-and-treat method: spotting from open ridges with binoculars and directing other staff to plants for treatment.

Actions:

Year	Action	Quarter
OIP YEAR 4 Oct.2010-Sept.2011	• Heli survey • Explore weed control options for steep areas. • Determine weed control strategy for this WCA.	• 3-4
OIP YEAR 5 Oct.2011-Sept.2012	• Conduct Psicat sweeps. • GPS WCA to define boundaries.	• 1-4
OIP YEAR 6 Oct.2012-Sept.2013	• Binocular survey and monitor for new Psicat and other incipient weed populations. Treat as necessary and feasible.	• 1-4
OIP YEAR 7 Oct.2013-Sept.2014	• Binocular survey and monitor for new Psicat and other incipient weed populations. Treat as necessary and feasible.	• 1-4

WCA: Helemano-08

Vegetation Type: Wet Montane

OIP Goal: 25% or less alien cover (rare taxa in WCA).

Target: *P. cattleianum*, tree weeds

Notes: Many steep areas make complete sweep coverage unfeasible. Weed control will be conducted so as not to compromise staff safety. To minimize impact to area, sweeps are done via spot-and-treat method: spotting from open ridges with binoculars and directing other staff to plants for treatment.

Actions:

Year	Action	Quarter
OIP YEAR 4 Oct.2010-Sept.2011	• Heli survey • Explore weed control options for steep areas. • Determine weed control strategy for this WCA.	• 3-4
OIP YEAR 5 Oct.2011-Sept.2012	• Conduct Psicat sweeps. • GPS WCA to define boundaries.	• 1-4
OIP YEAR 6 Oct.2012-Sept.2013	• Binocular survey and monitor for new Psicat and other incipient weed populations. Treat as necessary and feasible.	• 1-4
OIP YEAR 7 Oct.2013-Sept.2014	• Binocular survey and monitor for new Psicat and other incipient weed populations. Treat as necessary and feasible.	• 1-4

WCA: Helemano-09

Vegetation Type: Wet Montane

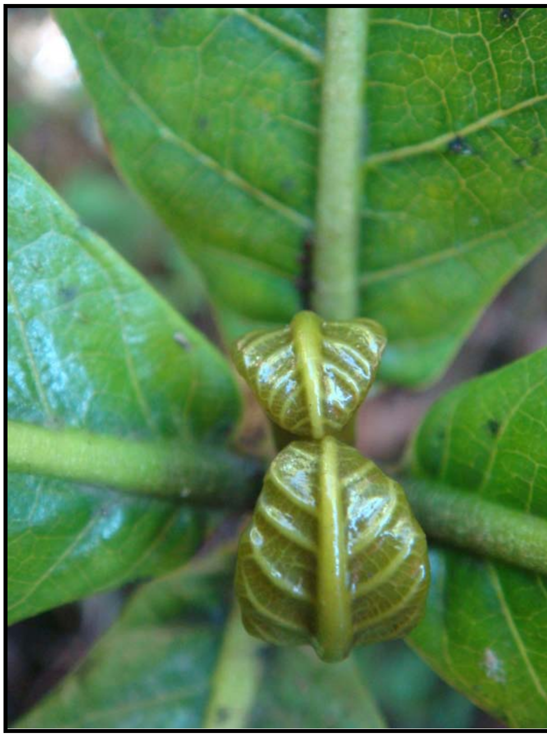
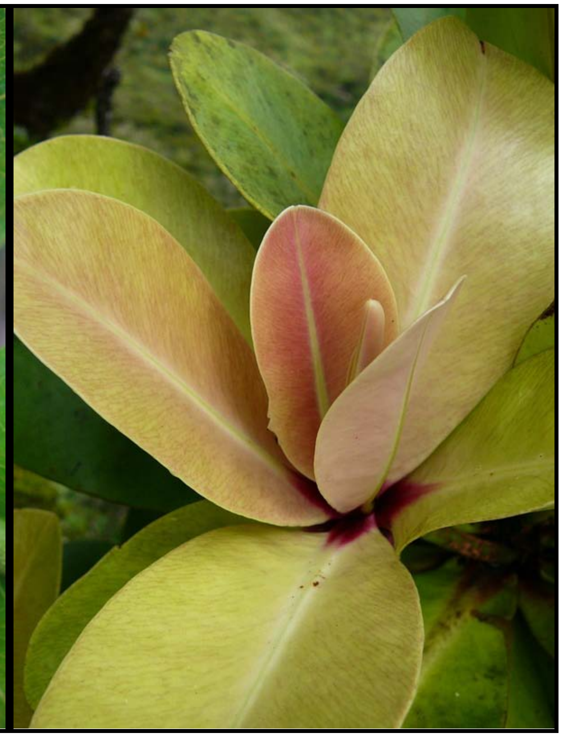
OIP Goal: 25% or less alien cover (rare taxa in WCA).

Target: *P. cattleianum*, tree weeds

Notes: Many steep areas make complete sweep coverage unfeasible. Weed control will be conducted so as not to compromise staff safety. To minimize impact to area, sweeps are done via Spot-and-treat method: spotting from open ridges with binoculars and directing other staff to plants for treatment.

Actions:

Year	Action	Quarter
OIP YEAR 5 Oct.2011-Sept.2012	• Heli survey • Explore weed control options for steep areas. • Determine weed control strategy for this WCA.	• 3-4
OIP YEAR 6 Oct.2012-Sept.2013	• Conduct Psicat sweeps. • GPS WCA to define boundaries.	• 1-4
OIP YEAR 7 Oct.2013-Sept.2014	• Binocular survey and monitor for new Psicat and other incipient weed populations. Treat as necessary and feasible.	• 1-4

Gardenia mannii *Myrsine pukooensis*

Helemano stream

1.4.2.5 Rodent Control

Threat Level: Unknown

Control method: To be determined

Seasonality: To be determined

Number of bait stations: None

Available tools: Rodenticide /Bait Stations, Aerial Broadcast, Hand Broadcast, Snap Traps, Tracking Tunnels, Chew Tabs

Management Objective:

- Implement rodent control if determined necessary for protection of rare snail and plant populations.

Monitoring Objectives:

- Census MU to determine distribution of *Achatinella sowerbyana.*
- Monitor rare plants to determine impacts by rodents.

To protect the ecosystem as a whole, MU wide rodent control is desirable, but not feasible with bait station and snap trap grids, because of steep terrain and dense vegetation. An alternative method of rodent control that may prove most effective in this MU maybe either aerial or hand broadcast of rodenticide. *Achatinella sowerbyana* is the most abundant *Achatinella* species in the Koolau Mountains. Past surveys have found many discrete *Achatinella sowerbyana* locations, scattered widely across the MU and genetic samples were recently taken from snails in the Helemano MU. Like *Achatinella sowerbyana*, rare plants (*Cyanea* spp., *C. viridiflora, P. hirta, V. oahuensis, C. rockii*) are scattered throughout the MU. Localized rodent control around impacted populations (plants or snails) or individual plants will be instituted as a short term method until larger scale control can be implemented if deemed necessary.

If it is determined after genetic testing that the *Achatinella sowerbyana* population of snails in the Helemano MU is distinct, then a rodent control grid will be initiated in an area with a large snail population (determined after MU census is completed).

If rodent control is deemed necessary for either rare snails or plants, the following monitoring tools will be implemented:

- Monitor changes in the rat population via tracking tunnels, chew tabs, bait take, or catch data.
- Monitoring positive effects on rare resources via census counts, sampling, incidental observations, etc.
- Monitoring changes of other ecosystem parameters, such as arthropod diversity/abundance, seedling diversity/abundance, plant composition in various vegetation types.

Rat Control Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009- Sept.2010 through OIP YEAR 7 Oct.2013-Sept. 2014	• Implement rodent control if determined necessary	• 1-4

1.4.2.6 Slug Control

Species: Slugs (multiple species assumed present but no collections to date)

Threat level: Unknown (no collections)

Control level: Localized

Seasonality: Wet season (September-May)

Number of sites: *C. crispa, C. koolauensis* and *C. st.-johnii* population(s)

Management Objective:

- Begin a pilot slug control program in the fall of 2011 using Sluggo around the *C. crispa, C. koolauensis* and *C. st.-johnii* population(s) if additional Special Local Needs labeling is approved by USFWS and HDOA.
- By 2014, reduce slugs by at least 50% of estimated baseline densities around the *C. crispa, C. koolauensis* and *C. st.-johnii* population(s) through a pilot control program.

Monitoring Objectives:

- Determine slug species present and estimate baseline densities using traps baited with beer in the fall of 2010.
- Annual census monitoring of slug densities during wet season.
- Annual census monitoring of *C. crispa, C. koolauensis* and *C. st.-johnii* seedling recruitment following fruiting events.

Effective molluscicides have been identified (Sluggo) and initial control programs are ongoing in Kahanahaiki. A pilot slug control program using Sluggo could begin at Helemano in the fall of 2011 should slug and *Cyanea* monitoring reveal slug damage to plants. If large-scale rat control is implemented, plots to monitor the effect of predator removal on slug population (if not already determined in other areas) may be considered.

Slug Control Actions:

Year	Action	Quarter
MIP YEAR 3 Oct.2009-Sept.2010	• Monitor slug activity at *C. crispa, C. koolauensis* and *C. st.-johnii* population(s) via traps baited with beer	• 1-4
MIP YEAR 4 Oct.2010-Sept.2011 through MIP YEAR 7 Oct.2012-Sept.2014	• Deploy slug bait around *C. crispa, C. koolauensis* and *C. st.-johnii* population(s) frequency to be determined during research phase • If slugs found to exceed acceptable levels during monitoring, maintain slug bait at sensitive plant population(s)	• 1-4 • 1-4

Cyanea st. johnii

1.4.2.7 Ant Control

Species: Solenopsis papuana, Pheidole megacephala

Threat level: Low

Control level: Localized

Seasonality: Varies by species, but nest expansion observed in late summer, early fall

Number of sites: 2 (Helemano fenceline, Lychee Landing Zone)

Acceptable Level of Ant Activity: Current level acceptable

Management Objective:

- If incipient species are found and deemed to be a high threat and/or easily eradicated locally (<0.5 acre infestation) begin control using a bait containing Hydramethylnon (Amdro, Maxforce or Seige).

Monitoring Objective:

- Continue to sample ants at human entry points (landing zone, fence line) a minimum of once a year. Use samples to track changes in existing ant densities and to alert NRS to any new introductions.

Ants have been documented to pose threats to a variety of resources, including native arthropods, plants (via farming of Hemipterian pests), and birds (Krushelnycky *et al.* 2005). The distribution and diversity of ant species in upland areas on Oahu, Helemano, has only begun to be studied and changes over time. Impacts to the rare species present in Helemano remain unknown, but it is likely they are having some type of effect on the ecosystem at large. NRS have already conducted some surveys across Helemano to determine which ant species are present and where they are located. Surveys were conducted using a standardized sampling method (see Appendix Invasive Ant Monitoring Protocol this document). *Solenopsis papuana* were found at high elevations (>2000 ft.) along Helemano fenceline 1 out of the 3 times it was surveyed this past year. No other ants were found. *Pheidole megacephala* was found at the Lychee Landing Zone but densities are unknown. Area should be surveyed using Invasive Ant Monitoring Protocol. If densities are high, then treatment of should begin using Hydramethylnon (Amdro, Maxforce or Seige) to prevent movement of ants to higher elevations.

Ant Control Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009-Sept.2010	• Conduct additional surveys for ants annually • Analyze results of surveys, develop management plan	• 1, 2 • 3,4
OIP YEAR 4 Oct.2009-Sept.2010 through OIP YEAR 7 Oct.2012-Sept.2014	• Implement control if deemed necessary • Conduct arthropod survey along transects in anticipation of rat trap out project.	• 1-4

1.4.2.8 Predatory Snail Control

Species: *Euglandina rosea* (rosy wolf snail), *Oxychilus alliarus* (garlic snail)

Threat level: Unknown (no collections from this area)

Control level: Localized

Seasonality: Year-Round

Number of sites: *Achatinella sowerbyana* sites

Management Objective:

- Continue to develop better methods to control predatory snails
- Keep sensitive snail populations safe from predatory snails via currently accepted methods (such as hand removal of alien snails, construction of barriers which prevent incursion from alien snails)

Monitoring Objectives:

- Annual or every other year census monitoring of *A. sowerbyana* population to determine population trend.
- Annual searches for predatory snails to confirm their absence or presence in proximity to *A. sowerbyana.*

No baits have been developed for the control of predatory snails. Little is known regarding their distribution and prey preference. Control is limited to hand removal. Visual searches are time-consuming, difficult, and not feasible over large areas and in steep terrain. It is also unknown whether predatory snail populations are reduced by hand removal. Although systematic searches for *E. rosea* have not been undertaken, anecdotal observations suggests they are absent from this MU. No searches for *O. alliarus* have been completed.

Predatory Snail Control Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009-Sept.2010	• Determine if any *E. rosea* or *O. alliarus* snails are present at the *A. sowerbyana* site	• 1-4
OIP YEAR 4-7 Oct.2010- Sept.2014	• Implement control as improved tools become available	• 1-4

1.4.2.9 Fire Control

Due to the very low threat from fire, no actions are proposed at this time.

Wikstroemia oahuensis

1.4.3 Kaala Ecosystem Restoration Management Plan

OIP Year 3-7, Sept. 2009 - Sept. 2014

MU: Kaala

1.4.3.1 Overall OIP Management Goals:

- Form a stable, native-dominated matrix of plant communities which support stable populations of IP taxa.
- Control ungulate, weed, predatory snail, rodent and slug threats in the next five years to allow for stabilization of IP taxa. Implement control methods by 2013.

1.4.3.2 Background Information

Location: Highest peak of Oahu in the central Waianae Mountains

Land Owner: City and County of Honolulu/Board of Water Supply (12.9 acres), State of Hawaii (57 acres), US Army (101.7 acres), FAA site (1.5 acres)

Land Manager: U.S. Army Garrison Hawaii/State of Hawaii (NARS)

Acreage: 171.6 acres

Elevation range: 3,400 to 4,020 ft.

Description: Bog and surrounding montane wet community; plateau and surrounding cliffs of Kaala peak; Moderate to steep slopes and cliffs, including small ridges and gulch bowls. The MU extends down into wet-mesic forest into Haleauau at approximately the 3,000 ft. elevation level.

Native Vegetation Types

Waianae Vegetation Types
Wet forest
Canopy includes: *Metrosideros* spp., *Cheirodendron* spp., *Cibotium* spp, *Ilex anomala*, *Myrsine sandwicensis*, and *Perrottetia sandwicensis*. Understory includes: Typically covered by a variety of ferns and moss; may include *Melicope* spp., *Cibotium chamissoi, Machaerina angustifolia*, *Nertera granadensis, Hedyotis centranthoides*, *Nothoperanema rubiginosa*, and *Broussaisia arguta*.
NOTE: For MU monitoring purposes vegetation type is mapped based on theoretical pre-disturbance vegetation. Alien species are not noted.
NOTE: For MU monitoring purposes, vegetation types were subdivided using topography (gulch, mid-slope, ridge). Topography influences vegetation composition to a degree. Combining vegetation type and topography is useful for guiding management in certain instances.

Primary Vegetation Types at Kaala

Wet forest

MIP/OIP Rare Resources

Organism Type	Species	Pop. Ref. Code	Population Unit	Management Designation	Wild/ Reintro.
Plant	*Cyanea acuminata*	ALA:A-I	Haleauau to Makaleha	MFS T1	Wild
Plant	*Labordia cyrtandrae*	ALA:A-C, G-Q	East Makaleha to North Mohiakea	MFS T1	Both
Plant	*Phyllostegia hirsuta*	None*	Kaala	GSC	Wild
Plant	*Schiedea trinervis*	ALA:A-E, G, J-O, Q, S, Y, X	Kalena to East Makaleha	MFS T1	Both
Snail	*Achatinella mustelina*	ESU-D1	North Kaluaa, SBS, Kaala	No mgmt.	Wild

MFS= Manage for Stability *= Population Dead
GSC= Genetic Storage Collection †=Reintroduction not yet done

Other Rare Taxa at Kaala MU

Organism Type	Species	Federal Status
Plant	*Melicope christophersenii*	Candidate
Plant	*Neraudia melastomafolia*	Species of concern
Plant	*Cyanea calycina*	Candidate
Plant	*Gunnera petaloidea*	Species of concern
Snail	*Auricullela* spp. (unknown spp.)	Species of concern
Snail	*Philonesia subrutila*	Species of concern
Bird	*Vestiaria coccinea*	State Endangered
Insect	*Drosophila substenoptera*	Endangered

Rare Resources at Kaala:

Labordia cyrtandrae

Schiedea trinervis

Cyanea acuminata

Achatinella mustelina

Rare Resources Locations at Kaala

Map removed,
available upon request

MU Threats to MIP/OIP MFS Taxa

Threat	Taxa Affected	Localized Control Sufficient?	MU scale Control required?	Control Method Notes
Pigs	All	No	Yes	MU partially fenced
Goats	All	No	Yes	Planning with State
Rats	All	Yes	Unknown	Could use if needed
Predatory snails	*Achatinella mustelina*	Unknown	Unknown	No, limited to hand-removal and physical barriers
Slugs	*Cyanea acuminata*, *Labordia cyrtandrae*, *Schiedea trinervis*	Yes	No	Currently being developed
Ants	Potential threat to *Drosophila substenoptera.*	Unknown	Unknown	Some available, depends on species
Weeds	All	No	Yes	Looking into HBT
Fire	No threat			

Management History:

Kaala is a very unique area, the wettest site in the Waianae mountains, the highest point on Oahu, dominated by wet native forest and home to a variety of rare taxa. Major threats to Kaala are ungulates and weeds. NRS actions have been geared towards mitigating these threats over the years. To accomplish meaningful threat control, NRS must work with the State, as both pigs and weeds cross property boundaries.

- 1996-2009: *H. gardnerianum* control including sweeps of WCAs and aerial surveys.
- 1996-2009: Sporadic goat control in Lower Kaala NAR.
- 2006: 90% of Strategic fencing completed mainly in Haleauau Gulch portion of Kaala Summit through partnership effort between BWS, State of Hawaii, TNC and Army NRS.
- 2006-2009: Pig control at Kaala MU using dogs, traps, and snaring.
- 2006-2009: *S. palustre* control research.
- 2007-2009: *Juncus effuses* and *Crocosmia crocosmifolia* control begun by outreach program.
- 2009: Goat control efforts initiated along Waianae Kai headwall area.

Native *Succinea*

Happy Face Spiders

1.4.3.3 Ungulate Control

Identified Ungulate Threats: Pigs, Goats

Threat Level: High

Primary Objectives:

- Maintain MU as pig and goat free.

Strategy:

- Eradication of pigs in the MU. Eradication of all pigs within proposed Lihue fence (SBW) and population reduction of goats through aerial and ground hunting efforts in the headwaters of Waianae Kai and Makaleha.

Monitoring Objectives:

- Biannual fence checks 2009-2014.
- Detect any pig sign in the fence while conducting rare plant monitoring or other weed control work in the MU.
- Monitor pig transect along blue flag trail quarterly.

Management Responses:

- If any ungulate activity is detected within the fenced unit, implement hunting and/or snaring and trapping program.

Maintenance issues

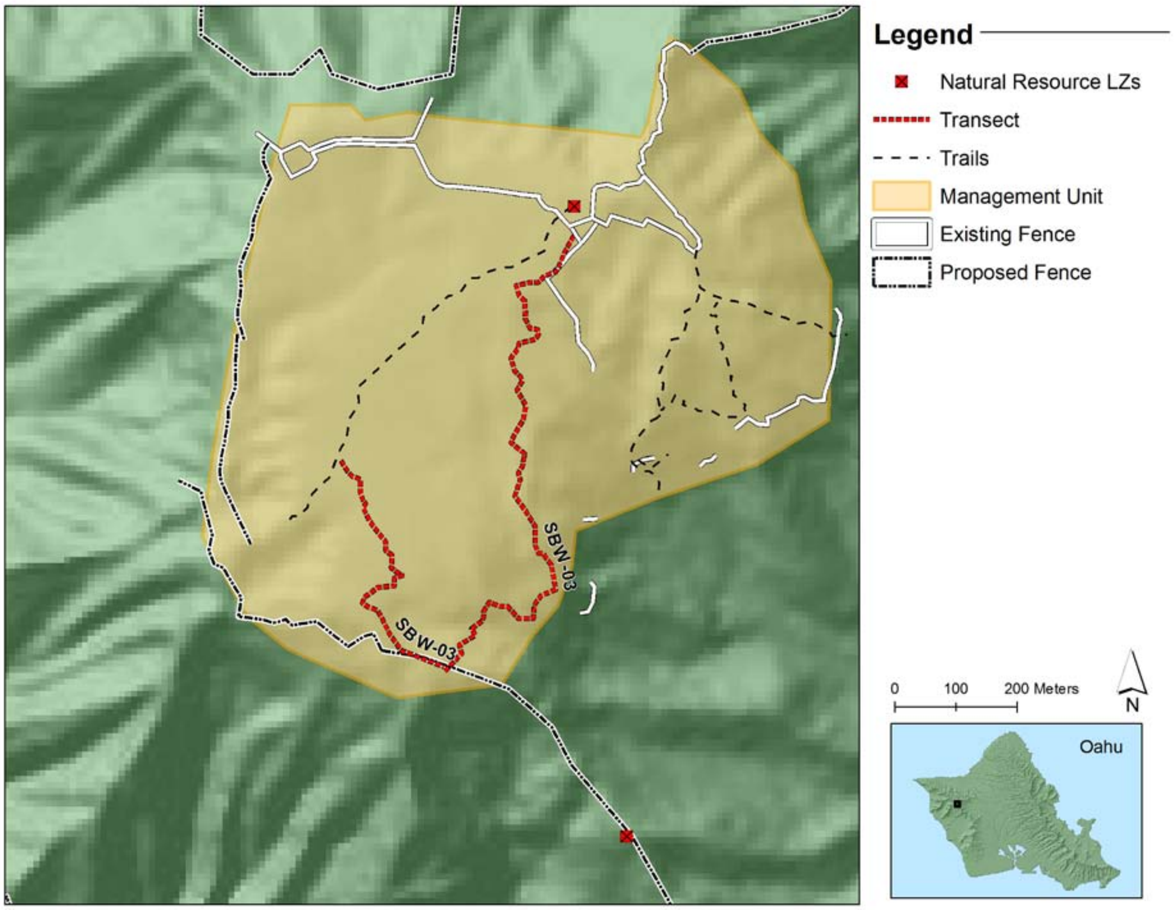
The MU fenced area takes advantage of large and small cliffs to strategically protect the area. The major threats to the fence include streams carrying rocks down gulches into the fence, fallen trees, and pigs uprooting areas beneath the fence line. Access to the area is significantly restricted, so vandalism should not be a problem.

Biannual checks on fence integrity will be conducted. Portions of the fence are already checked during monthly snare checks. Fences are also checked after extreme rainfall events. In particular, the Haleauau area fence line requires regular checks because of the streams in the area. Monitoring for ungulate sign also occurs during the course of other field activities.

Ungulate Control Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009-Sept.2010	• Biannual fence checks • Identify and scope high probability ungulate usage areas • Set and check additional snares along Transect Trail • Identify and scope hunting areas for goat control along Kalena Ridge • Control weeds along fence lines to assist with fence checks • Use pig hormones and baits to enhance snaring and trapping efforts	• 1-4 • 1-4 • 1-4 • 1-4 • 3 • 3
OIP YEAR 4 Oct.2010-Sept.2011 through OIP YEAR 7 Oct.2013-Sept.2014	• Re-clear new fence line along Waianae Kai and Makaha • Construct fence line for this last portion • Continue scoping high usage ungulate areas • Continue snaring and trapping to clear MU by Summer of 2011 and lower activity outside of fence through 2013 • Assist State efforts with Goat control as needed • Bi-annual fence checks	• 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 2,4

Ungulate Management and Survey Locations at Kaala



M. polymorpha

Epiphytes

1.4.3.4 Weed Control

Weed Control actions are divided into 4 subcategories:

1. Vegetation Monitoring
2. Surveys
3. Incipient Taxa Control (Incipient Control Area - ICAs)
4. Ecosystem Management Weed Control (Weed Control Areas - WCAs)

These designations facilitate different aspects of MIP/OIP requirements.

Vegetation Monitoring

Objectives:

- Conduct vegetation monitoring along transects every three years to determine total weed cover across the MU.
- Produce a preliminary vegetation map of the MU in conjunction with MU vegetation monitoring efforts.
- Conduct visual assessment of weed cover around *L. cyrtandrae* and *C. acuminata* plants at least annually.

Vegetation monitoring has not been done yet for the Kaala MU but will likely be done in early 2010 or possibly late 2009.

Surveys

Army Training: No

Other Potential Sources of Introduction: NRS, pigs, public hikers

Survey Locations: Roads, Landing Zones, Camp Sites, Fencelines, High Potential Traffic Areas

Management Objective:

- Prevent the establishment of any new invasive alien plant or animal species through regular surveys along roads, landing zones, camp sites, fencelines, trails, and other high traffic areas.

Monitoring Objectives:

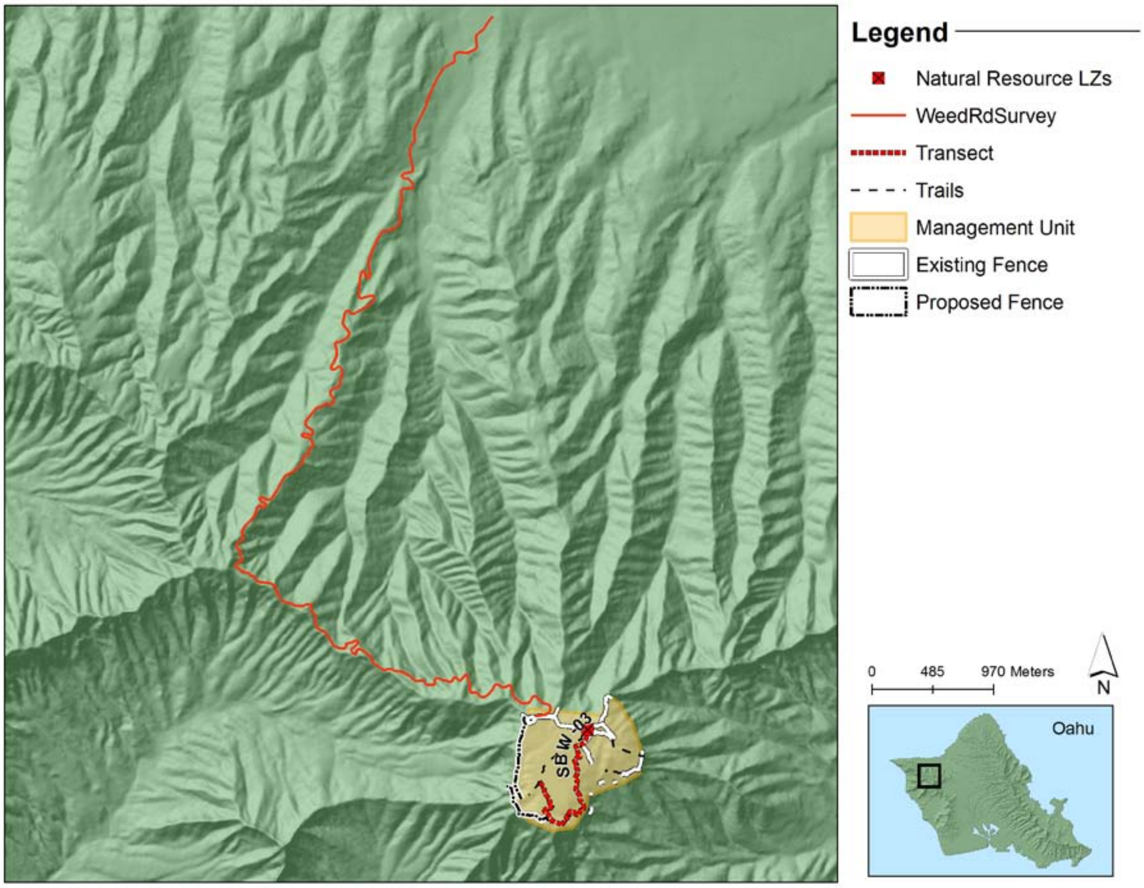
- Conduct road surveys, including parking areas, every year.
- Survey transects for weeds quarterly
- Quarterly surveys of LZ (if used) and Camp site.
- Note unusual, significant, or incipient alien taxa during the course of regular field work.

Management Responses:

- Any significant alien taxa found will be researched and evaluated for distribution and life history. If found to pose a major threat, control will begin and will be tracked via Incipient Control Areas (ICAs)

Surveys are designed to be the first line of defense in locating and identifying potential new weed species. Roads, landing zones, fencelines, and other highly trafficked areas are inventoried regularly to facilitate early detection and rapid response; Army roads and LZs are surveyed annually, non-Army roads are surveyed annually or biannually, while all other sites are surveyed quarterly or as they are used. See the *Survey Locations at Kaala* map. Weed transects will be implemented along existing ungulate transects and the boardwalk.

Survey Locations at Kaala



Weed Survey Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009-Sept.2010	• Kaala Road survey • LZ survey, as used • Camp site survey, as used • Install transect along boardwalk • Survey transects	• 1 • 1-4 • 1-4 • 3 • 1-4
OIP YEAR 4 Oct.2010-Sept.2011 through OIP YEAR 7 Oct.2013-Sept.2014	• Kaala Road survey • LZ survey as used • Camp site survey • Survey transects	• 1 • 1-4 • 1-4 • 1-4

Incipient Taxa Control (ICAs)

Management Objectives:

- As feasible, eradicate species identified as high priority incipient invasive aliens in the MU by 2014.
- Conduct seed dormancy trials for all high priority incipients by 2014.

Monitoring Objectives:

- Visit ICAs at stated revisitation intervals. Control all mature plants at ICAs and prevent any immature or seedling plants from reaching maturity.

Management Responses:

- If unsuccessful in preventing immature plants from maturing, increase ICA revisitation interval.

Incipient Control Areas (ICAs) are drawn around each discrete infestation of an incipient invasive weed. ICAs are designed to facilitate data gathering and control. For each ICA, the management goal is to achieve complete eradication of the invasive taxa. Frequent visitation is often necessary to achieve eradication. Seed bed life/dormancy and life cycle information is important in determining when eradication may be reached; much of this information needs to be researched and parameters for determining eradication defined. NRS will compile this information for each ICA species; assistance from graduate students for this research will be pursued.

The table below summarizes incipient invasive taxa at Kaala. While the list is by no means exhaustive, it provides a good starting point for discussing which taxa should be targeted for eradication in an MU. ICAs are not designated for every species in the table below; however, occurrences of all species in the table should be noted by field staff. All current ICAs are mapped. Three management designations are possible: Incipient (small populations, eradicable), Control Locally (significant threat posed, may or may not be widespread, control feasible at WCA level), and Widespread (common weed, may or may not pose significant threat, control feasible at WCA level).

Summary of Potential ICA Target Taxa

Taxa	Management Designation	Notes	No. of ICAs
Anthoxanthum odoratum	Incipient	Alien grass discovered in quarter one of 2009. First record on Oahu. Highly invasive in pastures on the Big Island. Good candidate for eradication. Population appears to be limited to the beginning of the boardwalk and the trailhead/LZ.	1
Araucaria columnaris	Incipient	One tree, likely planted. Potential for invasiveness has been observed elsewhere. Survey to determine if recruitment taking place; none observed yet. Consider control	1
Begonia foliosa	Widespread	Observed across the MU. NRS don't know how serious a threat this taxon poses. Low priority for control for now.	0
Begonia hirtella	Widespread	Observed across the MU primarily in drainages. Low priority for control.	0
Clidemia hirta	Widespread	Control in WCAs, particularly in the bog flats.	0
Crocosmia x crocosmifolia	Control locally	This species likely escaped from ornamental plantings at the FAA exclosure. Eradication will be difficult to achieve, as the population includes areas inside the FAA exclosure, on State land, and on Army land. However, NRS feel preventing the spread of *C. crocosmifolia* is an important goal; NRS have seen it dispersing down the boardwalk. Control is ongoing with volunteer groups. Control technique: manual removal of bulbs. Herbicide not required. Vegetative reproduction dominant, with occasional seed produced occasionally. Seed viability and seed bed life should be studied.	6

Taxa	Management Designation	Notes	No. of ICAs
Elaeocarpus angustifolius	Incipient	One tree, likely planted. Potential for invasiveness has been observed elsewhere. No recruitment observed. Tree was treated in the past, but is still alive.	1
Festuca arundinacea	Incipient	Invasive grass, known from along the road to the radio tower and around the radio tower exclosure. Highly invasive. Difficult to identify when vegetative. Controlled via foliar spraying.	1
Fraxinus uhdei	Control locally	1 small tree found on sweeps. Many trees seen during aerial surveys in valleys backing up to Kaala. Control as part of WCA efforts. Candidate for aerial herbicide treatment.	0
Hedychium coronarium	Incipient	One site known, on State land near the radio towers. Rarely flowers, no seed seen. 1 patch approximately 10 x 20 m in size, spreading vegetatively. This taxon is a huge problem in the Koolau mountains. NRS will offer assistance to the State to control. Potential volunteer project.	1
Hedychium gardnerianum	Control locally	Originally planted as an ornamental near the FAA facility, this species has spread widely. It is found across the bog flats and has spread down cliffs and into Haleauau (SBW). Aerial surveys show that it has not spread into Makaha and Waianae Kai at this time. Eradication would be extremely difficult/impossible to achieve. This species is highly invasive and poses a major threat to rare taxa and native forest integrity. Control is ongoing in WCAs. Candidate for aerial herbicide control on cliffs, remote areas of SBW.	0
Juncus effusus	Incipient	This taxon is restricted to the area around the boardwalk trailhead and around the radio towers. It is highly invasive and poses a significant threat to the area. NRS control it with volunteers, digging out roots and bagging seed heads (taken to H-power for disposal). Efforts have been very effective. Large patches are visible from the boardwalk on State land. Control efforts of these patches has been complicated by the presence of another invasive, *Sphagnum palustre*.	6
Leptospermum scoparium	Control locally	Plants occasionally found during WCA sweeps. Moderate-sized infestation known on the Kumaipo ridge; likely source population. Control conducted at Kumaipo around 2003-03. Recent aerial surveys show that population has rebounded, and there are many mature plants. NRS plan to work with partner agencies to control this infestation. Control does not require herbicide.	1
Melaleuca quinquenervia	Incipient	Plants occasionally found during WCA sweeps. No large stands known nearby; unclear where plants are dispersing from.	0
Odontonema stricta	Control locally	The full extent of this species is unknown. It appears to have originated from plantings outside the FAA exclosure. No flowers or fruit have been seen, but it reproduces vegetatively. It is unknown how much of a threat it poses, or how to kill it. NRS will survey the population and make a determination on whether or not to control it.	0
Psidium cattleianum	Widespread	Patches scattered across Kaala. These stands tend to be small, and are targeted by NRS during WCA sweeps.	0
Rubus argutus	Widespread	The bane of NRS at Kaala. This taxon is the most common weed in the MU. Control techniques have been tested, but it is difficult to achieve 100% kill with any known techniques. Although it is highly invasive, it is a low priority for control due to its density. Some control may be done in WCAs.	0
Setaria palmifolia	Incipient	Only one site known for this taxa. All known plants killed, have not seen any recruitment.	1

Taxa	Management Designation	Notes	No. of ICAs
Sphaeropteris cooperii	Control locally	Many trees seen during aerial surveys in valleys backing up to Kaala, particularly Haleauau. Control as part of WCA efforts. Candidate for aerial herbicide treatment. Zero tolerance for this species in the MU. Control shall be recorded in WCAs.	0
Sphagnum palustre	Incipient	This invasive moss poses a major threat to the native forest matrix at Kaala. For a full discussion of *S. palustre* at Kaala and research on control method, see the Research chapter. The goal of management is to eradicate *S. palustre* from at least the Army half of the MU. Trials indicate that *S. palustre* is highly susceptible to St. Gabriel's moss killer, a non-toxic product. NRS plant to begin control in 2009 quarter 4/ 2010 quarter 1. NRS controlled a small population on the radio tower road using hand pulling and St. Gabriel's; this was effective.	2
Toona ciliata	Control locally	Many trees seen during aerial surveys in valleys backing up to Kaala. Control as part of WCA efforts. Candidate for aerial herbicide treatment.	0

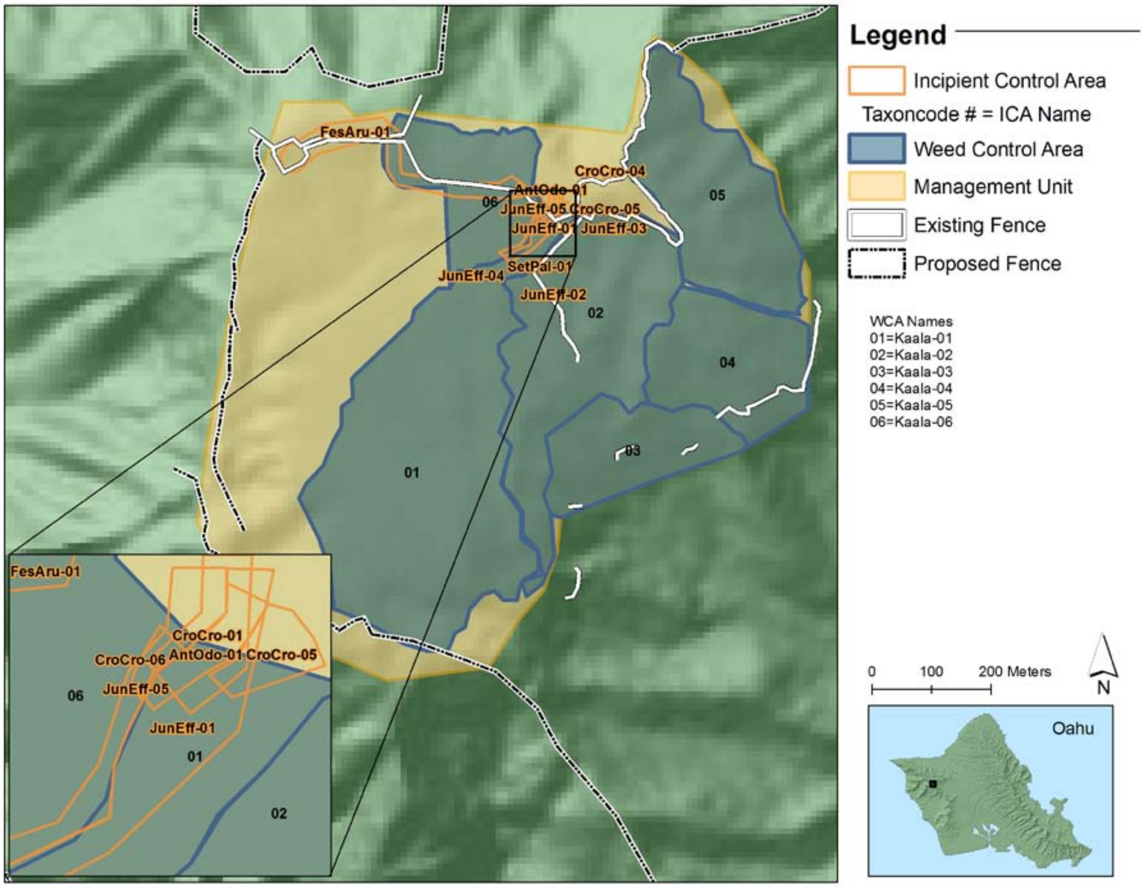
ICA Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009-Sept.2010	• SBW-Antodo-01 control every 6 months • SBW-Aracol-01 control; consider felling tree • SBW-Crocro-01 through -05; control with volunteers, visit sites every 6 months or as needed • Kaala-Crocro-06, control with volunteers, visit every 6 months or as needed • SBW-Elaang-01; girdle tree • SBW-Fesaru-01 control every 6 months • Hedcor; create ICA, work with state to control • SBW-Juneff -01 through -04; control with volunteers, visit sites every 6 months or as needed • Kaala-Juneff -05,06; control with volunteers, visit sites every 6 months or as needed • Kaala-Lepsco-01 control; set up interagency trip to control all plants seen on aerial survey • Odostri; survey extent of population, determine whether or not to control, whether volunteer appropriate • SBW-Setpal-01 monitor annually • SBW-Sphpal-01; begin control when trials complete (Dec 2009). Sweep entire ICA. Revisit in 6 months • Kaala -Sphpal-01; monitor and retreat every 6 months	• 2, 4 • 3 • 1-4 • 2, 4 • 3 • 2,3 • 2 • 2-4 • 2-4 • 1,3 • 1, 2 • 1 • 1, 3 • 1, 3

Year	Action	Quarter
OIP YEAR 4 Oct.2010-Sept.2011 through OIP YEAR 7 Oct.2013-Sept.2014	• SBW-Antodo-01 control every 6 months • SBW-Aracol-01; monitor annually for regrowth, seedlings, till determined dead. • SBW-Crocro-01 through -05; control with volunteers, visit sites every 6 months or as needed • Kaala-Crocro-06, control with volunteers, visit every 6 months or as needed • SBW-Elaang-01; monitor for regrowth, seedlings till determined dead • SBW-Fesaru-01 control every 6 months • Hedcor; assist with State • SBW-Juneff -01 through -04; control with volunteers, visit sites every 6 months or as needed • Kaala-Juneff -05,06; control with volunteers, visit sites every 6 months or as needed • Kaala-Lepsco-01; monitor/control every two years (OIP yr 5, 7) • Odostri; develop and implement control plan • SBW-Setpal-01 monitor annually • SBW-Sphpal-01; monitor/retreat annually until determined dead • Kaala -Sphpal-01; monitor/retreat annually until determined dead	• 2, 4 • 1 • 1-4 • 2, 4 • 3 • 2,3 • 2 • 2-4 • 2-4 • 1,3 • 1, 2 • 1-4 • 1 • 1, 3 • 1, 3

C. crocosmifolia volunteer trip at Kaala

Incipient and Weed Control Areas at Kaala



Ecosystem Management Weed Control (WCAs)

OIP Goals:

- Within 2m of rare taxa: 0% alien vegetation cover
- Within 50m of rare taxa: 25% or less alien vegetation cover
- Throughout the remainder of the MU: 50% or less alien vegetation cover

Management Objectives:

- Maintain 50% or less alien vegetation cover in the understory across the MU.
- Reach 50% or less alien canopy cover across the MU in the next 5 years.
- In WCAs within 50m of rare taxa, work towards achieving 25% or less alien vegetation cover in understory and canopy.

Management Responses:

- Increase/expand weeding efforts if MU vegetation monitoring (conducted every 3 years) indicates that goals are not being met.

The Kaala MU is one of the few MUs in the Waianae mountains that is dominated by native vegetation. Although MU vegetation monitoring has not been conducted at Kaala, NRS feel that it is safe to assume that the MU meets the 50% or less alien cover goal for the OIP. Vegetation across the MU includes

Metrosideros polymorpha, Cheirodendrom platyphyllum, Cheirodendron trigynum, Broussasia arguta, Melicope clusiifolia, Ilex anomala, Cibotium sp., *Machaerina angustifolia, Dianella sandwicensis*, and numerous other native ferns, herbs, and mosses. Most of the MU is divided into WCAs to facilitate data tracking and control efforts (see Incipient and Weed Control Areas map above). NRS focus effort on the Army owned portion of the MU.

The primary weed threats at Kaala are *H. gardnerianum, P. cattleianum*, and *S. palustre*. The *H. gardnerianum* control strategy over the last 4 years has been to sweep WCAs 1-6 on a rotational basis. The initial goal was to sweep three WCAs per year, with 100% area coverage per WCA, every two years. This goal was unrealistic, due to the large size of the WCAs, steep terrain, thick vegetation, and competing priorities. In 2009, NRS modified this control strategy; NRS feel that it is more realistic to sweep the hikable portions of two WCAs per year, every three years. NRS feel that this new timeline will still allow NRS to treat *H. gardnerianum* before they mature. The primary focus of sweeps will be to kill all the large, accessible mature *H. gardnerianum* patches. This strategy is based off of the fact that the more the amount of overall seed set is reduced, the fewer the number of new individuals in the WCAs there will be. NRS will revise strategy as needed. NRS track numbers of all treated plants, divided by size class. This data allow staff to fine tune revisitation timelines.

Aerial and ground surveys show that there are many large, mature patches of *H. gardnerianum* in steep areas, on the Kaala cliffs, and below Kaala in Haleauau. Developing alternative means of surveying and treating these areas will be a priority. Some options include aerial surveys, aerial mapping (photographs), aerial ball spraying, and aerial/ground Herbicide Ballistic Technology (HBT). Alternative herbicides, such as imazypyr (used in HBT) will be tested before aerial trials begin. NRS feel that these techniques have great potential in reducing the reproductive capacity of *H. gardnerianum* in the Kaala region.

P. cattleianum is scattered sparsely across the MU. It has the potential to become a major threat at Kaala. NRS will seek use to make use of volunteers to control large stands. Other tree weeds are occasionally found on Kaala; these are also a priority in every WCA.

S. palustre is incipient in the MU, and discussion of it here will be limited. Refer to the ICA section above. The presence of *S. palustre* along the boardwalk complicated other weed control efforts. It can be easily spread vegetatively, by bits of moss clinging to tabis and field gear. NRS avoid walking through *S. palustre* while conducting WCA sweeps. This has hampered control efforts on both the Army and State sides of the boardwalk. Trials conducted in 2009 suggest that *S. palustre* can be effectively controlled with St. Gabriel's moss killer. This product contains clove oil as its active ingredient and was chosen for testing after its recommendation to NRS by the Pesticides branch of the HDOA (L. Kobashigawa 2008). Results are promising; however tests are still on-going through the end of this year to achieve the lowest possible effective dose. A thorough description of control work is provided in Chapter 10: Research Activities. There appear to be few non-target effects. *S. palustre* control will reduce the potential for staff to act as vectors for this weed, and will allow for more efficient and effective WCA sweeps.

General WCA Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009-Sept.2010	• Finalize cliff side edges of relevant WCAs; GPS.	• 1, 2
OIP YEAR 4 Oct.2010-Sept.2011 through OIP YEAR 7 Oct.2013-Sept.2014	• Conduct aerial surveys to facilitate *H. gardnerianum* and other weed control	• 2

WCA: Kaala-01 (Boardwalk to Transect Trail)

Veg Type: Wet Forest

OIP Goal: 25% or less alien cover (rare taxa in WCA). No monitoring has been conducted, but it is likely this goal has been met.

Targets: *H. gardnerianum*, *P. cattleianum*, *M. quinqueveria, L. scoparium* and *C. hirta* in areas where it is not abundant.

Notes: Also known as the Bog Flats, this WCA encompasses the top of Kaala, on Army land. This is a largely intact area dominated by *Metrosideros polymorpha* (ohia). Other dominant natives include *Cheirodendron platyphyllum* (lapalapa) *Cheirodendron trigynum* (olapa) *Coprosma ochracea* (pilo) and *Ilex anomala* (kawau). Rare taxa include *S. trinervis, C. acuminata*, *L. cyrtandrae* and *C. calycina*. *H. gardnerianum* is the primary threat. Previous control efforts have been effective at reducing numbers of mature plants; seedlings and immature are most common now. It appears that *H. gardnerianum* had not spread across the entire WCA. NRS will look through previous sweep records and identify the *H. gardnerianum* zone. This will help determine how often to revisit various parts of the WCA. NRS will sweep the ginger priority zone every three years. *P.cattleianum* is relatively uncommon in the WCA and is a target during sweeps. *M. quinqueveria* and *L. scoparium* have been found in this WCA in the past. At the trailhead, there are several incipient species; control results in bare areas. Grass thrives in these areas. NRS are experimenting with common native transplants to rehabilitate the bare ground and reduce grass cover.

Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009-Sept.2010	• Complete full sweep of WCA in October • Weed around rare plant populations • Weedwhack/spray grass around *J. effusus* populations every 6 months, as needed • Plant/monitor *Cibotium* sp. reintros • Looking at old data, identify ginger priority zone	• 4 • 2,3 • 2,4 • 3 • 1
OIP YEAR 4 Oct.2010-Sept.2011	• Weed around rare plant populations • Plant/monitor *Cibotium* sp. reintros • Weedwhack/spray grass around *J. effusus* populations every 6 months, as needed	• 2 • 3 • 2, 4
OIP YEAR 5 Oct.2011-Sept.2012	• Sweep WCA for *H. gardnerianum*: ginger priority zone • Weed around rare plant populations • Plant/monitor *Cibotium* sp. reintros • Weedwhack/spray grass around *J. effusus* populations every 6 months, as needed	• 1,3 • • 2,3 • 3 • 2, 4
OIP YEAR 6 Oct.2012-Sept.2013	• Weed around rare plant populations • Plant/monitor *Cibotium* sp. reintros • Weedwhack/spray grass around *J. effusus* populations every 6 months, as needed	• 2,3 • 3 • 2,4
OIP YEAR 7 Oct.2013-2014	• Weed around rare plant populations • Sweep non-ginger priority zone sections of WCA every 5 years • Plant/monitor *Cibotium* sp. reintros • Weedwhack/spray grass around *J. effusus* populations every 6 months, as needed	• 2,3 • 1-4 • 3 • 2, 4

WCA: Kaala-02 (Transect Trail to Rainbow Ridge)

Veg Type: Wet Forest

OIP Goal: 25% or less alien cover (rare taxa in WCA). No monitoring has been conducted, but it is likely this goal has been met.

Targets : *H. gardnerianum*, *P. cattleianum*, and *C. hirta* in areas where it is not abundant.

Notes: This WCA includes some gulches and steep terrain which pose major challenges for conducting weed sweeps. The area is native dominated, but the gulches are thick with *R. argutus*. Rare taxa include *S. trinervis, L. cyrtandrae* and *C. calycina*. The primary weed target is *H. gardnerianum*. NRS plan to sweep all hikable portions of the WCA once every three years. Hopefully, this will facilitate control by allowing NRS to treat plants before they mature, and look for plants larger than seedling size. In those areas too steep to reach, NRS will investigate alternative methods to survey and treat *H. gardnerianum*.

Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009- Sept.2010	• Sweep WCA • Weed around rare plant populations	• 2,3 • 2,3
OIP YEAR 4 Oct.2010- Sept.2011	• Weed around rare plant populations	• 2,3
OIP YEAR 5 Oct.2011- Sept.2012	• Weed around rare plant populations	• 2,3
OIP YEAR 6 Oct.2012- Sept.2013	• Weed around rare plant populations • Sweep WCA	• 2,3 • 2,3
OIP YEAR 7 Oct.2013- Sept.2014	• Weed around rare plant populations	• 2,3

WCA: Kaala-03 (Lower Rainbow Ridge)

Veg Type: Wet Forest

OIP Goal: 25% or less alien cover (rare taxa in WCA). No monitoring has been conducted, but it is likely this goal has been met.

Targets : *H. gardnerianum*, *P. cattleianum*, and *C. hirta* in areas where it is not abundant.

Notes: This WCA is steep and ends abruptly in cliffs which lead down into Central Haleauau. *S. trinerva, L. cyrtandrae, C. acuminata* present, *G. petaloidea* in gulches. A high number of *L.cyrtandrae* are found in this WCA. *C. calycina*, *N. melastoma*, *L. hypoleuca* also present. There are many mature *H. gardnerianum* patches in the WCA. It is not possible to sweep the entire WCA, as parts of it are too steep. *R. argutus* is thick in the draws and slopes. NRS conducted sweeps across much of the WCA in summer of 2009. NRS will experiment with alternative survey/control methods on the steep slopes.

Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009- Sept.2010	• Weed around rare plant populations	• 2,3
OIP YEAR 4 Oct.2010- Sept.2011	• Aerial/HBT *H. gardnerianum* trials • Weed around rare plants	• 2, 3 • 2,3
OIP YEAR 5 Oct.2011- Sept.2012	• Aerial spray *H. gardnerianum* control • Sweep all hikable portions of WCA every 3 years, target *H. gardnerianum* matures, *P. cattleianum* • Weed around rare plants	• 3 • 2, 3 • 2,3
OIP YEAR 6 Oct.2012- Sept.2013 through OIP YEAR 7 Oct.2013- Sept.2014	• Aerial spray *H. gardnerianum* control • Weed around rare plants	• 3 • 2, 3

WCA: Kaala-04 (Rainbow Ridge to Blue Trail)

Veg Type: Wet Forest

OIP Goal: 25% or less alien cover (rare taxa in WCA). No monitoring has been conducted, but it is likely this goal has been met.

Targets: *H. gardnerianum*, *P. cattleianum*, and *C. hirta* in areas where it is not abundant.

Notes: This WCA is steep and ends abruptly in cliffs which lead down to Central Haleauau. It is bordered on two sides by access trails. Rare taxa present include *S. trinervis*, *L. cyrtandrae*, and *G. petaloidea* in gulches. *R. argutus* is thick, especially in gulches. Much of this area is too steep to safely survey. NRS will prioritize treating mature *H. gardnerianum* in hikable areas and will investigate alternative techniques for surveying and treating cliffside plants. There are numerous patches of *H. gardnerianum* below the fenceline, in Haleauau. NRS will seek to control these through aerial techniques.

Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009-Sept.2010	• Weed around rare plant populations • Sweep all hikable portions of WCA every 3 years, target *H. gardnerianum* matures, *P. cattleianum* • GPS WCA boundaries	• 2,3 • 2, 3 • 4
OIP YEAR 4 Oct.2010-Sept.2011	• Aerial/HBT *H. gardnerianum* trials • Weed around rare plants	• 2, 3 • 2,3
OIP YEAR 5 Oct.2011-Sept.2012	• Aerial spray *H. gardnerianum* control • Weed around rare plants	• 3 • 2, 3
OIP YEAR 6 Oct.2012-Sept.2013	• Sweep all hikable portions of WCA every 3 years, target *H. gardnerianum* matures, *P. cattleianum* • Aerial spray *H. gardnerianum* control • Weed around rare plants	• 2, 3 • 3 • 2, 3
OIP YEAR 7 Oct.2013-Sept.2014	• Aerial spray *H. gardnerianum* control • Weed around rare plants	• 3 • 2, 3

Dianella sandwicensis fruit

WCA: Kaala-05 (Blue Trail to Kamaohanui)

Veg Type: Wet Forest

OIP Goal: 25% or less alien cover (rare taxa in WCA). No monitoring has been conducted, but it is likely this goal has been met.

Target: *H. gardnerianum*, *P. cattleianum*, and *C. hirta* in areas where it is not abundant.

Notes: This WCA is very steep, and there is little hikable area. Rare taxa present include *C. acuminata*, *S. trinervis*, *L. cyrtandra, C. calycina* and *G. petaloidea* in gulches. *R. argutus* is thick, especially in gulches. *H. gardnerianum* is the primary weed target. NRS will prioritize treating mature plants in hikable areas, and will investigate alternative survey/control methods for the steep portions of the WCA. There are numerous patches of *H. gardnerianum* below the fenceline, on the cliffs and in Haleauau; NRS hope to control these using aerial techniques.

Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009-Sept.2010	• Weed around rare plant populations • GPS WCA boundaries	• 2,3 • 4
OIP YEAR 4 Oct.2010-Sept.2011	• Sweep all hikable portions of WCA every 3 years, target *H. gardnerianum* matures, *P. cattleianum* • Aerial/HBT *H. gardnerianum* trials • Weed around rare plants	• 2, 3 • 2,3 • 2, 3
OIP YEAR 5 Oct.2011-Sept.2012	• Aerial spray *H. gardnerianum* control • Weed around rare plants	• 3 • 2, 3
OIP YEAR 6 Oct.2012-Sept.2013	• Aerial spray *H. gardnerianum* control • Weed around rare plants	• 3 • 2, 3
OIP YEAR 7 Oct.2013-Sept.2014	• Sweep all hikable portions of WCA every 3 years, target *H. gardnerianum* matures, *P. cattleianum* • Aerial spray *H. gardnerianum* control • Weed around rare plants	• 2, 3 • 2,3 • 2, 3

Cheirodendron platyphyllum canopy

WCA: Kaala-06 (North of Boardwalk)

Veg Type: Wet Forest

OIP Goal: 25% or less alien cover (rare taxa in WCA). No monitoring has been conducted, but it is likely this goal has been met.

Target: *H. gardnerianum*, *P. cattleianum*, and *C. hirta* in areas where it is not abundant.

Notes: This WCA is located on State land. Rare taxa present include *S. trinervis* and *G. petaloidea*. NRS will work with NARS staff to determine a control strategy. Parts of this WCA lie outside the fenced portion of Kaala; in these areas, pig damage is considerable. Parts of the WCA are steep, and parts are thick with f *R. argutus*. NRS suggest targeting mature *H. gardnerianum*, and sweeping the area every three years.

Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009- Sept.2010	• Weed around rare plant populations • GPS WCA boundaries	• 2,3 • 4
OIP YEAR 4 Oct.2010- Sept.2011	• Sweep all hikable portions of WCA every 3 years, target *H. gardnerianum* matures, *P. cattleianum* • Aerial/HBT *H. gardnerianum* trials • Weed around rare plants	• 2, 3 • 2,3 • 2, 3
OIP YEAR 5 Oct.2011- Sept.2012	• Aerial spray *H. gardnerianum* control • Weed around rare plants	• 3 • 2, 3
OIP YEAR 6 Oct.2012- Sept.2013	• Aerial spray *H. gardnerianum* control • Weed around rare plants	• 3 • 2, 3
OIP YEAR 7 Oct.2013- Sept.2014	• Sweep all hikable portions of WCA every 3 years, target *H. gardnerianum* matures, *P. cattleianum* • Aerial spray *H. gardnerianum* control • Weed around rare plants	• 2, 3 • 2,3 • 2, 3

WCA: Kaala-07 (FAA Exclosure)

Veg Type: Wet Forest

OIP Goal: N/A. This exclosure is a built area, not a natural area.

Targets: *H. gardnerianum*.

Notes: The FAA exclosure is dominated by grass and has little other vegetation. However, it does have a patch of *H. gardnerianum*. NRS will seek to obtain permission from the National Guard and Federal Aviation Administration (FAA) to control these plants. The site will be monitored and retreated every two years.

Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009- Sept.2010	None	
OIP YEAR 4 Oct.2010- Sept.2011	• Control *H. gardnerianum* inside FAA exclosure	• 3
OIP YEAR 5 Oct.2011- Sept.2012	None	
OIP YEAR 6 Oct.2012- Sept.2013	• Control *H. gardnerianum* inside FAA exclosure	• 3
OIP YEAR 7 Oct.2013- Sept.2014	None	

1.4.3.5 Rodent Control

Threat level: High

Control method: None

Seasonality: N/A

Number of snap grids: None

Primary Objective:

- To implement rodent control if determined to be necessary for protection of rare plants and tree snails.

Monitoring Objective:

- Monitor rare plant (*Labordia cyrtandrae* and *Cyanea acuminate*) populations and *Achatinella mustelina* populations to determine impacts by rodents.

Rodent Control:

- Potentially threatened resources are widespread throughout the Kaala MU. The habitat quality is very high in the Kaala MU. Rare plant populations have been impacted by rodents in the past and no rodent control is currently in place. Airlayers on the branches of some *L.* cyrtandrae plants have been eaten into in the past and it is strongly suspected that rodents have girdled the bases and eaten the fruit off of some *C. acuminata* and possibly *L. cyrtandrae* fruits. If airlayers are installed again on *L. cyrtandrae* and/or fruits develop on the *L. cyrtandrae* OANRP will make a decision whether to conduct localized rodent control.

Rodent Control Actions:

Year	Actions	Quarter
OIP YEAR 3 Oct.2009-Sept.2010 through OIP YEAR 7 Oct.2013-Sept.2014	• Monitor rare plants and tree snails for predation by rats • Implement localized rodent control if determined to be necessary for the protection of *L. cyrtandrae*, *C. acuminata,* and *A. mustelina*	• 1-4 • 1-4

L. cyrtandrae flowers

1.4.3.6 Slug Control

Species: *Lehmannia valentiana*, *Deroceras leave*, *Limax maximus* and *Milax gagates*

Threat level: Low (slugs are observed in low densities in this area)

Control level: Localized

Seasonality: Probably year-round as area is extremely wet

Number of sites: *Labordia cyrtandrae* population

Primary Objective:

- Keep slug populations to a determined level to facilitate germination and survivorship of threatened rare taxa.

Management Objective:

- By the summer of 2010, determine the level of threat to *L. cyrtandrae* populations and decide if slug control is warranted and feasible.
- Begin a pilot slug control program in the summer of 2010 using Sluggo around the *L. cyrtandrae* populations as needed.
- By 2011, reduce slugs by at least 50% of estimated baseline densities around *L. cyrtandrae* populations through a pilot control program as needed.

Monitoring Objectives:

- Annual census monitoring of *L. cyrtandrae* populations to monitor slug damage.
- Slug density monitoring beginning in the summer of 2010 as needed.

Effective mollusicicides have been identified (Sluggo) and initial control programs are ongoing in Kahanahaiki. A slug control program may be started at the Kaala MU if slugs are continued to be observed feeding on *L. cyrtandrae* reproductive structures. Given rarity, slow growth and long lifespan of *L. cyrtandrae* leaves, and the dioecism of *L. cyrtandrae* species any slug damage can be significant.

Other rare plant populations like *C. acuminata* may also benefit from slug control. However, it remains to be determined whether the proximity of native snails would preclude application of molluscicides widely in this area.

Slug Control Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009-Sept.2010	• Determine need for and feasibility of slug control at Kaala for *L. cyrtandrae* (and possibly other rare plant species). • Begin slug control in the summer of 2010 to protect flowering/fruiting *L. cyrtandrae* trees. • Begin slug monitoring program if a control program is initiated.	• 1-4
OIP YEAR 4 Oct.2010-Sept.2011 through OIP YEAR 7 Oct.2013-Sept.2014	• Continue slug control and monitoring program as needed.	• 1-4

1.4.3.7 Predatory Snail Control

Species: *Euglandina rosea* (rosy wolf snail), *Oxychilus alliarus* (garlic snail)

Threat level: Low (*E. rosea* not found in MU, *O. alliarus* not found near *Achatinella*)

Control level: Localized

Seasonality: Unknown

Number of sites: 1 *Achatinella mustelina* site

Acceptable Level of Activity: Unknown

Primary Objective:

- Keep predatory snail populations to a low enough level that *A. mustelina* survival is unaffected.

Management Objective:

- Continue to develop better methods to control predatory snails
- Keep sensitive snail populations safe from predatory snails via currently accepted methods (such as hand removal of alien snails, construction of barriers which prevent incursion from alien snails)

Monitoring Objectives:

- Annual or every other year census monitoring of *A. mustelina* population to determine population trend.
- Annual searches for predatory snails to confirm their absence in proximity to *A. mustelina.*

No baits have been developed for the control of predatory snails. Little is known regarding their distribution and prey preference. Control is limited to hand removal. Visual searches are time-consuming, difficult, and not feasible over large areas and in steep terrain. It is also unknown whether predatory snail populations are reduced by hand removal. Fortunately, searches to date show no *E. rosea* in the Kaala MU. *Oxychilus alliarus* is present but restricted to an area <0.5 acres in the vicinity of the FAA tower and a short distance along the boardwalk.

Predatory Snail Control Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009-Sept.2010	• Determine if any *E. rosea* or *O. alliarus* snails are present at the *A. mustelina* SBW-R site or at other *A. mustelina* sites in the Kaala MU	• 1-4
OIP YEAR 4 Oct.2010-Sept.2011 through OIP YEAR 7 Oct.2013-Sept.2014	• Implement control as improved tools become available	• 1-4

O. alliarus

1.4.3.8 Ant Control

Species: *Solenopsis papuana, Ochetellus glaber, Tetramorium simillimum, Cardiocondyla venustula*, *C. wroughtoni, C. minutior*

Threat level: Low

Control level: Only for new incipient species

Seasonality: Varies by species, but nest expansion observed in late summer, early fall

Number of sites: 3 (Campsite, Boardwalk, Road)

Acceptable Level of Ant Activity: Acceptable at present densities

Primary Objective:

- Eradicate incipient ant invasions and control established populations when densities are high enough to threaten rare resources.

Management Objective:

- If incipient species are found and deemed to be a high threat and/or easily eradicated locally (<0.5 acre infestation) begin control using a bait containing Hydramethylnon (Amdro, Maxforce or Seige).

Monitoring Objective:

- Continue to sample ants at human entry points (landing zone, fence line) a minimum of once a year. Use samples to track changes in existing ant densities and to alert OANRP to any new introductions.
- If *Drosophila substenoptera* found, annual survey for ants needed to determine threat to immature larvae.

Ants have been documented to pose threats to a variety of resources, including native arthropods, plants (via farming of Hemipterian pests), and birds. The distribution and diversity of ant species in upland areas on Oahu, Kaala, has only begun to be studied and changes over time. Impacts to the rare species present in Kaala remain unknown, but it is likely they are having some type of effect on the ecosystem at large. The OANRP has already conducted some surveys across Kaala to determine which ant species are present and where they are located. Surveys were conducted using a standardized sampling method (see Appendix Invasive Ant Monitoring Protocol, this document). No ants found on the boardwalk, only rarely along road at elevations between 1500-2500 ft.

Ant Control Actions:

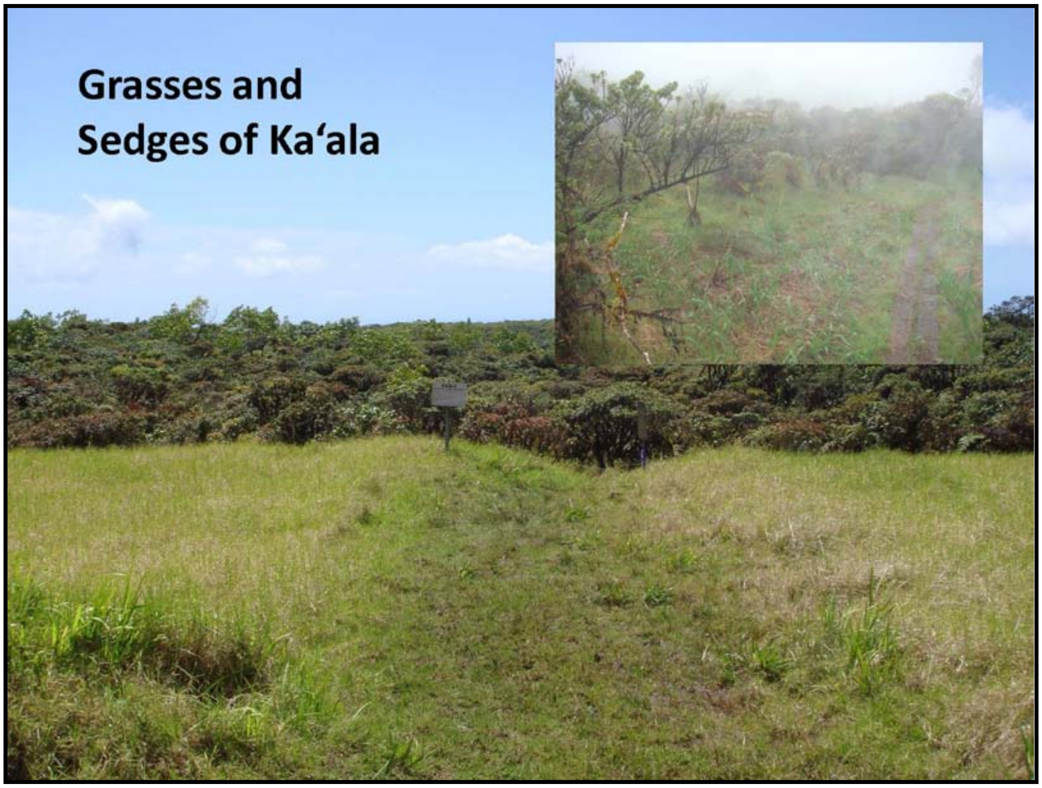
Year	Action	Quarter
OIP YEAR 3 Oct.2009-Sept.2010	• Conduct surveys for ants across MU with bait cards as needed • Analyze results of surveys, develop management recs	• 1-4
OIP YEAR 4 Oct.2010-Sept.2011 through OIP YEAR 7 Oct.2013-Sept.2014	• Implement control if deemed necessary	• 1-4

1.4.3.9 Fire Control

Due to the very low threat from fire, no actions are proposed at this time.

1.4.3.10 Supplemental Material

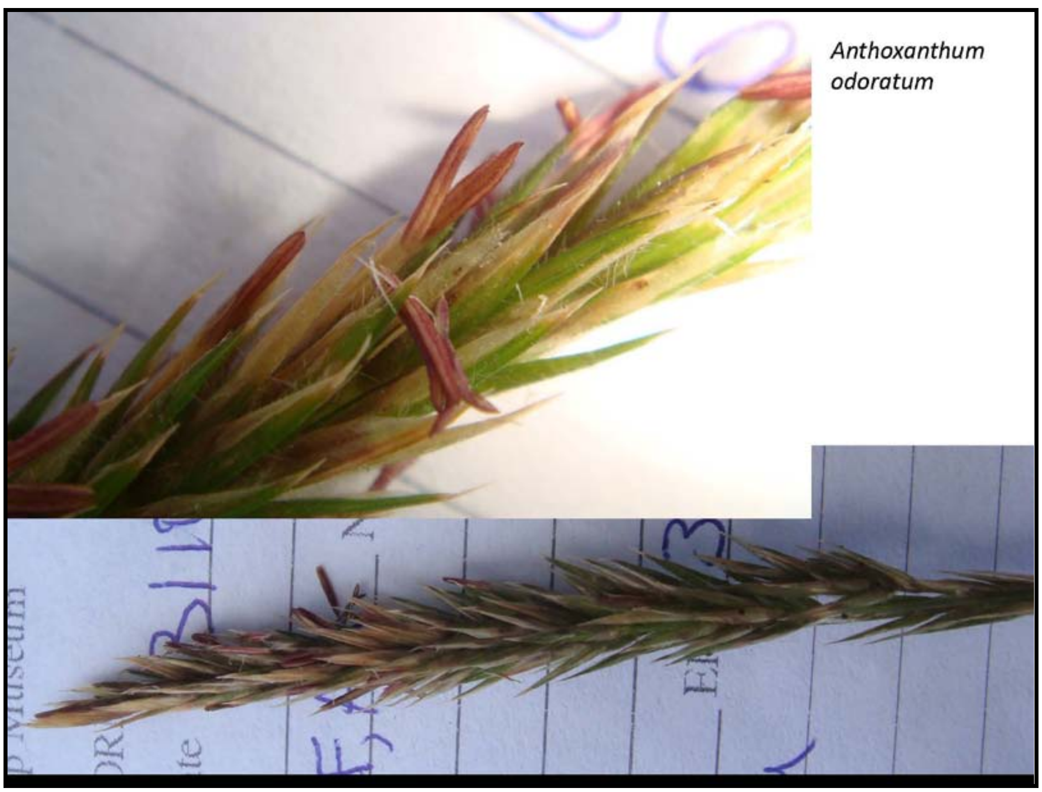
Invasive Grasses of Kaala




Festuca arundinacea


Festuca arundinacea
2004/10/ 6 3:02pm


Anthoxanthum odoratum, sweet vernal grass


Anthoxanthum odoratum


Anthoxanthum
odoratum


Pennisetum clandestinum, kikuyu grass

1.4.4 Kahanahaiki Ecosystem Restoration Management Plan

Date Updated: November 16, 2009

MIP Year 6-10, Oct. 2009 – Sept. 2014

MU: Kahanahaiki Subunit I and II

1.4.4.1 Overall MIP Management Goals:

- Form a stable, native-dominated matrix of plant communities which support stable populations of IP taxa.
- Control ungulate, rodent, arthropod, slug, snail, fire, and weed threats to support stable populations of IP taxa. Implement control methods by 2013.

1.4.4.2 Background Information

Location: Northern Waianae Mountains

Land Owner: US Army Garrison Hawaii

Land Manager: Oahu Army Natural Resources Program (OANRP)

Acreage: 104 acres

Elevation Range: 1400ft-2300ft

Description: Kahanahaiki MU is located in the Makua Military Reservation (MMR) and is accessed via the Mokuleia Forest Reserve. It is on the eastern border of Makua, at the eastern end of the valley. The Subunit I portion of the MU extends from a high point at the top of "C-Ridge" (the ridge that divides Makua into its two valleys) to the north and east. From C-Ridge, it extends north in a gentle slope that divides into two shallow gulches. These gulches converge at a cliff zone. North of the cliff area, it encompasses one large gulch and the ridges bordering it. This gulch runs north, and then curves to the west. A large cliff/waterfall marks the north boundary of Subunit I. Overall, the north and east aspects are relatively native while the south and west exposures are dominated by weeds. Subunit II is bordered by Subunit I on the east, and stretches across several ridges and gulches running west towards the floor of Makua valley.

Native Vegetation Types:

Waianae Vegetation Types
Mesic mixed forest
Canopy includes: *Acacia koa*, *Metrosideros polymorpha, Nestegis sandwicensis, Diospyros* spp., *Pouteria sandwicensis, Charpentiera* spp., *Pisonia* spp. ,*Psychotria* spp., *Antidesma platyphyllum*, *Bobea* spp. and *Santalum freycinetianum*. Understory includes: *Alyxia oliviformis, Bidens torta, Coprosma* spp., and *Microlepia strigosa*
NOTE: For MU monitoring purposes vegetation type is mapped based on theoretical pre-disturbance vegetation. Alien species are not noted.
NOTE: For MU monitoring purposes, vegetation types were subdivided using topography (gulch, mid-slope, ridge). Topography influences vegetation composition to a degree. Combining vegetation type and topography is useful for guiding management in certain instances.

Primary Vegetation Types at Kahanahaiki

Mesic Gulch

Mesic Mid-Slope

Mesic Ridge

Mesic Gulch

Mesic Mid-Slope

Mesic Ridge

View of Kahanahaiki

MIP/OIP Rare Resources:

Organism Type	Species	Pop. Ref. Code	Population Unit	Management Designation	Wild/ Reintroduction
Plant	*Alectryon macrococcus* var *macrococcus*	MMR-B, G,L	Kahanahaiki to West Makaleha	MFS	Both
Plant	*Cenchrus agrimonioides* var. *agrimonioides*	MMR- A-J	Kahanahiki and Pahole	MFS	Both
Plant	*Cyanea superba* subsp. *superba*	MMR-A, B, D-H	Kahanahaiki	MFS	Reintroduction
Plant	*Cyrtandra dentata*	MMR-A	Kahanahaiki	MFS	Wild
Plant	*Delissea subcordata*	MMR-A, B, C, E, F	Kahanahaiki to Keawapilau	MFS	Both
Plant	*Flueggea neowawraea*	MMR-A, B, F,G,H	Kahanahaiki to Kapuna	MFS	Both
Plant	*Hedyotis degeneri* var. *degeneri*	MMR- A	Kahanahaiki to Pahole	MFS	Wild
Plant	*Nototrichium humile*	MMR- C	Kahanahaiki	GSC	Wild
Plant	*Schiedea nuttallii*	MMR- B, C,D	Kahanahaiki to Pahole	MFS	Both
Plant	*Schiedea obovata*	MMR- C, D,E,F,G	Kahanahaiki to Pahole	MFS	Reintroduction
Snail	*Achatinella mustelina*	MMR-A, C,D,N	ESU-A	MFS	Wild
Bird	*Chasiempis sandwichensis ibidis*	N/A	MMR	None	Wild*

MFS= Manage for Stability *= Populaiton Dead
GSC= Genetic Storage Collection †=Reintroduction not yet done

Other Rare Taxa at Kahanahaiki MU:

Organism Type	Species	Status
Plant	*Alphitonia ponderosa*	Endangered
Plant	*Bobea sandwicensis*	Endangered
Plant	*Diellia falcata*	Endangered
Plant	*Euphorbia haeleeleana*	Endangered
Plant	*Lepidium arbuscula*	Endangered
Plant	*Pteralyxia macrocarpa*	Species of Concern

Rare Resources at Kahanahaiki

Locations of Rare Resources at Kahanahaiki

Map removed,
available upon request

MU Threats to MIP/OIP MFS Taxa:

Threat	Taxa Affected	Localized Control Sufficient?	MU scale Control required?	Control Method Available?
Pigs	All	No	Yes	Yes.
Rats	All	No	Yes	Yes. MU-wide snap trap grid installed May 2009
Predatory snails	*Achatinella mustelina*	Unknown	Unknown	No. Limited to hand-removal and physical barriers
Slugs	*C. superba* subsp. *superba, S. obovata, S. nuttalii*	Yes	No	Currently under development
Ants	Unknown	Unknown	Unknown	Some available, depends on species
Weeds	All	Yes	Yes	Yes
Fire	All		Yes	Yes

Management History

Much effort has been focused on the Kahanahaiki MU over the years. It is home to many MIP rare taxa, including plants, snails and birds. Since the area is diverse, easily accessible, and relatively small, many field techniques were first tested and installed by NRS here. These include the first large fence, first snail enclosure, first rat trap grid, first common native plant reintroduction, and lots of experimentation with weed control. Techniques developed at Kahanahaiki are used at all other MUs. Volunteers often visit and have dedicated countless hours caring for resources as well as learning about the importance of native forests from OANRP staff.

- 1995: OANRP begins management at Kahanahaiki. Surveys are conducted. Staff becomes familiar with MU.
- 1996: MU fence construction for Subunit I completed.
- 1998: Pigs eradicated from the Subunit I fence.
- 1998: Snail enclosure built around the core portion of the *A. mustelina* population.
- 1999-2009: Snaring outside fence reduces pressure on the fence from pigs.
- 1999-2009: Restoration work occurs across the MU focusing on most pristine areas. Work includes weed removal, and re-vegetation with common and rare species.
- 1998-2009: Rodent control though the use of bait stations with rodenticide and snap traps for the protection of *A. mustelina* and Elepaio.
- 2009: OANRP begins rodent control over the entire MU with a Trap Out grid.

Visiting New Zealand rodent control expert with wooden boxes for snap traps

1.4.4.3 Ungulate Control

Identified Ungulate Threats: Pigs

Threat Level: High

Primary Objectives:

- Maintain Subunit I as pig free. Make Subunit II pig free.

Strategy:

- Maintain Subunit I as pig free by maintaining fence and using snares in Subunit II to reduce impacts and pressure.
- Construct a fence in Subunit II and eradicate pigs from fence.

Monitoring Objectives:

- Conduct fence checks and read transects quarterly. GPS and mark the fence at ten meter intervals so that the fence will be one large transect. Discontinue Transects 10, 11.
- Monitor for pig sign while conducting other management actions in the fence.

Management Responses:

- If any pig activity is detected within the fenced unit, implement hunting and/or snaring program.
- If more than ten percent activity is detected along transects outside fence, increase snaring effort.

Maintenance Issues:

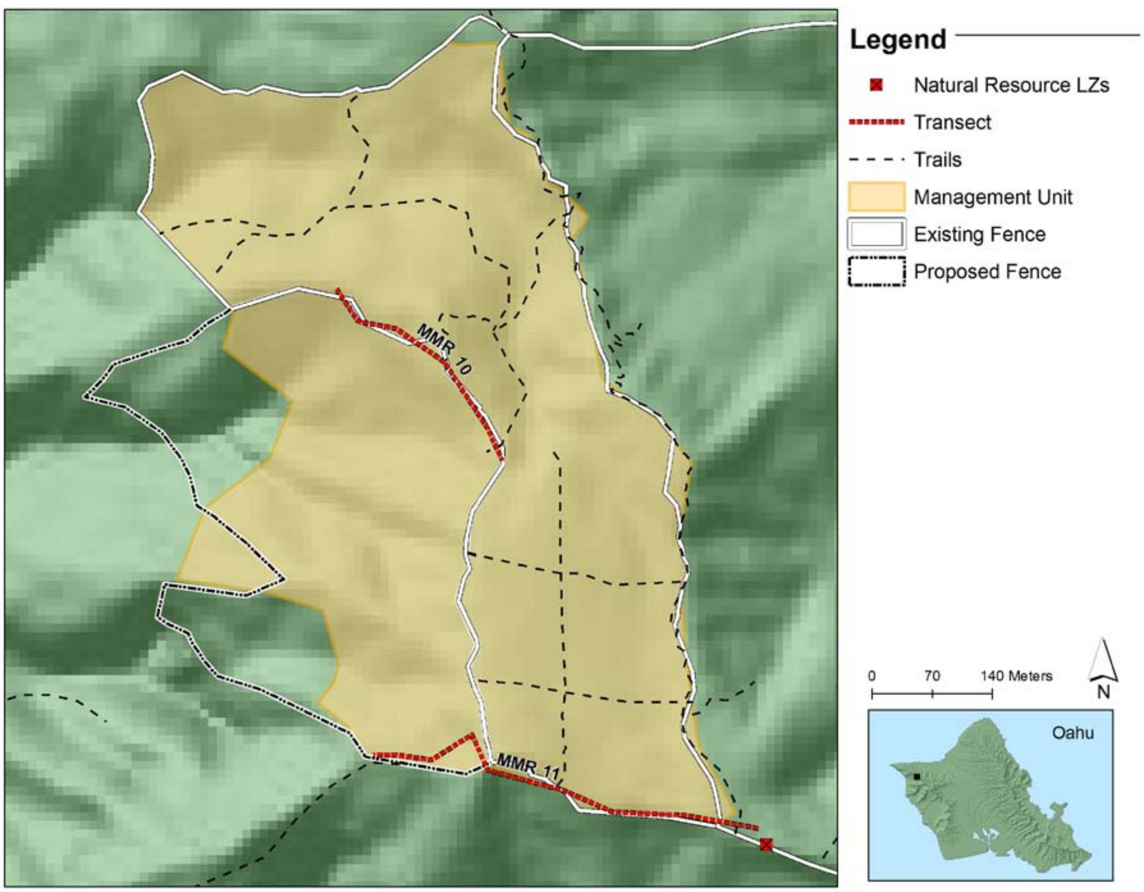
There is a perimeter fence around Subunit I. The MU fence is relatively small (64 acres). There are three small Population Unit (PU) fences in Subunit I which are not maintained and could be removed. The major threats to the perimeter fence include fallen trees and vandalism; there is one major gulch crossing. A large piece of reservoir liner is hung from a cable at the crossing and allows the water to pass under without opening access to pigs. There have been relatively few incidences of vandalism in the past. Special emphasis will be placed on checking the fence after extreme weather events. Monitoring for ungulate sign will occur during the course of other field activities. The fence will be kept clear of vegetation (especially grasses) to facilitate quarterly monitoring. This weed control is discussed in the Weed Control section.

Ungulate Control Actions:

Year	Action	Quarter
MIP YEAR 6 Oct 2009-Sept 2010	• Check MU fence for breaches, maintain integrity of fence, monitor for sign (transect) • Maintain 50-75 snares in the gulch bottom, C-ridge and Butt slide areas. Check at least twice a year. • Assess need for additional snaring in the Flueggea Gulch area of Subunit II. Install if necessary. • Subunit II is scheduled for construction in 2013	• 1-4 • 1, 3 • 2 • 1-4
MIP YEAR 7 Oct 2010-Sept 2011	• Check MU fence for breaches, maintain integrity of fence, monitor for sign (transect) • Maintain 50-75 snares in the gulch bottom, C-ridge and Butt slide areas. Check at least twice a year. • Eradicate pigs from subunit II fence	• 1-4 • 1, 3 • 1-4
MIP YEAR 8 Oct 2011- Sept 2012 through MIP YEAR 10 Oct 2013- Sept 2014	• Check MU fence for breaches, maintain integrity of fence, monitor for sign (transect) • Maintain snares if deemed necessary.	• 1-4 • 1, 3

Vandalism at Kahanahaiki

Ungulate Management and Survey Locations at Kahanahaiki



1.4.4.4 Weed Control

Weed Control actions are divided into 4 subcategories:

1. Vegetation Monitoring
2. Surveys
3. Incipient Taxa Control (Incipient Control Area - ICAs)
4. Ecosystem Management Weed Control (Weed Control Areas - WCAs)

These designations facilitate different aspects of MIP/OIP requirements.

Vegetation Monitoring

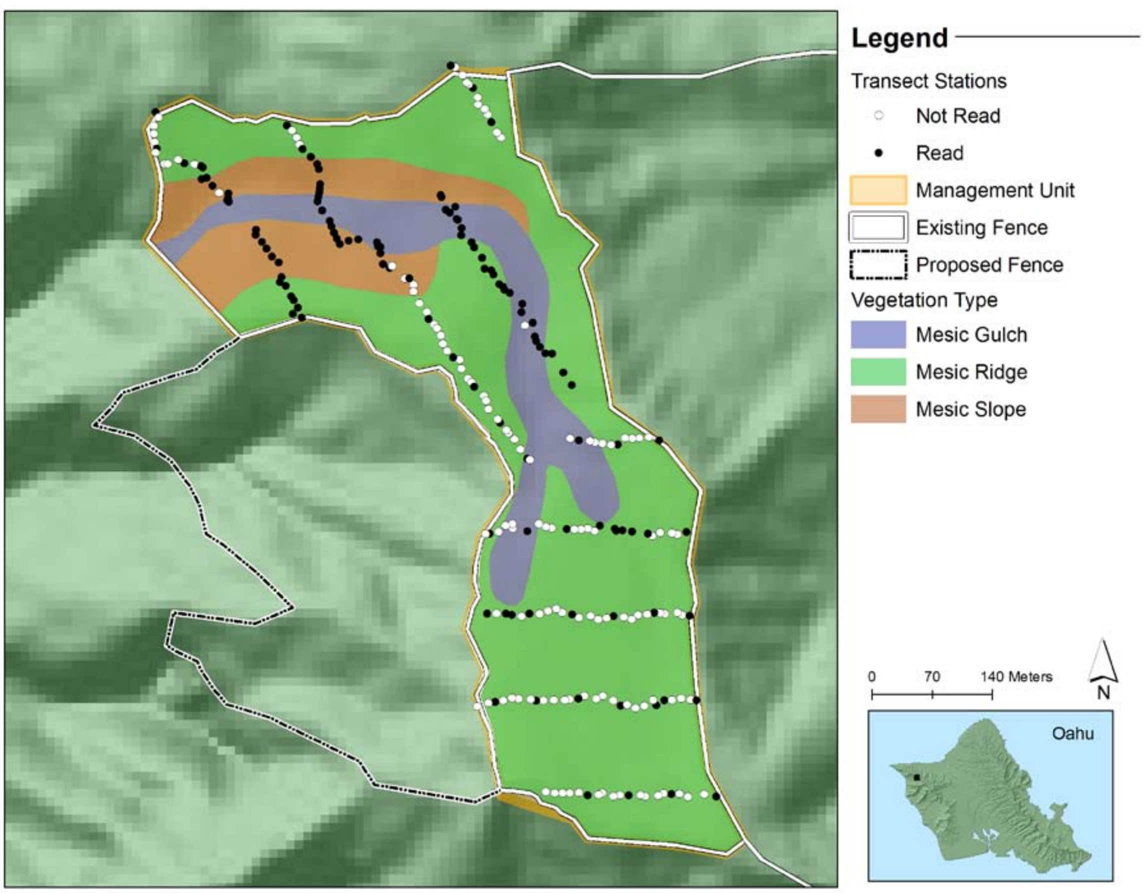
Objectives:

- Conduct MU/Subunit I vegetation monitoring every three years to measure the effectiveness of current weeding effort within the MU.

MU Vegetation Monitoring

From April – May 2009 vegetation monitoring was conducted for the Kahanahaiki MU. The total effort including commute time was 274 hours. The data collected will provide OANRP with trend analyses on vegetation cover and species diversity of the MU. Kahanahaiki MU vegetation plots will be read every three years to determine if current management effort is sufficient to reach MU vegetation goals.

Vegetation Monitoring Transects



MU Vegetation Monitoring Baseline Analyses

The mean alien vegetation cover in the understory was 36% across the MU. The 90% confidence interval for the mean was 31% to 40%. This percentage meets the management goal of 50% or less non-native cover in the understory. The mean alien canopy cover was 53%, which is above the 50% or less goal. The 90% confidence interval for the mean was 49% to 58% (refer to the MU Vegetation Monitoring Analyses table).

The mean native species count was eight in the understory and four in the canopy. The mean alien species count was seven in the understory and two in the canopy (refer to the MU Species Count Analysis Table). The alien canopy consists of few species, the key components being *Psidium cattleianum* and *Schinus terebinthifolius*. One of the primary reasons that species diversity is low is due to large monotypic stands of *P. cattleianum* and *S. terebinthifolius*. NRS will continue with an aggressive approach for conversion of these sections (refer to the Weed Control Section for more detail on management strategy).

Several species in Kahanahaiki, while too widespread to control as incipient, are of particular interest to NRS due to their distribution, density, and invasive characteristics. One of these is *Grevillea robusta*; the mean cover for *G. robusta* was 29% in the canopy and 20% in the understory. The NRS goal for *G. robusta* is to kill all mature plants by 2011. These efforts are outlined in relevant WCA discussions.

MU Vegetation Monitoring Analyses

Variable	Count	Mean	Standard Deviation	*Lower limit	*Upper limit
Native Shrub	119	14.7	17.3	12	17
Native Fern	119	11.8	15.3	9	14
Native Grass	119	1.0	0.3	0	1
Alien Shrub	119	20.8	18.7	18	24
Alien Fern	119	10.4	19.3	7	13
Alien Grass	119	7.2	18.0	4	10
Bryophytes	119	2.1	4.0	1	3
Non-veg understory	119	48.6	32.5	44	54
Native understory	119	26.6	22.6	23	30
Alien understory	119	35.6	27.2	31	40
Native Canopy	119	21.6	21.0	18	25
Alien Canopy	119	53.4	30.0	49	58
Total Canopy	119	65.3	24.1	62	69
*90% Confidence Level					

MU Species Count Analysis

Variable	Count	Mean	Standard Deviation	*Lower limit	*Upper Limit
Native understory	119	8	4	8	9
Alien understory	119	7	3	6	7
Native canopy	119	4	2	3	4
Alien canopy	119	2	1	2	3
*90% Confidence Level					

WCAs 7, 8, 9, 10, 11, and 12, located in the southern portion of the MU known as 'Maile Flats', have higher species diversity than the rest of the MU and are similar in vegetation cover and weed control strategy (see Incipient and Weed Control Areas at Kahanahaiki map). These WCAs also contain the entire *A. mustelina* population in Kahanahaiki. For these reasons, vegetation plots within Maile Flats were pooled together and analyzed (Refer to the two tables immediately below). In 2012, OANRP will read the MU plots to determine if the current management effort is sufficient at maintaining the habitat for *A. mustelina*. Mean native cover in the understory of Maile Flasts was 27%, with 90% confidence that the mean was 20% to 34%. The mean native canopy cover was 42% with 90% confidence that the mean was 31% to 52% (refer to the Vegetation Monitoring for Maile Flats table). The confidence interval indicates that canopy cover is close to the targeted alien cover of 50% or less in these WCAs.

Vegetation Monitoring Analyses for Maile Flats

Variable	Count	Mean	Standard Deviation	*Lower limit	*Upper limit
Native understory	33	41	27	33	50
Alien understory	33	27	23	20	34
Non Veg	33	29	30	20	37
Native Canopy	33	24	23	17	31
Alien Canopy	33	42	36	31	52
Total Canopy	33	60	27	52	68
*90% Confidence Level					

Species Count Analysis for Maile Flats

Variable	Count	Mean	Standard Deviation	*Lower Limit	*Upper Limit
Native understory	33	12	5	10	13
Alien understory	33	6	3	5	7
NativeCanopy	33	5	2	4	5
Alien Canopy	33	2	1	1	2
*90% Confidence Level					

To better inform WCA based management, the monitoring data was subdivided by topography and analyzed. See the Vegetation Monitoring Transects map above. All three of these communities meet the MU goal of 50% or less non-native vegetation in the understory. The mesic ridge community meets the MU vegetation goal of 50% in the canopy, but the slope and gulch communities do not. The mesic ridge community's mean alien cover was 32% in the understory and 36% in the canopy. The mesic slope community's mean alien cover was 37% in the understory and 59% in the canopy. The mesic gulch community's mean alien cover was 40% in the understory and 71% in the canopy (refer to the three tables immediately below).

Mesic Ridge Vegetation Type

Variable	Count	Mean	Standard Deviation	*Lower limt	*Upper Limit
Native understory	38	37.7	28.3	30	45
Alien understory	38	31.9	28.3	24	40
Non-Veg	38	38.2	33.4	29	47
Native Canopy	38	22	23.2	16	28
Alien Canopy	38	36.5	30.1	28	45
Total Canopy	38	54.2	26.7	47	61
*90% Confidence Level					

Mesic Slope Vegetation Type

Variable	Count	Mean	Standard Deviation	*Lower Limit	*Upper Limit
Native US	57	21.3	16.6	18	25
Alien US	57	36.9	27.9	31	43
Non-Veg	57	56.9	28.7	51	63
Native Canopy	57	24.8	21.6	20	30
Alien Canopy	57	58.5	24.6	53	64
Total Canopy	57	69.2	20.6	65	74
*90% Confidence Level					

Mesic Gulch Vegetation Type

Variable	N	Mean	Standard Deviation	*Lower Limit	*Upper Limit
Native US	23	19.4	17	13	25
Alien US	23	39.7	23.7	31	48
Non-Veg	23	47.3	35.1	34	60
Native Canopy	23	12.3	11.9	8	16
Alien Canopy	23	70.5	27.9	60	80
Total Canopy	23	74.6	21.8	67	82
*90% Confidence Level					

Vegetation Monitoring Response:

- Increase weeding efforts if the alien vegetation goals are not being met in the MU.
- In areas that are highly degraded, start out-planting common natives in order to encourage regeneration of native taxa.

Vegetation Monitoring Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Identify other possible small scale vegetation monitoring projects that aid weed control planning. Determine if needed	• 1-4
MIP YEAR 7 Oct.2008-Sept.2009	• Install additional monitoring, if deemed necessary.	• 1-4
MIP YEAR 8 Oct.2010-Sept.2011	• Read MU monitoring transects (every 3 years). First reading in Year 5 of MIP	• 1-4

Surveys

Army Training?: No

Other Potential Sources of Introduction: NRS, pigs, public hikers

Survey Locations: landing zones, fencelines, high potential traffic areas.

Management Objective:

- Prevent the establishment of any new invasive alien plant or animal species through regular surveys along roads, landing zones, camp sites, fencelines, trails, and other high traffic areas (as applicable).

Monitoring Objectives:

- Survey transects for weeds; when Transects 10 and 11 are discontinued, begin surveys of fenceline ungulate transect.
- Quarterly surveys of LZs (if used).
- Note unusual, significant, or incipient alien taxa during the course of regular field work.

Management Responses:

- Any significant alien taxa found will be researched and evaluated for distribution and life history. If found to pose a major threat, control will begin and will be tracked via Incipient Control Areas (ICAs)

Surveys are designed to be the first line of defense in locating and identifying potential new weed species. Roads, landing zones, fencelines, and other highly trafficked areas are inventoried regularly; Army roads and LZs are surveyed annually, non-Army roads are surveyed annually or biannually, while all other sites are surveyed quarterly or as they are used. At Kahanahaiki, only transects and LZs are currently surveyed. See the *Ungulate Management and Survey Locations at Kahanahaiki* map. NRS will consider installing additional surveys in other high traffic areas, however, due to Kahanahaiki's small size incidental observations during regular field management may suffice.

Weed Survey Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013- Sept.2014	• Survey Kahanahaiki Overlook LZ (81) whenever used, not to exceed once per quarter. If not used, do not need to survey. • Survey transect along fence quarterly.	• 1-4 • 1-4

Incipient Taxa Control (ICAs)

Management Objectives:

- As feasible, eradicate high priority species identified as incipient invasive aliens in the MU by 2014.
- Conduct seed dormancy trials for all high priority incipients by 2014.

Monitoring Objectives:

- Visit ICAs at stated revisitation intervals. Control all mature plants at ICAs and prevent any immature or seedling plants from reaching maturity.

Management Responses:

- If unsuccessful in preventing immature plants from maturing, increase ICA revisitation interval.

Incipient Control Areas (ICAs) are drawn around each discrete infestation of an incipient invasive weed. ICAs are designed to facilitate data gathering and control. For each ICA, the management goal is to achieve complete eradication of the invasive taxa. Frequent visitation is often necessary to achieve eradication. Seed bed life/dormancy and life cycle information is important in determining when eradication may be reached; much of this information needs to be researched and parameters for determining eradication defined. NRS will compile this information for each ICA species; assistance from graduate students for this research will be pursued.

The table below summarizes incipient invasive taxa at Kahanahaiki. Appendix 3.1 of the MIP lists significant alien species and ranks their potential invasiveness and distribution. Each species is given a weed management code: 0 = not reported from MU, 1 = incipient (goal: eradicate), 2 = control locally. If no code is listed in the 'original' column, the species was not evaluated by the IP, but was added later by

NRS. While the list is by no means exhaustive, it provides a good starting point for discussing which taxa should be targeted for eradication in an MU. NRS supplemented and updated Appendix 3.1 with additional target species identified during field work. In many cases, the weed management code assigned by the MIP has been revised to reflect field observations. ICAs are not designated for every species in the table below; however, occurrences of all species in the table should be noted by field staff. All current ICAs are mapped.

Summary of Potential ICA Target Taxa

Taxa	MIP weed man. code		Notes	No. of ICAs
	Original	Revised		
Acacia mearnsii	1	1	Known from 2 locations within MU. ICAs formed, control ongoing. Kahanahaiki is located at southern end of large forestry planting of *A. mearnsii* that begins in Kuaokala. Seeds persist in seed bank	2
Achyranthes aspera		1	Known from three locations. ICAs formed and control ongoing. Plants continue to be found, however numbers declining.	3
Angiopteris evecta	0	1	Plants occasionally found in the gulch. ICA formed and control ongoing; annual monitoring sufficient.	1
Axonopus compressus	1	1	Know from one location along the fenceline; on edge of Pahole. ICA formed, control ongoing. Regular treatment is required to make headway on eradicating this taxa.	1
Casuarina glauca	1	1	Known from 1 location. ICA formed and control ongoing. Most mature trees have been removed. Need to remove remaining plants from steep slope and monitor annually. Verify species as *glauca* or *equisetifolia*.	1
Ehrharta stipoides	1	1	Know from several locations along the fenceline; all sites in Pahole. Control efforts discussed in Pahole ERMUP (controlled in ICAs).	3
Macrotyloma axillare var *glabrum*		2	Taxa discovered this year. Very cryptic with *Neonotonia wightii*. Originally thought infestation was small, but during vegetation monitoring discovered that it is widespread in northwest of MU. Will target in WCA control.	
Montanoa hibiscifolia	2	2	Widespread through Subunit II, but uncommon in Subunit I. It appeared in 6 plots during vegetation monitoring. Only observed large plants in Subunit I in the last couple years. Control will be conducted in WCAs.	
Nephrolepis multiflora		2	Observed for the first time this year. Unfortunately, it appears to be spread across Maile Flats, and is not a good candidate for eradication. It will be treated in WCAs.	
Passiflora suberosa	0	2	In 2009 vegetation monitoring found this species in 8 plots. NRS will target it specifically across MU, but appears to be too widespread to target for eradication, especially as it is bird dispersed	
Pennisetum clandestinum	1	1	Known from 1 location on State land near Nike site. Population not spreading, no seed produced. NRS will monitor to detect potential changes in behavior and work with State to determine level of control.	
Rubus argutus	1	1	Known from two locations. ICAs formed and control ongoing. At one site, no plans have been found for several years; likely extirpated. At second site, plants persisting; control seems to require digging out roots coupled with 40% Garlon 4.	2
Salvia occidentalis		1	One site discovered this year. Possible candidate for eradication; however, final identification and determination pending. Temporary ICA formed, surveys/control planned.	1
Spathodea campanulata	1	2	Currently no mature plants are know from Subunit I, but taxa widespread across Subunit II. Any plants found in Subunit I will be targeted in WCA control. When control begins in Subunit II, *S. campanulata* will be targeted. Given that this species is wind dispersed, eradication may be unrealistic goal	

Taxa	MIP weed man. code		Notes	No. of ICAs
	Original	Revised		
Sphaeropteris cooperii	1	2	Plants have occasionally been found in the gulch. ICA formed and control ongoing; annual monitoring sufficient.	1
Syzigium malaccense	2	0	Not observed in MU. If found, NRS will consider control.	
Triumfetta semitrilobata	1	1	Known from many small locations across Subunit I. ICAs formed and control ongoing. Focus is to prevent *T. semitrilobata* from becoming established in Subunit I. There are currently 8 ICAs in the MU. NRS is optimistic about eradication with continued motoring and control.	8

ICA Actions:

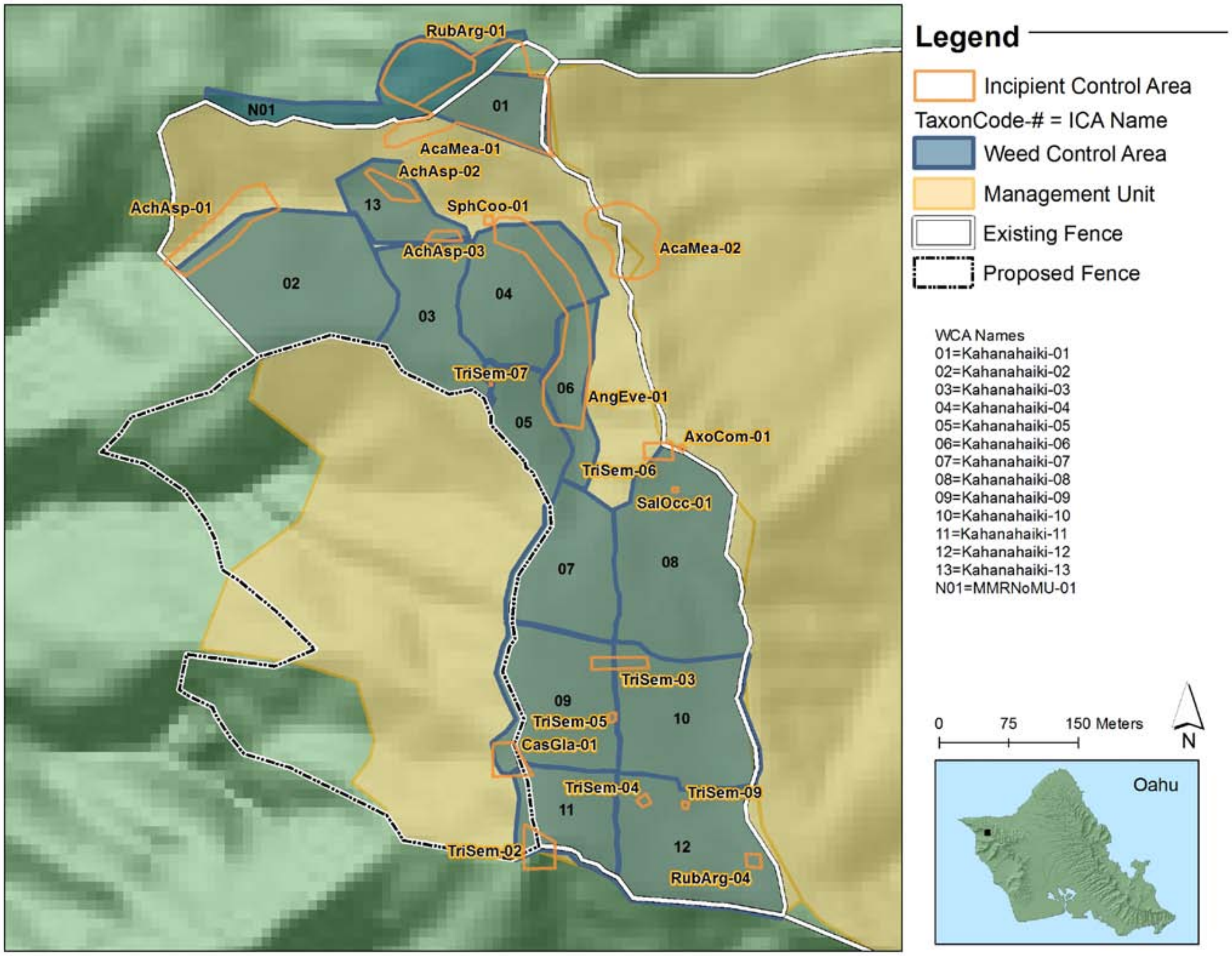
Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• MMR-Achasp-01 control • MMR-Achasp-02 control • MMR-Achasp-03 control • MMR-Trisem-02 control • MMR -Trisem-03 control • MMR -Trisem-04 control • MMR -Trisem-05 control • MMR -Trisem-06 control • MMR-Trisem-07 control • MMR-Trisem-08 control • MMR-Trisem-09 control • MMR–Axocom-01 control • MMR-Rubarg-01 control • MMR -Rubarg-04 control • MMR –AcaMea-01 control; use volunteers for flatter portions of area; NRS to sweep steeper sections • MMR –AcaMea-02 control • MMR –CasGla-01 control • MMR –CasGla-01 determine whether glauca or equisetifolia • MMR –CasGla-01 Rappel to remove plants from steep areas • MMR –SalOcc-01 verify species, determine level of control • MMR –AngEve-01 control • MMR –SphCoo-01 control	• 1, 3* • 1,3* • 1,3* • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1* • 1,3* • 1,3* • 1* • 1* • 1* • 4 • 1* • 1*

Year	Action	Quarter
MIP YEAR 7 Oct.2010-Sept.2011 through MIP YEAR 10 Oct.2013- Sept.2014	• MMR -Achasp-01 control • MMR -Achasp-02 control • MMR -Achasp-03 control • MMR -Trisem-02 control • MMR -Trisem-03 control • MMR -Trisem-04 control • MMR -Trisem-05 control • MMR -Trisem-06 control • MMR -Trisem-07 control • MMR -Trisem-08 control • MMR -Trisem-09 control • MMR –Axocom-01 control • MMR-Rubarg-01 control • MMR -Rubarg-04 control • MMR –AcaMea-01 control, use volunteers for flatter portions of area; NRS to sweep steeper sections • MMR –AcaMea-02 control • MMR –CasGla-01 control • MMR –SalOcc-01 control • MMR –AngEve-01 control • MMR –SphCoo-01 control	• 1, 3* • 1,3* • 1,3* • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1* • 1,3* • 1,3* • 1* • 1-4 • 1* • 1*

*= doesn't matter in which quarter control conducted

Volunteers controlling *P. cattleianum* in Kahanahaiki

Incipient and Weed Control Areas at Kahanahaiki



Ecosystem Management Weed Control (WCAs)

MIP Goals:

- Within 2m of rare taxa: 0% alien vegetation cover
- Within 50m of rare taxa: 25% or less alien vegetation cover
- Throughout the remainder of the MU: 50% or less alien vegetation cover

Management Objectives:

- Maintain 50% or less alien vegetation cover in the understory across the MU.
- Reach 50% or less alien canopy cover across the MU in the next 5 years.
- In WCAs within 50m of rare taxa, work towards achieving 25% or less alien vegetation cover in understory and canopy.

Management Responses:

- Increase/expand weeding efforts if MU vegetation monitoring (conducted every 3 years) indicates that goals are not being met.

Vegetation monitoring at Kahanahaiki indicates that the area already meets the MU 50% alien cover goal in the understory, and is close to that goal in the canopy. However, many of the WCAs are drawn around rare taxa sites; based on vegetation/topography type, no WCA currently meets the 25% or less weed cover goal for areas near rare taxa. This indicates that continued weed control is needed at Kahanahaiki. Areas near rare taxa will continue to be prioritized. Where *A. mustelina* are present, NRS will seek to avoid unintentional negative impact by being cognizant of snail presence and avoiding control of preferred snail trees.

In the southern, Maile Flats portion of the MU, which encompasses six WCAs (see map above), control strategies focus on sweeping through the most intact portions of forest, gradually removing canopy weeds, while simultaneously targeting *P. cattleianum* stands for more aggressive, clear-cut style control using volunteer labor. Through trial and error, NRS determined that this combination works in creating lasting changes over a moderately sized area. Via small test plots, NRS discovered that *P. cattleianum* stands respond best to clear-cutting or 100% basal/girdle treatment of all plants in a monoculture. Many of the trees in a monoculture are clones, connected below ground by runners, and unless all plants are treated, the clone can recover. *P. cattleianum* seedlings tend to flush after adult trees are killed, forming large seed beds. However, NRS learned that *P. cattleianum* seeds lose viability quickly, within 6 months. Timing treatment such that seeds are old/not viable, can greatly reduce the number of *P. cattleianum* seedlings requiring follow up treatment. Large numbers of *A. koa* seedlings have been observed recruiting thickly in the cleared *P. cattleianum* areas and common native plantings thrive. Volunteer labor is key in that it allows NRS to focus effort on more sensitive areas while still making a difference in weedy areas. .

In the northern, gulch portion of the MU, which encompasses six more WCAs (see map above), different strategies are used. The gulch is weedier and more varied than Maile Flats. Work here centers more tightly around rare taxa. Sweeps and volunteer labor are used to connect patches of native forest and treat *P. cattleianum*. Common reintroductions are used to complement weeding efforts.

Common reintroductions can include seed sowing, transplanting of seedlings already found in the field, and outplanting of greenhouse grown plants. NRS are experimenting with various techniques to identify effective, efficient, and easy restoration planting techniques at Kahanahaiki.

The areas not currently included in WCAs are located on the weedy south and west facing slopes of the gulch. NRS will consider creating new WCAs in these areas to facilitate control of specific canopy taxa (*Grevillea robusta*) and grass (fuel reduction).

General WCA Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2008-Sept.2009	• GPS boundaries of all existing WCAs. Use geographical and vegetation data. Use landmarks to mark in field • GPS trails • Scope creation of new WCAs on south and west facing gulch slope to facilitate canopy weed and grass control.	• 1-4
MIP YEAR 7 Oct.2008-Sept.2009	• GPS boundaries of new WCAs and begin control. • Modify ERMUP to reflect these new WCAs	• 1-4

WCA: Kahanahaiki-01 (Black Wattle)

Vegetation Type: Mesic Ridge

MIP Goal: 50% or less alien cover (no rare taxa in WCA). Monitoring shows for that this vegetation type, this goal is being met for both understory and canopy. NRS observations of this particular site disagree, indicating that WCA does not currently reach this standard.

Targets: All weeds, focusing on *Psidium cattleianum, Grevillea robusta*, and grasses.

Notes: In the past this area had a large infestation of Black Wattle, *Acacia mearnsii*. The Wattle infestation has been almost completely removed and its control is discussed in the Incipient Control section. Removing the *A. mearnsii* resulted in a large, open, bare area. NRS are working to rehabilitate it with native species via weed control and common native plantings. Previous common native plantings have met with mixed success; *Acacia koa* plantings have thrived, creating a canopy in areas. Other taxa have struggled but are still persisting. A seed sow plot of *Bidens torta* resulted in only a few seedlings. This WCA is extremely accessible as it is only a few minutes from the paved road; it is an ideal volunteer location, particularly for school groups with limited time and hiking experience. NRS will focus on using volunteers to achieve vegetation management goals here; this site will be a high priority volunteer project. NRS hope to develop a Project Stewardship type program here, testing the use of field nurseries, seed sows, and outplanting. If successful, NRS will consider using protocols and techniques developed here for Project Stewardship type activities at other MUs. *Melinis minutiflora* must be sprayed at least annually to prevent establishment and reduce fuel loads; this action will be undertaken by staff rather than volunteers. Continued efforts will ensure that the area becomes increasingly native.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Sweep entire WCA; gradually remove *P. cattleianum* patches. Focus effort around native elements. Target all large *G. robusta*. • Control weedy grasses across site as needed 6 months to a year. Target *M. minutiflora*. Focus around native elements; exercise caution around native shrubs. • Monitor common reintroductions • Install and manage field nursery; plant koa grown in field nursery	• 2 • 4 • 3 • 1-4
MIP YEAR 7 Oct. 2010 – Sept. 2011 through MIP YEAR 10 Oct.2013-Sept.2014	• Sweep entire WCA; gradually remove *P. cattleianum* patches. Focus effort around native elements. Target all large *G. robusta*. • Control weedy grasses across site as needed 6 months to a year. Target *M. minutiflora*. Focus around native elements; exercise caution around native shrubs. • Monitor common reintroductions • Install and manage field nursery; experiment with common native species other than *A. koa*.	• 2 • 4 • 3 • 1-4

WCA: Kahanahaiki-02 (Ptemac/Generals)

Vegetation Type: Mesic Ridge/ Mesic Slope/ Mesic Gulch

MIP Goal: 25% or less alien cover (rare taxa in WCA). This WCA spans several vegetation types, however monitoring results for all three indicate that the 25% goal is not currently being met.

Targets: All weeds, focusing on *G. robusta, S. terebinthifolius, Montanoa hibiscifolia* and *P. cattleianum*.

Notes: This large WCA spans a north facing gulch slope. Vegetation is highly variable. While some portions of the WCA are dominated by native canopy, other areas are dominated by alien canopy. There is a large grove of *Diospyros* in the middle of the WCA and a more diverse native forest patch, which includes *Pteralyxia macrocarpus*, on the east side of the WCA. Reintroductions of *C. superba*, *A. macrococcus* and *F. neowawraea* are planted in this diverse area, which is also home to a wild *D. subcordata*. Unfortunately there is an expansive area on the upper slope of the WCA that is dominated by *P. cattleianum*. Since the *P. cattleianum* is thick and dense, this area is appropriate for clear cut removal and chipping. Volunteers may be used to facilitate *P. cattleianum* control. NRS plan to focus efforts around rare taxa, sweeping around the reintroductions twice a year and across the entire WCA once every two years.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Control weeds across reintro zone every 6 months. Target understory weeds and gradual control of canopy weeds.	• 1, 3
MIP YEAR 7 Oct.2010- Sept. 2011	• Control weeds across reintro zone (every 6 months. Target understory weeds and gradual control of canopy weeds. • Control canopy and select understory weeds across WCA every 2 years. Focus around native forest patches. Target *S. terebinthifolius*, *C. hirta*, etc. Portions of this WCA are very steep.	• 1, 3 • 1-4
MIP YEAR 8 Oct.2011- Sept. 2012	• Consider developing area for use of Chipper. Target *P. cattleianum* stands with volunteers/chipper • Control weeds across reintro zone every 6 months. Target understory weeds and gradual control of canopy weeds.	• 1-4 • 1, 3
MIP YEAR 9 Oct.2012- Sept. 2013	• Control weeds across reintro zone every 6 months. Target understory weeds and gradual control of canopy weeds. • Control canopy and select understory weeds across WCA every 2 years. Focus around native forest patches. Target *S. terebinthifolius*, *C. hirta*, etc. Portions of this WCA are very steep.	• 1, 3 • 1-4
MIP YEAR 10 Oct.2013-Sept.2014	• Control weeds across reintro zone every 6 months. Target understory weeds and gradual control of canopy weeds. • Target *P. cattleianum* stands with volunteers/chipper.	• 1, 3 • 1-4

WCA: Kahanahaiki-03 (Ethan's)

Vegetation Type: Mesic Slope/ Mesic Ridge

MIP Goal: 25% or less alien cover (rare taxa in WCA). This WCA spans two vegetation types, however monitoring results for both indicate that the 25% goal is not currently being met.

Targets: All weeds, focusing on *G. robusta*, *S. terebinthifolius*, *P. cattleianum*, and grasses.

Notes: Much of this WCA is dominated by *P. cattleianum* and other weeds. Management has been focused in the past around pockets of native forest. Reintroductions of *C. superba, S. obovata,*and *D. subcordata* were planted into these pockets. Seedling *C. superba* were found below mature reintroduced trees in the last year. Weed management must be adapted accordingly; NRS must be extremely careful when weeding around the seedlings and around mature *C. superba*. Trampling shall be minimized. Hopefully, careful weed control around the mature plants will encourage additional recruitment. Extensive weed control has been conducted at Ethan's in the past. Volunteers treated large monotypic *P. cattleianum* stands, creating open areas. Common native species were planted in the open areas, and have been somewhat successful in rehabilitating the vegetation, although more time is needed before clear impacts are seen. NRS will continue to track the performance of the reintroduced common plants. NRS plan to work around the reintroductions twice a year and control invasive grasses as needed.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Conduct weed sweeps through reintros (common and rare) and native forest patches every 6 months. Control understory weeds, gradually remove canopy weeds, target Psicat monocultures (not gradual). Work to connect reintros and native patches. • Control weedy grasses across WCA every 6 months/year. • Sweep entire WCA for large Grerob one time. Follow up will be conducted during regular weed sweeps. • Monitor common reintros	• 2, 4 • 4 • 1 • 3
MIP YEAR 7 Oct.2010-Sept.2011 through MIP YEAR 10 Oct.2013- Sept.2014	• Conduct weed sweeps through reintros (common and rare) and native forest patches every 6 months. Control understory weeds, gradually remove canopy weeds, target Psicat monocultures (not gradual). Work to connect reintros and native patches. • Control weedy grasses across WCA every 6 months/year. • Montior common reintros	• 2, 4 • 4 • 3

WCA: Kahanahaiki-04 (Aunty Barbara's)

Vegetation Type: Mesic Slope/ Mesic Gulch

MIP Goal: 25% or less alien cover (rare taxa in WCA). This WCA spans two vegetation types, however monitoring results for both indicate that the 25% goal is not currently being met.

Targets: All weeds, focusing on *C. hirta, S. terebinthifolius, P. cattleianum*, and grasses.

Notes: Located just above the gulch bottom, on gentle slope, this WCA includes pockets of diverse native forest surrounded by *P. cattleianum* stands. Many rare taxa have been reintroduced into this area, including *C. superba*, *F. neowawraea, S. obovata,* and *D. subcordata*. Other rare taxa naturally occur here, including *C. agrimonioides, C. dentata*, and *D. falcata*. With such an abundance of rare species, this area has long been a high priority weeding site. Seedling *C. superba* were found below mature reintroduced trees in the last year. Weed management must be adapted accordingly; NRS must be extremely careful when weeding around the seedlings and around mature *C. superba*. Trampling shall be minimized. Hopefully, careful weed control around the mature plants will encourage additional recruitment. The *F. neowawraea* outplanting, which is in a large light gap, is plagued by quick growing invasives. NRS will sweep all reintroduction sites twice a year, with a special focus on the *Flueggea* site. Common native reintroductions (*H. terminalis* and *M. strigosa*) have had some success; NRS will continue to track them to help direct future restoration planting efforts. Large grass patches (*Paspalum conjugatum*) are problems in parts of the WCA; these will be controlled as needed.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• *F. neowawraea* reintro: control understory/canopy weeds in area around reintro. Target *Christella parasitica, Rubus rosifolius, Clidemia hirta, Buddleia asiatica*. Lots of *Blechnum appendiculatum* in gulch; consider gradual removal. • Control weedy grasses across WCA every 6 months/year. Target *P. conjugatum*, *O. hirtellus*. Focus around reintro areas first. • Conduct weed sweeps across WCA, focusing around *C. superba*/*D. subcordata*/common reintros, every 6 months. Target understory, target *P. cattleianum* monocultures, gradually remove other canopy elements. Expand weeded areas to fill WCA. • Sweep entire WCA for large *G. robusta* one time. Follow up will be conducted during regular weed sweeps.	• 2-4 • 2, 4 • 1, 3 • 3
MIP YEAR 7 Oct.2010-Sept.2011 through MIP YEAR 10 Oct.2013- Sept.2014	• *F. neowawraea* reintro: control understory/canopy weeds in area around reintro. Target *Christella parasitica, Rubus rosifolius, Clidemia hirta, Buddleia asiatica*. Lots of *Blechnum appendiculatum* in gulch; consider gradual removal. • Control weedy grasses across WCA every 6 months/year. Target *P. conjugatum*, *O. hirtellus*. Focus around reintro areas first. • Conduct weed sweeps across WCA, focusing around *C. superba*/*D. subcordata*/common reintros, every 6 months. Target understory, target *P. cattleianum* monocultures, gradually remove other canopy elements. Expand weeded areas to fill WCA.	• 2-4 • 2, 4 • 1, 3

WCA: Kahanahaiki-05 (Schwepps Trail to Pink Trail)

Vegetation Type: Mesic Ridge

MIP Goal: 25% or less alien cover (rare taxa in WCA). Monitoring results for the mesic ridge vegetation type indicate that the 25% goal is not currently being met.

Targets: All weeds, focusing on *S. terebinthifolius* and *P. cattleianum*.

Notes: This WCA hugs the western edge of the Subunit I exclosure, and is split by a cliff. The west and east portions of the WCA must be accessed from above and below the cliff. Staff needs to be cautious when working in proximity to the cliff. Above the cliff, there is a wild population of *C. agrimonioides*. Below the cliff, there is a wild population of *S. nuttalii* and a reintroduction of *S. obovata*. Above and on the cliff, the most prevalent weed is *S. terebinthifolius*. It should be removed gradually, over several years, so as not to dramatically change the character of the area. Grass is another threat along the ridge; NRS need to be vigilant about alien grasses and spray as needed. Below the cliff, the most prevalent weed is *P. cattleianum*. Areas directly around rare plants, particularly *S. nuttalii*, should be weeded gradually, again to prevent drastic changes to microsite conditions.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Conduct understory/canopy weed control across WCA. Area is split by a cliff; sweep along fence above cliff, sweep between cliff and Schwepps trail. Target *S. tereinthifolius* for gradual removal. Prioritize areas around reintros, wild plants. • Control weedy grasses across WCA annually or as needed. • Sweep entire WCA for large *G. robusta* one time. Follow up will be conducted during regular weed sweeps.	• 3 • 4 • 4
MIP YEAR 7 Oct.2010-Sept.2011 through MIP YEAR 10 Oct.2013- Sept.2014	• Conduct understory/canopy weed control across WCA. Area is split by a cliff; sweep along fence above cliff, sweep between cliff and Schwepps trail. Target Schter for gradual removal. Prioritize areas around reintros, wild plants. • Control weedy grasses across WCA annually or as needed.	• 3 • 4

WCA: Kahanahaiki-06 Upper Gulch

Vegetation Type: Mesic Gulch

MIP Goal: 25% or less alien cover (rare taxa in WCA). Monitoring results for the mesic gulch vegetation type indicate that the 25% goal is not currently being met.

Targets: All weeds, focusing on*, P. cattleianum, C. hirta, B. appendiculatum*.

Notes: Stretching along the southern part of Kahanahaiki gulch, this WCA is dominated by a weedy canopy, but has many native understory elements, particularly ferns. There are hundreds of wild *C. dentata* as well as a large reintroduction of *C. superba*. Typical vegetation in the area includes *Pisonia umbellifera, Pouteria sandwicensis*, and *Cibotium chamisoi*. *Aleurites mollucana* is one of the dominant canopy species in the gulch bottom, while *P. cattleianum* covers the slopes bordering the gulch. Currently, NRS remove only small *A. mollucana* from the area; the environment created by large trees appears to be beneficial to the rare taxa in the WCA for now. Seedling *C. superba* were found below mature reintroduced trees in the last year. Weed management must be adapted accordingly; NRS must be extremely careful when weeding around the seedlings and around mature *C. superba*. Trampling shall be minimized. Hopefully, careful weed control around the mature plants will encourage additional recruitment. Care must also be taken to avoid impacts to *C. dentata*, which forms easily disturbed seedling beds in the gulch bottom. After removal of pigs from the area, native ferns and *C. dentata* thrived. Especially notable is the proliferation of *C. chamisoi*. Where the tree ferns had been extirpated from accessible areas by ungulates before fencing occurred, they are now a major forest component. It has taken many years for this recovery to occur, and fortunately, it appears to be continuing. NRS will sweep the area at least once a year to control understory weeds and gradually improve the canopy.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013- Sept.2014	• Conduct understory/canopy control sweep from waterfalls to Camp Joe every 6 months/year. Target understory species, gradual removal of canopy. Exercise care when working around *C. dentata* and *C. superba*.	• 2, 4

Microlepia strigosa **reintroduction**

WCA: Kahanahaiki-07 (North West Quadrant)

Vegetation Type: Mesic Ridge/ Mesic Slope

MIP Goal: 25% or less alien cover (rare taxa in WCA). This WCA spans two vegetation types, however monitoring results for both indicate that the 25% goal is not currently being met. This WCA is also part of Maile Flats, and monitoring results for Maile Flats indicate that alien understory cover is 27%, very close to the MIP goal.

Targets: All weeds, focusing on, *P. cattleianum, S. terebinthifolius*, *G. robusta, M. hibiscifolia,* grasses.

Notes: This WCA is located on the northern edge of Maile Flats. It is bisected by a shallow gulch, in which there is a reintroduction of *C. superba*. While the *C. superba* appear healthy, they have not perfomed as spectacularly as others planted in Kahanahaiki gulch. No seedlings have been found under mature plants, but staff should remain vigilant while weeding around them. Other rare taxa in the WCA include *C. agrimonioides* and *D. falcata*. There are tree snails, *Achatinella mustelina,* in the southern portion of the WCA. The vegetation on the Makua rim/western side of the WCA is relatively native, with *Myrsine lessertiana*, *Metrosideros polymorpha*, and *C. chamissoi*. The vegetation on the eastern side of the WCA is dominated by *P. cattleianum*. NRS strategy is to sweep the whole WCA, focusing on the western, native portion of the WCA, with staff; the eastern, weedy portion of the WCA will be controlled using volunteer assistance. This is an ideal site to implement aggressive control via clear cutting/ chipping. Previously conducted trials indicate that aggressive control is most effective at killing *P. cattleianum*, and *A. koa* often pioneers the resulting light gaps. NRS will also target any *M. hibiscifolia*; this weed is a relatively recent arrival to Kahanahaiki. The WCA has already been swept once for large, mature *G. robusta*. Common native reintroductions may be used to jumpstart recovery.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 7 Oct.2010-Sept.2011	• Control weeds around *C. superba* reintro annually • Control *P. cattleianum* with volunteers. • Control weedy grasses across WCA annually • Control *M. hibiscifolia* annually	• 3 • 2-4 • 4 • 4
MIP YEAR 8 Oct.2011-Sept.2012	• Conduct weed sweeps across entire WCA, every 2-3 years. Target understory, gradual canopy removal. • Control *P. cattleianum* with volunteers • Control weedy grasses across WCA annually.	• 2-4 • 2-4 • 4
MIP YEAR 9 Oct.2012-Sept.2013 through MIP YEAR 10 Oct.2013- Sept.2014	• Control weeds around *C. superba* reintro annually • Control weedy grasses across WCA annually. • Control *P. cattleianum* with volunteers • Control *M. hibiscifolia* annually	• 3 • 4 • 2-4 • 4

WCA: Kahanahaiki-08 (North East Quadrant)

Vegetation Type: Mesic Ridge/ Mesic Slope

MIP Goal: 25% or less alien cover (rare taxa in WCA). This WCA spans two vegetation types, however monitoring results for both indicate that the 25% goal is not currently being met. This WCA is also part of Maile Flats, and monitoring results for Maile Flats indicate that alien understory cover is 27%, very close to the MIP goal.

Targets: All weeds, focusing on, *P. cattleianum, S. terebinthifolius*, *G. robusta, M. hibiscifolia,* grasses.

Notes: This WCA is on the northern edge of Maile Flats and is bisected by a shallow gulch. On the western margin of the WCA, in a native forest patch, there is a wild population of *C. agrimonioides*. Much of the WCA is dominated by *P. cattleianum* monocultures, although there are several native forest patches, including a koa stand in the northeast corner, and a low-stature *M. polymorpha* and *Sphenomeris chinensi* zone on the west side. Much of the eastern side of the WCA is mixed *S. terebinthifolius*, native forest. NRS will focus control efforts on sweeping the WCA every 2-3 years, targeting native forest patches, and gradually controlling weedy canopy elements. NRS will also target any *M. hibiscifolia*; this weed is a relatively recent arrival to Kahanahaiki. Volunteer assistance will be used whenever possible, particularly on *P. cattleianum*; this is an ideal site to implement aggressive control via clear cutting/ chipping. The WCA has already been swept once for large, mature *G. robusta*. The northern boundary of the WCA needs to be redrawn, following the cliff separating Maile Flats from the main gulch.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Control weedy grasses across WCA annually. • Re-GPS boundaries of WCA: in particular, define southern boundary of WCA, from top of switchbacks, above waterfall, to orange trail. • Control *P. cattleianum* with volunteers. • Control *M. hibiscifolia* in gulch area	• 4 • 2 • 2-4 • 4
MIP YEAR 7 Oct.2010-Sept.2011	• Conduct weed sweeps across entire WCA, every 2-3 years. Target understory, gradual canopy removal. • Control *P. cattleianum* with volunteers. • Control weedy grasses across WCA annually.	• 1-4 • 2-4 • 4
MIP YEAR 8 Oct.2011-Sept.2012 through MIP YEAR 9 Oct.2012-Sept.2013	• Control *P. cattleianum* with volunteers. • Control weedy grasses across WCA annually.	• 2-4 • 4
MIP YEAR 10 Oct.2013- Sept.2014	• Control *P. cattleianum* with volunteers. • Control weedy grasses across WCA annually. • Conduct weed sweeps across entire WCA, every 2-3 years. Target understory, gradual canopy removal.	• 2-4 • 4 • 1-4

WCA: Kahanahaiki-09 (Middle West Quadrant)

Vegetation Type: Mesic Ridge

MIP Goal: 25% or less alien cover (rare taxa in WCA). Monitoring results for the mesic ridge vegetation type indicate that the 25% goal is not currently being met. However, this WCA is also part of Maile Flats, and monitoring results for Maile Flats indicate that alien understory cover is 27%, very close to the MIP goal.

Targets: All weeds, focusing on, *P. cattleianum, S. terebinthifolius*, *G. robusta, M. hibiscifolia,* grasses.

Notes: Located in the middle of Maile Flats, this gently sloped area is home to the highest densities of *A. mustelina* in Kahanahaiki, as well as a large *C. agrimonioides* reintroduction. The western and southern portions of the WCA have more native vegetation, while the northern and eastern areas are dominated by *P. cattleianum*. The southern portion of the WCA is particularly diverse; native canopy associates include *M. polymorpha, A. koa, Psychotria mariniana, Psychotria hathewayi, Bobea elatior, Santalum frecinetium, Pouteria sandwicensis*, etc. Controlling weeds in this area is very rewarding. NRS sweep the WCA every 2-3 years, focusing around the native forest patches. NRS will also target any *M. hibiscifolia*; this weed is a relatively recent arrival to Kahanahaiki. The WCA has already been swept once for large, mature *G. robusta*. Volunteer assistance will continue to be used for *P. cattleianum* control; this is an ideal site to implement aggressive control via clear cutting/ chipping. Volunteers also will continue to assist with common native reintroductions. Previously planted reintroductions and transplantings are growing well, particularly *A. koa*; NRS will continue to monitor them and use this information to guide future common reintroduction efforts.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Control weedy grasses across WCA annually. • Control *P. cattleianum* with volunteers. • Monitor common reintros	• 4 • 2-4 • 3
MIP YEAR 7 Oct.2010-Sept.2011	• Conduct weed sweeps across entire WCA, every 2-3 years. Target understory, gradual canopy removal. Focus on native elements first, and expand out. • Control weedy grasses across WCA annually. • Control *P. cattleianum* with volunteers. • Monitor/plant common reintros	• 1-4 • 4 • 2-4 • 3, 4
MIP YEAR 8 Oct.2011-Sept.2012 through MIP YEAR 9 Oct.2012-Sept.2013	• Control weedy grasses across WCA annually. • Control *P. cattleianum* with volunteers. • Monitor/plant common reintros	• 4 • 2-4 • 3, 4
MIP YEAR 10 Oct.2013- Sept.2014	• Conduct weed sweeps across entire WCA, every 2-3 years. Target understory, gradual canopy removal. Focus on native elements first, and expand out. • Control weedy grasses across WCA annually. • Control *P. cattleianum* with volunteers. • Monitor/plant common reintros	• 1-4 • 4 • 2-4 • 3, 4

WCA: Kahanahaiki-10 (Middle East Quadrant)

Vegetation Type: Mesic Ridge

MIP Goal: 25% or less alien cover (rare taxa in WCA). Monitoring results for the mesic ridge vegetation type indicate that the 25% goal is not currently being met. However, this WCA is also part of Maile Flats, and monitoring results for Maile Flats indicate that alien understory cover is 27%, very close to the MIP goal.

Targets: All weeds, focusing on, *P. cattleianum, S. terebinthifolius*, *G. robusta, M. hibiscifolia,* grasses.

Notes: Located in the middle of Maile Flats, this gently sloped WCA is bisected by a shallow gulch. In the gulch, there is a reintroduction of *S. nuttalii* and *S. obovata*, installed in 1999; the *S. obovata* reintroduction is doing poorly and few outplants are extant, but the *S. nuttalii* reintroduction is healthy. A reintroduction site for *C. agrimonioides* has been scoped in the western portion of the WCA; it will be planted in 2009. As with the Northeast quadrant, the most native sections of this WCA are on the western side where there is a ridge that has an eastern exposure. OANRP will focus weeding efforts in this area. On the eastern side of the WCA, mixed native and alien vegetation dominates, particularly *S. terebinthifolius*. Gradual weed control will be the goal here. Sweeps will be conducted across the WCA every 2-3 years. NRS will also target any *M. hibiscifolia*; this weed is a relatively recent arrival to Kahanahaiki. The WCA has already been swept once for large, mature *G. robusta*. Volunteer assistance will continue to be used for *P. cattleianum* control; this is an ideal site to implement aggressive control via clear cutting/ chipping. Volunteers also will continue to assist with common native reintroductions. Previously planted reintroductions and transplantings are growing well, particularly *A. koa*; NRS will continue to monitor them and use this information to guide future common reintroduction efforts.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Conduct weed sweeps across entire WCA, every 2-3 years. Target understory, gradual canopy removal. • Control *P. cattleianum* with volunteers. • Control weedy grasses across WCA annually. • Conduct weed control around *S. obovata/S. nuttalii* reintro site every 6 months, as needed. If reintro fails, discontinue this action. • Monitor common reintros	• 2-4 • 2-4 • 4 • 2,4 • 3
MIP YEAR 7 Oct.2010-Sept.2011 through MIP YEAR 8 Oct.2011-Sept.2012	• Control *P. cattleianum* with volunteers. • Control weedy grasses across WCA annually. • Conduct weed control around *S. obovata/S. nuttalii* reintro site every 6 months, as needed. If reintro fails, discontinue this action. • Monitor/plant common reintros	• 2-4 • 4 • 2,4 • 3,4
MIP YEAR 9 Oct.2012-Sept.2013	• Conduct weed sweeps across entire WCA, every 2-3 years. Target understory, gradual canopy removal, Psicat monocultures. • Control *P. cattleianum* with volunteers. • Control weedy grasses across WCA annually. • Conduct weed control around *S. obovata/S. nuttalii* reintro site every 6 months, as needed. If reintro fails, discontinue this action. • Monitor/plant common reintros	• 2-4 • 2-4 • 4 • 2,4 • 3, 4
MIP YEAR 10 Oct.2013- Sept.2014	• Control *P. cattleianum* with volunteers. • Control weedy grasses across WCA annually. • Conduct weed control around *S. obovata/S. nuttalii* reintro site every 6 months, as needed. If reintro fails, discontinue this action. • Monitor/plant common reintros	• 2-4 • 4 • 2,4 • 3,4

WCA: Kahanahaiki-11 (South West Quadrant)

Vegetation Type: Mesic Ridge

MIP Goal: 25% or less alien cover (rare taxa in WCA). Monitoring results for the mesic ridge vegetation type indicate that the 25% goal is not currently being met. However, this WCA is also part of Maile Flats, and monitoring results for Maile Flats indicate that alien understory cover is 27%, very close to the MIP goal.

Targets: All weeds, focusing on, *P. cattleianum, S. terebinthifolius*, *G. robusta, M. hibiscifolia,* grasses.

Notes: Located at the southern end of Maile Flats, this WCA has more native forest than any other WCA in Kahanahaiki. Field observations suggest that it comes closer to reaching the 25% goal than any other WCA. There are wild and reintroducted *C. agrimonioides* in the WCA (it is thought that some of the wild plants, found on trails, were 'naturally' discpersed from reintroductions), as well as large numbers of *A. mustelina*. The WCA is on a gentle slope that gives the area a north aspect, which favors native vegetation. Previous weeding efforts targeted weeds found in the native dominated portions of the WCA; this WCA has shown impressive response to management. Native seedlings of canopy and understory species, including ferns, are common. The mesic forest is extremely diverse with many native canopy associates, including *M. polymorpha, A. koa, Psychotria mariniana, Psychotria hathewayi, Bobea elatior, Santalum freycinetium, Pouteria sandwicensis*, among others. Small *P. cattleianum* monocultures do exist in portions of the WCA. NRS will sweep the entire WCA every 3 years, targeting *P. cattleianum* monocultures as well as focusing around native forest patches. Volunteers will be used to control large *P. cattleianum* stands. *M. hibiscifolia* will be a particular target in this WCA; it recently moved into the Subunit I exclosure, and NRS would like to prevent it from becoming more widely established.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Conduct weed sweeps across entire WCA, every 3 years. Target understory, gradual canopy removal, *P. cattleianum* monocultures. • Control weedy grasses across WCA annually. • Sweep entire WCA for large *G. robusta* one time. Follow up will be conducted during regular weed sweeps.	• 1-4 • 4 • 1
MIP YEAR 7 Oct.2010-Sept.2011 through MIP YEAR 8 Oct.20110-Sept.2012	• Control weedy grasses across WCA annually. • Control *M. hibiscifolia* annually.	• 4 • 4
MIP YEAR 9 Oct.2012-Sept.2013	• Conduct weed sweeps across entire WCA, every 3 years. Target understory, gradual canopy removal, *P. cattleianum* monocultures. • Control weedy grasses across WCA annually.	• 1-4 • 4
MIP YEAR 10 Oct.2013-Sept.2014	• Control weedy grasses across WCA annually. • Control *M. hibiscifolia* annually.	• 4 • 4

WCA: Kahanahaiki-12 (South East Quadrant)

Vegetation Type: Mesic Ridge

MIP Goal: 25% or less alien cover (rare taxa in WCA). Monitoring results for the mesic ridge vegetation type indicate that the 25% goal is not currently being met. However, this WCA is also part of Maile Flats, and monitoring results for Maile Flats indicate that alien understory cover is 27%, very close to the MIP goal.

Targets: All weeds, focusing on, *P. cattleianum, S. terebinthifolius*, *G. robusta, M. hibiscifolia,* grasses.

Notes: Located on the southern border of Maile Flats, this WCA is not home to as much native forest as its South West neighbor. Native forest patches are centered along the western and southern sides of the WCA; *A. koa* canopy is common in the southern portion of the WCA, and *Alyxia oliviformis* forms near impenetrable tangles. Alien weeds dominate in the northern (*P. cattleianum*) and eastern (*S. terebinthifolius*) portions of the WCA. There is one *C. agrimonioides* reintroduction in the center of the WCA; it was a very small planting and is not thriving. The area does not appear to be ideal habitat for *Cenchrus*. NRS sweep the entire WCA, focusing around the native forest patches, every 2-3 years. NRS conducted extensive *P. cattleianum* removal with volunteers in the northwest corner of the WCA. The area responded well, native species are recruiting into the light gaps produced, common reintroductions (*M. strigosa*, *A. koa, H. terminalis*) are growing well, and native taxa dominate in an area where *P. cattleianum* used to be the only species present. Many lessons were learned during this process, and NRS have improved control/restoration techniques as a result. NRS will continue to control *P. cattleianum* and plant/monitor common natives with volunteer help. This is an ideal site to test out aggressive restoration techniques like chipping.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 7 Oct.2010-Sept.2011	• Control *P. cattleianum* with volunteers. • Control weedy grasses across WCA annually • Control *M. hibiscifolia* annually • Monitor/plant common reintroductions • Sweep entire WCA for large *G. robusta* one time. Follow up will be conducted during regular weed sweeps.	• 3 • 2-4 • 4 • 3 • 4
MIP YEAR 8 Oct.2011-Sept.2012	• Conduct weed sweeps across entire WCA, every 2-3 years. Target understory, gradual canopy removal. • Control *P. cattleianum* with volunteers • Control weedy grasses across WCA annually. • Monitor/plant common reintroductions	• 2-4 • 2-4 • 4 • 3
MIP YEAR 9 Oct.2012-Sept.2013 through MIP YEAR 10 Oct.2013- Sept.2014	• Control weedy grasses across WCA annually. • Control *P. cattleianum* with volunteers • Control *M. hibiscifolia* annually • Monitor/plant common reintroductions	• 4 • 2-4 • 4 • 3

WCA: Kahanahaiki-13 (Lower Fluneo)

Vegetation Type: Mesic Gulch/ Mesic Slope

MIP Goal: 25% or less alien cover (rare taxa in WCA). This WCA spans two vegetation types, however monitoring results for both indicate that the 25% goal is not currently being met.

Targets: All weeds, targeting *A. mollucana, P. cattleianum, S. terebinthifolius*, *G. robusta, M. hibiscifolia*, weedy ferns, and grasses.

Notes: This WCA is dominated by alien vegetation, particularly *P. cattleianum*. There is a *F. neowawraea* reintroduction in the gulch bottom, the only rare resource present in the WCA; it is the focus of most weeding efforts. The outplanting is not performing well; if it fails, NRS may discontinue/reduce control efforts around it. Until then, NRS will sweep the reintroduction site at six month intervals to maintain high light levels and reduce light-loving, fast-growing invasive weeds. Staff will sweep across the entire WCA every two years, focusing on native forest patches, specific targets such as *G. robusta*, and creating gradual change. Volunteer labor may be harnessed to control *P. cattleianum*.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Control weeds around *F. neowawraea* reintro every 6 months. Target understory (*C. dentata*). Maintain high light levels.	• 2, 4
MIP YEAR 7 Oct.2010-Sept.2011	• Control weeds around *F. neowawraea* reintro every 6 months. Target understory (*C. dentata*). Maintain high light levels. • Control weeds across entire WCA every 2 years. Focus on native forest patches. Target gradual canopy control and select understory control.	• 2, 4 • 1-4
MIP YEAR 8 Oct.2011-Sept.2012	• Control weeds around *F. neowawraea* reintro every 6 months. Target understory (*C. dentata*). Maintain high light levels.	• 2, 4
MIP YEAR 9 Oct.2012-Sept.2013	• Control weeds around *F. neowawraea* reintro every 6 months. Target understory (*C. dentata*). Maintain high light levels. • Control weeds across entire WCA every 2 years. Focus on native forest patches. Target gradual canopy control and select understory control.	• 2, 4 • 1-4
MIP YEAR 10 Oct.2013- Sept.2014	• Control weeds around *F. neowawraea* reintro every 6 months. Target understory (*C. dentata*). Maintain high light levels.	• 2, 4

WCA: MMRNoMU-01 (Re-veg Road)

Vegetation Type: Mesic Ridge

MIP Goal: N/A

Targets: Alien grasses.

Notes: This WCA is located on the northern boundary of Kahanahaiki, along a dirt road known as the 'Re-veg Road', on State land. The area is highly degraded, dominated by alien grasses and a scattering of alien trees. Only a portion of the road is drivable. Previous fires in Makua threatened Kahanahaiki, burning up to the Re-veg Road and even damaging the exclosure fence. NRS control grasses along the road to reduce the fuel load and improve accessibility. Some *A. koa* were planted along the road in the past. While some have thrived, grass growth has not been inhibited by their shade. NRS will consider using volunteers to create more dense outplantings in the future.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009- Sept. 2010 through MIP YEAR 10 Oct.2013- Sept.2014	• Control grasses along the re-veg road, from the weather station to the top of Black Wattle, quarterly or as needed. • Evaluate potential common reintroductions, implement if deemed worthwhile.	• 1-4 • 2-4

P. cattleianum **monoculture control (basal bark herbicide application)**

1.4.4.5 Rodent Control

Threat level: High

Current control method: Large scale trapping grid (MU control)

Seasonality: Year-Round

Number of control grids: 1 (402 snap traps in wooden boxes)

Primary Objective:

- To maintain rat/mouse populations to a level that facilitates stabilized or increasing plant and snail populations across the MU by the most effective means possible.

Management Objective:

- Continue to run large scale trapping grid for the control of rats.
- Less than 10% activity levels in rat tracking tunnels checked monthly.

Monitoring Objectives:

- Monitor tracking tunnels to determine rat activity within the trapping grid.
- Monitor ground shell plots for predation of *Achatinella mustelina* by rats.
- Monitor *Cyanea superba* subsp. *superba* for predation of fruits by rats.
- Monitor *Euglandina rosea* to determine if rat control will cause an increase in density.
- Monitor slugs to determine if rat control will cause an increase in density.
- Monitor seedling plots and seed rain buckets to determine rat impacts.
- Monitor arthropod composition and abundance to determine if rat control will have positive impacts to native arthropods.

Monitoring Issues:

- An acceptable level of rat activity, which promotes stable or increasing *A. mustelina* and *C. superba* subsp. *superba* populations, has not been clearly identified. It could be very low, less than 2%, or very high, 40%; in New Zealand, studies have shown that rat activity levels of 10% are low enough to maintain certain rare bird populations. A 10% activity level may also be the most achievable level using a large scale trapping grid. In order to determine this acceptable level, more intensive monitoring of rare resources is required.

MU Rodent Control:

- Threatened resources are widespread throughout the Kahanahaiki MU. The habitat quality is high, and the MU is small enough to treat easily but large enough to test the effectiveness of a large scale trapping grid. This pilot project was implemented in the May 2009, and will run for several years. Monitoring of rat activity via tracking tunnels and catch data will be vital in determining whether control is having the desired effect, as will intensive monitoring of *A. mustelina* populations and *Cyanea superba* subsp. *superba* outplantings.

Rodent Control Actions:

Year	Action	Quarter
MIP YEAR 6 Oct. 2009-Sept.2010	• Run trapping grid 2x a month • Monitor tracking tunnels monthly • Monitor slugs & *Euglandina* 1x a quarter • Monitor Cyasup fruit production & predation • Monitor seedling plots 2x a year • Monitor seed rain buckets 2x per month • Monitor arthropods 1x a year • Monitor Achmus ground shell plots 1x a year	• 1-4 • 1-4 • 1-4 • 4 • 2-4 • 1-4 • 4 • 1-4
MIP YEAR 7 Oct.2010-Sept.2011	• Run trapping grid 1x month • Monitor tracking tunnels, 6x a year • Evaluate efficacy of MU-wide grid, decide how to modify actions and continue project • Monitor Cyasup fruit production & predation • Monitor slugs & *Euglandina* 1x a quarter • Monitor seedling plots 2x a year • Monitor seed rain buckets 2x a month • Monitor arthropods 1x a year • Monitor Achmus ground shell plots 1x a year	• 1-4 • 1-4 • 2 • 4 • 2 • 1,3 • 1-4 • 2 • 1-4
MIP YEAR 8 Oct.2011-Sept.2012 through MIP YEAR 10 Oct.2013- Sept.2014	• Run trapping grid 1x month • Monitor tracking tunnels, 4x a year • Monitor Cyasup fruit production & predation • Monitor Achmus ground shell plots 1x a year	• 1-4 • 1-4 • 4 • 1-4

Wooden snap trap box

1.4.4.6 Slug Control

Species: *Deroceras leave, Limax maximus, Limax flavus, Meghimatium striatum*

Threat level: High

Control level: Localized

Seasonality: Wet season

Number of sites: 4 (*Cyanea superba* subsp. *superba* locations)

Primary Objective:

- Reduce slug population to levels where germination and survivorship of rare plant taxa are optimal.

Management Objective:

- Begin a pilot slug control program in the fall of 2011 using Sluggo around the *C. superba* populations if additional Special Local Needs labeling is approved by USFWS and HDOA.
- By 2013, reduce slugs by at least 50% of estimated baseline densities around the *C. superba* populations through a pilot control program.

Monitoring Objectives:

- Annual census monitoring of *C. superba* . seedling recruitment following fruiting events.
- Annual census monitoring of slug densities during wet season.
- Conduct additional monitoring of slug populations as part of the trap out rodent control program.

Effective molluscicides have been identified (Sluggo) and initial control programs are ongoing in Kahanahaiki under an Experimental Use Permit (EUP). A pilot slug control program using this product started in March 2009 and is on-going. Plots to monitor the effect of predator removal (rats) on slug populations were installed in May 2009.

Slug Control Actions:

Year	Action	Quarter
MIP YEAR 5 Oct.2008-Sept.2009	• Monitor slug activity at *C. superba* subsp. *superba* population(s) via traps baited with beer • Track seedling recruitment around fruiting adults	• 1-4 • 1-4
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 9 Oct.2012-Sept.2013	• Deploy slug bait around *C. superba* subsp. *superba* population(s) frequency to be determined during research phase • If slugs found to exceed acceptable levels during monitoring, maintain slug bait at sensitive plant population(s)	• 1-4 • 1-4

Right photo shows *Deroceras leave* consuming *C. superba* subsp. *superba*. Left photos show the same seedlings treated with Sluggo (white pellets).

1.4.4.7 Predatory Snail Control

Species: *Euglandina rosea* (rosy wolf snail), *Oxychilus alliarus* (garlic snail)

Threat level: High

Control level: Across MU

Seasonality: Year-Round

Number of sites: None, potentially 12 (*Achatinella mustelina* sites)

Acceptable Level of Activity: Unknown

Primary Objective: Reduce predatory snail populations to a level optimal for *A. mustelina* survival.

Management Objective:

- Continue to develop better methods to control predatory snails
- Keep sensitive snail populations safe from predatory snails via currently accepted methods (such as hand removal of alien snails, construction of barriers which prevent incursion from alien snails)
- Continue to maintain native snail exclosures to prevent incursion by predatory snails.

Monitoring Objectives:

- Annual or biannual *A. mustelina* population(s) census monitoring to determine population trend.
- Annual predatory snail searches to confirm their absence or presence in proximity to *A. mustelina.*

No baits have been developed for the control of predatory snails. Little is known regarding their distribution and prey preference. Control is limited to hand removal. Visual searches are time-consuming, difficult, and not feasible over large areas and in steep terrain. It is also unknown whether predatory snail populations are, in fact, affected by hand removal. Surveys confirm *E. rosea* is present in this Management Unit; however, it is unknown whether *O. alliarus* is also present. Surveys for the latter snail will begin in December 2009 using the same methodology used to estimate *E. rosea* populations (see the Research Activities chapter, this document). *Euglandina rosea* population monitoring began in June 2009 to detect changes due to predator (rat) removal. Data from these surveys appear in the Research Activities chapter of this document. Preliminary results show *E. rosea* numbers did not increase in response to rat removal.

Field trials using detector dogs (Working Dogs for Conservation, MT), to find and eliminate *E. rosea* took place in this unit from February – March 2009. Results were presented as a poster at the 2009 Hawaii Conservation Conference. This poster may be viewed online at: http://www.botany.hawaii.edu/faculty/duffy/DPW/HCC-2009/Dog_Poster.pdf

Preliminary observations suggest that dogs are unable to outperform humans in detecting snail presence.

Predatory Snail Control Actions:

Year	Action	Quarter
MIP YEAR 5 Oct.2008- Sept.2009	• Determine if any *E. rosea* or *O. alliarus* snails are present at the *A. mustelina* sites • Maintain physical barriers (exclosures) to protect *A. mustelina* form predatory snails	• 1-4 • 1-4
MIP YEAR 6 Oct.2009- Sept.2010 through MIP YEAR 9 Oct.2012- Sept.2013	• Implement control as improved tools become available	• 1-4

1.4.4.8 Ant Control

Species: *Anoplolepis gracilipes, Cardiocondyla emeryi, C. wroughtoni, C. venustula, Leptogenys falcigera, Ochetellus glaber, Plagiolepis alludi, Solenopsis geminata, S. papuana, Technomyrmex albipes, Tetramorium simillimum*

Threat level: High

Control level: Only for new incipient species

Seasonality: Varies by species, but nest expansion observed in late summer, early fall

Number of sites: 3 (Nike site Landing Zone (LZ), fenceline, gulch)

Acceptable Level of Ant Activity: Acceptable in gulch, however, *A. gracilipes* currently at unacceptable levels at Nike site LZ where control has been on-going since March 2009. New incipient infestation of *S. geminata* confirmed Oct. 2009 on fenceline.

Primary Objective: Eradicate incipient ant invasions and control established populations when densities are high enough to threaten rare resources.

Management Objective:

- If incipient species are found and deemed to be a high threat and/or easily eradicated locally (<0.5 acre infestation) begin control.
- Ant populations will be kept to a determined acceptable level across the MU to facilitate ecosystem health.

Monitoring Objectives:

- Continue to sample ants at human entry points (greenhouse, landing zones, fence line, outplanting sites) a minimum of once a year. Use samples to track changes in existing ant densities and to alert NRS to any new introductions.

Ants have been documented to pose threats to a variety of resources, including native arthropods, plants (via farming of Hemipterian pests), and birds. The distribution and diversity of ant species across Kahanahaiki Management Unit have been well sampled using standardized methods (see Appendix on Invasive Ant Monitoring Protocol). In this manner, incipient species, such as *Solenopsis geminata*, have been successfully eradicated in past years (YER 2007).

Ant Control Actions:

Year	Action	Quarter
MIP YEAR 5 Oct.2008-Sept.2009	• Conduct surveys for ants across MU with bait cards • Analyze results of surveys, develop management plan	• 1, 2 • 3,4
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 9 Oct.2012-Sept.2013	• Implement control if deemed necessary • Conduct arthropod survey along transects in anticipation of rat trap out project.	• 1-4 • 1-4

1.4.4.9 Black Twig Borer (BTB) Control

Species: Xylosandrus compactus

Threat level: High

Control level: Localized

Seasonality: Peaks have been observed from October-January

Number of sites: 5 (Flueggea neowawraea sites)

Acceptable Level of Activity: Unknown

Primary Objective: Reduce BTB populations to a level optimal for F. neowawraea survival.

Management Objective:

- Continue to develop better methods to control BTB

Monitoring Objectives:

- Annual monitoring of F. neowawraea populations to determine BTB damage.
- If BTB damage is found to be high, implement control for BTB (traps)

The current control method available for BTB involves the deployment of traps equipped with high-release ethanol bait. It is unclear whether this method reduces BTB damage to target plants (see Research Activities this document). Damage to F. neowawraea has been high (see Research Activities this document) spurring trap deployment in Dec. 2008-March 2009.

BTB Control Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2010-Sept.2011	• Determine whether BTB damage to *Flueggea neowraea* requires control	• 1-4
MIP YEAR 7-9 Oct.2011- Sept.2013	• Put out BTB high-release ethanol traps (see Research Activities Chapter) if BTB damage to target plants exceeds acceptable levels • Implement control as improved tools become available	• 1-4 • 1-4

1.4.4.10 Fire Control

Threat Level: Low

Available Tools: Fuelbreaks, Visual Markers, Helicopter Drops, Wildland Fire Crew, Red-Carded Staff.

Management Objective:

- To prevent fire from burning any portion of the MU at any time.

Preventative Actions:

NRS will review the 2007 Makua Biological Opinion (BO) and use it to guide fire management actions at Kahanahaiki. The BO, which is a reinitiation of the 1999 review by the U.S. Fish and Wildlife Service (FWS) of Army training in Makua, details several different options for reducing fire threat. Which options are required depends in part on the weapons/ munitions used during training. Recently, the Army announced that it would not be using certain classes of weapons at Makua; these weapons were the trigger for much of the fire mitigation. Recommendations from the 2007 BO are still under consideration in light of these new weapons restrictions. For now, NRS will focus on maintaining good communication with the Wildland Fire Working Group to facilitate positive on-the-ground fire response in the event of another catastrophic Makua brushfire. NRS will maintain red-carded staff to assist with fire response. Grass control is conducted across the Subunit I portion of the MU, see the Weed Control section for further notes. NRS will consider expanding grass control/common reintroduction actions on the northwestern side of the Subunit I fence; currently grass control is conducted along an access road, nicknamed the ‘Re-veg Road’, in this area.

Fire Actions: Non-weed related fire actions include the following

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013- Sept.2014	• Maintain LZs on ridgeline • Communicate with State on status of Kuaokala Road and Re-veg Road, as both can be used to access the northwestern edge of Kahanahaiki	• 2, 3 • 2, 3

The 2003 Makua fire burned up the back wall of the valley and damaged the eastern most part of the Kahanahaiki fence

1.4.5 Kaluakauila Ecosystem Restoration Management Plan

MIP Year 6-10, Oct. 2009-Sept. 2014

OIP Year 3-7, Oct. 2009-Sept. 2014

MU: Kaluakauila Gulch

1.4.5.1 Overall IP Management Goals

- Form a stable, native-dominated matrix of plant communities which support stable populations of IP taxa.
- Control ungulate, rodent, arthropod, slug, snail, fire, and weed threats to support stable populations of IP taxa. Implement control methods by 2014.

Background Information

Location:	Waianae Mountains, northern rim of Makua Military Reservation
Land Owner:	U.S. Army
Land Manager:	Oahu Army Natural Resources Program
Acreage:	110 acres
Elevation:	800- 1750 ft.

Description:

Northwest facing slope of Kaluakauila Gulch extending from the rim of Makua Valley to the gulch bottom of Kaluakauila stream. The MU consists mostly of steep rocky slopes with several large cliff faces. Soil thinly covers rocky areas and soils are considerably hydrophobic. The MU is bisected into two primary work sites by a large waterfall which divides the upper and lower management areas. Kaluakauila Stream is an intermittent stream with some perennial seeps due to the drop in elevation. Several smaller intermittent streambeds also dissect the northwest face of the MU. Northern rim of Makua Valley consists of exposed, weathered basalt. Talus slopes dominate the lower slope and gulch bottom areas. Winter rains produce small but significant flash flooding events which are responsible most of the erosion along the streambeds.

Characteristic steep terrain in the Kaluakauila MU

Two vegetation types intergrade at Kaluakauila. Along the ridges and crestline area, a mix of native and non-native elements comprise a lowland dry shrubland/grassland community. Large patches of *Heteropogon contortus* grass and *Dodonaea viscosa* still persist along the ridgeline dividing Kaluakauila

Gulch from Makua Valley, especially in the rockier areas where *Heteropogon contortus* can effectively compete against other alien grasses which need more soil.

In the gulch area, a diversty of native and non-native trees and shrubs comprise the mixed dry forest community. Significant stands of *Diospyros* spp. trees form the core of the two upper and lower Kaluakauila dry forest patches. *Aleurites moluccana* dominates the gulch bottom area of this community.

The native dry forest community is extremely rare on Oahu (less than 2% remains) and disappearing across the state. Stabilizing the dry forest habitat from further degradation in order to allow rare plant species to thrive is the most feasible goal in the long-term, given the amount of weeds already present and the small size of the native forest patches.

Native Vegetation Types

Waianae Vegetation Types
Dry Forest
Canopy includes: *Diospyros* sp., *Myoporum sandwicense, Erythrina sandwicensis, Reynoldsia sandwicensis, Rauvolfia sandwicensis, Pleomele sp.,Santalum ellipticum*, *Psydrax odoratum, Nestegis sandwicensis* and *Myrsine lanaiensis*. **Understory includes:** *Dodonaea viscosa, Sida fallax, Bidens sp.*
Dry shrubland/grassland
Canopy includes: *Erythrina sandwicensis*, *Myoporum sandwicense, Dodonaea viscosa, Santalum ellipticum, Hibiscus brackenridgei* subsp. *mokuleianus.* **Understory includes:** *Heteropogon contortus, Sida fallax, Eragrostis variabilis, Abutilon incanum, Leptecophylla tameiameiae. Bidens sp.*
NOTE: For MU monitoring purposes vegetation type is mapped based on theoretical pre-disturbance vegetation. Alien species are not noted.
NOTE: For MU monitoring purposes, vegetation types were subdivided using topography (gulch, mid-slope, ridge). Topography influences vegetation composition to a degree. Combining vegetation type and topography is useful for guiding management in certain instances.

Dry forest community at Kaluakauila

MIP/OIP Rare Resources at Kaluakauila

Organism Type	Species	Pop. Ref. Code	Management Designation	Wild/ Reintroduction/ Future Planting
Plant (MIP)	*Neraudia angulata*	MMR- F, G, H	MFS	Reintroduction
Plant (MIP)	*Melanthera tenuifolia*	MMR-F	MFS	Wild
Plant (MIP)	*Nototrichium humile*	MMR- A, J, L, M, N	MFS	Wild
Plant (MIP)	*Chamaesyce celastroides var. kaenana*	MMR-B	GSC	Wild
Plant (OIP)	*Abutilon sandwicense*	MMR-B MMR-C	GSC	Reintroduction
Plant (MIP)	*Hibiscus brackenridgei*	MMR- C, D, E	GSC	Reintroduction
Plant (MIP)	*Delissea subcordata*	MMR-D	GSC	Reintroduction

MFS= Manage for Stability
GSC= Genetic Storage Collection

Other Rare Taxa at Kaluakauila MU

Organism Type	Species	Status
Plant	*Euphorbia haeleeleana*	Endangered
Plant	*Schiedea. hookeri*	Endangered
Plant	*Bonamia menziesii*	Endangered
Plant	*Bobea sandwicensis*	SOC

Rare resources clockwise from left: *Euphorbia haeleeleana, Hibiscus brackenridgei subsp. mokuleianus, Neraudia angulata, Melanthera tenuifolia*

Locations of Rare Resources at Kaluakauila

Map removed,
available upon request

MU Threats to MIP/OIP MFS Taxa

Threat	Taxa Affected	Localized Control Sufficient?	MU scale Control required?	Control Method Available?
Pigs	All	No	Yes	MU fenced
Rats	All	No	Yes	Yes
Slugs	*D. subcordata*	Yes	No	Currently being developed
Ants	Unknown	Unknown	Unknown	Some available, depends on species
Black Twig Borer	*A. sandwicense N. angulata*	Yes	No	Currently under development
Weeds	All	Yes	Yes	Yes
Fire	All	No	Yes	Yes

Management History:

1970: Large military fire burns Makua Valley

1984: Large military fire burns Makua Valley

1995: OANRP begins management at Kahanahaiki. Surveys are conducted.

1995: Escaped prescribed fire in Makua burns to forest edge of Kaluakauila.

1997-2009: Rat control initiated and expanded to protect *E. haeleeleana* fruits and forest.

2001: Fence completed, ungulates removed. Heavy rains blow out fence, pigs re-enter MU and removed via snaring.

2001-2009 Grass and weed control in forest patches. Catchments installed.

2003: Escaped prescribed fire burns into Kaluakauila MU as well as burning most of Makua Valley

2005: White phosphorus fire burns Makua after escaping from fire break road

2006: Arson fire burns to forest edges, destroying a *H. brackenridgei* reintroduction and a portion of a *C. celastroides* var. *kaenana* wild population.

2007-2009: Slug, ant and arthropod surveys conducted. Low slug numbers detected.

2009: Rat tracking tunnels deployed (no activity detected).

1.4.5.2 Ungulate Control

Identified Ungulate Threats: Pigs

Threat Level: Low

Strategy: Eradication in the MU

Primary Objectives:

- Maintain the fenced area as ungulate free.

Monitoring Objectives:

- Conduct quarterly fence checks.
- GPS and mark fence at ten meter intervals to create a large transect to be read quarterly.
- Detect any pig sign in the fence while conducting 6 week interval rat control actions.

Management Responses:

- If any pig activity detected in the fence area, inspect and repair fence line and implement snaring program.

Maintenance Issues: Due to the very large waterfalls along the gulch bottom, a complete fence check requires considerable time and effort. Controlling the guinea grass along the westernmost makai line using aerial spraying of Roundup® and Oust® would make checking that line considerably easier. An initial cut would likely be required to facilitate spraying (as well as remove fuel loads). Checking the makai line could then be done from far more quickly. Alternatively, cursory aerial inspections could also be done for the crest line and the makai line as needed.

Fence blowouts occur at the base of the intermittent side streams on an irregular basis. These hog-wire sections need to be reinforced with hog panels and checked after extreme rainfall events. Additional panels may need to be placed upslope of the main fenceline to prevent rockfall from damaging the main fenceline itself.

Debris also frequently piles up along gulch bottom sections as these sections are built parallel to the slope. Removal of these debris piles is periodically necessary to prevent small pigs from passing through the larger holes in the panels and fence mesh.

The crestline fenceline is subjected to a considerable amount of pitting from winds and corrosion due to the salt air. Portions of this line should be carefully inspected and replaced before failure.

Three existing ungulate transects are no longer in use and should be switched out as when the new transect is installed.

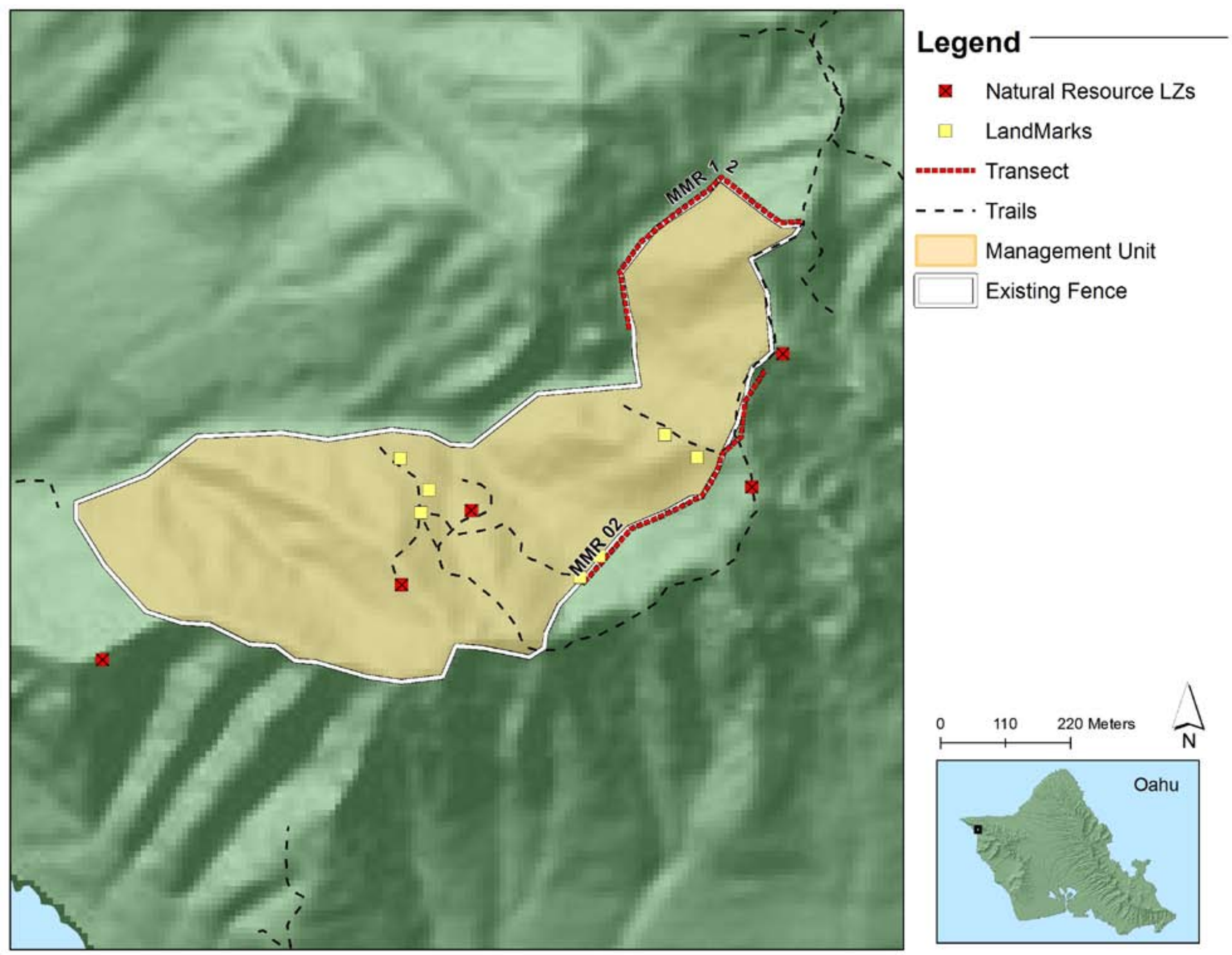
Ungulate Control Actions:

Year	Action	Quarter
MIP YEAR 6 Oct 2009- Sept 2010	• Repair rock crushed section with panel and other hog wire sections as needed • Install panel protection upslope of main fenceline in the gulch as needed • Check MU fence for breaches quarterly • Keep gulch bottom sections free of debris to prevent ingress of small pigs • GPS and mark fence at 10m intervals to create a large transect to be read quarterly.	• 4 • 1-3 • 1-4 • 1-4 • 1-3

Year	Action	Quarter
MIP YEAR 7 Oct 2010- Sept 2011	• Continue paneling over hog sections as needed • Begin and complete replacement of rusted crestline sections as needed • Check MU fence for breaches quarterly • Keep gulch bottom sections free of debris to prevent ingress of small pigs • Clear and maintain makai fenceline of grass as feasible	• 1-4*
MIP YEAR 8 Oct 2011- Sept 2012 through MIP YEAR 10 Oct 2013- Sept 2014	• Check MU fence for breaches quarterly • Keep gulch bottom sections free of debris to prevent ingress of small pigs • Maintain makai fenceline of grass as feasible	• 1-4*

Actual schedule to be determined by Field Coordinators

Fenceline and Transects at Kaluakauila



1.4.5.3 Weed Control

Weed Control actions are divided into 4 subcategories:

1. Vegetation Monitoring
2. Surveys
3. Incipient Taxa Control (Incipient Control Areas - ICAs) and
4. Ecosystem Management Control (Weed Control Areas - WCAs)

These designations facilitate different aspects of MIP/OIP requirements.

Vegetation Monitoring

Monitoring Objectives:

- In 2010, develop WCA weed transect protocol and a pilot monitoring program.
- Beginning in 2010, install and read WCA vegetation monitoring transects annually to measure the effectiveness of weed control efforts.
- Beginning in 2010, conduct vegetation transect monitoring across the MU every 5 years to measure the effectiveness of weed control efforts.
- Beginning in 2010, conduct monitoring along fuelbreaks in the spring and late summer each year to detect less than 1 foot alien grass heights.
- Conduct qualitative visual assessment of weed cover around reintroduced plants once/quarter.

Management Responses:

- Increase weeding efforts in WCAs and ICAs each quarter if monitoring detects that general management objectives are not being met.

Monitoring and Related General WCA Actions

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• GPS boundaries of all WCAs. Use geographical and vegetation data. Use landmarks to mark in field • GPS trails • Begin WCA vegetation monitoring transects once protocol developed • Conduct qualitative visual assessment of weed cover around reintroduced rare plants quarterly	• 1-4*
MIP YEAR 7 Oct.2010-Sept.2011	• Begin MU monitoring transects (read every 5 years) • Read WCA transects • If created, begin fuel break vegetation monitoring (detect less than 1 foot heights of grasses along 20 m fuel break at forest edge) • Conduct qualitative visual assessment of weed cover around reintroduced rare plants once a quarter	• 1-4*
MIP YEAR 8-9 Oct.2011-Sept.2013	• Read WCA transects • Read fuel breaks in the spring and late summer as needed • Conduct qualitative visual assessment of weed cover around reintroduced rare plants once a quarter	• 1-4*
MIP YEAR 10 Oct.2013-Sept.2014	• Read WCA transects • Read fuel breaks in the spring and late summer as needed • Conduct qualitative visual assessment of weed cover around reintroduced rare plants once a quarter • Read MU monitoring transects (every 5 years)	• 1-4*

Actual schedule to be determined by Field Coordinators

Surveys

Army Training?: No

Other Potential Sources of Introduction: OANRP, pigs, public hikers

Survey Locations: Roads, landing zones, camp sites, fence lines, potential high traffic areas

Management Objective:

- Prevent the establishment of any new invasive alien plant or animal species through regular surveys along roads, landing zones, camp sites, fence lines, trails, and other high traffic areas.

Monitoring Objectives:

- Annual road survey of Kuaokala Road.
- Annual surveys of fence lines.
- Annual surveys of LZs and Camp site (quarterly if used).

Surveys are designed to be the first line of defense in locating and identifying potential new weed species. Roads, landing zones, camp sites, fence lines, and other highly trafficked areas are inventoried regularly; LZs are surveyed annually, non-Army roads are surveyed annually or biannually, while all other sites are surveyed quarterly or as they are used.

Weed Survey Actions:

Year	Action	Quarter
MIP YEAR 6-10 Oct.2009- Sept.2014	• Survey all LZs, Camp sites (quarterly if used, if not annually) • Survey fenceline (annually) • Road Survey (annually)	• 1-4*

***Actual schedule to be determined by Field Coordinators**

Incipient Taxa Control (ICAs)

Management Objectives:

- As feasible, eradicate high priority species identified as incipient invasive aliens in the MU by 2014.
- Conduct seed dormancy trials for all high priority incipients by 2014.

Monitoring Objectives:

- Visit ICAs at stated revisitation intervals. Control all mature plants at ICAs and prevent any immature or seedling plants from reaching maturity.

Management Responses:

- If unsuccessful in preventing immature plants from maturing, increase ICA revisitation interval.

Incipient Control Areas (ICAs) are drawn around each discrete infestation of an incipient invasive weed. ICAs are designed to facilitate data gathering and control. For each ICA, the management goal is to achieve complete eradication of the invasive taxa. Frequent visitation is often necessary to achieve eradication. Seed bed life/dormancy and life cycle information is important in determining when eradication may be reached; much of this information needs to be researched and parameters for determining eradication defined. NRS will compile this information for each ICA species; assistance from graduate students for this research will be pursued.

The table below summarizes incipient invasive taxa at Kaluakauila. Each species is given a weed management code: 1 = incipient (goal: eradicate), 2 = control locally. All current ICAs are mapped in the Incipient and Weed Control Areas map below.

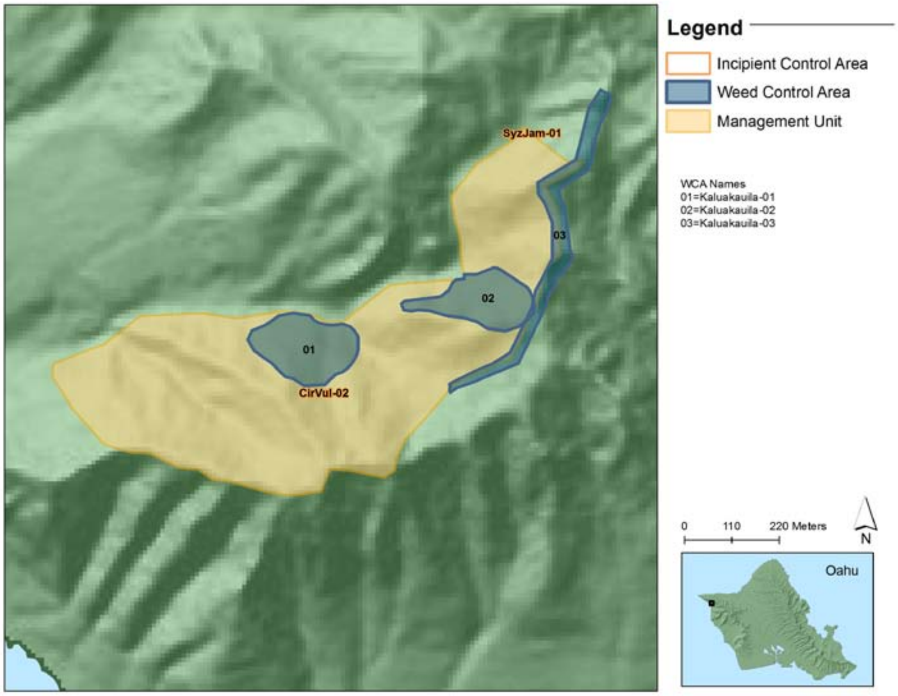
Summary of Potential ICA Target Taxa

Taxa	Mgmt. Code	Notes	No. of ICAs
Cirsium vulgare	1	Known only from one location in a streambed.It is considered highly invasive because it produces copious amounts of seed which are widely dispersed by wind, seeds remain viable over a long period of time, and it grows in a number of climates and habitats. This ICA is located in Kaluakauila Gulch on the far side of Makua Valley. NRS found only one immature individual here. This is quite a distance from the other known population on Ohikilolo. It is not clear where this individual dispersed from. The individual plant was pulled out and the area around was searched. None were found. NRS plans to re-survey the area on the quarterly scheduled trips to Kaluakauila MU. It is highly probable that NRS will be able to eradicate *C. vulgare* from this ICA.	1
Syzigium jambos	1	Known only from one location. While widespread in the Ko'olaus and southern parts of the Wai'anae Mountains, *S. jambos* is not well known from the Kaluakauila region, and thus is considered a priority weed in this area. This ICA was created when one immature *S. jambos* was found along a weed transect in 2005. It is likely that pig traffic is responsible for the spread of this incipient to the region. OANRP controlled it, and will monitor the site in the future. Only one individual was found and it is hoped that OANRP will be able to keep this weed out of Kaluakauila MU. The *Puccinia* rust is also controlling any unknown locations of individuals by reducing vigor if not killing trees outright.	1
Erigeron karvinski-anus	1	Known only from one location, the distribution needs further scoping. Daisy fleabane is normally found in wetter areas and is known from only one location near a seep on a open spur ridge off the main ridgeline dividing Makua Valley from Kaluakauila Gulch. Given the aridity of the area it is not likely to spread quickly but should be controlled given the sensitivity of neighboring cliff resources. No ICAs have been designated yet for this species and its location. Additional surveys are needed to determine the extent of the infestation.	TBD

ICA Actions:

Year	Action	Quarter
MIP YEAR 6-10 Oct.2009-Sept.2014	• Cirvul monitoring, control as needed (quarterly) • Syzjam monitoring, control as needed (quarterly) • Erikar scoping in Winter 2009, control as needed (quarterly)	• 1-4

Weed and Incipient Control Areas



Ecosystem Management Weed Control (WCAs)

IP Goals:

- Within 2m of rare taxa: 0% alien vegetation cover
- Within 50m of rare taxa: 25% or less alien vegetation cover
- Throughout the remainder of the MU: 50% or less alien vegetation cover

Management Objectives:

- Achieve less than 25% perennial weed cover within 2m of IP taxa by end of 2011 and maintain through 2014. Weed cover around rare taxa visually assessed qualitatively on a quarterly basis.
- Following baseline reads of WCA weed transects, implement quarterly weed control to ideally achieve 50% or less of canopy and perennial understory weed cover in WCA-01 and WCA-02 by 2014.
- By 2014, as feasible, conduct fire pre-suppression efforts in the spring and fall each year to reduce fuel loads and fire threats (see Fire Control section).

Management Responses:

- Increase weeding efforts in WCAs each quarter if monitoring detects that general management objectives are not being met.

WCA: Kaluakauila-01 Lower patch

Veg Type: Dry forest

IP Goal: Within 50m of rare taxa: 25% or less alien vegetation cover

Targets: All perennial weeds including *Schinus terebinthifolius, Leucaena leucocephala, Grevillea robusta, Panicum maximum ,Melinus minutifolia, and Rivinia humilis*

Notes:

Several rare taxa present. The lower patch is dominated at its center by a dense stand of *Diospyros ssp.* Large *Erythrina sandwicensis, Sapindus oahuensis,* and *Euphorbia haeleeleana* are also significant native components. *L. leucocephala* has been significantly reduced although it still recruits readily and control is ongoing.

Most of the weeding effort has been directed toward the control of *P. maximum* and other grasses in order to reduce fuel loads and increase shrub and canopy tree recruitment. *P. maximum* control should also focus on the cliff area below the WCA and to the western makai end to reduce the ability of any fire to move into the core dry forest area.

Annual weeds such as *Hyptis* ssp. are largely uncontrollable given their high density during the rainy season. *Hyptis* should be pulled or treated only at the bases of rare outplantings unless a better control method is found.

In addition to weeding outplantings, *S. terebinthifolius* needs to be controlled around *N.humile* plants and general weed control is also needed around the declining *Melanthera tenuifolia* population.

WCA Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Sweep entire WCA with phalanx one time • Spray grass in Spring and Early Winter	• 1-4 • 2, 4
MIP YEAR 7 Oct.2010-Sept.2011	• Sweep entire WCA with phalanx one time • Spray grass in Spring and Early Winter	• 1-4 • 2, 4
MIP YEAR 8 Oct.2011-Sept.2012	• Sweep entire WCA with phalanx one time • Spray grass in Spring and Early Winter	• 1-4 • 2, 4
MIP YEAR 9 Oct.2012-Sept.2013	• Sweep entire WCA with phalanx one time • Spray grass in Spring and Early Winter	• 1-4 • 2, 4
MIP YEAR 10 Oct.2013- Sept.2014	• Sweep entire WCA with phalanx one time • Spray grass in Spring and Early Winter	• 1-4 • 2, 4

WCA: Kaluakauila-02 Upper Patch

Veg Type: Dry forest

IP Goal: Within 50m of rare taxa: 25% or less alien vegetation cover

Targets: All perennial weeds including *Schinus terebinthifolius, Leucaena leucocephala, Grevillea robusta, Panicum maximum ,Melinus minutifolia, and Rivinia humilis*

Notes: Several rare taxa present including a large number of *N. humilis*. The lower patch is dominated at its center by a dense stand of *Diospyros ssp.* Large *Erythrina sandwicensis, Sapindus oahuensis,* and *Euphorbia haeleeleana* are also significant native components. *L. leucocephala* has been significantly reduced although it still recruits readily and control needs to be ongoing.

Most of the weeding effort has been directed toward the control of grasses in order to reduce fuel loads and increase shrub and canopy tree recruitment. Grass control should also focus on the area to the east of the WCA near the stream bed to reduce the ability of any fire to move into the core dry forest area.

Annual weeds such as *Hyptis* are largely uncontrollable given their high density during the rainy season. *Hyptis* should be pulled or treated only at the bases of rare outplantings unless a better control method is found.

In addition to weeding outplantings, *S. terebinthifolius* needs to be controlled around *N. humilis* plants. Grass and fern control is also needed on a quarterly basis for the *D. subcordata* population close to the gulch bottom.

WCA Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Sweep entire WCA with phalanx one time • Spray grass in Spring and Early Winter	• 1-4 • 2, 4
MIP YEAR 7 Oct.2010-Sept.2011	• Sweep entire WCA with phalanx one time • Spray grass in Spring and Early Winter	• 1-4 • 2, 4
MIP YEAR 8 Oct.2011-Sept.2012	• Sweep entire WCA with phalanx one time • Spray grass in Spring and Early Winter	• 1-4 • 2, 4
MIP YEAR 9 Oct.2012-Sept.2013	• Sweep entire WCA with phalanx one time • Spray grass in Spring and Early Winter	• 1-4 • 2, 4
MIP YEAR 10 Oct.2013- Sept.2014	• Sweep entire WCA with phalanx one time • Spray grass in Spring and Early Winter	• 1-4 • 2, 4

WCA: Kaluakauila-03 (See Fire Control Section)

1.4.5.4 Rodent Control

Threat level: High

Current control method: Bait station & snap trap grids (localized control)

Seasonality: Year-Round

Number of control grids: 2 (57 bait stations, 50 snap traps)

Primary Objective:

- To maintain rat/mouse populations to a level that facilitates stabilized or increasing plant populations across the MU by the most effective means possible.

Management Objective:

- Continue to maintain bait stations and snap trap grids (localized control) in dry forest patches.
- Less than 10% activity levels for rats in tracking tunnels.
- Evaluate current localized rodent control to determine if changes are needed.
- Determine feasibility of hand-broadcast of rodenticide for MU wide dry forest protection (MU control).

Monitoring Objectives:

- Monitor tracking tunnels to determine rodent activity within the bait station and trap grids quarterly.
- Monitor *Euphorbia haeleeleana* as a focal species to determine the occurrence of fruit predation by rodents.

Monitoring Issues:

- Attaining a 10% or less activity level in tracking tunnels is currently the level to achieve. The first baseline running of tracking tunnels conducted in early November 2009 detected no rat activity. With further monitoring over time, an acceptable level of activity can be identified, which will promote stable or increasing rare plant populations.

Localized Rodent Control:

- Localized control consists of bait station and snap trap grids deployed across two small patches of native dry forest. These localized grids are maintained every 4 to 6 weeks. Grids are centered around and extend slightly beyond the boundaries of the *E. haeleeleana* populations being protected. Monitoring of rat activity via tracking tunnels will be vital in determining whether control is having the desired effect, as will intensive monitoring of *E. haeleeleana.*

Localized Rodent Control Actions:

ActionsYear	Action	Quarter
MIP YEAR 6 Oct.2009- Sept.2010 through MIP YEAR 9 Oct.2012- Sept.2013	• Upper patch grid restock, every 4-6 weeks • Lower patch grid restock, every 4-6 weeks • Monitor tracking tunnels 1x a quarter • Monitor *E. haeleeleana* for rat predation	• 1-4 • 1-4 • 1-4 • 1-4

MU Rodent Control:

- Threatened resources are concentrated in two small forest patches within this MU. OANRP have had a positive response from the E. haeleeleana trees following years of localized rodent control. Prior to localized rodent control few fruit survived and little if any recruitment occurred. In the years following rodent control, E. haeleeleana saplings and seedlings are now present albeit in low numbers but this is not unexpected for such a dry area. If the current method of localized rodent control proves insufficient, the use of hand broadcast rodenticide will be evaluated.

MU Rodent Control Actions:

Year	Action	Quarter
MIP YEAR 7 Oct. 2010-Sept. 2011	• Evaluate feasibility of hand broadcast of rodenticide as a control method for rodents over entire MU	• 1-4
MIP YEAR 8 Oct. 2011-Sept 2012	• Establish protocol for hand broadcast of rodenticide for entire MU if deemed appropriate. • Establish monitoring protocols	• 1-4
MIP YEAR 9 Oct. 2012-Sept. 2013	• Institute program of hand broadcast of rodenticide over entire MU. • Institute monitoring program	• 1-4

1.4.5.5 Black Twig Borer (BTB) Control

Species: *Xylosandrus compactus*

Threat level: Medium

Control level: Localized

Seasonality: Peaks elsewhere have been observed from October-January

Number of sites: 5 (Abutilon sandwicense and Neraudia angulata sites)

Acceptable Level of Activity: Current level probably acceptable

Primary Objective: Reduce BTB populations to a level optimal for Abutilon sandwicense and Neraudia angulata survival.

Management Objective:

- Continue to develop better methods to control BTB

Monitoring Objectives:

- Annual or every other year census monitoring of *Abutilon sandwicense* and *Neraudia angulata* populations to determine BTB damage.
- If BTB damage is found to be high, implement control for BTB (traps)

The current control method available for BTB involves the deployment of traps equipped with high-release ethanol bait. It is unclear whether this method reduces BTB damage to target plants (see Chapter 6). Current damage caused by BTB to target plant populations has been observed to be low. Monitoring of rare plants to date make BTB control not recommended at this time (given available control methods).

BTB Control Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009-Sept.2010	• Determine whether BTB damage to *Abutilon sandwicense* and *Neraudia angulata* requires control	• 1-4
OIP YEAR 4-6 Oct.2010- Sept.2013	• Put out BTB high-release ethanol traps (see Research Activities Chapter) if BTB damage to target plants exceeds acceptable levels • Implement control as improved tools become available	• 1-4

1.4.5.6 Slug Control

Species: *Veronicella cubensis, Deroceras laeve*

Threat level: High

Control level: Localized

Seasonality: Wet season (September-May)

Number of sites: 1 (*Delissea subcordata* site)

Acceptable Level of Activity: Acceptable at current levels (*D. leave* at low densities)

Primary Objective: Control slugs to facilitate germination and survivorship of threatened rare taxa

Management Objectives:

- As needed, continue to determine slug species present and estimate baseline densities using traps baited with beer in the fall of 2010

Monitoring Objectives:

- Determine the need to conduct an annual census monitoring of slug densities during wet season.

Effective molluscicides have been identified (Sluggo) and initial control programs are ongoing in Kahanahaiki. A slug control pilot program could begin at the Kaluakauila MU in the fall of 2011 should slug damage to rare plants be observed. If large-scale rat control is implemented, plots to monitor the effect of predator removal on slug population (if not already determined in other areas) may be considered.

Slug Control Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Monitor slug activity at *Delissea subcordata* via traps baited with beer as needed	• 1-4
MIP YEAR 7 Oct.2010-Sept.2011 through MIP YEAR 10 Oct.2013- Sept.2014	• Deploy slug bait around *Delissea subcordata* as needed, frequency to be determined during research phase. • If slugs found to exceed acceptable levels during monitoring, maintain slug bait at sensitive plant population(s)	• 1-4 • 1-4

1.4.5.7 Ant Control

Species: *Anoplolepis gracilipes, Ochetellus glaber*

Threat level: High for *A. gracilipes*, low for *O. glaber*

Control level: Desirable for *A. gracilipes* however, this species not responsive to known control methods for ants

Seasonality: Varies by species, but nest expansion observed in late summer, early fall

Number of sites: Unknown

Acceptable Level of Ant Activity: Unknown, systematic ant sampling not yet undertaken

Primary Objective: Eradicate incipient ant invasions and control established populations when densities are high enough to threaten rare resources.

Management Objective:

- If incipient species are found and deemed to be a high threat and/or easily eradicated locally (<0.5 acre infestation) begin control using a bait containing Hydramethylnon (Amdro, Maxforce or Seige).

Monitoring Objective:

- Continue to sample ants at human entry points (landing zone, fence line) a minimum of once a year. Use samples to track changes in existing ant densities and to alert NRS to any new introductions.

Ants have been documented to pose threats to a variety of resources, including native arthropods, plants (via farming of Hemipterian pests), and birds. The distribution and diversity of ant species in upland areas on Oahu, Kaluakauila, has only begun to be studied and changes over time. Impacts to the rare species present in Kaluakauila remain unknown, but it is likely they are having some type of effect on the ecosystem at large. The OANRP has already conducted some surveys across Kaluakauila to determine which ant species are present and where they are located. Surveys were conducted using a standardized sampling method (see Appendix Invasive Ant Monitoring Protocol this document).

Ant Control Actions:

Year	Action	Quarter
OIP YEAR 6 Oct.2009-Sept.2010	• Conduct surveys for ants • Analyze results of surveys, develop management plan	• 1, 2 • 3,4
OIP YEAR 6 Oct.2009-Sept.2010 through OIP YEAR 9 Oct.2012-Sept.2013	• Implement control if deemed necessary • Conduct arthropod survey along transects in anticipation of rat trap out project.	• 1-4

1.4.5.8 Fire Control

Threat Level: High

Available Tools: Fuelbreaks, Visual Markers, Helicopter Drops, Wildland Fire Crew, HBT, Aerial spraying, Surveillance cameras, Red-Carded Staff

Veg Type: Dry forest and dry shrubland/grassland

IP Goal: 20 m wide fuelbreak along the forest edge and crestline area and down the makai fenceline.

Targets: *P.maximum, M.minutifolia, R.repens, A.viginicus, P.guajava, S.jamaicaense, L.leucocephalum*

Notes: As feasible, establish and maintain fuelbreaks along ridge, forest line and along makai fenceline.

Management Objectives:

- Conduct fire pre-suppression efforts in and around WCAs in the spring and fall each year to reduce fuel loads and fire threats.
- By Spring of 2010, determine the feasibility and cost of a 20m fuel break along the forest edge.
- By 2014, secure funding to subcontract work or use existing crews to create a 20m wide fire/fuel break along the Kaluakauila forest edge nearest to the Makua rim.
- By 2014, secure funding to subcontract work or use existing crews to clear and maintain a fuel break along the makai fenceline to a width of 20m

Monitoring Objectives:

- If fuel breaks are created, beginning in 2011, conduct monitoring along fuelbreaks in the spring each year to detect less than 1 foot heights of grasses.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2012-Sept.2014	• Maintain LZs on ridgeline • Ridgeline fuel break construction? • Ridgeline fuel break maintenance? • Install cyber stakes on top of fenceline along makai line? • Farrington Hwy. and mouth of Kaluakauila fuel break construction? • Farrington Hwy. fuel maintenance? • Makai fenceline fuel control? • Makai fenceline fuel maintenance? • Installation of mock or real surveillance cameras along Farrington Hwy.?	• 1-4

Escaped prescribed burn at Makua 2003 (Kaluakauila fenceline at left of photo)

Fire Issues

Kaluakauila MU is one of the most highly fire-threatened units in all of Makua. The area is vulnerable to fires from nearly all directions, with steep fuel-laden slopes which make fire suppression a difficult task. With each burn, the fires burn the edges of the native forest patches lessening their area. An aerial photo taken in 1977 showed that the forest was significantly larger particularly toward the Makua rim area. The burned areas have become established with invasive species, which serve as fuel for future fires. The last two recent fires that affected the area burned an outplanted *Hibiscus brackenridgei subsp. mokuleianus* population, and a group of *Chamaecyse celastroides var. kaenana* plants.

The Army Wildland Fire Crew outlined in their 2007 report, a plan for fire prevention and management to protect Kaluakauila MU from future burns. The plan consists mainly of three components, including the creation and maintenance of new fuelbreaks in strategic locations around the MU, the reduction of arson along Farrington Highway, and fuel reduction directly around protected species within the MU. Also, the 2007 Makua Biological Opinion (Reinitiation of the 1999 U.S. Fish and Wildlife Service for U.S. Army Military Training at Makua Valley) recommended a number of required measures and alternatives to protect the Kaluakauila MU. Recently however, the Army announced that it would not be using certain classes of weapons at Makua that were the trigger for the much of the fire mitigation measures at Kaluakauila and the surrounding Punapohaku area. Recommendations from the 2007 Makua BO are still under consideration in light of the new weapons restrictions. Also this past year, Dawn Greenlee of the FWS went on a site visit to look at different pre-suppression options with agency partners. Recommendations from the Army Wildland Fire Crew plan, Dawn Greenlee's notes, and recommendations from the Summary of Wildland Fires Aspects of the 2007 Makua Biological Opinion are included in Appendix 3.

NRS will also maintain red-carded staff to assist with a fire response.

Discussion of Proposed Actions

1. **Create a 20 m wide fuelbreak atop the ridge between Makua and Kaluakauila MU and along the forest edge.** This fuel break would ideally be wide enough to have a good chance of slowing and stopping fires before entering the forested area. Permanent helispots and safety zones were also recommended for this area in the 2007 Makua BO to provide firefighters with safe access to the area in the event of another catastrophic fire. A maximum height of one foot tall grass is the recommended standard for the fuel break (Army Integrated Wildfire Plan). Large patches of native grass may need to be killed in order to ensure adequate fuel reductions. The treated area would also be prone to erosion and invasion by herbicide tolerant weeds. To treat this large of an area, aerial ball or aerial boom spraying with Roundup and Oust may be the most cost-effective method after the initial cut to eliminate the dead biomass. Oust is a pre-emergent herbicide that has been effective in the Lower Ohikilolo area at reducing germination rates of grasses and other weeds and the amount of followup herbicidal treatments.

   OANRP will pursue additional funding from the Army to subcontract out this action as well as requesting assistance from the Army Wildland Fire Crew. If no additional funds are secured, a narrower fuel break constructed by OANRP staff (e.g. 10m) may have to suffice. This 20m wide fuelbreak encompasses some of the area already in WCA-03.

   Greenfire breaks have also been considered at Kaluakauila. Essentially, drought tolerant trees and/or shrubs would be planted with an irrigation system to eventually shade out grasses and slow any fires that approached the core areas. Research is ongoing regarding this approach by the U.S. Forest Service on the island of Hawaii at Pohakuloa Training Area. Results from those studies will hopefully be applicable in the near future to Makua and Kaluakauila.

   Some combination of these above approaches might also work and NRS remain open to committing resources to the best approach. The remaining actions largely rely on cooperation from other agencies and additional funding. They are included here for discussion purposes.

2. **Install real or mock surveillance cameras on Farrington Highway to deter roadside arsonists.** Reducing civilian ignitions near Farrington Highway may be possible through use of real or imitation surveillance cameras and an associated sign notifying trespassers that they are on government land, under surveillance, and illegal acts will be recorded and prosecuted to the fullest extent of the law. In 2009 alone, at least 7 small fires were started along this stretch of road between the Makua cave and the mouth of Kaluakauila Gulch. Two of these fires were stolen cars that were torched. OANRP will rely on the expertise of the Army Wildland Crew and other partners to plan and implement these pre-suppression actions.

3. **Build a fuelbreak along Farrington Highway and across the mouth of Kaluakauila drainage.** By improving a pre-existing road that cuts across the mouth of Kaluakauila drainage, it may be possible to stop fires before they ever pose a real threat. A small 20 m wide fuel break was recently created near the mouth of Makua Valley near the Range Control gate. Ideally this fuel break would be expanded to the area north of the base of Puakanoa and south to the Makua cave. Small, controlled burns on a one-time or regular basis may be the best method of clearing this area followed by herbicide treatments. OANRP will rely on the expertise of the Army Wildland Crew and other partners to plan and implement these pre-suppression actions.

4. **Manage fuels within and immediately surrounding the Kaluakauila MU.** A final defense against fires should be considered within the Kaluakauila MU itself. Cutting grass and shrubs and clearing downed vegetation around individuals and populations of protected species may allow the individuals to survive a fire. For example, clearing the guinea grass around the wild *C. celastroides* population would probably help it survive another fire. For a number of years now, NRS have been controlling the fuel loads in the core dry forest habitat (see also Weed control section). The fuel load has been substantially reduced within the upper and lower patches of remnant dry forest and this work will continue.

   Of particular concern at Kaluakauila are the guinea grass patches surrounding the core native areas. At the Upper Patch, a large patch of guinea lies to the west of WCA-02. At the Lower Patch around WCA-01, large patches of guinea grass lie to the south, east and west. Some type of systematic fuel control for these patches to essentially buffer the forest edge is needed. Again, aerial spraying using Roundup and Oust where feasible and allowable, might be the best short to medium term solution as expansion of the forest boundary is not likely given the scale of weed control, planting and supplemental irrigation that would be required. Backpack spraying of these additional areas is also possible near the cliffs where aerial spraying is difficult given the vertical areas. Herbicide ballistic technology (i.e. paintball guns) also has the potential make cliff control of grass patches and other fuels cost-effective.

   While less of a threat, the guinea grass at the base of the cliffs above the gulch bottom can also serve as fuel ladders to preheat vegetation above or carry fire into the core forested areas. These patches should also be carefully controlled given their proximity to rare resources especially the scattered *N. humilis* individuals.

5. **Manage fuels in Makua and Keawaula through targeted grazing.**

   See information in Appendix 3, Fire Management. OANRP will rely on the expertise of the Army Wildland Crew and other partners to plan and implement these pre-suppression actions.

1.4.6 Lower Makua Ecosystem Restoration Management Plan

MIP Year 6-10, Oct. 2009 – Sept. 2014

MU: Ohikilolo (Lower Makua)

1.4.6.1 Overall MIP Management Goals:

- Form a stable, native-dominated matrix of plant communities which support stable populations of IP taxa.
- Control ungulate, weed, predatory snail, rodent and slug threats in the next five years to allow for stabilization of IP taxa. Implement control methods by 2013.

1.4.6.2 Background Information

Location: Leeward side of Northern Waianae Mountains, Southern base of Makua valley

Land Owner: U.S. Army Garrison Hawaii

Land Manager: Oahu Army Natural Resource program

Acreage:

Elevation range: 1200-2200 ft.

Description: The managed area is on the northwest facing slope of Makua valley above ordnance and the *Panicum maximum* dominated valley bottom. Much of the area consists of a slope between 1400-2000 ft. Access is via a hike along valley floor or by helicopter.

Ohikilolo Management Unit (MU) is one of the larger MIP MUs. Management for this MU has long been divided informally among OANRP staff as the two following areas; Ohikilolo (Upper) and Lower Makua. The division is useful because the access issues to each of the areas vary; large cliffs run approximately along the 2000 ft contour between the two. While the ecosystem management objectives are mostly consistent across the entire MU, because the two 'areas' have been treated separately in past reports and because they are managed by two different field teams, they will be reported in Ecosystem Restoration Management Plans as two separate areas within the same MU. There are many challenges to management in Lower Makua. Scheduling with Range Control and EOD is required given the large amount of UXO and access is often limited. The area is not pig free. However, the area is one of very few lowland dry forests remaining. Two Chasiempis sandwichensis ibidis pair territories were monitored in June 2009.

Native Vegetation Types:

Waianae Vegetation Types
Dry forest
Canopy includes: *Diospyros* sp., *Myoporum sandwicense, Erythrina sandwicensis, Reynoldsia sandwicensis, Rauvolfia sandwicensis, Santalum ellipticum*, *Psydrax odoratum, Nestegis sandwicensis* and *Myrsine lanaiensis*. Understory includes: *Dodonaea viscosa, Sida fallax, Bidens* sp.
NOTE: For MU monitoring purposes vegetation type is mapped based on theoretical pre-disturbance vegetation. Alien species are not noted.

MIP Rare Resources

Organism Type	Species	Pop. Ref. Code	Population Unit	Management Designation	Wild/ Reintroduction
Plant	*Alectyron macrococcus*	MMR- A,D,E, F, O-R	Makua	MFS	Wild
Plant	*Flueggea neowawraea*	MMR-C, D, E	Ohikilolo	GSC	Wild
Plant	*Melanthera tenuifolia*	MMR-C, I, J	Ohikilolo	GSC	Wild
Plant	*Neraudia angulata*	MMR-A, D	Makua	MFS	Both
Plant	*Nototrichium humile*	MMR- D,E,H,I	Makua (S. side)	MFS	Both
Bird	*Chasiempis sanwichensis ibidis*	N/A		Manage	Wild

Other Rare Taxa at Ohikilolo MU Lower Makua

Organism Type	Species	Status
Plant	*Bobea sandwichensis*	Endangered
Plant	*Bonamia menzesii*	Endangered
Plant	*Ctenitis squamigera*	Endangered
Plant	*Nesoluma polynesicum*	
Plant	*Pleomele forbsii*	

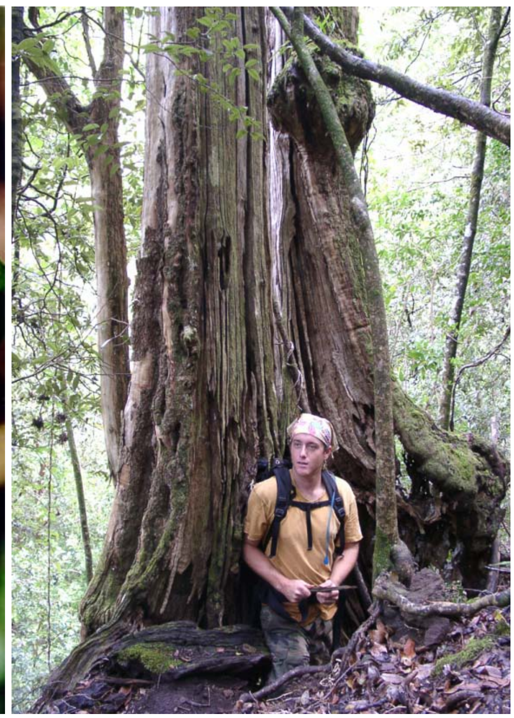
Chasiempsis sandwichensis ibidis

Alectryon macroccocus fruit

Neraudia angulata var. dentata

Nesaluma polynesicum

Nototrichium humile



Flueggea neowawraea

Locations of Rare Resources at Ohikilolo (lower)

MU Threats to MIP/OIP MFS Taxa

Threat	Taxa Affected	Localized Control Sufficient?	MU scale Control required?	Control Method Available?
Pigs	All	No	Yes	Yes
Rats	All	Yes for Elepaio, Unknown for plants	No	Yes
Slugs	Potential threat to *N. angulata, N. humile*	Yes	No	Currently being developed
Ants	Unknown	Unknown	Unknown	Some available, depends on species
Black Twig Borer	*A. macrococcus, F. neowawraea, N. angulata*	Yes	No	Currently under development
Weeds	All	Yes	Yes	Yes; No for species that occur on cliffs
Fire	All	Yes	Yes	Yes

Management History

- 1995-1997 ground hunts were started with the use of contract hunters from the U. S. Department of Agriculture Wildlife Services while plans for a fence to enclose MMR were finalized.
- 1996-1997 the first stretch of fencing (2 km) separating MMR from a public hunting area was completed by the National Park Service and ~8 km of fencing was erected around the eastern perimeter of the valley.
- 1999: Contract and Staff ground hunts continued from 1997-1999 to control numbers of goats. OANRP began to employ lethal neck snares as a management tool.
- 2000: Perimeter fence that was completed that separates the MU from the adjoining ‘Ōhikilolo Ranch and Kea‘au Game Management Area to the south.
- 2001: The last portion of the fence was completed separation the valley from the core populations of goats to the south and OANRP staff employed aerial shooting and “Judas goats” as management tools.
- 2002: NRS completed a small fence around a single *F. neowawraea* at MMR-C.
- 2003: A breach in the fence occurs allowing at least three goats to cross over to Mākua from Mākaha Valley. These three goats were subsequently caught and no more sign has been observed in the area of the breach, NRS completed a strategic fence protecting *N. angulata* MMR-D.
- 2004: NRS believes they have eradicated entire MU of feral goats.
- 2005: NRS completed two strategic fences in the very back of Ko‘iahi gulch that protect two populations of *N. angulata.*
- 2006: Four goats breached perimeter fence, all were caught.

1.4.6.3 Ungulate Control

Identified Ungulate Threats: Pigs, Goats

Threat Level: High

Primary Objective:

- To maintain all areas of the MU as goat-free and the fenced areas as pig-free.
- Decide best plan for completing MU fence. Initiate completion and eradicate all ungulates from within.

Strategy:

- Sustained levels of eradication for goats throughout the MU, and pigs within fences.

Monitoring Objectives:

- Conduct fence checks.
- Monitor for pig sign while conducting other management actions in the fence.

Management Responses:

- If any goat activity is detected in the MU implement hunting and/or snaring program.
- If any pig activity is detected in fenced units implement hunting and/or snaring program.

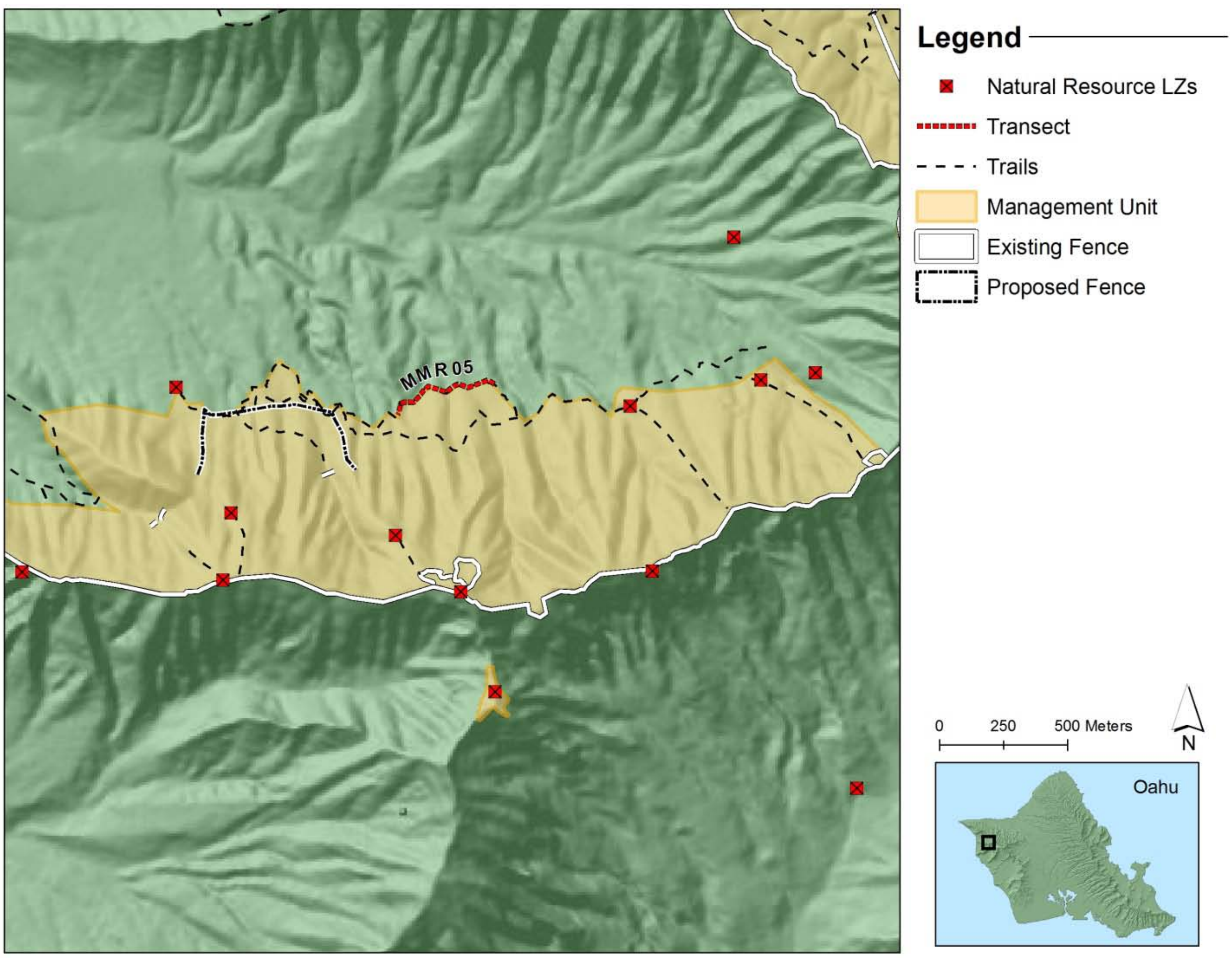
Maintenance Issues

There are four fences in this portion of the MU. The major threats to the fences include erosion, fallen trees and rocks, fire and vandalism. No incidences of vandalism have been observed. Special emphasis will be placed on checking the fence after extreme weather events.

Table 4: Ungulate Control Actions

Year	Action	Quarter
MIP YEAR 6 Oct 2009-Sept 2010	• Conduct annual and post storm fence monitoring trips.	• 1-4
MIP YEAR 6 Oct 2010-Sept 2011	• Conduct annual and post storm fence monitoring trips.	• 1-4
MIP YEAR 7 Oct 2011- Sept 2012 through MIP YEAR 9 Oct 2013- Sept 2014	• Conduct annual and post storm fence monitoring trips. • Select a route to complete the fencing of the MU. • Begin construction of the MU fence	• 1-4

Ungulate Management at Ohikilolo (lower)



1.4.6.4 Weed Control

Weed Control actions are divided into 4 subcategories:

1. Vegetation Monitoring
2. Surveys
3. Incipient Taxa Control (Incipient Control Area - ICAs)
4. Ecosystem Management Weed Control (Weed Control Areas - WCAs)

These designations facilitate different aspects of MIP/OIP requirements.

Vegetation monitoring

Objectives:

- Conduct vegetation monitoring for Lower Makua in MIP Year 6.
- Conduct MU vegetation monitoring for the cliff community in MIP Year 6-7.

MU Vegetation Monitoring:

Vegetation monitoring will be conducted for both the Upper Ohikilolo and Lower Makua sections of this MU (Refer to background information for discussion on reasons for division of the MU). OANRP is currently developing a vegetation monitoring protocol for cliff communities. Once this is set vegetation monitoring will be conducted for this section of the MU.

Monitoring Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Conduct vegetation monitoring across the accessible areas of Lower Makua.	• 1-2
MIP YEAR 6 Oct.2009-Sept.2010	• Conduct vegetation monitoring for the cliff community.	• 1-4
MIP YEAR 9 Oct.2012-Sept.2013	• Conduct vegetation monitoring across the accessible areas of Lower Makua.	• 1-2
MIP YEAR 9 Oct.2012-Sept.2013	• Conduct vegetation monitoring for the cliff community.	• 1-4

Surveys

Army Training?: Yes

Other Potential Sources of Introduction: NRS, pigs, poachers

Survey Locations: Roads, Landing Zones, Camp sites Fencelines, High Potential Traffic Areas.

Management Objective:

- Prevent the establishment of any new invasive alien plant or animal species through regular surveys along roads, landing zones, camp sites, fencelines, trails, and other high traffic areas (as applicable).

Monitoring Objectives:

- Annual survey of the firebreak roads
- Monitor/install transects to detect alien species ingress

- Quarterly surveys of LZs (if used).
- Note unusual, significant, or incipient alien taxa during the course of regular field work.

Management Responses:

- Any significant alien taxa found will be researched and evaluated for distribution and life history. If found to pose a major threat, control will begin and will be tracked via Incipient Control Areas (ICAs)

Surveys are designed to be the first line of defense in locating and identifying potential new weed species. Roads, landing zones, fencelines, and other highly trafficked areas are inventoried regularly; Army roads and LZs are surveyed annually, non-Army roads are surveyed annually or biannually, while all other sites are surveyed quarterly or as they are used. At Lower Makua, only landing zones and roads are currently surveyed regularly.

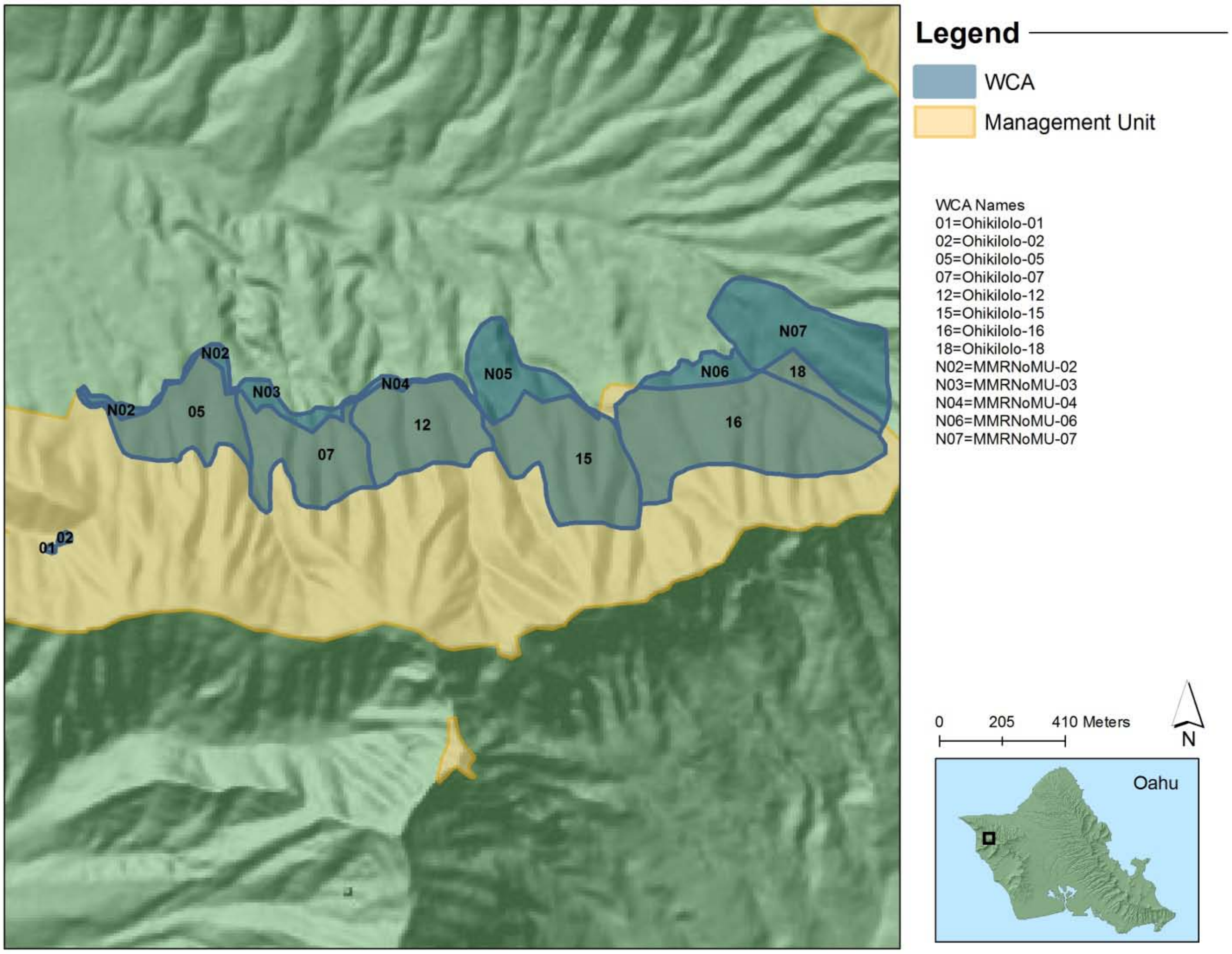
Survey Actions:

Year	Action	Quarter
MIP YEAR 5 Oct.2008-Sept.2009	• Survey Firebreak road. • Survey LZs quarterly as used • Survey camp site quarterly as used • Evaluate need for weed transects along, trails, staging areas, and install if necessary	• 1 • 1-4 • 1-4 • 4
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 9 Oct.2012-Sept.2013	• Continue survey of Firebreak road. Survey yearly • Survey all used LZs quarterly as used • Survey camp site quarterly as used • Install transects • Monitor transects if installed	• 1 • 1-4 • 1-4 • 4 • 4

Incipient Control Areas

No incipient species have been identified in MU. Appendix 3.1 from the MIP will be reviewed to identify possible incipient species.

Weed Control Areas at Lower Makua



Ecosystem Management Weed Control (WCAs)

MIP Goals:

- Within 2m of rare taxa: 0% alien vegetation cover
- Within 50m of rare taxa: 25% or less alien vegetation cover
- Throughout the remainder of the MU: 50% or less alien vegetation cover

Management Objectives:

- Maintain 50% or less alien vegetation cover in the understory across the MU.
- Reach 50% or less alien canopy cover across the MU in the next 5 years.

Management Responses:

- Increase/expand weeding efforts if MU vegetation monitoring (conducted every 3 years) indicates that goals are not being met.

The Lower Makua Dry Forest is unique with impressively tall native canopy and numerous *O. compta.* The native seed bank is still healthy and the area has responded well to weeding. There is continued pressure at the forest edge by encroaching alien grasses. Weed Control Areas are divided by a series of ridges and gulches and need to be GPS to aid weeding efforts. HBT (Weed kill by paintball guns) can extend weed control in difficult to reach areas. Weeds on cliff habitat can be decreased with HBT following trials to be done in MIP YEAR 6.

NRS propose altering the northern border of the MU to follow the forest edge. This change would not involve any major increase or decrease in MU area. This change would facilitate weed control, allow NRS to eliminate several No MU WCAs, and provide better management in Lower Makua. NRS propose the following steps:

1. GPS the Lower Makua trail.
2. GPS forest/native forest line; use aerial data if possible.
3. Adjust MU boundary; include *C. sandwicensis* habitat if appropriate
4. Adjust WCA boundaries to facilitate weed control. Seek to eliminate MMRNoMU-02, 03, 04, 05, 06, 07. Merge these areas with existing, neighboring WCAs.

Avoiding areas that contain solid *P. maximum* and/or UXO is a major safety concern. If an area is deemed unacceptably dangerous, NRS will not conduct weed management in it. This includes areas with certain types of UXO, and areas too thick with grass to see the ground. See the table below for details of proposed WCA changes.

Proposed WCA changes:

WCA to eliminate	Merge with following WCA	Notes
MMRNoMU-02	Ohikilolo-05	This is a small area, running just north of the Lower Makua trail. Propose adding this area to Ohikilolo-05, if native forest present
MMRNoMU-03	Ohikilolo-07	This is a small area, running just north of the Lower Makua trail. Propose adding this area to Ohikilolo-07, if native forest present
MMRNoMU-04	Ohikilolo-12	This is a small area, running just north of the Lower Makua trail. Propose adding this area to Ohikilolo-12, if native forest present
MMRNoMU-05	Ohikilolo-15	This is a large area, north of the Lower Makua Trail. Proposed adding this area to Ohikilolo-15, if native forest present.
MMRNoMU-06	Ohikilolo-16	This is a small area, south of the Lower Makua Trail, but north of the MU boundary. The area has been weeded in the past. Propose adding this are to Ohikilolo-16, as native forest is present.
MMRNoMU-07	leave as is or create new WCA in MU	This large area is located east of the MU. It has several historical *C. sandwicensis* records, and one current territory. The area was weeded in 2007 and 2008; in some areas, the forest was predominantly native and no mature weeds were left following control efforts. Propose either adding this area to the MU and renaming the WCA, or leaving as is.

<u>General WCA Actions</u>:

Year	Action	Quarter
MIP YEAR 6 Oct. 2009-Sept.2010	• GPS Lower Makua trail • GPS native forest line/use aerial data if possible • Adjust MU boundary, and WCA boundaries. • GPS boundaries of all WCAs. Use geographical and vegetation data. Use landmarks to mark in field	• 1-4 • 1-4 • 1-4 • 1-4
MIP YEAR 7 Oct.2010-Sept.2011 Through MIP YEAR 10 Oct.2013-Sept.2014	• Complete WCA/MU boundary changes	• 1-4

WCA Ohikilolo-01 (South Nerang)

Veg Type: Dry Forest

MIP Goal: Less than 25% non-native cover within 50m of IP taxa.

Targets: *Spathodea campanulata, Toona Ciliata*

Rare Taxa: Steep area with *N. angulata* on cliffs. There are a few *N. humile* at the foot of the cliffs. Decreasing weeds in this area could possibly help more native recruitment now that the area is protected by a small fence.

Notes: Fence repairs needed periodically. Weeding around *Micrlepia strigosa* will hopefully reduce alien understory and require less weeding in the future as this area is not visited often.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR10 Oct.2013- Sept.2014	• Conduct understory and canopy weed control across WCA annually. Focus around *N. angulata* and *N. humile* and native species patches. • Target select canopy weeds • Grass control annually as needed, end of summer.	• 3 • 3 • 2,4

WCA Ohikilolo-02 (North Nerang)

Veg Type: Dry Forest

MIP Goal: Less than 25% non-native cover

Targets: *Melinus minutifolia*

Rare Taxa: Steep area with *N. angulata* on cliffs. There are a few *N. angulata* at the foot of the cliffs. Controlling weeds in this area could possibly help more native recruitment now that the area is protected by a small fence.

Notes: Weeding around *M. strigosa* will hopefully reduce alien understory and require less weeding in the future as this area is not visited often. Hiking in water to spray grass is needed. Can also hand pull grass around natives.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013- Sept.2014	• Conduct understory and canopy weed control across WCA annually. Focus around *N. angulata* and native species patches. • Grass control when not as abundant and starting to grow. • Target select canopy weeds.	• 3 • 2,4 • 3

WCA Ohikilolo-05 (Fire break road to Nerang Gulch)

Veg Type: Lowland Mesic Forest

MIP Goal: Less than 50% non-native cover

Targets: *S. campanulata, Montenoa hibiscifolia, Melia azedarach, Syzygium cumini, S. terebinthifolia,*

Rare Taxa: *Bobea sanwichensis* present. Continued non-native canopy removal will possibly help native seedling get reestablished.

Notes: Spray grass on western end of WCA to minimize ingress into the native forest. *M. strigosa* was noted filling in the gaps after weed control. Spray below *Dodonaea viscosa* at the top of ridge to aid native recruitment.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013-Sept.2014	• Control canopy weeds and selected understory weeds across WCA. Focus on native forest patches. Sweep entire WCA once every 3-5 years. • Grass spray • Control *M. hibiscifolia* by rappel or with HBT	• 3 • 2,4 • 2

WCA Ohikilolo-07 (Nerang to Well Ridge)

Veg Type: Dry Forest

MIP Goal: Less than 25% non-native cover

Targets: *Blechnum appendiculatum, M. hibiscifolia, T. ciliata, S. terebinthifolius.*

Rare Taxa: *B. sandwicensis, Nesoluma polynesicum, Bonamia menziesii, Lobelia niihauensis, Melanthera tenuifolia* in the area. *N. angulata* outplanted.

Notes: Continued non-native canopy removal will possibly help native seedling get re-established. Weed in Lower Bowl to create a reintroduction site. Control *Blechnum appendiculatum* in Middle Bowl.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013- Sept.2014	• Control canopy weeds and selected understory weeds across WCA. Focus around *N. angulata* and *N.humile* plants and potential reintro spots.	• 3

WCA Ohikilolo-12

Veg Type: Dry Forest

MIP Goal: Less than 25% non-native cover

Targets: *Grevelia robusta, T. ciliata, S. campanulata, M. azedarach*

Rare Taxa: *B. sandwicensis, N. polynesicum, P. forbesii* in the area.

Notes: Continued non-native canopy removal will help native seedling get reestablished. Weed above *N. polynesicum.*

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10Oct.2013-Sept.2014	• Decrease canopy weeds and selected understory weeds across WCA. Focus on native forest patches. Sweep entire WCA once every 3-5 years starting in MIP year 6.	• 3

WCA Ohikilolo-15 (Dividing ridge to Campsite)

Veg Type: Dry Forest

MIP Goal: Less than 25% non-native cover

Targets: *G. robusta, T. ciliata, S. campanulata, M. azedarach*

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013-Sept.2014	• Decrease canopy weeds and selected understory weeds across WCA. Focus on native forest patches. Sweep entire WCA once every 3-5 years.	• 3

WCA Ohikilolo-16 (Campsite to Archsite)

Veg Type: Dry Forest

MIP Goal: Less than 25% non-native cover

Targets: *G. robusta, T. ciliata, S. campanulata*

Notes: Nice intact native forest.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 9 Oct.2012-Sept.2013	• Decrease canopy weeds and selected understory weeds across WCA. Focus on native forest patches. Sweep entire WCA once every 3-5 years starting in MIP year 6.	• 3

WCA Ohikilolo-18 (CteSqu to FluNeo)

Veg Type: Dry Forest

MIP Goal: Less than 25% non-native cover

Targets: *G. robusta, S. campanulata, T. ciliata* and other non-native canopy.

Rare Taxa: *A. macrococcus, F. neowawraea, C. squamigeria*

Notes: *P. macrocarpa,* Continued non-native canopy removal will possibly help native seedling get reestablished. Weed in the flat area below *Alphitonia ponderosa.*

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013- Sept.2014	• Decrease canopy weeds and selected understory weeds across WCA. Focus on native forest patches. Sweep entire WCA once every 3-5 years starting in MIP year 6.	• 3

1.4.6.5 Rat Control

Threat level: High

Control method: Bait station & snap trap grids

Seasonality: Plants: Year-Round / Elepaio: Breeding Season (January – June)

Number of plant grids: 1 (6 bait stations, 11 snap traps)

Elepaio territory grids: 2 (12 bait stations, 24 snap traps)

Primary Objective:

- To maintain rat populations to a level that facilitates stabilized or increasing rare plant and Elepaio (*Chasiempis sandwichensis ibidis*) populations across the MU by the most effective means possible.

Management Objective:

- Continue to maintain bait station and snap trap grids (localized control) around individual Elepaio breeding pair territories and *Alectryon macrococcus* var. *macrococcus*.

Monitoring Objectives:

- Monitor *A.macrococcus* var. *macrococcus* to determine the occurrence of fruit/plant predation by rats.

Localized Rodent Control:

- Localized rodent control consists of bait station and snap trap grids deployed around a discrete population of *Alectryon macrococcus* var. *macrococcus* and two breeding pairs of Elepaio. Rat control efforts for Elepaio management are focused on individual breeding pair territories only during the breeding season (January through June). If new Elepaio pairs are found in this MU, additional grids will be setup and maintained.

Localized Rodent Control Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 Through Oc.t2012-Sept.2013	• Elepaio territory grids, restock every 2 weeks • *Alemac* grid, restock every 4-6 weeks • Monitor *A. macrococcus* var. *macrococcus* for rat predation	• 1-2 • 1-4 • 1-4

MU Rodent Control:

- At this time no MU wide rodent control is being considered.

1.4.6.6 Fire Control

Threat Level: High

Available Tools: Fuelbreaks, Visual Markers, Helicopter Drops, Wildland Fire Crew, HBT, Aerial spraying, Red-Carded Staff

Management Objective:

- To prevent fire from burning any portion of the MU at any time.

Preventative Actions

There is little infrastructure/construction which would be helpful to reduce fire threat. NRS will focus on maintaining good communication with the Wildland Fire Working Group to facilitate positive on-the-ground fire response in the event of another catastrophic Makua brushfire. NRS will maintain red-carded staff to assist with fire response. Grass control is conducted across various MU where it is observed creeping into the native dominated forest. NRS will consider expanding grass control, common and non-native grass suppression reintroductions in and around the MU, and aerial boom spray operations.

Fire Actions: Non-weed related fire actions include the following

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013- Sept.2014	• Maintain LZs	• 2, 3

1.4.6.7 Slug Control

Species: Deroceras leave, Limax maximus

Threat level: Unknown

Control level: Localized

Seasonality: Wet season

Number of sites: 6 (Neraudia angulata and Nototrichium humile locations)

Primary Objective:

- Reduce slug population to levels where germination and survivorship of rare plant taxa are optimal.

Management Objective:

- Determine by the fall of 2011 whether slugs have an adverse impact on Neraudia angulata and Nototrichium humile survival.

Monitoring Objectives:

- Annual census monitoring of Neraudia angulata and Nototrichium humile seedling recruitment following fruiting events.
- Annual census monitoring of slug densities during wet season.
- Conduct additional monitoring of slug populations as part of the trap out rodent control program.

Effective molluscicides have been identified (Sluggo) and initial control programs are ongoing in Kahanahaiki. Slugs have not, to date, been observed feeding on Neraudia angulata and Nototrichium humile. Both taxa occur in habitat frequented by slugs making contact possible. Slug control is not recommended until impacts to target plants have been determined.

Slug Control Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Monitor slug activity at *Neraudia angulata* and *Nototrichium humile* population(s) via traps baited with beer • Monitor rare plants for signs of slug damage	• 1-4 • 1-4
MIP YEAR 7-10 Oct. 2010-Sept. 2014	• Deploy slug bait around *Neraudia angulata* and *Nototrichium humile* population(s) frequency to be determined during research phase • If slugs found to exceed acceptable levels during monitoring, maintain slug bait at sensitive plant population(s)	• 1-4 • 1-4

1.4.6.8 Ant Control

Species: Anoplolepis gracilipes, Plagiolepis alludi, Technomyrmex albipes

Threat level: Unknown

Control level: Only for new incipient species

Seasonality: Varies by species, but nest expansion observed in late summer, early fall

Number of sites: Unknown

Acceptable Level of Ant Activity: Unknown

Primary Objective: Eradicate incipient ant invasions and control established populations when densities are high enough to threaten rare resources.

Management Objectives:

- If incipient species are found and deemed to be a high threat and/or easily eradicated locally (<0.5 acre infestation) begin control.
- Ant populations will be kept to a determined acceptable level across the MU to facilitate ecosystem health.

Monitoring Objective:

- Sample ants at human entry points a minimum of once a year. Use samples to track changes in existing ant densities and to alert NRS to any new introductions.

Ants have been documented to pose threats to a variety of resources, including native arthropods, plants (via farming of Hemipterian pests), and birds. The distribution and diversity of ant species across the lower Makua MU has not yet been sampled. Collections to date are opportunistic only.

Ant Control Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Conduct surveys for ants across MU with bait cards • Analyze results of surveys, develop management plan	• 1, 2 • 3,4
MIP YEAR 7-10 Oct. 2010-Sept. 2014	• Implement control if deemed necessary • Conduct arthropod survey along transects in anticipation of rat trap out project.	• 1-4 • 1-4

1.4.6.9 Black Twig Borer (BTB) Control

Species: Xylosandrus compactus

Threat level: Unknown

Control level: Localized

Seasonality: Peaks elsewhere have been observed from October-January

Number of sites: 11 (Alectyron macrococcus and Flueggea neowawraea sites)

Acceptable Level of Activity: Unknown

Primary Objective: Reduce BTB populations to a level optimal for Alectyron macrococcus and Flueggea neowraea survival.

Management Objective:

- Continue to develop better methods to control BTB

Monitoring Objectives:

- Annual or every other year census monitoring of Alectyron macrococcus and Flueggea neowawraea populations to determine BTB damage.
- If BTB damage is found to be high, implement control for BTB (traps)

The current control method available for BTB involves the deployment of traps equipped with high-release ethanol bait. It is unclear whether this method reduces BTB damage to target plants (see Research Activities this document).

BTB Control Actions:

Year	Action	Quarter
OIP YEAR 4 Oct.2010-Sept.2011	• Determine whether BTB damage to *Alectyron macrococcus* and *Flueggea neowraea* requires control	• 1-4
OIP YEAR 5-6 Oct.2011- Sept.2013	• Put out BTB high-release ethanol traps (see Research Activities Chapter) if BTB damage to target plants exceeds acceptable levels • Implement control as improved tools become available	• 1-4 • 1-4

1.4.7 Ohikilolo Ecosystem Restoration Management Plan

MIP Year 6-10, Oct. 2009 – Sept. 2014

MU: Ohikilolo (Upper)

1.4.7.1 Overall MIP Management Goals:

- Form a stable, native-dominated matrix of plant communities which support stable populations of IP taxa.
- Control ungulate, rodent, arthropod, slug, snail, fire, and weed threats to support stable populations of IP taxa. Implement control methods by 2013.

1.4.7.2 Background Information

Location: Northern Waianae Mountains

Land Owner: U.S. Army: 575 acres, Board of Water Supply: 3 acres

Land Manager: U.S. Army

Acreage: 578 acres

Elevation Range: 800-3050ft

Description: Ohikilolo MU is located in the Makua Military Reservation (MMR). The area is accessed at the mouth of the valley, or by helicopter to LZs throughout the valley. The terrain of the lower portion of the MU includes deep gulches with steep walls, and broad ridges of mixed mesic forest. The upper portion, above the steep sided walls of Makua Valley, is comprised mostly of steep slope to the crest of the ridge.

The Ohikilolo Management Unit (MU) is one of the larger MIP MUs. Management for this MU has long been divided informally among OANRP staff as the two following areas; Ohikilolo (Upper) and Lower Makua. The division is useful for management purposes because the access issues to each of the areas vary; large cliffs run approximately along the 2000 ft contour between the two. Due to unexploded ordinance issues (UXO), Lower Makua also requires contract support from UXO specialists. The two ‘areas’ have been treated separately in past reports because they are managed by two different field teams. For the purposes of this year end report, they will be reported in Ecosystem Restoration Management Plans as two separate areas within the same MU.

Native Vegetation Types

Wai‘anae Vegetation Types
Mesic mixed forest
Canopy includes: *Acacia koa*, *Metrosideros polymorpha, Nestegis sandwicensis, Diospyros* spp., *Pouteria sandwicensis, Charpentiera* spp., *Pisonia* spp.,*Psychotria* spp., *Antidesma platyphylum*, *Bobea* spp. and *Santalum freycinetianum*. Understory includes: *Alyxia oliviformis, Bidens torta, Coprosma* spp., and *Microlepia strigosa*

Mesic Mixed Forest at Ohikilolo

MIP/OIP Rare Resources

Organism Type	Species	Pop. Ref. Code	Population Unit	Management Designation	Wild/ Reintroduction
Plant	*Alectryon macrococcus* var. *macrococcus*	MMR-C, J, N, O	Makua	MFS	Wild
Plant	*Dubautia herbstobatae*	MMR-A, B, C, D, E, F, G, H, I	Makaha/Ohikilolo, Ohikilolo Makai, Ohikilolo Mauka	GSC, MFS, and MFS	Wild
Plant	*Hedyotis parvula*	MMR-A, B,C	Ohikilolo	MFS	Wild
Plant	*Melanthera tenuifolia*	MMR-B, C, D, E	Ohikilolo	MFS	Wild
Plant	*Plantago princeps* var. *princeps*	MMR-A	Ohikilolo	MFS	Wild
Plant	*Prichardia kaalae*	MMR-A, B, C, D, E, H, I, J, K,L,M	Ohikilolo	MFS	Both
Plant	*Prichardia kaalae*	MMR-G	Ohikilolo East and West Makaleha	Manage Reintroduction for Stability	Reintroduction
Plant	*Sanicula mariversa*	MMR-A	Ohikilolo	MFS	Wild
Plant	*Tetramolopium filiforme*	MMR-A,B, C,D,E,F,H,I, J,K,L,M,N,O,P	Makaha/Ohikilolo Ridge and Ohikilolo	GSC and MFS	Wild
Plant	*Viola chamissoniana* var. *chamissoniana*	MMR-A,B, D,E,F,G,H	Makaha/Ohikilolo Ridge and Ohikilolo	MFS	Wild
Snail	*Achatinella mustelina*	MMR-E,F,G, H,I,J,K,L			

MFS= Manage for Stability
GSC= Genetic Storage Collection

Other Rare Taxa at Ohikilolo MU:

Organism Type	Species	Status
Plant	*Dubautia sherffiana*	Vulnerable
Bird	*Asio flammeus sandwichensis*	State Endangered
Mammal	*Lasiurus cinereus semotus*	Endangered

Rare Resources at Ohikilolo

Prichardia kaalae

Viola chamissoniana var. chamissoniana

Sanicula mariversa

Tetramolopium filiforme

Achatinella mustelina

Hedyotis parvula

Melanthera tenuifolia

Locations of Rare Resources at Ohikilolo

Map removed,
available upon request

MU Threats to MIP/OIP MFS Taxa:

Threat	Taxa Affected	Localized Control Sufficient?	MU scale Control required?	Control Method Available?
Pigs	All	Yes	Yes	MU fenced
Goats	All	Yes	Yes	MU fenced
Rats	All	No	Yes	Bait stations and snap traps
Predatory snails	*Achatinella mustelina*	Unknown	Unknown	No. Limited to hand-removal and physical barriers
Ants	Unknown	Unknown	Unknown	Some available, depends on species
Slugs	None	N/A	N/A	Currently under development but not needed for this MU
Weeds	All	No	Yes	Yes, except for cliff area. Options being developed for cliffs
Fire	All	No	Yes	Yes

Management History

- 1995-1997: ground hunts were started with the use of contract hunters from the U. S. Department of Agriculture Wildlife Services while plans for a fence to enclose MMR were finalized.
- 1996-1997: the first stretch of fencing (2 km) separating MMR from a public hunting area was completed by the National Park Service and ~8 km of fencing was erected around the eastern perimeter of the valley.
- 1999: OANRP constructed the Forest Patch Exclosure, a small enclosure that encompasses about two acres of high-quality intact native forest and *A. mustelina* habitat. Contract and Staff ground hunts and snaring continued from 1997-1999 to control numbers of goats.
- 2000: Perimeter fence was completed that separates the MU from the adjoining Ohikilolo Ranch and Keaau Game Management Area to the south.
- 2001: September, mature *Araucaria columnaris* tree killed, multiple treatments, fell to ground 2004. December 2001, NRS began to control the many seedlings of AraCol in the area. The last portion of the Ohikilolo Ridge Fence was completed separating the valley from the core populations of goats to the south. OANRP staff employed aerial shooting and “Judas goats” as management tools.
- 2002: December, an incipient population of Rubus argutus was discovered near a population of endangered Hedyotis parvula.
- 2003: A breach in the fence occured allowing at least three goats to cross over to Mākua from Makaha Valley. These three goats were subsequently caught and no more sign has been observed in the area of the breach.
- 2004: NRS completed the Prikaa A Fence, a 450m exclosure encompassing a relatively large portion of the remaining wild *P. kaalae*. NRS believes they have eradicated entire MU of feral goats.
- 2006: Four goats breached the fence, all were subsequently caught with snares
- 2007-2008: The Ohikilolo ridge fence is in need of some repair work. In 2007 and 2008, goats continued to breach the fence in small numbers. NRS removed seven via snares and continue to make needed repairs to the fence. NRS will consider replacement of some of the older portions of this fence.
- 2009: Cabin constructed

1.4.7.3 Ungulate Control

Identified Ungulate Threats: Pigs, goats

Threat Level: High

Primary Objective:

- To maintain all areas of the MU as goat-free and the fenced units pig free as well.

Secondary Objective:

- Complete fencing of MU and eradicate animals from within.

Strategy:

- Eradication in the MU and population reduction just outside the MU.

Monitoring Objectives:

- Conduct fence checks and read transects quarterly. GPS and mark the fence at ten meter intervals so that the fence will be one large transect.
- Monitor for pig sign while conducting other management actions in the fence.

Management Responses:

- If any goat activity is detected in the MU, implement snaring program.

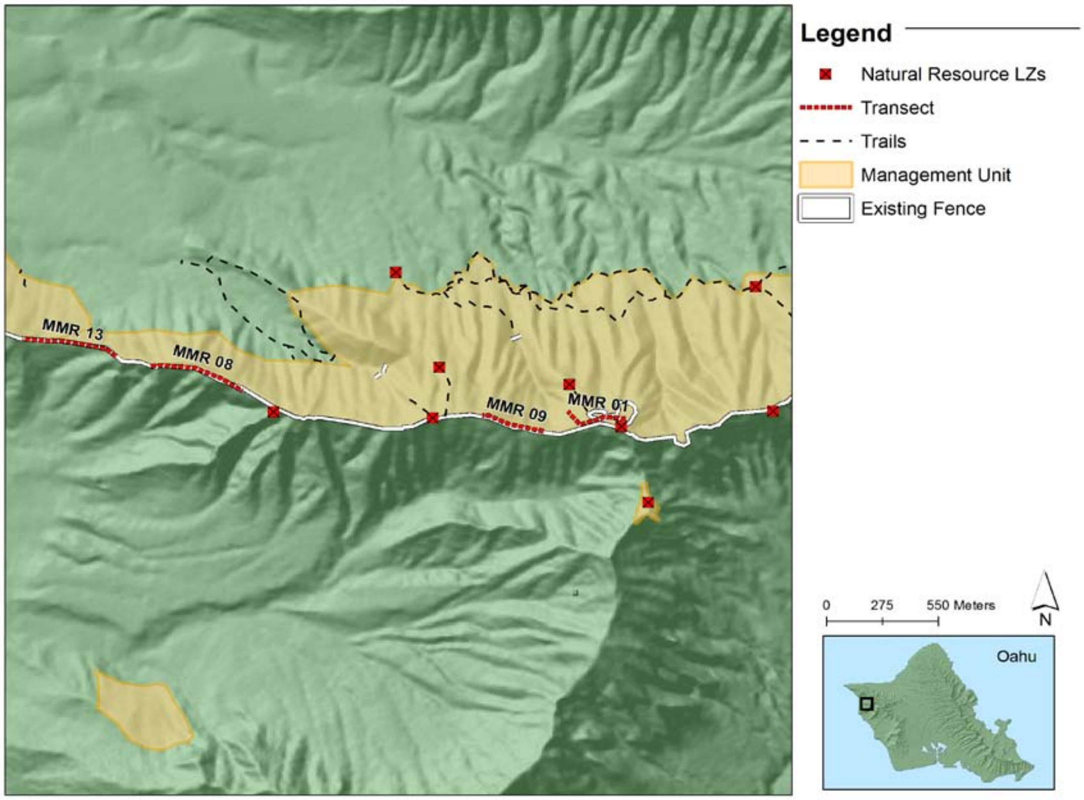
Maintenance Issues

There are seven fences in this MU including the large perimeter fence. The major threats to the fence include erosion, fallen trees and rocks, fire and vandalism; there are no major gulch crossings. No incidences of vandalism have been observed. Special emphasis will be placed on checking the fence after extreme weather events. There is also a significant amount of goat pressure on the fence from the Keaau Game Management Area adjacent to the lower southwestern rim fence. This is one of the oldest sections of fence, and its integrity is especially important given the goat pressure from the neighboring land. Substantial repair and or replacement of this section of fence will be evaluated this year. Monitoring for ungulate sign will occur during the course of other field activities and quarterly along three permanent ungulate transects (MMR01, MMR08, and MMR09).

Ungulate Control Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Check MU and small fences for breaches • Maintain and install snares for goat ingress from Keaau • Evaluate need to repair/replace lower southwest section of fence.	• 1-4 • 1-4 • 1-4
MIP YEAR 7 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013- Sept.2014	• Check MU fence for breaches • Repair perimeter fence • Maintain and install snares for goat ingress	• 1-4 • 1-4 • 1-4

Ungulate Management and Survey Locations at Ohikilolo



1.4.7.4 Weed Control

Weed Control actions are divided into 4 subcategories:

1. Vegetation Monitoring
2. Surveys
3. Incipient Taxa Control (Incipient Control Area - ICAs)
4. Ecosystem Management Weed Control (Weed Control Areas - WCAs)

These designations facilitate different aspects of MIP/OIP requirements.

Vegetation Monitoring

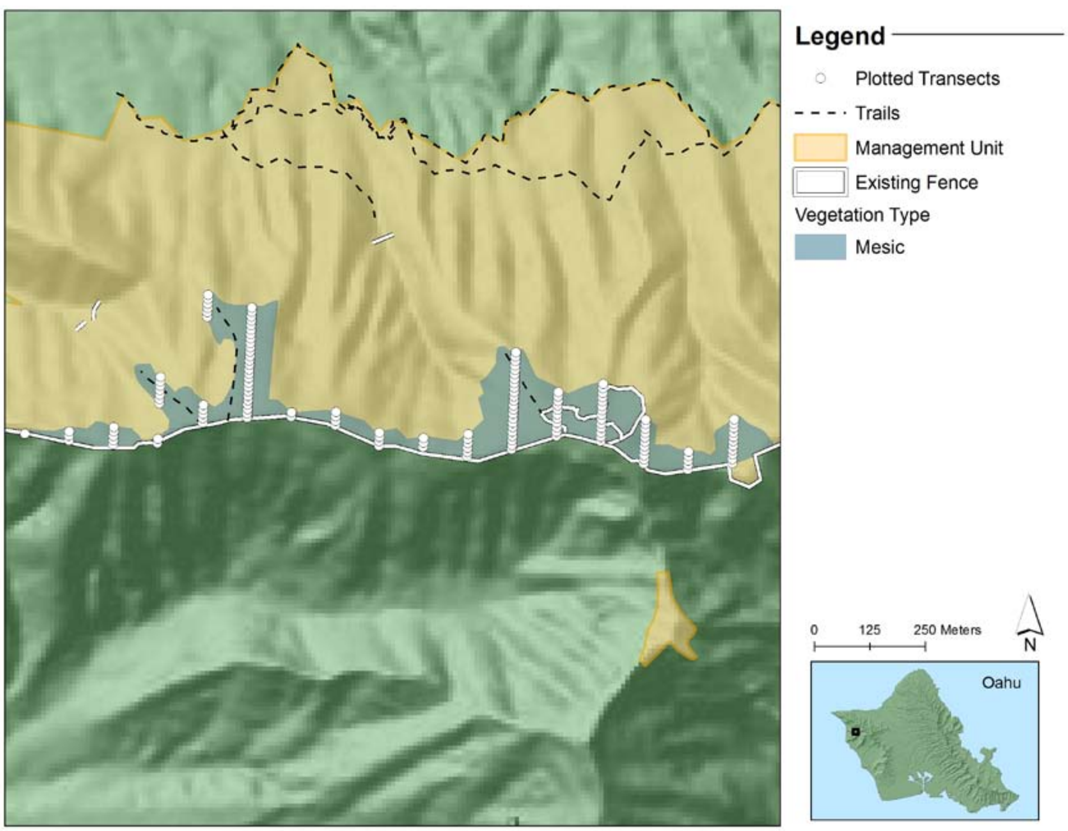
Objectives:

- Begin vegetation monitoring every three years for Ohikilolo (Upper) starting in MIP Year 6.
- Conduct MU vegetation monitoring for the cliff community in MIP Year 6-7.

MU Vegetation Monitoring

Vegetation monitoring will be conducted for both the Ohikilolo (Upper) and Lower Makua sections of this MU (Refer to background information for discussion on reasons for division of the MU). OANRP is currently developing a vegetation monitoring protocol for cliff communities. Once this is set vegetation monitoring will be conducted for this section of the MU.

MU Vegetation Monitoring Transects



Monitoring Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009- Sept.2010	• Conduct vegetation monitoring across the accessible areas of Upper Ohikilolo.	• 1-2
MIP YEAR 6 Oct.2009- Sept.2010	• Conduct vegetation monitoring for the cliff community.	• 1-4
MIP YEAR 9 Oct.2012- Sept.2013	• Conduct vegetation monitoring across the accessible areas of Upper Ohikilolo.	• 1-2
MIP YEAR 9 Oct.2012- Sept.2013	• Conduct vegetation monitoring for the cliff community.	• 1-4

Surveys

Army Training?: No

Other Potential Sources of Introduction: NRS, goats

Survey Locations: Roads, Landing Zones, Fencelines, High Potential Traffic Areas.

Management Objective:

- Prevent the establishment of any new invasive alien plant or animal species through regular surveys along roads, landing zones, camp sites, fencelines, trails, and other high traffic areas.

Monitoring Objectives:

- Survey transects for weeds.
- Quarterly surveys of LZs (if used).
- Note unusual, significant or incipient alien taxa during the course of regular field work.

Surveys are designed to be the first line of defense in locating and identifying potential new weed species. At Ohikilolo, landing zones are checked when used (not exceeding once per quarter), and transects along fencelines are inventoried quarterly. LZs within the MU include the following: Ohikilolo Mid (76), Pisonia (74), Koiahi (72), Red Dirt (70), and Makua Big Ridge (71). LZ surveys for this MU also include the Nike Site LZ. This Nike Site LZ is not in the MU, however it is where gear and personnel are usually flown from when accessing LZs in the Ohikilolo MU. Vehicle and personnel traffic across the Nike Site LZ is present; therefore quarterly surveys for both weeds and invasive insects at this LZ are important. Additionally, the road up to the Nike site is also surveyed once a year to track weed movement along the road, and to detect and prevent any new incipient weeds from being transported by vehicle or helicopter.

Weed Survey Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009- Sept.2010 through MIP YEAR 10 Oct.2013- Sept.2014	• Survey Weed Transects quarterly • Survey LZs once per quarter (no use, no survey)	• 1-4 • 1-4 (if used)

Incipient Control Areas

Management Objective:

- As feasible, eradicate high priority species identified as incipient invasive aliens in the MU by 2014.
- Conduct seed dormancy trials for all high priority incipients by 2014.

Monitoring Objective:

- Visit ICAs at stated re-visitation intervals. Control all mature plants at ICAs and prevent any immature or seedling plants from reaching maturity.

Management Responses:

- If unsuccessful in preventing immature plants from maturing, increase ICA revisitation interval.

ICAs are drawn around each discrete infestation of an incipient invasive weed. ICAs are designed to facilitate data gathering and control. For each ICA, the management goal is to achieve complete eradication of the invasive taxa. Frequent visitation is often necessary to achieve eradication. Seed bed life/dormancy and life cycle information is important in determining when eradication may be reached; much of this information needs to be researched and parameters for determining eradication defined. NRS will compile this information for each ICA species.

Table below summarizes incipient invasive taxa at Ohikilolo (Upper). Appendix 3.1 of the MIP lists significant alien species and ranks their potential invasiveness and distribution. Each species is given a weed management code: 0 = not reported from MU, 1 = incipient (goal: eradicate), 2 = control locally. While the list is by no means exhaustive, it provides a good starting point for discussing which taxa should be targeted for eradication in an MU. NRS supplemented and updated Appendix 3.1 with additional target species identified during field work. In many cases, the weed management code assigned by the MIP has been revised to reflect field observations. ICAs are not designated for every species in the table below; however, occurrences of all species in the table should be noted at Ohikilolo. ICAs have been designated for taxa in cells with bolded and underlined text.

Summary of Potential ICA Target Taxa

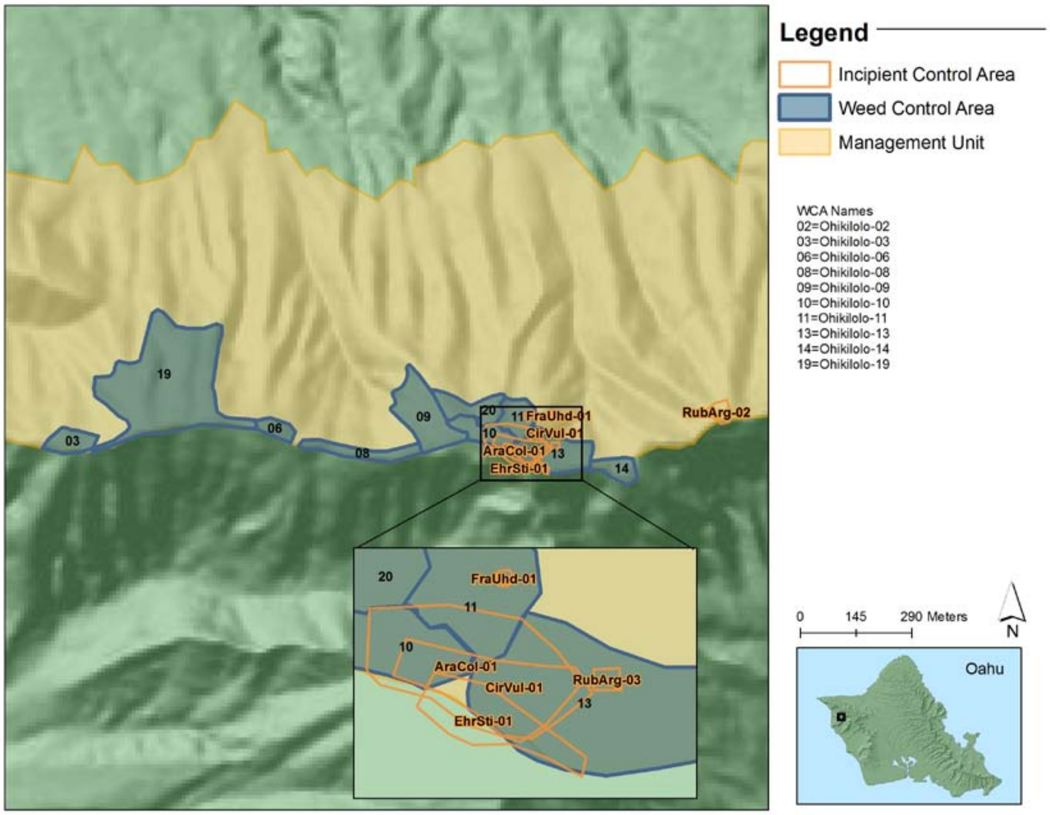
Taxa	MIP weed man. code		Notes	No. of ICAs
	Original	Revised		
Araucaria columnaris	**1**	**1**	**Nearby mature plant is dead. Will continue to sweep ICAs for immature individuals; zero tolerance for individuals in WCAs. Have observed seeds in area blown in from outside the MU. Therefore, reassessment of eradication goals may be needed.**	**1**
Axonopus fissifolius	1	2	Grass is prevalent on Ohikilolo LZ, but does not impact forest patches greatly. Will continue to control locally with other grasses during grass sweeps.	0
Blechnum appendiculatum	2	2	Zero tolerance for isolated patches found during weed sweeps. Will procede with *B. appendiculatum* related monitoring objectives (see WCA section below).	0
Cirsium vulgare	**0**	**1**	**Treated as an ICA since 2002. Will continue to sweep/treat every 6 months.**	**1**

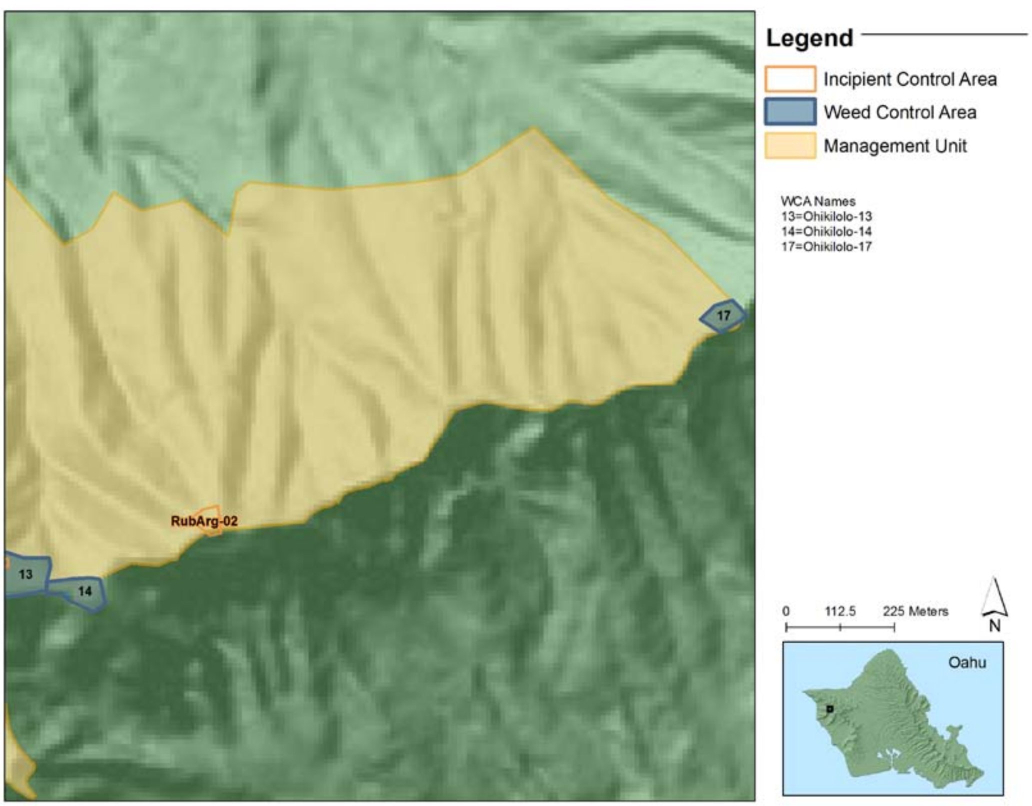
Taxa	MIP weed man. code		Notes	No. of ICAs
	Original	Revised		
Ehrharta stipoides	**0**	**1**	**First recognized in 2005; ongoing treatment since that date. Population is however increasing, likely due to irregularity of treatment and treatment method. Assess efficacy of Roundup 1% over Fusilade II, and treat at regular intervals.**	**1**
Fraxinus uhdei	0	2	Few plants found over the course of weed control history at Ohikilolo. Will continue to treat locally with other weeds during sweeps.	2
Grevillea robusta	2	2	Targeted for control in all WCAs, especially WCAs along main crest line.	0
Morella faya	1	0	Controlled in 1999. Has not been seen since. If found again will create an ICA	0
Passiflora suberosa	0	2	Has been identified in several WCAs. Will be targeted for local control. If population increases dramatically will consider more aggressive control.	0
Rubus argutus	**0**	**1**	**No reproductive individuals seen since 2005. Resprouts often found; need to refine control measures to reduce re-treatment. ICAs checked every 6 months.**	**2**

ICA Actions

Year	Action	Quarter
MIP YEAR 6 Oct.2009- Sept.2010	• Continue control at Aracol ICA • Continue control at Cirvul ICA • Continue control at Rubarg -02 ICA • Continue control at Rubarg -03 ICA • Declare eradication at Rubarg -03 ICA if no individuals found Qtr 2 2010. • Scope for Frauhd in Prikaa-A exclosure. • Declare eradication of Frauhd ICA if no individuals found Qtr 2 2010. • Continue control at Ehrsti ICA	• 1,3 • 1,3 • 1,3 • 2 • 2 • 2 • 2 • 1-4
MIP YEAR 7 Oct.2010- Sept.2011	• Continue control at Aracol ICA • Continue control at Cirvul ICA • Continue control at Rubarg ICA -02 • Continue control at Ehrsti ICA	• 1,3 • 1,3 • 1,3 • 1-4
MIP YEAR 8 Oct.2011- Sept.2012 through MIP YEAR 10 Oct.2013- Sept.2014	• Continue control at Aracol ICA • Reassess Aracol ICA; possibly treat as targets in WCAs and treat only as frequently as visit WCA. • Continue control at Cirvul ICA till reach eradication • Continue control at Rubarg ICA-02 till reach eradication • Determine paramaters for declaring eradication of ICAs at Ohikilolo	• 1 • 1 • 1,3 • 1-4 • 1-4

Incipient and Weed Control Areas at Ohikilolo





Ecosystem Management Weed Control (WCAs)

MIP Goals:

- Within 2m of rare taxa: 0% alien vegetation cover
- Within 50m of rare taxa: 25% or less alien vegetation cover
- Throughout the remainder of the MU: 50% or less alien vegetation cover

Management Objectives:

- Maintain 50% or less alien vegetation cover in the understory across the MU.
- Reach 50% or less alien canopy cover across the MU in the next 5 years.
- In WCAs within 50m of rare taxa, work towards achieving 25% or less alien vegetation cover in understory and canopy.

Management Responses:

- Increase/expand weeding efforts if MU vegetation monitoring (conducted every 3 years) indicates that goals are not being met.

No vegetation monitoring has been done yet at this MU to indicate the percentage of weed cover. Anecdotal observations from field staff indicate a dramatic change in native understory vegetation since the removal of goats in the WCA 10 (Forest Patch Exclosure) and 13 (Mauka Patch). Browse plots conducted in these WCAs also document the vegetation change post goat removal.

Ecosystem level management at this MU has currently been conducted throughout the less steep, forest patches (WCA 10 & 13 in maps above). While these forest patches are a unique vegetation type for such a narrow ridge, very few MIP rare plant species are found in this habitat. Current management helps preserve the forest found on this ridge, however, *Prichardia kaalae* and *Achatinella mustelina* are the only MIP species that benefits from management of this vegetation type. Management for the rare cliff MIP species is currently limited by the steepness of the terrain. Weed control methods on rappel, or through ballistic technology are not well developed.

Weed management in the forest patches has also been historically prioritized because the areas had overall more native cover to begin with. Due to the history of consistent weed control in these forest patches, re-visitation frequencies have lessened, and effort will now be made to expand into new weedier areas.

While weed control directly around rare plant populations on cliffs will be difficult, there are a few management actions that have been identified as benefiting the greater ridge ecosystem, thereby benefiting the rare species as well. One of these actions is thinning *Schinus terebinthifolius*. This weedy tree is well known for growing large and falling over. The ground is severely disturbed, causing greater erosion, and the fallen tree often continues to grow, excluding any understory beneath the mass of tree. *Grevillea robusta,* is similar in that it becomes unstable as it grows taller in shallow soil on cliffs. Thinning these tree species along and just off the crest of ridges can help preserve the integrity of steep habitat onto which rare species can spread. Common native species will be evaluated for their potential to replace these trees in steep areas where erosion is an issue.

General WCA Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013- Sept.2014	• GPS boundaries of all WCAs not yet delineated	• 1

WCA Ohikilolo-03 Prikaa-I

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native cover

Targets: All weeds and grasses with emphasis on slow removal of *S. terebinthifolius* and *G. robusta*. Still need to evaluate control of *B. appendiculatum.*

Notes: *P. kaalae* reintroduced in this area. *A. mustelina* also present. Conduct gradual removal of canopy weeds, focusing on *S. terebinthifolius* and *G. robusta* to foster native recruitment. Minimize changes to light levels, but open canopy around *P. kaalae* reintroductions to give them more sun. Remove understory weeds, focusing on shrubs, herbs, and *C. parasitica.*. Assess common reintroduction options; planting canopy species will complement weedy canopy removal. Determine appropriate species to use such as *Myrsine lessertiana, Pleomele forbsii, Nestigis sandwichensis*.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Assess/control weedy grasses throughout reintroduction area. Control within WCA, but focus on perimeter to prevent ingress. • Conduct annual sweep for understory weeds and gradual removal of canopy weeds.	• 1 • 1
MIP YEAR 7 Oct.2010-Sept.2011 through MIP YEAR 10 Oct.2013-Sept.2014	• Assess/control weedy grasses throughout reintroduction area. Control within WCA, but focus on perimeter to prevent ingress. • Conduct annual sweep for understory weeds and gradual removal of canopy weeds. • Assess common reintroduction options and usefulness; plant if needed	• 1 • 1 • 4

WCA Ohikilolo-06 Sanmar MMR-A

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native cover

Targets: Grasses, *Stachytarpheta dicotoma, Ageratina adenophora*, *S. terebinthifolius* and *G. robusta*.

Notes: Weed control is focused around *S. mariversa* in this WCA. Weed control also benefits *H. parvula, V. chamissoniana* subsp. *chamissoniana, D. herbstobatae* found on cliffs nearby and below the WCA. The WCA is just off the main ridge crest of Ohikilolo and control is therefore limited by steep terrain. Only a limited amount of area in *S. mariversa* habitat is accessible for weed control without rappel gear, and the WCA size reflects this. Weed control will be conducted every two years, to remove weedy trees gradually, focusing on *S. terebinthifolius,* and *G. robusta*. Weedy grass/shrub control around *S. mariversa* will be evaluated annually. Conduct all weed control in spring, when *S. mariversa* is visible to minimize trampling potential. Sweep through population, but also focus on edges, especially at bottom, to expand habitat, and along fence to prevent ingress.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013- Sept.2014	• Evaluate need for weedy grass/shrub control; control if needed • Control weedy trees gradually	• 2

WCA Ohikilolo-08 Ridge Crest and Slope

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 50% non-native cover

Targets: *S. terebinthifolius* and *G. robusta.*

Notes: Weed control is conducted in this WCA in order to protect habitat for a variety of MIP species on the upper slopes at the top of the cliffs, just below the ridge crest. Weedy trees are targeted for gradual removal to prevent further erosion of the ridge, and allow for native canopy regeneration. This WCA is also very steep, and the majority of the weed control will be conducted on the ridge crest. A complete sweep of the entire WCA will be expected within a 3 year timeline. A re-sweep will be conducted 3 years later.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 9 Oct.2012-Sept.2013	• Remove all *G. robusta* and some *S. terebinthifolius* to maintain some canopy. Focus along ridge crest and down side ridges where feasible. Work to sweep entire WCA in 3 years.	• 1
MIP YEAR 9 Oct.2013-Sept.2014	• No control necessary if entire WCA treated in years 6-8.	• 1

WCA Ohikilolo-09 Makai Gulch

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native cover

Targets: All *Grevillea robusta* will be targeted in this WCA, and *S. terebintifoilus* will be gradually removed. There is a large suite of understory weeds, and all will be targeted.

Notes: As per the MIP year 6, this WCA has been expanded to include more forest patch, and will then include several *A. macrocarpus var. macrocarpus* individuals. Due to a decline in need for weed control in neighboring forested WCAs, weed control can be expanded to this weedier, yet similar forest patch. Evaluation of the WCA and the exact areas where weed control is worthwhile still needs to be conducted. Until this process is finished, weed control of canopy and understory weeds will continue in the more native areas twice a year. Weedy trees will be removed gradually to minimize light changes. Grass spray will follow annually as needed.

Actions:

Year	**Action**	**Quarter**
MIP YEAR 6 Oct.2009-Sept.2010	• Continue to conduct current weed sweep (from upper to lower regions) in areas with high density of native cover. • Evaluate WCA shape and needs by conducting ground surveys.	• 1,3 • 3
MIP YEAR 7 Oct.2010-Sept.2011 through MIP YEAR 9 Oct.2013-Sept.2014	• Continue to conduct current weed sweep (from upper to lower regions) in areas with high density of native cover.	• 1,3

WCA Ohikilolo-10 Forest Patch Exclosure

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native cover

Targets: All weeds are targeted for removal. Understory weeds include: *S. dichotma, L. camara, R. rosifolius, A, adenophora* and a variety of grasses. Very few non-native canopy trees remain in this WCA, and all are targeted for removal.

Priority: High

Notes: Due to the high density of native cover, this WCA has one of the longest histories of weed control at Ohikilolo. It was also the area targeted first for fencing before all the goats were removed from Makua Valley. This area was highly impacted by goats browsing on the native vegetation; fencing and goat removal has contributed greatly to native regeneration. In this WCA, there is a large *P. kaalae* reintroduction as well as many *A. mustelina*. The long term weed control along with fencing has decreased many weedier pockets found throughout this WCA exclosure. Common native reintroductions of *A. koa, Myrsine lessertiana,* and *Microlepia strigosa* have also been used to fill in weedy areas. Weed control currently consists of weed sweeps through the entire WCA for all weeds every 2-3 years. A few weedier areas and the fence zone may be targeted more frequently. Grasses are also targeted throughout the entire WCA annually as needed.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013-Sept.2014	• Control grass throughout forest exclosure annually • Control weeds in weedy zones (below LZ, sanmar reintro, fence) annually. • Conduct weed sweeps across entire forest patch exclosure every 2-3 years • Monitor common reintroductions planted quarter 1 2008 annually • Monitor common reintros planted 2002 (koa) and 2003 (myrles) every 2 years.	• 3 • 3 • 3 • 3

WCA Ohikilolo-11 Prikaa A Patch

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% native cover.

Targets: Understory: *A. adenophora*, *L. camara, Stachytarpheta dicotoma*

Overstory: *S. terebinthifolius*

Notes: This WCA surrounds the largest patch of wild *P. kaalae*. This WCA has not had a significant amount of weed control as it is steep and as *P. kaalae* seedlings began to emerge throughout the patch, the threat of trampling was a concern. The patch is now full of hundreds of immature *P. kaalae* and trails been made through the patch to reduce trampling. Along with the *P. kaalae*, the canopy in the WCA is dominated by *Meterosideros tremuloides* and *S. terebinthifolius*. *S. terebinthifolius* has been thinned around the *P. kaalae* and continual slow removal of *S. terebinthifolius* is planned throughout the WCA.

Grass sprays will also be important follow-up to *S. terebintifolius* removal. There is a significant amount of *Melinus minutiflorus* throughout the WCA. There has been concern that spraying grasses in the WCA with the grass specific herbicide, Fusilade used with surfactant, would affect *P. kaalae* seedlings, also monocots. This year spray trials were conducted on freshly germinated seedlings, and about 2 year old greenhouse *P. kaalae* plants. No detrimental effect to these plants was noted. This year grass sprays will also be carefully conducted in a field trial to look for effects of Fusilade used with surfactant on *P. kaalae*. Assuming no affect through field trial observations, grass sprays will be conducted annually, or as needed.

Common native reintroductions may also be important within this WCA as there is a significant amount of eroded, bare dirt area on the edge of the *P. kaalae* patch. *M. minutiflorus* covers a good portion of this erosion scar, and will not be removed until something else can be planted to stabilize the soil there. *B. appendiculatum* also accounts for a significant amount of ground cover within the WCA. *P. kaalae* consistently germinate through this mat of ferns, and therefore aggressive removal of the fern in this sensitive WCA will not be initiated until much more is understood about potential *B. appendiculatum* effects and control.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Conduct canopy/understory weed control annually • Evaluate potential for use of common natives; select species to use • Continue evaluation of use of Fusilade with surfactant; if not found harmful to *P. kaalae,* spray grasses annually, or as needed.	• 2 • 2 • 2
MIP YEAR 7 Oct.2010-Sept.2011 through MIP YEAR 10 Oct.2013-Sept.2014	• Conduct canopy/understory weed control annually • Plant common natives if deemed useful • Spray grasses annually, or as needed	• 2 • 2 • 2

WCA Ohikilolo-13 Mauka Patch/Lancam Gulch

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native cover

Targets: Understory weeds

Notes: Another *P. kaalae* reintroduction is established in this WCA, and *A. mustelina* are found here as well. This WCA also has a long history of weed control. This WCA was also greatly impacted by goat browse. Since the removal of goats, there has been a significant increase in native fern and *F. arborea* cover. The areas with dense native cover are still patchy, but ever-increasing. Weed sweeps are conducted through the entire WCA, but more frequent efforts target weedier patches between native areas, or on the edges of native areas to allow for expansion.

A significant amount of grass is present throughout this WCA, especially in the more open areas where canopy is lacking. Biannual grass sprays may be initially required to set grass back, and later reduced to annually. Common native shrubs and understory are ideal for the weedier areas of this WCA where there is eroded bare ground, or areas densely covered in grass. Common reintroductions already established will be monitored every 1-2 years depending on how long they have already been planted. A seed sow trial of *A. koa* was initiated quarter 3, 2009, and will be monitored quarterly for one year.

The incipient weed *Ehrharta stipoides* was found several years ago in this WCA and is targeted for complete eradication as an ICA. This grass is more or less isolated in several areas, and spread of any kind will not be tolerated. Eradication of this weed makes it a high priority ICA.

This WCA is where *B. appendiculatum* control trials are being monitored and considered for use in selected areas throughout the MU. There are slopes in this MU where the understory is completely dominated by the weedy fern. Most control measures are rather aggressive at this point, and these methods will have to be weighed against the benefit for native cover. Investigations into this issue will continue to take place in this MU in areas where no rare species will be affected. Small discrete patches (less than square meter) can however be controlled with the typical

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013-Sept.2014	• GPS lower portion of WCA to ensure includes all suitable P. kaalae habitat for reintroduction and prior weed control. • Conduct weed sweeps across WCA twice a year. Remove canopy gradually, focus on *P. macrococcus* and *M. lessertiana* gulches. Use more aggressive control in Lancam Gulch and along cabin slope. • Spray grass across WCA twice a year • Monitor common reintros planted quarter 1 2008 annually (*M. strigosa*) • Monitor common reintros planted 2004 and 2005 every 2 years (*A. koa*) • Install/monitor *A. koa* seed sow • Evaluate need for future *B. appendiculatum* removal trials as well as need to pursue control measure. • Monitor *M. strigosa* reintroductions planted quarter 1 2008 annually. • Monitor *A. koa* reintroductions planted 2004 and 2005 every 2 years	• 1 • 2,4 • 2,4 • 3 • 3 • 3 • 2 • 3 • 3

WCA Ohikilolo-14

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% native cover

Targets: *M. minutiflorus*

Notes: This WCA focuses around management for *T. filiforme.* The WCA has a steep, almost pyramid shape, throughout which a population of *T. filiforme* is found. The weed control goal for this WCA is to keep grasses such as *M. minutiflora* from occupying this steep, rocky niche habitat. Grass control has only been conducted at this WCA once so far. The steep, fragile terrain, and the frequent high winds make grass control very difficult within this WCA. Grass control will continue with a grass specific herbicide with handsprayers, or small backpack sprayer, and only on days when winds are low. Due to the steepness of this WCA, management other than grass spray is very limited.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013- Sept.2014	• Spray grass throughout WCA	• 1

WCA Ohikilolo-17 Ctenitis Ridge

Veg Type: Mesic Mixed Ridge

MIP Goal: Less than 25% non-native cover

Targets: Gradually remove *S. terebinthifolius.* Target all understory species focusing on patches of A. adenophora.

Notes: This WCA is the only WCA east of Ohikilolo-14. It is a smaller WCA, and management has been conducted in this area because a reintroduction of *P. kaalae* has been established and fenced. The area has patches of *M. tremuloides* canopy, however does not have a continuous dense native cover. The area has benefited from the gradual weed control of *S. terebinthifolius* and removal of dense thickets of *A. adenophora*. *M. strigosa* has also been planted with hopes of establishing a denser native ground cover. Common reintroductions will continue, and will be monitored annually until well established. *B. appendiculatum* is a problem in this WCA as with many others in this MU. No treatment of this species will take place until control methods are more thoroughly developed. Grass spray has not yet been conducted in this WCA, however *M. minutiflora* patches have been noted and a spray regime will be implemented if determined necessary.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013-Sept.2014	• Conduct weed sweeps targeting area around *P. kaalae* biannually • Monitor/plant common natives if deemed useful • Spray grasses if needed	• 2,4 • 4 • 2

WCA Ohikilolo-19 Pisonia

Veg Type: Mesic Mixed Ridge

MIP Goal: Less than 50% non-native canopy

Targets: *S. terebinthifolius, G. robusta*

Notes: The shape for this WCA includes area that is steep and inaccessible on foot. Weed control will not be conducted in these areas. The WCA includes 3 wild *P. kaalae* individuals, as well as *A. mustelina*. It is also noted for the large *Pisonia brunoniana* patch, uncommon on the upper slopes of Ohikilolo Ridge. Weed control is focused on *S. terebinthifolius,* and *G. robusta* throughout the WCA. *G. robusta* will be targeted for complete removal where reachable. *S. terebinthifolius* will be gradually removed throughout the WCA. Understory weed composition will be evaluated and will be targeted in specific areas as necessary. A sweep through the entire WCA will be conducted from 2010 through 2011, after which follow-up control will be conducted every 3 years.

Depending on results from grass spray trials mentioned in the WCA-11 discussion, grasses may be sprayed around the *P. kaalae* individuals as there is a significant amount of *M. minutiflora* around these plants.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Sweep entire WCA • Spot treat grasses around *P. kaalae* • Re-sweep entire WCA every 3 years.	• 1-4 • 1-4 • 1

1.4.7.5 Rodent Control

Threat level: High

Current control method: Bait station & snap trap grids (localized control)

Seasonality: Year-Round

Number of control grids: 4 (39 bait stations, 49snap traps)

Primary Objective:

- To maintain rat/mouse populations to a level that facilitates stabilized or increasing plant and snail populations across the MU by the most effective means possible.

Management Objective:

- Continue to maintain bait stations and trap boxes (localized control) around *Achatinella mustelina* and rare plant populations.
- Less than 10% activity levels in rat tracking tunnels.
- Reconfigure bait station and snap trap grid in main *Pritchardia kaalae* patch (MMR-A).
- Evaluate current localized rodent control to determine if changes are needed.
- Determine feasibility of hand-broadcast of rodenticide for MU wide protection (MU control).

Monitoring Objectives:

- Monitor tracking tunnels to determine rodent activity within the bait station and trap grids once a quarter.
- Monitor ground shell plots for predation of *A. mustelina* by rats.
- Monitor *P. kaalae* and *Pteralyxia macrocarpa* as focal species to determine the occurrence of fruit predation by rats.

Monitoring Issues:

- An acceptable level of rat activity, which promotes stable or increasing *A. mustelina, P. kaalae*, and *P. macrocarpa* populations, has not been clearly identified. It could be very low, less than 2%, or very high, 40%; in New Zealand, studies have shown that rat activity levels of 10% are low enough to maintain certain rare bird populations. A 10% activity level may also be the most achievable level using a large scale trapping grid. In order to determine this acceptable level, more intensive monitoring of rare resources is required.

Localized Rodent Control:

- Bait station and snap trap grids are deployed around *A. mustelina, P. kaalae*, and *P. macrocarpa* populations and are restocked twice a quarter. Grids are centered around and extend slightly beyond the boundaries of the populations being protected. Monitoring of rat activity via tracking tunnels will be vital in determining whether control is having the desired effect, as will intensive monitoring of the rare snail and plant populations.

Localized Rodent Control Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept. 2010	• MMR-A Prikaa grid restock, twice a quarter • MMR-D Prikaa grid restock, twice a quarter • Forest Patch grid restock, twice a quarter • Ptemac Gulch grid restock, twice a quarter • Monitoring tracking tunnels 1x a quarter • Monitor Prikaa and Ptemac for rat predation • Reconfigure MMR-A w/ stations and trap boxes • Monitor ground shell plots 1x a quarter • Evaluate rodent control grids & modify if necessary	• 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 2 • 1-4 • 4
MIP YEAR 7 Oct.2010-Sept.2011 Through MIP YEAR 9 Oct. 2012-Sept.2013	• MMR-A Prikaa grid restock, twice a quarter • MMR-D Prikaa grid restock, twice a quarter • Forest Patch grid restock, twice a quarter • Ptemac Gulch grid restock, twice a quarter • Monitoring tracking tunnels 1x a quarter • Monitor ground shell plots 1x a quarter • Monitor Prikaa and Ptemac for rat predation • Evaluate rodent control grids & modify if necessary	• 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 4

MU Rodent Control:

If the current method of control proves to be insufficient for the protection of *A. mustelina*, the MU is a good candidate for broader scale control (hand broadcast of rodenticide) because of the large population of *A. mustelina* and unique stands of *P. kaalae* and *P. macrocarpa*. OANRP have observed a positive response from the *P. kaalae* trees following years of rodent control. Previously, few fruit survived and little if any recruitment occurred. In the years following rodent control, large dense seedling beds have developed underneath mature trees.

MU Rodent Control Actions:

Year	Action	Quarter
MIP YEAR 7 Oct. 2010-Sept. 2011	• Evaluate feasibility of hand broadcast of rodenticide as a control method for rodents over entire MU	1-4
MIP YEAR 8 Oct. 2011-Sept 2012	• Establish protocol for hand broadcast of rodenticide for entire MU if deemed appropriate. • Establish monitoring protocols	1-4
MIP YEAR 9 Oct. 2012-Sept. 2013	• Institute program of hand broadcast of rodenticide over entire MU. • Institute monitoring program	1-4

1.4.7.6 Predatory Snail Control

Species: *Euglandina rosea* (rosy wolf snail), *Oxychilus alliarus* (garlic snail)

Threat level: Low (*E. rosea* not found in MU, *O. alliarus* not confirmed)

Control level: Localized

Seasonality: Unknown

Number of sites: *Achatinella mustelina* sites

Acceptable Level of Activity: Unknown

Primary Objective: Reduce predatory snail populations to a level optimal for *Achatinella mustelina* survival.

Management Objective:

- Continue to develop better methods to control predatory snails
- Keep sensitive snail populations safe from predatory snails via currently accepted methods (such as hand removal of alien snails, construction of barriers which prevent incursion from alien snails)

Monitoring Objectives:

- Annual or every other year census monitoring of *A. mustelina* populations to determine population trend.
- Annual searches for predatory snails to confirm their absence in proximity to *A. mustelina.*

No baits have been developed for the control of predatory snails. Little is known regarding their distribution and prey preference. Control is limited to hand removal. Visual searches are time-consuming, difficult, and not feasible over large areas and in steep terrain. It is also unknown whether predatory snail populations are reduced by hand removal. Although systematic searches for *E. rosea* have not been undertaken, anecdotal observations suggests they are absent from this MU. No searches for *O. alliarus* have been completed.

Predatory Snail Control Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009- Sept.2010	• Determine if any *E. rosea* or *O. alliarus* snails are present in proximity to *A. mustelina* populations	• 1-4
OIP YEAR 4-6 Oct.2010- Sept.2013	• Implement control as improved tools become available	• 1-4

1.4.7.7 Ant Control

Species: *Pheidole megacephala, Ochotellus glaber*

Threat level: Low

Control level: Only for new incipient species

Seasonality: Varies by species, but nest expansion observed in late summer, early fall

Number of sites: 3 (Cabin, Landing Zone, Trails)

Acceptable Level of Ant Activity: Acceptable at present densities

Primary Objective: Eradicate incipient ant invasions and control established populations when densities are high enough to threaten rare resources.

Management Objective:

- If incipient species are found and deemed to be a high threat and/or easily eradicated locally (<0.5 acre infestation) begin control using a bait containing Hydramethylnon (Amdro, Maxforce or Seige).

Monitoring Objective:

- Continue to sample ants at human entry points (landing zone, fence line) a minimum of once a year. Use samples to track changes in existing ant densities and to alert NRS to any new introductions.

Ants have been documented to pose threats to a variety of resources, including native arthropods, plants (via farming of Hemipterian pests), and birds. The distribution and diversity of ant species in upland areas on Oahu, Ohikilolo, has only begun to be studied and changes over time. Impacts to the rare species present in Ohikilolo remain unknown, but it is likely they are having some type of effect on the ecosystem at large. NRS have already conducted some surveys across Ohikilolo to determine which ant species are present and where they are located. Surveys were conducted using a standardized sampling method (see Appendix Invasive Ant Monitoring Protocol, this document). Only half of six surveys attempted have yielded ants, suggesting ants are at low densities in this area. Species present are widely established and control is not recommended at this time.

Ant Control Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009-Sept.2010	• Conduct surveys for ants across MU with bait cards as needed • Analyze results of surveys, develop management recommendations	• 1-4
OIP YEAR 4-6 Oct.2010- Sept.2013	• Implement control if deemed necessary	• 1-4

1.4.7.8 Fire Control

There is no recent history of fires burning close to this section, Ohikilolo (Upper), or the MU. The area is somewhat protected by barren cliffs, however it is still assumed that fire is a threat to this area of the MU. The best way to address fire threats will be through early response and assistance from Wildland Fire crews to any fires in Makua Valley. Additionally, NRS will use resources to assist in controlling fires in Makaha and Keaau Valleys on the south side of the MU.

1.4.8 Palikea Ecosystem Restoration Management Plan

MIP Year 6-10, Oct. 2009 – Sept. 2014

MU: Palikea SubUnit 1 and Palikea NoMU

1.4.8.1 Overall MIP Management Goals:

- Form a stable, native-dominated matrix of plant communities which support stable populations of IP taxa.
- Control ungulate, rodent, arthropod, slug, snail, fire, and weed threats to support stable populations of IP taxa. Implement control methods by 2013.

1.4.8.2 Background Information

Location: Southern Waianae Mountains

Land Owner: Trust for Public Land/State of Hawaii

Land Manager: State of Hawaii/OANRP

Acreage: 24.6 acres

Elevation Range: 1900ft. -3100 ft.

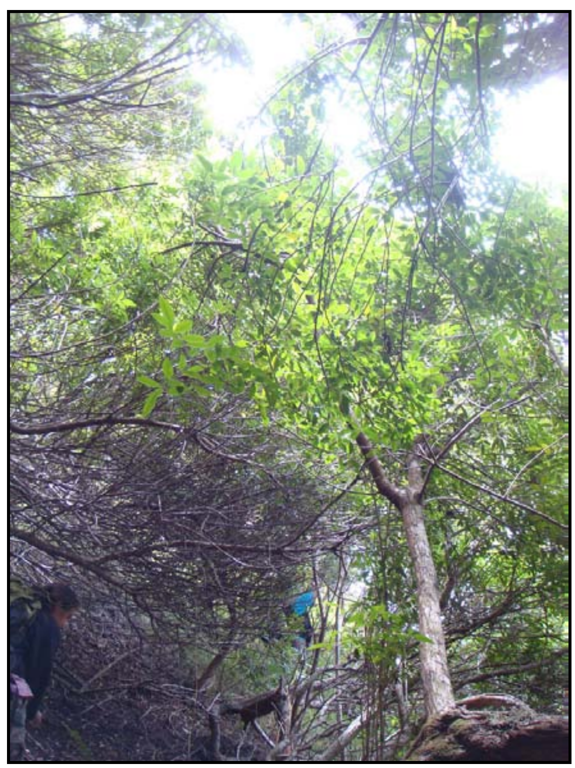
Description: Palikea MU is located at the southern end of the former Honouliuli Preserve. The managed area includes the ridge and windward slopes of part of Palawai gulch. The eastern edge of the MU ends abruptly in cliffs. The MU includes small ridges, gulch bowls, and one flat plain.

Native Vegetation Types

Waianae Vegetation Types
Mesic mixed forest
Canopy includes: *Acacia koa*, *Metrosideros polymorpha, Nestegis sandwicensis, Diospyros* spp., *Pouteria sandwicensis, Charpentiera* spp., *Pisonia* spp.,*Psychotria* spp., *Antidesma platyphylum*, *Bobea* spp. and *Santalum freycinetianum*. Understory includes: *Alyxia oliviformis, Bidens torta, Coprosma* spp., and *Microlepia strigosa*
Mesic-Wet forest
Canopy includes: *Metrosideros polymorpha polymorpha*. Typical to see *Cheirodendron trigynum* ,*Cibotium* spp., *Melicope* spp., *Antidesma platyphyllum*, and *Ilex anomala*. Understory includes: *Cibotium chamissoi*, *Broussasia arguta*, *Dianella sandwicensis*, *Dubautia* spp. Less common subcanopy components of this zone include *Clermontia* and *Cyanea* spp.
NOTE: For MU monitoring purposes vegetation type is mapped based on theoretical pre-disturbance vegetation. Alien species are not noted.
NOTE: For MU monitoring purposes, vegetation types were subdivided using topography (gulch, mid-slope, ridge). Topography influences vegetation composition to a degree. Combining vegetation type and topography is useful for guiding management in certain instances.

Primary Vegetation Types at Palikea

Mesic-Wet Summit Crest



Mesic Gulch

Uluhe dominated flats – not a separate vegetation type, but an anomalous feature in Palikea

Views of Palikea

View to the north, from a gulch towards the ridge.

View to the south, from the ridge towards Mauna Kapu.

MIP/OIP Rare Resources

Organism Type	Species	Pop. Ref. Code	Population Unit	Management Designation	Wild/ Reintroduction
Plant	*Cyanea grimesiana* subsp. *obatae*	PAK-A, B	Palikea	MFS	Wild and Reintroduction
Plant	*Cyanea superba* subsp. *superba*	N/A	N/A	None	Reintroduction
Snail	*Achatinella mustelina*	PAK-A, B,C, E, F, G, H, I, J, K, L, M	ESU-F	MFS	N/A
Snail	*Achatinella mustelina*	MAU-A	ESU-F	MFS	N/A
Bird	*Chasiempis sandwichensis ibidis*	N/A	N/A	None	N/A

MFS= Manage for Stability *= Populaiton Dead
GSC= Genetic Storage Collection †=Reintroduction not yet done

Other Rare Taxa at Palikea MU

Organism Type	Species	Status
Plant	*Cyanea calycina*	Endangered
Plant	*Exocarpos gaudichaudii*	Species of Concern
Plant	*Lobelia yuccoides*	Species of Concern
Plant	*Nothocestrum longifolium*	Species of Concern
Plant	*Phyllostegia parviflora lydgatei* (reintroduction)	Endangered
Plant	*Platydesma cornuta decurrens*	Species of Concern
Plant	*Solanum sandwicense* (reintroduction)	Endangered
Plant	*Urera kaalae* (reintroduction)	Endangered
Snail	*Achatinella concavospira*	Endangered
Snail	*Auriculella ambusta*	Species of Concern
Snail	*Laminella sanguinea*	Species of Concern
Fly	*Drosphila aglaia*	Endangered
Fly	*Drosophila hemipeza*	Endangered
Fly	*Drosophila montgomeryi*	Endangered
Bird	*Asio flammeus sandwichensis*	State Endangered
Bird	*Vestiaria coccinea*	State Endangered

Rare Resources at Palikea

A. mustelina on left, *C. grimesiana obatae* reintroduction on right

Locations of Rare Resources at Palikea

Map removed,
available upon request

MU Threats to MIP/OIP MFS Taxa

Threat	Taxa Affected	Localized Control Sufficient?	MU scale Control required?	Control Method Notes
Pigs	All	No	Yes	MU fenced
Rats	All	No	Yes	MU-wide trap out grid to be installed in 2010
Predatory snails	*Achatinella mustelina*	Unknown	Unknown	No. Limited to hand-removal and physical barriers
Slugs	*Cyanea grimesiana* subsp. *obatae*, *C. superba* subsp. *superba*	Yes	No	Currently being developed
Ants	Potential threat to *Drosphila aglaia, D. hemipeza, D. montgomeryi*	Unknown	Unknown	Some available, depends on species
Jackson's Chameleon	*Achatinella mustelina*	Unknown	No	Hand capture
Weeds	All	Yes	Yes	Yes
Fire	All	No	Yes	Yes

Management History

The Nature Conservancy of Hawaii (TNC) pioneered management at the Palikea MU during its tenure as steward of the Honouliuli Preserve. Naturally, TNC did not focus only on MIP taxa (as does OANRP), but rather managed all taxa found within Honouliuli. Thus, several plant populations listed in the two Rare Resources tables above include reintroductions which do not fall under the auspices of the MIP; these reintroductions are of *C. superba*, *U. kaalae*, *S. sandwicense*, and *P. parviflora*. TNC also conducted more widescale elepaio management in Palikea than OANRP currently does. When the transfer of Honouliuli to the State becomes complete, the State may continue these actions.

- 1993: TNC begins management at Honouliuli Preserve. Work at Palikea begins shortly thereafter. Surveys detect numerous rare taxa.
- 1997: *Drosophila* species found.
- 1999: Small fence constructed around wild *C. grimesiana* population, PAK-A.
- 2000-2006: Restoration work concentrated in small TNC fence. Work includes weed removal, catchment construction, and re-vegetation with common and rare species.
- 2003-04: First reintroductions of *C. grimesiana* planted into the small TNC fence.
- 2004: OANRP begins consistent rodent control efforts at Palikea. Rat control areas expand over time as more snail populations are found.
- 2008: 25 acre MU fence completed. The MU fence was closed in December 2007, but strategic sections at the summit portion of the fence were found to be insecure and additional fencing was completed in August 2008. Fence skirting in vulnerable (loose) soil was completed in September 2008. NRS were able to eradicate pigs from the fence prior to the completion of fence improvements; all ungulates were removed by May 2008.
- 2000-2009: Snaring outside fence reduces pig population by unknown level.
- 2009: Snaring program re-started outside the fence to protect newly discovered snail populations outside the fence area and unfenced MIP plant taxa.
- 2007: TNC ends most field work in Honouliuli. Some baiting continues at Palikea.
- 2009: TNC ends all management of Honouliuli. Honouliuli sold to The Trust for Public Land, who will turn the parcel over to the State of Hawaii in the next year or two.

Viola chamissoniana var *tracheliifolia*

1.4.8.3 Ungulate Control

Identified Ungulate Threats: Pigs

Threat Level: High

Primary Objective:

- Maintain the entire MU as ungulate-free.

Secondary Objective:

- Reduce current pig activity just outside of the fence to low and medium levels. Low level defined as <5% and Medium as <10% presence of pig sign averaged across ungulate monitoring transects.
- Protect the habitat of two snail populations located outside of the fence. Use snares.

Strategy:

- Maintain the MU fence as pig free by maintaining the fence and using snares outside the fence to reduce impacts and pressure. Use approximately 75 snares around the camp LZ, the bottom (east) fenceline, and around the two snail populations outside of the fence.

Monitoring Objectives:

- Conduct fence checks and read transects quarterly. GPS and mark the fence at ten meter intervals so that the fence will be one large transect.
- Monitor for pig sign while conducting other management actions in the fence.

Management Responses:

- If any pig activity is detected within the fenced unit, implement hunting and/or snaring program.
- If more than ten percent activity is detected along transects outside fence, increase snaring effort.

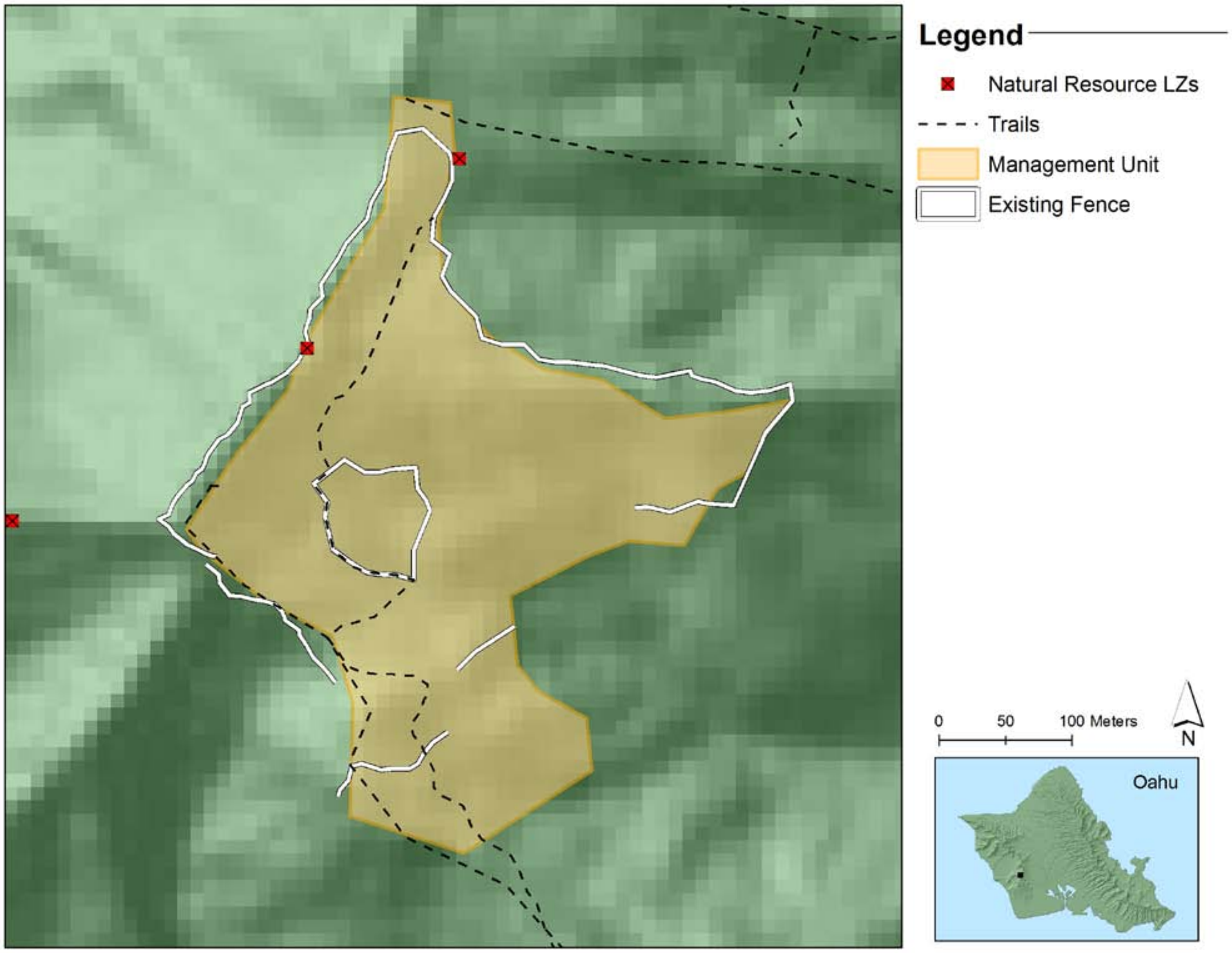
Maintenance

There are two fences in Palikea Subunit 1, the MU perimeter fence and the *C. grimesiana obatae* PU fence. The MU fence is relatively small (25 acres) and takes advantage of cliffs to strategically protect the area. The major threats to the fence include fallen trees and vandalism; there are no major gulch crossings. No incidences of vandalism have been observed, but since the fence is accessible to the public, there is the potential for vandalism to take place. Special emphasis will be placed on checking the fence after extreme weather events. Monitoring for ungulate sign will occur during the course of other field activities. The *C. grimesiana obatae* fence is very small (1.3 acres), and provides additional protection to both wild and reintroduced *C. grimesiana obatae*.

Ungulate Control Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Check MU fence for breaches • Identify and scope high probability ungulate usage areas • Install transects • Check snares • Check *C.grimesiana obatae* fence for breaches	• 1-4 • 1-4 • 1 • 1-4 • 1, 3
MIP YEAR 7 Oct.20010-Sept.2011 through MIP YEAR 10 Oct.2013-Sept.2014	• Check MU fence for breaches and check transects • Scope high probability ungulate usage areas • Check snareas • Check *C. grimesiana obatae* fence for breaches	• 1-4 • 1-4 • 1-4 • 1, 3

Ungulate Management Locations at Palikea



Laminella sanguinea

Lobelia yuccoides

1.4.8.4 Weed Control

Weed Control actions are divided into 4 subcategories:

1. Vegetation monitoring
2. Surveys
3. Incipient Control Areas, and
4. Weed Control Areas.

These designations facilitate different aspects of MIP/OIP requirements.

Vegetation Monitoring

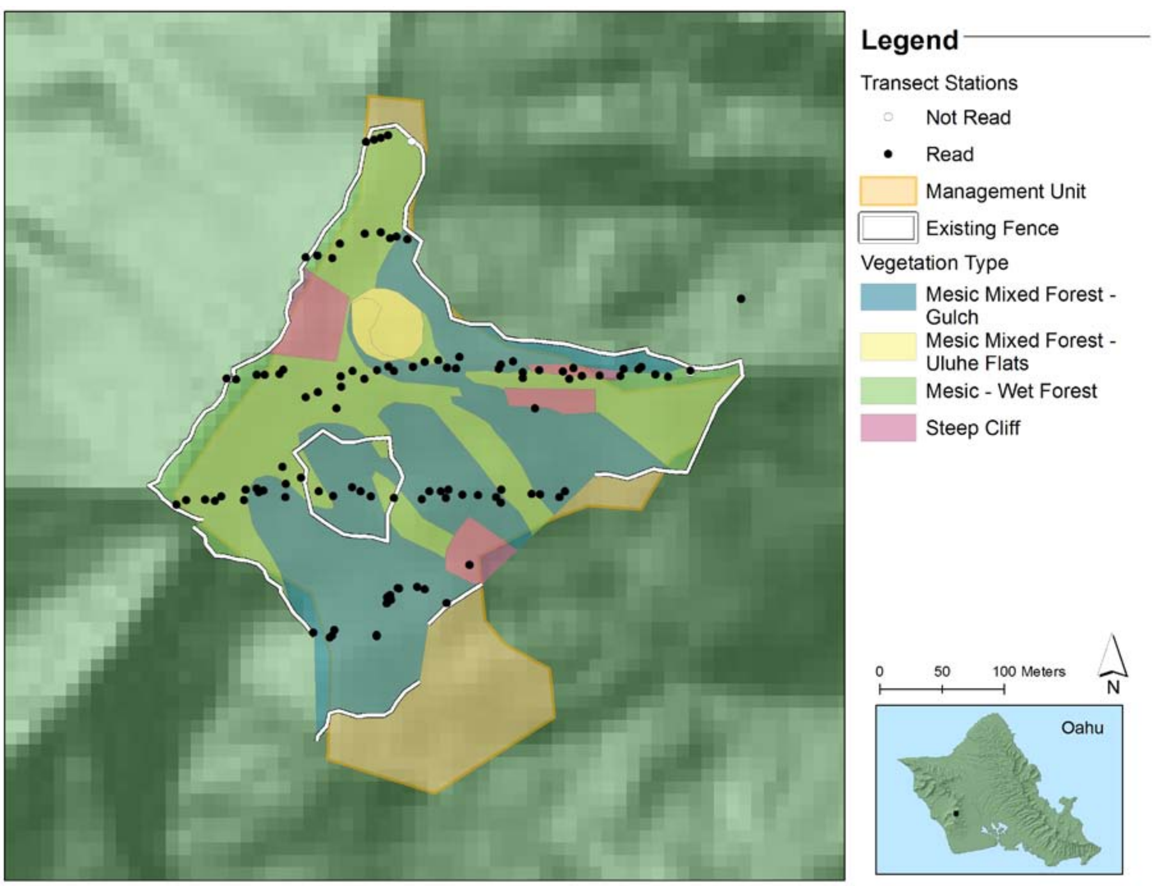
Objectives:

- Conduct MU vegetation monitoring every three years to measure the effectiveness of current weeding effort within the MU.

MU Vegetation Monitoring

From May – June 2008 vegetation monitoring was conducted across the Palikea management unit. The total effort including commute time was 261 hours. The data collected will provide OANRP with trend analyses on cover and species diversity of the MU. Palikea MU vegetation plots will be read every three years to determine if current management effort is sufficient to reach MU vegetation goals.

MU Monitoring Transects



MU Vegetation Monitoring Baseline Analyses

The mean non-native canopy cover was 44% (refer to MU vegetation monitoring analyses table). The 90% confidence interval for the mean was 38% to 51%. Non-native canopy cover was below 50%, which meets the MU goal. The confidence interval of the mean further strengthens this finding. It is important to keep a close watch on the canopy to insure the MU vegetation goals are met in the future. The alien vegetation cover in the understory was 35%. The 90% confidence interval for the mean was 31% to 40%. Alien understory cover also was below 50% and meets the MIP MU goal.

Bare (non-veg) ground covered 32% of the MU; this could be contributed to ungulate activity within the MU prior to fencing and dense *S. terebinthifolius* cover in some of the gulches. OANRP will need to watch this metric, as a change in percent bare ground cover could indicate the spread of alien species. If non-native vegetation starts expanding rapidly OANRP will increase weeding efforts.

An invasive species of concern in Palikea is *Morella faya*. The mean cover in 2008 was 28% in the canopy and 11% in the understory. OANRP will track *M. faya* percent coverage over time to gauge the success of weed control efforts across the MU. *M. faya* is not incipient, but is a specific target in each WCA. NRS do not want to observe any expansion of *M. faya* cover.

MU vegetation monitoring analyses

Variable	Count	Mean	Standard Deviation	*Lower limit	*Upper limit
Native Shrub	102	14.9	15.7	12.3	17.5
Native Fern	102	24.2	23.7	20.3	28.1
Native Grass	102	0.5	2.5	0	0.9
Alien Shrub	102	21.8	20	18.5	25
Alien Fern	102	5	11.9	3.1	7
Alien Grass	102	12.2	19.6	9	15.5
Bryophytes	102	10.7	19.3	7.5	13.8
Non-veg understory	102	31.9	28.3	27.3	36.5
Native understory	102	39.9	29.1	35.1	44.6
Alien understory	102	35.3	25.3	31.2	39.5
Native Canopy	57	21.5	23.8	16.2	26.8
Alien Canopy	57	44.4	30.5	37.7	51.2
Total Canopy	102	67.4	24.9	63.3	71.5
*90% Confidence level					

The mean native species count was 11.6 in the understory and 6.9 in the canopy. These data will be used to track the diversity of the MU over time.

MU Species count analysis

Variable	Count	Mean	Standard Deviation	*Lower limit	*Upper limit
Native understory	103	11.6	5.5	10.7	12.5
Alien understory	103	6.9	3	6.4	7.4
*90% Confidence level					

All the *C. grimesiana* are currently located in WCA 5, with the next outplanting location in WCA 6. Due to the presence of rare taxa, the alien vegetation cover goal for both WCAs is 25%. For this reason, plots within these WCAs were pooled together and analyzed. In 2008, the mean non-native cover in the understory was 34%. The MIP goal of 25% is not yet reached. Trend analysis will tell if vegetation cover goals will be reached with current management strategy.

WCA 5 and 6 vegetation monitoring analyses

Variable	Count	Mean	Standard Deviation	*Lower limit	*Upper Limit
Native understory	38	29.2	24	22	36
Alien understory	38	34	23	28	40
Non-veg understory	38	42.6	28.8	34.7	50.5
*90% Confidence level					

Vegetation Monitoring Response:

- Maintain weeding efforts to continue to meet alien vegetation goals on the MU level. Increase weed control efforts in WCAs 5 and 6 to meet the alien vegetation goal for rare taxa.

Vegetation Monitoring Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Identify other possible small scale vegetation monitoring projects that aid weed control planning. Determine if needed	• 1-4
MIP YEAR 7 Oct.2008-Sept.2009	• Read MU monitoring transects (every 3 years). First reading in Year 4 of MIP • Install additional monitoring, if deemed necessary.	• 2
MIP YEAR 10 Oct.2013-Sept.2014	• Read MU monitoring transects (every 3 years). First reading in Year 4 of MIP	• 2

Surveys

Army Training?: No

Other Potential Sources of Introduction: NRS, pigs, public hikers

Survey Locations: roads, landing zones, camp sites, fencelines, high potential traffic areas.

Management Objective:

- Prevent the establishment of any new invasive alien plant or animal species through regular surveys along roads, landing zones, camp sites, fencelines, trails, and other high traffic areas (as applicable).

Monitoring Objectives:

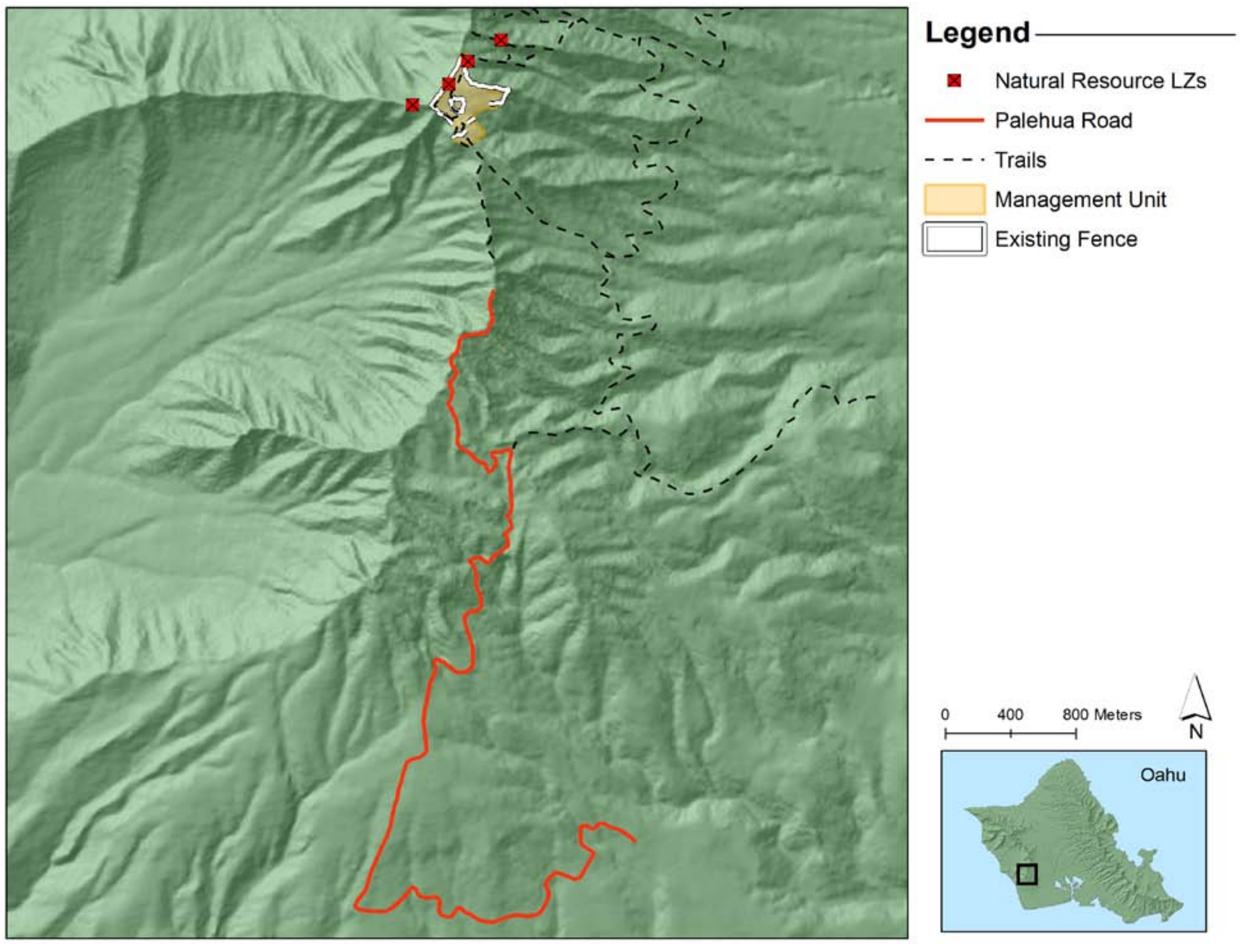
- Survey roads annually.
- Survey transects and camp sites for weeds
- Quarterly surveys of LZs (if used).
- Note unusual, significant, or incipient alien taxa during the course of regular field work.

Management Responses:

- Any significant alien taxa found will be researched and evaluated for distribution and life history. If found to pose a major threat, control will begin and will be tracked via ICAs.

Surveys are designed to be the first line of defense in locating and identifying potential new weed species. Roads, landing zones, camp sites, fencelines, and other highly trafficked areas are inventoried regularly; Army roads and LZs are surveyed annually, non-Army roads are surveyed annually or biannually, while all other sites are surveyed quarterly or as they are used. At Palikea, LZs, campsites, and roads are currently surveyed. NRS conducted the first road survey in January 2009. Due to the large number of novel species found along the Palehua road, NRS will conduct surveys annually instead of biannually. No weed transects have been established yet however, once the fenceline/ungulate transect is installed, NRS will monitor it for weeds.

Survey Locations at Palikea



Weed Survey Actions:

Year	Action	Quarter
MIP YEAR 5 Oct.2008-Sept.2009	• Begin new road survey, Palehua road from first gate to Mauna Kapu tower installation (no spur roads). Survey annually • GPS all LZs in region • Survey Puu Palikea LZ (107) quarterly (no use, no survey) • Survey Palikea Camp LZ quarterly (no use, no survey) • Add new LZs to survey list (Napepeiauolelo) • Evaluate need for weed transects along fence, trail, staging areas, and install if necessary	• 1 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013- Sept.2014	• Survey Palehua Road • Survey all LZs: Puu Palikea (107), Palikea Camp, + any new LZs • Survey transects	• 1 • 1-4 • 1-4

Incipient Taxa Control (ICAs)

Management Objectives:

- As feasible, eradicate high priority species identified as incipient invasive aliens in the MU by 2014.
- Conduct seed dormancy trials for all high priority incipients by 2014.

Monitoring Objectives:

- Visit ICAs at stated revisitation intervals. Control all mature plants at ICAs and prevent any immature or seedling plants from reaching maturity.

Management Responses:

- If unsuccessful in preventing immature plants from maturing, increase ICA revisitation interval.

ICAs are drawn around each discrete infestation of an incipient invasive weed. They are designed to facilitate data gathering and control. For each ICA, the management goal is to achieve complete eradication of the invasive taxa. Frequent visitation is often necessary to achieve eradication. Seed bed life/dormancy and life cycle information is important in determining when eradication may be reached; much of this information needs to be researched and parameters for determining eradication defined. NRS will compile this information for each ICA species.

The table below summarizes incipient invasive taxa at Palikea. Appendix 3.1 of the MIP lists significant alien species and ranks their potential invasiveness and distribution. Each species is given a weed management code: 0 = not reported from MU, 1 = incipient (goal: eradicate), 2 = control locally. If no code is listed in the 'original' column, the species was not evaluated by the IP, but was added later by NRS. While the list is by no means exhaustive, it provides a good starting point for discussing which taxa should be targeted for eradication in an MU. NRS supplemented and updated Appendix 3.1 with additional target species identified during field work. In many cases, the weed management code assigned by the MIP has been revised to reflect field observations. ICAs are not designated for every species in the table below; however, occurrences of all species in the table should be noted by field staff. ICAs are planned for taxa listed in bold, underlined font. All current ICAs are mapped.

Summary of Potential ICA Target Taxa

Taxa	MIP weed man. code: Original	MIP weed man. code: Revised	Notes	No. of ICAs
Acacia mearnsii	1	0	None within MU; large infestation along trail. Will consider control along trail with volunteer groups. Erosion a major potential side effect.	0
Araucaria columnaris	0	1	Population appears stable. Potential for invasiveness has been observed elsewhere. Survey to determine if recruitment taking place. If so, consider control	0
Casuarina glauca	**2**	**1**	**Very few plants found within MU; large population outside MU along trail. Low rate of spread. Should target any plants found within MU. Consider controlling outlying plants just outside MU with volunteer groups.**	**0**
Crocosmia x crocosmifolia	**2**	**1**	**Several stable populations were known prior to fence construction. After fence completed, NRS noted many new sites along fence; taxa likely moving via NRS activities. ICAs drawn both in and out of subunit. Control ongoing with volunteer groups. Control technique: manual removal of bulbs. Herbicide not required. Vegetative reproduction dominant, with seed produced occasionally. Seed viability and seed bed life is currently being studied.**	**5**
Ehrharta stipoides	2	2	Species widespread both in and outside of MU. Control needed to prevent greater spread of this species, this should take place in WCAs. Focus will be on keeping *E. stipoides* off the access trail.	0
Ficus macrophylla	**1**	**1**	**Few trees found within MU. Will create ICAs to track control and survey MU to identify all infestation sites. Control technique not determined; Garlon 4 20% effective on small trees but copious latex of large trees seems to pose additional challenges. Research control options for large trees.**	**0**
Fraxinus uhdei	**0**	**1**	**1 large tree found during monitoring. ICA to be drawn around site, control ongoing. MU to be surveyed to identify other infestation sites. Other scattered trees noted outside MU, will consider control. Control technique: Garlon 4 20%.**	**0**
Juniperus bermudiana	1	1	Population does not appear to be expanding. If status changes, will consider control. Potential volunteer project	0
Melaleuca quinquenervia	**2**	**1**	**Few to no trees found within subunit; will survey site and create ICAs around any plants found. Large infestation along access trail. Will consider treating outlier plants with volunteer control. Test control techniques.**	**0**
Montanoa hibiscifolia	1	0	None seen within Subunit 1. Present in other subunits. If seen, control is a high priority.	0
Schefflera actinophylla	1	0	None seen within Subunit 1. Present in other subunits. If seen, control is a high priority.	0
Setaria palmifolia	**2**	**1**	**Only 1 location found within subunit. ICA formed, control ongoing. 1 other location found on access trail, ICA to be drawn, control ongoing. Taxa may be widespread in other subunits. Control technique: handpull and remove plant material (may resprout), or spray with glyphosate.**	**1**
Sphaeropteris cooperii	1	2	During monitoring, found many plants scattered across MU. Large infestation known just outside MU, in Nanakuli. Zero tolerance for this species. Control shall be recorded in WCAs.	0
Toona ciliata	1	0	None seen within Subunit 1. Present in other subunits. If seen, control is high priority	0
Trema orientalis	**0**	**1**	**Some trees seen at the eastern edge of the MU fence on the middle ridge area, in an area with very steep terrain. Zero tolerance for this species inside MU. Will establish an ICA to control.**	**0**

ICA Actions:

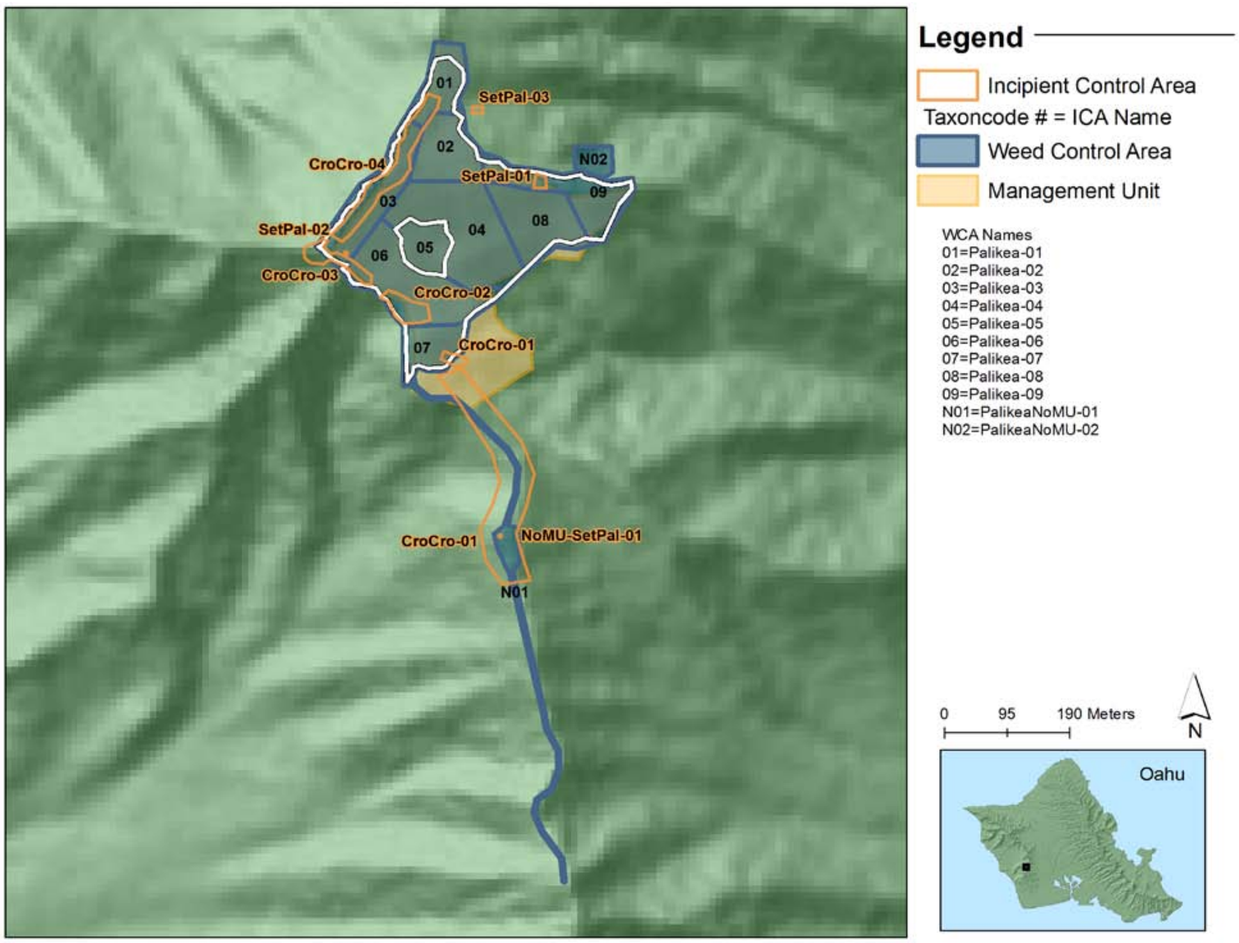
Year	Action	Quarter
MIP YEAR 5 Oct.2008-Sept.2009	• Palikea-CroCro-01 control; volunteer • Palikea-CroCro-02 control; volunteer • Palikea-CroCro-03 control; volunteer • Palikea-CroCro-04 control; volunteer • PalikeaNoMU-CroCro-01 control; volunteer • Palikea-SetPal-01 control • Palikea-SetPal-02 control • PalikeaNoMU-SetPal-01, draw ICA, control • CasGla; only in MU, draw ICAs and implement control • FraUhd; draw ICA and implement control • FicMic; draw ICA and implement control • TreOri; draw ICA and implement control	• 1, 3 • 1, 3 • 1, 3 • 1, 3 • 2,4 • 2, 4 • 1-4 • 3 • 3 • 3 • 3 • 3
MIP YEAR 6 Oct.2009-Sept.2010	• Continue control at 3 SetPal ICAs • Determine parameters for declaring eradication for SetPal • Continue control at 5 CroCro ICAs • Continue control at FraUhd ICAs (# to be determined) • Continue control at FicMic ICAs (# to be determined) • Continue control at TreOri ICAs (# to be determined) • Scope and begin control of CasGla in MU • Scope and begin control of MelQui in MU	• 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4
MIP YEAR 7 Oct.2010-Sept.2011	• Contine control 3 SetPal ICAs till reach eradication • Continue control at 5 CroCro ICAs • Determine parameters for declaring eradication for CroCro • Continue control for FraUhd ICAs • Determine parameters for declaring eradication for FraUhd • Continue control for FicMic ICAs • Determine parameters for declaring eradication for FicMic • Continue control for CasGla ICAs • Determine parameters for declaring eradication for CasGla • Continue control for MelQui ICAs • Determine parameters for declaring eradication for MelQui • Continue control for TreOri ICAs • Determine parameters for declaring eradication for TreOri	• 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4
MIP YEAR 8 Oct.2011-Sept.2012 through MIP YEAR 9 Oct.2012-Sept.2013	• Contine control 3 SetPal ICAs till reach eradication • Continue control at 5 CroCro ICAs till reach eradication • Continue control for FraUhd ICAs till reach eradication • Continue control for FicMic ICAs till reach eradication • Continue control for CasGla ICAs till reach eradication • Continue control for MelQui ICAs till reach eradication • Continue control for TreOri ICAs till reach eradication	• 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4

Incipient species at Palikea

C. crocosmifolia flower and corm

Large ficus at edge of uluhe flats

Incipient and Weed Control Areas at Palikea



Ecosystem Management Weed Control (WCAs)

MIP Goals:

- Within 2m of rare taxa: 0% alien vegetation cover
- Within 50m of rare taxa: 25% or less alien vegetation cover
- Throughout the remainder of the MU: 50% or less alien vegetation cover

Management Objectives:

- Maintain 50% or less alien vegetation cover in both the understory and canopy across the MU.
- In WCAs within 50m of rare taxa, work towards achieving 25% or less alien vegetation cover in understory and canopy.

Management Responses:

- Increase/expand weeding efforts if MU vegetation monitoring (conducted every 3 years) indicates that goals are not being met.

Vegetation monitoring at Palikea indicates that the MU already is 50% or less alien cover. This is a very encouraging starting point. Anecdotal observations from TNC indicate that the *C. grimesiana* fence, which was built in 1999, experienced a dramatic increase in vegetation cover post-fencing. Before fence construction, the region had a lot of bare ground, and looked very much like some of the area now outside the *C. grmesiana* fence – heavily shaded dirt and debris. Now, the *C. grimesiana* fence is remarkable for its native fern understory, dominated by *Diplazium sandwichianum* and *Dryopteris glabra*. This is likely due to persistent weed control following ungulate exclusion; this favored native fern growth. NRS conjecture that similar understory growth will occur in the MU fence as the area recovers from ungulate damage, but it is not clear whether native ferns will dominate, as they have in the *C. grimesiana* fence. Currently, bare ground covers 31% of the MU. NRS must be vigilant in weed control to ensure that the understory weed levels remain <50% and the bare ground areas do not convert completely to alien grasses, *Rubus rosifolius*, *C. hirta,* and other weeds.

In areas around rare taxa, alien canopy and understory cover exceeds 25%. This indicates that weed control is still a priority at Palikea. WCAs drawn around rare taxa or encompassing potential reintroduction sites are a higher priority for control than those containing no rare taxa.

Certain vegetation types are dominated by native species; NRS will begin by working in these areas, thereby maximizing weed control effort. Other vegetation types are dominated by alien species; while these areas are relatively small, they will require much time and effort to transform. These weedy areas generally will be lower in priority and restoration efforts may include common native reintroductions.

With the completion of the MU fence, NRS decided to divide the entire fenced area into WCAs to facilitate data tracking and control efforts. See the Incipient and Weed Control Areas at Palikea map above.

General WCA Actions

Year	Action	Quarter
MIP YEAR 5 Oct.2008-Sept.2009	• GPS boundaries of all WCAs. Use geographical and vegetation data. Use landmarks to mark in field • GPS trails	• 2-3
MIP YEAR 6 Oct.2009-Sept.2010	• Complete WCA and trail mapping with GPS.	• 3

WCA: Palikea-01

Vegetation Type: Mesic-Wet Forest (ridge)

MIP Goal: Less than 25% non-native cover given presence of MIP taxa (snails). Monitoring shows that for this vegetation type, native cover is at 50%.

Targets: All weeds, focusing on *M. faya*, *P. cattleianum, C. hirta* and grasses.

Notes: This WCA includes a native dominated forest patch home to *A. mustelina, A. concavospira* and *L. sanguinea*. There are few weeds and the area is small; a small amount of weed control effort would have great effect. Much of the WCA is bordered by the fenceline. NRS will target *E. stipoides*, other grasses, and *S. terebinthifolius* along the fenceline. Some of the area in this WCA may be appropriate habitat for a new *C. grimesiana* reintroduction; if a reintroduction does take place, NRS will target the reintroduction site. Follow up treatment of *B. appendiculatum*, *R. rosifolius*, *C.hirta*, and other understory weeds is required.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Sweep entire WCA with phalanx one time • Spray any grass found along ridgeline and fenceline, check quarterly, spray as needed • Finish catchment construction to facilitate grass control along fenceline.	• 4, 1 • 1-4 • 4, 1
MIP YEAR 7 Oct.2010-Sept.2011	• Spray any grass found along ridgeline and fenceline, quarterly	• 1-4
MIP YEAR 8 Oct.2011-Sept.2012	• Sweep entire WCA with phalanx one time • Spray any grass found along ridgeline and fenceline, check quarterly, spray as needed	• 4, 1 • 1-4
MIP YEAR 9 Oct.2012-Sept.2013	• Spray any grass found along ridgeline and fenceline, quarterly	• 1-4
MIP YEAR 10 Oct.2013-Sept.2014	• Sweep entire WCA with phalanx one time • Spray any grass found along ridgeline and fenceline, quarterly	• 4, 1 • 1-4

WCA: Palikea-02 (Uluhe flats)

Vegetation Type: Mesic Mixed Forest (uluhe dominated flats)

MIP Goal: 50% or less alien cover (no rare taxa in WCA). Monitoring data for this vegetation type is highly variable; however, the 50% alien cover goal has been met for the MU as a whole.

Targets: All weeds, focusing on *S. terebinthifolius*, *P. cattleianum*, *S. cooperi*, and shrubs.

Notes: Much of this WCA is covered with *Dicranopteris linearis* and requires little weed control. However, the areas around the flats include a lot of *S.terebinthifolius*, *C. hirta* and *P. cattleianum*. Targeting these regions would help to improve overall habitat quality and provide a more seamless transition to the surrounding WCAs, most of which are 50% or greater native cover. *A. mustelina* may be present in areas closest to cliff zone. If so, the MIP goal will change to 25% or less alien cover. *Vestiaria coccinea* have been observed in the *Metrosideros polymorpha* in this area. While *V. coccinea* have no federal status, this sighting is significant in that immature birds were seen, and there have only been a handful of sightings of any birds in the last ten years. *S. cooperi* has been found in this region; this taxa should be targeted in particular. The *P. cattleianum* monocultures may be appropriate for control via clear cut/chipping. In the *S.terebinthifolius* and *P. cattleianum* dominated areas, common native outplantings would be appropriate to speed rehabilitation. Possible common native species include: *D. sandwicensis, Rumex albescens, Acacia koa,* and *Hedyotis terminalis*. *S. terebinthifolius* is also being targeted along the fenceline.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• GPS boundary of WCA. Use geographical and vegetation data to determine boundary.	• 4
MIP YEAR 7 Oct.2010-Sept.2011	• Sweep *D. linearis*-dominated portion of WCA one time	• 2
MIP YEAR 8 Oct.2011-Sept.2012	• Begin control in weedier portions of WCA. Sweep entire WCA one time • Control *P. cattleianum* monocultures with chipper	• 1-4 • 2-4
MIP YEAR 9 Oct.2012-Sept.2013	• Continue control, focus in weedier portions of WCA. • Identify common native reintroduction sites; evaluate usefulness • Collect stock for common natives	• 1-4 • 2 • 1-4
MIP YEAR 10 Oct.2013- Sept.2014	• Sweep entire WCA one time. • Plant common natives	• 1-4 • 1, 4

WCA: Palikea-03 (Crestline)

Vegetation Type: Mesic-Wet Forest (ridge)

MIP Goal: 25% or less alien cover (rare taxa in WCA). Monitoring shows that this vegetation type is already at 50% native cover.

Targets: All weeds, focusing on *M. faya*, *S. terebinthifolius*, *P. cattleianum*, *E. stipoides*, other grasses.

Rare Taxa: *A. mustelina* and *C. calycina* present.

Notes: This region is steep, including much of the summit area in the MU. Some portions of the WCA include cliffs. Fortunately, the area is dominated by native species. *M. faya* forms a significant part of the canopy; control of this species will be staggered so as to minimize changes in the light regime. The area along the fenceline will be sprayed regularly for *E. stipoides* and other grasses; keeping *E. stipoides* from moving away from the fenceline is a priority. NRS will avoid negative impacts on *C. calycina* and *Schiedea pentamera*, a rare species with no IP status, found along the fence. There is a large population of *A. mustelina* on the southern end of the WCA; NRS will seek to avoid negative impacts to the population by exercising caution when working around snail trees. In open areas, NRS will consider using common native species seed sow or plantings to reduce habitat for *E. stipoides*. Appropriate species include *Rumex albescens* and *D. sandwicensis*. NRS will treat tree weeds on cliffs as technologies to do so become available.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 7 Oct.2011-Sept.2012	• Spray *E. stipoides* and other grasses along fenceline, check quarterly, spray as needed. • *R. albescens, D. sandwicensis* seed sow along trail, install and monitor	• 1-4 • 2
MIP YEAR 8 Oct.2011-Sept.2012 through MIP YEAR 9 Oct.2012-Sept.2013	• Spray *E. stipoides* and other grasses along fenceline • Sweep accessible portions of WCA 1 time each year; reduce *M. faya* cover gradually • Monitor seedsow	• 1-4 • 1-4 • 2
MIP YEAR 10 Oct.2013- Sept.2014	• Spray *E. stipoides* and other grasses along fenceline • Continue to treat *M. faya* gradually • Treat cliffs using rappel gear, HBT or other technology	• 1-4 • 1-4 • 1-4

WCA: Palikea-04 (Mid-Gulch)

Veg Type: Mesic Forest (gulch)/ Mesic-Wet Forest (Slope)

MIP Goal: 25% or less alien cover (rare taxa in WCA). This WCA spans two vegetation types. Monitoring shows that the mesic-wet vegetation type is already at 50% native cover, while the mesic gulch forest type is much more variable in cover (80-100% alien).

Targets: All weeds, focusing on *S. cooperi, M. faya, S. terebinthifolius, P. cattleianum, E. stipoides*, *Melinus minutiflora* and other grasses.

Notes: This WCA is large and stretches from the eastern edge of the MU, along the *C. grimesiana* fence, to the steep, cliff areas on the western edge of the MU. It encompasses a mesic gulch bordered by two ridges. The mesic forest vegetation type is the most degraded type in Palikea. It is dominated by *S. terebinthifolius*, has low species diversity, low native cover, and very high percent bare ground. The bare ground may be due more to dense shading by *S. terebinthifolius* than to ungulate activity. On the western end of the WCA, *P. cattleianum* provides most of the canopy, although vegetation is somewhat mixed. Despite the weedy character of the WCA, *A. mustelina*, *A. concavospira*, *L. sanguinea*, and *C. sandwichensis* are all present. Care needs to be taken to avoid significant negative impacts to these rare taxa. Control work will focus on gradual removal of *S. terebinthifolius* canopy; this will open up light gaps which will need to be monitored for weedy grasses, etc. Common native species plantings will be considered to jumpstart restoration. Planting species may include *Pisonia* sp., *Acacia koa, Gahnia beechii, Microlepia strigosa*, *Pipturus albidus, Carex* sp, *D. sandwicensis*, and *Hedyotis terminalis*. The ridges bordering the gulch include more native vegetation elements. These ridges will be swept, and *M. faya*, the primary weed, will be targeted gradually. The mixed *P. cattleianum* patches on the west of the area will be swept and weeded gradually.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Sweep ridges, begin gradual *M. faya* control 1x year • Spray any grass found in WCA 2x year • Sweep western *P. cattleianum* zone 1x year • Evaluate usefulness of common natives as a tool	• 1-4 • 1-4 • 1-4 • 1-4
MIP YEAR 7 Oct.2010-Sept.2011	• Control *S.terebinthifolius* gradually, opening small light gaps only, 1x year • Monitor for natural native plant regeneration in light gaps. • Plant common natives into light gaps if deemed applicable • Spray any grass found in WCA, as needed, 2x year	• 1-4 • 1-4 • 4,1 • 1-4
MIP YEAR 8 Oct.2011-Sept.2012	• Sweep ridges, gradually remove *M. faya* • Spray any grass found in WCA, as needed, 2x year • Plant/monitor common natives • Sweep western *P. cattleianum* zone 1x year	• 1-4 • 1-4 • 4, 1 • 1-4
MIP YEAR 9 Oct.2012-Sept.2013	• Control *S.terebinthifolius* gradually, opening small light gaps only, 1x year • Plant/monitor common natives • Sweep areas planted with common natives • Spray any grass found in WCA, as needed, 2x year	• 1-4 • 4,1 • 1-4 • 1-4
MIP YEAR 10 Oct.2013- Sept.2014	• Sweep ridges, gradually remove *M. faya* • Spray any grass found in WCA, as needed, 2x year • Plant/monitor common natives • Sweep western *P. cattleianum* zone 1x year	• 1-4 • 1-4 • 4, 1 • 1-4

WCA: Palikea-05 (CyaGri Fence)

Veg Type: Mesic Forest (gulch)

MIP Goal: 25% or less alien cover (rare taxa in WCA). Monitoring shows that for this vegetation type, percent native cover is highly variable.

Targets: All weeds, focusing on understory species.

Notes: This WCA encompasses the small TNC fence. Approximately an acre, the fence protects both wild and reintroduced *C. grimesiana*, as well as other rare species reintroductions planted by TNC. This area has been protected from pigs since 1999; since then, native ferns have thrived. Weed control has been ongoing at this site for many years; current efforts will be maintained. Portions of the WCA are still dominated by weeds, and the canopy throughout the WCA is made up of *Cryptomeria japonica*. *C. japonica* has not been observed recruiting aggressively in the MU and removal would be highly detrimental to the site; NRS have no plans to control it in Palikea-05 at this time. NRS are hopeful that native fern recruitment seen within the Subunit 1 fence will be echoed elsewhere in Palikea. Planting common native species such as *Pipturus albidus, Hedyotis terminalis,* and *D. sandwicensis* may help to jumpstart forest restoration in the weedier portions of this WCA.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Sweep gulch portion of WCA 2x year • Sweep rest of WCA 1x year • Evaluate efficacy of common natives, collect seed	• 1-4 • 1-4 • 1-4
MIP YEAR 7 Oct.2010-Sept.2011 through MIP YEAR 10 Oct.2013- Sept.2014	• Sweep gulch portion of WCA 2x year • Sweep rest of WCA 1x year • Plant/monitor common native reintroductions with volunteer groups	• 1-4 • 1-4 • 4,1

WCA: Palikea-06 (Tsugi Gulch)

Veg Type: Mesic Forest (gulch)/ Wet-Mesic Forest

MIP Goal: 25% or less alien cover (rare taxa in WCA). This WCA spans two vegetation types. Monitoring shows that the mesic-wet vegetation type is already at 50% native cover, while the mesic gulch forest type is much more variable in cover (80-100% alien).

Targets: All weeds, focusing on *M. faya, S. terebinthifolius, P. cattleianum, C. hirta, B. appendiculatum, S. cooperi, E. stipoides*, and grasses.

Rare Taxa: *A. mustelina* and *Chasiempis sandwichensis ibidis* in WCA.

Notes: Much of this WCA is dominated by *Cryptostegia japonica* and *P. cattleianum* canopy. The area is heavily shaded, with a very open understory and lots of bare ground. This WCA directly abuts the *C. grimesiana* fence, and reintroductions in WCA 6 are planned. It is hoped that native ferns will colonize much of the bare ground in the WCA, as they did in the TNC fence. NRS will work to foster this. Weed control efforts will focus on understory species and some *P. cattleianum* canopy control. Although not an IP identified Manage for Stability population, there are *C. sandwichensis* in the area and habitat requirements for *C. sandwichensis* place additional restrictions on weed control. *C. sandwichensis* prefer structured habitats; large scale control of *P. cattleianum* is not appropriate in *C. sandwichensis* habitat. Guidelines for weeding in *C. sandwichensis* habitat are being drafted and will be followed in this WCA. Gradual planned removal of *P. cattleianum* will be implemented. Common native species may be outplanted here to help provide native understory replacements for *P. cattleianum*. Seedsowing of *R. albescens* may also appropriate. *Lobelia yuccoides* seed collected by TNC was given to NRS. NRS will use the stock to conduct a seed sowing experiment along the Palikea access trail. This WCA contains appropriate *L. yuccoides* habitat; seed sowing instructios have been developed by the Propagule Specialist.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Sweep gulch for understory species, 1x year • *L. yuccoides* seedsow with TNC seed; install and monitor	• 1-4 • 4, 1
MIP YEAR 7 Oct.2010-Sept.2011 through MIP YEAR 10 Oct.2013- Sept.2014	• Sweep gulch for understory species, 1x year • Monitor *L. yuccoides* seedsow • Control small portions of *P. cattleianum*, as per *C. sandwichensis* limits, 2x year • Plant common natives into *P. cattleianum* areas	• 1-4 • 1-4 • 1-4 • 4,1

WCA: Palikea-07 (Norfolks, South Corner)

Veg Type: Mesic Mixed Fores (slope, ridge)

MIP Goal: 25% or less alien cover (rare taxa in WCA). Monitoring data for this vegetation type is highly variable; however, the 50% alien cover goal has been met for the MU as a whole.

Targets: All weeds, focusing on *Araucaria columnaris*, *M. faya*, *S. terebinthifolius*, *P. cattleianum*, *E. stipoides*, and grasses.

Notes: Much of the WCA is dominated by very large *Araucaria*. These trees originally were planted; while they are not naturalizing quickly, some keiki have been found. Removing the *Araucaria* would drastically alter light and moisture levels and could be quite dangerous. For now, any young *Araucaria* will be controlled and options for controlling (or leaving) the mature trees will be discussed. Other portions of the WCA are dominated by a mix of native species. Weeding efforts will focus in these areas. The Palikea trail runs through the WCA; grass control, especially *E. stipoides*, will be a priority along the fence. The northern part of this WCA has native forest patches, habitat for *A. mustelina* . These areas will be weeded cautiously to minimize potential impact to the tree snails.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Spray grasses, *E. stipoides*, along trail, as necessary (quarterly) • Common native planting/seed sow at *C. crocosmifolia* ,volunteer.	• 1-4 • 4, 1
MIP YEAR 7 Oct.2010-Sept.2011 through MIP YEAR 10 Oct.2013- Sept.2014	• Sweep entire WCA one time per year. Focus on understory species and gradual removal of overstory weeds. • Spray grasses, *E. stipoides*, along trail, as necessary • Monitor/plant common natives	• 1-4 • 1-4 • 4, 1

WCA: Palikea-08 (Mid-east Gulch)

Veg Type: Mesic Mixed Forest (gulch, ridge)

MIP Goal: 25% or less alien cover (rare taxa in WCA). Monitoring data for this vegetation type is highly variable; while the 50% alien cover goal has been met for the MU as a whole, the mesic gulch forest type is highly variable in cover (80-100% alien).

Targets: All weeds, focusing on *M. faya, S. terebinthifolius, P. cattleianum, M. minutiflora*, and grasses.

Notes: This WCA is very similar to Palikea-04 in terms of vegetation types, topographic features, and resources. Actions and plans for this WCA are likewise very similar. Control will focus on gradual removal from *S.terebinthifolius* from the gulch and *M. faya* from the ridges. Common natives may be used in the light gaps resulting from weeding. *A. mustelina* in the WCA are primarily found in a large *Freycinetia arborea* patch and in high numbers at the top of the WCA in the *D. linearis* patch. The perimeters of this patch will be weeded. *A. concavospira* are also found in this WCA.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Spray any grass found in WCA 2x year • Sweep ridges, begin gradual *M. faya* control 1x year	• 1-4 • 1-4
MIP YEAR 7 Oct.2010- Sept.2011	• Control *S.terebinthifolius* gradually, opening small light gaps only, 1x year • Monitor for natural native plant regeneration in light gaps. • Plant common natives into light gaps if deemed applicable • Spray any grass found in WCA, as needed, 2x year	• 1-4 • 1-4 • 4,1 • 1-4
MIP YEAR 8 Oct.2011- Sept.2012	• Sweep ridges, gradually remove *M. faya* • Spray any grass found in WCA, as needed, 2x year	• 1-4 • 1-4
MIP YEAR 9 Oct.2012- Sept.2013	• Control *S.terebinthifolius* gradually, opening small light gaps only, 1x year • Plant common natives into light gaps if deemed applicable • Spray any grass found in WCA, as needed, 2x year	• 1-4 • 4,1 • 1-4
MIP YEAR 10 Oct.2013- Sept.2014	• Sweep ridges, gradually remove *M. faya* • Spray any grass found in WCA, as needed, 2x year	• 1-4 • 1-4

WCA: Palikea-09 (East Corner)

Veg Type: Mesic-Wet Forest/ Mesic Mixed Forest

MIP Goal: 25% or less alien cover (rare taxa in WCA). This WCA spans two vegetation types. Monitoring shows that the mesic-wet vegetation type is already at 50% native cover, while the mesic gulch forest type is much more variable in cover (80-100% alien).

Targets: All weeds, focusing on *M. faya, S. terebinthifolius, P. cattleianum, T. orientalis* and *S. cooperi*.

Notes: This WCA encompasses the long north facing slope of the main ridge crossing the MU. The western end of the WCA borders on the uluhe flats, while the eastern end wraps around the main ridge to include a small gulch. It is very diverse, with many native and weedy elements and *A. mustelina*. Portions of the WCA are steep and may require more careful hiking. There are possible reintroduction sites for *C. grimesiana*, although there are no definitive plans to outplant, as stability numbers may be reached in WCAs 5 and 6. *V. coccinea* were observed here in the past year. Control efforts will focus on sweeping around the native forest patches for both canopy and understory weeds. The *P. cattleianum* monocultures will be targeted for clearcut removal/chipping. Hopefully, *A. koa* found on the ridge will recruit in the clear cut areas. If not, NRS will experiment with raking the ground to stimulate germination; this project may be accomplished with volunteers. Common native reintroductions may also be used. Along the fenceline, both *M. minutiflora* and *S. terebinthifolius* will be controlled to facilitate fenceline maintenance.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Control *S.terebinthifolius* along the fenceline • Sweep native dominated areas once	• 1-4 • 14
MIP YEAR 7 Oct.2010-Sept.2011	• Control *S.terebinthifolius* along the fenceline • Sweep native dominated areas once • Scope possible chipper *P. cattleianum* projects	• 1-4 • 1-4 • 1-4
MIP YEAR 8 Oct.2011-Sept.2012	• Sweep native dominated areas every other year • Control *P. cattleianum* monocultures, one stand per year, chipper. • Monitor for *A. koa* regeneration • Conduct ground raking experiment if *A. koa* germination low to non-existent.	• 1-4 • 1-4 • 1-4 • 3
MIP YEAR 9 Oct.2012-Sept.2013	• Control *P. cattleianum* monocultures, one stand per year, chipper. • Common native planting into chipper areas	• 1-4 • 4,1
MIP YEAR 10 Oct.2013- Sept.2014	• Sweep native dominated areas every other year • Control *P. cattleianum* monocultures, one stand per year, chipper. • Plant/monitor common natives	• 1-4 • 1-4 • 4, 1

WCA: PalikeaNoMU-01 (Palikea Trail)

Veg Type: Mesic-Wet Forest (ridge)

MIP Goal: This WCA does not fall in the Palikea MU. The MIP does not specify weed control goals outside MUs, except with regards to incipient invasive species. The objective of this WCA is to maintain the access trail to the MU fence and to keep the highly invasive *E. stipoides* off the trail, thus reducing the potential to spread it.

Targets: *E. stipoides* and other grasses, *M. quinquenervia, Casuarina* spp., *M. faya*.

Notes: The Palikea trail runs through a variety of plant communities, ranging from separate monocultures of bamboo, *Casuarina* spp., and *M. quinquenervia*, to native dominated mesic-wet forest. *E. stipoides* is also found along much of the access trail and is well established in the region; it is the most invasive species in the area. Control of *E. stipoides* is a high priority; the trail will be sprayed regularly to reduce the potential of staff to accidentally spread it to intact areas of Palikea or other MUs. Weedy tree species found in the native-dominated portions of the WCA will be controlled as time permits; this is a low priority. Volunteer labor may be highly useful for this.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Spray *E. stipoides* and other grasses along the trail, from the trailhead to the MU fence; check quarterly, spray as needed.	• 1-4
MIP YEAR 7 Oct.2010-Sept.2011 through MIP YEAR 10 Oct.2013- Sept.2014	• Spray *E. stipoides* and other grasses along the trail quarterly, from the trailhead to the MU fence • Control outlier *Casuarina* spp., *M. quinquenervia*, *M. faya* along the trail. Use volunteers.	• 1-4 • 1-4

WCA: PalikeaNoMU-02 (East SphCoo Bowl)

Vegetation Type: Mesic mixed forest (gulch)

MIP Goal: This WCA does not fall in the Palikea MU. The MIP does not specify weed control goals outside MUs, except with regards to incipient invasive species. The objective of this WCA is to control *S. cooperi* and reduce its ability to disperse into the MU.

Targets: *S. cooperi, Trema orientalis*, *M. faya* and other significant/unusual tree weeds.

Notes: Just outside the Palikea fence, in a gulch to the northeast, there is an infestation of *S. cooperi*. This species is widely but sparsely scattered across the Palikea exclosure. It is a target in all WCAs. *S. cooperi* is highly invasive, and can form dense stands in mesic/wet forest. Eliminating mature plants is a high priority. NRS hope that by targeting large infestations outside of the MU, control efforts within the MU will be more effective. Other taxa, particularly alien trees like *T. orientalis*, will also be controlled during weed sweeps.

Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Sweep entire area for *S. cooperi*, *T. orientalis*, etc once. • Survey WCA and GPS/ better define boundaries.	• 1-4
MIP YEAR 7 Oct.2010-Sept.2011	• Sweep entire area for *S. cooperi*, *T. orientalis*, etc once, every two years.	• 1-4
MIP YEAR 8 Oct.2011-Sept.2012	No action	
MIP YEAR 9 Oct.2012-Sept.2013	• Sweep entire area for *S. cooperi*, *T. orientalis*, etc once, every two years.	• 1-4
MIP YEAR 10 Oct.2013- Sept.2014	No action	

Sphaeropteris cooperi

1.4.8.5 Rodent Control

Threat level: High

Current control method: Bait station & snap trap grids (localized control)

Seasonality: Year-Round

Number of control grids: 12 (53 bait stations, 97 snap traps)

Primary Objective:

- To maintain rat/mouse populations to a level that facilitates stabilized or increasing plant and snail populations across the MU by the most effective means possible.

Management Objective:

- Continue to maintain bait station and snap trap grids (localized control) around individual *Achatinella mustelina* populations in the short term.
- Establish a large scale trapping grid (MU control) for the control of rats over the entire MU in summer 2010.
- Less than 10% activity levels in rat tracking tunnels checked monthly.

Monitoring Objectives:

- Monitor tracking tunnels to determine rat activity within the trapping grid.
- Monitor ground shell plots for predation of *Achatinella mustelina* by rats.
- Monitor *Cyanea grimesiana* subsp. *obatae* for predation of fruits by rats.
- Monitor arthropod composition and abundance to determine if rat control will have positive impacts to native arthropods.

Monitoring Issues:

- An acceptable level of rat activity, which promotes stable or increasing *A. mustelina* and *C. grimesiana* subsp. *obatae* populations, has not been clearly identified. It could be very low, less than 2%, or very high, 40%; in New Zealand, studies have shown that rat activity levels of 10% are low enough to maintain certain rare bird populations. A 10% activity level may also be the most achievable level using a large scale trapping grid. In order to determine this acceptable level, more intensive monitoring of rare resources is required.

Localized Rodent Control:

- Localized control consists of bait station and snap trap grids deployed around individual *A. mustelina* populations and outplanted and wild *C. grimesiana* subsp. *obatae* sites. These localized grids are maintained every 4 to 6 weeks. Grids are centered around and extend slightly beyond the boundaries of the population being protected.

Localized Rodent Control Actions:

Year	Action	Quarter
MIP YEAR 5 Oct.2008-Sept.2009 through MIP YEAR 6 Oct.2009-Summer 2010	• MAU-A Mauna Kapu grid restock, every 6 weeks • Palikea Site 1 grid restock, every 6 weeks • PAK-I grid restock, every 6 weeks • Palikea Site 2 grid restock, every 6 weeks • Palikea Site 3 grid restock, every 6 weeks • Palikea Site 4 grid restock, every 6 weeks • Palikea Exclosure grid restock, every 6 weeks • Palikea Ie Ie Patch grid restock, every 6 weeks • PAK-C Lunch Puu grid restock, every 6 weeks • PAK-H grid restock, every 6 weeks • PAK-L grid restock, every 6 weeks • PAK-D grid restock, every 6 weeks	• 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4 • 1-4
MIP YEAR 7 Fall 2010	• Phase out localized baiting grids	• 3

MU Rodent Control:

- Threatened resources are widespread throughout the Palikea MU. The habitat quality is high, and the MU is small enough to treat easily but large enough to test the effectiveness of a large scale trapping grid. This pilot project will be implemented in the summer of 2010, and will be designed to run for several years. Monitoring of rat activity via tracking tunnels will be vital in determining whether control is having the desired effect, as will intensive monitoring of *A. mustelina* populations and *C. grimesiana* subsp. *obatae* outplanting and wild plants.

MU Rodent Control Actions:

Year	Action	Quarter
MIP YEAR 6 Oct. 2009-Sept.2010	• Install/deploy wooden snap trap box grid across MU • Run snap trap grid daily during initial knockdown phase • Run snap trap grid 2x a month once initial knockdown complete; this frequency will in part be determined by the acceptable level of rat activity • Monitor tracking tunnels, 1x a quarter until knockdown, then 2x a quarter • Monitor Cyagri fruit production & predation • Monitor Achmus ground shell plots 1x a year • Monitor Arthropods 1x a year	• 2 • 3 • 3-4 • 1-4 • 1-4 • 1-4 • 1-4
MIP YEAR 7 Oct.2010-Sept.2011	• Run trapping grid 2x month • Monitor tracking tunnels, 6x a year • Evaluate efficacy of MU-wide grid, decide how to modify actions and continue project • Monitor Cyagri fruit production & predation • Monitor Achmus ground shell plots 1x a year • Monitor Arthropods 1x year	• 1-4 • 1-4 • 4 • 1-4 • 1-4 • 1-4
MIP YEAR 8 Oct.2011-Sept.2012	• Run trapping grid 1x month • Monitor tracking tunnels, 6x a year • Monitor Cyagri fruit production & predation • Monitor Achmus ground shell plots 1x a year	• 1-4 • 1-4 • 1-4 • 1-4
MIP YEAR 9 Oct.2012-Sept.2013	• Run trapping grid 1x month • Monitor tracking tunnels, 6x a year • Monitor Cyagri fruit production & predation • Monitor Achmus ground shell plots 1x a year	• 1-4 • 1- 4 • 1-4 • 1-4

1.4.8.6 Ant Control

Species: *Cardiocondyla venustula*, *Solenopsis papuana*

Threat level: Low

Control level: Only for new incipient species

Seasonality: Varies by species, but nest expansion observed in late summer, early fall

Number of sites: 4 (*Drosphila aglaia, D. hemipeza, D. montgomeryi* sites, trails, and fenceline)

Acceptable Level of Ant Activity: Current level acceptable

Management Objective:

- If incipient species are found and deemed to be a high threat and/or easily eradicated locally (<0.5 acre infestation) begin control using a bait containing Hydramethylnon (Amdro, Maxforce or Seige).

Monitoring Objective:

- Continue to sample ants at human entry points (landing zones, fence line, trails) a minimum of once a year. Use samples to track changes in existing ant densities and to alert OANRP to any new introductions.
- Sample ants at *Drosphila aglaia, D. hemipeza, D. montgomeryi* sites annually, as ants are likely to attack immature larvae.

Ants have been documented to pose threats to a variety of resources, including native arthropods, plants (via farming of Hemipterian pests), and birds. The distribution and diversity of ant species in upland areas on Oahu, Palikea, has only begun to be studied and changes over time. Impacts to the rare species present in Palikea remain unknown, but it is likely they are having some type of effect on the ecosystem at large. OANRP have already conducted some surveys across Palikea to determine which ant species are present and where they are located. Surveys were conducted using a standardized sampling method (see Appendix Invasive Ant Monitoring Protocol this document). *Solenopsis papuana* and *Cardiocondyla venustula* were found outside forested areas (on ridges) in low densities. Ant species present widely established, therefore control is not recommended at this time.

Ant Control Actions:

Year	Action	Quarter
OIP YEAR 6 Oct.2009-Sept.2010	• Conduct additional surveys for ants as needed • Analyze results of surveys, develop management plan	• 1, 2 • 3,4
OIP YEAR 6 Oct.2009-Sept.2010 through OIP YEAR 9 Oct.2012-Sept.2013	• Implement control if deemed necessary • Conduct arthropod survey along transects in anticipation of rat trap out project.	• 1-4

1.4.8.7 Slug Control

Species: *Limax maximus, L. flavus, Meghimatium striatum Deroceras leave*

Threat level: High

Control level: Localized

Seasonality: Wet season (September-May)

Number of sites: 2 (*Cyanea grimesiana* subsp. *obatae* populations)

Primary Objective:

- Reduce slug population to levels where germination and survivorship of rare plant taxa are optimal.

Management Objective:

- Begin a pilot slug control program in the fall of 2011 using Sluggo around the *Cyanea grimesiana* subsp. *obatae* populations if additional Special Local Needs labeling is approved by USFWS and HDOA.
- By 2013, reduce slugs by at least 50% of estimated baseline densities around the *Cyanea grimesiana* subsp. *obatae* populations through a pilot control program.

Monitoring Objectives:

- Determine slug species present and estimate baseline densities using traps baited with beer in the fall of 2010
- Annual census monitoring of *Cyanea grimesiana* subsp. *obatae* seedling recruitment following fruiting events
- Annual census monitoring of slug densities during wet season

Effective molluscicides have been identified (Sluggo) and initial control programs are ongoing in Kahanahaiki. A pilot slug control program using Sluggo could begin at Palikea in the fall of 2011 should slug and *Cyanea grimesiana* subsp. *obatae* monitoring reveal slug damage to plants. If large-scale rat control is implemented, plots to monitor the effect of predator removal on slug population (if not already determined in other areas) may be considered.

Slug Control Actoins:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Monitor slug activity at *Cyanea grimesiana* subsp. *obatae* via traps baited with beer	• 1-4
MIP YEAR 7 Oct.2010-Sept.2011	• Deploy slug bait around *Cyanea grimesiana* subsp. *obatae* frequency to be determined during research phase.	• 1-4
MIP YEAR 8 Oct.2012-Sept.2013	• Maintain slug bait around *Cyanea grimesiana* subsp. *obatae*	• 1-4

1.4.8.8 Predatory Snail Control

Species: *Euglandina rosea* (rosy wolf snail), *Oxychilus alliarus* (garlic snail)

Threat level: High

Control level: Localized

Seasonality: Year-Round

Number of sites: None, potentially 13 (*A. mustelina* sites)

Acceptable Level of Activity: Unknown

Primary Objective:

- Reduce predatory snail populations to a level optimal for *A. mustelina* survival.

Management Objective:

- Continue to develop better methods to control predatory snails
- Keep sensitive snail populations safe from predatory snails via currently accepted methods (such as hand removal of alien snails, construction of barriers which prevent incursion from alien snails)

Monitoring Objectives:

- Annual or every other year census monitoring of *A. mustelina* population(s) to determine population trend.
- Annual searches for predatory snails to confirm their absence or presence in proximity to *A. mustelina.*

No baits have been developed for the control of predatory snails. Little is known regarding their distribution and prey preference. Control is limited to hand removal. Visual searches are time-consuming, difficult, and not feasible over large areas and in steep terrain. It is also unknown whether predatory snail populations are, in fact, reduced by hand removal. *Euglandina rosea* has been found in this MU, but in low numbers. No searches for *O. alliarus* have yet been completed.

Predatory Snail Control Actions:

Year	Action	Quarter
OIP YEAR 3 Oct.2009-Sept.2010	• Determine if any *E. rosea* or *O. alliarus* snails are present at the *A. mustelina* sites	• 1-4
OIP YEAR 4-6 Oct.2010- Sept.2013	• Implement control as improved tools become available	• 1-4

Euglandina rosea

1.4.8.9 Jackson's Chameleon Control

Threat: *Chamaeleo jacksonii* subsp. *xantholophus* (Jackson's Chameleon)

Threat level: Unknown, perhaps High

Control level: Localized

Seasonality: Year-Round

Number of sites: None, potentially 13 (*A. mustelina* sites)

Acceptable Level of *C. jacksonii* Activity: Unknown

Primary Objective:

- Determine if *C. jacksonii* pose a threat in the MU.

Secondary Objectives:

- Determine if *C. jacksonii* are still present along the Palehua road.
- Determine if *C. jacksonii* are having an impact on *A. mustelina* in the MU.

Management Objective:

- By end of 2010, conduct a distribution survey for *C. jacksonii* along Palehua Road and through the residential area.
- By end of 2010, survey the Palikea MU and determine whether *C. jacksonii* are present in the MU.
- If needed, develop a control technique and strategy for *C. jacksonii*.

Monitoring Objectives:

- If a resident population of *C. jacksonii* exists, monitor extent and geographic distribution regularly.

Recent discovery of *A. mustelina* shells in the stomachs of *C. jacksonii* found in the Puu Kumakalii region suggests that beleaguered tree snails have yet another predator. Too little is known about the possible threat *C. jacksonii* pose to rare taxa to know how serious the threat is. Palikea is home to a large population of *A. mustelina*. NRS have reported seeing *C. jacksonii* along the Palehua road, the primary access point for Palikea. No chameleons have been seen in the MU itself, despite numerous day and night surveys conducted for *A. mustelina* monitoring. Additional surveys are vital to determining the extent of the chameleon population in the region. Once more information is known about the distribution of and threats posed by *C. jacksonii*, NRS will update the five year plan for Palikea.

Jackson Chameleon Actions:

Year	Action	Quarter
MIP YEAR 6 Oct.2009-Sept.2010	• Survey for *C. jacksonii* along Palehua road/ cabins • Survey for *C. jacksonii* in MU fence. • Depending on survey findings, plan action items and control for next 5 years	• 1 • 2 • 3
MIP YEAR 7 Oct.2010-Sept.2011 through MIP YEAR 10 Oct.2013- Sept.2014	• Survey/ control *C. jacksonii* as deemed necessary	• 1-4

1.4.8.10 Fire Control

Threat Level: Low

Available Tools: Fuelbreaks, Visual Markers, Helicopter Drops, Wildland Fire Crew, Red-Carded Staff

Management Objective:

- To prevent fire from burning any portion of the MU at any time.

Preventative Actions

There is little infrastructure/construction which would be helpful to reduce fire threat. NRS will focus on maintaining good communication with the Wildland Fire Working Group to facilitate positive on-the-ground fire response in the event of another catastrophic Nanakuli brushfire. NRS will maintain red-carded staff to assist with fire response.

Nanakuli Fire

Fire burning up leeward slopes in Nanakuli, towards the Waianae summit and Palikea

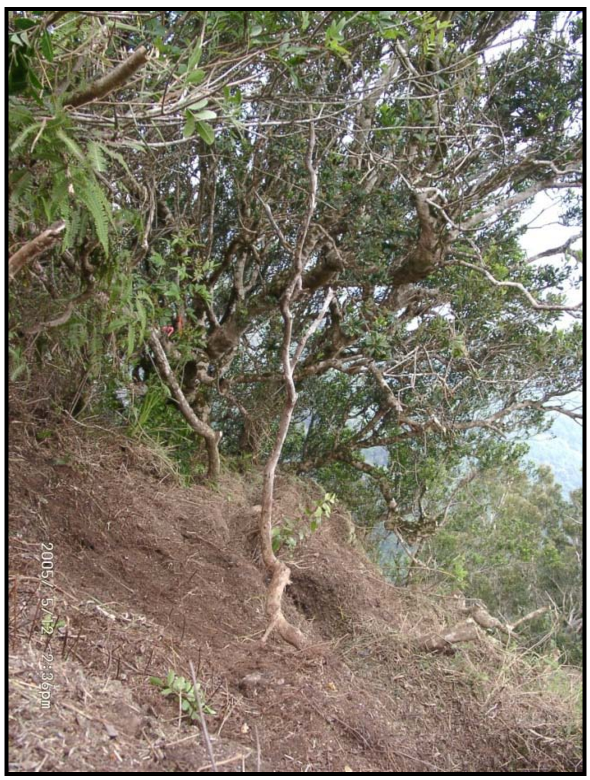
Grass control in the MU is discussed in the Weed Control section of the plan. Appropriate WCAs are listed here: PalikeaNoMU-03

Fire Actions: Non-weed related fire actions include the following

Year	Action	Quarter
MIP YEAR 5 Oct.2008-Sept.2009	• Maintain LZs on ridgeline • Decide whether to construct catchment on top of ridge • Construct catchment	• 2, 3 • 1, 2
MIP YEAR 6 Oct.2009-Sept.2010 through MIP YEAR 10 Oct.2013-Sept.2014	• Maintain LZs on ridgeline • Maintain catchments as needed	• 2, 3 • 1-4

Fire Mitigation Activities at Palikea

Receiving a watertank above the *C. grimesiana* fence



Fuel break along the ridge

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CHAPTER 2: FIVE YEAR RARE PLANT PLANS

2.1 INTRODUCTION

OANRP has begun to develop detailed plans for each IP plant taxon. These plans are intended to ocument all pertinent information for stabilization. In many cases, data or information is still being gathered and these plans are will continue to be updated. A brief description of each slide is given here:

Species Description: These first slides provide an overview of each taxon. The IP stability requirements are given along with a taxon description, biology, distribution, population trends, habitat and taxonomic history. Much of this information was transcribed from the original MIP and OIP documents and has been updated by OANRP.

Reproductive Biology Table: OANRP has begun to document basic information to inform management strategies. This information was summarized by OANRP based on best available data from the MIP, OIP, USFWS 5-year Status Updates, OANRP field observations and other published research. Phenology is primarily based on observations in the OANRP rare plant database. The suspected pollinator is based on pollinator syndromes as reported in the MIP and OIP. The information on seeds is from data collected at the Army seed lab and from collaborative research with the USDA National Center for Genetic Resources Preservation (NCGRP) and Lyon Arboretum.

Pictures: These are intended to document habitat, habit, floral morphology and variation, all stage/age classes and many stages of maturing fruit and seed. This should serve as a reference for field staff making collections and searching for seedlings.

Species Occurrence Maps: Detailed maps will be provided for OANRP and the IT. These will display historic and current locations, MUs, landmarks and any other useful geographic data for each taxon. Larger features may be used on public documents to obscure locations of rare elements.

Population Units: A summary of the PUs for each taxon is provided with current management designations, action areas and management units.

Population Structure: A discussion of the observed structure for each PU and a plan to establish or maintain structure at levels that will sustain stability goals. A history of observed structure is given to provide a background for developing strategies. In many cases, establishing or documenting a healthy stable population structure may require developing new techniques (sub-sampling) or overcoming legal obstacles (slug control).

Monitoring Plan: Current techniques and plans are discussed in this section. Monitoring of the *in situ* and reintroduction populations will be conducted to determine progress toward attaining taxon stability. Data to be collected may include number, vigor, and phenological phase of all or samples of the individuals in the PU by size class. This information may 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.

Genetic Storage Section: This section provides an overview of propagation and genetic storage issues. A standardized table is used to display information recorded for each taxon, or PU where applicable. The plan for genetic storage is displayed and discussed. In most cases, seed storage is the preferred genetic storage technique; as it is the most cost-effective method, requires the least amount of maintenance once established, and captures the largest amount of genetic variability. For taxa that do not produce enough mature seed for collection and testing, micropropagation is considered the next best genetic storage technique. The maintenance of this storage method is continual, but requires much less resources and personnel than establishing a living collection. For those taxa that do not produce seed that can be stored and cannot be established in micropropagation, a living collection of plants in the greenhouse or an inter-situ site is the last preferred genetic storage option. The preferred genetic storage method is displayed and in most cases current research is ongoing to determine the most applicable method. For species with substantial seed storage data, a schedule may be proposed for how frequently seed bank collections will need to be refreshed to maintain genetic storage goals. This schedule is solely based on storage potential for the species, and other factors such as threats and plant health must be applied in order to recalculate how frequent refresher collections need to occur for a particular plant. Viability trends for seeds in storage can only be extrapolated when viability has been observed to decline. Therefore, the frequency will constantly be adjusted to reflect the most current storage data. However, for a taxon that has shown little to no decrease in viability after a period of time, this length of time is obviously shorter than necessary to maintain genetic storage goals. For example, *Delissea waianaeensis* shows no decrease in viability after five years. NRS would not have to re-collect every five years as the number of viable seeds in storage would not have yet begun to drop. But since a storage trend cannot be predicted, it is impossible to select an appropriate collection frequency greater than five years. Therefore, the recommended frequency remains five years. The status of seed storage research is displayed. Collaborative research with the USDA National Center for Genetic Resources Preservation (NCGRP) and Lyon Arboretum Seedlab is ongoing.

Reintroduction Plan: A standardized table is used to display the plans for each PU. Each outplanting site in each PU is displayed shoeing the number of plants to be established, the PU stock and number of founders to be used and type and size of plant. Comments focus on details of propagation and planting stragtegies and provide a schedule for completing many of the planned reintroductions.

5-Year Action Plan: This slide displays a table to be used by OANRP staff to schedule actions for each PU. All monitoring, collection, outplanting and threat control is planned by 'MIP or OIP Year' and the corresponding calendar dates are listed. Comments focus on details of certain actions or explain the phasing or timeline in some PUs.

2008-2009 Stabilization Goals Update: For each PU, the status of compliance with stability goals is displayed. Three or four PUs are listed for each taxa. 'YES, NO or PARTIAL' are used to represent compliance with each stability goal. For population targets, whether or not the each PU has enough mature plants is displayed, followed by an estimate on whether a stable population structure is present. Threats are listed separately for each PU. The boxes are shaded to display whether each threat is present at each PU. A dark shade identifies PU where the threat is present and the lighter shaded boxes where the threat is not applicable. The corresponding status of threat control is listed for each PU. A summary of the status of genetic storage is displayed in the last column. This section will become part of the 2010 OANRP Annual Report for all IP taxa.

The last section in each 5-Year Plan is the taxon update from the current year. This includes the 2008-2009 Highlights/Issues, MIP Year 6 Plans, Taxon Status Table and the Gentic Storage Status Table.

2.2 FIVE YEAR PLANS

The PowerPoint slides containing the five year plans for the species *Chamaesyce herbstii*, *Cyanea grimesiana* subsp. *obatae*, *Cyanea superba* subsp. *superba*, *Delissea waianaeensis*, *Hedyotis parvula*, *Pritchardia kaalae*, and *Stenogyne kanehoana* are included in this section.

Chamaesyce herbstii

- **Scientific name:** *Chamaesyce herbstii* W. L. Wagner
- **Hawaiian name:** *`akoko*
- **Family:** Euphorbiaceae (Spurge family)
- **Federal status:** Listed endangered on October 10, 1996
- **Requirements for MIP Stability**
  - 3 Population Units (PUs)
  - 25 reproducing individuals in each PU (long-lived perennial)
  - Stable population structure
  - Threats controlled
  - Complete genetic representation of all PUs in storage
- **Description and biology:** *Chamaesyce herbstii* is a milky-sapped tree 3-8 m tall. The leaves are usually 8-19.5 cm long, oppositely arranged, and held in a horizontal plane. The inflorescences are open, branched, measure 7-17 cm long, and bear 3-15 cyathia (specialized flower-like inflorescences with a single central female flower surrounded by much-reduced male flowers). The capsules measure 5-10 mm long, and up to 8 mm in diameter, are colored green or green and red, and contain three seeds (excerpt from MIP 2003).
- **Known distribution:** *Chamaesyce herbstii* has a disjunct range. It has been recorded from elevations of 530-700 m. The main portion of the species' range is in the northern portion of the Waianae Mountains in the Mokuleia region. Two population units were known from this region: Makaleha and the adjacent gulches of Pahole and Kapuna. The third unit was known from the southern Waianaes in South Ekahanui Gulch in Honouliuli. (excerpt from MIT 2003).

Makua Implementation Team (MIT). 2003. Final Makua Implementation Plan. Prepared for the U.S. Army Garrison, Schofield Barracks, HI..

Chamaesyce herbstii

- **Population trends:** *C. herbstii*'s population units have been decreasing in number, and the numbers of plants in them have been shrinking . Only 1 of the 3 recorded *C. herbstii* population units is now extant. The population in South Ekahanui Gulch was first discovered in the late 1970's, when 15 mature trees and several seedlings were reported. In 1987, the number was reported to be about 11 trees. The number declined to four trees by 1991, and two trees by 2000. The last two trees died in 2001. In Makaleha, it was described as being "locally dominant" in a very small area in 1950 (Hatheway 1952). In 1987, 10-12 were recorded by Steve Perlman, but none were observed when he searched the site again in 2001. The only extant population unit is in Pahole and Kapuna gulches of the Pahole NAR. It was estimated to have about 170 trees in the MIP in 2003. By 2005, the estimates were revised and 56 trees were known. In 2008, a total of 45 wild plants were known.

- **Habitat:** *Chamaesyce herbstii* typically grows in gulch bottoms and on gulch slopes. It usually occurs in mesic forests dominated by a diverse mix of tree species.

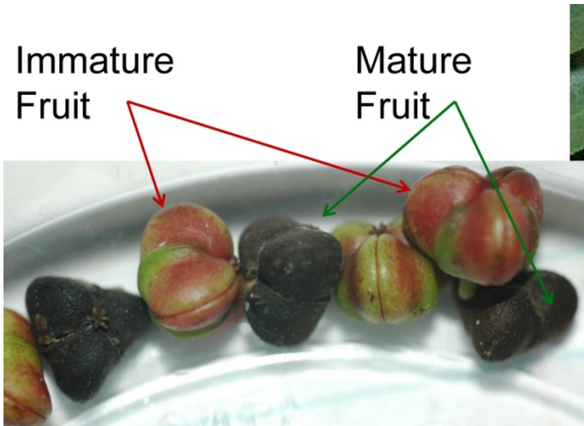
- **Taxonomic background:** There are 16 native species of *Chamaesyce* in Hawaii; all are endemic. Several alien species of this genus are also found in Hawaii. The genus *Chamaesyce* is considered by some to be a subgenus of the large genus *Euphorbia* (Koutnik 1987). The elevation of *Chamaesyce* to the genus level leaves only a single Hawaiian *Euphorbia*, *E. haeleeleana*, which occurs only on Kauai and the Waianae Mountains of Oahu.

Reproductive Biology Table

	Observed Phenology			Reproductive Biology		Seeds	
Population Unit	Flower	Immature Fruit	Mature Fruit	Breeding System	Suspected Pollinator	Average # Per Fruit	Dormancy
ALL	July-Oct	Aug-Jan	Oct-Feb	Monoecious (cyathia)	Insect	3*	Not Dormant

* Ovary 3-carpellate but often only 0-1 seed per fruit observed

- Bees and flies visit the flowers of *C. herbstii* (Lau pers. comm. 2000), and presumably act as pollination agents for the taxon.
- Mature *Chamaesyce* capsules split open explosively when they dry, flinging the seeds for a short distance.
- *C. herbstii* has a copious amount of sticky substance on its seeds. Dispersal of its seeds in pre-human times is thus theorized to have been carried out by birds, including the many now extinct flightless Hawaiian birds (excerpt from MIT 2003).



Map removed, available upon request

Population Units

Manage For Stability Population Units	PU Type	Which Action Area is the PU inside?	Management Units for Threat Control
Pahole to Kapuna	In situ and Augmentation	MMR	Pahole and Kapuna
Makaha	Introduction	None	Makaha Subunit I
West Makaleha	Reintroduction	None	West Makaleha
Genetic Storage Population Units			
None			

Population Structure

- In the Pahole to Kapuna PU, seedlings are observed and become established as immature plants at both the in situ and augmentation sites.
- In Makaha, outplanted immature plants have been observed to mature and flower. Seedlings were observed at the reintroduction in Makaha less than two years after reintroducing immature plants.
- As the population structure develops, OANRP will track survivorship of seedlings and immature plants.
- If population structure in Makaha will maintain the stabilization goal of 25 mature plants, no further planting may be needed. If monitoring shows that survivorship may not be sufficient to maintain the stability goal, the management strategy will be adapted.

Population Unit Monitoring History

Population Unit	2003 Mat/Imm/Seedling	2005 Mat/Imm/Seedling	2007 Mat/Imm/Seedling	2008 Mat/Imm/Seedling	2009 Mat/Imm/Seedling
Pahole to Kapuna **in situ**	(170)/0 (combined Mat & Imm)	40/5/0	49/12/0	34/1/0	32/7/0
Pahole to Kapuna **outplanted**	0	0	0/18/0	21/44/0	23/67/3
Makaha **outplanted**	0	0	0/22/0	6/22/0	19/29/28

Monitoring Plan

- All PUs will be monitored annually for population structure, trends and threats.
- All individuals at outplanting sites will be monitored twice annually for reproductive status, vigor and growth.
- New seedlings at all sites will be counted and areas with seedlings will be delineated on sketch maps. New immature plants at all in situ sites will be tagged and monitored to track survivorship and growth.
- After three years of records from the annual census of seedlings and growth rates and survivorship of immature plants, projections of population structure will be developed.

Genetic Storage Plan

What propagule type is used for meeting genetic storage goal?	What is the source for the propagules?	What is the Genetic Storage Method used to meet the goal?	What is the proposed re-collection interval for seed storage?	Is seed storage testing ongoing?	Plan for maintaining genetic storage.
Seeds	Reintroductions	Seed banking	5+ years	Yes	Collections will be made from reintroductions as needed.

Genetic Storage Plan Comments: Seed storage protocols are still being developed. Complete five-year results, with storage condition recommendations, will be available in 2012. Seeds have germinated after four years of storage. To allow for as much in situ regeneration as possible, collections for genetic storage are not made from wild plants. Collections from wild plants are grown and outplanted. Seed collections from the outplanted individuals will be stored to represent all available founders.

Reintroduction Plan

Population Unit	Reintroduction Site(s)	Number of Plants to be planted	Propagule Type	Propagule Population(s) Source	Number of Founders in Source Population.	Plant Size	Pot Size
Pahole to Kapuna	Pahole: PAH-R	112	Immature plants	Kapuna & Pahole	56	To Be Determined	1 gal. round or tall
Pahole to Kapuna	Kapuna: KAP-A (NARS planting)	0					
Makaha	Makaha: MAK- A	112	Immature plants	Kapuna & Pahole	56	To Be Determined	1 gal. round or tall
West Makaleha	LEH- A – Not yet established	112	Immature plants	Kapuna & Pahole or Makaha	56	To Be Determined	1 gal. round or tall

Reintroduction Plan Comments

- The reintroduction in the Pahole to Kapuna PU began in February 2006 and will continue until the founders are balanced. Most founders are currently represented at this site and the planting may require two more years to complete.
- The Kapuna site is not an OANRP site and is not used. Oahu NARS staff had grown two immature plants from seed collected in the area and planted them in 1995. Both plants have matured and flowered and are still there and healthy.
- *C. herbstii* was first planted in Makaha by OANRP in March of 2007. This planting may require three more years to complete.
- There has been regeneration of seedlings in the outplanting sites at both the Makaha and Pahole to Kapuna PUs so that a single outplanting effort may result in a healthy population structure.
- The West Makaleha reintroduction will begin once construction of the management unit fence is complete. This reintroduction will be established using seed collected from the founders remaining in the in situ sites in the Pahole to Kapuna PU. If that founder has died and is represented in the Makaha reintroduction, collections from those plants will be used to represent it.

5 Year Action Plan

	Proposed Actions for the following years:				
Population Unit	MIP YEAR 6 Oct 2009 – Sep 2010	MIP YEAR 7 Oct 2010 – Sep 2011	MIP YEAR 8 Oct 2011 – Sep 2012	MIP YEAR 9 Oct 2012- Sep 2013	MIP YEAR 10 Oct 2013- Sep 2013
Pahole to Kapuna	•Reintroduce •Monitor all sites •Collect for propagation	•Reintroduce •Monitor all sites •Collect for propagation	•Monitor all sites •Collect for propagation	•Monitor	•Monitor
Makaha	•Reintroduce •Monitor outplantings	•Reintroduce •Monitor outplantings	•Monitor •Collect for propagation & GS	•Monitor •Collect for propagation & GS	•Monitor & Collect
West Makaleha	•None	• Begin fence construction	•Reintroduce •Monitor	•Reintroduce •Monitor	•Reintroduce •Monitor

2008-2009 Stabilization Goals Update

MFS Population Units	PU Stability Target		MU Threat Control						Genetic Storage
	Has the Stability Target for mature plants been met?	Does the PU have observed structure to support the stability target in the long-term?	Ungulates	Weeds	Rodents	Fire	Slugs	BTB	Are there enough propagules in Genetic Storage?
Pahole to Kapuna	YES	NO	YES	YES	NO	NO	NO	NO	YES
Makaha	YES	NO	YES	YES	NO	NO	NO	NO	N/A
West Makaleha	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

West Makaleha will be established once the fence is complete, therefore N/A for many columns. Pahole to Kapuna is the only PU with in situ stock. Makaha and West Makaleha will be established with this stock. Although structure to support stability targets has not yet been meet there is regeneration on site. Hopefully, these goals can be met with more mature plants within the PUs. Other threats have not been observed to impact this taxa.

2008-2009 Highlights

Major Highlights/Issues MIP Year 5

- The stability goal of 25 individuals is met for the Pahole to Kapuna PU. There are new naturally occurring seedlings and immature plants in the wild and reintroduction sites.
- The Makaha fence was declared pig free in the summer of 2009 and OANRP continue to assist NARS in removing ungulates from the Kapuna fences.
- OANRP continue to supplement the reintroduction at the Makaha PU with additional founders. Naturally occurring seedlings and immature plants are at this site and the stability goal of 25 reproducing individuals should be met in the next year.

Plans for MIP Year 6

- Conduct census monitoring and continue to track survivorship of F1 plants
- Continue to supplement the reintroduction for the Makaha PU
- Collect seeds from unrepresented founders in the Pahole to Kapuna PU to propagate for the reintroduction sites
- Collection for genetic storage will begin once the remaining founders are represented in the reintroductions and begin to flower

2008-2009 Taxon Status Table

Action Area: In

TaxonName: Chamaesyce herbstii TaxonCode: ChaHer

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kapuna to Pahole	Manage for stability	32	7	0	25	67	0	57	55	0	57	74	0	More plants were added to the reintroduction site and three new juvenile plants were observed within the outplanting
	Total for Taxon:	32	7	0	25	67	0	57	55	0	57	74	0	

Action Area: Out

TaxonName: Chamaesyce herbstii TaxonCode: ChaHer

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Makaha	Manage reintroduction for stability	0	0	0	19	29	28	6	23	0	19	29	28	18 immatures were planted and many new immature plants and seedlings were observed in the last year
West Makaleha	Manage reintroduction for stability	0	0	0	0	0	0	0	0	0	0	0	0	The reintroduction will begin once the MU fence is complete
	Total for Taxon:	0	0	0	19	29	28	6	23	0	19	29	28	

2008-2009 Genetic Storage Status Table

	# 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
Chamaesyce herbstii							
Kapuna to Pahole	32	7	27	20	0	14	10
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				20	0	14	10

Cyanea grimesiana subsp. *obatae*

- **Scientific name:** *Cyanea grimesiana* Gaud. subsp. *obatae* (St. John) Lammers
- **Hawaiian name:** *Haha, ohawai*
- **Family:** Campanulaceae (Bellflower family)
- **Federal status:** Listed endangered July 27, 1994
- **Requirements for Stability**
  - 4 Population Units (PUs) (4 due to presence in two action areas)
  - 100 reproducing individuals in each PU (short-lived perennial with large fluctuations in population size and recent history of decline)
  - Stable population structure
  - Threats controlled
  - Complete genetic representation of all PUs in storage
- **Description and biology:** *Cyanea grimesiana* subsp. *obatae* is a shrub 1-3.2 m tall, and is either single-stemmed or sparingly branched. The leaves are pinnately divided, measure 27-58 cm long, and are clustered towards the tips of the stems. The six to 12 flowered inflorescences are borne among the leaves. The corollas are curved, usually yellowish white with purple and measure 55-80 mm long. The berries are orange at maturity, and measure 18-30 mm long.

  As with other *Cyanea*s with their long tubular flowers, this taxon is thought to have been pollinated by nectar-feeding birds. It is capable of self-pollination, evidenced by the fact that isolated plants produce viable seeds. The taxon's orange berries are indicative of seed dispersal by fruit-eating birds. *Cyanea grimesiana* subsp. *obatae* presumably lives for less than 10 years like other *Cyanea*s of its size, and is thus a short-lived taxon for the purposes of the Implementation Plan. (MIT 2003)

Cyanea grimesiana subsp. *obatae*

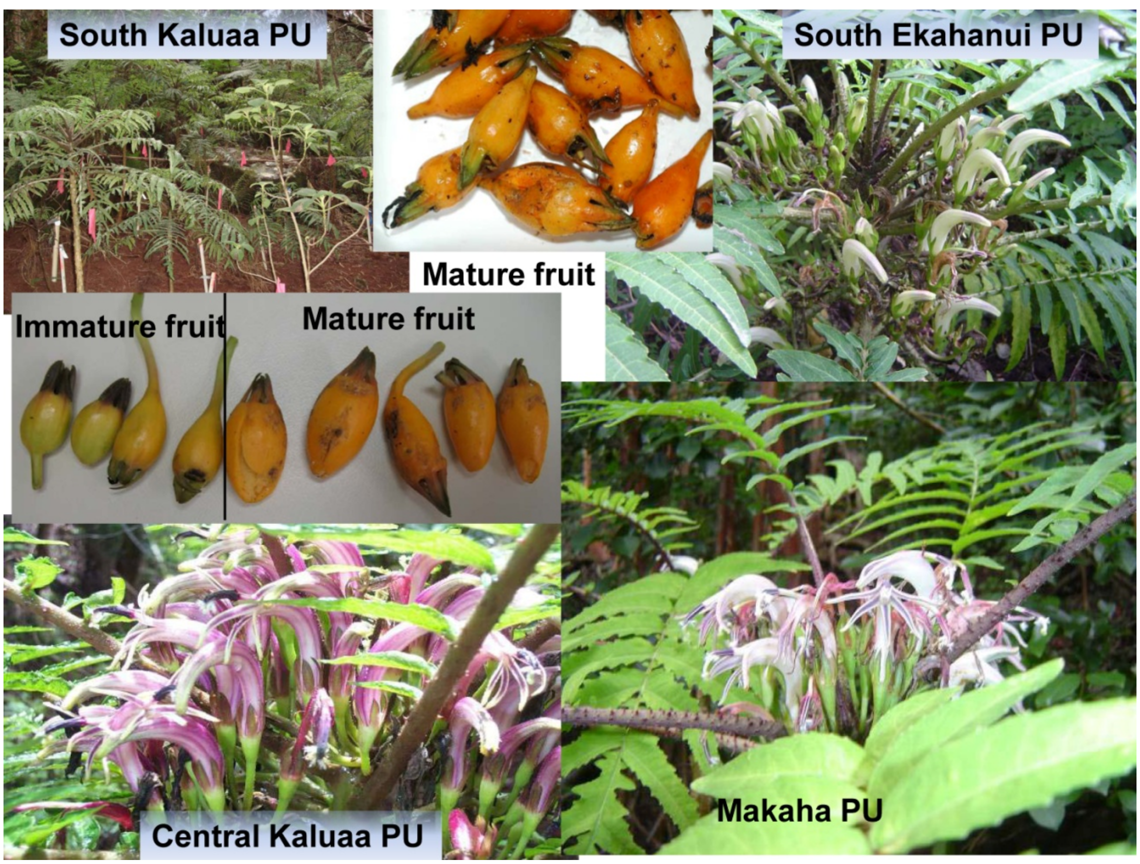
- **Known distribution:** *C. grimesiana* subsp. *obatae* was discovered in 1965 and until the 1990s, was known only from the southern and central Waianae Mountains. The species is now also known from the Mokuleia region of the northern Waianae Mountains and from Makaha Valley. It ranges from 550-670 meters in elevation.
- **Population trends:** Most of the *C. grimesiana* subsp. *obatae* population units have not been known for very long, but those that have been tracked for at least 15 or 20 years have either died out or declined markedly. The known Ekahanui plants had died by 2004. The wild population at the Palikea (South Palawai) site has grown significantly from 18 individuals in 1999 to 52 in 2009. The plant in Central Kaluaa was discovered in 2004 and an immature plant was observed there in 2009. The South Kaluaa plant died in 2005. The Makaha plant was discovered in 2005. The Palikea Gulch PU was discovered in 1999 and has not yet matured.
- **Habitat:** *Cyanea grimesiana* subsp. *obatae* grows in mesic forests, usually in partly sunny to shady locations in gulch bottoms or on gulch slopes. The plants often grow on steep to vertical embankments consisting of rock or a mix of rock and soil.
- **Taxonomic background:** *Cyanea grimesiana* includes two subspecies; *obatae* and *grimesiana* subsp. *grimesiana*, has been recorded primarily in the Koolau Mountains of Oahu, but has also been found in the northern and central Waianae Mountains and on Molokai. The two subspecies are distinguished by the size and shape of their calyx lobes. Certain *Cyanea* populations on Molokai, Maui, Lanai, and Hawaii formerly included in *C. grimesiana* have recently been recognized as constituting three separate species (Lammers 1998).

Reproductive Biology Table

	Observed Phenology			Reproductive Biology		Seeds	
Population Unit	Flower	Immature Fruit	Mature Fruit	Breeding System	Suspected Pollinator	Average # Per Fruit	Dormancy
Central Kaluaa	Mar-Aug	July-Aug	July-Aug	hermaphroditic	Bird*	186 ± 225	Not Dormant
Palikea (South Palawai)	July-Oct	Oct-Dec	Nov-Jan	hermaphroditic	Bird*	236 ± 150	Not Dormant
Makaha	July-Oct	Sept-Nov	Oct-Dec	hermaphroditic	Bird*	94 ± 18	Not Dormant
Pahole to West Makaleha	July-Oct	Sept-Nov	Oct-Dec	hermaphroditic	Bird*	355 ± 146	Not Dormant
North branch of South Ekahanui	May-Aug	May-Feb	Feb? (range TBD)	hermaphroditic	Bird*	430 ± 111	Not Dormant
Palikea Gulch	Plant is immature	TBD	TBD	hermaphroditic	Bird*	236 ± 150	Not Dormant
South Kaluaa	May-Aug	July-Sept	Aug-Sept	hermaphroditic	Bird*	236 ± 150	Not Dormant

*Smith, T.B. L.A. Freed, J.K. Lepson, J.H. Carothers. 1995.
Evolutionary Consequences of Extinctions in Populations of a Hawaiian Honeycreeper. Conservation Biology 9: 1, 107-113.

*Lammers, T.G. & C.E. Freeman. 1986. Ornithophily among the Hawaiian Lobelioideae (Campanulaceae): evidence from nectar sugar compositions. American Journal of Botany 73: 1613-1619.



Map removed, available upon request

Population Units

Manage For Stability Population Units	PU Type	Which Action Area is the PU inside?	Management Units for Threat Control
Central Kaluaa	Both in situ and augmentation	None	Kaluaa and Waieli
Palikea (South Palawai)	Both in situ and augmentation	None	Palikea
Makaha	Both in situ and augmentation	None	Makaha
Pahole to West Makaleha	Both in situ and augmentation	MMR	Pahole and West Makaleha
Genetic Storage Population Units			
North branch of South Ekahanui	Reintroduction	None	Ekahanui
Palikea Gulch	in situ	SBMR	None
South Kaluaa	Reintroduction	None	Kaluaa and Waieli

Population Structure

- Regeneration of seedlings has been observed at a few wild sites since 1999, (West Makaleha, Palikea (South Palawai), and Central Kaluaa), but not from any outplantings. Planted individuals have matured and produced viable fruit at sites in Pahole, Ekahanui, Kaluaa and Palikea (South Palawai) but no regeneration has been observed. It may be that seedlings are too difficult to distinguish until several true leaves emerge and are being depredated by slugs. Therefore, significant numbers of seedlings and immature plants may be needed to maintain population stability goals. All PUs will need augmentation or reintroductions to establish the population structure to meet and maintain stability goals.
- Slugs are thought to depredate seedlings of *C. grimesiana* subsp. *obatae* and may limit regeneration of seedlings at most PUs. Slug control may be needed at all PUs before seedlings and immature plants are able to become established.
- Plants are observed to grow slowly and have high mortality rates in all size classes. However, due to limited observations of natural regeneration, little data is available on growth rates and survivorship of young plants. The immature plant was discovered in Palikea Gulch in 2000, when the plant was less than 10 cm tall. This plant has been monitored regularly since, but has not yet been observed to have flowered.
- At Palikea (South Palawai), the developing population structure is being closely monitored as it is the only site with significant recruitment. Seedlings have been observed to survive to be immature plants. Data on stage class distribution and survivorship will be collected and management adapted accordingly.
- OANRP will develop techniques to increase seedling establishment at all sites. Particularly at sites where slug control with Sluggo may not be possible due to the presence of rare snails, trials may include collecting mature fruit and applying fruit to adjacent substrates. Potential sites to be considered include Central Kaluaa and Makaha.
- Mature fruits have been removed from in situ plants and smeared on adjacent slopes and cliffs. Immature plants were observed to emerge from this effort, but died before maturing. Additional fruit smears at Kaluaa and Pahole did not result in any surviving plants and results at Palikea (South Palawai) were inconclusive.
- OANRP will continue to pursue a new label for Sluggo so that it can be applied at sites without rare snails. The sites in West Makaleha may be good candidates for slug control trials since *Achatinella* are not observed within the PU.

Population Estimate History

Manage for Stability Population Unit	2003 (IP) Mat/Imm/ Seedling	2003 Mat/Imm/ Seedling	2004 Mat/Imm/ Seedling	2005 Mat/Imm/ Seedling	2006 Mat/Imm/ Seedling	2007 Mat/Imm/ Seedling	2008 Mat/Imm/ Seedling	2009 Mat/Imm/ Seedling
Central Kaluaa in situ	0	1/0/0	1/0/0	1/0/0	1/0/0	1/0/0	1/0/0	1/1/0
Central Kaluaa outplanted	0	0	0	0/70/0	26/40/0	18/30/0	10/45/0	11/45/0
Palikea (S. Palawai) in situ	3/25/0	8/7/0	8/7/15	8/7/10	10/12/20	7/11/10	10/35/0	13/36/0
Palikea (S. Palawai) outplanted	0	0/35/0	0/35/0	12/18/0	44/18/0	64/14/0	78/4/0	79/1/0
Makaha in situ	0	0	0	1/0/0	1/0/0	1/0/0	1/0/0	1/0/0
Pahole to West Makaleha in situ	8/5/1	7/3/0	7/3/0	7/3/0	7/1/8	6/0/9	6/6/4	5/6/4
Pahole to West Makaleha outplanted	0	14/19/0	15/15/0	15/15/0	24/2/0	19/18/0	28/9/0	27/12/0
Genetic Storage Population Units								
North branch of South Ekahanui in situ	5/0/0	0	0	0	0	0	0	0
North branch of South Ekahanui outplanted	0	0	0	0	21/18/0	23/14/0	30/0/0	30/0/0
Palikea Gulch in situ	0/1/0	0/1/0	0/1/0	0/1/0	0/1/0	0/1/0	0/1/0	0/1/0
South Kaluaa in situ	2/0/0	1/0/0	1/0/0	1/0/0	1/0/0	1/0/0	1/0/0	1/0/0
South Kaluaa outplanted	0	0	0	0	0	9/0/0	5/14/0	4/10/0

Monitoring Plan

- All PUs will be monitored annually for population structure, trends and threats. Reintroduced and wild plants will be monitored twice annually for reproductive status, vigor and growth.
- All sites with reproductive plants will be monitored in order to time the installation of rodent protection as the fruit develops. Sites with reproductive plants will be protected from rodent impacts as feasible and monitored to ensure fruit development.
- Sites with reproductive plants will also be monitored in the spring for new seedlings. Monitoring will focus on areas under fruiting plants. Seedlings at all sites will be counted and areas with seedlings will be delineated on sketch maps. New immature plants at all sites will be tagged and monitored for vigor and growth.
- Sites with seedlings will be examined and a profile of micro-site requirements will begin to be developed.
- Seedlings will be monitored to track survivorship and growth. Slug impacts will be documented as another focus of the searches.

Genetic Storage Plan

What propagule type is used for meeting genetic storage goal?	What is the source for the propagules?	What is the Genetic Storage Method used to meet the goal?	What is the proposed re-collection interval for seed storage?	Is seed storage testing ongoing?	Plan for maintaining genetic storage.
Seeds	Wild plants and Reintroductions	Seed banking (5C or -80C / 20% RH)	5+ yrs.	Yes	Collections will be made from reintroductions as needed.

Genetic Storage Plan Comments: As many of the wild founder plants have died, a number of collections are made from reintroductions. Founders are tracked and collections made appropriately. When F1s at wild sites become reproductive, collections will be made to represent these individuals as they may represent new mixes and have undergone selective pressures at the seed, seedling, and immature stages. The re-collection interval will likely be increased to 10 years pending 10 year storage results and results from newly tested storage conditions.

Reintroduction Plan for MFS PUs

Manage for Stability Population Unit	Reintroduction Site(s)	Number of Plants to be planted *	Propagule Type	Propagule Population(s) Source	Number of Founders in Source Population.	Plant Size	Pot Size
Central Kaluaa	KAL-D	100 (218%)	Immature plants	Central Kaluaa	1	> 20 cm	1 gallon
Pahole to West Makaleha	Pahole: PAH-C	50**	Immature plants	Pahole: PAH-A, B	5	> 20 cm	1 gallon
Pahole to West Makaleha	Pahole: PAH-D	50 (274%)	Immature plants	Pahole: PAH-A, B	5	> 20 cm	1 gallon
Pahole to West Makaleha	West Makaleha: LEH- B	50 (162%)	Immature plants	West Makaleha	5	> 20 cm	1 gallon
Makaha	MAK- B (Not established yet)	50 (162%)	Immature plants	Makaha MAK-A	1	> 20 cm	1 gallon
Makaha	MAK- C (Not established yet)	50 (162%)	Immature plants	Makaha & West Makleha	6	> 20 cm	1 gallon
Palikea (South Palawai)	PAK-B	100 (116%)	Immature plants	Palikea (South Palawai)	19+	> 20 cm	1 gallon
Palikea (South Palawai)	PAK-C (not established yet)	100 (116%)	Immature plants	Palikea (South Palawai)	19+	> 20 cm	1 gallon

*Number of Plants to be Planted: The target number for each site is listed followed by a percentage. For sites with existing plantings, the total number planted (adjusted for time to mature after planting) was divided by the number of these plants that are mature. The percentage displayed is the multiplier needed to compensate for the survivorship of mature plants calculated for each site. The target number is multiplied by this percentage to get the number of plants to be planted. For sites with no or few existing plants, an averaged percentage (162%) from across all reintroductions is multiplied by the target. Percent survival varies significantly between PUs.

**The PAH-C reintroduction is space limited. Therefore, only 50 plants total were planted at this site, and the remaining plants will be planted at PAH-D.

+More founders may be collected from this site

Reintroduction Plan for Genetic Storage Population & Other Units

Genetic Storage Population Unit	Reintroduction Site(s)	Number of Plants to be planted *	Propagule Type	Propagule Population(s) Source	Number of Founders in Source Population.	Plant Size	Pot Size
North branch of South Ekahanui	EKA-C	100 (117%)	Immature plants	South Ekahanui	2	>20 cm	1 gallon
South Kaluaa	KAL-E	100 (162%)	Immature plants	South Kaluaa	1	>20 cm	1 gallon
N/A	KAL-C	0*	Immature plants	South Kaluaa	1	>20 cm	1 gallon
N/A	EKA-B	0*	Immature plants	South Kaluaa & Ekahanui	2	>20 cm	1 gallon

*These are older TNC outplantings with a few individuals left. They will be monitored but OANRP will not add any additional plants.

Reintroduction Plan Comments

- There are a total of seven established outplanting sites (one each in Central Kaluaa, South Kaluaa, West Makaleha, Palikea (South Palawai) and South Ekahanui and two in Pahole). There are plans for three more; two in Makaha and another in Palikea (South Palawai). All MFS PUs will require outplantings to reach goals.
- Reintroduction techniques are still being refined. Recent field observations indicate that reintroductions have done better in partly sunny areas compared with more shady areas as plants receiving more sunlight may be able to outpace slug damage with faster leaf production.
- Central Kaluaa: There is one reintroduction site (KAL-D) to represent the single founder from the KAL-B in situ site. These plants are grown from seed collected from the wild plant. Additional planting will continue.
- Pahole to West Makaleha: There are two sites in Pahole to represent the 5 available founders. Each will have XXX plants and planting will continue until founders are balanced. The West Makaleha site will be augmented on an adjacent slope with plants grown from seed collected from all available founders at that site.
- Makaha PU: Two augmentations will be established beginning in 2011. The first will be into Subunit I and will use stock from the single founder from Makaha. The second will be into Subunit II and will use plants grown from the Makaha plant mixed with all available founders from the West Makaleha site.
- Palikea (South Palawai): One augmentation (PAK-B) began in 2004. The goal is to have 2 plants from each of the available founders (19+) planted here by MIP Year 8. Another augmentation planting will be planned for the larger Palikea MU fence using stock grown from the wild plants.
- North branch of South Ekahanui: Two founders are available from the extirpated stock. Both are represented at the reintroduction at EKA-D and planting will continue there until founders are balanced. The EKA-C site is an older TNC outplanting of stock from Ekahanui mixed with plants grown from South Kaluaa. This site will be monitored and collected from to represent those PUs but not used for additional plantings.
- South Kaluaa: There is one reintroduction site in this PU to represent the single available founder. Planting began in 2007and will likely continue until MIP Year 9.

5 Year Action Plan

	Proposed Actions for the following years:				
Manage for Stability Population Unit	**MIP YEAR 6 October 1, 2009 – September 31, 2010**	**MIP YEAR 7 October 1, 2010 – September 31, 2011**	**MIP YEAR 8 October 1, 2011 – September 31, 2012**	**MIP YEAR 9 October 1, 2012 – September 31, 2013**	**MIP YEAR 10 October 1, 2013 – September 31, 2014**
Central Kaluaa	•Reintroduce •Monitor & Collect	•Reintroduce •Monitor & Collect	•Reintroduce •Monitor & Collect	•Monitor & Collect	•Monitor & Collect
Palikea (South Palawai)	•Reintroduce •Monitor & Collect	•Reintroduce •Monitor & Collect	•Reintroduce •Monitor & Collect	•Begin new reintroduction •Monitor & Collect	•Reintroduce •Monitor & Collect
Makaha	•Monitor & Collect	•Reintroduce •Monitor & Collect •Begin slug control	•Reintroduce •Monitor & Collect •Slug control	•Reintroduce •Monitor & Collect •Slug control	•Reintroduce •Monitor & Collect •Slug Control
Pahole to West Makaleha	•Reintroduce •Monitor & Collect	• Reintroduce •Monitor & Collect •Begin slug control at West Makaleha	• Reintroduce •Monitor & Collect •Slug control at West Makaleha	• Reintroduce •Monitor & Collect •Slug control at West Makaleha	•Monitor &Collect •Slug control at West Makaleha
Genetic Storage Population Units					
South Kaluaa	•Reintroduce •Monitor	•Reintroduce •Monitor	•Reintroduce •Monitor	•Reintroduce •Monitor	•Monitor
North branch of South Ekahanui	•Reintroduce •Monitor	•Reintroduce •Monitor & Collect	•Reintroduce •Monitor & Collect	•Reintroduce •Monitor & Collect	•Reintroduce •Monitor
Palikea Gulch	•Monitor & Collect	•Monitor & Collect	•Monitor & Collect	•Monitor & Collect	•Monitor & Collect

2008-2009 Stabilization Goals Update

Manage for Stability Population Units	PU Stability Target		MU Threat Control						Genetic Storage
	Has the Stability Target for mature plants been met?	Does the PU have observed structure to support the stability target in the long-term?	Ungulates	Weeds	Rodents	Fire	Slugs	Black Twig Borer	Are there enough propagules in Genetic Storage?
Central Kaluaa	NO	NO	YES	YES	NO	NO	NO	NO	YES
Pahole to West Makaleha	NO	NO	YES	YES	PARTIAL	NO	NO	NO	YES
Makaha	NO	NO	YES	YES	YES	NO	NO	NO	YES
Palikea (South Palawai)	NO	NO	YES	YES	NO	NO	NO	NO	YES
Genetic Storage PU									
North branch of South Ekahanui	N/A	N/A	YES	YES	PARTIAL	NO	NO	NO	YES
Palikea Gulch	N/A	N/A	YES	NO	NO	NO	NO	NO	NO
South Kaluaa	N/A	N/A	YES	PARTIAL	NO	NO	NO	NO	YES

2008-2009 Highlights

Major Highlights/Issues MIP Year 5

- The Palikea (South Palawai) PU is close to the goal of 100 reproducing individuals (95 including augmentation). Other Manage for Stability (MFS) PUs are far below the goal.
- The Central Kaluaa PU reintroduction continues to decline despite supplemental plantings (33% survivorship since 2004, 50 plants remain). Slug damage has been documented as a common cause of death at this site.
- Large MU fences at three of the four MFS sites (Central Kaluaa, Makaha, Palikea (South Palawai) are complete and pig free. All plants at the Pahole to West Makaleha PU are protected from pigs, however the larger West Makaleha MU fence is still being planned.
- Collections continued at the Makaha PU, Palikea (South Palawai) PU, and Pahole to West Makaleha PU. All available founders from the Makaha PU, Central Kaluaa PU, South Kaluaa PU, South Ekahanui PU, Pahole to West Makaleha PU are now represented in genetic storage. Collections continue from Makaha and Pahole to West Makaleha PUs because although storage goals are met, survivorship is low when plants are germinated. The single plant at Palikea Gulch has not yet matured.
- OANRP began outplanting at the West Makaleha PU with 3 individuals. Although reintroduction goals are higher, only three were large enough to plant due to low survivorship of the seedlings grown from this PU. Reintroductions continued at South Ekahanui, Pahole, and Central and South Kaluaa.
- A new immature plant was noted below the single mature plant in the Central Kaluaa PU

2008-2009 Plans

Plans for MIP Year 6

- Conduct census monitoring and seedling/immature searches at all sites in the spring and fall of 2010
- Finalize plans and agreements for the West Makaleha MU fence
- Supplement reintroductions at Pahole to West Makaleha, Palikea (South Palawai), Central and South Kaluaa, and South Ekahanui and continue propagation for the new reintroduction at Makaha scheduled to begin in 2010.
- Continue to collect for genetic storage from new and unrepresented founders
- Expand rodent control to unprotected sites as feasible (4 of 7 active sites have year round rodent control).
- Pursue SLN label for Sluggo
- Determine what is limiting seedling at sites where viable fruit is known to be readily available on mature plants. Studies to determine if the fruit is being naturally dispersed and trials to identify sites with conditions favorable for germination will be considered.

2008-2009 Taxon Status Table

Action Area: In

TaxonName: Cyanea grimesiana subsp. obatae **TaxonCode: CyaGriOba**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Pahole to West Makaleha	Manage for stability	5	6	4	27	12	0	34	15	4	32	18	4	New seedlings and immature plants were noted in the W. Makaleha wild site. More plants were added to all existing outplantings and a few outplanted plants died.
	Total for Taxon:	5	6	4	27	12	0	34	15	4	32	18	4	

Action Area: Out

TaxonName: Cyanea grimesiana subsp. obatae **TaxonCode: CyaGriOba**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Central Kaluaa	Manage for stability	1	1	0	28	22	0	11	45	0	29	23	0	In the outplanting, many of the immature plants matured in the last year. At the wild site, a small immature plant was observed under the single wild individual.
Makaha	Manage for stability	1	0	0	0	0	0	1	0	0	1	0	0	Monitoring showed no change
North branch of South Ekahanui	Genetic Storage	0	0	0	31	0	0	30	0	0	31	0	0	Population counts were revised after updating old observations
Palikea (South Palawai)	Manage for stability	13	36	0	79	1	0	88	39	0	92	37	0	In the reintroduction site two immature plants died and one matured. In the wild site, three new mature and one new immature plant were noted.
Palikea Gulch	Genetic Storage	0	1	0	0	0	0	0	1	0	0	1	0	This plant has been observed in the last year
South Kaluaa	Genetic Storage	0	0	0	4	10	0	5	14	0	4	10	0	In the reintroduction sites, two mature and three immature plants have died and an immature plant flowered for the first time.
	Total for Taxon:	15	38	0	142	33	0	135	99	0	157	71	0	

2008-2009 Genetic Storage Table

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	Storage Goals Met: # Plants that Met Goal
Cyanea grimesiana subsp. obatae							
Central Kaluaa	1	1	0	1	0	1	1
Makaha	1	0	0	1	0	1	1
North branch of South Ekahanui	0	0	2	1	2	2	2
Pahole to West Makaleha	5	6	5	10	0	9	10
Palikea (South Palawai)	13	36	5	13	5	9	13
Palikea Gulch	0	1	0	0	0	0	0
South Kaluaa	0	0	1	1	0	1	1
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				27	7	23	28

Hedyotis parvula

- **Scientific name:** *Hedyotis parvula* (A. Gray) Fosb.
- **Hawaiian name:** None known
- **Family:** Rubiaceae (Coffee family)
- **Federal status:** Listed endangered October 29, 1991
- **Requirements for Stability:**
  - 3 Population Units (PUs)
  - 50 reproducing individuals in each PU (short-lived perennial)
  - Stable population structure
  - Threats controlled
  - Complete genetic representation in storage of all PUs
- **Description and biology:** *Hedyotis parvula* is an erect to sprawling perennial shrub with branches measuring 10-30 cm long. Its oppositely arranged leaves are 1-4 cm long. Its inflorescences are borne at the tips of the branches. The flowers' corollas usually have four lobes, which are white to white tinged with purplish pink towards their tips, and measure 5-6 mm long. The flowers are either perfect (possessing both male and female reproductive parts), or pistillate (possessing only female reproductive parts). The capsules are almost round, measure about 3.3-4.0 mm long, split open across the top upon maturity, and contain small dull brown seeds.
- As with certain other Hawaiian cliff species the flowers of *H. parvula* are relatively large and white or light colored, and are prominently displayed above the plant's foliage, suggesting that the species' pollinating agent are night-flying moths. Flowering and fruiting has been recorded throughout the year. Little is known about *H. parvula*'s breeding system and seed dispersal agents.
- **Known distribution:** *Hedyotis parvula* is endemic to the Waianae Mountains, and has been documented throughout the mountain range. Recorded elevations for this species range from 720-830 m.

Hedyotis parvula

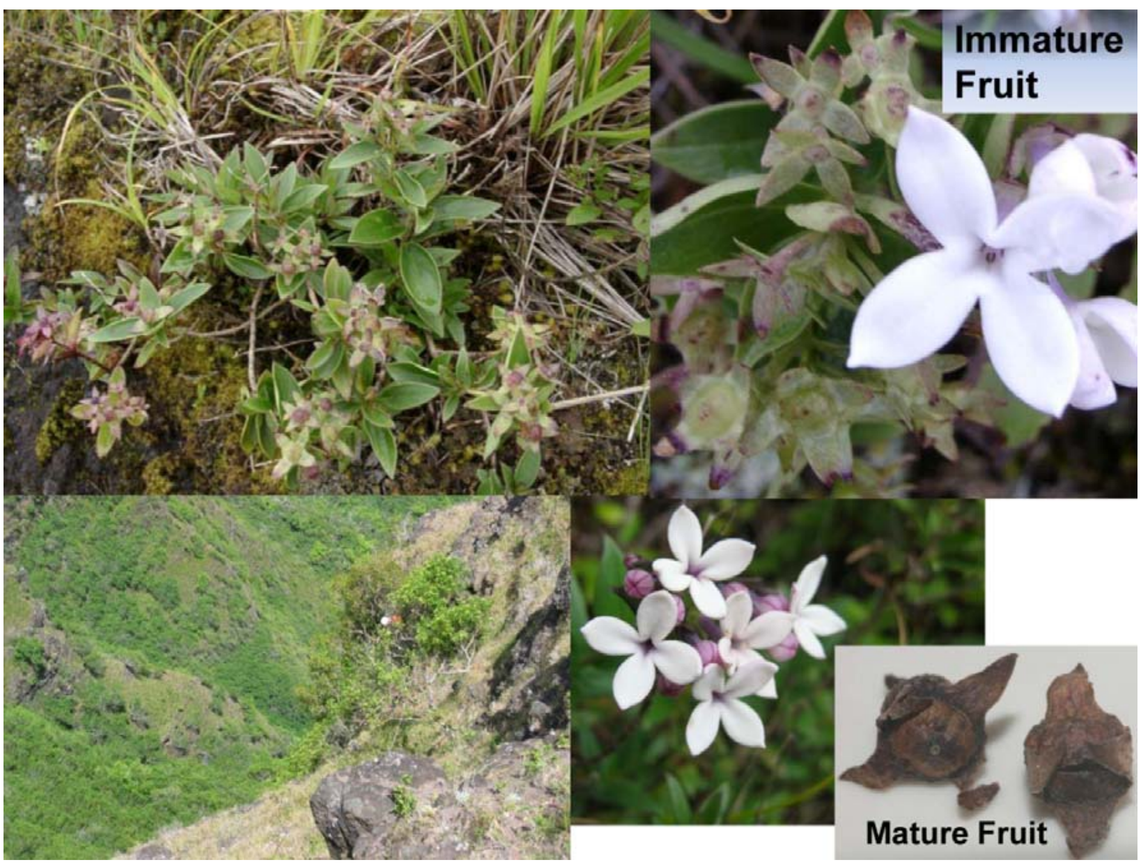
- **Population trends:** All of the currently known populations of *H. parvula* were discovered within the past three decades, so little information on the species' population trends is available.
- **Habitat:** *Hedyotis parvula* typically grows on cliff faces or on exposed rocky ridges. The vegetation in these areas is mesic, usually short and sparse, and includes native herbs, grasses, sedges, and shrubs.
- **Taxonomic background:** There are noticeable morphological differences among herbarium specimens of *H. parvula.* These differences may be genetically based. *Hedyotis parvula* forma *sessilis* is a form that was described based on its leaf shape (Fosberg 1943). It was thought that the plants from the southern Waianae Mountains represented this form, whereas the plants from the northern Waianaes represented the typical form *H. parvula* forma *parvula*. Findings from additional study of the morphological differences within the species may result in future alterations of the species' conservation plans.
- **Threats:** Feral goats and pigs constitute major threats to *H. parvula*. Although many plants grow on steep cliffs where they cannot be reached by ungulates, many others are within their reach. Furthermore, the animals degrade the plants' habitat by hastening the spread of invasive weeds and by disturbing substrates above the cliffs, thus increasing the size and frequency of landslides and rock falls, which directly affect even the inaccessible plants and their steep cliff habitat. Alien plants threaten *H. parvula* by altering the species' habitat and competing with it for moisture, light, nutrients, and growing space. Also, the spread of highly flammable alien grasses increases the incidence and destructiveness of wildfires

*Above description is an excerpt from MIT 2003. Population trends was updated from discovered date as three, rather than two, decades ago.

Fosberg, F.R. 1943. The polynesian species of *Hedyotis* (Rubiaceae). Bernice P. Bishop Mus. Bull. 174:1-102.
Makua Implementation Team (MIT). 2003. Final Makua Implementation Plan. Prepared for the U.S. Army Garrison, Schofield Barracks, HI.

Reproductive Biology Table

	Observed Phenology			Reproductive Biology		Seeds	
Population Unit	Flower	Immature Fruit	Mature Fruit	Breeding System	Suspected Pollinator	Average# Per Fruit	Dormancy
Ohikilolo	November-January	November-June	May-June	Hermaphroditic	Moth	54 ± 47	Not Dormant
Halona	November-January	November-June	May-June	Hermaphroditic	Moth	39 ± 24	Not Dormant



Map removed,
available upon request

Population Units

Manage for Stability Population Units	PU Type	Which Army Action Area is the PU inside?	Management Unit(s) designated for threat control
Ohikilolo	in situ	MMR	Ohikilolo
Halona	in situ	None	Halona
East Makaleha	Reintroduction	None	East Makaleha
Genetic Storage Population Units			
None			

Population Structure

- The priority for stabilizing the population structure at the Ohikilolo and Halona Population Units is to maintain the current estimate for mature plants.
- Since the trend displayed in the monitoring estimates for the two extant PU have been stable, the plan is to maintain current estimates for Immature and Seedlings.
- NRS will work to determine an appropriate level of decline in estimates that would trigger additional management.
- The population structure for the East Makaleha PU will be established by reintroducing 200+ immature or mature plants to a single site. If population structure does not begin to develop after 5 years, another reintroduction will be initiated.

	Population Monitoring History		
Population Unit	2008 Mat/Imm/Seedling	2006 Mat/Imm/Seedling	2002 Mat/Imm/Seedling
Ohikilolo	120/28/40	119/34/34	100/18/11
Halona	97/35/19	97/35/19	none

Monitoring Plan

Ohikilolo PU

- Estimates will be made during a census of all known sites every two years. This will document a trend for each site.
- Digital photos of each site will be taken during each census and may be used to detect changes in distribution and abundance.
- Any threats to the sites will be noted.

Halona PU

- Estimates will be made during a census of all known sites every two years. This will document a trend for each site.
- Digital photos of each site will be taken during each census and may be used to detect changes in distribution and abundance.
- Any threats to the sites will be noted.

East Makaleha PU

- Monitoring of the reintroduction will begin when it is established in MIP YEAR 8 (2011)
- Digital photos of the site will be taken during each census and may be used to detect changes in distribution and abundance.
- Any threats to the site will be noted.

Genetic Storage Plan

What propagule type is used to meet genetic storage goals?	What is the source for the propagules?	What is the Genetic Storage Method used to meet the goal?	What is the proposed re-collection interval for seed storage?	Is seed storage testing ongoing?	Plan for maintaining genetic storage.
Mature Seed	in situ	Seeds (-18C and 20%RH)	5+ years	Yes	Collections will continue to be made from the in situ sites.

Genetic Storage Plan Comments: Seed storage trials are ongoing and the re-collection interval may be adjusted

Reintroduction Plan

Population Unit	Reintroduction Site(s)	Year initiated	Propagule Source	# of Founders in Source Population	# of Plants to be planted	Propagule Type	Plant Size	Pot Size
East Makaleha	East Makaleha	2011	Ohikilolo	108	216	Immature plants	10-30 cm.	4 inch round

Reintroduction Plan Comments:

East Makaleha Population Unit

•Reintroduction Site: A single site will be selected and all planting completed in 1-2 years. If initial survivorship is good, the plants will be given five years to establish population structure. If the population structure are not met in five years, additional reintroduction attempts will be initiated.

•Year initiated: Propagation for reintroduction will begin in MIP YEAR 8 (2010) and planting will begin in MIP YEAR 9 December 2011.

•Propagule Population(s) Source: Two plants from each of the available founders in the Ohikilolo PU will be propagated from collections of seed already in storage. The seeds were collected from the sites over several years and the oldest collections will be used first .

•Pot Size: Small plants will be installed into cliff habitat by personnel on rappel.

5 Year Action Plan

	Proposed Actions				
Population Unit 	**MIP YEAR 6 Oct.2009-Sept.2010**	**MIP YEAR 7 Oct.2010-Sept. 2011**	**MIP YEAR 8 Oct.2011- Sept. 2012**	**MIP YEAR 9 Oct.2012-Sept.2013**	**MIP YEAR 10 Oct.2013-Sept.2014**
Ohikilolo	•Monitoring	•None	•Monitoring	•None	•Monitoring
Halona	•Monitoring	•None	•Monitoring	•None	•Monitoring
East Makaleha	•None	•None	•Begin propagation	•Reintroduce	•Reintroduce •Monitoring

MIP YEAR 8 Comments: The East Makaleha PU will be established by reintroduction starting in MIP YEAR 8 (2011).

2008-2009 Stabilization Goals Update

MFS Population Units	PU Stability Target		MU Threat Control						Genetic Storage
	Has the Stability Target for mature plants been met?	Does the PU have observed structure to support the stability target in the long-term?	Ungulates	Weeds	Rodents	Fire	Slugs	Black Twig Borer	Are there enough propagules in Genetic Storage?
Ohikilolo	YES	Unk	YES	PARTIAL	NO	NO	NO	NO	YES
Halona	YES	Unk	NO	NO	NO	NO	NO	NO	YES
East Makaleha	N/A	N/A	NO	NO	NO	NO	NO	NO	N/A

2008-2009 Highlights

Major Highlights/Issues MIP Year 5

- Both extant PUs have met the stability goal of having more than 50 reproducing plants
- Genetic storage goals have been met for both extant PUs.

Plans for MIP Year 6

- Conduct a thorough monitoring of the ʻŌhikilolo PU to locate juvenile plants.

2008-2009 Taxon Status Table

Action Area: In

TaxonName: Hedyotis parvula **TaxonCode: HedPar**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Ohikilolo	Manage for stability	120	28	40	0	0	0	120	28	40	120	28	40	No monitoring in the last year
	Total for Taxon:	120	28	40	0	0	0	120	28	40	120	28	40	

Action Area: Out

TaxonName: Hedyotis parvula **TaxonCode: HedPar**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
East Makaleha	Manage reintroduction for stability	0	0	0	0	0	0	0	0	0	0	0	0	Reintroduction will begin once the fence is complete
Halona	Manage for stability	97	35	19	0	0	0	97	35	19	97	35	19	No monitoring in the last year
	Total for Taxon:	97	35	19	0	0	0	97	35	19	97	35	19	

2008-2009 Genetic Storage Status Table

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	Storage Goals Met: # Plants that Met Goal
Hedyotis parvula							
East Makaleha	0	0	0	0	0	0	0
Halona	97	35	0	70	0	4	62
Ohikilolo	120	28	5	108	0	0	102
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				178	0	4	164

Pritchardia kaalae

- **Known distribution:** *Pritchardia kaalae* has been found only in the northern Waianae Mountains. The great majority of the trees are on either Ohikilolo Ridge or on the northern side of Kaala from East Makaleha Valley to Manuwai Gulch. The few known trees beyond the major concentrations are in the bottom of Makaha Valley and on the ridge between Waianae Kai and Schofield Barracks Military Reservation. The recorded range in elevation for this species is from 460-945 meters.

  In some parts of Hawaii, the current distribution of *Pritchardia* is apparently at least partially determined or influenced by the planting of trees by native Hawaiians (Hodel 1980). This is especially evident in the Kona region of Hawaii Island where there are no sites where *P. affinis* can be considered truly wild. All of the currently known older trees are in areas that were densely populated at the time of western contact. In the case of *P. kaalae*, however, there does not seem to be any evidence of native Hawaiian influences in the distribution of the species (Lau pers. comm. 2000).
- **Habitat:** *Pritchardia kaalae* is found in the mesic zone on moderately steep slopes to very steep cliffs. Many of the trees in the lower elevations are in forests dominated by *lama* (*Diospyros sandwicensis*) and/or *ohia* (*Metrosideros* spp.). The highest trees are in the upper wetter zone of the mesic forest, which is often dominated by *lehua ahihi* (a species of *ohia*, *Metrosideros tremuloides*). The steeper, more open cliffs where this species grows are vegetated largely with shrubs, grasses and sedges, and small trees.
- **Taxonomic background**: *Pritchardia* is a genus restricted to the tropical Pacific islands and the Hawaiian Islands. It includes includs about 25 species, about 20 of which are endemic to the Hawaiian Islands. The taxonomy of the Hawaiian species of *Pritchardia* are difficult because characteristics used to distinguish the species appear to be highly plastic (Read and Hodel 1990). *Pritchardia kaalae*'s extremely long inflorescences sets the species apart from all other Hawaiian *Pritchardia* species except one.

  The Waianae Mountains to the south of *kolekole pass* are devoid of *Pritchardia*s of any kind, with the exception of a *Pritchardia* colony south of Pohakea Pass in North Palawai Gulch. There are only two mature trees and one juvenile in the colony. These plants are the only members of what is considered to be an undescribed species most closely related to *P. martii*, the sole species of *Pritchardia* in the Koolau Mountains (Gemmill 1996).

Reproductive Biology Table

	Observed Phenology			Reproductive Biology		Seeds	
Population Unit	Flower	Immature Fruit	Mature Fruit	Breeding System	Suspected Pollinator	Average # Per Fruit	Dormancy
ALL	Year-round	Year-round	Year-round	Hermaphroditic	Wind + Insect	1	Morpho-physiological Dormancy*

*All palms have either MD (morphological dormancy) or MPD (morphophysiological dormancy) (C. Baskin pers. comm. 2009). Seeds of *P. remota* have MPD (Perez 2006). Since seeds of *P. kaalae* take >30 days to germinate, they have MPD.

Perez, H. 2006. Implications of Embryo Desiccation Tolerance, Seed Dormancy, and Seed Damage for Conservation of *Pritchardia* Palms Endemic to Hawaii. Dissertation Submitted to the University of Hawaii.

Map removed,
available upon request

Population Units

Manage For Stability Population Units	PU Type	Which Action Area is the PU inside?	Management Units for Threat Control
Ohikilolo	Both in situ and Augmentation	MMR	Ohikilolo
Ohikilolo East and West Makaleha	Reintroduction	MMR	Ohikilolo and West Makaleha
Makaleha to Manuwai	Both in situ and Augmentation	SBMR	East Makaleha & Manuwai
Genetic Storage Population Units			
Makaha	in situ	None	None
Waianae Kai	in situ	SBMR	None

Population Structure

- Since very few juvenile plants were observed in any of the wild sites before rat control began, it is difficult to determine what population structure is needed to maintain the stability target for reproducing trees.
- The Ohikilolo PU has met the stability goal of 25 reproducing trees and OANRP plan to establish a population structure that will maintain the current levels of mature trees.
- Rat control will continue in all MFS PUs to encourage in situ germination.
- In July of 2009, a reintroduced plant on in the Ohikilolo PU was observed flowering. This was the first time a plant reintroduced into a natural area had flowered. The tree had been planted in 2001 and was about ten years old.
- When necessary, reintroduction will be used to augment natural recruitment in the Manage for Stability PUs. Reintroductions maybe staggered over several years to establish plants of different age classes within the sites if population structure targets are not met.
- OANRP will consider a trial to transfer seeds from in situ sites to reintroduction sites to further develop population structure as the outplantings mature.

Monitoring Plan

- An annual census of the mature plants in the Ohikilolo and most sites in the Makaleha to Manuwai PU will be conducted. An estimate of juvenile and seedlings will be made every other year to minimize damage to the sites. Sub-sampling will be investigated as a way to minimize impacts.
- Sites in the Makaleha to Manuwai and Makaha PUs that are difficult to access will be monitored annually with binoculars from across the valley or by helicopter until an access route can be determined.
- The Waianae Kai PU will be monitored while collecting for genetic storage.
- Additional threats to any of the sites will be noted and management adapted.

Genetic Storage Plan

What propagule type is used for meeting genetic storage goal?	What is the source for the propagules?	What is the Genetic Storage Method used to meet the goal?	What is the proposed re-collection interval for seed storage?	Is seed storage testing ongoing?	Plan for maintaining genetic storage.
Mature Seed	in situ	Seed banking	To be determined	Yes	Collections will be made from the wild sites when needed.

Genetic Storage Plan Comments: Mature seed will be collected from the wild sites and stored at the Army Seed Storage Lab. Testing is ongoing to determine the optimal re-collection interval and preferred storage conditions.

Reintroduction Plan

Population Unit	Reintroduction Site(s)	Number of Plants to be planted	Propagule Type	Propagule Population(s) Source	Number of Founders in Source Population.	Plant Size	Pot Size
Ohikilolo	Ohikilolo	450	Immature plants	Ohikilolo	72	10-30 cm.	1 gallon tall
Ohikilolo	Lower Ohikilolo	90	Immature plants	Lower Ohikilolo	3	10-30 cm.	1 gallon tall
Ohikilolo East and West Makaleha	Ohikilolo	350	Immature plants	Ohikilolo, Makaleha to Manuwai	72 + 50	10-30 cm.	1 gallon tall
Makaleha to Manuwai	East Makaleha	350	Immature plants	Makaleha to Manuwai	70	10-30 cm.	1 gallon tall

Reintroduction Plan Comments

- Ohikilolo PU: Two reintroductions will be established in the Ohikilolo PU. The main site will use 450 plants grown from the 72 founders in the main patch. This planting will be completed in MIP YEAR 7. The Lower Ohikilolo reintroduction will use 90 plants grown from the three founders in the lower site. This site will be maintained separately from the other larger site. NRS will assess the need to conduct additional plantings to enhance the population structure in MIP YEAR 8.
- Ohikilolo East and West Makaleha PU: This PU has no wild trees. It will be established by reintroducing about 350 plants. Two plants from each of the 72 founders in the main Ohikilolo East patch plus two from 50 founders in the Makaleha to Manuwai PU will be planted in this site by MIP YEAR 8. NRS will assess the need to conduct additional plantings to enhance the population structure in MIP YEAR 9.
- Makaleha to Manuwai PU: The reintroduction for this PU will be established using 350 plants grown from 70 of the founders in Makaleha and Manuwai.
- In total, 553 immature trees have been planted since 1999. Total survivorship in all sites is high (93%) and plants are growing vigorously.
- With effective rat control seed should begin to germinate in reintroductions as in wild sites. Trees are expected to take at least ten years to mature.
- OANRP will determine if transplanted seeds can be used to establish seedlings and help to develop a population structure that will maintain stability goals.

5 Year Action Plan

	Proposed Actions for the following years:				
Manage for Stability Population Unit	**MIP YEAR 6 October 1, 2009 – September 31, 2010**	**MIP YEAR 7 October 1, 2010 – September 31, 2011**	**MIP YEAR 8 October 1, 2011 – September 31, 2012**	**MIP YEAR 9 October 1, 2012 – September 31, 2013**	**MIP YEAR 10 October 1, 2013 – September 31, 2014**
Ohikilolo	•Monitor & Collect •Reintroduce	•Monitor & Collect •Reintroduce •Develop plan for a seed sowing trial	•Monitor & Collect •Reintroduce •Begin seed sowing trial	•Monitor •Monitor seed sowing trial	•Monitor •Monitor seed sowing trial
Ohikilolo East and West Makaleha	•Monitor •Reintroduce	•Monitor •Reintroduce	•Monitor •Reintroduce	•Monitor	•Monitor
Makaleha to Manuwai	•Monitor & Collect •Complete Manuwai fence	•Monitor & Collect •Expand Rat Control	•Monitor & Collect •Construct East Makaleha fence •Reintroduce at Manuwai	•Monitor & Collect •Reintroduce at Manuwai	•Monitor & Collect •Reintroduce at Manuwai •Reintroduce at East Makaleha
Genetic Storage Population Units					
Makaha	•Monitor		•Monitor •Collect if possible		•Monitor •Collect if possible
Waianae Kai	•Monitor &Collect	•Monitor &Collect	•Monitor &Collect	•Monitor	•Monitor

2008-2009 Stabilization Goals Update

MFS Population Units	**PU Stability Target**		**MU Threat Control**						**Genetic Storage**
	Has the Stability Target for mature plants been met?	Does the PU have observed structure to support the stability target in the long-term?	Ungulates	Weeds	Rodents	Fire	Slugs	Black Twig Borer	Are there enough propagules in Genetic Storage?
Ohikilolo	YES	NO	YES	YES	PARTIAL	NO	NO	NO	NO
Ohikilolo East and West Makaleha	NO	NO	YES	YES	N/A	NO	NO	NO	N/A
Makaleha to Manuwai	YES	NO	NO	NO	PARTIAL	NO	NO	NO	NO
Genetic Storage Population Units									
Makaha	N/A	N/A	NO	NO	NO	NO	NO	NO	NO
Waianae Kai	N/A	N/A	NO	NO	NO	NO	NO	NO	NO

2008-2009 Highlights

Major Highlights/Issues MIP Year 5
•The stability goal of 25 reproducing plants has been met for the ʻŌhikilolo PU and Makaleha to Manuwai PU.
•The first OANRP reintroduced plant to reach maturity was documented this year. It had been planted 8 years prior and the collection had been made ten years prior.
•Construction of the Manuwai fence has begun. This fence will be completed in 2010 and will protect the *P. kaalae* in Manuwai.
•Rat control continues to be successful in allowing the development of mature fruit and the establishment of seedlings within the ʻŌhikilolo PU and Makaleha to Manuwai PU. Collections of seed for genetic storage and reintroduction continue in the ʻŌhikilolo PU and Makaleha to Manuwai PU.
•Continued expansion of the reintroduction sites in the ʻŌhikilolo PU with an additional 63 plants.

Plans for MIP Year 6
•Conduct monitoring at all Manage for Stability PUs.
•NRS will continue to collect from unrepresented founders from the ʻŌhikilolo and Makaleha to Manuwai PUs for reintroduction and genetic storage.
•Continue to expand the reintroductions in the ʻŌhikilolo PU and East ʻŌhikilolo to West Makaleha PU with stock from additional founders.
•Investigate the strategy of using seed collected from the Ohikilolo PU to conduct a seed sowing trial at one of the reintroduction sites.
•Complete the large scale Manuwai MU fence
•Survey the Makaleha to Manuwai PU to revise population estimates
•Monitor for seedlings in East Makaleha and determine the need to construct small fences.
•Monitor the Waiʻanae Kai PU and assess the need for rat control in order to collect for genetic storage
•Determine feasibility of accessing the plants in the Mākaha PU.

2008-2009 Taxon Status Table

Action Area: In

TaxonName: Pritchardia kaalae **TaxonCode: PriKaa**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Ohikilolo	Manage for stability	75	644	20	1	377	0	75	1002	20	**76**	**1021**	**20**	More plants were added to the reintroduction sites and one flowered for the first time.
Ohikilolo East and West Makaleha	Manage reintroduction for stability	0	0	0	0	122	0	0	84	0	**0**	**122**	**0**	Additional plants were added to the existing reintroduction
	Total for Taxon:	75	644	20	1	499	0	75	1086	20	**76**	**1143**	**20**	

Action Area: Out

TaxonName: Pritchardia kaalae **TaxonCode: PriKaa**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Makaha	Genetic Storage	4	0	0	0	0	0	4	0	0	**4**	**0**	**0**	No monitoring in the last year
Makaleha to Manuwai	Manage for stability	70	4	0	0	0	0	70	4	0	**70**	**4**	**0**	Monitoring showed no change
Waianae Kai	Genetic Storage	4	5	0	0	0	0	4	5	0	**4**	**5**	**0**	No monitoring in the last year
	Total for Taxon:	78	9	0	0	0	0	78	9	0	**78**	**9**	**0**	

2008-2009 Genetic Storage Status Table

Population Unit Name	# of Potential Founders: Current Mature	# of Potential Founders: Current Imm.	# of Potential Founders: NumWild Dead	Partial Storage Status: # Plants >= 10 in Seedbank	Partial Storage Status: # Plants >=1 Microprop	Partial Storage Status: # Plants >=1 Army Nursery	Storage Goals Met: # Plants that Met Goal
Pritchardia kaalae							
Makaha	4	0	0	0	0	0	0
Makaleha to Manuwai	70	4	0	7	0	18	15
Ohikilolo	75	644	0	6	13	32	18
Waianae Kai	4	5	0	0	1	0	0
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				13	14	50	33

Stenogyne kanehoana

- **Scientific name:** *Stenogyne kanehoana* Sherff
- **Hawaiian name:** None recorded
- **Family:** Lamiaceae (Mint family)
- **Federal status:** Listed endangered May 13, 1992
- **Requirements for OIP Stability**
  - 4 Population Units (PUs)
  - 50 reproducing individuals in each PU (long-lived perennial with a history of precipitous decline, extirpated in the wild, and extremely low genetic variability)
  - Stable population structure
  - Threats controlled
  - Complete genetic representation in storage of all PUs
  - Tier 1 stabilization priority
- **Description and biology:** *Stenogyne kanehoana* is a scandent vine with tomentose stems 1-2 m long. The leaves are opposite, densely tomentose, narrowly ovate to oblong-ovate, and measure 6-14 cm long and 2.5-4.8 cm 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 long. The lip of the corolla is pinkish purple. The nutlets are about 9 mm long (*excerpt from OIP 2008).

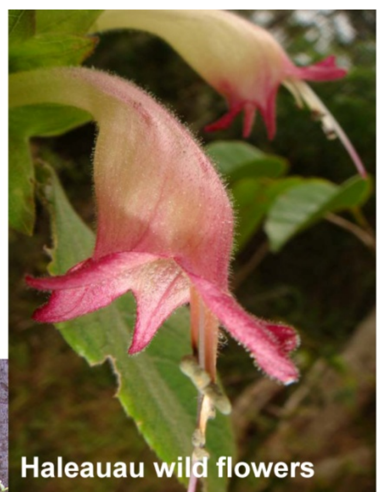
Stenogyne kanehoana

- **Description and biology continued:** Little is known of *S. kanehoana*'s biology since this species has always been very rare. It has been observed reproducing both sexually (flowers) and asexually (clonally), though fruit set has yet to be seen. As with other species of *Stenogyne*, *S. kanehoana* has long, rambling stems, which can root when contacting the ground. Eventually, this growth can lead to the formation of additional plants.
- There are no reports with respect to this taxon's pollinating agents, but the flower's long, curved corolla is suggestive of pollination by birds, and Hawaiian endemic honeycreepers have been seen visiting other species of *Stenogyne* (Jeffrey, pers.obs., Lindqvist et.al. 2003). Flowering and fruiting has been recorded from January through June. OANRP has observed flowering and fruiting from March through June in situ, and cultivated plants may flower year-round. Dispersal agents for this species are unknown. For the purposes of the OIP, the species is considered short-lived (OIP 2008).
- **Known distribution:** Until recently *S. kanehoana* had been known only from a few records from a small area south of Kolekole Pass, in Honouliuli. About three plants were known from the Huliwai-Kaluaa Ridge, but were gone by 1996. A single plant was known from Kaluaa Gulch, but died in 2005. In 2004, a large plant was discovered in Haleauau Gulch on the West Range of SBMR, north of Kolekole Pass, below Mt. Kaala. The recorded elevations for this species range from 730-760 m (2,400-2,500 ft).
- **Habitat:** *S. 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 21 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.

Reproductive Biology Table

	Observed Phenology			Reproductive Biology		Seeds	
Population Unit	Flower	Immature Fruit	Mature Fruit	Breeding System	Suspected Pollinator	Average # Per Fruit	Dormancy
ALL	Mar-April	April-June	Not observed	Herma-phroditic	Bird*	4	Not known

* C. Lindqvist, T.J. Motley, J.J. Jeffrey & V.A. Albert. 2003. Cladogenesis & reticulation in the Hawaiian endemic mints (Lamiaceae). *Cladistics* **19**: 480-495.



Full sized nutlet ca. 9 mm long (Wagner et al 1990)

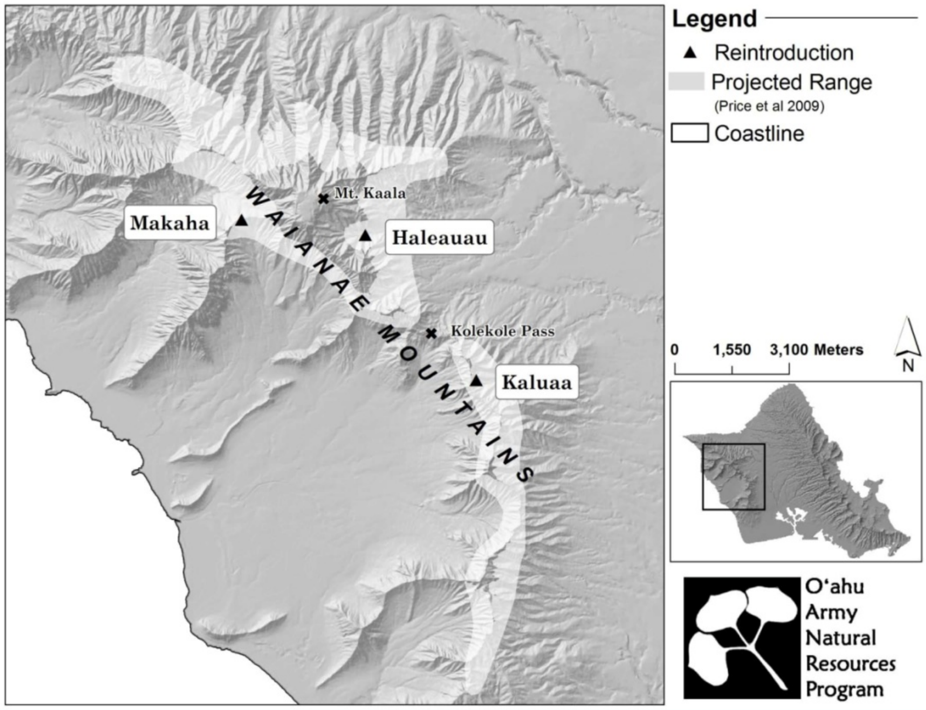
Map removed, available upon request

Population Units

Manage For Stability Population Units	PU Type	Which Action Area is the PU inside?	Management Units for Threat Control
Kaluaa	Reintroduction	None	Kaluaa
Haleauau	Augmentation	SBMR	Lihue
Makaha/other* (Pending IT & landowner approval)*	Reintroduction	None	Makaha Subunit II
Genetic Storage Population Units			
None			

•Kaluaa: This PU covers both extirpated historic locations known from this area and will be established by reintroducing clones of the Kaluaa Gulch stock in one site and a mixing the Kaluaa and Haleauau at another outplanting.
•Haleauau: The wild plant will be augmented once the large Lihue fence is complete.
•*Makaha: In order to reduce the risk that a single large catastrophic event (i.e. hurricane, fire) may cause the extirpation of this narrow endemic species, OANRP propose to create a new PU that is geographically removed from the Kaluaa and Haleauau regions. Modeling used in a technical report by Price et.al. 2009, identifies suitable habitat based on identified climate zones and biogeographical regions, substrate age at extant populations, and the level of human impact. Since *S. kanehoana* is now known to occur both north and south of Kolekole Pass, suitable habitat across the entire Waianae Mountain should be considered (J. Lau pers comm 2009). With these considerations and pending further consultations with the IT, OANRP will pursue an additional PU within the projected habitat. The Management Units of Puu Palikea, Pualii, Makaha Subunit II, West Makaleha, East Makaleha and Manuwai will be considered.

Projected Habitat Range (based on modeling in Price et.al. 2009)



Price, J.P., S.M. Gon, J.D. Jacobi, D. Matsuwaki. 2009. Mapping Plant Species Ranges in the Hawaiian Islands: Developing a Methodology & Associated GIS Layers. Technical Report HCSU-008. pgs.1-67.

Population Structure

- Plants have been observed to reproduce vegetatively, but no recruitment from seed has been observed. Due to limited records for this taxon, it is difficult to project what an adequate population structure to sustain stability goals may be.
- OANRP is developing techniques to produce viable seed with in situ, outplanted and greenhouse plants. At this time, no seedlings or immature plants are expected to be observed in any sites. Instead, individual plants may be maintained as long stems re-root and separate from the original plant.
- OANRP will further develop techniques to encourage vegetative reproduction at outplanting and in situ sites.

Monitoring Plan

- All sites will be monitored annually and particularly in March-April for flowers. If flowers are observed, a schedule will be determined to continue pollination trials and fruit collection.
- OANRP will determine the definition of 'Mature' as it applies to this taxon. This will take into account asexual reproduction and that all plants are clones of individuals that have flowered.
- All reintroductions will be monitored closely to locate places where plants are beginning to form new roots.
- Threats to any of the sites will be noted and management adapted.

Genetic Storage Plan

What propagule type is used for meeting genetic storage goal?	What is the source for the propagules?	What is the Genetic Storage Method used to meet the goal?	What is the proposed re-collection interval for seed storage?	Is seed storage testing ongoing?	Plan for maintaining genetic storage.
Clones	in situ	In vitro and GH living collections	N/A	N/A	Recollections will be made from GH living collections if needed.

Genetic Storage Plan Comments: Greenhouse crosses will be conducted when there is an opportunity. Self-pollinating the Kaluaa and Haleauau stock will be attempted in addition to cross-pollinating these stocks. Seed generated from these attempts can be used for seed storage testing, genetic storage, and for reintroduction stock. In situ and outplanted individuals will also be used for pollination attempts when possible.

Reintroduction Plan

Population Unit	Reintroduction Site(s)	Number of Plants to be planted	Propagule Type	Propagule Population(s) Source	Number of Founders in Source Population.	Plant Size	Pot Size
Kaluaa	South Fenceline (KAL-B)	TBD* ($\geq$ 100)	Immature plants	Kaluaa and Haleauau	2	To be determined	0.5-1 gallon
Kaluaa	Pu'u Hapapa (KAL-D)	TBD* ($\geq$ 100)	Immature plants	Kaluaa	1	To be determined	0.5-1 gallon
Haleauau	South Haleauau	TBD* ($\geq$ 100)	Immature plants	Haleauau	1	To be determined	0.5-1 gallon
Makaha	Makaha Subunit II	TBD* ($\geq$ 100)	Immature plants	Kaluaa and Haleauau	2	To be determined	0.5-1 gallon

* The number of plants will be determined after more comprehensive data on mortality is collected at these sites, as well as an estimate of years to maturity after planting.

Reintroduction Plan Comments

- Reintroductions are done using stock grown in the nursery from clones of the two original founders. If viable seed is collected and more founders become available, OANRP will re-visit reintroduction strategies and adapt management accordingly.
- Reintroduction techniques are being refined. Based on recent field observations, plants appear to perform better when placed into uluhe with little to no disturbance. The micro-climates in these locations may favor survivorship as uluhe can block out most light and may retain soil moisture longer.
- Kaluaa: OANRP has established three reintroduction sites in Kaluaa. One of the three (KAL-C) was abandoned because all 24 planted individuals died within two years. The remaining sites will be monitored to track survivorship.
- Haleauau: The existing PU fence is not big enough for an augmentation, however, construction of the large Lihue fence will secure additional suitable habitat in Haleauau Gulch. Stock grown from clones of the single Haleauau plant will be used to augment this PU. Sections of the 'tram-line trail' have been identified as a good candidate site for planting.
- Makaha: The third MFS PU will be established using clones from both Kaluaa and Haleauau. See the discussion on the Makaha PU in the Population Structure section.

5 Year Action Plan

	Proposed Actions for the following years:				
Population Unit	**MIP YEAR 6 October 1 2009 – September 31 2010**	**MIP YEAR 7 October 1 2010 – September 31 2011**	**MIP YEAR 8 October 1 2011 – September 31 2012**	**MIP YEAR 9 October 1 2012 – September 31 2013**	**MIP YEAR 10 October 1 2013 – September 31 2014**
Kaluaa	•Reintroduce •Hand Pollinate •Monitor & Collect	•Reintroduce •Hand Pollinate •Monitor & Collect	•Hand Pollinate •Monitor & Collect	•Hand Pollinate •Monitor & Collect	•Hand Pollinate •Monitor & Collect
Haleauau	•Monitor &Collect •Hand Pollinate	•Monitor &Collect •Hand Pollinate	•Monitor & Collect •Hand Pollinate	•Reintroduce •Monitor & Collect •Hand Pollinate	•Reintroduce •Monitor & Collect •Hand Pollinate
Makaha* (Pending IT & landowner approval)*	•None	•Determine reintroduction site	•None	•Reintroduce •Hand Pollinate •Monitor & Collect	•Reintroduce •Hand Pollinate •Monitor & Collect

2008-2009 Stabilization Goals Update

Manage for Stability Population Units	PU Stability Target		MU Threat Control						Genetic Storage
	Has the Stability Target for mature plants been met?	Does the PU have observed structure to support the stability target in the long-term?	Ungulates	Weeds	Rodents	Fire	Slug	BTB	Are there enough propagules in Genetic Storage?
Kaluaa	YES	NO	YES	YES	NO	NO	NO	NO	YES
Haleauau	NO	NO	NO	PARTIAL	NO	NO	NO	NO	YES
Makaha	NO	NO	NO	NO	NO	NO	NO	NO	N/A

2008-2009 Highlights

Major Highlights/Issues OIP Year 2

•Both available founders are represented in genetic storage both as a living collection in the greenhouse and at the Micropropagation Lab at Lyon Arboretum.

•A herbarium voucher of the Haleauau stock was submitted to Bishop Museum.

•Since 2006, 159 *S. kanehoana* have been reintroduced into Central Kaluaa. Survivorship has improved significantly over the last three years. The first two outplantings had survival rates of 11% and 44%, while the most recent has survival rate of 88%. At this new site the, clones were planted into dense uluhe patches and care was taken not to damage the ferns. This approach has promising results so far and some plants at one of the reintroduction sites in Central Kaluaa are reproducing vegetatively.

•The Haleauau wild plant flowered in the last year and OANRP attempted hand-pollination. No seed were observed to develop before the entire branch with the inflorescence died. At the time of hand-pollination, the flowers appeared slightly past maturity and no pollen was available. It is uncertain if they naturally self-pollinated. The only other pollen available at the time had been stored for 2 years and was from the Kaluaa living collection stock. It is uncertain if pollen can be stored.

•Horticultural staff has made great strides in maintaining greenhouse stock. Two Kaluaa greenhouse plants also produced several dozen flowers in the last year. Flowers were self-pollinated by hand with fresh pollen but no seeds developed.

•Leaf samples from different stems of the wild plant in the Haleauau PU and from the greenhouse clones were brought to UH Botany faculty Dr. Cliff Morden for genetic analyses. Results are pending.

2008-2009 Plans for OIP Year 3

Plans for OIP Year 3

- In the spring of 2010, OANRP will monitor all outplanting sites for flowers and continue to track vegetative reproduction.
- Manage nursery collection to promote flowering. Continue research in pollination and continue to hand-pollinate. This includes collecting pollen, testing pollen viability, and pollinating all flowering plants, both in situ and ex situ.
- Continue to supplement all outplanting sites with clones from the nursery collection
- OANRP propose to combine the Central Kaluaa (Gulch 2) PU and Central Kaluaa (South Fenceline) PU into one MFS PU called Central Kaluaa.
- To replace that MFS PU, OANRP propose to establish a new PU with a reintroduction into Makaha. This new Makaha PU will have the designation of “Manage Reintroduction for Stability.” This action is supported by species range modeling done by Price et al 2009 and is pending approval from the IT and BWS. All potential reintroduction sites in Makaha and in the proposed East Makaleha MU and the Manuwai MU will be analyzed and discussed in the coming year.

2008-2009 Taxon Status Table

Action Area: In

TaxonName: Stenogyne kanehoana **TaxonCode: SteKan**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Haleauau	Manage for stability	1	0	0	0	0	0	1	0	0	1	0	0	Monitoring showed no change
	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	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Central Kaluaa (Gulch 2)	Manage for stability	0	0	0	0	29	0	0	26	0	0	29	0	More plants were added to the reintroduction site
Central Kaluaa (South Fenceline)	Manage for stability	0	0	0	0	44	0	0	53	0	0	44	0	Thorough monitoring showed a decline in the last year
	Total for Taxon:	0	0	0	0	73	0	0	79	0	0	73	0	

2008-2009 Genetic Storage Status Table

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	Storage Goals Met: # Plants that Met Goal
Stenogyne kanehoana							
Central Kaluaa (South Fenceline)	0	0	1	0	1	1	1
Haleauau	1	0	0	0	1	1	1
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				0	2	2	2

Delissea waianaeensis

- **Scientific name:** *Delissea waianaeensis* Lammers
- **Hawaiian name:** Haha, Ohawai
- **Family:** Campanulaceae (Bellflower family)
- **Federal status:** Listed endangered October 10, 1996
- **Requirements for Stability:**
  - 4 Population Units (PUs)
  - 100 reproducing individuals in each PU (short-lived perennial with population fluctuations and local declines, potentially an obligate out-crosser)
  - Threats controlled
  - Complete genetic representation of all PUs in storage
- **Description and biology:** *Delissea waianaeensis* is a shrub 1-2.5 m tall, with a single stem; or it is occasionally branched, usually as the result of an injury. The stems are erect and topped by a cluster of leaves. The leaf blades measure 11-24 cm long, and their margins are toothed lobed or cut to various degrees. The inflorescences are 5-12 flowered racemes, and are borne close to the stem among the leaves. The corollas are white to green, curved, and measure 45-62 mm long. The berries measure 7-16 mm long, and are purple when ripe (Lammers 2005). Flowering and fruiting has been documented by OANRP at various times of the year, with most flowering recorded from March through May, and fruiting from March through July. As with other species of *Delissea* , floral morphology of *waianaeensis* is indicative of bird pollination. It is capable of self-pollination, as evidenced by the production of viable seeds by isolated plants (Smith et. al. 1995, Lammers and Freeman 1986). The purple berries of *D. waianaeensis* are indicative of seed dispersal by fruit-eating birds. The longevity of individual plants is unknown. The species presumably lives for less than 10 years like other taxa of its size in the genus *Delissea* and in the closely-related genus *Cyanea*. Therefore, *Delissea* is considered a short-lived species for the purposes of the Implementation Plan (MIT 2003).

Delissea waianaeensis

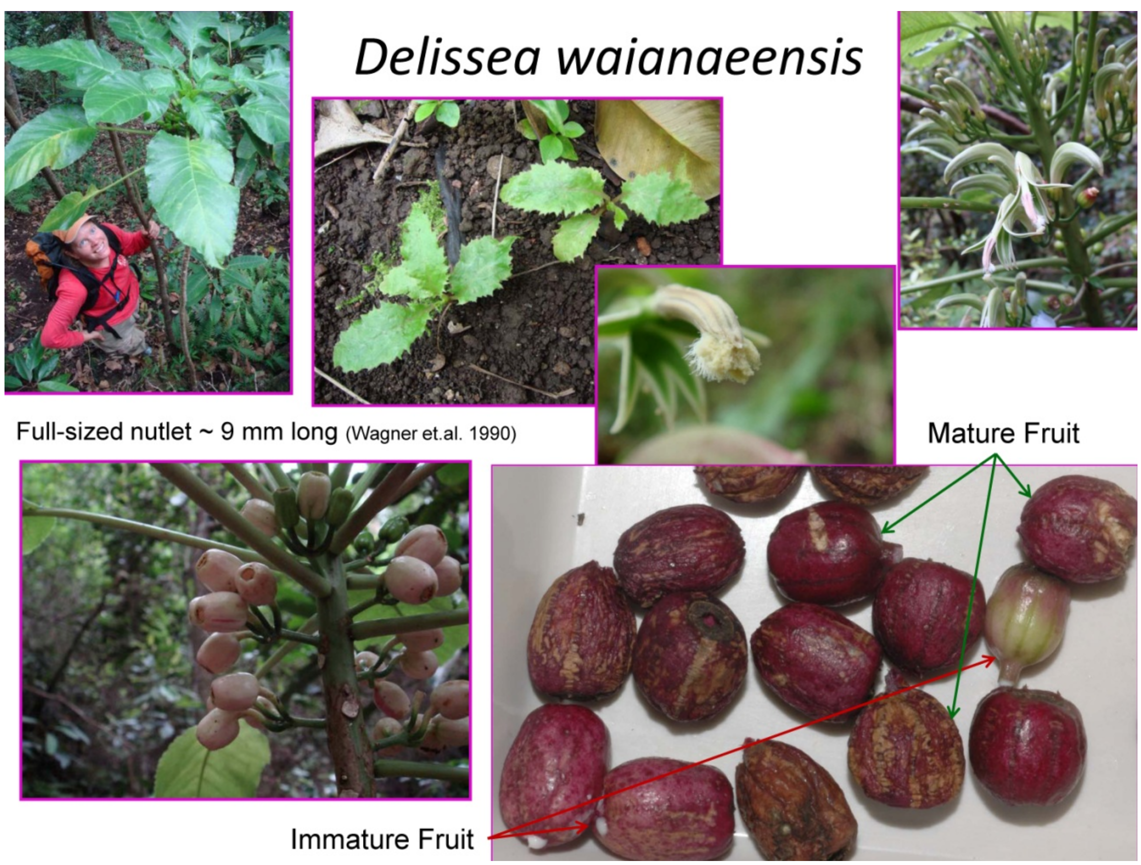
- **Known distribution:** *Delissea waianaeensis* is endemic to the Waianae Mountains and has been documented from elevations of 245-760 m (Lammers 2005). It has been found primarily along the windward side of the range from Palawai in the south to Kawaihapai in Mokuleia. The only recorded leeward site was in Kahanahaiki Valley on MMR.
- **Habitat:** *Delissea waianaeensis* is usually found growing on north-facing gulch slopes, and sometimes in gulch bottoms. It occurs in mesic forests dominated by *lama* (*Diospyros sandwicensis*), *ohia* (*Metrosideros polymorpha*), and/or *koa* (*Acacia koa*). It can also occur in forests composed of a diverse mix of trees. It grows either under the forest canopy or in sunny openings in the forest (MIT 2003).
- **Taxonomic background:** There are 15 species in the endemic Hawaiian genus *Delissea.* All species are endemic to a single island. Eleven are presumed extinct and the remaining four are listed endangered. In addition to *D. waianaeensis,* there are five species that have been recorded from Oahu, but are now presumed to be extinct. *D. laciniata* and *D. lauliiana* have been documented only from the southeastern Koolau Mountains and last collected prior to 1872. *D. sinuata* has been documented only from the northern Waianae Mountains and was last collected in 1937. *D. subcordata* is endemic to the Koolau Mountains and two sub-species are recognized. Neither has been collected since 1934. *D. takeuchii* is endemic to the Waianae Mountains and was last collected in 1987. It has leaves 3-4 times longer than wide compared with 1.3-2.7 for *D. waianaeensis*. *D. takeuchii* differs further in having smaller and finer marginal teeth, wider corolla lobes and shorter anthers than *D. waianaeensis.*

Reproductive Biology Table

	Observed Phenology			Reproductive Biology		Seeds	
Population Unit	Flower	Immature Fruit	Mature Fruit	Breeding System	Suspected Pollinator	Average # Per Fruit	Dormancy
ALL	Mar-May	Mar-June	June-July	Hermaph-roditic	Bird*	127 ± 84	Not Dormant

*Smith, T.B. L.A. Freed, J.K. Lepson, J.H. Carothers. 1995.
Evolutionary Consequences of Extinctions in Populations of a Hawaiian Honeycreeper. Conservation Biology 9: 1, 107-113.

*Lammers, T.G. & C.E. Freeman. 1986. Ornithophily among the Hawaiian Lobelioideae (Campanulaceae): evidence from nectar sugar compositions. American Journal of Botany 73: 1613-1619.



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available upon request

Population Units

Manage for Stability Population Units	PU Type	Which Action Area is the PU inside?	Management Units for Threat Control
Kahanahaiki to Keawapilau	Both in situ and Augmentation	MMR	Kahanahaiki, Pahole, Kapuna
Manuwai	Reintroduction	None	Manuwai
Kaluaa	Both in situ and Augmentation	None	Kaluaa and Waieli
Ekahanui	Both in situ and Augmentation	None	Ekahanui
Genetic Storage Population Units			
South Mohiakea	in situ	SBMR	Mohiakea
Kealia	in situ	None	Kaluakauila*
Palawai	in situ	None	North Palawai
Palikea Gulch	in situ	None	Kapuna*

- *The Kealia and Palikea Gulch PUs are not protected with fences so stock has been reintroduced into the listed Management Units.
- OANRP plan to incorporate all founders into reintroductions/augmentations. Currently, only the North Palawai PU stock is not represented in any outplanting.
- OANRP will continue to facilitate population genetic research to refine units by the Bishop Museum and may adapt management accordingly.

Population Structure

- Limited recruitment of seedlings has been observed at most in situ sites. Slugs are thought to depredate seedlings of *D. waianaeensis* and could limit regeneration at all sites. Seedlings have been observed to survive to be new mature founders at some in situ sites. However, at most in situ sites there have been very few (1-8) mature plants observed limiting the number of seeds that have been dispersed.
- At the much larger reintroduction sites, more seedlings and immature plants are becoming established as many of the planted individuals are now producing fruit.
- Although observations show a developing population structure, data on stage class transitions are still limited. Data collection on stage class distribution and survivorship will be collected and management adapted management accordingly.
- If population structure will maintain the stabilization goal of 100 mature plants, no further planting may be needed. If monitoring shows that survivorship may not be sufficient to maintain the stability goal, the management strategy will be adapted.

	Population Unit Monitoring History						
Population Unit	2003 Mat/Imm/ Seedling	2004 Mat/Imm/ Seedling	2005 Mat/Imm/ Seedling	2006 Mat/Imm/ Seedling	2007 Mat/Imm/ Seedling	2008 Mat/Imm/ Seedling	2009 Mat/Imm/ Seedling
Kahanahaiki to Keawapilau **in situ**	4/0/0	5/0/0	4/0/0	4/0/0	5/0/0	5/0/0	5/0/0
Kahanahaiki to Keawapilau **outplanted**	26/0/0	24/1/0	21/1/0	18/0/0	17/111/0	134/41/0	139/41/0
Kaluaa **in situ**	1/1/0	1/1/0	1/1/0	1/0/11	1/5/2	2/6/0	4/5/1
Kaluaa **outplanted**	43/0/0	43/0/0	34/0/0	27/0/0	24/1/5	24/1/5	80/21/0
Ekanahui **in situ**	1/9/0	3/1/0	4/0/0	4/0/0	4/0/0	3/0/0	2/0/0
Ekahanui **outplanted**	0/44/0	0/44/0	81/0/0	109/0/0	109/0/0	95/77/0	83/67/62
Kaluakauila **outplanted**	0	0	0	0	0/45/0	7/45/0	12/35/0
Palikea Gulch **in situ**	5/0/0	2/0/0	1/0/0	2/0/0	2/0/0	1/0/0	3/5/1
South Mohiakea **in situ**	1/1/0	1/1/0	1/1/0	1/1/0	2/0/0	3/3/0	3/3/4

Monitoring Plan

- All PUs will be monitored annually for population structure, trends and threats. All plants will be monitored for reproductive status, vigor and growth. Monitoring will focus on areas under fruiting plants. Seedlings and immature plants will be counted and mapped and areas delineated on sketch maps. Immature plants will be individually tagged to track survivorship and growth between stage classes. Slug impacts will be documented as another focus of the searches.
- In addition, all in situ sites with the potential to have new founders will be monitored in May-June in order to collect from any new plants. Sites with newly reproductive plants will be protected from rodent impacts as feasible and monitored to ensure fruit development.
- All individuals at outplanting sites will be monitored twice annually for reproductive status, vigor and growth.
- Sites with seedlings will be examined and a profile of micro-site requirements will begin to be developed.
- Records from the annual census of seedlings and growth rates and survivorship of immature plants, projections of population structure may be developed.

Genetic Storage Plan

What propagule type is used for meeting genetic storage goal?	What is the source for the propagules?	What is the Genetic Storage Method used to meet the goal?	What is the proposed re-collection interval for seed storage?	Is seed storage testing ongoing?	Plan for maintaining genetic storage.
Seed	in situ and reintroductions	Seed banking (5C or -80C / 20% RH)	5 years	Yes	Recollections will be made from GH living collections if needed.

Comments: Given the recommended interval for re-collection, some founders may have died prior to the expiration of stored collections. In this case, collections from the reintroduction of stock from that original founder will be used to replace the expired collections in storage. This strategy will continue to maximize the genetic variability represented by the stored collections and keep all original founders available for mixing into future outplantings. The re-collection interval will likely increase after future results are analyzed.

Reintroduction Plan

Manage for Stability Population Unit	Reintroduction Site(s)	Number of Plants to be planted *	Propagule Type	Propagule Population(s) Source	Number of Founders in Source Population.	Plant Size	Pot Size
Kahanahaiki to Keawapilau	PAH-C	220 (133%)	Immature plants	PAH-A, B , E KAP-A,B, C	11	25-50 cm	4" - 1 gallon
Kahanahaiki to Keawapilau	MMR-A	30 (133%)	Immature plants	KAP-A,B, C	6	25-50 cm	4" - 1 gallon
Manuwai	ANU-A**	TBD	Immature plants	ALI-A, B	6	25-50 cm	4" - 1 gallon
Kaluaa	KAL-C	175 (133%)	Immature Plants	SBW-A	5	25-50 cm	4" - 1 gallon
Kaluaa	ELI-A**	TBD	Immature plants	KAL-B	5	25-50 cm	4" - 1 gallon
Ekahanui	EKA-D	150 (133%)	Immature plants	EKA-A, B, C	6	25-50 cm	4" - 1 gallon
Genetic Storage Population Unit							
Kealia	Kaluakauila: MMR-D	70 (133%)	Immature plants	LIA-A	2	25-50 cm	4" - 1 gallon
Palawai	TBD**	TBD	Immature plants	PAL-A, B	6	25-50 cm	4" - 1 gallon
Palikea Gulch	Kapuna: KAP-D	60 (133%)	Immature plants	ALI-A, B	6	25-50 cm	4" - 1 gallon

*Number of Plants to be Planted: The mean survivorship for all PUs is approximately 75%. The target number for each site is listed followed by a percentage. The total number planted was divided by the number of these plants that are still alive. The percentage displayed is the multiplier needed to compensate for the survivorship calculated for each site. Since most plants mature within the first year after planting, all planted individuals were used to calculate survivorship. The target number is multiplied by this percentage to get the number of plants to be planted. This calculation was applied to all reintroductions.

**Reintroduction has not yet begun, TBD= OANRP to develop plans

Reintroduction Plan Comments

- Since 1999, OANRP has reintroduced 756 plants into 9 separate sites in all the MFS PUs. Mean survivorship of *D. waianaeensis* is approximately 75%.
- Planting protocols for *D. waianaeensis* are well developed and will be followed for the remaining outplantings. The propagule type, plant and pot size are standardized. High-density plantings are established in order to attract frugivorous birds that may disperse seeds and to maximize the potential for regeneration. There has been regeneration of seedlings in the outplanting sites at all PUs where planting has occurred (Kahanahaiki to Keawapilau, Ekahanui and Kaluaa).
- The reintroduction sites in the Kahanahaiki to Keawapilau PU (MMR-A, PAH-C) are complete with all available founders represented.
- The Manuwai reintroduction will begin once the MU fence is complete. Founders from Palikea Gulch will be planted at a site to be determined in MIP Year 6. Since many of the founders from Palikea Gulch are now dead, the Kapuna (KAP-D) reintroduction will be the source for those collections since all are represented there.
- The KAL-C reintroduction of Mohiakea stock into the Kaluaa PU began in 2002 and will continue until the founders are balanced. Most founders are currently represented at this site (3/5) and the planting may require two more years to complete.
- The Waieli (ELI-A) reintroduction of all available founders from the Kaluaa PU (KAL-B) will begin once construction of the Waieli Gulch fence is complete.
- The Ekahanui Gulch reintroduction was started by TNC in 2003. All six available founders are represented in the reintroduction at EKA-D. Planting will continue for two more years until the founders are balanced.
- Stock from both available founders in the Kealia PU (LIA-A) were used to establish an outplanting into Kaluakauila Gulch in 2007. This planting is complete and collections from this site will be used to represent the Kealia PU in genetic storage.
- Stock from the Palawai PU will be used to establish a reintroduction into a site to be determined by OANRP.
- Stock from all 6 currently available founders in the Palikea Gulch PU (ALI-A, ALI-B) were used to establish an outplanting into Kapuna Gulch. This planting is ongoing. Three additional founders were found at the ALI-A site in 2009, but collections were not made. Collections will be made this coming year to supplement the Kapuna gulch reintroduction. Collections from this site will be used to represent the Palikea Gulch PU in genetic storage.

5 Year Action Plan for MFS PUs

	Proposed Actions for the following years:				
Manage for Stability Population Unit	**MIP YEAR 6 October 1, 2009 – September 31, 2010**	**MIP YEAR 7 October 1, 2010 – September 31, 2011**	**MIP YEAR 8 October 1, 2011 – September 31, 2012**	**MIP YEAR 9 October 1, 2012 – September 31, 2013**	**MIP YEAR 10 October 1, 2013 – September 31, 2014**
Kahanahaiki to Keawapilau	• Monitor & Collect	• Monitor & Collect • Slug Control Trial	• Monitor & Collect	•Monitor & Collect	•Monitor & Collect
Manuwai	•Select & prepare reintroduction site	• Reintroduce	• Reintroduce	• Monitor	•Monitor
Kaluaa	• Reintroduce and Augment •Monitor & Collect	• Reintroduce and Augment •Monitor &Collect	• Reintroduce and Augment •Monitor &Collect	•Monitor &Collect	•Monitor &Collect
Ekahanui	• Reintroduce and Augment •Monitor & Collect	• Reintroduce and Augment •Monitor & Collect	•Monitor & Collect	•Monitor & Collect	•Monitor & Collect

5 Year Action Plan for Genetic Storage PUs

	Proposed Actions for the following years:				
Genetic Storage Population Unit	**MIP YEAR 6 October 1, 2009 – September 31, 2010**	**MIP YEAR 7 October 1, 2010 – September 31, 2011**	**MIP YEAR 8 October 1, 2011 – September 31, 2012**	**MIP YEAR 9 October 1, 2012 – September 31, 2013**	**MIP YEAR 10 October 1, 2013 – September 31, 2014**
South Mohiakea	•Monitor & Collect	•Monitor & Collect	•Monitor & Collect	•Monitor & Collect	•Monitor & Collect
Kealia	•NARS staff to Monitor & Collect	• NARS staff to Monitor & Collect	• NARS staff to Monitor & Collect	•NARS staff to Monitor & Collect	•NARS staff to Monitor & Collect
Kaluakauila Reintroduction of Kealia PU Stock	•Monitor	•Monitor	•Monitor &Collect	•Monitor &Collect	•Monitor &Collect
Palawai	•Monitor & Collect	•Monitor & Collect	•Monitor & Collect	•Monitor & Collect	•Monitor & Collect
Palikea Gulch	•Monitor & Collect	•Monitor & Collect	•Monitor & Collect	•Monitor & Collect	•Monitor & Collect

2008-2009 Stabilization Goals Update

MFS Population Units	PU Stability Target		MU Threat Control						Genetic Storage
	Has the Stability Target for mature plants been met?	Does the PU have observed structure to support the stability target in the long-term?	Ungulates	Weeds	Rodents	Fire	Slugs	Black Twig Borer	Are there enough propagules in Genetic Storage?
Kahanahaiki to Keawapilau	YES	NO	YES	PARTIAL	PARTIAL	NO	NO	NO	YES
Manuwai	NO	NO	NO	NO	NO	NO	NO	NO	N/A
Kaluaa	NO	NO	YES	YES	NO	NO	NO	NO	YES
Ekahanui	NO	NO	YES	PARTIAL	PARTIAL	NO	NO	NO	YES
Genetic Storage Population Units									
South Mohiakea	NO	NO	YES	PARTIAL	NO	NO	NO	NO	YES
Kealia	NO	NO	NO	NO	NO	NO	NO	NO	YES
Palawai	NO	NO	YES	PARTIAL	NO	NO	NO	NO	YES
Palikea Gulch	NO	NO	NO	NO	NO	NO	NO	NO	NO

2008-2009 Highlights

Major Highlights/Issues MIP Year 5

- The goal of 100 reproducing plants is met for the Kahanahaiki to Keawapilau PU
- Both the Ekahanui PU and Kaluaa PU will likely reach the goal of 100 reproducing individuals in the next year given the number of immature plants at those sites.
- Three of the four Manage for Stability sites are protected by large fences. Construction of the Manuwai fence began this year for protection of future reintroduction area.
- All available founders from the Ekahanui, Kealia, South Mohiakea, Kahanahaiki to Keawapilau, Palawai sites are represented in seed storage. New founders from Palikea Gulch, South Mohiakea and Kaluaa were collected from in the last year.
- There are numerous seedlings and immature plants that are beginning to form a population structure at the Ekahanui and Kaluaa reintroduction sites
- Molecular analyses of several founders were done by Shelly James of the Bishop Museum and the draft report submitted to OANRP.
- Outplanting continued to supplement the Kahanahaiki to Keawapilau PU, Ekahanui PU and Kaluaa PU
- The reintroduction of stock from the Kealia PU into Kaluakauila is complete.
- A reintroduction of stock from the Palikea Gulch PU is ongoing. New founders were discovered this year and will be added to the outplanted when collections are secured.
- Reintroduction strategy developed for the Manuwai PU
- UH graduate student began a pollination biology study in Kahanahaiki gulch

2008-2009 Plans for MIP Year 6

Plans for MIP Year 6

- Conduct census monitoring at all Manage for Stability PUs
- Continue to supplement the augmentations in the Kahanahaiki to Keawapilau, Ekahanui and Kaluaa PUs in order to balance founders at these Manage for Stability PUs
- Collect fruit from any new founders for propagation and genetic storage
- Complete Manuwai MU fence construction
- Continue molecular study with Bishop Museum and facilitate studies by UH researcher

2008-2009 Taxon Status Table

Action Area: In

TaxonName: Delissea waianaeensis **TaxonCode: DelWai**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kahanahaiki to Keawapilau	Manage for stability	5	0	0	151	28	0	139	41	0	156	28	0	Small changes were noted during monitoring in the last year
Kaluakauila	Manage reintroduction for storage	0	0	0	12	35	0	7	45	0	12	35	0	A few more plants died in the last year and the reintroduction was completed.
South Mohiakea	Genetic Storage	3	3	4	0	0	0	3	3	0	3	3	4	Small changes were noted during monitoring in the last year
	Total for Taxon:	8	3	4	163	63	0	149	89	0	171	66	4	

Action Area: Out

TaxonName: Delissea waianaeensis **TaxonCode: DelWai**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Ekahanui	Manage for stability	2	0	0	83	67	62	98	77	0	85	67	62	Small changes were noted during monitoring in the last year and many new seedlings were observed
Kaluaa	Manage for stability	4	5	1	80	21	0	26	7	5	84	26	1	New plants were observed in the wild site and plants were added to the reintroduction sites
Kealia	Genetic Storage	2	0	0	0	0	0	2	0	0	2	0	0	No OANRP monitoring in the last year
Manuwai	Manage reintroduction for stability	0	0	0	0	0	0	0	0	0	0	0	0	The reintroduction will begin once the MU fence is complete
Palawai	Genetic Storage	3	3	0	0	0	0	3	3	0	3	3	0	Monitoring showed no change
Palikea Gulch	Genetic Storage	3	5	1	64	8	0	53	7	0	67	13	1	New plants were observed at one of the wild sites and more were added to the reintroduction site
	Total for Taxon:	14	13	2	227	96	62	182	94	5	241	109	64	

2008-2009 Genetic Storage Status Table

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	Storage Goals Met: # Plants that Met Goal
Delissea waianaeensis							
Ekahanui	2	0	4	6	0	3	6
Kahanahaiki to Keawapilau	5	0	8	11	1	4	11
Kaluaa	4	5	1	5	0	2	5
Kealia	2	0	0	2	0	0	2
Palawai	3	3	3	6	0	0	6
Palikea Gulch	3	5	5	6	4	1	6
South Mohiakea	3	3	3	4	0	4	5
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				40	5	14	41

Cyanea superba subsp. *superba*

- **Scientific name:** *Cyanea superba* (Cham.) A. Gray subsp. *superba*
- **Hawaiian name:** *Haha, ohawai*
- **Family:** Campanulaceae (Bellflower family)
- **Federal status:** Listed endangered September 11, 1991
- **MIP Requirements for Stability**
  - 4 Population Units (PU)
  - 50 reproducing individuals in each PU (long-lived perennial with a history of precipitous decline, extirpated in the wild, and extremely low genetic variability
  - Threats controlled
  - Stable population structure
  - Complete genetic representation in storage of all PUs
- **Description and biology:** *Cyanea superba* subsp. *superba* is a tree 4-6 m tall with a single major stem, or occasionally two or more major stems arising from the base of the plant. Two of the basal-branching plants formerly growing at Kahanahaiki each had about 8-10 major stems (Lau pers. comm. 2000). The taxon's leaves measure 0.5-1.0 m long, and are clustered at the stem tips. The inflorescences hang below the leaves, and terminate in a cluster of 5-15 flowers. The corollas are whitish to cream, curved, and measure 5.5-8.8 cm long. The berries are yellow to orange, egg-shaped, and measure 16-22 mm long (excerpt from MIT 2003).

Cyanea superba subsp. *superba*

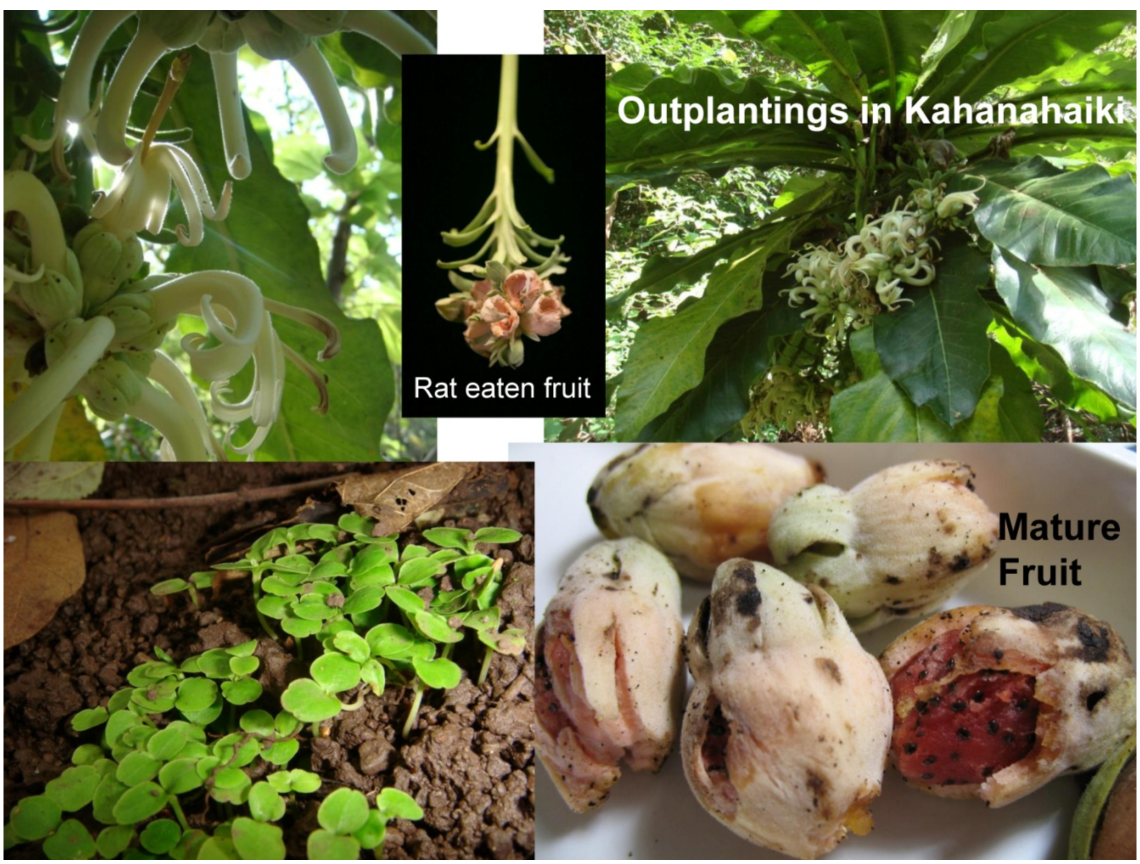
- **Description and biology cont.:** This taxon reportedly flowers from September through October. It was probably originally pollinated by nectar-feeding birds, as is thought for *Cyanea*s in general, with their long tubular flowers. *Cyanea superba* subsp. *superba* is capable of self-pollination, as evidenced by the production of fertile seeds in the Kahanahaiki population unit in years when only a single plant had flowered. Fruit-eating birds presumably dispersed the seeds. Based on growth rates and the size of mature plants, *C. superba* subsp. *superba* may live for up to 20 years or more (Lau pers. comm. 2000).
- **Known distribution:** The few documented locations for *C. superba* subsp. *superba* are all in the northern Waianae Mountains. These locations are the eastern slope of Mt. Kaala, Makaleha Valley, Pahole Gulch, and Kahanahaiki Valley. After the original collections prior to 1870, no plants were known until its rediscovery in 1971 in Pahole. The Kahanahaiki site was discovered in 1987. By 1991, a total of less than 20 plants were knows from Pahole and Kahanahaiki. The Pahole plants were gone by 1994 and the last Kahanahaiki plant died in 2002.
- **Habitat:** The historic sites in Kahanahaiki Valley and Pahole Gulch, are on the lower to upper gulch slopes. These slopes are fairly steep. The vegetation at these sites consists of mesic forest comprised of a mix of various native and alien tree species.
- **Taxonomic background:** *Cyanea superba* is endemic to Oahu. It is comprised of two subspecies: subsp. *superba* of the northern Waianaes, and subsp. *regina* of the southeastern Koolau Mountains. *Cyanea superba* subsp. *regina* was last recorded in 1960. In 1913, Joseph Rock wrote in <u>The Indigenous Trees of the Hawaiian Islands</u>, "The queen of all is the lobeliaceous *Cyanea superba* var. *regina,* an exceedingly beautiful plant found only on Oahu, in the gulches of Wailupe and Niu, and in Makaleha of the Kaala range."

Reproductive Biology Table

	Observed Phenology			Reproductive Biology		Seeds	
Population Unit	Flower	Immature Fruit	Mature Fruit	Breeding System	Suspected Pollinator	Average # Per Fruit	Dormancy
ALL	Sept-Oct	Oct-Jan	Oct-Jan	Hermaph-roditic	Bird*	112 ± 80	Not Dormant

*Smith, T.B. L.A. Freed, J.K. Lepson, J.H. Carothers. 1995.
Evolutionary Consequences of Extinctions in Populations of a Hawaiian Honeycreeper. Conservation Biology 9: 1, 107-113.

*Lammers, T.G. & C.E. Freeman. 1986. Ornithophily among the Hawaiian Lobelioideae (Campanulaceae): evidence from nectar sugar compositions. American Journal of Botany 73: 1613-1619.




Seedlings germinating
Slug damage
Seeds under outplanted plants


Map removed,
available upon request

Population Units

Manage For Stability Population Units	PU Type	Which Action Area is the PU inside?	Management Units for Threat Control
Kahanahaiki	Reintroduction	MMR	Kahanahaiki
Central and East Makaleha	Reintroduction	None	East Makaleha
Makaha	Reintroduction	None	Makaha Subunit I
Pahole to Kapuna	Reintroduction	MMR	Pahole and Kapuna
Genetic Storage Population Units			
None			

Population Structure

- Seedlings or immature plants were never observed when OANRP was monitoring the Kahanahaiki in situ site from 1995-2002.
- In 2009, regeneration of seedlings under outplanted individuals was first observed. After a few more years of continued recruitment and survival through larger age classes, the reintroduction sites may begin to have a population structure that would maintain at least 50 mature plants.
- OANRP will continue to monitor and record population structure trends. If the observed population structure will maintain the stabilization goal of 50 mature plants, no further planting may be needed. If monitoring shows that survivorship may not be sufficient to maintain the stability goal, the management strategy will be adapted.
- OANRP will develop techniques to increase seedling establishment at all sites. Particularly at sites where slug control with Sluggo may not be possible due to the presence of rare snails, trials may include collecting mature fruit and applying fruit to adjacent substrates.

Population Unit Monitoring History

Population Unit	1998 Mat/Imm/ Seedling	2000 Mat/Imm/ Seedling	2001 Mat/Imm/ Seedling	2002 Mat/Imm/ Seedling	2005 Mat/Imm/ Seedling	2006 Mat/Imm/ Seedling	2007 Mat/Imm/ Seedling	2008 Mat/Imm/ Seedling	2009 Mat/Imm/ Seedling
Kahanahaiki **in situ**	5/0/0	2/0/0	0	0	0	0	0	0	0
Kahanahaiki **outplanted**	0/8/0	0/50/0	0/58/0	0/75/0	0/62/0	17/108/0	19/92/0	18/126/0	33/127/193
Pahole to Kapuna **outplanted**	0	32/42/0	18/176/0	18/177/0	29/148/0	72/84/0	72/68/0	92/85/0	91/100/255
Makaha **outplanted**	0	0	0	0	0	0	0	0	0/42/0

Monitoring Plan

- All PUs will be monitored annually for population structure, trends and threats.
- All individuals at outplanting sites will be monitored twice annually for reproductive status, vigor and growth.
- All sites with reproductive plants will be monitored every December in order to time the installation of rodent protection as the fruit develops.
- Sites with reproductive plants will also be monitored in the spring for new seedlings. Monitoring will focus on areas under fruiting plants. Seedlings at all sites will be counted and areas with seedlings will be delineated on sketch maps. New immature plants at all sites will be tagged and monitored for vigor and growth.
- Sites with seedlings will be examined and a profile of micro-site requirements will begin to be developed.
- Seedlings will be monitored to track survivorship and growth. Slug impacts will be documented as another focus of the searches. The sites with seedlings in the Pahole to Kapuna PU have no ongoing slug control. These sites will be used as an experimental control to document the impact of slug control on seedlings in the Kahanahaiki PU.
- Records from the annual census of seedlings and growth rates and survivorship of immature plants, projections of population structure may be developed.

Genetic Storage Plan

What propagule type is used for meeting genetic storage goal?	What is the source for the propagules?	What is the Genetic Storage Method used to meet the goal?	What is the proposed re-collection interval for seed storage?	Is seed storage testing ongoing?	Plan for maintaining genetic storage.
Seeds	Reintroductions	Seed banking (5c or -80C / 20% RH)	> 10 years	Yes	Collections will be made from reintroductions as needed.

Genetic Storage Plan Comments:

• As no wild plants remain collections are made from reintroductions. Founders are tracked and collections made appropriately.

• When F1s become reproductive collections will be made to represent these individuals as they may represent new founders and have undergone selective pressures at the seed, seedling, and immature stages.

• Collection procedures changed in December 2006 to improve longevity of seeds in storage. Thorough storage testing began in January 2007. Five year results will be available in 2012. Data from older collections suggest that re-collection efforts may be between every 10-20 years.

Reintroduction Plan

Population Unit	Reintroduction Site(s)	Number of Plants to be planted*	Propagule Type	Propagule Population(s) Source	Number of Founders in Source Population	Plant Size	Pot Size
Kahanahaiki	MMR-E	100 (166%)	Immature Plants	Kahanahaiki and Pahole to Kapuna	3	> 25cm	1-2 gallon
Kahanahaiki	MMR-H	100 (166%)	Immature Plants	Kahanahaiki and Pahole to Kapuna	3	> 25cm	1-2 gallon
Kahanahaiki	MMR- B, D, F, G	0	Immature Plants	Kahanahaiki and Pahole to Kapuna	3	> 25cm	1-2 gallon
Pahole to Kapuna	Pahole: PAH-A	100 (137%)	Immature Plants	Kahanahaiki and Pahole to Kapuna	3	> 25cm	1-2 gallon
Pahole to Kapuna	Pahole: PAH-B**	0	Immature Plants	Kahanahaiki and Pahole to Kapuna	3	> 25cm	1-2 gallon
Pahole to Kapuna	Kapuna: KAP- A,B**	0	Immature Plants	Kahanahaiki and Pahole to Kapuna	3	> 25cm	1-2 gallon
Makaha	MAK- A	150	Immature Plants	Kahanahaiki and Pahole to Kapuna	3	> 25cm	1-2 gallon
Central and East Makaleha	East Makaleha: LEH- A – Not yet established	150	Immature Plants	Kahanahaiki and Pahole to Kapuna	3	> 25cm	1-2 gallon
Genetic Storage Population Unit							
None							

*Number of plants to be planted: The target number for each site is listed followed by a percentage for sites with existing plantings. The total number planted (adjusted for time to mature after planting) was divided by the number of these plants that are mature. The percentage displayed is the multiplier needed to compensate for the survivorship of mature plants calculated for each site. The target number is multiplied by this percentage to get the number of plants to be planted. For sites with no existing or recently planted plants, the baseline 150 plants (50 of each of the three founders) will be planted initially, and more will be added if needed.

**Older state reintroduction will be monitored and collected from by OANRP but not planted into.

Reintroduction Plan Comments

- The reintroduction of *C. superba* into Kahanahaiki was the first endangered species in the nation to be reintroduced onto Army managed lands.
- The MMR-B, D, F, G sites in Kahanahaiki are no longer supplemented due to poor performance when compared with MMR-E and MMR-H.
- The sites in the Pahole to Kapuna PU at KAP-A, KAP-B and PAH-B are Oahu NARS reintroductions planted from 1995 to 1999. They are monitored but not used.
- Reintroduction protocols for *C. superba* are well developed and will be followed for the Makaleha reintroduction. The propagule type, plant and pot size are standardized.

5 Year Action Plan

	Proposed Actions for the following years:				
Population Unit	**MIP YEAR 6 October 1, 2009 – September 31, 2010**	**MIP YEAR 7 October 1, 2010 – September 31, 2011**	**MIP YEAR 8 October 1, 2011 – September 31, 2012**	**MIP YEAR 9 October 1, 2012 – September 31, 2013**	**MIP YEAR 10 October 1, 2013 – September 31, 2014**
Kahanahaiki	•Reintroduce •Monitor •Slug control	•Reintroduce •Monitor & Collect •Slug control •Seed sowing trial	•Reintroduce •Monitor & Collect •Slug control •Seed sowing trial	•Monitor •Slug control	•Monitor •Slug control
Central and East Makaleha	None	• Begin fence construction	• Complete fence construction •Begin propagation	•Reintroduce	•Reintroduce
Makaha	•Reintroduce •Monitor	•Reintroduce •Monitor	•Reintroduce •Monitor	•Monitor •Slug Control	•Monitor •Slug Control
Pahole to Kapuna	•Reintroduce •Monitor	•Reintroduce •Monitor & Collect	•Reintroduce •Monitor & Collect •Slug Control	•Monitor •Slug Control	•Monitor •Slug Control
Genetic Storage Population Units					
None					

2008-2009 Stabilization Goals Update

MFS Population Units	PU Stability Target		MU Threat Control						Genetic Storage
	Has the Stability Target for mature plants been met?	Does the PU have observed structure to support the stability target in the long-term?	Ungulates	Weeds	Rodents	Fire	Slugs	Black Twig Borer	Are there enough propagules in Genetic Storage?
Kahanahaiki	NO	NO	YES	YES	YES	NO	PARTIAL	NO	YES
Central and East Makaleha	NO	NO	N/A	N/A	N/A	N/A	N/A	NO	N/A
Makaha	NO	NO	YES	YES	NO	NO	NO	NO	N/A
Pahole to Kapuna	YES	NO	YES	PARTIAL	NO	NO	NO	NO	N/A

2008-2009 Highlights

Major Highlights/Issues MIP Year 5

- The stability goal of 50 reproducing individuals is met for the Pahole to Kapuna PU.
- Naturally occurring seedlings were observed in several locations in the last year. At the Kahanahaiki PU over 300 in total were found under 8 separate plants. An additional 300 seedlings were observed under two plants in the Pahole to Kapuna PU. In addition, one immature plant was observed under a reintroduced plant at Puu Palikea that had been planted by TNCH.
- There are now a total of nearly 200 immature plants in the Kahanahaiki PU beneath four separate reintroduced individuals (Figure 2.7.1). As slugs are known to attack seedlings of this species, the organic molluscicide, Sluggo, was applied under an Experimental Use Permit valid through February 2010. Sluggo application coincided with seedling counts.
- The Mahaka fence was declared pig free in the summer of 2009 and reintroductions began in the last year.
- A large-scale rat control grid was established in the Kahanahaiki MU protecting maturing fruit from rats.
- UH Botany graduate student, R. Pender, began a study of pollination biology at the Kahanahaiki PU.

Plans for MIP Year 6

- Continue to supplement the reintroduction at Makaha.
- Pursue fencing plans for East Makaleha with the State of Hawaii.
- Conduct seedling searches under all mature plants in January and February 2010.
- Continue to track seedlings at both the Kahanahaiki PU and the Pahole to Kapuna PU and monitor for potential benefits of slug control.
- Pursue Special Local Needs (SLN) labeling of Sluggo for use in natural areas devoid of *Achatinella.*
- Develop plans for a seed sowing trial that will seek to identify microhabitats that will support germination

2008-2009 Taxon Status Table

Action Area: In

TaxonName: Cyanea superba subsp. superba **TaxonCode: CyaSupSup**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kahanahaiki	Manage for stability	0	0	0	33	127	193	18	126	0	33	127	193	More plants were added to the reintroduction sites and many seedlings were observed
	Total for Taxon:	0	0	0	33	127	193	18	126	0	33	127	193	

Action Area: Out

TaxonName: Cyanea superba subsp. superba **TaxonCode: CyaSupSup**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Central and East Makaleha	Manage reintroduction for stability	0	0	0	0	0	0	0	0	0	0	0	0	This reintroduction will begin when the MU fence is complete
Makaha	Manage reintroduction for stability	0	0	0	0	42	0	0	0	0	0	42	0	The reintroduction was established in the last year
Pahole to Kapuna	Manage reintroduction for stability	0	0	0	91	100	255	92	85	0	91	100	255	More plants were added to the reintroduction sites and many seedlings were observed
	Total for Taxon:	0	0	0	91	142	255	92	85	0	91	142	255	

2008-2009 Genetic Storage Status Table

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	Storage Goals Met: # Plants that Met Goal
Cyanea superba subsp. superba							
Kahanahaiki	0	0	6	3	3	3	3
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				3	3	3	3

CHAPTER 3: MIP/OIP RARE PLANT STABILIZATION PLANS

3.1 INTRODUCTION

This section includes population status updates, the current genetic storage status for each IP taxon and a brief discussion of highlights from the last year and priority actions for the next year. The requirements for stabilization are to achieve a stable number of mature plants, a population structure which can maintain that number of mature plants, obtain full genetic storage of all PUs, and control all observed threats at each Manage for Stability (MFS) PU. This will be done by implementing Population Unit (PU) and Management Unit (MU) actions at all of the MFS PUs. All management actions are discussed in the Ecosystem Management section. Management changes discussed at last years IT meeting have been incorporated into this report.

Propagation infrastructure

OANRP continue to use three nursery facilities to propagate plants for outplanting and hold living collections for genetic storage. The newest shade-house at the Schofield Barracks West Range baseyard is being used along with the older shade-house at East Range. NRS has continued to work with State NARS Horticulturist, Doug Okamoto, on projects at the Pahole Mid-Elevation Nursery and on propagating stock from the Pahole NAR. The Lyon Arboretum Micropropagation Lab is used to maintain and clone important collections and to germinate seeds from immature fruit. All seed collections are processed and stored at the Schofield Barracks East Range baseyard by OANRP staff. Plans are being developed for improvements to the seed processing facilities. Additional space is needed to maintain and expand collection efforts and potential facilities are being considered.

Research Issues

The OANRP continues to support work by researchers from the University of Hawaii. In the last year, the OANRP has continued to facilitate graduate research by Lauren Weisenberger (*Schiedea*), Dr. Cliff Morden (*Chamaesyce*) and Richard Pender (*Cyanea superba* subsp. *superba*, *Delissea waianaeensis*). All projects are funded and supervised by OANRP and all projects will continue in the coming year. In addition, OANRP contracted Shelly James of the Bishop Museum to extract and analyze DNA from several plants of *Delissea waianaeensis*. Results are pending. Research issues related to threats to MIP taxa are discussed in detail in the Species Status Summary for each taxon.

Snails at Nurseries

In August of 2008, an infestation of several species of snail was discovered at all three OANRP nurseries. Surveys uncovered a total of 7 different snails: Succinea tenella, Zonitoides arboreus, Subulinid sp., Gonaxis kibweziensis, Liardetia doliolum, Euglandina rosea and Tornitellinid sp. (possibly native). Snail identification was confirmed by Dr. Robert Cowie at the University of Hawaii. In an October-December 2008 article in the International Journal of Pest Management, Dr. Cowie and others presented the results of a baseline survey of snail and slugs species in 40 nurseries in Hawaii (Cowie 2008). In an effort to develop inspection, quarantine and control techniques for the new pests, OANRP consulted with Dr. Cowie and Dr. Rob Hollingsworth at UH-Hilo. Dr. Hollingsworth had published results from trials to determine effective control techniques for Zonitoides arboreus at orchid nurseries in Hilo, Hawaii (Hollingsworth 2003).

A combination of inspection, quarantine, and control protocols were developed to eradicate snails from all facilities. Inspections by OANRP staff were instigated to determine the distribution of each species. New more efficient techniques were developed where potted plants are routinely baited with lettuce to attract snails, and lettuce and soil below lettuce examined for snail presence. If, following 8 weeks of visual examination, snails are never found, then plants are cleared for out-planting. Quarantine protocols were developed to isolate each bench by standing the legs in a container of salt pellets to exclude snails from clean benches and keep them on infested ones. All benches were removed and power-washed and all other equipment is soaked in bleach before re-use. Greenhouse facilities are sprayed with a liquid metaldehyde product (Slugfest) and baited using Sluggo, Deadline and Cory's Slug and Snail Pellets. If snails are found, infected plants are treated with metaldehyde (Hollingsworth & Armstrong, 2003, Hollingsworth pers. comm. 2009). Many infested plants were cloned and destroyed. Many that could not be cloned were stripped of all growing media, cleaned and repotted. OANRP will continue inspection and quarantine protocols to ensure that snails are not able to access greenhouse benches. Control on infested benches will continue until inspections find no snails for at least 8 weeks.

Example of Species Status Summary

The following species status summary outlines all work conducted for each Population Unit of the IP taxa. Each species summary has the same format and is explained in detail in the example below:

Requirements for Stability: This section defines requirements for reaching stability.

Population Units (PUs): At least 3 are designated for all species. However, for species meeting the following criteria 4 PUs have been designated:

- in both Makua Action Area (AA) and Oahu AA (Example: *Plantago princeps*)

- occurring in high fire threat area (Example: *Chamaesyce celastroides*)

- no extant wild PUs and dependant on reintroduction (Example: *Cyanea superba*)

[25-100] reproducing individuals in each PU: This varies for each taxa based on the number of extant individuals, average life span, life form, breeding system, history of large fluctuations in population size and other factors listed the final IP.

Stable Population Structure: This is not defined for any species. OANRP will develop projections based on observations of stable populations and future survivorship studies. Most IP species do not have a population structure that can maintain stability goals but this has not been studied.

Threats controlled: Threat control may include fences, weed control, arthropod and rodent control and fire prevention. All known threats to MFS PUs must be controlled.

Genetic storage of all PUs: Genetic storage from up to 50 founders from each PU. Storage goals may be met by maintaining plants of each founder in nursery living collections, seeds in proven storage conditions or in tissue culture storage at Lyon Arboretum**.**

Example of Taxon Status Table

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Stenogyne kanehoana **TaxonCode: SteKan**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2006	NRS Immature 2006	NRS Seedling 2006	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Haleauau	Manage for stability	1	0	0	0	0	0	1	0	0	1	0	0	Monitoring showed no change in the last year.
	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	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2006	NRS Immature 2006	NRS Seedling 2006	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Central Kaluaa (Gulch 2)	Manage for stability	0	0	0	0	23	0	0	0	0	0	23	0	
Central Kaluaa (South Fenceline)	Manage for stability	0	0	0	0	53	0	0	30	0	0	53	0	
	Total for Taxon:	0	0	0	0	76	0	0	30	0	0	76	0	

The above table displays the current status of the wild and outplanted plants in each PU and the population estimates from the previous year for comparison. Currently, the extant PUs are grouped into those in and out of the Makua AA. In the coming year OANRP will revise this table to display which AA each PU is within.

Population Unit Name: Only PUs designated to be Manage for Stability (MFS) or

Genetic Storage (GS) are shown in the table. Other PUs with No Management designations are not frequently monitored or managed and will not be reported. For “Reintroduction for Stability/Storage” PUs which have not yet been established, zeros are displayed for poplation numbers. If the PU is new this year and was not known in the previous year, these rows are left blank.

Management Designation: This is based on the latest decisions from the last IT meeting. For PUs with naturally occurring (*in situ*) plants remaining, the designation is either ‘Manage for Stability’ or ‘Genetic Storage’. When reintroductions alone will be used to reach stability, the designation is ‘Manage Reintroduction for Stability.’ When a reintroduction will be used for producing propagules for genetic storage, the designation is ‘Manage Reintroduction for Storage’.

Current Mature, Immature, Seedling (Wild): These first three columns display the most up to date population estimates of the wild (*in situ*) plants in each PU. In most cases these numbers are generated from OANRP monitoring data, but data from the O‘ahu Plant Extinction Prevention Program (OPEP) and State NARS staff are used for some PUs. The current estimates reported may have changed from last year if new monitoring data was taken or if the PUs have been split or merged since the last reporting period. If no additional monitoring was conducted in the last year, the estimate given in the previous year.

Current Mature, Immature, Seedling Augmented: The second set of three columns display the numbers of individuals OANRP and partner agencies have outplanted into each PU. In most cases, the number represents augmentations into the existing PU rather than reintroductions of genetic stock from that PU into other areas. While most augmentations of a PU will be from genetic stock from that PU, there are exceptions.

NRS Mature, Immature and Seedling 2008: This displays the **SUM** of the number of *wild and outplanted* mature, immature plants and seedlings from the previous year’s Status Report. For populations discovered since the 2008 IP Status Report, this column is left blank. If a PU was split, thus creating a new where there was none the previous year, a zero is used in order to distinguish it from entirely new PUs, which are left blank.

Total Mature, Immature, Seedling: The **sum** of the current numbers of *wild and outplanted* individuals in each PU. This number will be used to determine if each PU has reached stability goals. These three columns should be compared with the NRS 2008 estimates to determine the trend for each PU in the last year.

Population Trend Notes: Comments on the general population trend of each PU is given here. This may include notes on whether the PU was monitored in the last year, a brief discussion of the changes in population numbers from the 2008 numbers to the current ones, and some explanation of whether the change is due to new plants being discovered in the same site, a new site being found, reintroductions or augmentations that increased the numbers or fluctuations in the numbers of wild plants. In some cases where the numbers have not changed, NRS has monitored the PU and observed no change. In other cases when the PU has not been monitored, the number from 2007 is used.

Example 'Genetic Storage Summary' Table

Genetic Storage Goals Met Summary

Population Unit Name	# of Potential Founders: Current Mature	# of Potential Founders: Current Imm.	# of Potential Founders: NumWild Dead	Storage Goals Met: # Plants that Met Goal
Stenogyne kanehoana				
Central Kaluaa (South Fenceline)	0	0	1	1
Haleauau	1	0	0	1
				Total # Plants that Met Goal
				2

The above table shows the status of genetic storage for each taxa. Collections from OANRP and other partner agencies are totaled for this table.

Number of Potential Founders: This column lists the current live immature and mature plants (which have been collected from or may be collected from in the future) and the number of dead plants from which collections were made in the past. Immature plants are included as founders for all taxa, but they can only serve as founders for some taxa. For example, for *Hibiscus brackenridgei*, cuttings can be taken from immature plants for propagation. In comparison, for *S. mariversa,* cuttings are not taken and seeds are the primary propagule used in collecting for genetic storage. Therefore, including immature plants in the number of potential founders for *S. mariversa* gives an over-estimate. 'Manage reintroduction for stability' PUs may be on this list but have zero potential founders when the stock for reintroduction is coming from another PU.

Partial Storage Status: To meet the IP genetic storage goal for each PU, for taxa where seed storage is the preferred genetic storage method, at least 50 seeds must be stored from up to 50 plants. However in order to show intermediate progress, this column displays the number individual plants that have collections of >10 seeds in storage. For taxa where vegetative collections will be used to meet storage goals, a minimum of three clones per plant in either the Lyon Micropropagation Lab or the Army or Pahole Mid-elevation Nursery is required to meet stability goals. For these taxa, plants with one or more plant in either the Lyon Micropropagation Lab or the nursery considered to partially meet storage goals and the number of plants that have met this goal is displayed.

Storage Goals Met: This column displays the total number of plants in each PU that have met the IP genetic storage goals. As discussed above, a plant is considered to meet the storage goal if it has 50 seeds in storage, or three clones in micropropagation or three in the nursery. For some PUs, the number of founders has increased in the last year, therefore; it is feasible that NRS could be farther from reaching our collection goals than last year. In other PUs where collections have been happening for many years, the number of founders represented in genetic storage may exceed the number of plants currently in each PU. In some cases, plants that are being grown for reintroductions are being counted for genetic storage. These plants will eventually leave the greenhouse and the genetic storage goals will be met by retaining clones of all available founders or by seeds in storage. This column does not show the total number of seeds in storage; in some cases thousands of seeds have been collected from one plant.

3.2 ABUTILON SANDWICENSE

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)
- Stable population structure
- Threats controlled
- Genetic storage collections from all PUs
- Tier 1 stabilization priority

Major Highlights/Issues for OIP Year 2

- The stability goal of 50 reproducing individuals is met for the Makaha Makai PU.
- Fence construction began for the Manuwai MU. This will protect a portion of the Kaawa to Puulu PU.
- Fence construction began for the Ekahanui Subunit III MU. This will protect the Ekahanui portion of the Ekahanui and Huliwai PU.
- Genetic storage collections began for the Makaha PU and continued at the Ekahanui and Huliwai PU.
- Additional plants were added to the reintroduction in the Kaluakauila PU.

Plans for OIP Year 3

- Conduct census monitoring of all Manage for Stability PUs.
- Continue seed collections for genetic storage from the Makaha PU as well as the Ekahanui and Huliwai PU
- Reintroduction will begin for the Ekahaunui PU
- Complete construction of the Ekahanui Sub-unit III and Manuwai MU fences.
- Conduct surveys in Makua to find more stock to supplement the reintroduction of the single clone at the Kaluakauila PU.
- Begin to prioritize and survey PUs with historic records, but no known plants (Halona, South Mikilua, Nanakuli)

Table 3.1a Taxon Status Summary

Action Area: In

TaxonName: Abutilon sandwicense **TaxonCode: AbuSan**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kaawa to Puulu	Manage for stability	31	77	5	0	0	0	36	88	6	**31**	**77**	**5**	Small changes were noted during monitoring in the last year
Kahanahaiki	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
Kaluakauila	Manage reintroduction for stability	0	0	0	0	19	0	0	4	0	**0**	**19**	**0**	More plants were added to the reintroduction site
Keaau	Genetic Storage	1	0	10	0	0	0	1	0	10	**1**	**0**	**10**	No monitoring in the last year
	Total for Taxon:	32	77	15	0	19	0	37	92	16	**32**	**96**	**15**	

Action Area: Out

TaxonName: Abutilon sandwicense **TaxonCode: AbuSan**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
East Makaleha	Genetic Storage	2	2	40	0	0	0	2	2	40	**2**	**2**	**40**	No monitoring in the last year
Ekahanui and Huliwai	Manage for stability	16	28	0	0	0	0	14	30	0	**16**	**28**	**0**	Small changes were noted during monitoring in the last year
Halona	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
Makaha Makai	Manage for stability	73	27	6	0	0	0	73	27	6	**73**	**27**	**6**	Monitoring showed no change
Makaha Mauka	Genetic Storage	5	58	4	0	0	0	5	58	4	**5**	**58**	**4**	No monitoring in the last year
Nanakuli	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
North Mikilua	Genetic Storage	2	39	0	0	0	0	2	39	0	**2**	**39**	**0**	No monitoring in the last year
South Mikilua	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
Waianae Kai	Genetic Storage	2	0	0	0	0	0	2	0	0	**2**	**0**	**0**	No monitoring in the last year
West Makaleha	Genetic Storage	0	2	0	0	0	0	0	2	0	**0**	**2**	**0**	No monitoring in the last year
	Total for Taxon:	100	156	50	0	0	0	98	158	50	**100**	**156**	**50**	

Table 3.1b 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
Abutilon sandwicense							
East Makaleha	2	2	0	0	0	0	0
Ekahanui and Huliwai	16	28	3	7	0	0	6
Kaawa to Puulu	31	77	0	0	0	0	0
Kahanahaiki	0	0	1	0	0	1	0
Keaau	1	0	0	0	0	0	0
Makaha Makai	73	27	1	9	0	0	8
Makaha Mauka	5	58	0	0	0	0	0
North Mikilua	2	39	0	0	0	0	0
Waianae Kai	2	0	0	1	0	0	1
West Makaleha	0	2	0	0	0	0	0
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				17	0	1	15

3.3 ALECTRYON MACROCOCCUS VAR. MACROCOCCUS

Requirements for stability

- 4 Population Units (PUs)
- 50 reproducing individuals in each PU (long-lived perennial with reproductive problems)
- Stable population structure
- Threats controlled
- Complete genetic representation of all PUs in storage

Major Highlights/Issues for MIP Year 5

- The stability goal of 50 reproducing individuals has been met only for the Makaha PU.
- Construction of the Kaluaa and Waieli MU Sub-Unit IIB fence has begun. This fence will secure reintroduction habitat for the Central Kaluaa to Central Waieli PU.
- The Mahaka MU is ungulate free as of August 2009 protecting most of the trees in the Makaha PU.
- Air-layers were collected from ten trees in the last year. Five were in poor health when collected and are dead, three have became established in the greenhouse and the remaining two are still rooting on the mist bench.
- OANRP recently installed air-layers on two healthy trees in Makaha. Threats that were observed to have killed previous air-layers were addressed. To prevent rat damage the air-layers were caged in hardware wire. Ethanol baited traps were installed to kill Black Twig Borers. In addition, a new rooting hormone product was used. So far, both have produced roots and one has been collected to add to the greenhouse living collection.
- Fruit collected in the last year from a single tree in the Makua PU are germinating and will be kept as part of the greenhouse living collection.
- Thorough censuses of the Makua PU and Central Kaluaa to Central Waieli PU showed a decline from previous reports. Many of these trees had not been visited in several (2-10) years and were observed dead for the first time this year.

Plans for MIP Year 6

- Conduct thorough monitoring at the Kahanahaiki to West Makaleha, Waianae Kai and Makaha PUs
- Continue to install air-layers on healthy trees in the Makaha PU
- Complete construction of the fence for Kaluaa and Waieli MU Sub-Unit IIB
- Maintain and expand the greenhouse living collection for genetic storage. These collections will be used to produce additional material for air-layering and grafting.
- Search for trees in all PUs that have fruit and continue to collect mature fruit for propagation and to send to the National Center for Genetic Resources Preservation (Fort Collins, CO) for storage viability testing in liquid nitrogen.

Table 3.2a Taxon Status Summary

Action Area: In

TaxonName: Alectryon macrococcus var. macrococcus   TaxonCode: AleMacMac

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kahanahaiki to West Makaleha	Manage for stability	36	4	0	0	2	0	36	7	0	**36**	**6**	**0**	Small changes were noted during monitoring in the last year
Makua	Manage for stability	22	0	0	0	0	0	30	0	0	**22**	**0**	**0**	Thorough monitoring showed a decline in the last year
South Mohiakea	Genetic Storage	4	0	0	0	0	0	4	0	0	**4**	**0**	**0**	Monitoring showed no change
	Total for Taxon:	62	4	0	0	2	0	70	7	0	**62**	**6**	**0**	

Action Area: Out

TaxonName: Alectryon macrococcus var. macrococcus   TaxonCode: AleMacMac

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Central Kaluaa to Central Waieli	Manage for stability	17	1	0	0	5	0	19	9	0	**17**	**6**	**0**	Thorough monitoring showed a decline in the last year
Makaha	Manage for stability	63	5	2	0	0	0	63	5	2	**63**	**5**	**2**	Monitoring showed no change
Waianae Kai	Genetic Storage	6	0	0	0	0	0	6	0	0	**6**	**0**	**0**	No monitoring in the last year
	Total for Taxon:	86	6	2	0	5	0	88	14	2	**86**	**11**	**2**	

Table 3.2b Genetic Storage Summary

Population Unit Name	# of Potential Founders: Current Mature	# of Potential Founders: Current Imm.	# of Potential Founders: NumWild Dead	Partial Storage Status: # Plants >= 10 in Seedbank	Partial Storage Status: # Plants >=1 Microprop	Partial Storage Status: # Plants >=1 Army Nursery	Storage Goals Met: # Plants that Met Goal
Alectryon macrococcus var. macrococcus							
Central Kaluaa to Central Waieli	17	1	0	0	0	1	0
Kahanahaiki to West Makaleha	36	4	0	0	0	0	0
Makaha	63	5	0	0	0	1	0
Makua	22	0	1	0	1	2	1
South Mohiakea	4	0	0	0	0	1	0
Waianae Kai	6	0	0	0	0	0	0
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				0	1	5	1

3.4 CENCHRUS AGRIMONIOIDES VAR. AGRIMONIOIDES

Requirements for Stability

- 3 Population Units (PUs)
- 50 reproducing individuals in each PU (short-lived perennial)
- Stable population structure
- Threats controlled
- Complete genetic representation of all PUs in storage

Major Highlights/Issues MIP Year 5

- The goal of 50 reproducing individuals is met for the Central Ekahanui PU and the Kahanahaiki and Pahole PU.
- The Ekahanui MU fence is complete and ungulates are being removed around the Central Ekahanui PU.
- The Makaha MU is ungulate free as of August 2009 and will be used for the Makaha and Waianae Kai PU reintroductions.
- Only three of the 13 plants remain from the first attempt of the reintroduction in the Makaha and Waianae Kai PU. Another site will be selected in the coming year and planting will resume in 2010.
- Naturally recruiting seedlings have been observed in several of the reintroductions in the Kahanahaiki and Pahole PU and the Central Ekahanui PU.
- A few new wild plants have been observed in both the Kahanahaiki and Pahole PU and the Central Ekahanui PU while other older mature plants in both sites have died.
- Clones of founders from all PUs are being maintained as a living collection in the nursery for genetic storage. Seed collections from the reintroductions for genetic storage will continue as the rest of the founders are added. Once founders are represented in reintroductions and seed storage, the nursery living collection will be retired.

Plans for MIP Year 6

- Conduct census monitoring at all Manage for Stability PUs
- Complete eradication of ungulates from the Ēkahanui MU fence
- Establish a new reintroduction site in Makaha for the Mākaha and Waiʻanae Kai PU
- Complete reintroduction at the Central Ekahanui PU and the Kahanahāiki and Pahole PU
- Continue collection of mature seed for genetic storage from the reintroductions in the Central Ekahanui PU and the Kahanahāiki and Pahole PU.

Table 3.3a Taxon Status Summary

Action Area: In

TaxonName: Cenchrus agrimonioides var. agrimonioides TaxonCode: CenAgrAgr

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kahanahaiki and Pahole	Manage for stability	67	12	14	264	19	25	331	44	11	**331**	**31**	**39**	Small changes were noted during monitoring in the last year
	Total for Taxon:	67	12	14	264	19	25	331	44	11	**331**	**31**	**39**	

Action Area: Out

TaxonName: Cenchrus agrimonioides var. agrimonioides TaxonCode: CenAgrAgr

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Central Ekahanui	Manage for stability	37	8	5	56	1	37	90	10	16	**93**	**9**	**42**	Plants were added to the reintroduction sites and new seedlings and immature plants were observed. Small changes were also noted in the wild sites.
Makaha and Waianae Kai	Manage for stability	5	0	0	3	0	0	20	0	0	**8**	**0**	**0**	Thorough monitoring showed a decline in the last year
South Huliwai	Genetic Storage	18	2	0	0	0	0	21	0	0	**18**	**2**	**0**	Small changes were noted during monitoring in the last year
	Total for Taxon:	60	10	5	59	1	37	131	10	16	**119**	**11**	**42**	

Table 3.3b 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	Storage Goals Met: # Plants that Met Goal
Cenchrus agrimonioides var. agrimonioides							
Central Ekahanui	37	8	9	11	0	27	15
Kahanahaiki and Pahole	67	12	25	49	0	39	47
Makaha and Waianae Kai	5	0	6	2	0	9	6
South Huliwai	18	2	4	10	0	20	16
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				72	0	95	84

3.5 CHAMAESYCE CELASTROIDES VAR. KAENANA

Requirements for Stability

- 4 Population Units (PU) (high fire threat)
- 25 reproducing individuals in each population (long-lived perennial)
- Stable population structure
- Threats controlled
- Complete genetic representation of all PUs in storage

Major Highlights/Issues for MIP Year 5

- The stability goal of 25 reproducing individuals is met for the Makua PU, Kaena and Keawaula (Kaena) PU and the Puaakanoa PU.
- Both the Makua PU and the Kaena and Keawaula (Kaena) PU have at least 50 plants represented in seed storage. Nearly all available founders from the Kaena (East of Alau) PU are also represented in storage.
- Weed control and fuel-load reduction for fire prevention has begun at the Puaakanoa PU
- In July 2009, a wildfire burned to within 95 meters of the Kaena (East of Alau) PU. This is the same area that burned in August 2007.

Plans for MIP Year 6

- Conduct monitoring at all Manage for Stability PUs
- Conduct more thorough surveys at the Kaena (East of Alau) PU to determine if there are any immature plants that will mature allowing the PU to increase to 25 or if augmentation will be required.
- Continue seed collections for genetic storage
- Continue to facilitate research on *Chamaesyce* by the UH Botany Department
- Monitor accessible plants in the Waianae Kai PU and begin genetic storage collections
- Determine the need to install fuel breaks to protect the Kaena (East of Alau) PU and the Puaakanoa PU from wildfire

Table 3.4a Taxon Status Summary

Action Area: In

TaxonName: Chamaesyce celastroides var. kaenana TaxonCode: ChaCelKae

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
East Kahanahaiki	Genetic Storage	2	0	0	0	0	0	2	0	0	**2**	**0**	**0**	Monitoring showed no change
Kaluakauila	Genetic Storage	8	4	0	0	0	0	8	4	0	**8**	**4**	**0**	Monitoring showed no change
Makua	Manage for stability	118	16	0	0	0	0	89	45	20	**118**	**16**	**0**	The most thorough census of the known area since 2005 found more mature plants, but fewer immature plants and no seedlings
North Kahanahaiki	Genetic Storage	177	0	0	0	0	0	177	0	0	**177**	**0**	**0**	No monitoring in the last year. This is an estimate from 2003.
Puaakanoa	Manage for stability	160	10	0	0	0	0	160	10	0	**160**	**10**	**0**	No monitoring in the last year. This numbers were last updated in 2006.
	Total for Taxon:	465	30	0	0	0	0	436	59	20	**465**	**30**	**0**	

Action Area: Out

TaxonName: Chamaesyce celastroides var. kaenana TaxonCode: ChaCelKae

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kaena (East of Alau)	Manage for stability	21	0	1	0	0	0	21	4	20	**21**	**0**	1	The most thorough monitoring since 2001 observed a small decline in the wild site. The seedlings were not observed but may have been missed.
Kaena and Keawaula (Kaena)	Manage for stability	300	0	0	0	0	0	300	0	0	**300**	**0**	**0**	This estimate has not been revised since 2005. No monitoring to detect smaller size classes has been done yet, but they are observed to be there.
Kaena and Keawaula (Keawaula)	Genetic Storage	53	2	2	0	0	0	51	4	2	**53**	**2**	**2**	Small changes were observed in the last year
Waianae Kai	Genetic Storage	33	0	0	0	0	0	33	0	0	**33**	**0**	**0**	No monitoring in the last year
	Total for Taxon:	407	2	3	0	0	0	405	8	22	**407**	**2**	**3**	

Table 3.4b 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
Chamaesyce celastroides var. kaenana							
East Kahanahaiki	2	0	0	1	0	0	0
Kaena (East of Alau)	21	0	0	21	0	1	19
Kaena and Keawaula (Kaena)	300	0	0	57	0	2	55
Kaena and Keawaula (Keawaula)	53	2	0	22	0	0	13
Kaluakauila	8	4	0	2	0	0	0
Makua	118	16	6	71	0	0	59
North Kahanahaiki	177	0	17	14	0	0	11
Puaakanoa	160	10	0	14	0	4	3
Waianae Kai	33	0	0	0	0	0	0
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				202	0	7	160

3.6 CHAMAESYCE HERBSTII

Requirements for Stability

- 3 Population Units (PUs)
- 25 reproducing individuals in each PU (long-lived perennial)
- Stable population structure
- Threats controlled
- Complete genetic representation of all PUs in storage

Major Highlights/Issues MIP Year 5

- The stability goal of 25 individuals is met for the Pahole to Kapuna PU. There are new naturally occurring seedlings and immature plants in the wild and reintroduction sites.
- The Makaha fence was declared pig free in the summer of 2009 and OANRP continue to assist NARS in removing ungulates from the Kapuna fences.
- OANRP continue to supplement the reintroduction at the Makaha PU with additional founders. Naturally occurring seedlings and immature plants are at this site and the stability goal of 25 reproducing individuals should be met in the next year.

Plans for MIP Year 6

- Conduct census monitoring and continue to track survivorship of F1 plants
- Continue to supplement the reintroduction for the Makaha PU
- Collect seeds from unrepresented founders in the Pahole to Kapuna PU to propagate for the reintroduction sites
- Collection for genetic storage will begin once the remaining founders are represented in the reintroductions and begin to flower

Table 3.5a Taxon Status Summary

Action Area: In

TaxonName: Chamaesyce herbstii   TaxonCode: ChaHer

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kapuna to Pahole	Manage for stability	32	7	0	25	67	0	57	55	0	**57**	**74**	**0**	More plants were added to the reintroduction site and three new juvenile plants were observed within the outplanting
	Total for Taxon:	32	7	0	25	67	0	57	55	0	**57**	**74**	**0**	

Action Area: Out

TaxonName: Chamaesyce herbstii   TaxonCode: ChaHer

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Makaha	Manage reintroduction for stability	0	0	0	19	29	28	6	23	0	**19**	**29**	**28**	18 immatures were planted and many new immature plants and seedlings were observed in the last year
West Makaleha	Manage reintroduction for stability	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	The reintroduction will begin once the MU fence is complete
	Total for Taxon:	0	0	0	19	29	28	6	23	0	**19**	**29**	**28**	

Table 3.5b 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
Chamaesyce herbstii							
Kapuna to Pahole	32	7	27	20	0	14	10
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				20	0	14	10

3.7 CHAMAESYCE ROCKII

Requirements for Stability

- 3 population units (PUs)
- 50 reproducing individuals in each PU (short-lived perennial)
- Stable Population Structure
- Threats controlled
- Genetic storage collections from all PUs
- Tier 2 Priority

Major Highlights/Issues OIP Year 2

- The Kawainui to Koloa and Kaipapau PU is near the stability goal of 50 reproducing plants. Ongoing surveys will likely yield enough plants for the goal to be met in the next few years.
- Samples for population genetic studies by the UH Botany Department were collected from 12 individuals in Koloa Gulch. Results are pending.

Plans for OIP Year 3

- Monitor and survey the Helemano PU and the Waiawa and Waimano PU
- Obtain a license agreement with Hawaii Reserves Inc. to cover construction of the Koloa MU
- Continue to survey the Kawainui to Koloa and Kaipapau PU for more plants
- When mature fruit is observed during monitoring, collect to initiate seed storage testing
- Continue to facilitate research on *Chamaesyce* by UH Manoa Botany Department by collecting leaf samples for genetic testing from additional plants

Table 3.6a Taxon Status Summary

Action Area: In

TaxonName: Chamaesyce rockii TaxonCode: ChaRoc

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Helemano	Manage for stability	7	1	0	0	0	0	7	1	0	**7**	**1**	**0**	No monitoring in the last year
Kaluanui and Maakua	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring since the HBMP estimate of 100-200 mature plants in 2001.
Kaukonahua to Kipapa	Genetic Storage	28	2	0	0	0	0	28	2	0	**28**	**2**	**0**	No monitoring in the last year
Kawaiiki	Genetic Storage	48	2	0	0	0	0	48	2	0	**48**	**2**	**0**	No monitoring in the last year
Kawainui to Koloa and Kaipapau	Manage for stability	43	16	3	0	0	0	48	25	4	**43**	**16**	**3**	Population counts were revised after updating old observations
	Total for Taxon:	126	21	3	0	0	0	131	30	4	**126**	21	3	

Action Area: Out

TaxonName: Chamaesyce rockii TaxonCode: ChaRoc

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Halawa summit	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No observations of this historic site where one plant was reported in the 2005 OIP
Waiawa and Waimano	Manage for stability	15	0	0	0	0	0	15	0	0	**15**	**0**	**0**	No monitoring in the last year
	Total for Taxon:	15	0	0	0	0	0	15	0	0	**15**	**0**	**0**	

Table 3.6b Genetic Storage Summary

Population Unit Name	# of Potential Founders			Partial Storage Status			Storage Goals Met
	Current Mature	Current Imm.	NumWild Dead	# Plants >= 10 in Seedbank	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants that Met Goal
Chamaesyce rockii							
Helemano	7	1	0	0	0	0	0
Kaukonahua to Kipapa	28	2	0	0	0	0	0
Kawaiiki	48	2	0	0	0	0	0
Kawainui to Koloa and Kaipapau	43	16	0	0	0	0	0
Waiawa and Waimano	15	0	0	0	0	0	0
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				0	0	0	0

3.8 CYANEA ACUMINATA

Requirements for stability

- 3 Population Units (PUs)
- 50 reproducing individuals in each PU (short-lived perennial)
- Stable population structure
- Threats controlled
- Genetic storage collections from all PUs
- Tier 1 stabilization priority

Major Highlights/Issues for OIP Year 2

- The stability goal of 50 reproducing plants is met for the Makaleha to Mohiakea PU and the Helemano-Punaluu Summit Ridge to North Kaukonahua PU.
- New plants were observed during surveys of the Kaluanui and Maakua PU
- Surveys of the Makaleha to Mohiakea PU in the last year found 25 new plants.
- There are 89 individuals within the Ka'ala MU fence, but not all ungulates are yet excluded.

Plans for OIP Year 3

- Complete repairs and additions to the Kaala MU fence
- Continue to monitor fruit development to determine stage of maturity for collection or whether fruit are aborting prematurely. This needs to be determined prior to continuing genetic storage collections from all PUs.
- Begin construction of the Schofield Barracks Lihue fence which will protect most known plants in the Makaleha to Mohiakea PU.
- Survey for additional plants in the Kahana and South Kaukonakua PU and then begin to prioritize and survey PUs with historic records, but no known plants (Pia, Kawaiiki, Konahuanui and Kaipapau).

Table 3.7a Taxon Status Summary

Action Area: In

TaxonName: Cyanea acuminata — TaxonCode: CyaAcu

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Helemano-Punaluu Summit Ridge to North Kaukonahua	Manage for stability	59	13	7	0	0	0	59	13	7	**59**	**13**	**7**	No monitoring in the last year
Kahana and South Kaukonahua	Manage for stability	2	0	0	0	0	0	2	0	0	**2**	**0**	**0**	No monitoring in the last year
Kawaiiki	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
Makaleha to Mohiakea	Manage for stability	89	38	0	0	0	0	85	33	0	**89**	**38**	**0**	A thorough census of the known area found more plants
	Total for Taxon:	150	51	7	0	0	0	146	46	7	**150**	**51**	**7**	

Action Area: Out

TaxonName: Cyanea acuminata — TaxonCode: CyaAcu

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kahana and Makaua	Genetic Storage	11	3	0	0	0	0	5	0	0	**11**	**3**	**0**	Population counts were revised after updating old observations
Kaipapau	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
Kaluanui and Maakua	Genetic Storage	13	8	0	0	0	0	0	0	0	**13**	**8**	**0**	New plants were discovered during surveys
Konahuanui	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
Pia	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
Puukeahiakahoe	Genetic Storage	3	0	0	0	0	0	0	0	0	**3**	**0**	**0**	Population counts were revised after updating old observations
Puuokona	Genetic Storage	0	0	0	0	0	0	1	0	0	**0**	**0**	**0**	No monitoring in the last year
	Total for Taxon:	27	11	0	0	0	0	6	0	0	**27**	**11**	**0**	

Table 3.7b Genetic Storage Summary

Population Unit Name	# of Potential Founders			Partial Storage Status			Storage Goals Met
	Current Mature	Current Imm.	NumWild Dead	# Plants >= 10 in Seedbank	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants that Met Goal
Cyanea acuminata							
Helemano-Punaluu Summit Ridge to North Kaukonahua	59	13	0	4	0	0	4
Kahana and Makaua	11	3	0	0	0	0	0
Kahana and South Kaukonahua	2	0	0	0	0	0	0
Kaluanui and Maakua	13	8	0	0	0	0	0
Makaleha to Mohiakea	100	43	0	0	0	0	0
Puukeahiakahoe	3	0	0	0	0	0	0
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				4	0	0	4

3.9 CYANEA CRISPA

Requirements for Stability

- 3 population units (PUs)
- 50 reproducing individuals (short-lived perennial)
- Stable population structure
- Threats controlled
- Genetic storage collections from all PUs
- Tier 2 stabilization priority

Major Highlights/Issues OIP Year 2

- The Helemano MU fence is complete and protects the small reintroduction of stock from the Kawaiiki PU.
- The three other MU fences (Wailupe, Kawaiiki, Kahana) are not scheduled to begin until OIP Year 12.
- One new immature individual was discovered while surveying in the Kaipapau PU.
- Collections for genetic storage were made from the Kahana and Makaua PU

Plans for OIP Year 3

- Work with OPEP and Kualoa Ranch staff to monitor and collect from the Kahana and Makaua PU
- Collect additional propagules from the Kawaiiki PU to supplement the Helemano PU
- As time allows, survey for additional plants in Manage for Stability PUs and collect for genetic storage

Table 3.8a Taxon Status Summary

Action Area: In

TaxonName: Cyanea crispa — TaxonCode: CyaCri

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kawaiiki	Manage for stability	2	4	0	0	0	0	2	4	0	**2**	**4**	**0**	Monitoring showed no change
	Total for Taxon:	2	4	0	0	0	0	2	4	0	**2**	**4**	**0**	

Action Area: Out

TaxonName: Cyanea crispa — TaxonCode: CyaCri

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Aihualama	Genetic Storage	1	0	0	0	0	0	1	0	0	**1**	**0**	**0**	No monitoring in the last year
Helemano	Manage reintroduction for storage	0	0	0	0	3	0	0	3	0	**0**	**3**	**0**	Monitoring showed no change
Kahana and Makaua	Manage for stability	7	7	0	0	0	0	6	0	0	**7**	**7**	**0**	A thorough census of the known area found more plants
Kaipapau	Genetic Storage	0	2	0	0	0	0	0	1	0	**0**	**2**	**0**	Small changes were noted during monitoring in the last year
Kapakahi	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
Kawaipapa	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
Maakua	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
Maunawili	Genetic Storage	0	0	0	0	0	0	1	0	0	**0**	**0**	**0**	No monitoring in the last year
Pia	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
Pukele	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
Wailupe	Manage for stability	5	1	0	0	0	0	5	1	0	**5**	**1**	**0**	No monitoring in the last year
	Total for Taxon:	13	10	0	0	3	0	13	5	0	**13**	**13**	**0**	

Table 3.8b 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
Cyanea crispa							
Aihualama	1	0	0	0	0	0	0
Kahana and Makaua	7	7	2	1	2	0	3
Kaipapau	0	2	0	0	0	1	0
Kawaiiki	2	4	14	0	1	0	0
Wailupe	5	1	0	5	0	0	5
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				6	3	1	8

3.10 CYANEA GRIMESIANA SUBSP. OBATAE

Requirements for Stability

- 4 Population Units (PUs) (in both Makua and Oahu AA)
- 100 reproducing individuals in each PU (short-lived perennial with large fluctuations in population size and recent history of decline)
- Stable population structure
- Threats controlled
- Complete genetic representation of all PUs in storage

Major Highlights/Issues MIP Year 5

- The Palikea (South Palawai) PU is close to the goal of 100 reproducing individuals (95 including augmentation). Other Manage for Stability (MFS) PUs are far below the goal.
- The Central Kaluaa PU reintroduction continues to decline despite supplemental plantings (33% survivorship since 2004, 50 plants remain). Slug damage has been documented as a common cause of death at this site.
- Large MU fences at three of the four MFS sites (Central Kaluaa, Makaha, Palikea (South Palawai) are complete and pig free. All plants at the Pahole to West Makaleha PU are protected from pigs, however the larger West Makaleha MU fence is still being planned.
- Collections continued at the Makaha PU, Palikea (South Palawai) PU, and Pahole to West Makaleha PU. All available founders from the Makaha PU, Central Kaluaa PU, South Kaluaa PU, South Ekahanui PU, Pahole to West Makaleha PU are now represented in genetic storage. Collections continue from Makaha and Pahole to West Makaleha PUs because although storage goals are met, survivorship is low when plants are germinated. The single plant at Palikea Gulch has not yet matured.
- OANRP began outplanting at the West Makaleha PU with 3 individuals. Although reintroduction goals are higher, only three were large enough to plant due to low survivorship of the seedlings grown from this PU. Reintroductions continued at South Ekahanui, Pahole, and Central and South Kaluaa.
- A new immature plant was noted below the single mature plant in the Central Kaluaa PU

Plans for MIP Year 6

- Conduct census monitoring and seedling/immature searches at all sites in spring and fall of 2010
- Finalize plans and agreements for the West Makaleha MU fence
- Supplement reintroductions at Pahole to West Makaleha, Palikea (South Palawai), Central and South Kaluaa, and South Ekahanui and continue propagation for the new reintroduction at Makaha scheduled to begin in 2010.
- Continue to collect for genetic storage from new and unrepresented founders
- Expand rodent control to unprotected sites as feasible (4 of 7 active sites have year round rodent control).
- Pursue SLN label for Sluggo
- Determine what is limiting seedling at sites where viable fruit is known to be readily available on mature plants. Studies to determine if the fruit is being naturally dispersed and trials to identify sites with conditions favorable for germination will be considered.

Table 3.9a Taxon Status Summary

Action Area: In

TaxonName: Cyanea grimesiana subsp. obatae TaxonCode: CyaGriOba

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Pahole to West Makaleha	Manage for stability	5	6	4	27	12	0	34	15	4	**32**	**18**	**4**	New seedlings and immature plants were noted in the W. Makaleha wild site. More plants were added to all existing outplantings and a few outplanted plants died.
	Total for Taxon:	5	6	4	27	12	0	34	15	4	**32**	**18**	**4**	

Action Area: Out

TaxonName: Cyanea grimesiana subsp. obatae TaxonCode: CyaGriOba

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Central Kaluaa	Manage for stability	1	1	0	28	22	0	11	45	0	**29**	**23**	**0**	In the outplanting, many of the immature plants matured in the last year. At the wild site, a small immature plant was observed under the single wild individual.
Makaha	Manage for stability	1	0	0	0	0	0	1	0	0	**1**	**0**	**0**	Monitoring showed no change
North branch of South Ekahanui	Genetic Storage	0	0	0	31	0	0	30	0	0	**31**	**0**	**0**	Population counts were revised after updating old observations
Palikea (South Palawai)	Manage for stability	13	36	0	79	1	0	88	39	0	**92**	**37**	**0**	In the reintroduction site two immature plants died and one matured. In the wild site, three new mature and one new immature plant were noted.
Palikea Gulch	Genetic Storage	0	1	0	0	0	0	0	1	0	**0**	**1**	**0**	This plant has been observed in the last year
South Kaluaa	Genetic Storage	0	0	0	4	10	0	5	14	0	**4**	**10**	**0**	In the reintroduction sites, two mature and three immature plants have died and an immature plant flowered for the first time.
	Total for Taxon:	15	38	0	142	33	0	135	99	0	**157**	**71**	**0**	

Table 3.9b Genetic Storage Summary

Population Unit Name	# of Potential Founders			Partial Storage Status			Storage Goals Met
	Current Mature	Current Imm.	NumWild Dead	# Plants >= 10 in Seedbank	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants that Met Goal
Cyanea grimesiana subsp. obatae							
Central Kaluaa	1	1	0	1	0	1	1
Makaha	1	0	0	1	0	1	1
North branch of South Ekahanui	0	0	2	1	2	2	2
Pahole to West Makaleha	5	6	5	10	0	9	10
Palikea (South Palawai)	13	36	5	13	5	9	13
Palikea Gulch	0	1	0	0	0	0	0
South Kaluaa	0	0	1	1	0	1	1
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				27	7	23	28

3.11 CYANEA KOOLAUENSIS

Requirements for stability

- 3 Population Units
- 50 reproducing individuals per MFS PU (short-lived perennial)
- Stable population structure
- Threats controlled
- Genetic storage collections from all PUs
- Tier 1 stabilization priority

Major Highlights/Issues for OIP Year 2

- The stability goal of 50 plants is met for the Kaipapau, Koloa, and Kawainui PU
- New plants were discovered while surveying in the Kaukonahua PU, and the Opaeula to Helemano PU

Plans for OIP Year 3

- Secure a license agreement with Kamehameha Schools to pursue fencing for the Lower Opaeula PU
- Secure license agreement with Hawaii Reserves Inc. for construction of the Koloa MU fence
- Survey the lower Helemano drainage for more plants within the Opaeula to Helemano PU and the Kaukonahua PU to locate more plants
- Collect propagules for genetic storage testing
- As feasible, conduct census monitoring at all Manage for Stability PUs

Table 3.10a Taxon Status Summary

Action Area: In

TaxonName: Cyanea koolauensis   TaxonCode: CyaKoo

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kaipapau, Koloa and Kawainui	Manage for stability	57	25	6	0	0	0	51	25	6	**57**	**25**	**6**	A few more plants were observed in the known sites
Kamananui-Kawainui Ridge	Genetic Storage	6	2	0	0	0	0	6	2	0	**6**	**2**	**0**	No monitoring in the last year
Kaukonahua	Manage for stability	14	2	0	0	0	0	11	1	0	**14**	**2**	**0**	A thorough census of the known area found more plants
Kawaiiki	Genetic Storage	3	4	0	0	0	0	3	3	0	**3**	**4**	**0**	A thorough census of the known area found more plants
Lower Opaeula	Genetic Storage	3	1	0	0	0	0	3	1	0	**3**	**1**	**0**	No monitoring in the last year
Opaeula to Helemano	Manage for stability	14	5	0	0	0	0	10	3	0	**14**	**5**	**0**	A few more plants were observed in the known sites
Poamoho	Genetic Storage	12	0	0	0	0	0	12	0	0	**12**	**0**	**0**	No monitoring in the last year
	Total for Taxon:	109	39	6	0	0	0	96	35	6	**109**	**39**	**6**	

Action Area: Out

TaxonName: Cyanea koolauensis   TaxonCode: CyaKoo

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Halawa	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
Halawa-Kalauao Ridge	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
Lulumahu	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
Waialae Nui	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
Waiawa to Waimano	Genetic Storage	3	0	0	0	0	0	1	0	0	**3**	**0**	**0**	New plants were discovered during surveys
Wailupe	Genetic Storage	1	0	0	0	0	0	0	0	0	**1**	**0**	**0**	No monitoring in the last year
Waimalu	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
	Total for Taxon:	4	0	0	0	0	0	1	0	0	**4**	**0**	**0**	

Table 3.10b 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	Storage Goals Met: # Plants that Met Goal
Cyanea koolauensis							
Kaipapau, Koloa and Kawainui	57	25	0	0	0	0	0
Kamananui-Kawainui Ridge	6	2	0	0	0	0	0
Kaukonahua	14	2	1	0	0	0	0
Kawaiiki	3	4	0	0	0	0	0
Lower Opaeula	3	1	0	0	0	0	0
Opaeula to Helemano	14	5	0	0	0	0	0
Poamoho	12	0	0	0	0	0	0
Waiawa to Waimano	3	0	0	0	0	0	0
Wailupe	1	0	0	0	0	0	0

Total # Plants w/ >=10 Seeds in Seedbank	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants that Met Goal
0	0	0	0

3.12 CYANEA LONGIFLORA

Requirements for Stability:

- 3 Population Units (PUs)
- 75 reproducing individuals in each PU (short-lived perennial with fluctuating population numbers and trend of local decline)
- Threats controlled
- Complete genetic representation of all PUs in storage

Major Highlights/Issues MIP Year 5

- OANRP continues to assist the state with ungulate removal and repairs of the Upper Kapuna MU fence.
- Collections for genetic storage continued and seeds are now being stored from 61 plants
- Rats are a threat and plants in Kapuna were observed to have damage on the stems in the last year.
- Slugs have been observed eating fruit on the plants in the Pahole PU.

Plans for MIP Year 6

- Conduct census monitoring at all Manage for Stability PUs
- Work with NARS to develop an augmentation strategy for the Pahole PU
- Continue to collect seeds from unrepresented individuals in all PUs for genetic storage
- Determine strategy to prevent rat damage to plants in the Kapuna to West Makaleha PU.

Table 3.11a Taxon Status Summary

Action Area: In

TaxonName: Cyanea longiflora — TaxonCode: CyaLon

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kapuna to West Makaleha	Manage for stability	21	13	0	18	5	0	35	27	1	**39**	**18**	**0**	Small changes were noted during monitoring in the last year
Pahole	Manage for stability	56	49	2	0	0	0	51	43	15	**56**	**49**	**2**	Small changes were noted during monitoring in the last year
	Total for Taxon:	77	62	2	18	5	0	86	70	16	**95**	**67**	**2**	

Action Area: Out

TaxonName: Cyanea longiflora — TaxonCode: CyaLon

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Makaha and Waianae Kai	Manage for stability	3	6	0	0	0	0	2	10	0	**3**	**6**	**0**	Thorough monitoring showed a decline in the last year
	Total for Taxon:	3	6	0	0	0	0	2	10	0	**3**	**6**	**0**	

Table 3.11b Genetic Storage Summary

Population Unit Name	# of Potential Founders: Current Mature	# of Potential Founders: Current Imm.	# of Potential Founders: NumWild Dead	Partial Storage Status: # Plants >= 10 in Seedbank	Partial Storage Status: # Plants >=1 Microprop	Partial Storage Status: # Plants >=1 Army Nursery	Storage Goals Met: # Plants that Met Goal
Cyanea longiflora							
Kapuna to West Makaleha	21	13	3	18	1	9	18
Makaha and Waianae Kai	3	6	2	2	1	1	2
Pahole	56	49	8	41	1	3	41

Total # Plants w/ >=10 Seeds in Seedbank	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants that Met Goal
61	3	13	61

3.13 CYANEA ST.-JOHNII

Requirements for stability

- 3 Population Units
- 50 reproducing individuals per MFS PU (short-lived perennial)
- Stable population structure
- Threats controlled
- Complete genetic representation of all PUs in storage
- Tier 1 stabilization priority

Major Highlights/Issues for OIP Year 2

- Clearing for the Waimano PU fence began and the material has been placed on site.
- Monitoring of the Waimanalo-Wailupe Summit Ridge PU by OPEP showed a significant decline.
- Some genetic storage collections are being held at Lyon Arboretum. However, plants have not become successfully established in the nursery when removed from tissue culture media.
- OPEP and OANRP collaborated on a plan to study the pollination and breeding system of this taxon. This plan was initiated due to the difficulty in collecting mature fruit and the observed fruit abortion at the Helemano PU. Flowers were hand-pollinated with several treatments at 3 PUs. Pollinator observations were conducted at Helemano PU. OANRP was unable to collect hand-pollinated fruit at Helemano, and fruit are currently immature at the other PUs. All of the immature fruits disappeared between visits to Helemano. It is uncertain why they disappeared (aborted, matured, predated?).

Plans for OIP Year 3

- Obtain the FONSI for the OIP Environmental Assessment and construct the Waimano PU fence.
- Work with OPEP and Lyon Arboretum to develop protocols for transferring plants from micropropagation to nursery potting media
- Work with OPEP to continue pollination and breeding system studies and collect propagules for genetic storage and augmentation
- Prioritize monitoring by OPEP/OANRP of the Waihee-Waimalu summit Ridge PU and the North of Puu Pauao PU
- Survey for additional plants at all sites.
- Determine whether to prioritize fencing of the Ahuimanu-Halawa PU

Table 3.12a Taxon Status Summary

Action Area: In

TaxonName: Cyanea st.-johnii **TaxonCode: CyaStj**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Helemano	Manage for stability	5	0	0	0	0	0	6	0	0	**5**	**0**	**0**	Thorough monitoring showed a decline in the last year
North of Puu Pauao	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
	Total for Taxon:	5	0	0	0	0	0	6	0	0	**5**	**0**	**0**	

Action Area: Out

TaxonName: Cyanea st.-johnii **TaxonCode: CyaStj**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Ahuimanu-Halawa Summit Ridge	Manage for stability	11	3	1	0	0	0	14	0	20	**11**	**3**	**1**	Thorough monitoring showed a decline in the last year. Pig sign was observed where many of the seedlings had been observed.
Waiahole-Waiawa Summit Ridge	Genetic Storage	6	0	3	0	0	0	6	0	1	**6**	**0**	**3**	A few more seedlings were noted during monitoring in the last year
Waihee-Waimalu summit ridge	Genetic Storage	10	0	0	0	0	0	10	0	0	**10**	**0**	**0**	No monitoring in the last year
Waimanalo-Wailupe Summit Ridge	Genetic Storage	7	0	0	0	0	0	11	0	0	**7**	**0**	**0**	Thorough monitoring showed a decline in the last year
Waimano	Manage for stability	14	5	0	0	0	0	14	5	0	**14**	**5**	**0**	Monitoring showed no change
	Total for Taxon:	48	8	4	0	0	0	55	5	21	**48**	**8**	**4**	

Table 3.12b 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	Storage Goals Met: # Plants that Met Goal
Cyanea st.-johnii							
Ahuimanu-Halawa Summit Ridge	11	3	0	3	1	0	3
Helemano	5	0	1	1	4	0	4
Waiahole-Waiawa Summit Ridge	6	0	0	1	2	0	2
Waihee-Waimalu summit ridge	10	0	0	0	0	0	0
Waimanalo-Wailupe Summit Ridge	11	0	0	2	2	0	2
Waimano	14	5	0	2	3	0	3

Total # Plants w/ >=10 Seeds in Seedbank	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants that Met Goal
9	12	0	14

3.14 CYANEA SUPERBA

Requirements for Stability

- 4 Population Units (PUs)
- 50 reproducing individuals in each PU (long-lived perennial with a history of precipitous decline, extirpated in the wild, and extremely low genetic variability)
- Threats controlled
- Stable population structure
- Complete genetic representation in storage of all PUs

Major Highlights/Issues MIP Year 5

- The stability goal of 50 reproducing individuals is met for the Pahole to Kapuna PU.
- Naturally occurring seedlings were observed in several locations in the last year. At the Kahanahaiki PU over 300 in total were found under 8 separate plants. An additional 300 seedlings were observed under two plants in the Pahole to Kapuna PU. In addition, one immature plant was observed under a reintroduced plant at Puu Palikea that had been planted by TNCH.
- There are now a total of nearly 200 immature plants in the Kahanahaiki PU beneath four separate reintroduced individuals. As slugs are known to attack seedlings of this species, the organic molluscicide, Sluggo, was applied under an Experimental Use Permit valid through February 2010. Sluggo application coincided with seedling counts.
- The Mahaka fence was declared pig free in the summer of 2009 and reintroductions began in the last year.
- A large-scale rat control grid was established in the Kahanahaiki MU protecting maturing fruit from rats.
- UH Botany graduate student, R. Pender, began a study of pollination biology at the Kahanahaiki PU.

Plans for MIP Year 6

- Continue to supplement the reintroduction at Makaha.
- Pursue fencing plans for East Makaleha with the State of Hawaii.
- Conduct seedling searches under all mature plants in January and February 2010.
- Continue to track seedlings at both the Kahanahaiki PU and the Pahole to Kapuna PU and monitor for potential benefits of slug control.
- Pursue Special Local Needs (SLN) labeling of Sluggo for use in natural areas devoid of *Achatinella.*
- Develop plans for a seed sowing trial that will seek to identify microhabitats that will support germination

Table 3.13a Taxon Status Summary

Action Area: In

TaxonName: Cyrtandra subumbellata TaxonCode: CyrSub

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kaukonahua	Manage for stability	2	0	1	0	0	0	2	0	1	2	0	1	No monitoring in the last year
	Total for Taxon:	2	0	1	0	0	0	2	0	1	2	0	1	

Action Area: Out

TaxonName: Cyrtandra subumbellata TaxonCode: CyrSub

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kahana	Manage for stability	8	7	0	0	0	0	8	7	0	8	7	0	No monitoring in the last year
Punaluu	Manage for stability	200	0	0	0	0	0	200	0	0	200	0	0	No monitoring in the last year
Uwao	Genetic Storage	2	0	0	0	0	0	2	0	0	2	0	0	No monitoring in the last year
	Total for Taxon:	210	7	0	0	0	0	210	7	0	210	7	0	

Table 3.13b Genetic Storage Summary

Population Unit Name	# of Potential Founders			Partial Storage Status			Storage Goals Met
	Current Mature	Current Imm.	NumWild Dead	# Plants >= 10 in Seedbank	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants that Met Goal
Cyanea superba subsp. superba							
Kahanahaiki	0	0	6	3	3	3	3
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				3	3	3	3

3.15 CYRTANDRA DENTATA

Requirements for Stability:

- 4 Population Units (PUs)
- 50 reproducing individuals in each PU (short-lived perennial)
- Stable population structure
- Threats controlled
- Complete genetic representation of all PUs in storage

Major Highlights/Issues MIP Year 5

- The stability goal of 50 reproducing individuals has been met for the Kahanahaiki PU and the Pahole to Kapuna to West Makaleha PU.
- A large management unit fence around most of the plants in the Kapuna and Keawapilau sections of the Pahole to Kapuna to West Makaleha PU was completed in 2008. OANRP continue to assist the State of Hawaii in the removal of ungulates from the Upper Kapuna MU and with repairs caused by vandalism and flooding.
- OANRP continues to work on a license agreement with Kamehameha Schools for fencing and other management at the Opaeula and Kawaiiki PUs.
- The genetic storage goals have been met for the Pahole to Kapuna to West Makaleha PU.

Plans for MIP Year 6

- Assist the State of Hawaii in clearing the Upper Kapuna MU fence of ungulates
- Monitor the Opaeula PU and determine fence line placement for the Lower Opaeula MU
- Begin genetic storage collections from the Kawaiiki PU, Opaeula PU, and the Central Makaleha PU
- Conduct monitoring work with Botanist Joel Lau to update population estimates of pure *C. dentata* in the Kawaiiki PU

Table 3.14a Taxon Status Summary

Action Area: In

TaxonName: Cyrtandra dentata — TaxonCode: CyrDen

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kahanahaiki	Manage for stability	156	57	27	0	0	0	156	57	27	**156**	**57**	**27**	No monitoring in the last year
Pahole to Kapuna to West Makaleha	Manage for stability	577	615	238	0	0	0	542	530	173	**577**	**615**	**238**	Population counts were revised after updating old observations
	Total for Taxon:	733	672	265	0	0	0	698	587	200	**733**	**672**	**265**	

Action Area: Out

TaxonName: Cyrtandra dentata — TaxonCode: CyrDen

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Central Makaleha	Genetic Storage	3	0	0	0	0	0	3	0	0	**3**	**0**	**0**	No monitoring in the last year
Kawaiiki (Koolaus)	Manage for stability	15	31	39	0	0	0	15	31	39	**15**	**31**	**39**	No monitoring in the last year
Opaeula (Koolaus)	Manage for stability	16	12	0	0	0	0	16	12	0	**16**	**12**	**0**	No monitoring in the last year
	Total for Taxon:	34	43	39	0	0	0	34	43	39	**34**	**43**	**39**	

Table 3.14b 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
Cyrtandra dentata							
Central Makaleha	3	0	0	0	0	0	0
Kahanahaiki	156	57	0	21	0	0	21
Kawaiiki (Koolaus)	15	31	0	0	0	0	0
Opaeula (Koolaus)	16	12	0	0	0	0	0
Pahole to Kapuna to West Makaleha	577	615	0	49	0	1	50

Total # Plants w/ >=10 Seeds in Seedbank	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants that Met Goal
70	0	1	71

3.16 CYRTANDRA SUBUMBELLATA

Requirements for Stability:

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

Major Highlights/Issues OIP Year 2

- The stability goal of 50 reproducing individuals has been met for the Punaluu PU.
- OANRP has not prioritized time to monitor this Tier 3 species in the last year.
- OANRP obtained a license agreement with Kamehameha Schools for management access to their land which includes the Punaluu PU. A longer term license agreement that will allow for fencing actions at this PU should be granted in the coming year.

Plans for OIP Year 3

- Survey for additional plants while conducting management in the Kaukonahua and Kahana PUs

Table 3.15a Taxon Status Summary

Action Area: In

TaxonName: Cyrtandra subumbellata   TaxonCode: CyrSub

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kaukonahua	Manage for stability	2	0	1	0	0	0	2	0	1	2	0	1	No monitoring in the last year
	Total for Taxon:	2	0	1	0	0	0	2	0	1	2	0	1	

Action Area: Out

TaxonName: Cyrtandra subumbellata   TaxonCode: CyrSub

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kahana	Manage for stability	8	7	0	0	0	0	8	7	0	8	7	0	No monitoring in the last year
Punaluu	Manage for stability	200	0	0	0	0	0	200	0	0	200	0	0	No monitoring in the last year
Uwao	Genetic Storage	2	0	0	0	0	0	2	0	0	2	0	0	No monitoring in the last year
	Total for Taxon:	210	7	0	0	0	0	210	7	0	210	7	0	

Table 3.15b 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	Storage Goals Met: # Plants that Met Goal
Cyrtandra subumbellata							
Kahana	8	7	0	0	0	1	1
Kaukonahua	2	0	0	0	0	0	0
Punaluu	200	0	0	0	0	0	0
Uwao	2	0	0	0	0	0	0

Total # Plants w/ >=10 Seeds in Seedbank	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants that Met Goal
0	0	1	1

3.17 CYRTANDRA VIRIDIFLORA

Requirements for Stability:

- 3 population units (PUs)
- 50 reproducing individuals (intermediate long-lived perennial)
- Stable population structure
- Threats controlled
- Genetic storage collections from all PUs
- Tier 2 stabilization priority

Major Highlights/Issues OIP Year 2

- The goal of 50 reproducing individuals is nearly met for the Opaeula to Helemano PU.
- New plants were discovered during surveys of the Kawainui and Koloa PU.

Plans for OIP Year 3

- Finalize design of the Koloa MU fence and secure a license agreement with Hawaii Reserves Inc.
- Collect fruit for seed storage testing
- Survey the South Kaukonahua to Kipapa summit PU and Koloa PU to locate more plants

Table 3.16a Taxon Status Summary

Action Area: In

TaxonName: Cyrtandra viridiflora **TaxonCode: CyrVir**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Helemano and Opaeula	Manage for stability	46	15	6	0	0	0	45	15	6	46	15	6	No monitoring in the last year
Kawainui and Koloa	Manage for stability	25	6	1	0	0	0	21	5	1	25	6	1	Small changes were noted during monitoring in the last year
South Kaukonahua to Kipapa summit	Manage for stability	0	2	0	0	0	0	0	2	0	0	2	0	No monitoring in the last year
	Total for Taxon:	71	23	7	0	0	0	66	22	7	71	23	7	

Action Area: Out

TaxonName: Cyrtandra viridiflora **TaxonCode: CyrVir**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kaalaea	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	No monitoring in the last year
Kaluanui to Maakua Ridge	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	No monitoring in the last year
	Total for Taxon:	0	0	0	0	0	0	0	0	0	0	0	0	

Table 3.16b 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	Storage Goals Met: # Plants that Met Goal
Cyrtandra viridiflora							
Helemano and Opaeula	46	15	0	7	0	0	5
Kaluanui to Maakua Ridge	0	0	0	0	0	0	0
Kawainui and Koloa	25	6	0	1	0	0	1
South Kaukonahua to Kipapa summit	0	2	0	0	0	0	0

Total # Plants w/ >=10 Seeds in Seedbank	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants that Met Goal
8	0	0	6

3.18 DELISSEA WAIANAEENSIS

Requirements for Stability:

- 4 Population Units (PUs)
- 100 reproducing individuals in each PU (short-lived perennial with population fluctuations and local declines, potentially an obligate out-crosser)
- Threats controlled
- Complete genetic representation of all PUs in storage

Major Highlights/Issues MIP Year 5

- The goal of 100 reproducing plants is met for the Kahanahaiki to Keawapilau PU
- Both the Ekahanui PU and Kaluaa PU will likely reach the goal of 100 reproducing individuals in the next year given the number of immature plants at those sites.
- Three of the four Manage for Stability sites are protected by large fences. Construction of the Manuwai fence began this year for protection of future reintroduction area.
- All available founders from the Ekahanui, Kealia, South Mohiakea, Kahanahaiki to Keawapilau, Palawai sites are represented in seed storage. New founders from Palikea Gulch, South Mohiakea and Kaluaa were collected from in the last year.
- There are numerous seedlings and immature plants that are beginning to form a population structure at the Ekahanui and Kaluaa reintroduction sites
- Molecular analyses of several founders were done by Shelly James of the Bishop Museum and the draft report submitted to OANRP.
- Outplanting continued to supplement the Kahanahāiki to Keawapilau PU, Ekahanui PU and Kaluaa PU
- The reintroduction of stock from the Kealia PU into Kaluakauila is complete.
- A reintroduction of stock from the Palikea Gulch PU is ongoing. New founders were discovered this year and will be added to the outplanted when collections are secured.
- Reintroduction strategy developed for the Manuwai PU
- UH graduate student began a pollination biology study in Kahanahaiki gulch

Plans for MIP Year 6

- Conduct census monitoring at all Manage for Stability PUs
- Continue to supplement the augmentations in the Kahanahaiki to Keawapilau, Ekahanui and Kaluaa PUs in order to balance founders at these Manage for Stability PUs
- Collect fruit from any new founders for propagation and genetic storage
- Complete Manuwai MU fence construction
- Continue molecular study with Bishop Museum and facilitate studies by UH researcher

Table 3.17a Taxon Status Summary

Action Area: In

TaxonName: Delissea waianaeensis TaxonCode: DelWai

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kahanahaiki to Keawapilau	Manage for stability	5	0	0	151	28	0	139	41	0	**156**	**28**	**0**	Small changes were noted during monitoring in the last year
Kaluakauila	Manage reintroduction for storage	0	0	0	12	35	0	7	45	0	**12**	**35**	**0**	A few more plants died in the last year and the reintroduction was completed.
South Mohiakea	Genetic Storage	3	3	4	0	0	0	3	3	0	**3**	**3**	**4**	Small changes were noted during monitoring in the last year
	Total for Taxon:	8	3	4	163	63	0	149	89	0	**171**	**66**	**4**	

Action Area: Out

TaxonName: Delissea waianaeensis TaxonCode: DelWai

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Ekahanui	Manage for stability	2	0	0	83	67	62	98	77	0	**85**	**67**	**62**	Small changes were noted during monitoring in the last year and many new seedlings were observed
Kaluaa	Manage for stability	4	5	1	80	21	0	26	7	5	**84**	**26**	**1**	New plants were observed in the wild site and plants were added to the reintroduction sites
Kealia	Genetic Storage	2	0	0	0	0	0	2	0	0	**2**	**0**	**0**	No OANRP monitoring in the last year
Manuwai	Manage reintroduction for stability	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	The reintroduction will begin once the MU fence is complete
Palawai	Genetic Storage	3	3	0	0	0	0	3	3	0	**3**	**3**	**0**	Monitoring showed no change
Palikea Gulch	Genetic Storage	3	5	1	64	8	0	53	7	0	**67**	**13**	**1**	New plants were observed at one of the wild sites and more were added to the reintroduction site
	Total for Taxon:	14	13	2	227	96	62	182	94	5	**241**	**109**	**64**	

Table 3.17b 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	Storage Goals Met: # Plants that Met Goal
Delissea waianaeensis							
Ekahanui	2	0	4	0	0	3	3
Kahanahaiki to Keawapilau	5	0	8	0	0	4	3
Kaluaa	4	5	1	0	0	2	2
Kealia	2	0	0	0	0	0	0
Palawai	3	3	3	0	0	0	0
Palikea Gulch	3	5	5	0	0	1	0
South Mohiakea	3	3	3	0	0	4	4

Total # Plants w/ >=10 Seeds in Seedbank	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants that Met Goal
0	0	14	12

3.19 DUBAUTIA HERBSTOBATAE

Requirements for Stability

- 3 Population Units (PUs)
- 50 reproducing individuals in each PU (short-lived perennial)
- Stable population structure
- Threats controlled
- Complete genetic representation of all PUs in storage

Major Highlights/Issues MIP Year 5

- Both the Ohikilolo Mauka and Ohikilolo Makai PUs meet the stability goal of having more than 50 reproducing individuals.
- The Makaha PU was monitored in the last year and showed no change.
- The greenhouse genetic storage collection of founders grown from clones of the Makaha PU and the Waianae Kai PU and the only founder from the Kamaileunu PU has been maintained. This collection is used to produce seed for genetic storage.
- Ten-year seed storage results show no decrease in viability. Results remain difficult to interpret due to low seed set in achenes.

Plans for MIP Year 6

- Conduct a thorough monitoring of the Ohikilolo Mauka and Ohikilolo Makai PUs over the next two years.
- Conduct thorough monitoring of the Makaha PU in the next year to determine the need to augment or reintroduce stock to meet the stability goal of 50 reproducing plants.
- Continue pollination study of greenhouse plants to determine if enough seed can be produced to meet genetic storage goals for the Makaha, Kamaileunu and Waianae Kai PUs.
- Collect cuttings from unrepresented plants while monitoring the Makaha and Waianae Kai PUs

Table 3.18a Taxon Status Summary

Action Area: In

TaxonName: Dubautia herbstobatae **TaxonCode: DubHer**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Keaau	Genetic Storage	70	0	0	0	0	0	70	0	0	70	0	0	No monitoring in the last year
Makaha/Ohikilolo	Genetic Storage	350	0	0	0	0	0	350	0	0	350	0	0	No monitoring in the last year
Ohikilolo Makai	Manage for stability	358	0	0	0	0	0	358	0	0	358	0	0	No monitoring in the last year
Ohikilolo Mauka	Manage for stability	382	6	0	0	0	0	382	6	0	382	6	0	No monitoring in the last year
	Total for Taxon:	1160	6	0	0	0	0	1160	6	0	1160	6	0	

Action Area: Out

TaxonName: Dubautia herbstobatae **TaxonCode: DubHer**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kamaileunu	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	No monitoring since 2001
Makaha	Manage for stability	36	1	0	0	0	0	36	1	0	36	1	0	Monitoring showed no change in the last year
Waianae Kai	Genetic Storage	10	4	0	0	0	0	10	4	0	10	4	0	No monitoring in the last year
	Total for Taxon:	46	5	0	0	0	0	46	5	0	46	5	0	

Table 3.18b Genetic Storage Summary

Population Unit Name	# of Potential Founders: Current Mature	# of Potential Founders: Current Imm.	# of Potential Founders: NumWild Dead	Partial Storage Status: # Plants >= 10 in Seedbank	Partial Storage Status: # Plants >=1 Microprop	Partial Storage Status: # Plants >=1 Army Nursery	Storage Goals Met: # Plants that Met Goal
Dubautia herbstobatae							
Kamaileunu	0	0	1	1	1	1	1
Keaau	70	0	0	0	0	0	0
Makaha	36	1	4	12	0	7	11
Makaha/Ohikilolo	350	0	0	1	0	0	0
Ohikilolo Makai	358	0	0	0	0	0	0
Ohikilolo Mauka	382	6	0	1	0	0	1
Waianae Kai	10	4	0	5	0	4	4
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				20	1	12	17

3.20 EUGENIA KOOLAUENSIS

Requirements for Stability

- 3 Population Units (PUs)
- 50 reproducing individuals in each PU (long-lived perennial, doubled target number due to threat from Ohia rust (*Puccinia psidii*))
- Stable population structure
- Threats controlled
- Genetic storage collections from all PUs
- Tier 1 stabilization priority

Major Highlights/Issues OIP Year 2

- The stability goal of 50 reproducing individuals is met for the Pahipahialua PU.
- The Ohia rust remains uncontrolled in wild populations. Research by Janice Uchida at UH to develop control techniques have yet to yield significant results. As OANRP has expended significant funding to this project hopefully results will be forthcoming.
- Weeds remain a threat to the survivorship of seedlings and immature plants at all sites
- Fire remains a significant threat for most PUs especially the Palikea and Kaimuhole PU and in Kahuku where 80% of the population resides.
- Fences are complete around all trees in the three Manage for Stability PUs and at the Kaleleiki PU, but ungulates remain a threat at all the remaining PUs.
- Cuttings from a few trees have been established in the last year by OANRP and Doug Okamoto.
- The Hanaimoa PU was monitored for the first time in ten years and a few more plants were discovered.
- The foliar-applied fungicide Tebuconizale continues to be successfully used to suppress the Ohia rust on nursery plants

Plans for OIP Year 3

- Increase the living collection of trees in the nursery by collecting cuttings from additional founders prioritizing those that may otherwise be lost. Collect mature fruit from wild trees when available.
- Prioritize weed management for the fenced sites in Kahuku Training Area and the Kaleleiki PU
- Investigate permit options for using Tebuconizale in a natural area
- Develop a monitoring plan for the large PUs in Kahuku in order to better track survivorship of younger plants and document impact of the Ohia rust
- Determine if the tree in Kaimuhole Gulch is still alive after the 2007 fire
- Work with State Horticulturist to obtain a fruit collection from greenhouse plants to send to the National Center for Genetic Resources Preservation for liquid nitrogen seed storage testing

Table 3.19a Taxon Status Summary

Action Area: In

TaxonName: Eugenia koolauensis — TaxonCode: EugKoo

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Aimuu	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
Kaiwikoele and Kamananui	Genetic Storage	16	16	15	0	0	0	16	16	15	**16**	**16**	**15**	No monitoring in the last year
Kaunala	Manage for stability	48	93	6	0	0	0	48	93	6	**48**	**93**	**6**	Estimates have not been changed in the last year
Ohiaai and East Oio	Genetic Storage	5	8	10	0	0	0	5	8	10	**5**	**8**	**10**	Monitoring showed no change
Oio	Manage for stability	18	56	0	0	0	0	18	56	0	**18**	**56**	**0**	The estimate for immature plants was not updated in the last year
Pahipahialua	Manage for stability	57	234	1	0	0	0	57	234	1	**57**	**234**	**1**	No thorough monitoring in the last year
	Total for Taxon:	144	407	32	0	0	0	144	407	32	**144**	**407**	**32**	

Action Area: Out

TaxonName: Eugenia koolauensis — TaxonCode: EugKoo

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Hanaimoa	Genetic Storage	2	1	1	0	0	0	1	0	0	**2**	**1**	**1**	A thorough census of the known area found more plants
Kaleleiki	Genetic Storage	25	30	250	0	0	0	25	30	250	**25**	**30**	**250**	No monitoring in the last year
Palikea and Kaimuhole	Genetic Storage	3	0	0	0	0	0	3	0	0	**3**	**0**	**0**	The two plants in Palikea have been monitored but the Kaimuhole tree has not been observed since before the fire in 2007
Papali	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
	Total for Taxon:	30	31	251	0	0	0	29	30	250	**30**	**31**	**251**	

Table 3.19b 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	Storage Goals Met: # Plants that Met Goal
Eugenia koolauensis							
Aimuu	0	0	0	0	0	0	0
Hanaimoa	2	1	0	0	0	0	0
Kaiwikoele and Kamananui	16	16	0	0	0	0	0
Kaleleiki	25	30	0	0	0	0	0
Kaunala	48	93	4	0	0	0	0
Ohiaai and East Oio	5	8	1	0	0	2	0
Oio	18	56	1	0	0	2	1
Pahipahialua	57	234	3	0	0	5	1
Palikea and Kaimuhole	3	0	0	0	0	0	0
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				0	0	9	2

3.21 FLUEGGEA NEOWAWRAEA

Requirements for Stability

- 4 Population Units (PU) (due to presence in both MMR and Oahu AAs)
- 50 reproducing individuals in each PU (long-lived perennial, dioecious, low to no reproduction, all senescent, major pest problems)
- Stable population structure
- Threats controlled
- Complete genetic representation of all PUs in storage

Major Highlights/Issues for MIP Year 5

- The Makaha MU fence was declared pig free in August 2009.
- Three outplanting sites were established in Makaha following the model of Kahanahaiki. Most canopy trees were removed bringing in light and removing root competition. Five *F. neowawraea* were planted at each site as a trial. All sites are performing well.
- A new reintroduction site was established in Keawapilau Gulch adjacent to Kapuna in the last year. The above protocols were followed at this site and five immature plants were added. All are alive and healthy as of August 2009.
- Collections from unrepresented trees in the Kahanahaiki to Kapuna PU and the West Makaleha PU were made with assistance from the State Horticulturist Doug Okamoto. These collections were used to develop grafting protocols. Preliminary results are positive, and grafting should prove to be a useful tool for the remaining unrepresented founders that have shown to be difficult in establishing via cuttings and air-layers.
- Clones from 21 of the 36 known trees are established in a living collection at the Pahole Mid Elevation Nursery. Collections from five additional trees were grafted in the last year by the State Horticulturist and OANRP staff.
- Pollen stored for 2 years has been used to pollinate female nursery stock and produced seed with the same high viability as seeds resulting from crosses with fresh pollen.
- Plants are represented through clones in the greenhouse and seeds and pollen in storage.
- One unknown founder (LEH-I-10) was determined to be a male after a cutting flowered on the mist bench. There are seven founders remaining whose sex is unknown.

Plans for MIP Year 6

- Continue to use grafting techniques to secure stock from unrepresented trees.
- Continue to work to determine the sex of the seven remaining unknown trees.
- Supplement the Makaha and Kahanahaiki to Kapuna PUs with stock grown from seed collected from the living collection in the greenhouse. There are approximately 100 saplings from 18 different combinations from 10 females to reintroduce this year. Additional sites in Keawapilau and Pualii are being considered.
- Continue research on Black Twig Borer control using traps baited with ethanol in combination with repellants.
- Continue to collect seeds for propagation and genetic storage from greenhouse collection. Saplings grown from these collections will be used for reintroductions and root-stock for grafting.

- Continue to collect and store pollen from male trees in the living collection and in the wild from unrepresented individuals

Table 3.20a Taxon Status Summary

Action Area: In

TaxonName: Flueggea neowawraea — TaxonCode: FluNeo

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kahanahaiki to Kapuna	Manage for stability	7	0	0	0	61	0	7	67	0	7	61	0	Six of the reintroduced immature plants were observed dead in the last year after heavy rain
Ohikilolo	Genetic Storage	1	0	0	0	0	0	1	0	0	1	0	0	Monitoring showed no change
West Makaleha	Genetic Storage	5	0	0	0	0	0	5	0	0	5	0	0	Monitoring showed no change
	Total for Taxon:	13	0	0	0	61	0	13	67	0	13	61	0	

Action Area: Out

TaxonName: Flueggea neowawraea — TaxonCode: FluNeo

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Central and East Makaleha	Manage for stability	5	0	0	0	0	0	5	0	0	5	0	0	Monitoring showed no change in the last year
Halona	Genetic Storage	2	0	0	0	0	0	2	0	0	2	0	0	No monitoring in the last year
Kauhiuhi	Genetic Storage	1	0	0	0	0	0	1	0	0	1	0	0	No monitoring in the last year
Makaha	Manage for stability	10	0	0	0	15	0	10	0	0	10	15	0	15 immature plants were reintroduced in the last year
Manuwai	Manage reintroduction for stability	0	0	0	0	0	0	0	0	0	0	0	0	Reintroductions will begin once MU fences are complete
Mikilua	Genetic Storage	1	0	0	0	0	0	1	0	0	1	0	0	Monitoring showed no change in the last year
Mt. Kaala NAR	Genetic Storage	3	0	0	0	0	0	3	0	0	3	0	0	Monitoring showed no change
Nanakuli, south branch	Genetic Storage	1	0	0	0	0	0	1	0	0	1	0	0	No monitoring in the last year
	Total for Taxon:	23	0	0	0	15	0	23	0	0	23	15	0	

Table 3.20b Genetic Storage Summary

Population Unit Name	# of Potential Founders: Current Mature	# of Potential Founders: Current Imm.	# of Potential Founders: NumWild Dead	Partial Storage Status: # Plants >= 10 in Seedbank	Partial Storage Status: # Plants >=1 Microprop	Partial Storage Status: # Plants >=1 Army Nursery	Storage Goals Met: # Plants that Met Goal
Flueggea neowawraea							
Central and East Makaleha	5	0	1	1	0	3	2
Halona	2	0	0	0	0	2	0
Kahanahaiki to Kapuna	7	0	0	1	0	3	2
Kauhiuhi	1	0	0	0	0	1	0
Makaha	10	0	0	0	0	7	2
Mikilua	1	0	1	0	0	0	0
Mt. Kaala NAR	3	0	0	1	1	1	1
Nanakuli, south branch	1	0	0	0	0	1	0
Ohikilolo	1	0	1	0	0	1	1
West Makaleha	5	0	0	0	0	2	1

Total # Plants w/ >=10 Seeds in Seedbank	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants that Met Goal
3	1	21	9

3.22 Gardenia manii

Requirements for stability

- 3 Population Units (PUs)
- 50 reproducing individuals in each PU (long-lived perennial; large percentage of non-flowering/ fruiting plants)
- Stable population structure
- Threats controlled
- Genetic storage collections from all PUs
- Tier 1 stabilization priority

Major Highlights/Issues for OIP Year 2

- Two of the four trees in the Haleauau Manage for Stability PU and one of the trees in the Kaluaa and Manauna PU are fenced.
- Two new mature trees discovered and air-layered in the Haleauau PU.
- There are clones from 2 plants in the Haleauau PU and one from the Kaluaa and Manauna PU represented in the nursery. These were established with air-layers.
- In the effort to collect fruit from the Haleauau and Poamoho PU, it was observed that flowers may be functionally dioecious. Two flower types have been identified. Types vary in pollen presence, anther length and color, and stigma size and shape. Flowers where pollen was present have not developed into fruit.

Plans for OIP Year 3

- Conduct census and/or sample monitoring of all Manage for Stability PUs.
- Continue collection efforts to secure genetic representation from all four individuals of Waianae Mountain stock and a sampling of Koolau stock particularly from the Manage for Stability PUs.
- Continue pollination and breeding system studies. Many more plants need to be visited to observe flowers and fruit production before dioecy can be concluded. Non-invasive methods to investigate stigma receptivity will be determined and applied.
- Complete and gain approvals for the OIP EA to allow further threat control actions (e.g. fencing).
- Continue to determine the fencing, collection, and threat control strategies for individuals in the Helemano and Poamoho PUs and the Lower Peahinaia PUs.
- Begin construction of the approximately 1,800 acre Schofield Barracks Lihue Fence.

Table 3.21a Taxon Status Summary

Action Area: In

TaxonName: Gardenia mannii **TaxonCode: GarMan**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Haleauau	Manage for stability	4	0	0	0	0	0	2	0	0	4	0	0	Two new trees were discovered in the last year
Helemano and Poamoho	Manage for stability	14	0	0	0	0	0	18	0	0	14	0	0	Thorough monitoring showed a decline since original estimates in 2005
Kaiwikoele, Kamananui, and Kawainui	Genetic Storage	20	0	0	0	0	0	20	0	0	20	0	0	No monitoring in the last year
Kaukonahua	Genetic Storage	2	0	0	0	0	0	2	0	0	2	0	0	No monitoring in the last year
Lower Peahinaia	Manage for stability	37	1	0	0	0	0	37	1	0	37	1	0	No monitoring in the last year
Opaeula	Genetic Storage	8	0	0	0	0	0	8	0	0	8	0	0	No monitoring in the last year
Opaeula/Helemano	Genetic Storage	1	0	0	0	0	0	1	0	0	1	0	0	Monitoring showed no change
	Total for Taxon:	86	1	0	0	0	0	88	1	0	86	1	0	

Action Area: Out

TaxonName: Gardenia mannii **TaxonCode: GarMan**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Ihiihi-Kawawainui ridge	Genetic Storage	2	0	0	0	0	0	2	0	0	2	0	0	No monitoring in the last year
Kahana and Makaua	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	No monitoring in the last year
Kaipapau to Punaluu	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	No monitoring in the last year
Kalauao	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	No monitoring in the last year
Kaluaa and Maunauna	Genetic Storage	2	0	0	0	0	0	1	0	0	2	0	0	Population counts were revised after updating old observations
Kamananui-Malaekahana Summit Ridge	Genetic Storage	13	0	0	0	0	0	13	0	0	13	0	0	No monitoring in the last year
Kapakahi	Genetic Storage	4	0	0	0	0	0	4	0	0	4	0	0	No monitoring in the last year
Manana-Waimano Ridge	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	No monitoring in the last year
Pukele	Genetic Storage	1	0	0	0	0	0	1	0	0	1	0	0	No monitoring in the last year
Waialae Nui	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	No monitoring in the last year
	Total for Taxon:	22	0	0	0	0	0	21	0	0	22	0	0	

Table 3.21b 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	Storage Goals Met: # Plants that Met Goal
Gardenia mannii							
Haleauau	4	0	3	0	0	2	0
Helemano and Poamoho	14	0	0	0	0	0	0
Ihiihi-Kawawainui ridge	2	0	0	0	0	0	0
Kaiwikoele, Kamananui, and Kawainui	20	0	0	0	0	0	0
Kaluaa and Maunauna	2	0	0	0	0	2	0
Kamananui-Malaekahana Summit Ridge	13	0	0	0	0	0	0
Kapakahi	4	0	0	0	0	0	0
Kaukonahua	2	0	0	0	0	0	0
Lower Peahinaia	37	1	0	0	0	0	0
Opaeula	8	0	0	0	0	0	0
Opaeula/Helemano	1	0	0	0	0	0	0
Pukele	1	0	0	0	0	0	0

Total # Plants w/ >=10 Seeds in Seedbank	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants that Met Goal
0	0	4	0

3.23 GOUANIA VITIFOLIA

Requirements for Stability

- 3 population units (PUs)
- 50 reproducing individuals (suspected dioecy)
- Stable population structure
- Threats controlled
- Genetic storage collections from PUs managed for stability

Major Highlights/Issues for MIP Year 5

- The stability goal of 50 reproducing individuals has been met for the Keaau PU.
- OANRP has begun to scope a proposed fence to exclude goats from the Keaau PU, but are waiting on status of funding for expedited species before continuing.
- A living collection of this species has been established in the nursery in order to investigate the breeding system.
- A survey of appropriate habitat in the Kamaile Gulch region of Makaha found appropriate habitat and identified a potential fence line and reintroduction site.

Plans for MIP Year 6

- Survey historic locations in Makaleha in order to select a reintroduction site
- Continue to work with DOFAW to improve the fire access road to provide better access in case of a fire that threatens the Kea‘au PU.
- Complete scoping the proposed fence line and the Environmental Assessment for management of the Keaau PU
- Collect cuttings at the Waianae Kai PU to establishing clones of the plants in the greenhouse

Table 3.22a Taxon Status Summary

Action Area: In

TaxonName: Gouania vitifolia **TaxonCode: GouVit**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Keaau	Manage for stability	60	1	0	0	0	0	60	1	0	60	1	0	Monitoring showed no change
	Total for Taxon:	60	1	0	0	0	0	60	1	0	60	1	0	

Action Area: Out

TaxonName: Gouania vitifolia **TaxonCode: GouVit**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Makaha	Manage reintroduction for stability	0	0	0	0	0	0	0	0	0	0	0	0	Reintroduction will begin when the fence is complete
Makaleha or Manuwai	Manage reintroduction for stability	0	0	0	0	0	0	0	0	0	0	0	0	NRS will revisit historic sites in Makaleha in the next year and reintroduction will begin once the fence is complete
Waianae Kai	Genetic Storage	2	0	0	0	0	0	2	0	0	2	0	0	Monitoring showed no change
	Total for Taxon:	2	0	0	0	0	0	2	0	0	2	0	0	

Table 3.22b 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	Storage Goals Met: # Plants that Met Goal
Gouania vitifolia							
Keaau	60	1	0	46	11	6	36
Waianae Kai	2	0	0	0	0	0	0
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				46	11	6	36

3.24 HEDYOTIS DEGENERI VAR. DEGENERI

Requirements for Stability

- 3 Population Units (PUs)
- 50 reproducing individuals in each PU (short-lived perennial)
- Threats controlled
- Stable population structure
- Complete genetic representation of all PUs in storage

Major Highlights/Issues MIP Year 5

- Construction of the Manuwai MU fence has begun and will be completed in 2010. This fence will protect the Manuwai portion of the Alaiheihe to Manuwai PU.
- The stability goal of 50 reproducing individuals is met for the Kahanahaiki to Pahole PU.
- Seed collections for genetic storage continued from all extant PUs

Plans for MIP Year 6

- Conduct monitoring and genetic storage collection at all Manage for Stability PUs
- Survey for new locations in the East branch of East Makaleha PU
- Determine a strategy to protect the Central Makaleha and West branch of East Makaleha PU from ungulates

Table 3.23a Taxon Status Summary

Action Area: In

TaxonName: Hedyotis degeneri var. degeneri — TaxonCode: HedDegDeg

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kahanahaiki to Pahole	Manage for stability	186	204	100	0	0	0	186	205	101	**186**	**204**	**100**	Small changes were noted during monitoring in the last year
	Total for Taxon:	186	204	100	0	0	0	186	205	101	**186**	**204**	**100**	

Action Area: Out

TaxonName: Hedyotis degeneri var. degeneri — TaxonCode: HedDegDeg

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Alaiheihe and Manuwai	Manage for stability	27	6	0	0	0	0	31	6	1	**27**	**6**	**0**	Thorough monitoring showed a decline in the last year
Central Makaleha and West Branch of East Makaleha	Manage for stability	23	33	4	0	0	0	21	39	0	**23**	**33**	**4**	Thorough monitoring showed a decline in the last year
East branch of East Makaleha	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
	Total for Taxon:	50	39	4	0	0	0	52	45	1	**50**	**39**	**4**	

Table 3.23b 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
Hedyotis degeneri var. degeneri							
Alaiheihe and Manuwai	27	6	6	26	1	5	25
Central Makaleha and West Branch of East Makaleha	20	36	21	28	0	9	25
East branch of East Makaleha	0	0	0	0	0	0	0
Kahanahaiki to Pahole	186	204	9	40	0	7	30
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				94	1	21	80

3.25 HEDYOTIS PARVULA

Requirements for Stability:

- 3 Population Units (PUs)
- 50 reproducing individuals in each PU (short-lived perennial)
- Stable population structure
- Threats controlled
- Complete genetic representation in storage of all PUs

Major Highlights/Issues MIP Year 5

- Both extant PUs have met the stability goal of having more than 50 reproducing plants
- Genetic storage goals have been met for both extant PUs.

Plans for MIP Year 6

- Conduct a thorough monitoring of the ʻŌhikilolo PU to locate juvenile plants.

Table 3.24a Taxon Status Summary

Action Area: In

TaxonName: Hedyotis parvula TaxonCode: HedPar

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Ohikilolo	Manage for stability	120	28	40	0	0	0	120	28	40	**120**	**28**	**40**	No monitoring in the last year
	Total for Taxon:	120	28	40	0	0	0	120	28	40	**120**	**28**	**40**	

Action Area: Out

TaxonName: Hedyotis parvula TaxonCode: HedPar

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
East Makaleha	Manage reintroduction for stability	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	Reintroduction will begin once the fence is complete
Halona	Manage for stability	97	35	19	0	0	0	97	35	19	**97**	**35**	**19**	No monitoring in the last year
	Total for Taxon:	97	35	19	0	0	0	97	35	19	**97**	**35**	**19**	

Table 3.24b 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	Storage Goals Met: # Plants that Met Goal
Hedyotis parvula							
East Makaleha	0	0	0	0	0	0	0
Halona	97	35	0	70	0	4	62
Ohikilolo	120	28	5	108	0	0	102

Total # Plants w/ >=10 Seeds in Seedbank	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants that Met Goal
178	0	4	164

3.26 HESPEROMANNIA ARBORESCENS

Requirements for Stability

- 3 population units (PUs)
- 25 reproducing individuals (long-lived perennial)
- Stable population structure
- Threats controlled
- Genetic storage collections from all PUs
- Tier 1 stabilization priority

Major Highlights/Issues OIP Year 2

- The stability goal of having more than 25 individuals is met for the Kamananui to Kaluanui PU and the Kaukonahua PU. Additional plants were observed in both PUs in the last year.

Plans for OIP Year 3

- Monitor and survey the Lower Opaeula PU to locate more plants and revise population estimates.
- Survey for plants in a PUs with historic records but no known plants (Palikea Gulch, Kapakahi, Halawa, Waimano, Niu-Waimanalo Summit Ridge, Ohiaai Ridge)
- Begin to collect for seed storage testing
- Obtain a license agreement with Kamehameha Schools to begin MU fence construction

Table 3.25a Taxon Status Summary

Action Area: In

TaxonName: Hesperomannia arborescens TaxonCode: HesArbo

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kamananui to Kaluanui	Manage for stability	56	46	14	0	0	0	54	45	14	**56**	**46**	**14**	Small changes were noted during monitoring in the last year
Kaukonahua	Manage for stability	76	56	124	0	0	0	76	51	122	**76**	**56**	**124**	Small changes were noted during monitoring in the last year
Lower Opaeula	Manage for stability	9	15	0	0	0	0	9	15	0	**9**	**15**	**0**	No monitoring in the last year
Ohiaai ridge	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
Palikea Gulch	Manage for stability	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	All known individuals have been observed dead
Poamoho	Genetic Storage	38	16	3	0	0	0	38	16	3	**38**	**16**	**3**	No monitoring in the last year
	Total for Taxon:	179	133	141	0	0	0	177	127	139	**179**	**133**	**141**	

Action Area: Out

TaxonName: Hesperomannia arborescens TaxonCode: HesArbo

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Halawa	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
Kapakahi	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
Niu-Waimanalo Summit Ridge	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
Waimano	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
	Total for Taxon:	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	

Table 3.25b Genetic Storage Summary

Population Unit Name	# of Potential Founders: Current Mature	# of Potential Founders: Current Imm.	# of Potential Founders: NumWild Dead	Partial Storage Status: # Plants >= 10 in Seedbank	Partial Storage Status: # Plants >=1 Microprop	Partial Storage Status: # Plants >=1 Army Nursery	Storage Goals Met: # Plants that Met Goal
Hesperomannia arborescens							
Kamananui to Kaluanui	56	46	0	0	0	0	0
Kaukonahua	76	56	1	0	0	0	0
Lower Opaeula	9	15	0	0	0	0	0
Palikea Gulch	0	0	3	0	0	0	0
Poamoho	38	16	0	0	0	0	0

Total # Plants w/ >=10 Seeds in Seedbank	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants that Met Goal
0	0	0	0

3.27 HESPEROMANNIA ARBUSCULA

Requirements for Stability:

- 4 Population Units (PUs)
- 75 reproducing individuals in each PU (long-lived perennial but with low seed set, tendency for large declines or fluctuations in population size, and recent severe population declines)
- Stable population structure
- Threats controlled
- Complete genetic representation of all PUs in storage

Major Highlights/Issues MIP Year 5

- Fencing began around the Napepeiauolelo PU.
- The Mahaka MU fence was declared pig free in August 2009.
- Hand pollinations were conducted again this year; unfortunately only two plants flowered. One plant was in the Waianae Kai PU and another was in the greenhouse. The greenhouse plant was a clone from a snatchling from the Palawai PU and represented a new founder source. No fruit matured on the greenhouse plant. Fourteen heads were pollinated on the Waianae Kai PU plant. Ten infructescences were collected. Seed set was 18% and mean seed viability is greater than 50% and ongoing. This year's efforts have resulted in 76 seedlings of a new cross (WAI-A-7 x PAL-A-12).
- All greenhouse plants from 2007 and 2008 crosses were measured quarterly as part of the pollination study to measure fitness of offspring.

Plans for MIP Year 6

- Monitor all plants in all PUs
- Continue surveys for additional populations (SBMR, Waianae Kai, Makaha, Honouliuli)
- Pollinations will be conducted next year to target under-represented crosses
- Continue to clone greenhouse plants with air layers
- Complete the fence around the Napepeiauolelo PU
- Assist Oahu NARS staff in the removal of ungulates from the Upper Kapuna MU fence
- Begin reintroduction into both Kapuna and Pualii with stock produced by hand-pollinations in 2007 and 2008

Table 3.26a Taxon Status Summary

Action Area: In

TaxonName: Hesperomannia arbuscula TaxonCode: HesArbu

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kapuna	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	No monitoring in the last year
	Total for Taxon:	0	0	0	0	0	0	0	0	0	0	0	0	

Action Area: Out

TaxonName: Hesperomannia arbuscula TaxonCode: HesArbu

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Haleauau	Manage for stability	0	1	0	0	0	0	0	1	0	0	1	0	Monitoring showed no change
Makaha	Manage for stability	2	4	0	0	0	0	3	3	0	2	4	0	Population counts were revised after updating old observations
Napepeiauolelo	Genetic Storage	0	4	0	0	0	0	0	4	0	0	4	0	Monitoring showed no change
North Palawai	Manage for stability	1	0	0	0	0	0	1	0	0	1	0	0	Monitoring showed no change
Waianae Kai	Manage for stability	2	1	0	0	0	0	2	1	0	2	1	0	Monitoring showed no change
	Total for Taxon:	5	10	0	0	0	0	6	9	0	5	10	0	

Table 3.26b 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	Storage Goals Met: # Plants that Met Goal
Hesperomannia arbuscula							
Haleauau	0	1	0	0	0	0	0
Kapuna	0	0	0	0	0	0	0
Makaha	2	4	1	0	0	1	1
Napepeiauolelo	0	4	0	0	0	0	0
North Palawai	1	0	16	0	2	8	3
Waianae Kai	2	1	8	0	1	2	2

Total # Plants w/ >=10 Seeds in Seedbank	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants that Met Goal
0	3	11	6

3.28 HIBISCUS BRACKENRIDGEI SUBSP. MOKULEIANUS

Requirements for Stability

- 4 Population Units (PU)
- 50 reproducing individuals in each PU (short-lived perennial)
- Stable population structure
- Threats controlled
- Complete genetic representation of all PUs in storage

Major Highlights/Issues MIP Year 5

- A new population was discovered in Keaau Valley by a local resident. OANRP and DOFAW visited the site in June 2009 and observed five mature and two immature plants. This discovery prompted a change in the proposed stabilization plan for the Keaau PU. The plan had proposed to establish a stable PU at Keaau by reintroducing clones from the Makua PU into a managed area northwest of the new wild site. OANRP now propose to maintain and manage the wild site for stability in coordination with DOFAW.
- The large fence proposed to protect the Kaimuhole and Palikea Gulch PU has been scoped and the NEPA review has begun.
- A new technique to monitor seedlings was deployed in the Mākua PU. Thirty five immature plants were marked with red PVC rings in order to facilitate tracking.
- Twenty-three plants were planted to augment the Makua PU in February of 2008. Only two have died (91% survival) and most of the survivors are healthy.
- The genetic storage goal is met for the Makua PU since all 29 available founders are kept in a living collection in the nursery.
- The reintroduction of the Haili to Kawaiu PU at Dillingham Military Reservation (DMR) has a low (32%) survival rate. Although only one plant died in the first two years after planting, only one of the individuals planted in 2005 is alive today. While the primary reason for this decline has not been determined, many potential threats have been observed at the site including plants being completely smothered by *Sicyos pachycarpus*, ants and scale insects, thick *Panicum maximum*, African snails and an unidentified mildew on the leaves.
- OARNP contracted the construction of a 35 acre fuel-break in the *Panicum maximum* dominated fallow agriculture fields along the Kaukonahua Road above Waialua. This will assist in protecting the Kaomoku Nui PU, Kihakapu PU and the Kaimuhole and Palikea Gulch PU from a fire starting along the road and decreases the chance of fires jumping the road in this area.
- Fire pre-suppression plans set forth by FWS for the Kaomoku Nui PU, Kihakapu PU and the Kaimuhole and Palikea Gulch PU have been reviewed and discussed with landowners.
- Clones of twenty-one plants from the Kaomoku Nui PU, Kihakapu PU and the Kaimuhole and Palikea Gulch PU were collected in the last year for genetic storage.
- No decline in seed viability has been documented after five years of storage.

Plans for MIP Year 6

- Conduct census monitoring of all Manage for Stability PUs
- Conduct follow up monitoring and surveys at the new Keaau PU. Plans for pre-fire suppression, weed control and fencing will be developed.
- Begin the Environmental Assessment for fence construction of the Keaau PU
- Contract construction of a fence around the Kaimuhole and Palikea Gulch PU when funding becomes available
- Begin fire pre-suppression actions around the Kaimuhole and Palikea Gulch PU when funding becomes available
- Continue to augment the Mākua PU with plants grown from clones of all the wild plants
- Monitor the reintroduction at the Haili to Kawaiū PU to determine if threat control can improve survivorship or if a new site needs to be selected
- Collect from any new wild founders in the Haili to Kawaiū PU
- Begin another inter-situ planting at MMR Range Control to hold the living collection of the Makua PU

Table 3.27a Taxon Status Summary

Action Area: In

TaxonName: Hibiscus brackenridgei subsp. mokuleianus TaxonCode: HibBraMok

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Keaau	Manage for stability	5	2	0	0	0	0	0	0	0	**5**	**2**	**0**	A new wild site was discovered in the last year
Makua	Manage for stability	11	27	1	20	0	0	34	2	68	**31**	**27**	1	Many new immature plants were observed in the wild site. Two mature plants in the augmentation died and one new seedlind was observed.
	Total for Taxon:	16	29	1	20	0	0	34	2	68	**36**	**29**	1	

Action Area: Out

TaxonName: Hibiscus brackenridgei subsp. mokuleianus TaxonCode: HibBraMok

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Haili to Kawaiu	Manage for stability	5	2	0	15	0	0	21	4	9	**20**	**2**	**0**	Small changes were noted during monitoring of the reintroduction in the last year
Kaimuhole and Palikea Gulch	Manage for stability	4	1141	10	0	0	0	6	1012	0	4	**1141**	**10**	Additional post-fire surveys found more plants a few old sites. The mature plants from 2008 had died, but new mature plants and seedlings were observed.
Kaumoku Nui	Genetic Storage	1	114	0	0	0	0	0	250	300	1	**114**	**0**	Monitoring showed a decline from the initial post-fire estimates given in 2008. No plants were observed inside the fence.
Kihakapu	Genetic Storage	2	144	3	0	0	0	1	0	0	**2**	**144**	**3**	The initial post-fire surveys did not visit all the sites that were observed in the last year. All sites had evidence of the fire and had likely been completely burned in 2007.
	Total for Taxon:	12	1401	13	15	0	0	28	1266	309	**27**	**1401**	13	

Table 3.27b 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	Storage Goals Met: # Plants that Met Goal
Hibiscus brackenridgei subsp. mokuleianus							
Haili to Kawaiu	5	2	5	0	0	9	6
Kaimuhole and Palikea Gulch	4	1141	7	1	0	20	12
Kaumoku Nui	1	114	7	1	0	6	3
Keaau	5	2	0	0	0	7	3
Kihakapu	2	144	3	3	0	12	13
Makua	11	27	19	20	0	29	29

Total # Plants w/ >=10 Seeds in Seedbank	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants that Met Goal
25	0	83	66

3.29 HUPERZIA NUTANS

Requirements for Stability

- 3 population units (PUs)
- Help to develop propagation techniques
- 50 reproducing individuals (short-lived perennial)
- Stable population structure
- Threats controlled
- Genetic storage collections from all PUs
- Tier 1 stabilization priority

Major Highlights/Issues OIP Year 2

- No PUs have stable population structure
- The main priority for this species is developing propagation techniques. Due to the low number of extant individuals and the risk of removing material from the known plants, testing has been started on the more common *H. phyllanthus*. Modified airlayers have been installed in Makaua. Cuttings have been successfully established in the greenhouse. Strobili collections have been made to experiment with spore germination at the Lyon Arboretum Micropropagation Laboratory. No testing will be conducted on *H. nutans* until all methods have been determined on *H. phyllanthus*.
- 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 because 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 PU.
- There are no plants that are currently protected from ungulates. However, they will be protected in the future and included within the Koloa and Kaipapau MUs as well as the South Kaukonahua I MU fence.

Plans for OIP Year 3

- Continue to develop propagation techniques using *H. phyllanthus*.
- Work with the Oahu Plant Extinction Prevention Program to monitor all known plants and conduct surveys to locate more.

Table 3.28a Taxon Status Summary

Action Area: In

TaxonName: Huperzia nutans TaxonCode: HupNut

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kahana and North Kaukonahua	Manage for stability	5	0	0	0	0	0	6	0	0	**5**	**0**	**0**	One plant was observed to be dead in the last year
Koloa and Kaipapau	Manage for stability	3	2	0	0	0	0	3	0	0	**3**	**2**	**0**	Small changes were noted during monitoring in the last year
South Kaukonahua	Manage for stability	1	0	0	0	0	0	1	0	0	**1**	**0**	**0**	Monitoring showed no change
	Total for Taxon:	9	2	0	0	0	0	10	0	0	**9**	**2**	**0**	

Table 3.28b 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	Storage Goals Met: # Plants that Met Goal
Huperzia nutans							
Kahana and North Kaukonahua	5	0	1	0	0	0	0
Koloa and Kaipapau	3	2	0	0	0	0	0
South Kaukonahua	1	0	0	0	0	0	0

Total # Plants w/ >=10 Seeds in Seedbank	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants that Met Goal
0	0	0	0

3.30 LABORDIA CYRTANDRAE

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)
- Stable population structure
- Threats controlled
- Genetic storage collections from both PUs
- Tier 1 stabilization priority

Major Highlights/Issues for OIP Year 2

- The East Makaleha to North Mohiakea PU is nearing the stability goal of 100 individuals and 7 new plants were discovered in the last year.
- The current Kaala MU fence is not adequate in excluding pigs from the MU. Although there has not been any documented damage to *L. cyrtandrae*, the ungulate threat level for the PU is high. A line to extend the Waianae Kai section has been surveyed and the OIP EA is being completed
- Genetic storage goals will be met by storing seed collected from both wild and reintroduced plants. However, viable seed has been collected from only ten of the known female plants over the last twelve years of monitoring. A living collection of plants kept in the nursery for pollination trials and for genetic storage, has not been successful in producing many viable seeds. Due to the small number of plants producing viable seeds OANRP began an extensive pollination effort to try and increase seed set in lone plants. This trial is ongoing but preliminary results are positive as fruit is currently developing on pollinated plants.
- OPEP and OANRP visited the Manana individual a few times in the last year in an effort to collect pollen from the lone male plant but were unsuccessful.
- Significant control work on *Hedychium gardnerium* has been ongoing around populations of *L. cyrtandrae*

Plans for OIP Year 3

- Complete construction of Kaala MU fence extension and eradicate pigs
- Complete Lihue fence and initiate ungulate eradication program
- Continue to hand-pollinate more females and collect fruit for propagation and storage
- Survey historic sites in the Koolau Mountains to find additional plants
- Monitor and determine the sex of the newly discovered and other unknown plants

Table 3.29a Taxon Status Summary

Action Area: In

TaxonName: Labordia cyrtandrae **TaxonCode: LabCyr**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
East Makaleha to North Mohiakea	Manage for stability	69	3	0	18	13	0	84	16	2	87	16	0	Small changes were noted during monitoring in the last year
	Total for Taxon:	69	3	0	18	13	0	84	16	2	87	16	0	

Action Area: Out

TaxonName: Labordia cyrtandrae **TaxonCode: LabCyr**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Manana	Manage for stability	1	0	0	0	0	0	1	0	0	1	0	0	Monitoring showed no change
	Total for Taxon:	1	0	0	0	0	0	1	0	0	1	0	0	

Table 3.29b 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	Storage Goals Met: # Plants that Met Goal
Labordia cyrtandrae							
East Makaleha to North Mohiakea	69	3	3	3	4	12	7
Manana	1	0	0	0	0	0	0
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				3	4	12	7

3.31 LOBELIA GAUDICHAUDII SUBSP. KOOLAUENSIS

Requirements for Stability

- 3 population units (PUs)
- 100 reproducing individuals (short-lived perennial; monocarpic; inconsistent flowering)
- Stable population structure
- Threats controlled
- Genetic storage collections from all PUs
- Tier 3 stabilization priority

Major Highlights/Issues OIP Year 2

- The Kawaiiki PU is protected by an ungulate fence and ungulates are controlled around the Kaukonahua PU.
- This taxon has been successfully propagated from seed and this is the preferred propagation technique. Stored seeds show a decline after five years of storage. Ten year results will be available next year. This is similar to what has been documented for species of *Cyanea*. Additional collections will be used to test a new storage temperature (-80C) and a few seeds will be sent to NCGRP for lipid testing.

Plans for OIP Year 3

- In the coming year OANRP will begin to collect seed from Kaukonahua PU for additional storage testing and genetic storage.
- OANRP will identify PUs that could be protected with fence projects constructed in coordination with OPEP and KMWP.

Table 3.30a Taxon Status Summary

Action Area: In

TaxonName: Lobelia gaudichaudii subsp. koolauensis TaxonCode: LobGauKoo

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kaukonahua	Manage for stability	1	35	1	0	0	0	3	45	2	1	35	1	Thorough monitoring showed a decline in the last year
Kawaiiki	Genetic Storage	2	0	0	0	0	0	2	0	0	2	0	0	No monitoring in the last year
	Total for Taxon:	3	35	1	0	0	0	5	45	2	3	35	1	

Action Area: Out

TaxonName: Lobelia gaudichaudii subsp. koolauensis TaxonCode: LobGauKoo

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kipapa	Manage for stability	0	100	20	0	0	0	0	100	20	0	100	20	No monitoring in the last year
Waiawa to Waimano	Manage for stability	0	200	0	0	0	0	0	200	0	0	200	0	No monitoring in the last year
	Total for Taxon:	0	300	20	0	0	0	0	300	20	0	300	20	

Table 3.30b Genetic Storage Summary

Population Unit Name	# of Potential Founders: Current Mature	# of Potential Founders: Current Imm.	# of Potential Founders: NumWild Dead	Partial Storage Status: # Plants >= 10 in Seedbank	Partial Storage Status: # Plants >=1 Microprop	Partial Storage Status: # Plants >=1 Army Nursery	Storage Goals Met: # Plants that Met Goal
Lobelia gaudichaudii subsp. koolauensis							
Kaukonahua	1	35	0	4	0	0	3
Kawaiiki	2	0	0	2	0	0	2
Kipapa	0	100	0	0	0	0	0
Waiawa to Waimano	0	200	0	0	0	0	0
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				6	0	0	5

3.32 MELANTHERA TENUIFOLIA

Requirements for Stability

- 3 Population Units (PUs)
- 50 genetically unique individuals in each PU (short-lived perennial with tendency to reproduce vegetatively)*
- Stable population structure
- Threats controlled
- Complete genetic representation of all PUs in storage

* It is difficult to distinguish genetic individuals, since vegetative reproduction creates identical adjacent plants. Genetic studies suggest that plant material separated by >2 m is genetically distinct.

Major Highlights/Issues Year 5

- Stability goal of 50 reproducing individuals met at all 3 Manage for Stability PUs
- Construction of the Manuwai fence has begun. This fence will be completed in 2010 and will protect the Mt. Kaala NAR PU.
- OANRP continue to maintain a collection of clones from 40 founders from Kahanahaiki and 18 from the makai end of the Ohikilolo PU for genetic storage.
- A temperature data logger has been maintained at one wild site in the Ohikilolo PU to help determine what temperature fluctuations may stimulate germination *in situ*. Additional dataloggers still need to be placed at other sites to capture the temperature range across the elevation gradient of this taxon.
- OANRP monitored the makai end of the Ohikilolo PU in August 2009 and saw only one plant. The plant was in poor condition. This observation continues the decline from the previous years but was done in the dry season when seedlings are hard to find.
- A fire starting at the highway near MMR in July of 2009 did not damage any plants and burned the same area as previous fire stopping at the bare rock below the Ohikilolo PU.

Plans for Year 6

- Complete the Manuwai MU fence which will protect all plants in the Mt. Kaala NAR PU
- Revisit small PUs that are highly threatened by fire from training at Mākua Military Reservation and collect clones from new founders to expand the greenhouse genetic storage collections.
- Determine how greenhouse plants will be used to produce seed for storage.
- Continue studies to investigate dormancy-breaking mechanisms in order to determine the storage potential of seeds collected for genetic storage goals.
- Deploy additional data loggers at higher elevation sites in the Ohikilolo PU
- Determine a strategy to protect the Kamaileunu and Waianae Kai PUs from ungulate threats

Table 3.31a Taxon Status Summary

Action Area: In

TaxonName: Melanthera tenuifolia   TaxonCode: MelTen

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kahanahaiki	Genetic Storage	11	2	2	0	0	0	11	2	2	**11**	**2**	**2**	No monitoring in the last year
Kaluakauila	Genetic Storage	64	20	40	0	0	0	64	20	40	**64**	**20**	**40**	No monitoring in the last year
Keawaula	Genetic Storage	45	15	0	0	0	0	45	15	0	**45**	**15**	**0**	No monitoring in the last year
Ohikilolo	Manage for stability	1233	0	0	0	0	0	1235	0	0	**1233**	**0**	**0**	Two plants in the most makai section of this PU were observed dead leaving one left. The rest of the PU has not been monitored recently.
	Total for Taxon:	1353	37	42	0	0	0	1355	37	42	**1353**	**37**	**42**	

Action Area: Out

TaxonName: Melanthera tenuifolia   TaxonCode: MelTen

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kamaileunu and Waianae Kai	Manage for stability	880	269	297	0	0	0	880	269	297	**880**	**269**	**297**	No monitoring in the last year
Mt. Kaala NAR	Manage for stability	300	0	0	0	0	0	300	0	0	**300**	**0**	**0**	No monitoring in the last year
	Total for Taxon:	1180	269	297	0	0	0	1180	269	297	**1180**	**269**	**297**	

Table 3.31b 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
Melanthera tenuifolia							
Kahanahaiki	11	2	25	11	0	29	17
Kaluakauila	64	20	0	9	0	9	7
Kamaileunu and Waianae Kai	880	269	0	0	0	0	0
Keawaula	45	15	0	0	0	0	0
Mt. Kaala NAR	300	0	0	0	0	0	0
Ohikilolo	1233	0	35	16	0	19	15
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				36	0	57	39

3.33 MELICOPE LYDGATEI

Requirements for Stability:

- 3 population units (PUs)
- 50 reproducing individuals (long-lived perennial with threats from invertebrates)
- Threats controlled
- Stable population structure
- Surveys to find one additional PU
- Genetic storage collections from all PUs
- Tier 1 stabilization priority

Major Highlights/Issues OIP Year 2

- Two plants established from cuttings from a single plant in the Kaiwikoele-Kawainui Ridge are being kept as a living collection in the nursery and used to produce fruit for germination testing.
- Seeds collected in 2006 are still germinating, with the latest seed germinating 680 days after sowing.

Plans for OIP Year 3

- Prioritize a survey and monitoring trip for the Kawaiiki and Opaeula PU to update population status and collect for genetic storage
- A longer term license agreement that will cover fencing actions should be coming in the next year. This will allow OANRP and KWMP to pursue fencing at the Lower Peahinaia MU which will protect a portion of the Kawaiiki to Opaeula PU
- Determine other historic locations to conduct surveys for additional PUs

Table 3.32a Taxon Status Summary

Action Area: In

TaxonName: Melicope lydgatei TaxonCode: MelLyd

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kaiwikoele-Kawainui Ridge	Manage for stability	3	0	0	0	0	0	3	0	0	3	0	0	No monitoring in the last year
Kawaiiki and Opaeula	Manage for stability	42	0	0	0	0	0	43	0	0	42	0	0	Population counts were revised after updating old observations
Poamoho	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	No monitoring of the historic site in the last year
	Total for Taxon:	45	0	0	0	0	0	46	0	0	45	0	0	

Action Area: Out

TaxonName: Melicope lydgatei TaxonCode: MelLyd

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Manana	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	No monitoring of the historic site in the last year
	Total for Taxon:	0	0	0	0	0	0	0	0	0	0	0	0	

Table 3.32b Genetic Storage Summary

Population Unit Name	# of Potential Founders: Current Mature	# of Potential Founders: Current Imm.	# of Potential Founders: NumWild Dead	Partial Storage Status: # Plants >= 10 in Seedbank	Partial Storage Status: # Plants >=1 Microprop	Partial Storage Status: # Plants >=1 Army Nursery	Storage Goals Met: # Plants that Met Goal
Melicope lydgatei							
Kaiwikoele-Kawainui Ridge	3	0	0	0	0	1	1
Kawaiiki and Opaeula	42	0	1	0	0	0	0
Poamoho	0	0	0	0	0	0	0

Total # Plants w/ >=10 Seeds in Seedbank	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants that Met Goal
0	0	1	1

3.34 MYRSINE JUDII

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 from across the distribution
- Tier 2 stabilization priority
- Stable population structure

Major Highlights/Issues OIP Year 2

- OANRP staff began counts in a portion of the Opaeula MU in order to refine population estimates. As estimates are refined, the total will be updated.
- A large fruit collection was made for seed storage testing purposes.

Plans for OIP Year 3

- OANRP will continue to refine population estimates and collect GPS data to create a more accurate description of species distribution.

Table 3.33a Taxon Status Summary

Action Area: In

TaxonName: Myrsine juddii TaxonCode: MyrJud

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kaukonahua to Kamananui-Koloa	Manage for stability	455	0	0	0	0	0	455	0	0	**455**	**0**	**0**	This is an estimate for the entire range in the Northern Koolaus and has not been updated in the last year
	Total for Taxon:	455	0	0	0	0	0	455	0	0	**455**	**0**	**0**	

Table 3.33b 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	Storage Goals Met: # Plants that Met Goal
Myrsine juddii							
Kaukonahua to Kamananui-Koloa	455	0	0	0	0	0	0
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				0	0	0	0

3.35 NERAUDIA ANGULATA

Requirements for Stability

- 4 Population Units (PUs) (for both var. *angulata* and var. *dentata* and high fire threat)
- 100 reproducing individuals in each Manage for Stability PU (short-lived perennial, mostly dioecious, prone to large declines or fluctuations in population size)
- Stable population structure
- Threats controlled
- Complete genetic representation of all PUs in storage

Major Highlights/Issues MIP Year 5

- The stability goal of 100 reproducing individuals is met for the Kaluakauila PU.
- The wild sites in the Makua PU were observed to have declined over the past year, but more surveys need to be completed to verify the latest observations.
- No new plants were observed at the historic site in Manuwai
- New naturally occurring F1 plants were observed at reintroductions in both the Kaluakauila and Makua PUs.
- Construction began of the Manuwai MU fence which will protect the historic site and secure habitat for future reintroduction.
- The lower sections of both the Waianae Kai Makai PU and Waianae Kai Mauka PU fences are complete. The historic site in lower Waianae Kai was surveyed and no plants were found. OANRP will postpone that proposed fence until more plants are observed.
- Continued to plant clones of var. *dentata* stock from the Manuwai PU at the reintroduction site in lower Kaluakauila and clones of the Punapohaku and Kapuna PUs into the upper site.

Plans for MIP Year 6

- Complete the Manuwai MU fence
- Complete PU fences around the Wai‘anae Kai Mauka and Slot Gulch
- Continue to supplement/augment the Kaluakauila and Makua PUs
- Conduct census monitoring at all MFS PUs
- Continue to collect clones from new founders at wild populations in order to meet genetic storage goals with living collections in the greenhouse
- Continue monitoring wild and outplanted plants to guide reintroduction plans and gather further information about life histories, sex ratios, reproductive strategies, and habitat requirements
- Determine the need to augment the Wai‘anae Kai Mauka PU in order to reach the stability goal of 100 reproducing plants after the fence is complete
- Continue weeding operations below cliffs of populations

Table 3.34a Taxon Status Summary

Action Area: In

TaxonName: Neraudia angulata TaxonCode: NerAng

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kaluakauila	Manage reintroduction for stability	0	0	0	113	24	1	46	0	0	**113**	**24**	**1**	Additional plants were added to the existing reintroduction sites and a seedling was observed for the first time
Kapuna	Genetic Storage	2	0	0	0	0	0	2	2	0	**2**	**0**	**0**	No monitoring in the last year
Makua	Manage for stability	17	77	0	11	6	3	38	79	0	**28**	**83**	**3**	Small changes were noted during monitoring in the last year
Punapohaku	Genetic Storage	1	0	0	0	0	0	1	0	0	**1**	**0**	**0**	Monitoring showed no change in the last year
	Total for Taxon:	20	77	0	124	30	4	87	81	0	**144**	**107**	**4**	

Action Area: Out

TaxonName: Neraudia angulata TaxonCode: NerAng

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Halona	Genetic Storage	30	4	0	0	0	0	30	4	0	**30**	**4**	**0**	No monitoring in the last year
Leeward Puu Kaua	Genetic Storage	9	0	0	0	0	0	9	0	0	**9**	**0**	**0**	No monitoring in the last year
Makaha	Genetic Storage	10	0	0	0	0	0	10	1	0	**10**	**0**	**0**	Small changes were noted during monitoring in the last year
Manuwai	Manage for stability	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	Monitoring did not detect any new plants
Waianae Kai Makai	Genetic Storage	45	35	25	0	0	0	46	35	25	**45**	**35**	**25**	Monitoring showed no change in the last year
Waianae Kai Mauka	Manage for stability	43	25	4	0	0	0	57	29	54	**43**	**25**	**4**	Population counts were revised after updating old observations
	Total for Taxon:	137	64	29	0	0	0	152	69	79	**137**	**64**	**29**	

Table 3.34b 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	Storage Goals Met: # Plants that Met Goal
Neraudia angulata							
Halona	30	4	0	0	0	12	10
Kapuna	2	0	0	1	0	2	2
Leeward Puu Kaua	9	0	0	0	0	1	1
Makaha	10	0	7	2	0	8	8
Makua	17	77	62	2	0	32	20
Manuwai	0	0	6	0	0	2	2
Punapohaku	1	0	0	0	0	1	1
Waianae Kai Makai	45	35	0	0	0	0	0
Waianae Kai Mauka	43	25	1	0	0	4	3

Total # Plants w/ >=10 Seeds in Seedbank	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants that Met Goal
5	0	62	47

3.36 NOTOTRICHIUM HUMILE

Requirements for Stability

- 4 Population Units (PUs) (4 due to high fire risk to PUs)
- 25 reproducing individuals in each PU (long-lived perennial)
- Stable population structure
- Threats controlled
- Complete genetic representation in storage of all PUs

Major Highlights/Issues MIP Year 5

- All four MFS PUs have again met the goal of more than 25 reproducing plants.
- Two of the four MFS PUs have many immature plants (Kaluakauila and Waianae Kai). However, seedlings are either absent or not observed at these two PUs.
- Fence construction for the Waianae Kai Slot Gulch PU began. The lower section is complete and the only the small upper section is left to complete.
- Landowner negotiations and a strategy for managing the ungulate and fire threats to the Kaimuhole and Palikea PU are still ongoing.
- Fire pre-suppression efforts below the Kaimuhole and Palikea MFS PU have included significant fuel load reductions along Kaukonahua Road and in the adjacent pasture area by the local rancher.
- Re-located a historic site with plants in the Palikea Gulch section of the Kaimuhole and Palikea PU.
- Continued to collect clones from the founders in the Kaimuhole and Palikea Gulch (Kihakapu) PU and the Kolekole (east side) PU.
- A large fruit collection was made at the inter situ Waimea Arboretum collection of clones from the Kahanahaiki PU. Over 6000 fruit were collected from 12 plants but only one seed was found and it was empty.
- Another proposed planting site at Waimea Arboretum was selected to establish and hold a living collection of clones from an additional PU in the coming year.

Plans for MIP Year 6

- Complete the Waianae Kai Slot Gulch PU fence
- Conduct census monitoring at all MFS PUs. Several of these PUs have not been thoroughly monitored in several years.
- Mating and breeding system studies will be initiated with plants in the greenhouse that have been up-potted to promote flowering.
- Monitor and collect from the Keaau, Nanakuli, Makua (East Rim) & Makaha PUs. These have not been observed recently and have had few or no collections for genetic storage.
- Continue to collect from founders in the Kaimuhole and Palikea Gulch (Kihakapu) and Kolekole (east side) PUs.
- Continue to maintain the living collection of clones from the smallest and most fire-threatened PUs in the greenhouse and at Waimea Botanical Garden.

- Determine management unit boundaries and strategy for managing the Kaimuhole and Palikea Gulch (Kihakapu) PU.
- Determine a PU to represent with a living collection at Waimea Botanical Garden

Table 3.35a Taxon Status Summary

Action Area: In

TaxonName: Nototrichium humile TaxonCode: NotHum

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kahanahaiki	Genetic Storage	67	10	0	0	0	0	67	10	0	67	10	0	No monitoring in the last year
Kaluakauila	Manage for stability	198	35	0	0	0	0	198	35	0	198	35	0	No monitoring in the last year
Keaau	Genetic Storage	21	31	0	0	0	0	21	31	0	21	31	0	No monitoring in the last year
Keawaula	Genetic Storage	138	5	0	0	0	0	138	5	0	138	5	0	No monitoring in the last year
Makua (East rim)	Genetic Storage	1	0	0	0	0	0	1	0	0	1	0	0	No monitoring in the last year
Makua (south side)	Manage for stability	56	1	0	10	0	0	69	2	0	66	1	0	Small changes were noted during monitoring of the reintroduction site in the last year
Punapohaku	Genetic Storage	302	14	7	0	0	0	302	14	7	302	14	7	No monitoring in the last year
	Total for Taxon:	783	96	7	10	0	0	796	97	7	793	96	7	

Action Area: Out

TaxonName: Nototrichium humile TaxonCode: NotHum

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kaimuhole and Palikea Gulch	Manage for stability	53	5	0	0	0	0	51	4	0	53	5	0	A historic location was observed by OANRP for the first time adding a few more plants.
Keawapilau	Genetic Storage	5	0	0	0	0	0	5	0	0	5	0	0	No monitoring in the last year
Kolekole (east side)	Genetic Storage	12	0	0	0	0	0	12	0	0	12	0	0	No monitoring in the last year
Makaha	Genetic Storage	15	3	0	0	0	0	15	3	0	15	3	0	No monitoring in the last year
Nanakuli	Genetic Storage	5	0	0	0	0	0	5	0	0	5	0	0	No monitoring in the last year
Puu Kaua (Leeward side)	Genetic Storage	2	0	0	0	0	0	2	0	0	2	0	0	No monitoring in the last year
Waianae Kai	Manage for stability	199	105	0	0	0	0	224	5	0	199	105	0	New estimates of more immature plants and a few less mature plants in the largest of the known sites.
	Total for Taxon:	291	113	0	0	0	0	314	12	0	291	113	0	

Table 3.35b 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	Storage Goals Met: # Plants that Met Goal
Nototrichium humile							
Kahanahaiki	67	10	1	5	0	10	6
Kaimuhole and Palikea Gulch	53	5	0	0	0	25	20
Kaluakauila	198	35	0	5	0	0	4
Keaau	21	31	0	0	0	0	0
Keawapilau	5	0	0	0	0	5	2
Keawaula	138	5	0	0	0	9	0
Kolekole (east side)	12	0	0	0	0	10	3
Makaha	15	3	0	0	0	0	0
Makua (East rim)	1	0	0	0	0	0	0
Makua (south side)	56	1	0	0	0	0	0
Nanakuli	5	0	0	0	0	0	0
Punapohaku	302	14	1	0	0	11	1
Puu Kaua (Leeward side)	2	0	0	0	0	0	0
Waianae Kai	199	105	0	0	0	4	2
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				10	0	74	38

3.37 PHYLLOSTEGIA HIRSUTA

Requirements for Stability

- 3 Population Units (PUs)
- 100 reproducing individuals (short-lived perennial)
- Stable population structure
- Threats controlled
- Genetic storage collections from all PUs
- Tier 1 stabilization priority

Major Highlights/Issues OIP Year 2

- The Hapapa to Kaluaa PU is partially fenced
- While not all PUs were monitored in the last year, several PUs showed declines. No wild plants are known south of Kaluaa.
- New collections from a plant in the Haleauau to Mohiakea PU and seedlings from the Hapapa to Kaluaa PU are becoming established in the greenhouse.
- Surveys conducted at a historic site in the Haleauau to Mohiakea PU did not locate any plants. A few new plants were observed near a known site in the Helemano PU and a possible hybrid *P. hirsuta* was found in the Kawaiiki PU.

Plans for OIP Year 3

- Conduct census monitoring at the Haleauau to Mohiakea and Hapapa to Kaluaa Manage for Stability PUs.
- Continue collection efforts from other PUs for genetic storage
- Re-collect the putative hybrid at Crispa Rock.
- Continue surveys in the Koloa MU, the Helemano PU, and the Haleauau to Mohiakea PU including the Kaala area.
- Begin construction of the 1800 acre Schofield Barracks Lihue Fence.
- Collect propagules from Mohiakea and Makaha-Waianae Kai Ridge PUs for a possible augmentation in the Kaala MU.
- Evaluate sites at Kaala for reintroduction of stock from the Haleauau to Mohiakea PU.
- Complete the Kaala fence and eradicate pigs from the fenced area.
- Continue to monitor recently extirpated sites (Palawai and Huliwai) for any new founders

Table 3.36a Taxon Status Summary

Action Area: In

TaxonName: Phyllostegia hirsuta TaxonCode: PhyHir

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Haleauau to Mohiakea	Manage for stability	8	10	0	0	0	0	6	12	0	8	10	0	Small changes were noted during monitoring in the last year
Helemano and Opaeula	Genetic Storage	13	2	6	0	0	0	14	5	6	13	2	6	Thorough monitoring showed a decline in the last year
Helemano to Poamoho	Genetic Storage	1	0	0	0	0	0	1	0	0	1	0	0	No monitoring in the last year
Kaipapau and Kawainui	Genetic Storage	9	0	0	0	0	0	7	0	0	9	0	0	Small changes were noted during monitoring in the last year
Kaukonahua	Genetic Storage	4	2	0	0	0	0	4	2	0	4	2	0	No monitoring in the last year
Kawaiiki	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	No monitoring in the last year
Laie & Puu Kainapuaa	Manage for stability	0	0	0	0	0	0	0	0	0	0	0	0	No monitoring in the last year
	Total for Taxon:	35	14	6	0	0	0	32	19	6	35	14	6	

Action Area: Out

TaxonName: Phyllostegia hirsuta TaxonCode: PhyHir

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Ekahanui	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	No monitoring of the histroic site in the last year
Hapapa to Kaluaa	Manage for stability	3	11	3	0	0	0	11	9	7	3	11	3	Thorough monitoring showed a decline in the last year
Huliwai	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	No monitoring of the histroic site in the last year
Kaluanui	Genetic Storage	5	0	0	0	0	0	5	0	0	5	0	0	No monitoring in the last year
Makaha-Waianae Kai Ridge	Genetic Storage	2	0	0	0	0	0	2	0	0	2	0	0	No monitoring in the last year
Palawai	Genetic Storage	0	0	0	0	0	0	0	1	0	0	0	0	The known plant died in the last year
	Total for Taxon:	10	11	3	0	0	0	18	10	7	10	11	3	

Table 3.36b 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	Storage Goals Met: # Plants that Met Goal
Phyllostegia hirsuta							
Ekahanui	0	0	0	0	0	0	0
Haleauau to Mohiakea	8	10	0	0	1	1	1
Hapapa to Kaluaa	3	11	0	1	0	3	2
Helemano and Opaeula	13	2	1	0	0	4	1
Helemano to Poamoho	1	0	0	0	0	1	0
Huliwai	0	0	3	0	0	1	0
Kaipapau and Kawainui	9	0	0	0	0	0	0
Kaluanui	5	0	0	0	0	0	0
Kaukonahua	4	2	0	0	0	0	0
Kawaiiki	0	0	0	0	0	0	0
Laie & Puu Kainapuaa	0	0	0	0	0	0	0
Makaha-Waianae Kai Ridge	2	0	0	0	0	0	0
Palawai	0	0	1	0	0	1	0

Total # Plants w/ >=10 Seeds in Seedbank	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants that Met Goal
1	1	11	4

3.38 PHYLLOSTEGIA KAALAENSIS

Requirements for Stability

- 4 Population Units (PUs)
- 50 genetically unique, reproducing individuals in each PU (short-lived perennial, vegetative reproducing)
- Stable population structure
- Threats controlled
- Complete genetic representation of all PUs in storage

Major Highlights/Issues MIP Year 5

- Two of the 379 individuals planted over the last three years were alive as of August 2009. These are the only plants remaining in the wild at this time.
- Genetic storage goals are met with all available founders (8) represented at Lyon Arboretum and in the living collection in the nursery. Plants kept at the Micropropagation Lab have been successfully removed from vials and transferred to the nursery.
- The MU fences for Makaha and Pahole are complete and ungulate free
- Fences for the Keawapilau to Kapuna PU are complete and ungulates are being removed
- MU fence construction has begun for the Manuwai PU
- Trials to produce larger plants for new reintroductions using new mixes of growing media and a new bulb-pan containers is ongoing

Plans for Year MIP 6

- Complete fencing to secure sites for the Manuwai PU reintroductions
- Continue to refine horticulture methods in order to produce plants that may be better able to become established and survive in reintroductions.
- Once these plants are available, OANRP will select a site or sites that will allow for more frequent monitoring and management. Experimental treatments will be used to better understand what is causing such high mortality in outplanting sites.
- Pollination and breeding system studies will be conducted on living collection stock during next flowering period.
- OANRP will collect and analyze data from the two HOBO® stations. Data was not collected this past year.

Table 3.37a Taxon Status Summary

Action Area: In

TaxonName: Phyllostegia kaalaensis — TaxonCode: PhyKaa

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Keawapilau to Kapuna	Manage for stability	0	0	0	1	0	0	2	0	0	1	0	0	Only one plant in poor health remains in the reintroduction
Pahole	Manage for stability	0	0	0	1	0	0	0	7	0	1	0	0	Only one plant in poor health remains in the reintroduction
Palikea Gulch	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	No monitoring in the last year
	Total for Taxon:	0	0	0	2	0	0	2	7	0	2	0	0	

Action Area: Out

TaxonName: Phyllostegia kaalaensis — TaxonCode: PhyKaa

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Makaha	Manage reintroduction for stability	0	0	0	0	0	0	29	0	0	0	0	0	All of the reintroduced plants were observed to be dead in the last year
Manuwai	Manage reintroduction for stability	0	0	0	0	0	0	0	0	0	0	0	0	The reintroduction will begin once the MU fence is complete
Waianae Kai	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	No monitoring in the last year
	Total for Taxon:	0	0	0	0	0	0	29	0	0	0	0	0	

Table 3.37b Status of Genetic Storage

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	Storage Goals Met: # Plants that Met Goal
Phyllostegia kaalaensis							
Keawapilau to Kapuna	0	0	1	1	1	1	1
Pahole	0	0	4	0	2	2	2
Palikea Gulch	0	0	5	0	3	1	3
Waianae Kai	0	0	4	1	2	2	2
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				2	8	6	8

3.39 PHYLLOSTEGIA MOLLIS

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 collections from all PUs
- Tier 1 stabilization priority
- Stable population structure

Major Highlights/Issues OIP Year 2

- The reintroductions at the Kaluaa PU, Ekahanui PU and Pualii PU were planned but not implemented as alien snails contaminated reintroduction stock in the greenhouse.
- Genetic goals have been met for this species as all available founders are represented in the nursery living collection and at the Lyon Arboretum Micropropagation Lab.
- Poor survivorship (28%) observed at the Kaluaa augmentation. Over the last 3 years, 100 plants were introduced and 28 plants have survived. The Kaluaa site consists of two separate reintroductions separated by about 200 m. About a third of the plants were introduced into the lower site in 2006, and the remainder of the plantings went into the upper site. The lower site was discontinued as a planting site due to high mortality; but the few remaining plants at this lower site are now fairly large, healthy individuals for this species. No recruitment was noted at the lower site. At the upper site, high mortality also occurred over the last two years, but recruitment was observed. This is the first time that recruitment has been noted from OANRP reintroductions.
- Poor survivorship (14.75%) was also observed at the initial Ekahanui reintroduction. Over the last 2 years, 61 plants were introduced and only 9 plants have survived. Survivorship at Ekahanui did improve significantly in the last year. In 2007, 0% survived after one year, and in 2008, 21% survived after one year.
- Recruitment continues to be observed at the Mohiakea PU with four immatures observed in the last year. In addition to the single plant at Kaluaa, these are the only extant wild plants.
- Surveys were conducted in both Mohiakea and Haleauau but none were found.
- Construction began on the Waieli Subunit III fence that will protect additional habitat in the Kaluaa and Waieli area.
- An undetermined mildew remains a significant and uncontrolled potential threat for wild and reintroduced plants.

Plans for OIP Year 3

- Conduct census monitoring at Manage for Stability PUs and collection from additional founders
- Continue to examine microsite differences at wild and reintroduction sites to refine planting strategies and maximize potential for longer lived plants that recruit and vegetatively reproduce.
- Begin the Pualii reintroduction and continue to plant in the Kaluaa and Ekahanui PUs
- Begin construction of 1800 acre Schofield Barracks Lihue fence for additional habitat protection.
- Complete construction of the Waieli Subunit III fence.

Table 3.38a Taxon Status Summary

Action Area: In

TaxonName: Phyllostegia mollis — TaxonCode: PhyMol

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Mohiakea	Genetic Storage	0	3	0	0	0	0	0	4	0	**0**	**3**	**0**	Small changes were noted during monitoring in the last year
	Total for Taxon:	0	3	0	0	0	0	0	4	0	**0**	**3**	**0**	

Action Area: Out

TaxonName: Phyllostegia mollis — TaxonCode: PhyMol

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Ekahanui	Manage for stability	0	0	0	9	0	0	35	0	0	**9**	**0**	**0**	No monitoring of the historic wild site. Many of the reintroduced plants died in the last year.
Huliwai	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring of the historic site in the last year
Kaluaa	Manage for stability	1	0	0	19	9	5	38	11	0	**20**	**9**	**5**	Thorough monitoring of the reintroduction showed a decline, but new seedlings were observed.
Pualii	Manage for stability	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring of the historic site in the last year
Waieli	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	Monitoring showed no change
	Total for Taxon:	1	0	0	28	9	5	73	11	0	**29**	**9**	**5**	

Table 3.38b 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	Storage Goals Met: # Plants that Met Goal
Phyllostegia mollis							
Ekahanui	0	0	1	0	1	1	1
Huliwai	0	0	1	1	1	1	1
Kaluaa	1	0	0	1	0	1	1
Mohiakea	0	3	12	1	5	5	5
Pualii	0	0	1	0	1	1	1
Waieli	0	0	5	3	4	5	4
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				6	12	14	13

3.40 PLANTAGO PRINCEPS VAR. PRINCEPS

Requirements for Stability

- 4 Population Units (PUs) (in both Makua and Oahu AA)
- 50 reproducing individuals in each PU (short-lived perennial)
- Stable population structure
- Threats controlled
- Complete genetic representation of all PUs in storage

Major Highlights/Issues MIP Year 5

- Both the Ekahanui PU and Halona PU have many reproducing individuals, but the stability goal of 50 plants is not met for any PUs.
- Monitoring and collections were hampered by a program freeze on rappelling efforts that has since been partially resolved.
- The North Palawai PU is not fenced but some ungulate control occurs near this PU.
- Laboratory results suggest that seeds may form a soil seedbank. Degree of persistence is unknown and an *in situ* study would need to be conducted to determine degree of persistence.
- Collections from 98 plants are being held in seed storage.

Plans for MIP Year 6

- Conduct census monitoring at all Manage for Stability populations.
- Secure genetic storage collections from unrepresented plants.
- Complete ungulate removal from the Ekahanui MU fence.
- Begin construction of the Schofield Barracks Lihue fence which will protect the North Mohiakea PU.
- Determine a new reintroduction site within the new larger Ekahanui management unit and continue to augment the Waieli PU.

Table 3.39a Taxon Status Summary

Action Area: In

TaxonName: Plantago princeps var. princeps TaxonCode: PlaPriPri

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
North Mohiakea	Manage for stability	10	16	2	0	0	0	10	16	2	**10**	**16**	**2**	No monitoring in the last year
Ohikilolo	Manage for stability	11	0	0	0	0	0	11	0	0	**11**	**0**	**0**	No monitoring in the last year
Pahole	Genetic Storage	2	6	6	0	0	0	2	6	6	**2**	**6**	**6**	No monitoring in the last year
	Total for Taxon:	23	22	8	0	0	0	23	22	8	**23**	**22**	8	

Action Area: Out

TaxonName: Plantago princeps var. princeps TaxonCode: PlaPriPri

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Ekahanui	Manage for stability	29	37	7	0	0	0	29	37	7	**29**	**37**	**7**	Monitoring showed no change
Halona	Manage for stability	29	43	0	0	0	0	29	43	0	**29**	**43**	**0**	No monitoring in the last year
North Palawai	Genetic Storage	1	2	0	0	0	0	2	2	0	**1**	**2**	**0**	Small changes were noted during monitoring in the last year
Waieli	Manage reintroduction for storage	0	0	0	8	17	0	10	0	0	**8**	**17**	**0**	More plants were added to the reintroduction site
	Total for Taxon:	59	82	7	8	17	0	70	82	7	**67**	**99**	7	

Table 3.39b 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	Storage Goals Met: # Plants that Met Goal
Plantago princeps var. princeps							
Ekahanui	29	37	20	46	0	4	42
Halona	29	43	1	18	0	1	18
North Mohiakea	10	16	11	13	0	4	12
North Palawai	1	2	3	1	0	0	1
Ohikilolo	11	0	14	18	0	0	12
Pahole	2	6	1	2	1	0	2
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				98	1	9	87

3.41 PRITCHARDIA KAALAE

Requirements for Stability

- 3 Population Units (PU)
- 25 reproducing individuals in each PU (long-lived perennial)
- Stable population structure
- Threats controlled
- Complete genetic representation of all PUs in storage

Major Highlights/Issues MIP Year 5

- The stability goal of 25 reproducing plants has been met for the ‘Ōhikilolo PU and Makaleha to Manuwai PU.
- The first OANRP reintroduced plant to reach maturity was documented this year. It had been planted 8 years prior and the collection had been made ten years prior.
- Construction of the Manuwai fence has begun. This fence will be completed in 2010 and will protect the *P. kaalae* in Manuwai.
- Rat control continues to be successful in allowing the development of mature fruit and the establishment of seedlings within the ‘Ōhikilolo PU and Makaleha to Manuwai PU. Collections of seed for genetic storage and reintroduction continue in the ‘Ōhikilolo PU and Makaleha to Manuwai PU.
- Continued expansion of the reintroduction sites in the ‘Ōhikilolo PU with an additional 63 plants.

Plans for MIP Year 6

- Conduct monitoring at all Manage for Stability PUs.
- NRS will continue to collect from unrepresented founders from the ‘Ōhikilolo and Makaleha to Manuwai PUs for reintroduction and genetic storage.
- Continue to expand the reintroductions in the ‘Ōhikilolo PU and East ‘Ōhikilolo to West Makaleha PU with stock from additional founders.
- Investigate the strategy of using seed collected from the Ohikilolo PU to conduct a seed sowing trial at one of the reintroduction sites.
- Complete the large scale Manuwai MU fence
- Survey the Makaleha to Manuwai PU to revise population estimates
- Monitor for seedlings in East Makaleha and determine the need to construct small fences.
- Monitor the Wai‘anae Kai PU and assess the need for rat control in order to collect for genetic storage
- Determine feasibility of accessing the plants in the Mākaha PU.

Table 3.40a Taxon Status Summary

Action Area: In

TaxonName: Pritchardia kaalae   TaxonCode: PriKaa

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Ohikilolo	Manage for stability	75	644	20	1	377	0	75	1002	20	**76**	**1021**	**20**	More plants were added to the reintroduction siles and one flowered for the first time.
Ohikilolo East and West Makaleha	Manage reintroduction for stability	0	0	0	0	122	0	0	84	0	**0**	**122**	**0**	Additional plants were added to the existing reintroduction
	Total for Taxon:	75	644	20	1	499	0	75	1086	20	**76**	**1143**	**20**	

Action Area: Out

TaxonName: Pritchardia kaalae   TaxonCode: PriKaa

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Makaha	Genetic Storage	4	0	0	0	0	0	4	0	0	**4**	**0**	**0**	No monitoring in the last year
Makaleha to Manuwai	Manage for stability	70	4	0	0	0	0	70	4	0	**70**	**4**	**0**	Monitoring showed no change
Waianae Kai	Genetic Storage	4	5	0	0	0	0	4	5	0	**4**	**5**	**0**	No monitoring in the last year
	Total for Taxon:	78	9	0	0	0	0	78	9	0	**78**	**9**	**0**	

Table 3.40b Genetic Storage Summary

Population Unit Name	# of Potential Founders: Current Mature	# of Potential Founders: Current Imm.	# of Potential Founders: NumWild Dead	Partial Storage Status: # Plants >= 10 in Seedbank	Partial Storage Status: # Plants >=1 Microprop	Partial Storage Status: # Plants >=1 Army Nursery	Storage Goals Met: # Plants that Met Goal
Pritchardia kaalae							
Makaha	4	0	0	0	0	0	0
Makaleha to Manuwai	70	4	0	7	0	18	15
Ohikilolo	75	644	0	6	13	32	18
Waianae Kai	4	5	0	0	1	0	0
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				13	14	50	33

3.42 PTERIS LYDGATEI

Requirements for Stability:

- 3 population units (PUs)
- 50 reproducing individuals (short-lived perennial)
- Stable population structure
- Threats controlled
- Complete genetic representation of all PUs in storage when protocols are developed
- Tier 1 stabilization priority

Major Highlights/Issues OIP Year 2

- OPEP and OANRP visited a historic site in North Kaukonahua but none were observed. One plant was observed while monitoring a potion of the South Kaukonahua PU.

Plans for OIP Year 3

- A license agreement with Kamehameha Schools that will cover fencing actions should be obtained in the next year. This will allow OANRP to pursue fencing at the Kawainui.
- Work with OPEP to monitor and search for new plants.
- Develop collection and propagation protocols with OPEP and Lyon Arboretum.

Table 3.41a Taxon Status Summary

Action Area: In

TaxonName: Pteris lidgatei **TaxonCode: PteLid**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Helemano	Manage for stability	0	2	2	0	0	0	0	2	2	0	2	2	No monitoring in the last year
Kawaiiki	Manage for stability	3	0	0	0	0	0	3	0	0	3	0	0	No monitoring in the last year
Kawainui	Genetic Storage	0	1	0	0	0	0	0	1	0	0	1	0	No monitoring in the last year
North Kaukonahua	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	Monitoring showed no change
South Kaukonahua	Manage for stability	6	0	0	0	0	0	6	0	0	6	0	0	Only a portion of the PU was visited and one plant was seen
	Total for Taxon:	9	3	2	0	0	0	9	3	2	9	3	2	

Action Area: Out

TaxonName: Pteris lidgatei **TaxonCode: PteLid**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kaluanui	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	No monitoring in the last year
Waimano	Genetic Storage	0	2	0	0	0	0	0	2	0	0	2	0	No monitoring in the last year
	Total for Taxon:	0	2	0	0	0	0	0	2	0	0	2	0	

Table 3.41b 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
Pteris lidgatei							
Helemano	0	2	0	0	0	0	0
Kaluanui	0	0	0	0	0	0	0
Kawaiiki	3	0	0	0	0	0	0
Kawainui	0	1	0	0	0	0	0
North Kaukonahua	0	0	0	0	0	0	0
South Kaukonahua	6	0	0	0	0	0	0
Waimano	0	2	0	0	0	0	0
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				0	0	0	0

3.43 SANICULA MARIVERSA

Requirements for Stability

- 3 Population Units (PUs)
- 100 reproducing individuals in each PU (short-lived perennial with infrequent, inconsistent flowering)
- Stable population structure
- Threats controlled
- Complete genetic representation in storage of all PUs

Major Highlights/Issues for Year 5

- Temperature data loggers have been placed at all wild sites to collect *in situ* temperature fluctuations to help determine how they might affect germination *in situ*. All data loggers have been collected and replaced at least once and all have up to a year of data to date.
- At the Keaau PU, the fence line has been determined and cleared.
- Due to the inability to access Ohikilolo and Keaau due to Army training and the expiration of rappelling certification, no seed collections were made this year.
- At the Kamaileunu PU, an *in situ* germination study was conducted. This study attempts to determine what percentage of seeds produced in a given year will become seedlings the following year. This study coincides with the population structure monitoring over the past two years. These efforts are ongoing and attempt to assess the stability of the population for this PU.

Plans for Year 6

- Conduct census monitoring of all Manage for Stability PUs. Continue to monitor the germination study at the Kamaileunu PU in January 2010.
- Complete the PU fence at the Keaau site
- Collect mature seed for storage and dormancy/germination studies
- Begin to analyze temperature data

Table 3.42a Taxon Status Summary

Action Area: In

TaxonName: Sanicula mariversa **TaxonCode: SanMar**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Keaau	Manage for stability	11	300	40	0	0	0	11	300	40	11	300	40	No thorough census in the last year
Ohikilolo	Manage for stability	3	112	0	0	0	0	3	112	0	3	112	0	No thorough census in the last year
	Total for Taxon:	14	412	40	0	0	0	14	412	40	14	412	40	

Action Area: Out

TaxonName: Sanicula mariversa **TaxonCode: SanMar**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kamaileunu	Manage for stability	10	178	13	0	0	0	10	178	13	10	178	13	No thorough census in the last year
Puu Kawiwi	Genetic Storage	2	11	0	0	0	0	2	11	0	2	11	0	No thorough census in the last year
	Total for Taxon:	12	189	13	0	0	0	12	189	13	12	189	13	

Table 3.42b 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	Storage Goals Met: # Plants that Met Goal
Sanicula mariversa							
Kamaileunu	10	178	41	56	0	1	49
Keaau	11	300	42	65	0	0	48
Ohikilolo	3	112	92	66	0	0	34
Puu Kawiwi	2	11	1	3	0	0	3
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				190	0	1	134

3.44 SANICULA PURPUREA

Requirements for Stability

- 3 population units (PUs)
- 100 reproducing individuals (short-lived perennial, inconsistent flowering)
- Threats controlled
- Genetic storage collections from all PUs
- Tier 2 stabilization priority

Major Highlights/Issues OIP Year 2

- No populations were monitored in the last year

Plans for OIP Year 3

- Revisit and monitor the North of Puu Pauao PU

Table 3.43a Taxon Status Summary

Action Area: In

TaxonName: Sanicula purpurea **TaxonCode: SanPur**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
North of Puu Pauao	Manage for stability	0	21	0	0	0	0	0	21	0	0	21	0	No monitoring in the last year
Opaeula-Punaluu Summit Ridge	Genetic Storage	0	0	0	1	2	1	1	2	1	1	2	1	No monitoring in the last year
Poamoho Trail Summit	Manage for stability	2	10	12	0	0	0	2	10	12	2	10	12	No monitoring in the last year
Schofield-Waikane Trail Summit	Manage for stability	2	25	0	0	0	0	2	25	0	2	25	0	No monitoring in the last year
	Total for Taxon:	4	56	12	1	2	1	5	58	13	5	58	13	

Action Area: Out

TaxonName: Sanicula purpurea **TaxonCode: SanPur**

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Wailupe-Waimanalo Summit Ridge	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	No monitoring in the last year
	Total for Taxon:	0	0	0	0	0	0	0	0	0	0	0	0	

Table 3.43b 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	Storage Goals Met: # Plants that Met Goal
Sanicula purpurea							
North of Puu Pauao	0	21	0	0	0	0	0
Poamoho Trail Summit	2	10	0	2	0	0	0
Schofield-Waikane Trail Summit	2	25	0	0	0	0	0
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				2	0	0	0

3.45 SCHIEDEA KAALAE

Requirements for Stability

- 4 Population Units (PUs)
- 50 reproducing individuals in each PU (short-lived perennial)
- Stable population structure
- Threats controlled
- Complete genetic representation of all PUs in storage

Major Highlights/Issues for MIP Year 5

- The stability goal of 50 reproducing plants is met for the Kaluaa and Waieli PU.
- All available founders from the Kaluaa and Waieli PU, North Palawai PU and the Pahole PU are represented in genetic storage.
- OANRP continues to remove ungulates from the large scale management unit fence in Ekahanui. This fence protects all known sites in the South Ekahanui PU.
- Clones from additional founders in the South Ekahanui, Makaua, and Kahana PUs were collected for the greenhouse living collection. These will be used as a source for producing propagules for storage and reintroduction.
- OANRP assisted in the growing and outplanting of more than 1400 *S. kaalae* as part of the doctoral research by UH Botany graduate student Lauren Weisenberger to determine the effects of inbreeding and outbreeding.

Plans for MIP Year 6

- Conduct census monitoring of all Manage for Stability PUs
- Complete removal of ungulates from the Ekahanui MU
- Build a fence around the plants in the Kahana PU
- Balance founders at existing reintroduction and/or augmentation sites
- Begin to collect seed for storage from the reintroductions in Kaluaa and Waieli, South Ekahanui, Pahole and Makaua
- Pursue labeling of Sluggo® for field use
- Expand the greenhouse collections of clones when available and continue to use the plants to produce propagules for storage and reintroduction
- Continue to support research to determine the effects of inbreeding and outbreeding on *S. kaalae*

Table 3.44a Taxon Status Summary

Action Area: In

TaxonName: Schiedea kaalae — TaxonCode: SchKaa

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Pahole	Manage for stability	2	0	0	40	12	0	41	11	0	**42**	**12**	**0**	More plants were added to the reintroduction sites while others died
	Total for Taxon:	2	0	0	40	12	0	41	11	0	**42**	**12**	**0**	

Action Area: Out

TaxonName: Schiedea kaalae — TaxonCode: SchKaa

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kahana	Genetic Storage	6	1	0	3	0	0	9	2	0	**9**	**1**	**0**	Small changes were noted during monitoring in the last year
Kaluaa and Waieli	Manage for stability	0	0	0	82	10	0	116	19	0	**82**	**10**	**0**	Thorough monitoring showed a decline at the reintroduction sites in the last year
Maakua (Koolaus)	Manage for stability	10	0	0	0	0	0	10	0	0	**10**	**0**	**0**	No monitoring in the last year
Makaua (Koolaus)	Genetic Storage	1	0	0	6	27	0	9	0	0	**7**	**27**	**0**	Population counts were revised after updating old observations of the OPEP reintroduction
North Palawai	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring of this historic site in the last year
South Ekahanui	Manage for stability	13	7	0	22	0	0	51	7	0	**35**	**7**	**0**	Thorough monitoring showed a decline at the reintroduction site in the last year
	Total for Taxon:	30	8	0	113	37	0	195	28	0	**143**	**45**	**0**	

Table 3.44b Genetic Storage Summary

Population Unit Name	# of Potential Founders: Current Mature	# of Potential Founders: Current Imm.	# of Potential Founders: NumWild Dead	Partial Storage Status: # Plants >= 10 in Seedbank	Partial Storage Status: # Plants >=1 Microprop	Partial Storage Status: # Plants >=1 Army Nursery	Storage Goals Met: # Plants that Met Goal
Schiedea kaalae							
Kahana	6	1	3	3	6	6	8
Kaluaa and Waieli	0	0	1	1	1	1	1
Maakua (Koolaus)	10	0	1	2	4	2	4
Makaua (Koolaus)	1	0	1	0	1	1	0
North Palawai	0	0	1	1	0	1	1
Pahole	2	0	0	2	1	2	2
South Ekahanui	13	7	4	15	2	14	13

Total # Plants w/ >=10 Seeds in Seedbank	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants that Met Goal
24	15	27	29

3.46 SCHIEDEA NUTTALII

Requirements for Stability

- 3 Population Units (PUs)
- 50 reproducing individuals in each PU (short-lived perennial)
- Stable population structure
- Threats controlled
- Complete genetic representation of all PUs in storage

Major Highlights/Issues MIP Year 5

- The stability goal of 50 reproducing individuals has been met for the Kahanahaiki to Pahole PU.
- The Makaha fence was declared pig free in the summer of 2009.
- All known plants are extirpated from the Kapuna-Keawapilau Ridge PU. There is no ex situ representation of this stock and thorough surveying in this PU has not located additional founders.
- The genetic storage goals have been maintained by holding clones of plants from the Kahanahaiki to Pahole PU in the greenhouse.
- OANRP continue to assist in removal of ungulates form the Kapuna MU fence. This fence protects the extirpated sites in the Kapuna-Keawapilau Ridge PU.
- The Makaha reintroduction is performing well with 6:8 plants surviving and in good health more than two years since planting.
- OANRP continued to collect clones from new founders in the Kahanahaiki to Pahole PU.
- OANRP continued to outplant at the Puu 2210 reintroduction site of Pahole stock. Overall survivorship is high with 78% (42 of 54) remaining.
- Survivorship at the reintroduction of Kahanahaiki stock at the Switchbacks site is moderate at 42% (42 of 100). However, six seedlings were found at the site this year.
- OANRP assisted in the growing and outplanting of 150 *S. nuttallii* as part of the doctoral research of UH Botany graduate student Lauren Weisenberger to determine the effects of inbreeding and outbreeding.

Plans for MIP Year 6

- Conduct census monitoring of all Manage for Stability PUs.
- Continue to supplement the reintroduction sites of Kahanahaiki stock into Makaha and at the Switchbacks site in Pahole.
- Continue the reintroduction site of Pahole stock at the Pu‘u 2210 site
- Determine reintroduction/augmentation strategy for the Kapuna to Keawapilau PU
- Collect from the reintroduction sites in both PUs for genetic storage.
- Continue to support research by UH Botany graduate student Lauren Weisenberger to determine the effects of inbreeding and outbreeding on *S. nuttallii.*
- Continue to assist Oahu NARS in removing ungulates from the Upper Kapuna MU

Table 3.45a Taxon Status Summary

Action Area: In

TaxonName: Schiedea nuttallii TaxonCode: SchNut

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kahanahaiki to Pahole	Manage for stability	13	1	3	87	21	16	93	4	0	100	22	19	More plants were added to the reintroduction sites and many new immature plants and seedlings were observed at one of the outplantings
Kapuna-Keawapilau Ridge	Manage for stability	0	0	0	0	0	0	0	0	0	0	0	0	No monitoring in the last year
	Total for Taxon:	13	1	3	87	21	16	93	4	0	100	22	19	

Action Area: Out

TaxonName: Schiedea nuttallii TaxonCode: SchNut

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Makaha	Manage reintroduction for stability	0	0	0	6	0	0	6	0	0	6	0	0	Monitoring of the reintroduction showed no change
	Total for Taxon:	0	0	0	6	0	0	6	0	0	6	0	0	

Table 3.45b Genetic Storage Summary

Population Unit Name	# of Potential Founders			Partial Storage Status			Storage Goals Met
	Current Mature	Current Imm.	NumWild Dead	# Plants >= 10 in Seedbank	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants that Met Goal
Schiedea nuttallii							
Kahanahaiki to Pahole	13	1	51	20	2	41	35
Kapuna-Keawapilau Ridge	0	0	4	0	0	0	0
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				20	2	41	35

3.47 SCHIEDEA OBOVATA

Requirements for Stability

- 3 Population Units (PUs)
- 100 reproducing individuals in each PU (short-lived perennial which is prone to large fluctuations)
- Stable population structure
- Threats controlled

Major Highlights/Issues MIP Year 5

- The stability goal of 100 reproducing plants is met for the Kahanahaiki to Pahole PU and Keawapilau to West Makaleha PU.
- Significant recruitment continues to be observed at a number of the reintroduction sites, although most sites still lack a healthy population structure.
- Genetic storage collections from all available founders are complete
- Pigs were cleared from the Makaha MU fence.
- Continued to balance founders at existing reintroduction sites
- Progeny from hand-pollinated crosses of all greenhouse stock (representing all population sites) have been outplanted into Kahanahaiki to measure plant fitness as part of a study by UH Botany graduate student Lauren Weisenberger to determine the effects of inbreeding and outbreeding.
- Slug control research with Sluggo® in the field began
- Sites were evaluated for the future Makaha reintroduction

Plans for MIP Year 6

- Conduct census monitoring at all Manage for Stability PUs
- Continue to balance founders at existing reintroduction sites and develop the reintroduction strategy for the Makaha PU
- Continue slug control research with Sluggo® in the field
- Continue to support research by UH Botany graduate student Lauren Weisenberger to determine the effects of inbreeding and outbreeding on *S. obovata.* Results will aide in development of a strategy for the Makaha reintroduction.
- Collect seeds for genetic storage from completed reintroductions, including mature F1 plants.

Table 3.46a Taxon Status Summary

Action Area: In

TaxonName: Schiedea obovata TaxonCode: SchObo

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kahanahaiki to Pahole	Manage for stability	0	0	0	144	110	15	151	130	0	**144**	**110**	**15**	Thorough monitoring showed an increase at the outplanting sites. Many new immature plants were observed.
Keawapilau to West Makaleha	Manage for stability	18	8	0	164	65	0	123	19	20	**182**	**73**	**0**	Thorough monitoring showed a decline at some of the outplantings. Many planted last year matured and new immature plants were observed increasing the total. Ed
	Total for Taxon:	18	8	0	308	175	15	274	149	20	**326**	**183**	**15**	

Action Area: Out

TaxonName: Schiedea obovata TaxonCode: SchObo

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Makaha	Manage reintroduction for stability	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	The reintroduction will begin in 2011
	Total for Taxon:	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	

Table 3.46b 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	Storage Goals Met: # Plants that Met Goal
Schiedea obovata							
Kahanahaiki to Pahole	0	0	5	6	1	5	6
Keawapilau to West Makaleha	18	8	40	73	1	12	72

Total # Plants w/ >=10 Seeds in Seedbank	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants that Met Goal
79	2	17	78

3.48 SCHIEDEA TRINERVIS

Requirements for Stability

- Maintain one PU with at least 150 reproducing individuals
- Stable population structure
- Threats controlled
- Genetic storage collection from 50 individuals across the range of the species
- Tier 1 stabilization priority

Major Highlights/Issues for OIP Year 2

- The Kaala MU fence is not adequate in keeping pigs out; OANRP significantly increased our ungulate control efforts (snaring and trapping) in response to an increase in pig activity in the MU.
- Collections for genetic storage continued from plants in the Kaala MU
- Ten year seed storage results indicate no decrease in viability in appropriate storage conditions.

Plans for OIP Year 3

- Complete Kaala MU fence and eradicate all pigs from fence through snares and traps
- Continue mapping of all known and new plants
- Re-evaluate population site distribution and create units to capture all known or potential habitat. Re-prioritize genetic storage collections to balance collections from across entire distribution of plants.

Table 3.47a Taxon Status Summary

Action Area: In

TaxonName: Schiedea trinervis TaxonCode: SchTri

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kalena to East Makaleha	Manage for stability	179	198	318	0	0	0	180	196	318	**179**	**198**	**318**	Small changes were noted during monitoring in the last year
	Total for Taxon:	179	198	318	0	0	0	180	196	318	**179**	**198**	**318**	

Table 3.47b 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	Storage Goals Met: # Plants that Met Goal
Schiedea trinervis							
Kalena to East Makaleha	179	198	16	52	2	7	51
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				52	2	7	51

3.49 STENOGYNE KANEHOANA

Requirements for Stability

- 3 Population Units (PUs)
- 100 reproducing individuals in each PU (long-lived perennial with a history of precipitous decline, extirpated in the wild, and extremely low genetic variability)
- Stable population structure
- Threats controlled
- Complete genetic representation in storage of all PUs
- Tier 1 stabilization priority

Major Highlights/Issues OIP Year 2

- Both available founders are represented in genetic storage both as a living collection in the greenhouse and at the Micropropagation Lab at Lyon Arboretum.
- A herbarium voucher of the Haleauau stock was submitted to Bishop Museum.
- Since 2006, 159 *S. kanehoana* have been reintroduced into Central Kaluaa. Survivorship has improved significantly over the last three years. The first two outplantings had survival rates of 11% and 44%, while the most recent has survival rate of 88%. At this new site the, clones were planted into dense uluhe patches and care was taken not to damage the ferns. This approach has promising results so far and some plants at one of the reintroduction sites in Central Kaluaa are reproducing vegetatively.
- The Haleauau wild plant flowered in the last year and OANRP attempted hand-pollination. No seed were observed to develop before the entire branch with the inflorescence died. At the time of hand-pollination, the flowers appeared slightly past maturity and no pollen was available. It is uncertain if they naturally self-pollinated. The only other pollen available at the time had been stored for 2 years and was from the Kalua'a living collection stock. It is uncertain if pollen can be stored.
- Horticultural staff has made great strides in maintaining greenhouse stock. Two Kaluaa greenhouse plants also produced several dozen flowers in the last year. Flowers were self-pollinated by hand with fresh pollen but no seeds developed.
- Leaf samples from different stems of the wild plant in the Haleauau PU and from the greenhouse clones were brought to UH Botany faculty Dr. Cliff Morden for genetic analyses. Results are pending.

Plans for OIP Year 3

- In the spring of 2010, OANRP will monitor all outplanting sites for flowers and continue to track vegetative reproduction.
- Manage nursery collection to promote flowering. Continue research in pollination and continue to hand-pollinate. This includes collecting pollen, testing pollen viability, and pollinating all flowering plants, both *in situ* and *ex situ*.
- Continue to supplement all outplanting sites with clones from the nursery collection
- OANRP propose to combine the Central Kaluaa (Gulch 2) PU and Central Kaluaa (South Fenceline) PU into one MFS PU called Central Kaluaa.

- To replace that MFS PU, OANRP propose to establish a new PU with a reintroduction into Makaha. This new Makaha PU will have the designation of “Manage Reintroduction for Stability.” This action is supported by species range modeling done by Price et al 2009 and is pending approval from the IT and BWS. All potential reintroduction sites in Makaha and in the proposed East Makaleha MU and the Manuwai MU will be analyzed and discussed in the coming year

Table 3.48a Taxon Status Summary

Action Area: In

TaxonName: Stenogyne kanehoana TaxonCode: SteKan

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Haleauau	Manage for stability	1	0	0	0	0	0	1	0	0	**1**	**0**	**0**	Monitoring showed no change
	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	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Central Kaluaa (Gulch 2)	Manage for stability	0	0	0	0	29	0	0	26	0	**0**	**29**	**0**	More plants were added to the reintroduction site
Central Kaluaa (South Fenceline)	Manage for stability	0	0	0	0	44	0	0	53	0	**0**	**44**	**0**	Thorough monitoring showed a decline in the last year
	Total for Taxon:	0	0	0	0	73	0	0	79	0	**0**	**73**	**0**	

Table 3.48b Genetic Storage Summary

Population Unit Name	# of Potential Founders			Partial Storage Status			Storage Goals Met
	Current Mature	Current Imm.	NumWild Dead	# Plants >= 10 in Seedbank	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants that Met Goal
Stenogyne kanehoana							
Central Kaluaa (South Fenceline)	0	0	1	0	1	1	1
Haleauau	1	0	0	0	1	1	1
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				0	2	2	2

3.50 TETRAMOLOPIUM FILIFORME

Requirements for Stability

- 4 Population Units (PUs) (in both MMR and Oahu AA)
- 50 reproducing individuals in each PU (short-lived perennial)
- Stable population structure
- Threats controlled
- Complete genetic representation of all PUs in storage

Major Highlights/Issues MIP Year 5

- The stability goal of 50 reproducing individuals has been met for the Ohikilolo PU.
- The genetic storage goals have been met for the Kahanahāiki PU and Ohikilolo PU.
- There was a single plant remaining at the wild site in the Puhawai PU when it was monitored in March of 2008.
- A living collection of clones from plants in the Kalena PU and Puhawai PU is maintained for collecting seeds for genetic storage and outplanting.
- All 31 reintroduced plants in the Puhawai site were observed to be dead in the last year, but two immature F1 plants were seen and were healthy.
- No detected decline in viability of stored seeds after ten years for preferred storage conditions. Test results and modeling suggest decline in viability as soon as the next year. Low seed set has continued to complicate interpretation of viability results.

Plans for MIP Year 6

- Produce plants grown from both the Kalena and Puhawai PUs in order to determine if there are any characteristics unique to one or the other. This may be used to guide augmentation strategy at these two PUs.
- Continue to maintain the living collection from the Kalena PU and Puhawai PU
- Begin to collect cuttings from Waianae Kai PU
- Conduct census monitoring of all Manage for Stability PUs. In the case of the Ohikilolo PU a sampling protocol will need to be developed.
- Continue to augment the Puhawai PU with stock collected from the greenhouse living collection
- Begin construction of the 1800 acre Schofield Barracks Lihue fence.

Table 3.49a Taxon Status Summary

Action Area: In

TaxonName: Tetramolopium filiforme — TaxonCode: TetFil

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Kahanahaiki	Genetic Storage	45	0	0	0	0	0	45	0	0	**45**	**0**	**0**	No monitoring in the last year
Kalena	Manage for stability	9	0	6	0	0	0	9	0	6	**9**	**0**	**6**	No monitoring in the last year
Keaau	Genetic Storage	30	41	17	0	0	0	30	41	17	**30**	**41**	**17**	No monitoring in the last year
Makaha/Ohikilolo Ridge	Genetic Storage	300	0	0	0	0	0	300	0	0	**300**	**0**	**0**	No monitoring in the last year
Ohikilolo	Manage for stability	2542	582	21	0	0	0	2542	582	21	**2542**	**582**	**21**	No monitoring in the last year
	Total for Taxon:	2926	623	44	0	0	0	2926	623	44	**2926**	**623**	**44**	

Action Area: Out

TaxonName: Tetramolopium filiforme — TaxonCode: TetFil

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Puhawai	Manage for stability	1	0	0	0	2	0	1	2	0	**1**	**2**	**0**	No monitoring in the last year
Waianae Kai	Manage for stability	30	8	1	0	0	0	30	8	1	**30**	**8**	**1**	No monitoring in the last year
	Total for Taxon:	31	8	1	0	2	0	31	10	1	**31**	**10**	**1**	

Table 3.49b Genetic Storage Summary

Population Unit Name	# of Potential Founders: Current Mature	# of Potential Founders: Current Imm.	# of Potential Founders: NumWild Dead	Partial Storage Status: # Plants >= 10 in Seedbank	Partial Storage Status: # Plants >=1 Microprop	Partial Storage Status: # Plants >=1 Army Nursery	Storage Goals Met: # Plants that Met Goal
Tetramolopium filiforme							
Kahanahaiki	45	0	36	99	0	0	60
Kalena	9	0	0	9	0	7	7
Keaau	30	41	0	17	0	0	2
Makaha/Ohikilolo Ridge	300	0	0	0	0	0	0
Ohikilolo	2542	582	1	139	0	1	51
Puhawai	1	0	9	5	0	3	5
Waianae Kai	30	8	0	1	0	0	0
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				270	0	11	125

3.51 VIOLA CHAMISSONIANA SUBSP. CHAMISSONIANA

Requirements for Stability

- 4 Population Units (PUs) (in both MMR and Oahu AA)
- 50 reproducing individuals in each PU (short-lived perennial)
- Stable population structure
- Threats controlled
- Complete genetic representation of all PUs in storage

Major Highlights/Issues MIP Year 5

- The stability goal of 50 reproducing individuals is met for the Ohikilolo PU.
- A decline in viability has been documented for seeds stored for ten years, and modeling suggests an even shorter half-life time. Storage conditions used for this test, however, are likely not ideal for this taxon, and decline in viability could potentially slow in different conditions.

Plans for MIP Year 6

- Continue to collect seeds for genetic storage from the greenhouse collection of clones from the Puu Hapapa, Puu Kumakalii and Makaleha PUs
- Search historic sites within the Kamaileunu PU
- Continue to collect clones from new founders in the Puu Hapapa PU
- Monitor the Puu Kumakalii, Makaha and Halona PU to determine if they will reach the stability goal of 50 reproducing plants with threat control. If not, OANRP will begin to strategize reintroduction plans.

Table 3.50a Taxon Status Summary

Action Area: In

TaxonName: Viola chamissoniana subsp. chamissoniana TaxonCode: VioChaCha

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Keaau	Genetic Storage	40	10	0	0	0	0	40	10	0	**40**	**10**	**0**	No monitoring in the last year
Makaha/Ohikilolo Ridge	Genetic Storage	7	0	0	0	0	0	7	0	0	**7**	**0**	**0**	No monitoring in the last year
Ohikilolo	Manage for stability	435	10	0	0	0	0	435	10	0	**435**	**10**	**0**	No monitoring in the last year
Puu Kumakalii	Manage for stability	44	0	0	0	0	0	44	0	0	**44**	**0**	**0**	No monitoring in the last year
	Total for Taxon:	526	20	0	0	0	0	526	20	0	**526**	**20**	**0**	

Action Area: Out

TaxonName: Viola chamissoniana subsp. chamissoniana TaxonCode: VioChaCha

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Halona	Manage for stability	41	3	0	0	0	0	41	3	0	**41**	**3**	**0**	No monitoring in the last year
Kamaileunu	Genetic Storage	35	0	0	0	0	0	35	0	0	**35**	**0**	**0**	No monitoring in the last year
Makaha	Manage for stability	37	2	0	0	0	0	17	2	0	**37**	**2**	**0**	A thorough census of the known area found more plants
Makaleha	Genetic Storage	34	1	0	0	0	0	34	1	0	**34**	**1**	**0**	No monitoring in the last year
Puu Hapapa	Genetic Storage	13	5	0	0	0	0	13	5	0	**13**	**5**	**0**	No monitoring in the last year
	Total for Taxon:	160	11	0	0	0	0	140	11	0	**160**	**11**	**0**	

Table 3.50b 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	Storage Goals Met: # Plants that Met Goal
Viola chamissoniana subsp. chamissoniana							
Halona	41	3	0	2	0	2	1
Kamaileunu	35	0	0	0	0	0	0
Keaau	40	10	0	0	0	0	0
Makaha	17	2	0	0	0	0	0
Makaha/Ohikilolo Ridge	7	0	0	0	0	0	0
Makaleha	34	1	0	0	0	10	0
Ohikilolo	435	10	0	1	0	4	2
Puu Hapapa	13	5	1	5	0	11	5
Puu Kumakalii	44	0	0	11	0	18	11
				Total # Plants w/ >=10 Seeds in Seedbank	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants that Met Goal**
				19	0	45	19

3.52 VIOLA OAHUENSIS

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

Major Highlights/Issues OIP Year 2

- The stability goal of 50 reproducing individuals has been met for the Helemano and Opaeula PU and two additional plants were found in the last year.

Plans for OIP Year 3

- Continue to survey for new plants in the Koloa PU and the Kaukonahua PU
- Begin to prioritize and survey PUs with historic records, but few or no known plants
- Collect to begin seed storage testing

Table 3.51a Taxon Status Summary

Action Area: In

TaxonName: Viola oahuensis — TaxonCode: VioOah

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Helemano and Opaeula	Manage for stability	163	146	22	0	0	0	162	145	22	**163**	**146**	**22**	Small changes were noted during monitoring in the last year
Kamananui	Genetic Storage	1	0	0	0	0	0	1	0	0	**1**	**0**	**0**	No monitoring in the last year
Kaneohe-Moanalua Summit Ridge	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
Kaukonahua	Manage for stability	25	0	0	0	0	0	25	0	0	**25**	**0**	**0**	No monitoring in the last year
Kawaiiki	Genetic Storage	13	9	11	0	0	0	13	9	11	**13**	**9**	**11**	No monitoring in the last year
Koloa	Manage for stability	36	9	6	0	0	0	36	9	6	**36**	**9**	**6**	Monitoring showed no change in the last year
Poamoho	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
	Total for Taxon:	238	164	39	0	0	0	237	163	39	**238**	**164**	**39**	

Action Area: Out

TaxonName: Viola oahuensis — TaxonCode: VioOah

Population Unit Name	Management Designation	Current Mature (Wild)	Current Immature (Wild)	Current Seedling (Wild)	Current Augmented Mature	Current Augmented Immature	Current Augmented Seedling	NRS Mature 2008	NRS Immature 2008	NRS Seedling 2008	Total Mature	Total Immature	Total Seedling	Population Trend Notes
Ahuimanu-Halawa Summit Ridge	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
Konahuanui	Genetic Storage	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	No monitoring in the last year
Waiahole-Waiawa Summit Ridge	Genetic Storage	1	0	0	0	0	0	1	0	0	**1**	**0**	**0**	No monitoring in the last year
Waimalu to Kahaluu Summit	Genetic Storage	50	0	0	0	0	0	50	0	0	**50**	**0**	**0**	No monitoring in the last year
	Total for Taxon:	51	0	0	0	0	0	51	0	0	**51**	**0**	**0**	

Table 3.51b 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	Storage Goals Met: # Plants that Met Goal
Viola oahuensis							
Helemano and Opaeula	163	146	0	0	0	0	0
Kamananui	1	0	0	0	0	0	0
Kaukonahua	25	0	0	0	0	0	0
Kawaiiki	13	9	0	0	0	0	0
Koloa	36	9	0	0	0	0	0
Waiahole-Waiawa Summit Ridge	1	0	0	0	0	0	0
Waimalu to Kahaluu Summit	50	0	0	0	0	0	0

Total # Plants w/ >=10 Seeds in Seedbank	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants that Met Goal
0	0	0	0

Chapter 4: MIP *Achatinella mustelina* Management

The MIP stabilization plan for *Achatinella mustelina* outlines protection measures for each Evolutionarily Significant Unit (ESU). Each ESU is considered a genetically distinct group and thus important to conserve in stabilizing the taxon. In order to reach stability for *A. mustelina*, NRS must work towards attaining the goals below.

4.1 *Achatinella mustelina* Stabilization Plan Summary

4.1.1 Long Term Goals

- Manage snail populations at eight field locations to encompass the extant range of the species and all six genetically defined ESUs.
- Achieve at least 300 snails per population.
- Maintain captive populations for each of the six recognized ESUs.
- Control all threats at each managed field location.

This update will cover the following sections: captive propagation, monitoring, reintroduction, threats, threat control development, research and status by ESU. Each ESU status update contains highlights from the reporting year and plans for the upcoming year.

4.1.2 Captive Propagation

The MIP captive propagation goal is stated above. Questions that arise in considering how to meet this goal include:

1. What is the minimum number of snails required to consider an ESU adequately represented?
2. What is the recollection interval and what triggers recollection: low numbers, slow reproduction, age structure consideration?
3. What is the purpose of the captive population? Many of these ESUs span large geographic areas and the MIP 300 snails target can be met by managing only a portion of this range. Is the captive population for restoration of managed sites if they are extirpated or severely reduced in numbers? Or is it to represent the ESU across its range?
4. What reduction in the wild population would trigger using a captive population in this manner?

Results of recent research projects can be used to better define this goal and provide clear guidance to OANRP.

A. mustelina captive populations have undergone rapid recent declines. Reasons for this decline are unclear but active investigation in order to resolve any propagation technique issues are underway. OANRP fully support making changes to the laboratory conditions to best suit each tree snail taxon and maximize population growth and success in the lab. As of last year's MIT Snail meeting, the tree snail lab did not want to receive any more wild collected *A. mustelina* until after propagation technique investigations were completed. OANRP wish to revisit this discussion at the next IT meeting. All of the *A. mustelina* captive populations have critically low numbers. See the 2009 Captive Snail Propagation Summary for *A. mustelina* below for details. A few of the populations listed in this table are not from managed portions of the ESUs which means that these managed areas are not represented offsite at all. The number of *A. mustelina* that died in the laboratory during this reporting period was 58 and only two were born. For trends see the table *Achatinella mustelina* Laboratory Population Deaths 2004-2009.

2009 Captive Snail Propagation Summary for *Achatinella mustelina*

Population	ESU	Date	# juv	# sub	# adult	# Individuals
Peacock Flats	A	1995	0	0	6	6
		2003	--	--	--	21
		4/2004	8	11	4	23
		9/2005	3	15	2	20
		8/2006	1	12	3	16
		7/2007	0	9	2	11
		8/2008	0	3	3	6
		8/2009	0	2	0	2
Ohikilolo – Makai	B1	2003	0	0	10	10
		4/2004	27	0	4	31
		9/2005	15	8	0	23
		8/2006	3	9	0	12
		7/2007	1	9	1	11
		8/2008	0	9	0	9
		8/2009	0	8	0	8
Ohikilolo – Mauka	B1	2003	0	0	8	8
		4/2004	20	5	0	25
		9/2005	18	7	0	25
		8/2006	0	21	2	23
		7/2007	0	12	1	13
		8/2008	0	11	1	12
		8/2009	0	10	0	10
Kaala S-ridge	B2	2003	0	0	10	10
		4/2004	23	0	6	29
		9/2005	19	5	0	24
		8/2006	4	11	0	15
		7/2007	0	4	1	5
		8/2008	0	3	1	4
		8/2009	0	2	1	3
Alaiheihe Gulch	C	2003	0	0	10	10
		4/2004	14	4	4	22
		9/2005	17	5	0	22
		8/2006	2	20	0	22
		7/2007	2	21	0	23
		8/2008	1	20	0	21
		8/2009	0	17	0	17
Palikea Gulch	C	2003	0	0	10	10
		4/2004	20	1	8	29

Population	ESU	Date	# juv	# sub	# adult	# Individuals
		9/2005	22	3	2	27
		8/2006	12	13	0	25
		7/2007	0	22	2	24
		8/2008	0	20	1	21
		8/2009	0	17	1	18
Schofield Barracks West Range	C	2003	0	0	10	10
		4/2004	15	1	9	25
		9/2005	27	1	2	30
		8/2006	8	22	0	30
		7/2007	2	28	0	30
		8/2008	0	26	1	27
		8/2009	0	23	1	24
10,000 snails	D1	2001	0	0	9	9
		2003	--	--	--	29
		4/2004	8	22	0	30
		9/2005	3	24	3	30
		8/2006	1	24	3	28
		7/2007	7	14	4	25
		8/2008	8	13	0	21
		8/2009	9	2	0	11
Schofield South Range	D1	2003	0	0	10	10
		4/2004	18	7	3	28
		9/2005	24	2	0	26
		8/2006	11	12	0	23
		7/2007	0	21	0	21
		8/2008	0	15	3	18
		8/2009	0	11	2	13
Makaha	D2	2003	0	0	10	10
		4/2004	16	0	8	24
		9/2005	23	0	3	26
		8/2006	10	14	0	24
		7/2007	5	17	0	22
		8/2008	0	20	0	20
		8/2009	0	10	0	10
Ekahanui - Honouliuli	E	2003	0	0	10	10
		4/2004	24	2	3	29
		9/2005	22	2	0	24
		8/2006	7	9	0	16
		7/2007	2	9	1	12

Population	ESU	Date	# juv	# sub	# adult	# Individuals
		8/2008	0	8	0	8
		8/2009	0	6	0	6
Palikea Lunch / former Palehua	F	1997	1	0	0	1
		4/2004	4	0	4	8
		9/2005	20	0	2	22
		8/2006	5	14	0	19
		7/2007	1	15	0	16
		8/2008	0	13	0	13
		8/2009	0	3	0	3
TOTAL		2003	--	--	--	138
TOTAL		4/2004	--	--	--	303
TOTAL		9/2005	--	--	--	299
TOTAL		8/2006	--	--	--	255
TOTAL		7/2007	--	--	--	213
TOTAL		8/2008	--	--	--	180
TOTAL		8/2009	--	--	--	127

Juvenile=<10mm, Subadult=>10mm no thickened lip, Adult=thickened lip

Achatinella mustelina Laboratory Population Deaths 2004-2009

ARMY POPULATION DEATHS 2004-2009	Jan04-Dec04*	Jan05-Dec05*	Jan06-Jun06	Jul06-Sept06	Oct06-Jul07	Aug07-Dec07	Jan08-Jun08	Jul08-Dec08	Jan09-Jun09	Jul09-Aug09
Cage and location	**j/s/a**	**j/s/a**	**j/s/a**	**j/s/a**	**j/s/a**	**j/s/a**	**j/s/a**	**j/s/a**	**j/s/a**	**j/s/a**
Ka'ala S-ridge chamber 4 bottom	1/1/6	9/3/2	2/1/0	2/2/0	2/6/0	0/0/0	0/0/0	0/1/0	0/0/0	0/0/0
Ala‘ihe‘ihe Gulch chamber 5 top	3/0/6	1/0/1	0/0/0	0/0/0	0/0/0	0/0/0	0/3/0	0/2/0	0/1/0	0/0/0
Palikea Gulch chamber 5 top	2/0/6	7/0/4	0/0/1	0/0/0	0/2/1	0/1/0	0/0/0	0/3/0	0/0/0	0/0/0
‘Ōhikilolo Mauka chamber 5 top	0/0/3	0/0/0	0/1/0	0/0/1	0/9/1	0/0/0	0/0/0	0/1/1	0/1/0	0/0/0
Schofield West chamber 5 top	2/0/4	3/1/4	0/0/2	0/0/0	0/0/0	0/1/0	0/1/0	0/2/1	0/0/1	0/0/0
Mākaha chamber 5 top	3/0/5	3/0/3	1/0/1	0/1/1	0/2/0	0/0/0	0/2/0	0/8/0	0/0/0	0/3/0
‘Ēkahanui Gulch chamber 5 bottom	4/0/6	1/2/0	0/4/0	0/2/0	1/3/0	0/1/0	0/2/0	0/2/0	0/0/0	0/1/0
‘Ōhikilolo Makai chamber 5 bottom	6/1/6	12/4/0	0/0/0	0/0/0	0/1/0	0/1/1	0/0/0	0/1/0	0/0/0	0/0/0
Schofield South chamber 5 bottom	7/0/1	5/0/7	0/0/2	0/0/0	0/2/0	0/1/0	0/0/0	0/3/0	0/0/0	0/2/0
Schofield chamber 5 bottom	2/0/0	4/0/2	5/0/1	0/0/0	1/0/2	0/0/0	0/0/0	0/0/0	0/0/0	0/0/0
Palehua chamber 1	2/0/0	4/0/3	1/0/0	0/0/0	0/3/0	0/0/0	0/7/0	0/5/0	0/2/0	0/1/0
Peacock Flats chamber 1	1/0/1	2/0/2	0/3/1	0/0/1	0/5/1	0/1/0	0/2/1	0/0/4	0/0/0	0/0/0
10,000 snails chamber 1	1/0/0	0/1/0	1/1/1	0/0/0	9/8/1	4/2/0	1/2/4	1/4/0	0/6/0	0/1/0
Total mortality	81	90	29	10	60	13	25	39	11	8
Mortality by age class	35/2/44	51/11/28	10/10/9	2/5/3	13/41/6	4/8/1	1/19/5	1/32/6	0/10/1	0/8/0

ARMY POPULATION DEATHS 2004-2009	Jan04-Dec04*	Jan05-Dec05*	Jan06-Jun06	Jul06-Sept06	Oct06-Jul07	Aug07-Dec07	Jan08-Jun08	Jul08-Dec08	Jan09-Jun09	Jul09-Aug09
Cage and location	**j/s/a**	**j/s/a**	**j/s/a**	**j/s/a**	**j/s/a**	**j/s/a**	**j/s/a**	**j/s/a**	**j/s/a**	**j/s/a**
Totals										
Births during period	122	43	8	2	15	7	4	2	1	0
Total live *A. mustelina* at end of period	327	280	259	251	206	200	179	146	136	127
Population totals at beginning of period by age	188/57/41 286	213/75/39 327	189/73/18 280	121/124/14 259	55/183/13 251	19/176/11 206	10/180/10 200	9/160/10 179	9/130/8 146	9/122/5 136
Percent mortality by age class	9.2/1.6/45.6	11.6/7.6/42	5.2/13.7/50	1.7/4/21	23.6/22.4/46	21/4.5/9	10/10.6/50	10/19.7/46	0/7.7/12.5	0/7/0

*(1 year)

4.1.3 Genetic Issues

OANRP continue to assist in making collections for genetic investigations. The results of these additional collections are not available yet for discussion.

4.1.4 Monitoring

Monitoring methods were compared and contrasted in a table prepared by K. Hall last year for the IT meeting. This document is included as Appendix 4-1.

Considering this comparison of monitoring techniques, OANRP propose the monitoring schedule included in the table below for each *A. mustelina* population reference site within each of the 8 managed populations. The Capture Mark Recapture method is abbreviated as CMR. OANRP have opted not to continue the alphanumeric glue marking of snails at the K. Hall study sites in ESU-A and ESU-F because the monitoring schedule required to make this intensive effort worthwhile is too frequent for OANRP to maintain. We will utilize the CMR method with a paint pen every three years to obtain trends in population numbers which minimizes snail handling and field site impacts. The ESU-A study site will be monitored annually in order to inform rat control management efforts underway. Monitoring methods proposed for other sites are based on habitat impact and population density considerations. The most important change that will be made to snail counts and surveys is methods standardization otherwise results cannot be viewed as a trend. Particularly the use of night surveys or binoculars must be standardized. In addition, the area of survey needs to be defined and unchanging.

The following are definitions for some of the content in the proposed monitoring table:

Monitoring Method – three options for population trend monitoring include Capture mark recapture (CMR) entire site, population count and population count-sweep. CMR involves the marking of snail shells one day and later recapturing snails to determine the proportion unmarked to marked in order to estimate true population size. Population count involves conducting a comprehensive survey of snails in a repeatable manner generally at a discrete and small (<30m x 30m) site. Population count-sweep is the same definition except applied across a larger landscape and involving a large group of surveyors moving across a site in a phalanx. Also included in this column is 'ground shell plot' used to track shell litter and predation.

Purpose – For all monitoring an assumed purpose is reporting to the IT and the USFWS but any other management guiding purpose is listed here.

Method specifics – Includes details from Appendix 4-1 table comparing CMR technique. For all sites, the number of people and area covered will be standardized. Binoculars should always be used by observers when conducting population monitoring. If night surveys are used then they must be consistently used.

Proposed monitoring plan for *A. mustelina*

ESU	Pop Ref Site Code (s)	Monitoring Method	Frequency	Purpose	Method specifics	Notes
A	MMR-A - Snail Enclosure	CMR entire site	annually	Guide rat control	paint pen, entire site, 2 days	Continuing at K. Hall research plots
A	MMR-C (Hall Study Site)	CMR entire site	annually	Guide rat control	paint pen, entire site, 2 days	Continuing at K. Hall research plots
A	MMR-C (greater Maile Flats)	population count-sweep	every 3 years			

ESU	Pop Ref Site Code (s)	Monitoring Method	Frequency	Purpose	Method specifics	Notes
A	PAH-A State Snail Enclosure	population count	Quarterly/ OANRP monitor every 3 years			Hadfield Lab doing quarterly counts within 5x5m study plots/OANRP survey whole exclosure
A	Maile Flats	Ground Shell Plots	annually	Guide rat control grid		
B1	MMR-E, F Ohikilolo	population count-sweep	every 3 years			
B1	MMR-H - Koiahi Gulch	population count	every 3 years			
B1	Ohikilolo	Ground Shell Plots	annually	Guide rat control		
B2	LEH-C - Culvert 69	population count-sweep	every 3 years		Night where you can walk	Rappel survey to cliff spots
B2	LEH-D - Culvert 73	population count-sweep	every 3 years			
B2	LEH-J - Lower Down Culvert 69	population count	every 3 years			Habitat easily impacted by monitoring visits. Minimum being proposed.
B2	LEH-C, D	Ground Shell Plots	annually	Guide rat control		
C	SBW-A, B, C - Haleauau	population count	every 6 months	guide additional collections	night survey combo with Eugros seek and destroy	translocation monitoring
C	SBW-A - Haleauau	Ground Shell Plots	annually	Guide rat control		
D1	KAL-A - Land of 10,000 Snails, SBS-B - Puu Hapapa	population count-sweep	every 3 years		night	quarterly searches for Eugros
D1	KAL-A - Land of 10,000 Snails, SBS-B - Puu Hapapa	Ground Shell Plots	annually	Guide rat control		
D2	To be determined					IT and OANRP decide to manage Makaha or Kalena
D2	Misc	Ground Shell Plots	annually	Guide rat control		
E	EKA-A thru F - Ekahanui	population count-sweep	every 3 years			Too steep for night survey
E	EKA-A - Ekahanui	Ground Shell Plots	annually	Guide rat control		
F	PAK B-L - Palikea, and MAU-A - Mauna Kapu	population count	every 3 years			

ESU	Pop Ref Site Code (s)	Monitoring Method	Frequency	Purpose	Method specifics	Notes
F	PAK- M - Palikea	CMR-entire site	annually	Guide rat control	paint pen, entire site, 2 days	Continuing at K. Hall research plots
F	PAK-B-M Palikea	Ground Shell Plots	annually	Guide rat control		

4.1.5 Reintroduction

NRS spearheaded drafting rare snail reintroduction protocols in collaboration with the State of Hawaii, the Navy, UH Snail experts and the U.S. Fish and Wildlife Service (USFWS). In 2007, a final draft of these Rare Snail Reintroduction Guidelines was provided to the USFWS for approval as official guidelines. These guidelines have yet to be officially adopted by USFWS thus OANRP is still lacking an official protocol for conducting this activity.

4.1.6 Threats

Jackson's Chamaeleons

On June 9, 2009, two NRS were conducting rare snail surveys on Puu Kumakalii in the Schofield Barracks West Range (within ESU-D) when two Jackson's chamaeleons were discovered. This is a very unusual occurrence because NRS usually work in higher elevation areas while the chameleons are usually found in lower elevations. The specimens were collected and later dissected in order to examine the stomach contents. Surprisingly, one of the chameleons had eaten one *Achatinella mustelina* and four other common native snails. The other chamaeleon had eaten two other common snails. This is the first time that Jackson's chameleons have been shown to prey on endangered tree snails in Hawaii. Besides native snails present in gut contents there were also body parts of five native insect taxa.

Another survey was conducted on June 23, 2009, and this time four chamaeleons were collected and later dissected. No endangered tree snails were found in these chameleons, but one of them was collected in a tree that did contain six endangered tree snails. NRS plan to conduct further surveys and attempt to discover the extent of this infestation and the severity of the threat to native species. The Jackson's chameleons are native to East Africa but have been in Hawaii since the early 1970s. Presently there are no restrictions on selling or keeping chameleons as pets.

In response to this new observed threat, OANRP plan to conduct outreach to educate the general public and soldiers about the impacts of pet releases to the wild. OANRP will also provide information on the proper way to dispose of unwanted pets.

4.1.7 Threat Control Development

Exclosure Design

Euglandina barrier research continued over this reporting period. OANRP built a test box for a new design recommended by B. Holland from the UH Snail Lab. OANRP call it the "Angle Box" which is shown in the photo below. This small 1 ft. square wooden box was fitted with Plexiglass pieces set at approximately 15 degree angles to the plywood wall. When *Euglandina rosea* were placed in this box they would crawl under the plastic obstacles but fail to turn upside down, transferring themselves to the plexiglass. Instead they would crawl until their shell hit the plexiglass and became entrapped by their shell and could not progress up the wall. Preliminary tests are very encouraging. OANRP will pursue formal trials with this design in the next year.


E. rosea **plexiglass testing box** **Working Dogs for Conservation**

Using Detector Dogs to find *Euglandina rosea*

Euglandina rosea, the predatory snail native to the Southeast United States and released in Hawaii in 1955 to control the giant African snail (*Achatina fulica*), is regarded as one of the primary threats to the survival of native Hawaiian land and tree snails. Finding and controlling *Euglandina rosea* poses many problems for natural resource managers as the predatory snails are often difficult to locate and without building a snail exclosure, impossible to keep out of native snail habitat. Detector dogs have been used on many conservation projects and have been trained to detect many different targets, such as: animal scat, plants, and animals. OANRP contracted with Working Dogs for Conservation based in Montana to train two dogs to detect *Euglandina rosea*. Initial training took place in Montana during November/December 2008 and January/February 2009. The dogs and their trainers continued to train here in the Waianae Mountains of Oahu between February 24 and March 19, 2009 (see photo above).

One of the problems that the dogs encountered was that the Hawaiian environment was very different compared to where they trained in Montana where they were primarily indoors. Also, as the trainers pointed out to us, usually the dogs can hone in on a target after they've experienced about 150 reinforcements. By the time the dogs were leaving Hawaii they had had approximately 250 repetitions. The trainers explained that for some exceptionable targets like detecting a drop of blood at a crime scene or drugs at the airport, these dogs often require 400-600 repetitions as the norm. When they left Hawaii, one of three dogs had been successful at finding *E. rosea* in a realistic field scenario which people had not located.

This project was a trial to gauge the feasibility of using dogs here in Hawaii to assist field workers with *Euglandina rosea* detection. The dogs proved that they have a lot of potential and perhaps could be a valuable asset working cooperatively with humans to increase the chances of finding more predatory snails in the field. Additional training repetitions were conducted in Montana over the summer in order to determine if another work trip to Hawaii should be pursued. The results of these supplemental trials were encouraging, thus OANRP are planning to bring Working Dogs for Conservation back in the Early Spring of 2010 to conduct extensive field repetitions in the Hawaiian environment.

4.1.8 Research

OANRP funded the following three research projects:

1) UH PhD Candidate, Marty Meyer, completed his third year of research on *Euglandina rosea* habitat utilization. Over these three years, he studied factors that influence the distribution and abundance of *E. rosea*. His early work demonstrated that E. rosea can consume small snails whole, making this predation impossible to detect in the field. His final report applies his results to management (Appendix 4-2). He showed that *E. rosea* reside in the leaf litter during the day. His study demonstrated that *E. rosea*, other non-native prey species, and native tornatellinids are found in much higher densities in the gulch than on the ridges. He showed that *E. rosea* moves no more than 10 meters per month which means that controlling them at local levels around rare snail populations would be valuable. In addition, M. Meyer and A. Shiels published a paper in 2009 demonstrating that *E. rosea* is predated by alien rats and that this relationship must be considered in rat control programs (Appendix 4-3).

2) Kevin Hall received his PhD this year and completed his third year of research on *Achatinella*. He has published one paper on the use of harmonic radar to study *Achatinella* dispersal in his project (Appendix 4-4). Additionally, a paper is in review concerning *A. mustelina* translocation considerations which is particularly important for populations of snails within predator exclosures. The last component of his research relates to inter and intra population genetics. These data are not yet ready for publication but will have implications for OANRP management.

3) Aaron Shiels, a PhD candidate at UH, completed his final year of rat research within the Kahanahaiki gulch MU over this reporting period. A research summary of his work this year is included in Appendix 4-5. His work on determining rat home range and density in Oahu mesic forest habitat is critical in evaluating the effectiveness of current rat baiting efforts. Bait station spacing for rodenticide use in Hawaii is based on research from Hawaii Island wet forest habitat and may not best fill the needs of Oahu mesic and wet forest habitats. NRS will use the results of this study and adapt current management practices.

4.2 ESU UPDATES

The following section contains brief updates for each of the eight OANRP managed sites. Tables contain information about the current status of *A. mustelina* at each ESU. The following is an explanation of information contained in these status tables.

<u>Population Reference Site</u>. The first column lists the population reference code for each field site. This consists of a three-letter abbreviation for the gulch or area name. For example, MMR stands for Makua Military Reservation. Next, a letter code is applied in alphabetic order according to the order of population discovery. This coding system allows NRS to track each field site as a unique entity. This code is also linked to the Army Natural Resource geodatabase. In addition, the "common name" for the site is listed as this name is often easier to remember than the population reference code.

<u>Management Designation</u>. In the next column, the management designation is listed for each field site. The tables used in this report only display the sites chosen for MFS, where NRS is actively conducting management. These sites are generally the most robust sites in terms of snail numbers, habitat quality, and manageability. Other field sites where NRS has observed snails are tracked in the database but under the designation 'no management.' In general, these sites include only a few snails in degraded habitat where management is logistically challenging. The combined total for sites designated as MFS should be a minimum of 300 total snails in order to meet stability requirements.

<u>Population Numbers</u>. The most current and most accurate monitoring data from each field site are used to populate the 'total snails' observed column and the numbers reported by 'size class' columns. In some cases, complete monitoring has not been conducted within this reporting period because of staff time constraints, therefore, older data are used.

Threat Control. It is assumed that ungulate, weed, rat and *Euglandina* threats are problems at all the managed sites. If this is not true of a site, special discussion in the text will be included. If a threat is being managed at all in the vicinity of *A. mustelina* or affecting the habitat occupied by *A. mustelina*, a "Yes" designation is assigned. The "No" designation is assigned when there is no ongoing threat control at the field site.

4.2.1 ESU-A Pahole to Kahanahaiki

There are well over 300 snails in ESU-A as shown in the status table above, therefore, this ESU meets stabilization goals. Over this reporting period, the Kahanahaiki MU has been maintained as pig free. Snail habitat within the fence is weeded for both canopy and understory weeds.

***Achatinella mustelina* in ESU-A Manage for Stability Sites**

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control			
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina
Achatinella mustelina											
KAP-C **One Acre Site**	Manage for stability	24	2006/08/09	21	0	3	0	Yes	Yes	No	No
MMR-A **Kahanahaiki Exclosure**	Manage for stability	95	2008/11/12	57	14	24	0	Yes	Yes	Yes	Yes
MMR-C **Maile Flats**	Manage for stability	212	2009/08/31	171	26	15	0	Yes	Yes	No	No
PAH-B **Pahole Exclosure**	Manage for stability	29	2007/06/01	20	5	4	0	Yes	Yes	Yes	Yes
	ESU Total:	360		269	45	46	0				

Size Class Definitions

SizeClass	DefSizeClass
Large	>18 mm
Medium	8-18 mm
Small	< 8 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 A. mustelina.

Major Highlights/Issues Year 5

- Comprehensive surveys of MMR-C were conducted for the first time since 2004. This survey covers a large area and is very time consuming so we propose to conduct this full survey every 3 years (see monitoring proposal). The map below, *Achatinella mustelina* distribution in the Kahanahaiki portion of ESU-A, shows survey results. The total number of snails counted this year was 266 compared to the 2004 count number which was 331.
- A *Euglandina rosea* exclosure site was surveyed at Kapuna Gulch and snails surveyed.
- Significant upgrade and maintenance was conducted at the Pahole Snail Exclosure. Rat bait stations and snap traps continue to be deployed.
- A total of 10 *A. mustelina* were collected from outside of the Kevin Hall study area in Kahanahaiki and given to the UH lab for captive rearing. All were released along with 6 captive-reared juvenile snails on 3/12/09.
- Ten genetic samples collected from Kahanahaiki snail exclosure to analyze possible inbreeding. Results of this analysis are pending review for publication (Hall et al. in review 2009).
- A total of seven ground shell plots were installed in Kahanahaiki to monitor for *Euglandina rosea* in preparation for the MU scale rat grid establishment.

- The MU wide rat control grid was established at Kahanahaiki. The goal is to maintain rat activity levels to <10 percent. Extensive monitoring was initiated to detect any *E. rosea* increases as a result of this expanded control.
- Twelve snails were sampled for genetic analysis from KAP-C, results are pending.
- No rat predation was observed during this reporting period in ground shell plots but three live *Euglandina rosea* were collected.
- Only two *A. mustelina* were counted in Hadfield study plots at MMR-B, the Pahole exclosure as compared to eight observed last year.

Plans for Year 6

- Work toward restoring the Pahole exclosure site to increase canopy closure.
- Sample lab snails to determine if the Peacock Flats lab collection is indeed in ESU-A compare to genetic samples taken from wild KAP-C individuals.
- Pursue construction of the *Euglandina* exclosure proposed for the Kapuna Gulch site with the State of Hawaii.
- Obtain results of the snail removal to the lab and return to wild by Kevin Hall on 3/12/ 09.

***Achatinella mustelina* distribution in the Kahanahaiki portion of ESU-A**

Map removed,
available upon request

4.2.2 ESU-B

ESU-B is a very large ESU. For management purposes it has been split into two portions. ESU-B1 includes snail occurrences on Ohikilolo Ridge and B2 includes occurrences in Central and East Makaleha. Each is discussed separately.

ESU-B1 Ohikilolo

This ESU is still over the stability goal of 300 for *A. mustelina*. The table below shows the current status at this ESU. Management of this ESU continues as it has in years past. The Ohikilolo ridgeline goat exclusion fence continues to be maintained and monitored. Weed control is conducted in the forest surrounding most of the snail sites within this ESU for both canopy and understory weeds (including introduced grasses). In addition, restoration has been conducted with suitable host trees for *A. mustelina*. *A. mustelina* have been observed on some of the oldest plantings of *Myrsine lessertiana* on Ohikilolo. Rat control via snap traps and rat baiting continues to be maintained at least quarterly in areas where rat predation has been observed. Although *Euglandina* are listed as a threat at this ESU, no *E. rosea* have ever been observed. NRS will continue to be vigilant when importing gear and equipment into this ESU to avoid its inadvertent introduction.

Achatinella mustelina **in ESU-B1 Manage for Stability Sites**

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes: Large	Medium	Small	Unk	Threat Control: Ungulate	Weed	Rat	Euglandina
Achatinella mustelina											
MMR-E **Ohikilolo Mauka**	Manage for stability	77	2004/08/11	62	8	7	0	Yes	Yes	Yes	No
MMR-F **Ohikilolo Makai**	Manage for stability	240	2004/08/10	190	25	25	0	Yes	Yes	Yes	No
MMR-G **Ohikilolo Alemac Site**	Manage for stability	28	2002/06/04	24	0	4	0	Yes	Yes	No	No
MMR-H **Ohikilolo Koiahi Prikaa Reintro Site**	Manage for stability	3	2008/07/22	3	0	0	0	Yes	Yes	No	No
	ESU Total :	348		279	33	36	0				

Size Class Definitions

SizeClass	DefSizeClass
Large	>18 mm
Medium	8-18 mm
Small	< 8 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 A. mustelina.

Major Highlights/Issues Year 5

- Rat control was maintained.
- Ground Shell plots were monitored. One plot in an un-baited area showed evidence of rat predation. As a result the rat grid was expanded.
- Current rat activity levels were measured in preparation for a complete re-vamping of the rat control grid to make it more effective.
- Established one Ground Shell Plot in the mauka patch.

Plans for Year 6

- Conduct a survey at MMR-H and establish a baiting grid if necessary.
- Perform thorough surveys in all known areas and obtain current snail numbers.
- Completely redesign the rat grid at Ohikilolo to maximize protection of *A. mustelina*.

ESU-B2 East and Central Makaleha

This portion of ESU-B2 covers a wide geographic area. *Achatinella mustelina* exist on almost every ridge from Central to East Makaleha. Due to management limitations and the geographic spread of these sites, NRS only plan to manage two of the sites within the proposed East Makaleha MU fence. There are sufficient numbers of snails encompassed within this MU to achieve stability goals. For current *A.*

mustelina status in ESU-B2, see the table below. New surveys were not conducted in this ESU over this reporting period because of habitat impact concerns. NRS are proposing to monitor this ESU once every three years until the MU fence is constructed. OANRP are concerned that pig damage will intensify along *A. mustelina* surveying trails. The habitat across ESU-B2 is dissected by narrow ridges which drop off steeply on both sides into deep gulches. This terrain is too steep to construct an *E. rosea* exclosure similar to those existing in ESU-A.

The goat population is again increasing in this area. Significant goat damage to snail habitat continues to be observed. Goats are moving up into more intact native areas and expanding their range closer to the Kaala Road and more directly into core snail populations. Significant goat reductions are needed in the next year. DOFAW staff have been alerted to this issue and NRS will continue to assist their staff in control efforts to the extent allowable under current RCUH firearms use restrictions.

Genetic analyses using microsatellite techniques have been conducted for this ESU in order to determine intra-population variation. These data showed that snails from more than one ridge away were substantially different and that founders should not be mixed from these distances. This data can be used to guide additional collections for captive propagation.

***Achatinella mustelina* in ESU-B2 Manage for Stability Sites**

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control			
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina
Achatinella mustelina											
LEH-C East Branch of East Makaleha (culvert 69)	Manage for stability	423	2006-05-23	241	119	63	0	No	No	No	No
LEH-D East Branch of East Makaleha (culvert 73)	Manage for stability	39	2006-05-01	20	16	3	0	No	No	No	No
LEH-J East Makaleha (culvert 69 - lower down	Manage for stability	2	2006-11-16	2	0	0	0	No	No	No	No
	ESU Total :	464		263	135	66	0				

Size Class Definitions

SizeClass	DefSizeClass
Large	>18 mm
Medium	8-18 mm
Small	< 8 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 A. mustelina.

Major Highlights/Issues Year 5

- Two ground shell plots have been monitored quarterly.
- 10 genetic samples were collected from culvert 69 (LEH-C-1).

Plans for Year 6

- Collect from the East Makaleha portion of this ESU for representation in the UH Tree Snail Lab.
- Control incipient canopy weeds in the ESU including *Psidium cattelianum* and *Toona ciliata*.
- Perform thorough surveys in all known areas and obtain current snail numbers.
- Meet with DOFAW to plan for construction of the East Makaleha MU fence.
- Continue to monitor ground shell plots quarterly.

- Pursue goat control in East Makaleha with the State of Hawaii.
- Consider collecting snails from managed portions of this ESU to create a laboratory population.

4.2.3 ESU-C Schofield Barracks West Range (SBW), Alaiheihe and Palikea Gulches

The number of snails in ESU-C is extremely low (see the status table below). Access restrictions limit the number of visits NRS can make each year to the most 'manageable' sites in this ESU (SBW-A, SBW-B and SBW-C) because they lie above the impact area within Schofield Barracks West Range. The Mt. Kaala NAR populations in this ESU were monitored this past year. Management options at these sites are limited by extremely steep terrain, degraded habitat and critically low population numbers.

Achatinella mustelina **in ESU-C Manage for Stability Sites**

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control			
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina
Achatinella mustelina											
ALI-A Palikea gulch	Manage for stability	0	2009-06-02	0	0	0	0	No	No	No	No
ALI-B Palikea gulch west. Just east of Alaiheihe/Palikea dividing ridge.	Manage for stability	0	2009-06-02	0	0	0	0	No	No	No	No
ANU-A Manuwai gulch	Manage for stability	1	2004-06-02	0	1	0	0	No	No	No	No
IHE-A Alaiheihe Gulch Western Most Site	Manage for stability	0	2005-03-22	0	0	0	0	No	No	No	No
IHE-B Alaiheihe middle site "Ptemac Site"	Manage for stability	3	2009-06-02	1	2	0	0	No	No	No	No
IHE-C Alaiheihe below Nalu's LZ, TT's spot	Manage for stability	0	2005-03-22	0	0	0	0	No	No	No	No
SBW-A North Haleauau Hame Ridge	Manage for stability	33	2009-05-22	23	7	3	0	Yes	No	Yes	No
SBW-B North Haleauau one ridge north of Hame	Manage for stability	7	2009-05-22	5	2	0	0	Yes	No	No	No
	ESU Total :	44		29	12	3	0				

Size Class Definitions

SizeClass	DefSizeClass
Large	>18 mm
Medium	8-18 mm
Small	< 8 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 A. mustelina.

Major Highlights/Issues Year 5

- Rat control grids continue to be maintained within SBW-A and SBW-C where *A. mustelina* are still extant.
- Fences have been constructed in SBW-A.
- Surveys last year revealed more snails than had been observed in recent years at SBW-A.
- Resurveyed sites within Mt. Kaala NAR that had not been visited recently.

- Translocated seven *A. mustelina* from SBW-C where there is no ungulate fence into a fenced area inside SBW-B. Found wild snails in SBW-B after translocation. See more complete discussion below.

Plans for Year 6

- Secure additional collections to bolster lab population as necessary.
- Continue rat control.
- Perform thorough surveys in all known areas and obtain current snail numbers.
- Discuss removing Lower Kaala NAR populations to the lab to bolster numbers (Translocation Guidelines USFWS 2009) and then returning them to the wild after habitat protection and threat control in place.
- Continue to monitor translocated snails.
- Begin construction of 1,800 acre Lihue fence which will pave the way for use of aerial rodenticide and benefit the *A. mustelina* in this ESU.

SBW-C translocation to SBW-B site

In May 2009, with permission from the USFWS and Dr. Michael Hadfield, OANRP translocated a total of seven *Achatinella mustelina* from SBW-C (unfenced) into SBW-B (fenced). The next month when the site was monitored only one snail was seen. Because this area lies behind the live fire ranges at Schofield Barracks it is very difficult to get permission to camp overnight there. When permission was granted to camp September 6, 2009, a total of four of the marked snails were counted. Also, five previously unrecorded *Achatinella mustelina* were found inside the exclosure approximately 30 meters from the translocated snails.

Four new bait stations were deployed in SBW-A and six at SBW-C. They will be monitored as access allows. Figure 3.1.8 shows the ground shell plot proposed for installation after the ungulate fences are complete. Without ungulate fences, these plots would be difficult to monitor due to the intense pig digging in the area. The terrain at both of these sites is favorable for constructing a *Euglandina* exclosure. This may be pursued in the future as access allows and especially as NRS develop new lower maintenance exclosure designs.

4.2.4 ESU-D North Kaluaa, Waieli, Puu Hapapa, SBS, and Makaha

ESU-D is by far the largest ESU geographically. For management purposes it has been split into two portions. D1 includes North Kaluaa, Waieli, Puu Hapapa, and SBS. D2 includes Makaha.

ESU D1 North Kaluaa, Waieli, Puu Hapapa and SBS

This ESU is over stability goal numbers and threat control is in place, see the status table below. The most substantial remaining challenge is the high numbers of *E. rosea* observed in the area. Large scale common native reintroduction was conducted by TNC and has successfully improved habitat within the core of this ESU.

Achatinella mustelina in ESU-D1 Manage for Stability Sites

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control			
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina
Achatinella mustelina											
KAL-A **Land of 10,000 snails**	Manage for stability	386	2009-04-03	310	42	34	0	Yes	Yes	Yes	No
SBS-B **Puu Hapapa**	Manage for stability	144	2009-07-14	77	34	33	0	No	Yes	Yes	No
	ESU Total :	530		387	76	67	0				

Size Class Definitions

SizeClass	DefSizeClass
Large	>18 mm
Medium	8-18 mm
Small	< 8 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 A. mustelina.

Major Highlights/Issues Year 5

- Maintained rat control grid twice per quarter.
- Determined the best route for a predator fence for the KAL-A site with Island Conservation.
- Conducted current snail census surveys.
- Performed area sweeps to remove *E. rosea* and removed a total of 103 predatory snails.
- Monitored ground shell plots, no *E. rosea* observed.

Plans for Year 6

- Continue rat grid maintenance and ground shell plot monitoring.
- Remove *E. rosea* quarterly.

<u>SBS-A Land of 10,000 snails</u>

A thorough night survey was conducted on 4/3/2009 and a total of 386 snails were counted in 18 hours. In 2006 a total of 430 snails were counted in 10 hours search time. The numbers show that there are still an appreciable number of snails here but that their numbers are in decline. In January 50 *E. rosea* were collected here, 21 in April and another 52 in July. For live *E. rosea* these figures are the highest NRS have ever seen anywhere on Oahu. It has been recommended that quarterly sweeps for *E. rosea* become the rule.

<u>SBS-B Puu Hapapa</u>

NRS recommended surveying for possible strategic fencing that could allow the removal of pigs from this portion of ESU D1 but because of a backlog of fences, NRS did not pursue this action in the last year. Access was not reliable over the last year. This fence is on the list of fencing projects being pursued by the Army NR fence crew but will be a lower priority than most of the other planned MU fences as over 300 snails are known from within the already fenced portion of this ESU. Weed control projects should be investigated and initiated. Rat bait was available all year long in stations thus effecting protection for *A. mustelina* at this site. Access to the baiting grid was regular and predictable this year which is an improvement since last year.

A night survey was conducted here on 7/14/2009 and a total of 144 *Achatinella mustelina* were counted. This was just a partial survey as most of this area is too steep to survey at night.

ESU D2 Makaha

This site has very low *A. mustelina* numbers; therefore, OANRP are considering switching the managed site from Makaha to the Puu Kalena portion of SBW. OANRP have observed a total of 130 *A. mustelina* at Makaha within areas proposed for fencing and existing fences and at the Puu Kalena site OANRP have observed a total of 162. The Puu Kalena site is scheduled for large scale fencing this year. The table below, entitled Comparison between Makaha and Puu Kalena sites within ESU D2, outlines differences between these two sites. This table and any additional information available will be reviewed by the IT to assist in choosing the final site to be managed as D2. Maps showing the distribution at the Puu Kalena and Makaha sites are included along with two tables summarizing the current numerical status at each of these sites. The discussion of management in Makaha follows after the Makaha status table.

Comparison between Makaha and Puu Kalena sites within ESU D2

MAKAHA SITE			PUU KALENA SITE	
Consideration	**Pro**	**Con**	**Pro**	**Con**
Warming Climate	Management on Leeward and Windward sides of range to buffer for more intense hurricanes	Leeward Waianaes, noticeably drier than windward sites, elevation range: 2,200-2,400 ft.	Windward Waianaes, elevation range: 2,700-3,000 ft.	Management would be concentrated only on Windward sides of range would not buffer for more intense hurricanes
Habitat Protection	Subunit I fenced	Subunit II not fenced but slated for construction 2010-2011	1,400 acre fence funded for construction in 2010	Not currently fenced
Access	Regular access available			Helicopter access required, range use, EOD escort
Population Size		Number maybe close to actual	Number maybe lower than actual	
Habitat Condition		Patches of alien canopy amongst native components		Patches of alien canopy amongst native components
Terrain	Some population reference sites not steep	Some population reference sites on steps between cliffs	Most snail sites not steep	Some snails on narrow sub-ridges

***Achatinella mustelina* in Makaha ESU-D2 Manage for Stability Sites**

Pop Reference Site	Management Status	Total Snails	Date of Survey	Large >18 mm	Medium 8-18 mm	Small <8 mm
SBW-D	No Mgmt	7		2	5	0
SBW-E	No Mgmt	1		1	0	0
SBW-Q	No Mgmt	81		47	32	2
SBW-T	No Mgmt	33		25	1	7
SBW-U	No Mgmt	17		13	3	1
SBW-V	No Mgmt	31		21	9	1
TOTAL		**170**		**109**	**50**	**11**

Achatinella mustelina in Makaha ESU-D2 Manage for Stability Sites

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control			
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina
Achatinella mustelina											
MAK-A Isolau ridge	Manage for stability	46	2009/06/17	27	7	12	0	Yes	Yes	No	No
MAK-B Kumaipo ridge crest	Manage for stability	15	2005/01/11	11	4	0	0	Yes	No	No	No
MAK-C Near pinnacle rocks. Includes Hesarb ridge.	Manage for stability	9	2009/06/18	8	1	0	0	Yes	No	No	No
MAK-D On ledge below ridge crest above MAK-A site.	Manage for stability	24	2009/06/18	15	6	3	0	Yes	No	No	No
MAK-E Ridge east of Cyasup exclosure	Manage for stability	36	2009/06/18	28	6	2	0	Yes	No	No	No
	ESU Total :	130		89	24	17	0				

Size Class Definitions

SizeClass	DefSizeClass
Large	>18 mm
Medium	8-18 mm
Small	< 8 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 A. mustelina.

Major Highlights/Issues Year 5

- Performed thorough surveys in some areas and obtained current snail numbers.
- Conducted weed control in areas where *A. mustelina* is known.

Plans for Year 6

- Install ground shell plots at sites in Makaha if chosen over Puu Kalena.
- Coordinate with Aaron Shiels from UH regarding rat studies within the fence unit.
- Continue surveys along crestline and Makai Ridge fenceline.
- Investigate installing predator control in Makaha if site chosen.

4.2.5 ESU-E Puu Kaua/Ekahanui

No new surveys were conducted during this reporting period; therefore, the numbers of snails reported this year are identical to last year. The table below summarizes the current population numbers for each reference code within this ESU. Rat management is underway at all the known ESU-E sites with the exception of EKA-D and EKA-F.

***Achatinella mustelina* in ESU-E Manage for Stability Sites**

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes: Large	Medium	Small	Unk	Threat Control: Ungulate	Weed	Rat	Euglandina
Achatinella mustelina											
EKA-A Mamane Ridge and Near Plapripri EKA-A	Manage for stability	183	2004/10/13	93	30	60	0	Yes	Yes	Yes	No
EKA-B Below north population of Tetlep. Between Plapri EKA-A, EKA-B and EKA-C	Manage for stability	55	2004/10/14	46	6	3	0	Yes	Yes	Yes	No
EKA-C At Plapripri EKA-C site	Manage for stability	6	2004/10/14	6	0	0	0	Yes	Yes	Yes	No
EKA-D Puu Kaua	Manage for stability	202	2004/10/12	158	31	13	0	Yes	No	No	No
EKA-E Amastra site	Manage for stability	13	2004/10/05	9	3	1	0	Yes	Yes	Yes	No
EKA-F from Plapri-C head along blue trail under cliffs mauka	Manage for stability	3	2006/02/01	2	1	0	0	Yes	Yes	No	No
EKA-G Cenagr	Manage for stability	2	2008/04/10	1	1	0	0	Yes	Yes	No	No
	ESU Total :	464		315	72	77	0				

Size Class Definitions

SizeClass	DefSizeClass
Large	>18 mm
Medium	8-18 mm
Small	< 8 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 A. mustelina.

Major Highlights/Issues Year 5

- Completed the large subunit fence construction.
- Conducted weed control at sites with *A. mustelina*.
- Continued to restock rat bait grids.
- Monitored ground shell plot, no rat predation observed.

Plans for Year 6

- Continue rat control.
- Monitor ground shell plot.
- Perform thorough surveys in all known areas and obtain current snail numbers.

- Pursue MU scale rat grid for Ekahanui in the Spring/Summer of 2010 to protect many more *A. mustelina* from rat predation.

4.2.6 ESU-F Puu Palikea/Mauna Kapu (Palehua)

Rat control is being conducted at most population reference sites in this ESU. The status of all MFS populations within ESU-F are shown in the status table below. In August 2008, at total of 10 snails were collected from outside the PAK-C study area and brought to the lab at UH for captive rearing. The 10 adults were released back into the wild on 3/12/2009 along with six snails that were born in captivity.

Major Highlights/Issues Year 5

- Conducted recent surveys in most all known snail sites.
- NRS continued monitoring three new ground shell plots in ESU-F.
- NRS expanded two rat baiting grids to better encompass snail trees and established one new rat grid at PAK-D, a site north of the Palikea MU.
- The largest single concentration of *A. mustelina* was discovered during this reporting period and is named PAK-M. See the table below for exact numbers.

Plans for Year 6

- Conduct weed control at all MFS snail sites.
- Perform thorough surveys in all known areas and obtain current snail numbers.
- Pursue MU scale rat grid for Palikea, and in the meantime deploy small scale rat grid at the new PAK-M large concentration of snails.
- OANRP will obtain results from K. Hall of the 3/12/09 snail collection and their subsequent return to the wild.
- Monitor ground shell plots.

Achatinella mustelina in ESU-F Manage for Stability Sites

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control			
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina
Achatinella mustelina											
MAU-A **Mauna Kapu (Palehua)**	Manage for stability	22	2009/03/25	16	4	2	0	No	No	Yes	No
PAK-A **Puu Palikea-Ohia spot**	Manage for stability	29	2008/04/22	26	0	3	0	Yes	Yes	Yes	No
PAK-B **Iele Patch**	Manage for stability	1	2008/10/29	1	0	0	0	Yes	No	Yes	No
PAK-C **Steps spot**	Manage for stability	33	2008/08/14	19	9	5	0	Yes	Yes	Yes	No
PAK-D **Joel Lau's site**	Manage for stability	20	2008/09/23	15	5	0	0	No	No	Yes	No
PAK-E **Exogau site**	Manage for stability	4	2006/05/22	3	0	1	0	Yes	Yes	Yes	No
PAK-F **Dodonaea site**	Manage for stability	5	2008/04/22	5	0	0	0	Yes	Yes	Yes	No
PAK-G **Hame and Alani site just above Cyagri fence**	Manage for stability	30	2006/01/25	13	11	6	0	Yes	Yes	Yes	No
PAK-H **Mike Hadfield's study site at Puu Palikea**	Manage for stability	16	2008/09/24	12	1	3	0	Yes	Yes	Yes	No
PAK-I **One ridge truck side of E and F**	Manage for stability	5	2006/01/26	4	0	1	0	No	No	Yes	No
PAK-K **Pilo site**	Manage for stability	36	2009/03/25	29	5	2	0	Yes	Yes	Yes	No
PAK-L **Olapa site north of Puu Palikea**	Manage for stability	32	2008/09/25	28	3	1	0	Yes	Yes	Yes	No
PAK-M **Middle Site**	Manage for stability	83	2009/03/25	58	20	5	0	Yes	Yes	No	No
	ESU Total :	316		229	58	29	0				

Size Class Definitions

SizeClass	DefSizeClass
Large	>18 mm
Medium	8-18 mm
Small	< 8 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 A. mustelina.

CHAPTER 5: OIP *ACHATINELLA* SPECIES MANAGEMENT

The OIP stabilization plan for *Achatinella* outlines protection measures for each Geographic Unit (GU). GUs were designated based on closest geographic groupings with an emphasis on representing the entire range of the taxon in management. The term GU in this case is used also as a surrogate for genetically defined ESUs for *A. mustelina* in the MIP. In order to reach stability for Koolau *Achatinella*, NRS must work towards attaining the goals below for each taxon.

OIP Long Term Goals:

- Manage snail populations at six GUs (up to eight if available) per snail taxon
- Achieve at least 300 snails in each GU
- Maintain captive populations of significant Gus
- Control all threats at each managed field location

5.1 KOOLAU *ACHATINELLA* STABILIZATION OVERVIEW

Most GUs are not approaching the stated OIP stability goals. The situation for Koolau *Achatinella* is less than optimistic at this point in time. There are only two large populations (>300 snails) known for any of these taxa, one for *Achatinella byronii/decipiens* and the other of *Achatinella sowerbyana* in Opaeula. *Achatinella lila* and *Achatinella livida* only remain as a few small populations.

Unfortunately, the greater conservation community is not actively managing these species aside from some support for their conservation at the tree snail laboratory at UH. Captive populations are not a substitute for active on the ground conservation. The Army has been tasked to stabilize these Koolau *Achatinella* taxa but for OANRP these actions are low priority given the limited nexus to military training (Tier 2). The Army cannot pull these snail taxa back from their current trajectory alone. Conservation agencies with a mandate to protect these snails must become involved in field conservation programs for these taxa to prevent their extinction.

Over the next year, OANRP will focus on obtaining a comprehensive status update for the many small populations of Koolau *Achatinella* (<30 snails). Based on these findings, OANRP will strategically implement conservation actions for each taxon to ensure at least one large population exists per taxon by focusing management efforts on the site closest to this goal. OANRP will enlist assistance from other partner agencies. In particular for the Poamoho parcel, slated to become a Natural Area Reserve, OANRP hope to jointly survey with NARS staff. OANRP will also invite any FWS Hawaii office staff interested in contributing field assistance on surveys. UH tree snail laboratory staff are also welcome if available.

In next year's report, OANRP will present a detailed action plan for each population reference code based on current population numbers in hopes that the USFWS will pursue funding for an Oahu Snail Extinction Prevention Program (similar to OPEP for plants) which could have full time staff working on these issues. The Oahu Rare Snail Working Group could provide guidance to this OSEP staff and these staff could work cooperatively with OANRP to implement positive conservation for Koolau *Achatinella*. In addition, over the next three years, OANRP will shift staff time to focus on fence construction and will pursue partnering with the Koolau Mountains Watershed Partnership Staff to construct some of the management unit fences critical to the conservation of Koolau *Achatinella*. In general, management of Koolau Achatinella needs a Program leader from a government agency. It is beyond the Army's mandate to solely provide that leadership role.

5.1.1 Captive Propagation

Most Koolau *Achatinella* taxa are not thriving in captivity with the exception of *A. lila* and *A. fuscobasis.* Investigations are underway by lab staff to resolve this poor performance. Additional collections will not be made until the UH lab is ready for more snails. Current captive population representation is insufficient but the same set of questions presented in the MIP Snail Chapter apply for Koolau

Achatinella taxa and should be addressed prior to bringing in more wild snails (See Chapter 4). These questions are even more pressing given the extreme rarity of many of the Koolau taxa. OANRP will communicate with the UH tree snail lab regarding future collections.

The ideas presented in the draft Translocation Protocol (Appendix 5-1) prepared by the USFWS should be discussed at the upcoming IT meeting. In this document, the USFWS recommends removing entire groups of wild snails from populations at the medium size to captivity for short periods to bolster numbers. Many of the extant sites for Koolau *Achatinella* are at critically low levels and this option should be considered. However, it is the opinion of OANRP that pathogen concerns are not adequately addressed in the document. Of course this course of action must be accompanied by *in situ* threat control and site preparation for return of these captive snails to the wild.

In addition, *A. lila* is performing incredibly well in captivity. OANRP and the UH Tree Snail Laboratory have been in discussions about reintroducing some of this stock into a protected Koolau exclosure. Genetic results are pending from the UH tree snail laboratory. These results should be discussed at the upcoming IT meeting. OANRP escorted Kamehameha Schools (KS) land managers to the proposed site for a Koolau predator exclosure. Permissions for building this structure will be included in the 20-year license agreement that is pending from KS.

The following table summarizes the captive propagation status for each Koolau *Achatinella* taxon.

Captive *Achatinella* Propagation Data for Koolau Taxa (2007-2009)

	August 2007	August 2008	August 2009	
Taxon	Juv/sub/adult total	Juv/sub/adult total	Juv/sub/adult total	Source Population Notes
A. lila	215/246/8 470	151/372/21 544	175/363/118 656	North of Poamoho Summit (3 minutes north of rock slide)
A. sowerbyana	4/14/3 21	8/14/3 25	7/13/5 25	KLO- T Frog pond and KLO-L or KLO-M
A. livida	50/66/6 122	28/75/5 108	17/51/17 85	KLO-C Radio and possible KLO-A Crispa
A. byronii/decipiens	5/14/9 28	6/17/7 30	3/17/5 25	KLO-E North Kaukonahua
A. apexfulva	3/4/1 8	2/0/0 2	0/2/0 2	Poamoho trail
A. bulimoides	21/4/9 34	24/15/4 43	18/22/3 43	Punaluu and Poamoho cliffs

5.1.2 Genetic Issues

OANRP continue to assist *Achatinella* researchers in making genetic collections from field sites. Results are pending from these collections and will be presented and discussed at the IT by these researchers. Details about samples made this year are presented within the taxon section bullets.

5.1.3 Monitoring

Monitoring methods were compared and contrasted in a table prepared by K. Hall last year for the IT meeting. The table from this document is included in Appendix 4-1.

Considering this comparison of monitoring techniques, OANRP will use the monitoring schedule included in the table below for each Koolau *Achatinella* population reference sites within each GU. The Capture Mark Recapture method is abbreviated as CMR. OANRP have opted not to continue the alphanumeric glue marking of snails at the K. Hall study sites for *A. sowerbyana* at GU-C because the monitoring schedule required to make this intensive effort worthwhile is too frequent for OANRP to sustain. We will utilize the CMR method with a paint pen every three years to obtain trends in population numbers which minimizes snail handling and field site impacts. Monitoring methods proposed for other sites are based on habitat impact and population density considerations. The most important change that will be made to snail counts and surveys is methods standardization; otherwise, results cannot be viewed as a trend. In addition, the area of survey needs to be clearly defined and unchanging. Binoculars are now a required standard tool for conducting snail surveys.

The most noteworthy consideration for Koolau *Achatinella* monitoring over *A. mustelina* monitoring is the extremely low numbers observed at sites that represent the only snails in a given GU. Based on these low numbers, the table identifies night surveys as a technique for the sites with critically low population numbers in order to improve the detection rate of snails. For *A. sowerbyana*, not all sites are proposed for monitoring if a large population exists within the GU. This applies for GU- C. See the table definitions from the MIP snail section for column interpretation.

Proposed monitoring schedule for Koolau *Achatinella*

Taxon Name	GU	Pop Ref Site Code (s)	Current accurate GU Total Snails	Monitoring Method	Frequency	Method specifics	Notes
Achbyr/ dec	A	SBE-B thru SBE-E	6	Population counts	annually	night	Survey all four ref sites in combined trip
Achbyr/ dec	B	KLO-D Puu Pauao	16	Population Count	annually	night	
Achbyr/ dec	C	KLO-B, KLO-C and KLO-F	69	Population Count	annually	night	
Achbyr/ dec	D	KLO-H, KLO-I	7	Population Count	annually	night	Current numbers critically low
Achbyr/ dec	E	KLO-E North Kaukonahua	445	Population Count-sweep	Every 3 years	night	Concerned about creating trails that pigs follow
Achbyr/ dec	E	KLO-E North Kaukonahua	455	Ground shell plots	annually		Not baiting but concerned about frequent visits impacting habitat so annual visits not quarterly
Achlil	A	KLO-B North of Poamoho Trail	15	Population Count	annually	night	
Achlil	B	KLO-C and KLO-F	11	Population Count	annually	night	
Achlil	C	KLO-D and KLO-E	45	Population Count	annually	night	
Achliv	A	KLO-A Crispa	86	Population Count	annually	night	
Achliv	A	KLO-A Crispa	86	Ground Shell	annually		Rat control on going
Achliv	B	KLO-B Northern	9	Population count	annually	night	
Achliv	C	KLO-C Radio and PAP-A	18	Population count	annually	night	
Achsow	A	No extant sites known	0				Priority for survey
Achsow	B	KLO-K Bloody Finger	28	Population Count	annually	night	Only extant site known, need surveys
Achsow	B	KLO-P Kawaiiki	1	Survey			Last observed in 1997 requires more survey

Taxon Name	GU	Pop Ref Site Code (s)	Current accurate GU Total Snails	Monitoring Method	Frequency	Method specifics	Notes
Achsow	C	KLO-J Hypalon	220	CMR entire site	every 3 years	Paint pen, 2 days	Pay close attention to site impacts. Can do more frequently if incidental observations show need
Achsow	C	KLO-L 290	43	Population count	annually	night	Noted impacts from monitoring, focus on largest site in GU
Achsow	C	KLO-M Shaka	47	Population count	annually	night	Noted impacts from monitoring, focus on largest site in GU
Achsow	D	KLO-C North of Poamoho Summit	177	Population count-sweep	annually		
Achsow	D	KLO-FF South of Poamoho Summit	19	Population count	annually	night	
Achsow	D	KLO-GG Poamoho Trail upper 1/3	77	Population count-sweep	annually	night	Does not require helicopter to access
Achsow	E	KLO-A Poamoho Pond	35	Population count	annually	night	Only site known in this GU
Achsow	F	KLO-AA Little Italy	2	Survey	annually	Night	Priority on finding more snails w/in GU
Achsow	G	KLO-S, T, V	5	Survey	annually		Priority on finding more snails w/in GU

5.1.4 Reintroduction

During this reporting period, OANRP visited the proposed site for building a predator exclosure at the top of the Poamoho trail with KS land managers. They plan to include the proposed exclosure in the 20-year license agreement currently being prepared. This protected site would be used to reintroduce snails from the *A. lila* captive population. OANRP are awaiting genetic diversity comparisons between wild populations of *A. lila* and the lab population before proceeding. In addition, OANRP are still awaiting the acceptance of the Rare Snail Reintroduction Protocols by the USFWS. These have been in draft form since 2007.

5.1.5 Threats

Threat updates for *Achatinella* are covered in the MIP Snail Chapter.

5.1.6 Threat Control Development

Threat control development updates are covered in the MIP Snail Chapter.

5.1.7 Research

All research projects discussed in the MIP Snail Chapter also apply to Koolau *Achatinella*. Results specific to Koolau taxa will be discussed within the taxa updates to follow.

5.2 GU UPDATES

The following section contains brief updates for each of the Koolau *Achatinella* taxa. There are no separate updates per GU as with *A. mustelina* ESUs because there is much less to report.

5.2.1 *Achatinella curta, Achatinella leucorapphe, Achatinella apexfulva*

Major Highlights/Issues Year 5

There is no change in status to report for these taxa.

Plans for Year 6

OANRP will conduct two surveys next year for each of these taxa and will request assistance from partner agencies in these survey efforts.

5.2.2 *Achatinella bulimoides*

Major Highlights/Issues Year 5

- Laboratory populations of *A. bulimoides* are unchanged since last year.
- A license agreement was obtained from Kamehameha Schools for access to Punaluu.

Plans for Year 6

OANRP will conduct two surveys next year for this taxon and will request assistance from partner agencies in these survey efforts.

5.2.3 *Achatinella byronii/decipiens*

***Achatinella byronii/decipiens* Status**

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes: Large	Medium	Small	Unk	Threat Control: 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				

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	5	2009-04-06	5	0	0	0	No	No	No	No
	GU Total:	7		7	0	0	0				
GU: E North Kaukonahua											
KLO-E **North Kaukonahua**	Manage for stability	445	2009-08-31	355	50	40	0	No	No	No	No
	GU Total:	445		355	50	40	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 A. mustelina.

Major Highlights/Issues Year 5

- OANRP conducted comprehensive night surveys at the North Kaukonahua population of this taxon which revealed substantially more snails.
- Genetic collections were secured in the past year from the KLO-I population to support laboratory investigations. Five snails were observed at this site as compared to the one observed in 2007.
- The ground shell plot at KLO-E was monitored when OANRP visited the site this year.

Plans for Year 6

- OANRP will conduct night surveys over the next year at all sites with <30 remaining individuals and will request assistance from partner agencies in these survey efforts.
- OANRP will consider promoting the MU fence construction date to secure the habitat for KLO-E if partner assistance can be obtained.

5.2.4 *Achatinella lila*

***Achatinella lila* Status**

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes: Large	Medium	Small	Unk	Threat Control: Ungulate	Weed	Rat	Euglandina
Achatinella lila											
GU: A Poamoho Summit											
KLO-A South of Poamoho Trail	Manage for stability	0	2004-12-01	0	0	0	0	No	No	No	No
KLO-B North of Poamoho Trail	Manage for stability	15	2008-08-12	12	2	1	0	No	No	Yes	No
	GU Total:	15		12	2	1	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
KLO-G East of 290	Manage for stability	21	2007-04-02	18	3	0	0	No	No	No	No
	GU Total:	66		51	12	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 A. mustelina.

Major Highlights/Issues Year 5

- OANRP secured access to Punaluu Cliffs from KS and conducted one genetic sample collection trip with UH tree snail laboratory staff. Samples were collected to compare *A. lila* genetic diversity at wild sites with that observed in the huge lab population. Results are pending.
- Genetic collections were secured in the past year from the KLO-E and KLO-G population to support laboratory investigations.
- Rat control was maintained twice per quarter at KLO-C and KLO-B as weather allowed.

Plans for Year 6

- OANRP will conduct night surveys over the next year at all sites with <30 remaining individuals and will request assistance from partner agencies in these survey efforts.

- OANRP will monitor the ground shell plot at KLO-E once this year with partner agencies.
- OANRP will consider promoting the MU fence to secure the habitat for KLO-E if partner assistance can be secured.
- Rat control will be maintained twice per quarter at KLO-C and KLO-B.

5.2.5 *Achatinella livida*

***Achatinella livida* Status**

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	86	2009-04-28	56	13	17	0	No	No	Yes	No
	GU Total:	86		56	13	17	0				
GU: B Northern											
KLO-B Northern	Manage for stability	9	2009-04-27	6	2	1	0	No	No	Yes	No
	GU Total:	9		6	2	1	0				
GU: C Radio											
KLO-C Radio	Manage for stability	7	2009-04-28	4	2	1	0	No	No	Yes	No
PAP-A Windward side of radio	Manage for stability	11	2008-02-27	8	2	1	0	No	No	No	No
	GU Total:	18		12	4	2	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 A. mustelina.

Major Highlights/Issues Year 5

- Comprehensive night survey conducted at KLO-A; population count currently at 86, up from 60.
- Genetic collections were secured from KLO-A to supplement the *A. livida* investigation samples. Also the genetic diversity within these samples can be used to compare to the genetics of the lab population from KLO-C.
- In the last year the number of snails known at KLO-B increased due to intensive night survey efforts.
- Rat control continues as all three *A. livida* sites on a twice per quarter basis.
- The ground shell plots at KLO-A were monitored and no rat predation was detected. One live *E. rosea* was removed.

- A reduction was observed at KLO-C since 2004 when 77 snails were observed. In 2006, only 11 were observed. This year only 7 were seen. A flatworm was observed at this site in 2006.

Plans for Year 6

- OANRP will run rat tracking tunnels in February 2010 to determine how to best configure rat control efforts at all three GUs. Snap trap boxes will be installed and grid reconfigured according to findings within the next year.
- OANRP will continue to maintain rat control and read ground shell plots.
- OANRP will conduct a night survey at KLO-C with a visiting flatworm researcher to further investigate the reduction of snails at this site.

5.2.6 *Achatinella sowerbyana*

Achatinella sowerbyana* Status

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	0	2007-05-15	0	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:	0		0	0	0	0				
GU: B Kawaiiki Ridge											
KLO-K Bloody finger	Manage for stability	28	2009-01-05	16	6	6	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:	29		17	6	6	0				

*This long table has been formatted to keep population reference sites within one GU together. In order to maximize use of space the bullets for this taxon are included between the status tables.

Major Highlights/Issues Year 5

- Kevin Hall completed his field study at KLO-J and KLO-C observed adult survival at near 80%, detailed results of this work are in review for publication.
- Maintained rat control at KLO-J and KLO-C, KLO-L and KLO-M twice per quarter.
- Eighteen genetic samples were collected from KLO-K to supplement *A. livida* versus *A. sowerbyana* analyses.
- Collected 14 genetic samples from the upper portion of the Poamoho trail (southernmost *A. sowerbyana* site) in order to compare to other populations of this taxon. Results are pending.

Plans for Year 6

- OANRP will continue to maintain ongoing rat control efforts.

- OANRP will focus survey efforts at small population within GU-A, B, E and F over the next year. It is unlikely that large concentrations will be uncovered at sites within GU-A and GU- F and the IT should consider the potential implications on stability efforts at these.

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 Peahinaia 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 **Peahinaia 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`ahinai`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`ahinai`a trail pulcherima like snails**	Manage for stability	5	2006-07-18	2	3	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	2003-08-27	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	220	2008-08-11	105	90	25	0	Yes	Yes	Yes	No
KLO-KK **Second ridge off Peahinaia 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`ahinaia fence**	Manage for stability	43	2008-09-16	17	16	10	0	Yes	Yes	Yes	No
KLO-LL **East of 290**	Manage for stability	3	2007-04-02	3	0	0	0	No	No	No	No

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes: Large	Medium	Small	Unk	Threat Control: Ungulate	Weed	Rat	Euglandina
KLO-M **Shaka**	Manage for stability	47	2008-09-17	30	11	6	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:	370		172	124	44	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	77	2008-05-05	63	9	5	0	No	No	No	No
	GU Total:	273		112	99	43	19				
GU: E	**Poamoho Pond**										
KLO-A **Poamoho Pond**	Manage for stability	35	2006-08-23	25	6	4	0	No	No	No	No
	GU Total:	35		25	6	4	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				

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	0	2008-10-07	0	0	0	0	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:	5		0	0	0	5				

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 A. mustelina.

CHAPTER 6: RESEARCH PROGRAM

This chapter describes the status and outcome of actions carried out under the direction of the program's Research Specialist (RS). It contains on-going actions proposed in the OANRP Year End Report of 2005-2006[1] and builds upon findings presented in the OANRP Year End Report of 2006-2007[2]. Reference to these documents will be indicated by the abbreviation YER followed by the year. This chapter includes some projects carried out in 2007 but not included in the 2007-2008 YER due to a gap in employment.

Program objectives outlined in 2005-2006 centered on improving control methods for slugs (Mollusca: Gastropoda) and the black twig borer (*Xylosandrus compactus*). These remain a focus of study with some new additions (*Sphagnum palustre* control). Research findings are organized by pest species.

All statistical analyses were performed with Minitab Release 14 software of Minitab Inc. (Ryan *et al*. 2005). Significance during hypothesis testing was characterized by p-values less than 0.05. Nonparametric statistical methods were used to analyze datasets with non-normally distributed residuals and dissimilar variation between groups, otherwise parametric methods were used.

6.1 BLACK TWIG BORER (BTB) TRAP-OUT STUDY

6.1.1 Introduction

Xylosandrus compactus (black twig borer or BTB) is a major threat to a number of rare and endangered plants, notably *Flueggea neowawraea* (Euphorbiaceae). Published documentation is lacking, however OANRP and the DLNR have observed these species to suffer under BTB attack. Sequestered within the plant pith, BTB cannot be removed manually or with pesticides applied on the plant surface. Greenhouse collections of *F. neowawraea* are treated with the systemic insecticides Merit (Bayer Crop Research, Triangle Park, NC) applied as a root drench and Marathon (Olympic Horticultural Products, Mainland, PA) applied to the base of the plant in granular form. Neither is legal to use in a natural setting, but a Special Local Needs (SLN) Label (Nagamine and Kobashigawa 2003) could be pursued with permission from the manufacturer, HDOA and USFWS. OANRP is currently engaged in the process of SLN approval for a molluscicide, Sluggo and have found the process to be lengthy. Rather than embark on this long process for BTB management, OANRP looked for solutions which could be put into use immediately if found to be effective.

6.1.2 Methods

OANRP tested the efficacy of modified Japanese Beetle Traps equipped with high-release ethanol bait (AlphaScents, NJ) and Vaportape insecticidal strips (Hercon Environmental, PA) to reduce BTB gallery formation in a target tree species (*F. neowawraea*). Prior tests demonstrated this lure to effectively capture BTB (Dudley *et al.* 2007) but it was unknown whether traps could be used to control BTB populations locally. We conducted field experiments to determine whether a ring of 6 traps placed around *F. neowawraea* could reduce attack rates relative to a control group (YER 2007, Figure 5.1.1). Work took place at two *F. neowawraea* stands, 250 m apart, located within the Kahanahaiki Mangement Unit at an elevation of 2000 ft (YER 2007, Fig. 5.2.1). The two sites, referred to here as Up Gulch (UG) and Down Gulch (DG), provide habitat for 37 and 24 trees respectively. Trees were reared in the greenhouse and planted by OANRP on February 17, 2005, February 22, 2006, (UG) and January 27, 2007 (DG). DG contains 24 trees, seven of which were transplanted from a nearby site, Pteralyxia Gulch (PG), where they

[1] OANRP 2005-2006 Year End Report 6.1-6.13 http://www.botany.hawaii.edu/faculty/duffy/DPW/2006_YER/ . Accessed November 16, 2009.

[2] OANRP 2006-2007 Year End Report 5.1-5.4 http://www.botany.hawaii.edu/faculty/duffy/DPW/2007_YER/ . Accessed November 16, 2009.

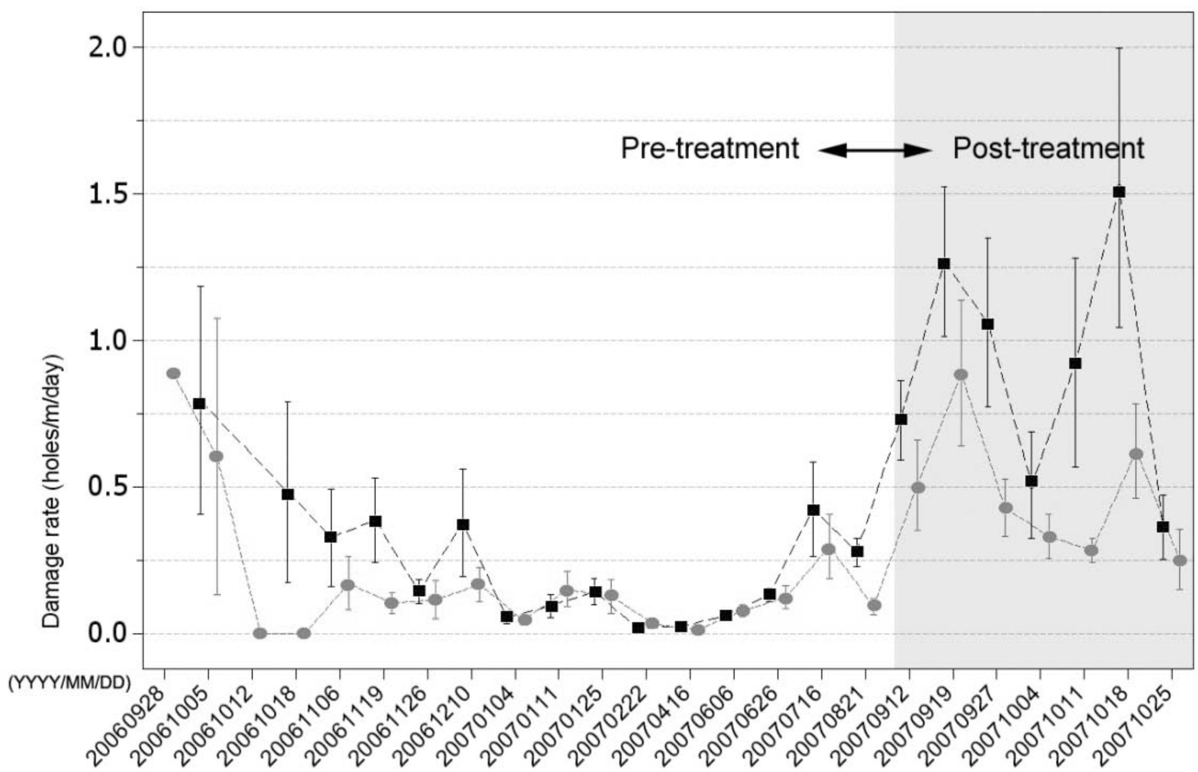
had been doing poorly. These seven, plus an additional 19 plants were originally planted at PG on December 10, 2003.

A total of 10 trees at the DG site and 20 trees at the UG site were included in this study. All trees were1 meter or more in height. Half of the trees at each site were randomly assigned to a treatment (traps) or control (no traps) group for a total of 15 replicates per group. The rate of attack was determined using counts of new entry holes divided by the height of the tree accumulated over time. This method has been used elsewhere (Gillette *et al.* 2006) to evaluate the success of experimental repellents. Using white latex paint, we marked existing holes on 30 *F. neowawraea* and recorded new holes on a weekly basis for six weeks. Prior to trap deployment attack rates had been monitored at irregular intervals for one year.

6.1.3 Results and discussion

Post-treatment results were mixed (see figure below). While those trees receiving traps had a consistently lower rate of attack compared to the controls, these differences were not significant when adjusted for pre-existing differences between the two groups.

Damage to *F. neowawraea* by BTB over time before (white shaded area) and after (grey shaded area) trap deployment. The control group of trees (N=15) are shown in black squares with a dotted black mean connect line while the treatment group is shown in grey circles (N-15). Attack rate on the X- axis is displayed in units of new holes (twig borer galleries) per meter of tree height per day. Bars are ± one SEM.



Despite the failure of trapping to appreciably reduce damage to *F. neowawraea*, some useful information was obtained. First, it was discovered that baseline levels of attack where extremely high. At the peak of twig-borer season trees in the control group accumulated three new entry holes per 1 meter of bole length every two days. This probably over-estimates twig borer damage however, because not all newly drilled holes result in the successful formation of a gallery. Second, the traps consistently yielded a steady number of beetles, at times as high as 100 or more. Each insect trapped was a gravid female due to the insects' somewhat unique reproductive behavior. Males are incapable of flight, and upon hatching, they mate with related females and remain within the gallery, never to emerge (Hara and Beardsley 1979). Third, the traps did not exhibit a hypothesized potential counter-productive effect of increasing attack rates on *F. neowawraea*. This might have occurred if the traps attracted more beetles to the area than would naturally occur.

Future research with more replicates may find that traps can serve as a sink for BTB on a small scale, slowing damage to *F. neowawraea*. Nonetheless, the data presented here suggest that trapping alone does not prevent appreciable numbers of BTB's from forming galleries within the host plant. As a result, we plan future tests with a combination of repellents and attractants. Also possible is the use of injection systems to more safely deliver systemic insecticides to the plant. In the meantime, we are deploying traps with high release ethanol bait as a means of both monitoring numbers of twig borer and as our only current means of combating this threat.

6.2 MOLLUSCICIDE SPECIAL LOCAL NEEDS LABELING (SLN) STATUS

6.2.1 Introduction

Slug control has been shown to effectively enhance survivorship of *Cyanea superba* and *Schiedea obovata* (Joe and Daehler 2008); however, no molluscicides are labeled for conservation use. With guidance from USFWS and HDOA, OANRP has worked with the manufacturer of the organic molluscicide, Sluggo (Neudorff, Germany) to expand its use as a conservation tool under a SLN label. Such labeling would allow for expanded use of Sluggo outside of agricultural and residential areas within the State of Hawaii. In support of an SLN, OANRP has conducted field studies under an Experimental Use Permit granted by HDOA in 2007 and current through February 2010. Research to date (section 5.3, YER 2007) shows Sluggo is effective against the target pest and safe to use in a forested setting

6.2.2 Project Status

No new research is required from HDOA for the SLN label (L. Kobashigawa *pers. comm.* Aug. 2009). USFWS is awaiting a draft label for review after which they will proceed with a Section 7 consultation (K. Swift pers. comm. Oct. 2009). OANRP is in contact with Sluggo company representatives to produce a draft SLN label for USFWS review in early 2010.

6.3 *SPHAGNUM PALUSTRE* IMPACTS AND CONTROL

The following research was presented as a poster at the 2009 Hawaii Conservation Conference (Honolulu Convention Center, Honolulu HI) under the title: Smothered in Sphagnum: Managing Moss at Kaala. A color version of this section can be viewed in poster format at: http://www.botany.hawaii.edu/faculty/duffy/DPW/HCC-2009/

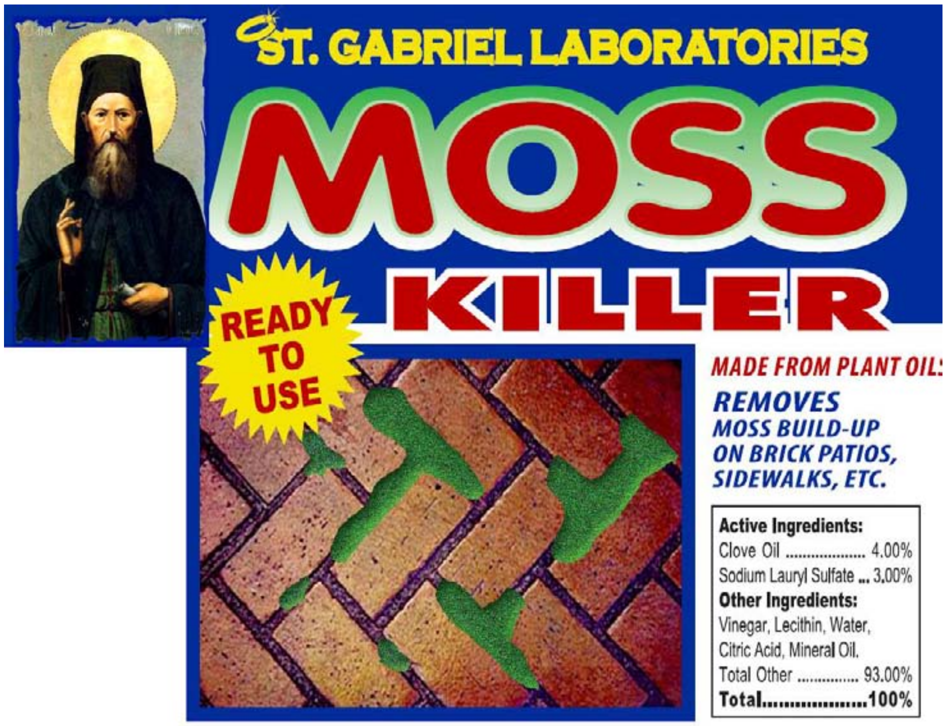
6.3.1 Introduction

The high level of expertise required for bryophyte identification has meant that invasive mosses have been given little attention in Hawaii. *Sphagnum palustre*, a bog moss, was purposely introduced to the Kaala Natural Area Reserve (NAR) on Oahu in the 1960s (Hoe 1973) from the Big Island, where it is thought to be indigenous (Hotchkiss *et al.* 2002). Though *Sphagnum*, on Oahu, cannot produce spores, an eightfold increase in the size of the core infestation has been observed over the last 12 years. Through vegetative reproduction, Sphagnum now occupies an area estimated at 1.25 ha.

Sphagnum impacts in Hawaii are not well documented; nonetheless, bryologists consider it a threat to endemic bryophytes and speculate it may prevent regeneration of *Metrosideros polymorpha*, an endemic tree species (Waite 2007). Results of a formal Weed Risk Assessment following the model developed by Daehler and Denslow (2007) demonstrate Sphagnum is "likely to be invasive in Hawaii and on other Pacific Islands" (Clifford and Chimera 2009). Elsewhere, *Sphagnum* species are known to strongly modify their habitat. *Sphagnum* has morphological attributes which favor the formation of highly-saturated, heat-retaining, nutrient-poor, acidic soils. These conditions enhance their growth at the expense of vascular plant growth (van Breeman 1995).

In the fall of 2008, OANRP conducted two field studies. STUDY 1 compared vascular plant species richness and abundance between pristine (*Sphagnum*-free) and invaded (*Sphagnum*) areas. STUDY 2 investigated the efficacy of manual removal of *Sphagnum* against that achieved with the application of a low or a high dose of St. Gabriel's Moss Killer (SGMK). SGMK is an organic mossicide composed of clove oil and vinegar (see figure below). It shows promise as a safe, less labor-intensive means of controlling *Sphagnum* than manual removal. In addition, we wanted to document any non-target impacts to native vascular plant species attributable to these control methods.

Label and active ingredients in St. Gabriel's Moss Killer (SGMK)



6.3.2 Methods

6.3.2.1 STUDY 1

Sixty plots measuring 1 m^2 were established at Kaala NAR. Half were situated 5-15 m from the furthest edge of a *Sphagnum* invaded area, while the remainder fell within the invasion but at least 1 m from the boardwalk which bisects the infestation. All plots were at least 2 m from the next nearest plot. All *Sphagnum* plots were 100% invaded. The species identity and number of stems above and below 1 m were recorded for all vascular plants. Following data collection, comparison of species richness between *Sphagnum* and *Sphagnum* free plots were analyzed using a two-sample T-test. The effect of sphagnum on the abundance (as indicated by stem counts) of common vascular plant species < 1 m was analyzed using a general linear model (GLM). *Only* species that occurred in 4 or more plots of each type (referred to here as common species) were used in the analysis.

These species follow: *Cibotium* spp., *Dianella sandwicensis*, *Dryopteris glabra*, *Leptecophylla tameiameiae*, *Lycopodium cernua*, *Metrosideros polymorpha* and *Vaccinium calycinum*. Incidental species and those above 1 m could not be used due to small sample size.

6.3.2.2 STUDY 2

We established 40, 1 m^2 plots at Kaala NAR (10 replicates per treatment plus a control) according to methodology described in STUDY 1 for the *Sphagnum* group only (no *Sphagnum* free plots were used).

All plots had 100% living *Sphagnum* cover prior to treatment. Each was randomly assigned to one of the following groups:

1. No treatment (control)
2. Manual removal of all living (green) *Sphagnum*
3. High dose of SGMK applied at a rate of 300 l/1.5 H_2O
4. 4. Low dose of SGMK applied at a rate of 150 ml/1.5 H_2O

Efficacy was evaluated using percent cover estimates of living (green) sphagnum remaining 6 months after treatment compared against control plots. Differences due to treatment were analyzed using a one-way analysis of variance (ANOVA) followed by a Tukey's honestly significant differences test (Tukey's HSD).

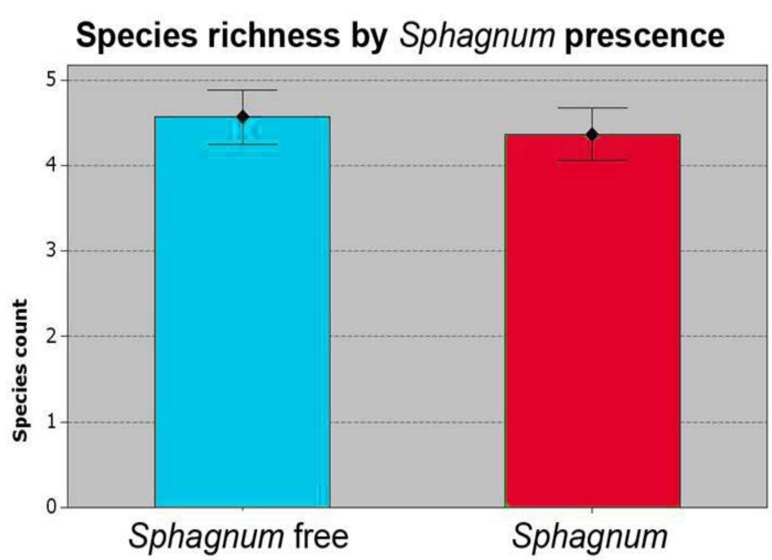
Impacts to non-target species were measured using stem counts of vascular plant species 1 week before and 6 months after treatment. Changes in stem count due to treatment were analyzed using a GLM. As in STUDY 1, species above 1 m and those which occurred in fewer than 4 plots (of each treatment) were excluded from the analysis due to small sample size. Species included follow: *Cibotium spp*., *Dianella sandwicensis*, *Leptecophylla tameiameiae Metrosideros polymorpha* and *Vaccinium calycinum.*

6.3.3 Results and discussion

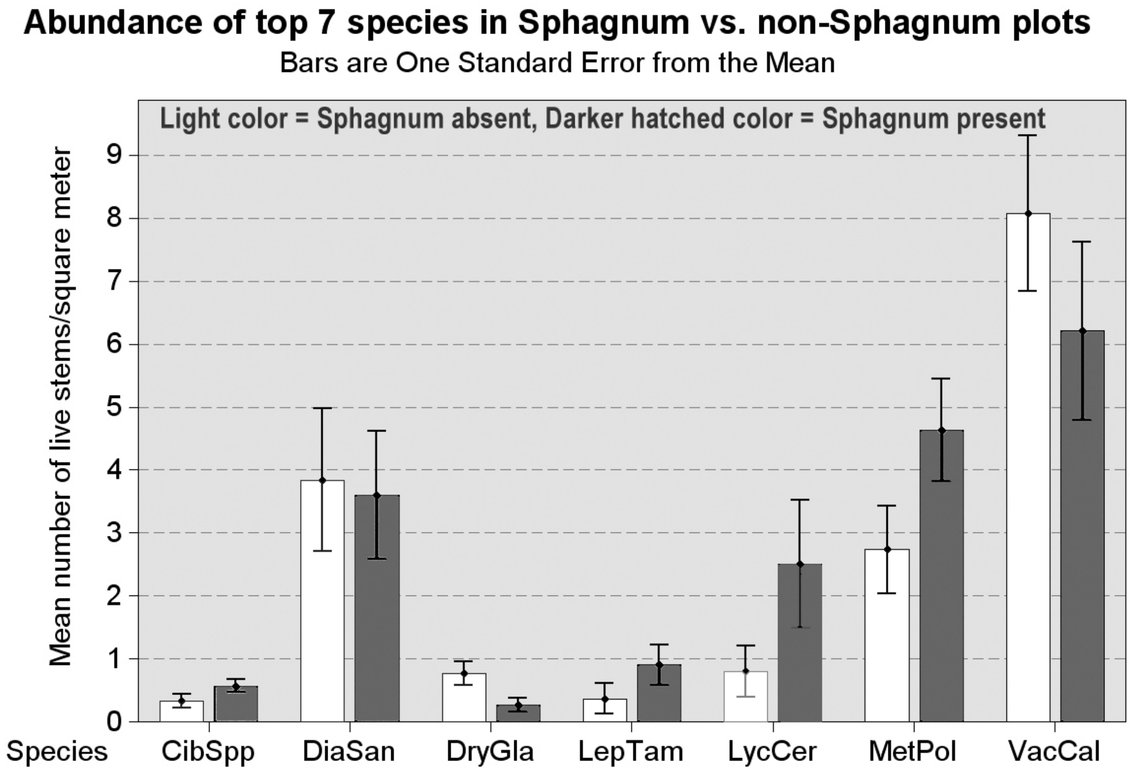
6.3.3.1 STUDY 1

Vascular plant species richness was similar in both *Sphagnum* and *Sphagnum* free areas (see first figure below). Both contained, on average, 5 species. Abundance of common natives is shown in second figure below. No significant difference in the abundance of these species due to *Sphagnum* presence or absence was found. Results suggest that *Sphagnum* does not uniformly depress the growth of all species, rather, it interacts with some positively (*e.g. Lycopodium*) others negatively (*e.g. Dryopteris*) and not at all with others (*e.g. Cibotium*). Such an outcome would not be surprising as *Sphagnum* is known to alter soil characteristics. Serious limitations in our study design, however, make further speculation difficult. While the placement of *Sphagnum* plots within the infestation was fairly uniform, those outside this area were likely not representative of *Sphagnum* free areas. In addition, we do not know whether areas remain free of *Sphagnum* because there has not been sufficient time for colonization to occur or whether this is due to micro site characteristics that prevent expansion. More study is merited.

Vascular plant species richness in *Sphagnum* vs. *Sphagnum* free plots. Bars are ± 1 SEM



Vascular plant species abundance in *Sphagnum* vs. *Sphagnum* free plots. Bars are ± 1 SEM.

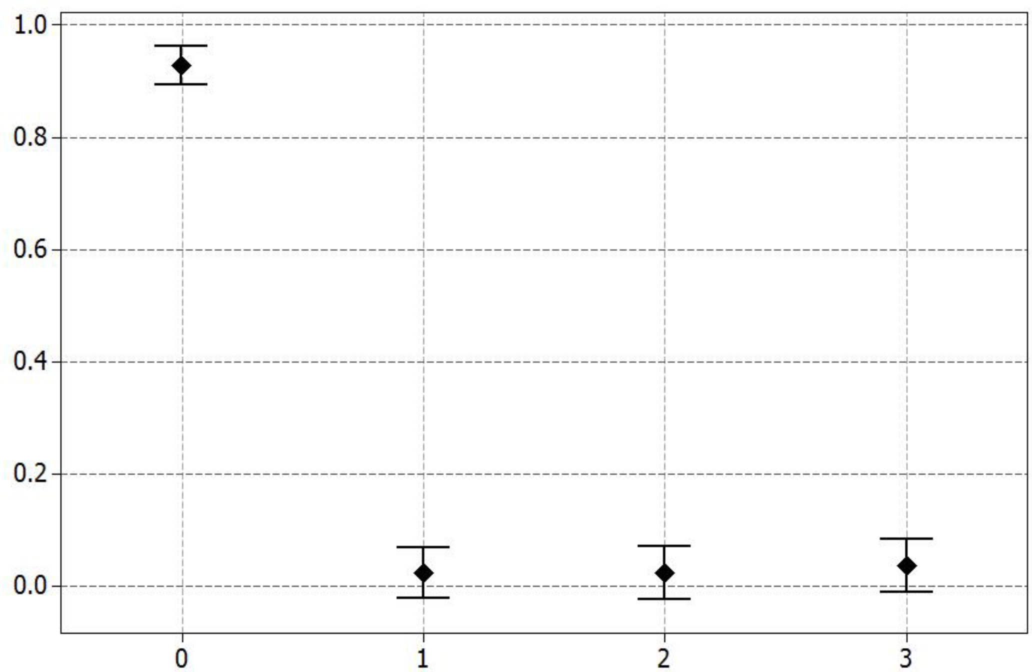


6.3.3.2 STUDY 2

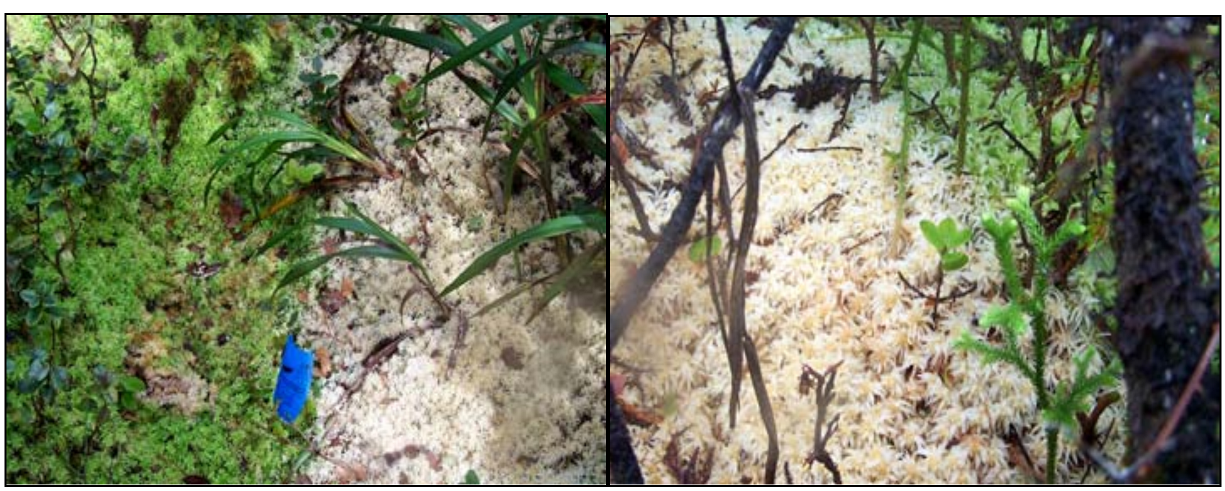
All three *Sphagnum* removal methods significantly reduced cover relative to the control (see next graph). No differences in efficacy were detected between the three Sphagnum control methods, all reduced cover approximately 95%. These results are promising as they provide an alternative to labor intensive manual removal of moss. Further, they suggest that smaller doses of SGMK can and should be tested for efficacy. In fact, trials recently concluded with doses as small as 75 ml have apparently killed moss 2 weeks following treatment (see photos below).

Though differences were not significant, reductions in common native species were, on average, higher in the manual removal and high dose SGMK treatments compared to either the control or low dose SGMK groups (see second graph below). The lack of significance may be due to small sample size and future work should investigate impacts to potentially sensitive species (e.g. *Leptecophylla* and *Dianella*). Interestingly, manual removal of moss was not without risk to non-target species. These data suggest that a low dose of SGMK is safer (fewer risks to non-target species) and more efficacious than manual removal. Indeed, future tests of progressively lower doses of SGMK may reduce risk without sacrificing efficacy.

Comparison of *Sphagnum* removal methods. Sphagnum cover (percent) is shown on the Y axis. Treatment codes shown on the X axis correspond to the following groups: 0 = control; 1 = SGMK low dose; 2 = SGMK high dose; 3 = manual removal. Bars are ± 1 SEM

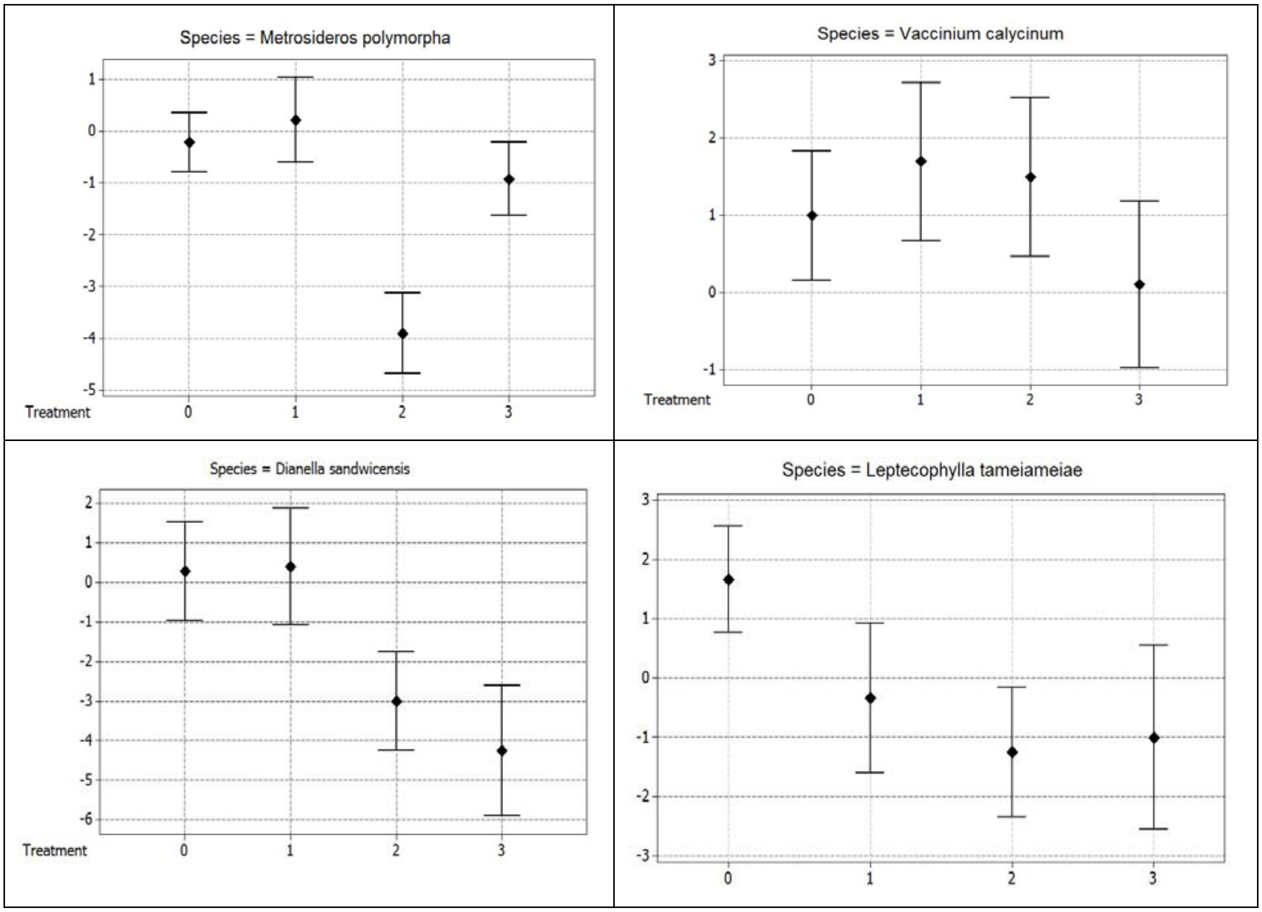


Sphagnum treated with 75 ml of SGMK 2 weeks after application. The darker area was not sprayed.



This figure can be viewed in color at http://www.botany.hawaii.edu/faculty/duffy/DPW/HCC-2009/

Change in native species abundance 6 months after treatment. Y axis units are in number of stems/m^2. Treatment codes shown on the X axis correspond to the following groups: 0 = control; 1 = SGMK low dose; 2 = SGMK high dose; 3 = manual removal. Bars are ± 1 SEM

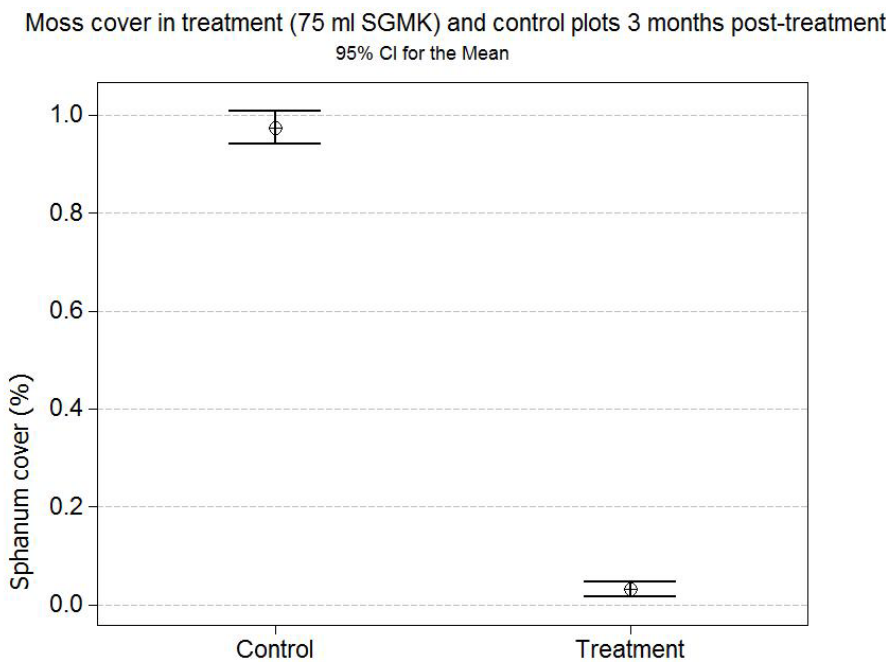


6.4 *SPHAGNUM PALUSTRE* SENSITIVITY TO SGMK LABORATORY RESULTS

6.4.1 Introduction

Previous research showed no difference (after 6 months) in *Sphagnum palustre* response to high (300 ml) and low (150 ml) doses of SGMK. These results led OANRP to treat an additional 10 plots with an even lower dose (75ml) of SGMK on June 4, 2009. Results 3 months post-treatment showed SGMK applied at a rate of 75 ml/m^2 reduced Sphagnum cover significantly over the control group (see next graph). As preliminary results showed SGMK equally effective regardless of dose, further field testing was halted until the sensitively of Sphagnum to extremely low doses of SGMK could be determined in the laboratory. This section describes our laboratory experiment.

***Sphagnum* cover was significantly reduced (2 sample T-Test, P<0.0001) in plots treated with 75 ml SGMK. Average reduction in *Sphagnum* cover for 75 ml after 3 months was similar to that found at 6 months for higher doses.**



6.4.2 Methods

Sphagnum was collected from the Kaala NAR on August 6, 2009, and maintained for 1 week in a growth chamber at the University of Hawaii at Manoa (Temp. 67° F; 12 hour light/dark cycle) prior to testing. Replicates consisted of three strands of healthy (green) *Sphagnum*, 1 inch long, placed in a petri dish with moist filter paper. Forty two dishes of *Sphagnum* were prepared in this manner, arranged in rows and randomly assigned to 1 of 6 treatments (see next photo).

Arrangement of dishes and group assignments prior to treatment. Note that all *Sphagnum* was alive prior to treatment and that treatments were randomized within each column for a total of 7 replicates per group.

Numeric codes written on petri dish covers correspond to the following treatment groups:

Group 1: No treatment (control)

Group 2: 75 ml SGMK/1.5 l H_2O

Group 3: 37.5 ml SGMK/1.5 l H_2O

Group 4: 19 ml SGMK/1.5 l H_2O

Group 5: 9.5 ml SGMK/1.5 l H_2O

Group 6: 5 ml SGMK/1.5 l H_2O

Treatment was applied by dipping moss for 1 second in SGMK solution (control group dipped in water only) after which the strand was returned to the petri dish. Moss was scored as either green (alive) or brown (dead). Thus, a dish with no living *Sphagnum* received a score of 0, while one with all three strands alive received a score of 1 (see next photo). Moss color was recoreded1 hour post treatment and then every two days over a period of 2 weeks (August 12-26, 2009).

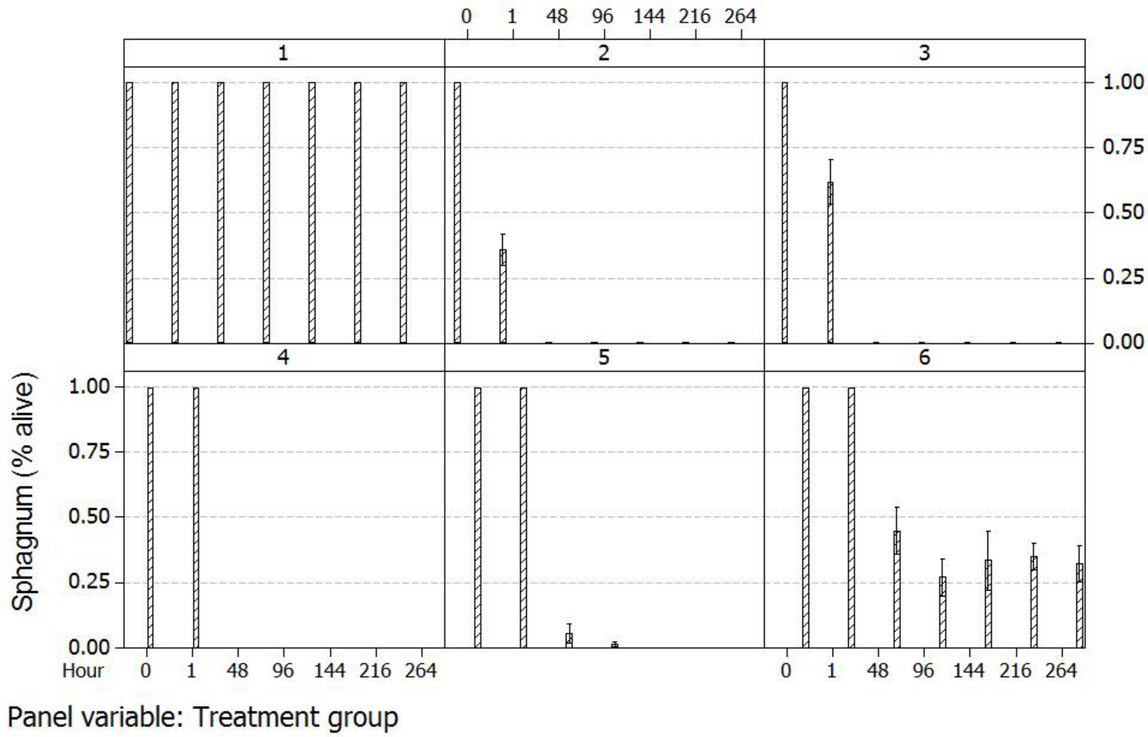
Example of color changes due to treatment. The *Sphagnum* on the left received a score of 1, indicating that all 3 strands remain green, while that on the right received a 0 (none alive).

This figure can be viewed in color on-line at http://www.botany.hawaii.edu/faculty/duffy/DPW/YER_2009/

6.4.3 Results and discussion

Moss survival by treatment over time is shown in the below graph. Moss survival at two weeks was significantly reduced in all SGMK treatments compared to the control. Only the lowest concentration of SGMK (5 ml) failed to kill 100 percent of the moss. SGMK at concentrations 19 ml and above resulted in 100 percent mortality after 48 hours. SGMK at concentrations >19 ml showed browning within 1 hour of application. Based on these findings, an application rate of 25 ml SGMK per square meter was field tested on September 4, 2009.

Moss survival over time (hours) by treatment. Panel headings correspond to the following treatment groups: one: No treatment (control); two: 75 ml SGMK/1.5 l H_2O; three: 37.5 ml SGMK/1.5 l H_2O; four: 19 ml SGMK/1.5 l H_2O; five: 9.5 ml SGMK/1.5 l H_2O; six: 5 ml SGMK/1.5 l H_2O



6.5 ANT SURVEYS

OANRP has conducted a thorough survey of ants in all Management Units with native endangered *Achatinella* species using a protocol developed by S. M. Plentovich, PhD (University of Hawaii at Manoa Zoology) and P. D. Krushelnycky, PhD (University of Hawaii at Manoa Plant Environmental Pest Program). This protocol appears in Appendix 6-1 titled Invasive Ant Monitoring Protocol. Below, please find a table of management units surveyed this past year. Collections are still being sorted. Management implications and analysis of these findings will appear in next year's annual report.

Management Units Surveyed in 2008-2009

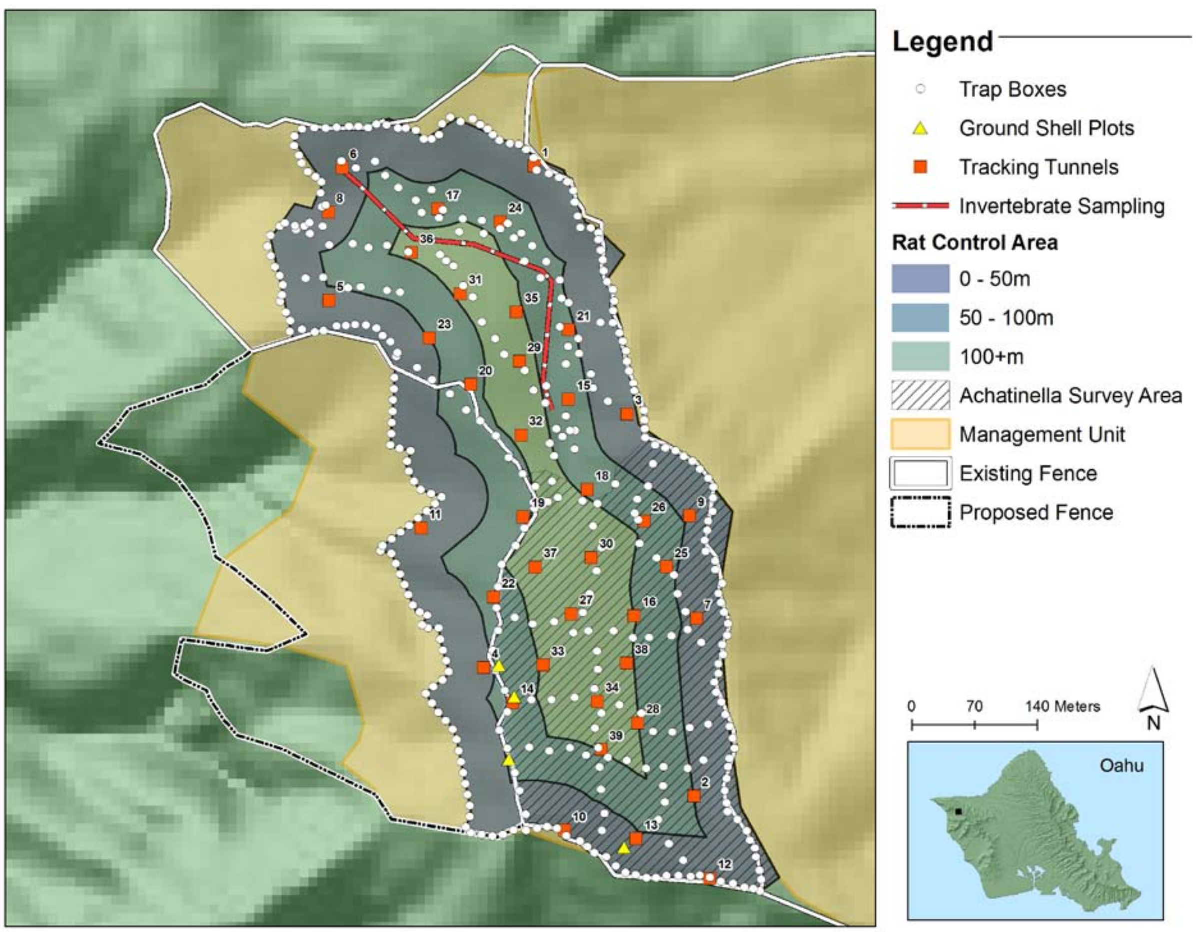
Management Unit	Ant Species Found 2008-2009
Helemano	*Pheidole megacephala, Solenopsis papuana*
Kaala	*Cardiocondyla minutior, C. venustula, C. wroughtoni, Ochetellus glaber, Solenopsis papuana, Tetramorium simillimum*
Kaena Point	*Ochetellus glaber, Monomorium floricola, Paratrechina longicornis, Tetramorium simillimum*
Kahanahaiki	*Anoplolepis gracilipes, Cardiocondyla emeryi, C. wroughtoni, C. venustula, Leptogenys falcigera, Ochetellus glaber, Plagiolepis alludi, Solenopsis geminata, S. papuana, Technomyrmex albipes, Tetramorium simillimum*
Kaluakauila	*Anoplolepis gracilipes, Ochetellus glaber*
Ekahanui	*Plagiolepis alludi*, *Solenopsis papuana*
Ohikilolo	*Ochetellus glaber, Pheidole megacephala*
Pahole	*Paratrechina longicornis*, *Solenopsis papuana*
Palikea	*Cardiocondyla venustula*, *Solenopsis papuana*

6.6 Rat – Kahanahaiki: Large Scale Trapping Grid

6.6.1 Introduction

In May 2009, a large scale kill trapping grid for rat (*Rattus* sp.) control was initiated over an area of 65 acres (26 ha) at the Kahanahaiki MU (see figure below). The control grid follows the New Zealand Department of Conservation's current best practices for kill trapping rats (see Appendix 6-2). OANRP purchased wooden snap trap boxes and tracking tunnel monitoring equipment that is only available from New Zealand to facilitate this method of control (photos on next page). The trap out grid was established as a pilot study with a goal of reducing rat activity in the MU to < 10%, as well as to determine the efficacy of this method of rat control and to determine labor requirements and costs. The grid encompasses 11 endangered plant species, both wild and reintroduced populations, and a large population of endangered *Achatinella mustelina*. The focal endangered taxa to be monitored closely are *Cyanea superba* subsp. *superba* and *Achatinella mustelina*. Beyond monitoring the focal taxa, OANRP will in addition monitor seedlings, seed fall, and arthropod composition and abundance. Slug and *Euglandina rosea* populations were monitored closely to determine if rats have had a suppressing affect on these introduced species. The Pahole Natural Area Reserve (NAR) will be used as a control site to determine what impacts rats are having (seedlings, arthropods, *C. superba* subsp. *superba*, slugs, and *E. rosea*).

Kahanahaiki MU: Rat control area and monitoring locations.



(A) Wooden snap trap box with Victor snap trap. (B) Wooden snap trap box deployed. (C) Plastic tracking tunnel with inked tracking card. (D) Tracking card with mouse tracks.

6.6.2 Data Collection/Methods

6.6.2.1 Rat Control (Kahanahaiki MU only)

The trap out grid was established with a total of 402 traps (figure above, on previous page). The perimeter consists of 234 traps spaced at 12.5m apart. The interior contains 168 traps established on transects and existing trails (9 trap lines) at a spacing of 25m between traps. Traps were initially set and baited on May 4, 2009. Traps were checked daily for approximately the first two weeks, then on a weekly basis for eight weeks, then two three week intervals, with the current checking interval bi-weekly. Traps will continue to be checked every other week, unless determined through monitoring a change in interval length is needed. Baits that have been used include: peanut butter, macadamia nut halves, coconut chucks, scented surf wax, and Ferafeed (non-toxic bait from New Zealand).

6.6.2.2 Tracking Tunnels (Kahanahaiki MU & Pahole NAR)

Kahanahaiki MU – Tracking tunnel locations (39) were randomly generated with ArcGIS into three buffer zones (0-50m, 50-100m, +100m), with each zone containing 13 tunnels (Figure 10.7.1). The minimum distance allowable between tunnels was set at 50m. The first running of tracking tunnels was on 30 April to 01 May (4 days) prior to baiting the trap out grid. The seconded running occurred two weeks later on 18 to 19 May. Each subsequent check will be monthly.

Pahole NAR- Tracking tunnels (30) were located within the two main drainages at 50 m intervals. Tracking tunnels will be run once a quarter with the initial running occurring on 17-18 August 2009.

6.6.2.3 Slug Abundance Monitoring (Kahanahaiki MU & Pahole NAR)

Relative slug density and species composition was determined through the use of beer baits left out for one week at each site. Two 8 ounce glass jars were deployed at 25 m intervals along a 475 m transect. A total of 40 jars were deployed and baited with 5 oz. of beer. The number and species identity of slugs captured in this manner were recorded at four month intervals.

6.6.2.4 Euglandina rosea Abundance Monitoring (Kahanahaiki MU & Pahole NAR)

Euglandina rosea density was determined through timed searches along the same 475 m transect being use for slug sampling at each site. Ten plots (3 x 25 m) were searched for one person hour. Each plot was separated from its closet neighbor by an interval of 25 m. Live *E. rosea* were measured and their prescience noted, but left onsite recorded. Empty *E. rosea* shells were removed from plots and scored for rat damage (categories: intact, damage rat, damage other). Monitoring occurred at four month intervals.

6.6.2.5 Arthropod Composition & Abundance Sampling (Kahanahaiki MU & Pahole NAR)

Two types of arthropod sampling were conducted: pitfall trapping and vegetation beating. Sixteen pitfall traps, spaced at 25 m intervals along the same 475 m transect (used for both slug and *Euglandina* monitoring), were established at each site. These 16 traps consisted of 10 ounce plastic cups sunk in the ground, and were operated for one week. In addition, four shrub or tree species were sampled for arthropods (*Psidium cattleianum, Pipturus albidus, Pisonia umbelifera* and *Charpenteria tomentosa*). Eight individuals of each of the four plant species were sampled. These were selected randomly along the 475 m transect. Each individual shrub/tree was sampled once per sampling event, which involves tapping low branches five times while holding a square sheet beneath the branches. All arthropods dislodged in this way were collected. Samples were collected at six month intervals.

6.6.2.6 Seedling Monitoring (Kahanahaiki MU & Pahole NAR)

Eighty and sixty-five seedling plots were established within the gulch area of the Kahanahaiki MU and Pahole NAR respectively. Within each seedling plot (1 x 2 m), all woody plants≥ 10 cm height (but less than 1 m height; henceforth seedlings) were identified, measured for height, measured for stem diameter above the root crown, and marked with an aluminum tag. Any woody plants < 10 cm height were identified but not measured or marked. Within each seedling plot, percent cover of dead wood and leaf litter, total vegetation cover (including grasses, herbs, and woody plants), and litter depth (at four standardized points in each of the corners of the seedling subplots) were measured. Seedling plots will be read once a year.

6.6.2.7 Seed Monitoring (Kahanahaiki MU only)

Rodent-chewed seeds were monitored using seed buckets placed on the ground (bucket height and diameter each ca. 30 cm), with a cotton cloth attached to the bottom of the bucket, in Kahanahaiki forest. Forty-eight seed buckets were partitioned equally among 12 plots (each 15 x 15 m) that were previously established in Kahanahaiki gulch. The four buckets per plot were placed without regard to the canopy tree species, therefore allowing for a representative sample the natural seed rain of species that comprise the forest. An additional 10 buckets were placed below lama trees (*Diospyros hillebrandia*), which is an indigenous species to Hawaii that has seeds previously determined as highly vulnerable to *R. rattus* (A. Shiels, unpublished data). Because lama has a patchy distribution in Kahanahaiki, the 10 seed buckets were split evenly between two patches (each patch contained at least eight lama trees either overhanging buckets or within 3 m of a bucket). In addition to lama, the other indicator species that was assessed for seed damage among the 48 buckets was strawberry guava (*Psidium cattleianum*). Strawberry guava also has seeds that are highly vulnerable to rats (A. Shiels, unpublished data); it is also one of the most invasive trees in Hawaiian forests, and is the dominant tree species in Kahanahaiki gulch. Seed buckets will be monitored every two weeks.

6.6.2.8 Achatinella mustelina Monitoring (Kahanahaiki MU only)

An *Achatinella* census was conducted across the southern area of the Kahanahaiki MU in August 2009 (Figure 10.7.1). This area will have censuses conducted at three year intervals.

6.6.2.9 Cyanea superba subsp. superba Monitoring (Kahanahaiki MU & Pahole NAR)

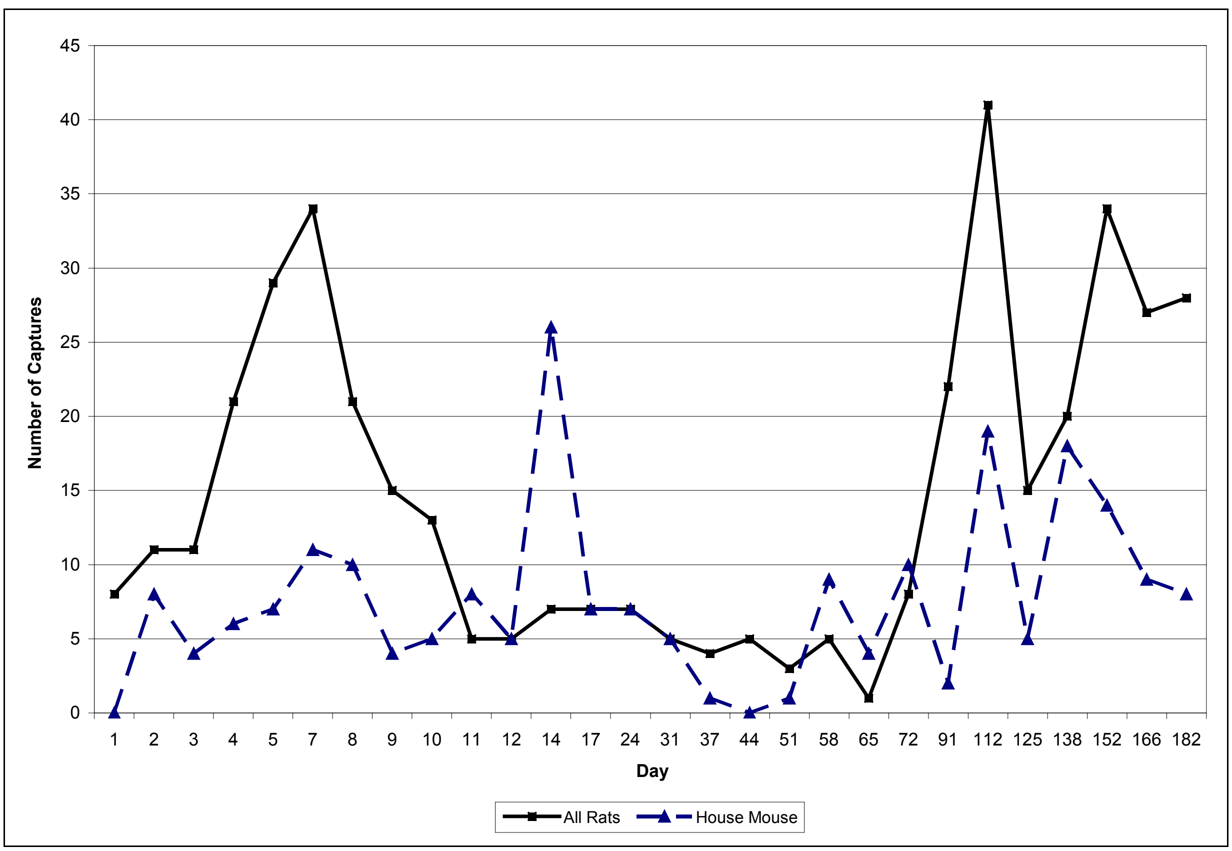
All mature fruiting *C. superba* subsp. *superba* will be monitored closely at both the Kahanahaiki MU and Pahole NAR from mid December through the first week of January (4 weeks) each year. The total number of fruit on each infructescence will be counted at each visitation. The following will be recorded (as a percentage of the total number of fruits present), 1) natural fruit fall (fruits will be counted on the ground where they occur), 2) fruits that have been damaged or eaten by rodents, 3) fruits which have been wholly or partially eaten by birds, 4) fruits which have rotten on the plant.

6.6.3 Results

6.6.3.1 Rat Control (Kahanahaiki MU) & Tracking Tunnel Monitoring (Kahanahaiki MU & Pahole NAR)

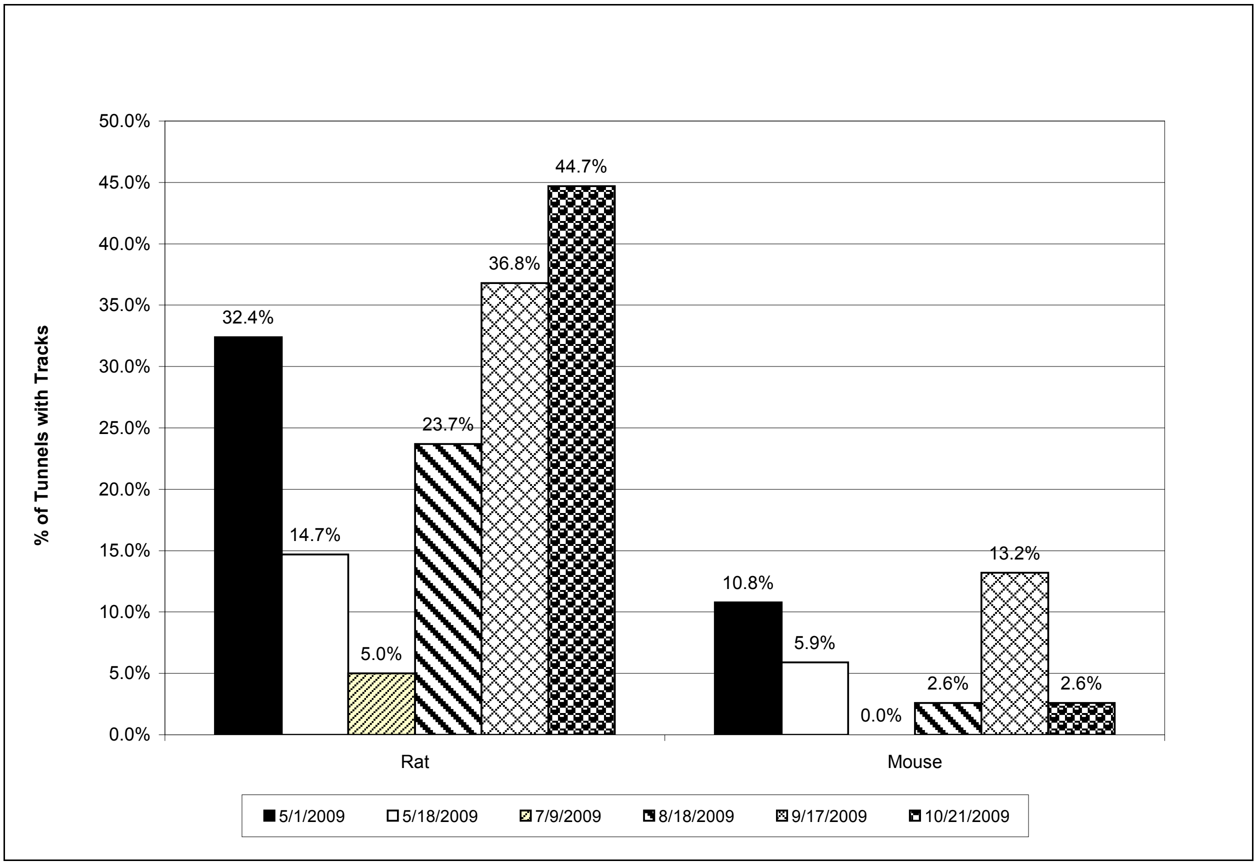
The trap out grid has been checked 27 times over a six month period with a total of 412 rats and 213 mice trapped (figure below). Fifty percent of rat and mouse captures occurred within the first 40 days. Initially captures for rats peaked at Day 6 and declined sharply by Day 11 and continued on a downward trend with one capture on Day 65 (figure below). A steady increase in rat captures occurred following the downward trend with the highest number of captures occurring on Day 112 (41 rats). Rat captures have remained high over last 60 days. Mouse captures have tracked rat captures with the exception of a spike in captures occurring on Day 14 (figure below).

Rat and mouse captures over 182 day trapping period (May 5 – October 21, 2009) at Kahanahaiki.



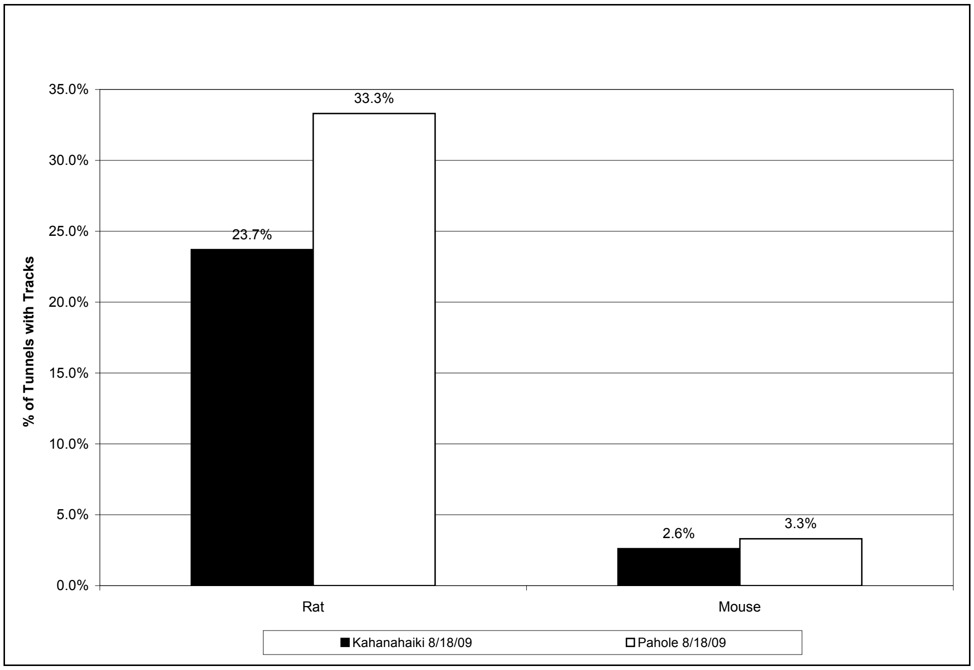
Tracking tunnels at the Kahanahaiki MU have been run six times over a six month period (May 1 – October 29, 2009) (figure below). The initial running of tracking tunnels four days before the start of trapping yielded 32.4% rat activity among 37 tunnels deployed. Fourteen days after trapping commenced rat activity dropped to 14.7% and farther declined to 5% by Day 65. Following this downward trend activity steady increased each month, peaking at 44.7% on Day 170. Mouse activity followed a similar trend as the rats, except for not peaking on Day 170 and instead declining in activity.

Tracking tunnel data for rat and mouse activity during six tracking tunnel session at the Kahanahaiki MU (01 May – 21 October 2009).



On Day 106 (18 August 2009) tracking tunnels were simultaneously run at both the Kahanahaiki MU and the Pahole NAR to compare the two sites (Management vs. Control). The Kahanahaiki MU had 23.7% rat activity among the tracking tunnels, while the Pahole NAR hat 33.3% activity (next figure). Mouse activity was similar between the two sites.

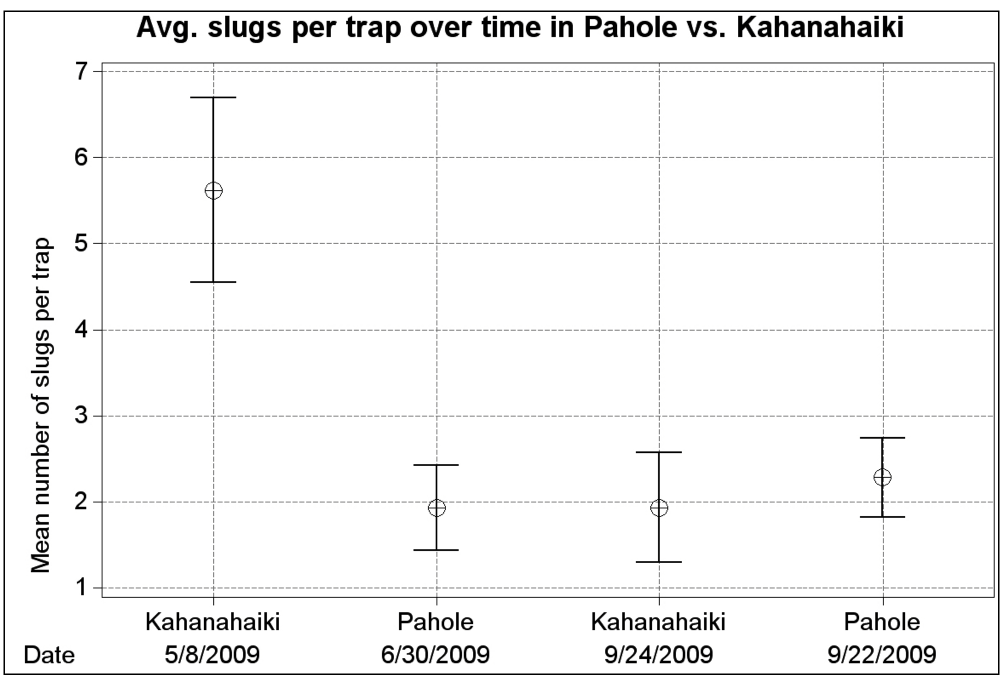
Tracking tunnels in Kahanahaiki and Pahole (17-18 August 2009).



6.6.3.2 Slug Monitoring (Kahanahaiki MU & Pahole NAR)

Slugs at the Kahanahaiki MU were initially sampled in early May upon the commencing of rat control with the initial Pahole NAR sampling occurring in late June (figure below). The higher number of slugs captured in May at the Kahanahaiku MU maybe a seasonal difference (spring vs. summer), then indicating a higher number of slugs at the Kahanahaiki MU versus the Pahole NAR. Slugs were sampled for the second time during the same week in late September. A similar number of slugs were captured at both sites in September.

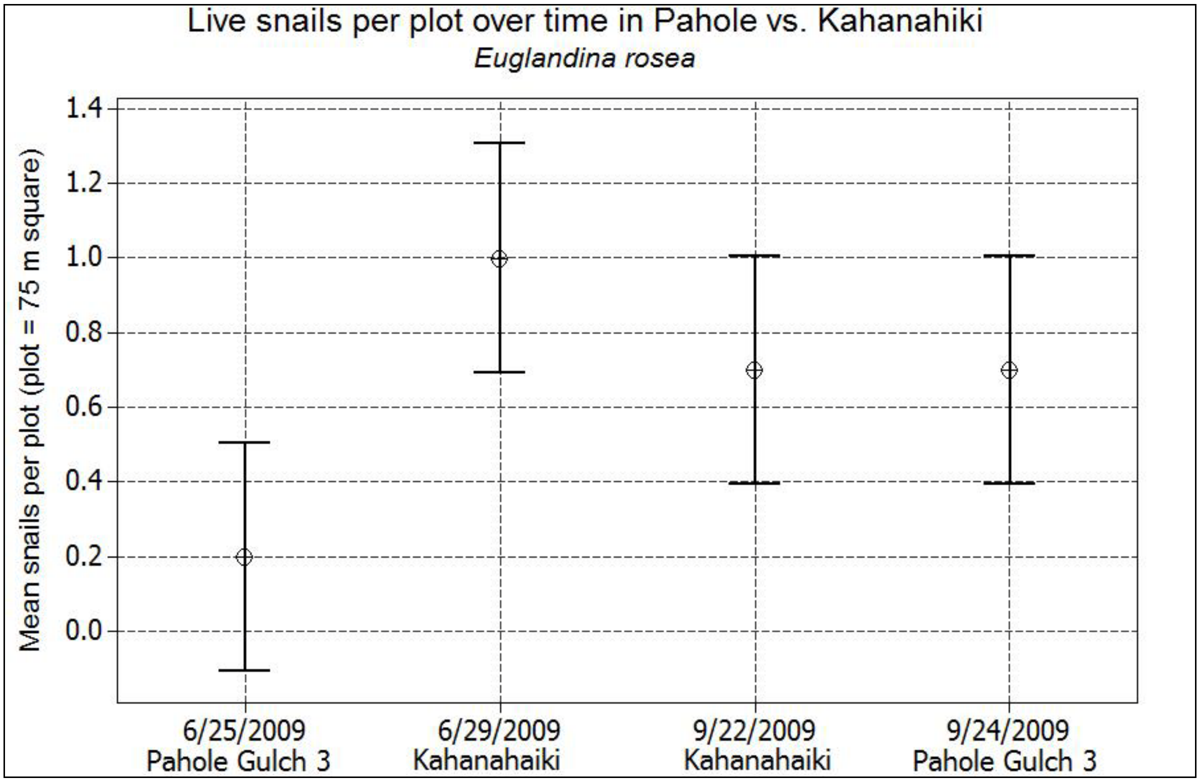
Mean number of slugs captured per trap in Kahanahaiki and Pahole. Bars are ± 1 SEM.



6.6.3.3 Euglandina Monitoring (Kahanahaiki MU & Pahole NAR)

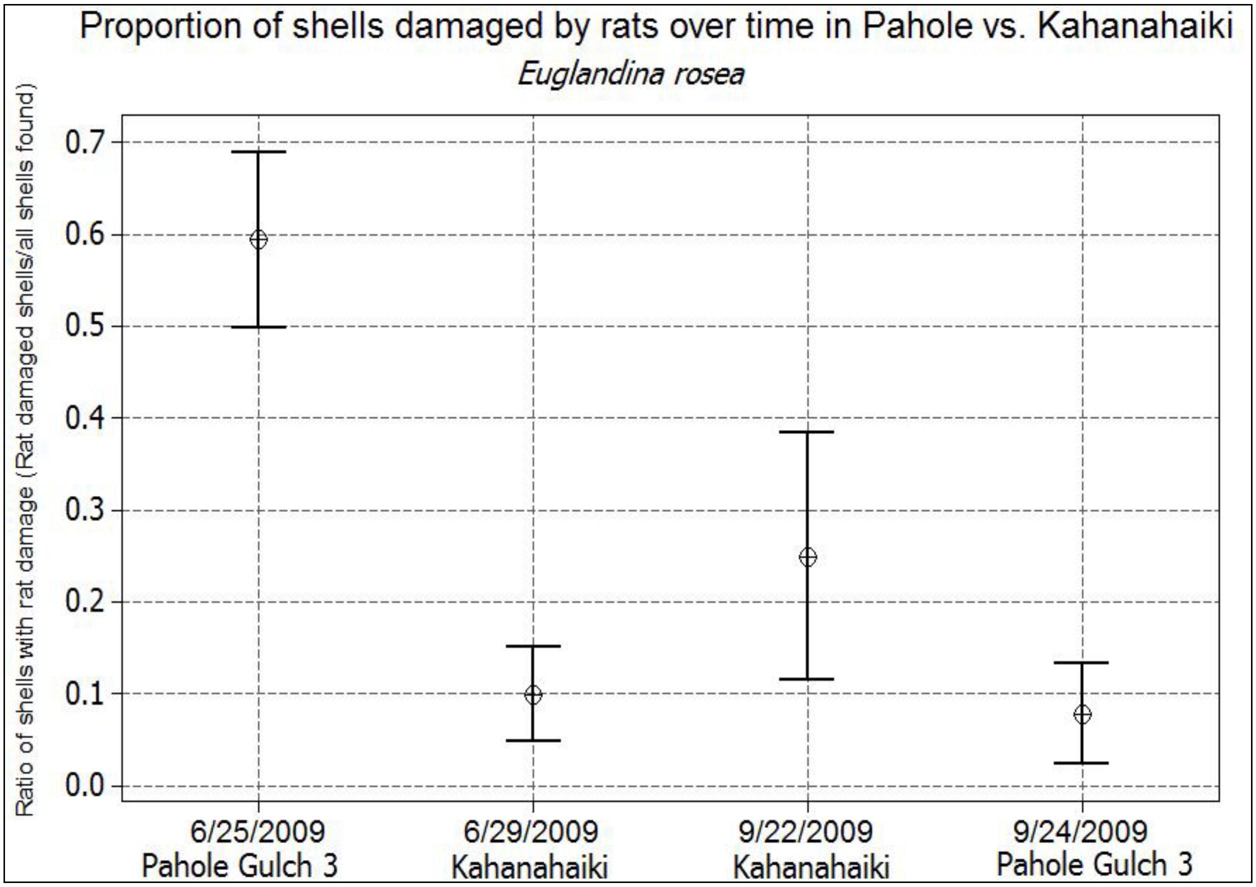
Data was collected during two sampling periods for both sites in late June and late September (next figure). The mean number of live *Euglandina* found in plots differed slightly between sites during the first sampling period in late June and showed no difference during the second sampling period in late September.

Mean number of live *Euglandina rosea* found at Kahanahaiki and Pahole during two sampling periods.



The ratio of *E. rosea* shells chewed by rats over the total number of shells found in each plot is shown over time by site (next figure). If rats are, in fact, consuming high numbers of *E. rosea* then this should be reflected in a higher proportion of empty shells observed to be chewed rather than intact. Only the second sampling period (September) is a valid comparison between the two sites, since these ratios reflect the shells accumulated in the plots since their clearing for the first time in June. The initially high number of shells with rat-damage in Pahole Gulch 3, therefore, may not indicate high rat activity as they may simply have been washed or rolled into the gulch over time. There is no difference between the sites during the second sampling period.

Proportion of rat damaged *Euglandina rosea* shells from Kahanahaiki and Pahole (Each site has 10 plots that are each 75m^2).



6.6.3.4 Arthropod Composition and Abundance Sampling (Kahanahaiki MU & Pahole NAR)

Initial arthropod sampling was conducted in June 2009 for both the Kahanahaiki MU and Pahole NAR. Sixteen pitfall samples and 32 vegetation beating samples (eight each from four plant species) were collected. The second sampling period will be conducted in December 2009. June samples are currently being processed.

6.6.3.5 Seedling Monitoring (Kahanahaiki MU & Pahole NAR)

From the initial (year 2009) seedling census, there were 313 individual seedlings marked within the 80 seedling plots established at Kahanahaiki. The majority of seedlings were *Psidium cattleianum* and *Clidemia hirta* and a total of seven non-indiginous species were represented. There were several (12) indigenous seedling species represented in the census, yet there were relatively few individuals of each indigenous species. Maile (*Alyxia stellata*, formerly *A. oliviformis)* was the most frequent indigenous seedling measured.

At Pahole, there were 140 seedlings marked within the 65 seedling plots. Interestingly, there tends to be slightly more individuals that are indigenous than non-indigenous. Maile was the most common indigenous seedling, out of 10 total indigenous species tagged, but lama (*P. hillebrandii*) also had relatively high representation in the seedling plots. Strawberry guava and *Rubus rosifolius* (thimbleberry) were the two most common non-indigenous species out of the seven total non-indigenous species tagged at Pahole.

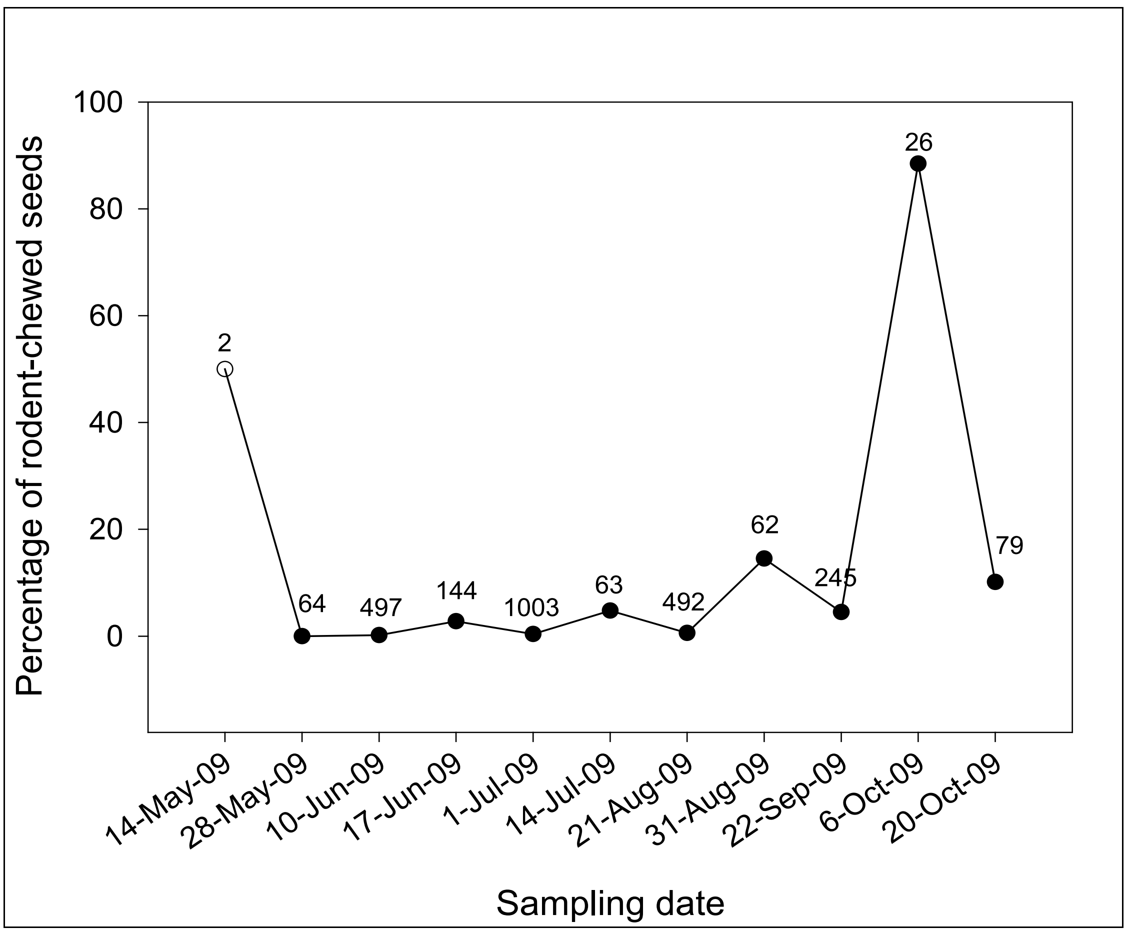
6.6.3.6 Seed Monitoring (Kahanahaiki MU only)

The 48 seed buckets were placed in the field at the start of the rat control (May 5, 2009). Ten additional seed buckets were placed below lama trees on May 28, 2009. Seed buckets have been checked approximately every two weeks and assessed for the number of intact and rodent-damaged lama and strawberry guava seeds.

A total of 71 lama diaspores (fruits+seeds) were collected from the 10 seed buckets beneath lama trees and not one of the fruits or seeds showed signs of rodent damage (i.e., all seeds were intact). The total number of lama diaspores at each collection period (nine collection periods to date) ranged from 1-24.

The other indicator species, strawberry guava, had a number of seeds collected in the 48 seed buckets that had been chewed (and destroyed) by rodents, particularly at the beginning of the trap-out and on 06 October 2009 sampling (figure below). An average of 16 +/- 8.5 (mean +/- SE) destroyed seeds of strawberry guava can be expected on each sampling date. There was only one sampling date (May 28) that did not have any rodent-chewed seeds. The only remaining evidence of destroyed seeds was chewed parts of the seed coat. Although the presence of rodent-chewed seeds of strawberry guava indicate that rodents are still present in Kahanahaiki gulch, the numbers of such rodent-chewed seeds has dramatically decreased from the 2 years prior to the trap-out (A. Shiels, unpublished data).

Percentage of *Psidium cattleianum* (strawberry guava) seeds destroyed by rodents in Kahanahaiki gulch.



Seeds were collected from 48 seed buckets for each sampling date (May-Oct 2009). Above each data point is the total number of seeds (intact+chewed) collected from seed buckets for the sampling date. The rodent trap-out began on May 5, 2009.

6.6.3.7 Achatinella mustelina Monitoring (Kahanahaiki MU only)

A total of 212 *Achatinella mustelina* were counted during the August 2009 census of the Maile Flats area of the Kahanahaiki MU (for more information see MIP 2009 Snail section). A census of this area will be conducted every three years. If necessary this interval will be reduced to annually.

6.6.3.8 Cyanea superba subsp. superba Monitoring (Kahanahaiki MU & Pahole NAR)

Monitoring will be initiated in December 2009 and into January 2010.

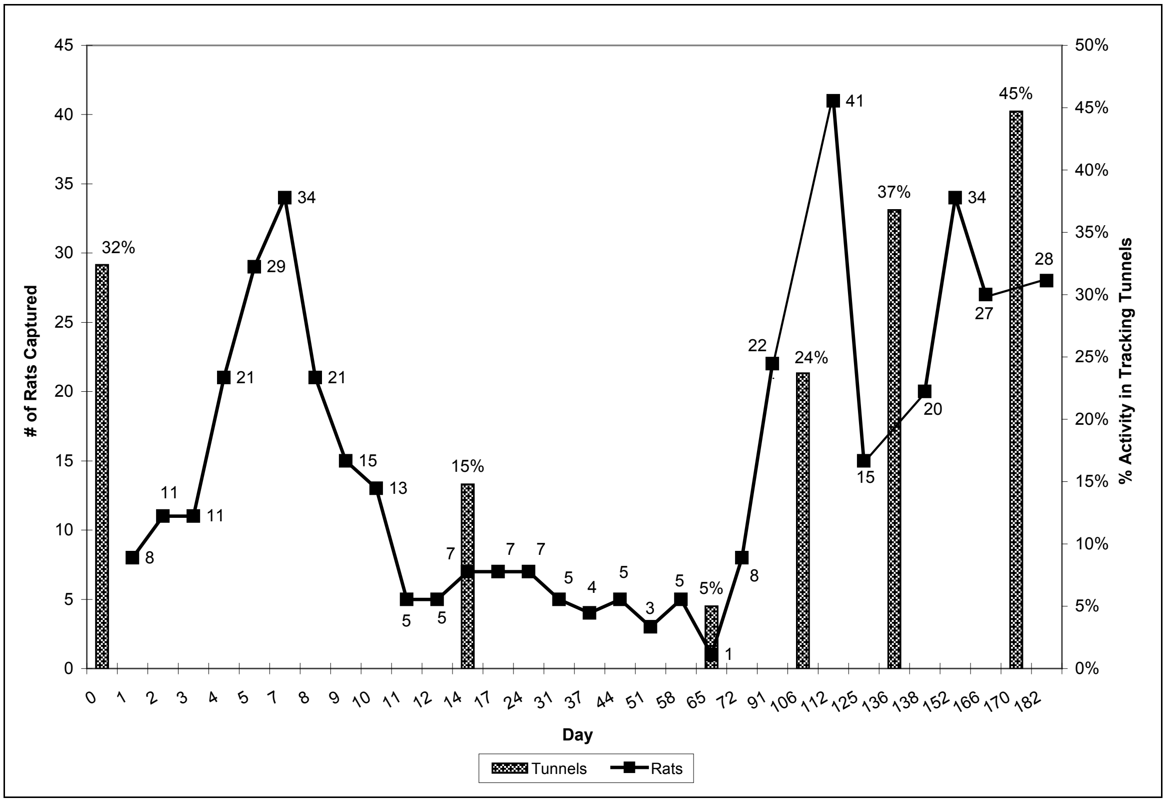
6.6.4 Discussion

This large scale trap out grid is the first of its kind to be implemented in Hawaii for conservation purposes. In New Zealand the Department of Conservation has had tremendous success in controlling rats for the benefit of endangered forest birds using large scale trap out grids. Among New Zealand standards the Kahanahaiki MU grid would be considered very small for landscape scale control. OANRP is viewing the Kahanahaiki MU trap out grid as a pilot study to determine this methods effectiveness, as well as looking at cost comparisons among other available methods of control.

The goal of this control work is to reduce rat activity to < 10 percent within the Kahanahaiki MU, as well as reduce or eliminate rat predation on *Cyanea superba* subsp. *superba* fruits during the fruiting producing period (October through early January) and to reduce rat predation on tree snails. An additional goal is to see a positive change in general forest health through the increase recruitment of native plant species. Over time the OANRP should be able to determine a threshold of rat activity which negatively or positively influences desired focal species conservation. It will take months or even years to make these sorts of determinations as knowledge is slowly gained through continual and close monitoring of rat activity and resource responses to control.

Capture and tracking tunnel data showed an initial peak in captures within the first week (10 May) followed by a decline in both number of captures and tracking tunnel activity by Day 65 (08 July). By Day 91 (03 August), an upward trend in captures and tracking tunnel activity ensued, with the number of captures peaking on Day 112 (24 August) at 41 rat and tracking tunnels on Day 170 (21 October) at 45 percent (next figure). This increased number of rat captures and rat activity in tracking tunnels may possibly be attributed to the natural rat population cycle. A. Shiels (unpublished data) found rat activity (trapping) to be at their highest during the period between August and December at Kahanahaiki. It appears that the resident population of rats was reduced very quickly at the start of the trapping, but increased with the influx of rats from outside the trapping grid. This assumption will only be confirmed with continued trapping and monitoring over time.

Rat captures in traps and percent activity in tracking tunnels at Kahanahaiki.



Preliminary results suggest rat removal did not cause an increase in slug or *E. rosea* abundance. This is reflected in the lack of significant differences between Pahole and Kahanahaiki in either the number of slugs or *E. rosea* in the month of September, approximately four months after rat removal was begun in the treatment area. Further sampling, however, is needed to confirm this observation. An initial arthropod sampling has been conducted at both sites and the second sampling will take place in December 2009. Strawberry guava seed bucket data has closely tracked the rat capture and tracking tunnel data. As data continues to be collected over time a clearer picture will be obtained as to how and when the trap out grid methods need to be modified to gain the desired outcome.

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APPENDIX 1 CHAPTER 1 APPENDICES

Appendix 1 contains supplemental information for Chapter 1. Contents of Appendix 1 include:

- Appendix 1-1: Environmental Outreach 2009
- Appendix 1-2: Weed Control
- Appendix 1-3: Oil-Based Carrier Herbicide Trials
- Appendix 1-4: OED Survey Results for Schofield Barracks and Wheeler AAF

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APPENDIX 1-1: ENVIRONMENTAL OUTREACH 2009

VOLUNTEER SERVICE TRIPS:

Volunteers remove the incipient weed, *Juncus effusus,* from the summit of Kaala.

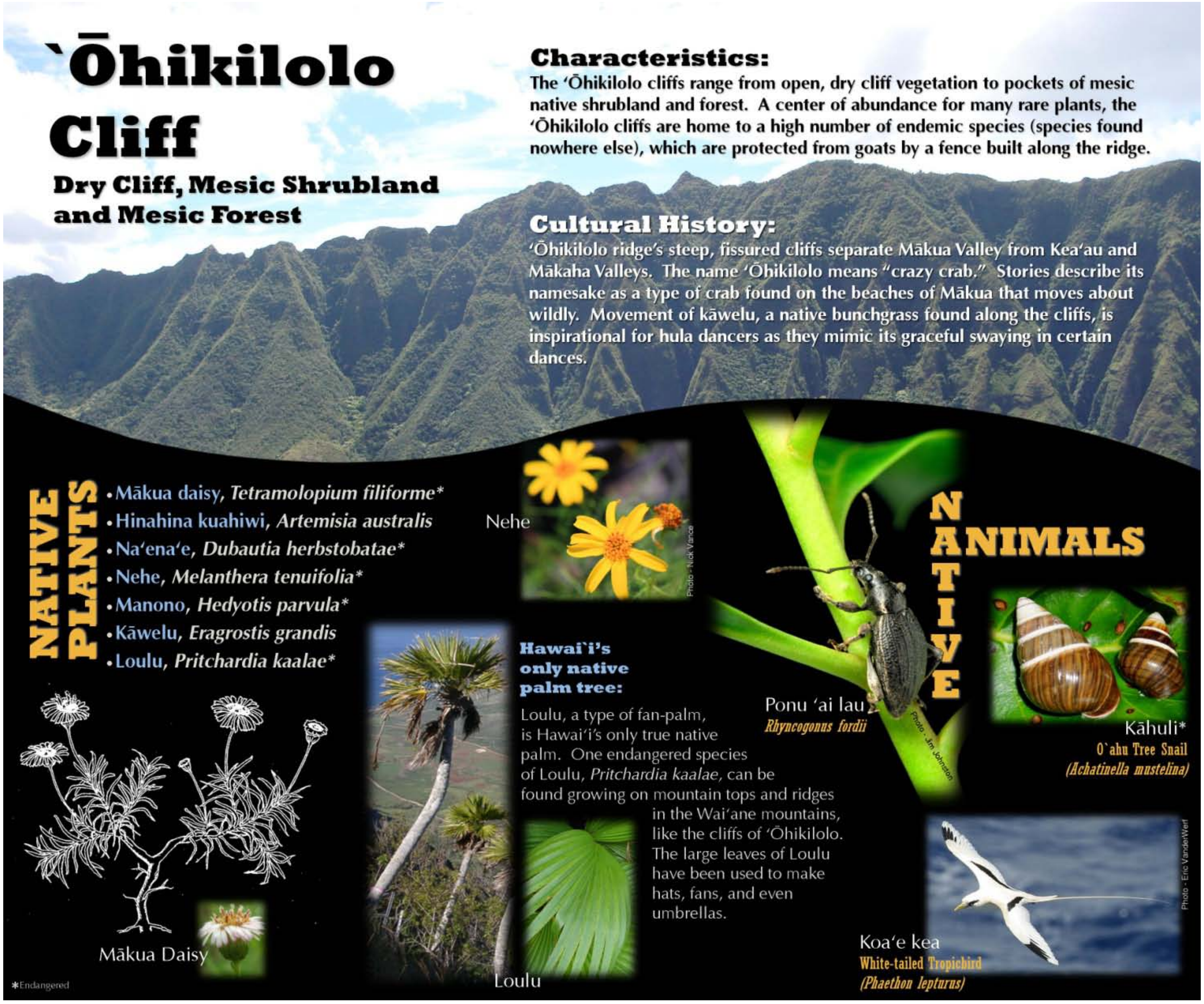
Scouts carry supplies to construct a water catchment, trail steps, and fence crossings.

Volunteers help clear invasive weeds around the site of a future field nursery for National Public Lands Day 2009.

Members of the Hawaii Youth Conservation Corps help remove invasive strawberry guava in the forest at Kahanahaiki.

Volunteers endure muddy conditions while removing the incipient weed, *Crocosmia* x *crocosmiifolia* at Kaala.

EDUCATIONAL MATERIALS:



Example of one of the interpretive signs designed for the OANRP's new baseyard interpretive garden.

Alien Snails Found in Greenhouses - Can We Keep Them Out of Our Native Forests?

O'ahu Army Natural Resources Program

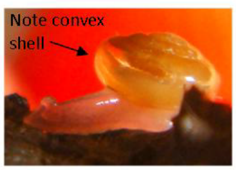
The O`ahu Army Natural Resources Program (OANRP) maintains two endangered plant nurseries where propagules are raised for genetic storage and to be out-planted back into the wild. Within the last several months, it has been discovered that much of the nursery stock are harboring multiple species of alien snails. It has been shown that horticultural facilities act as critical vectors for many alien snail and slug species, highlighting the need for greater awareness about these species (Cowie et al., 2008). The purpose of this informational flyer is threefold: 1) to provide additional information for any agencies/organizations conducting out-plantings in the wild by highlighting the species found in OANRP nurseries; 2) to garner any information that the horticultural, botanical, and conservation community may have regarding quarantine and eradication methods; and 3) to garner any information the horticultural, botanical, and conservation community may have regarding known distribution of these alien snail species in the wild.

Five snails of concern:

Zonitoides arboreus

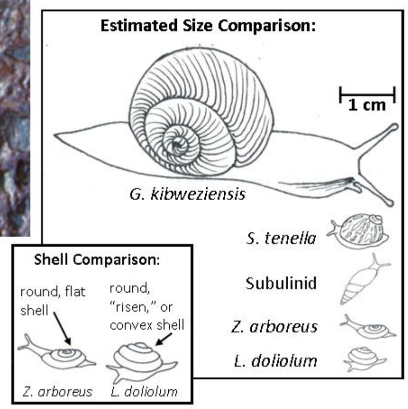
Subulinid

Gonaxis kibweziensis



Liardetia doliolum

Succinea tenella



RISKS associated with accidental forest introduction:

- Competition with native snails for food
- Increased prey for snail predators
- Potential to transmit diseases to native snails (currently little known)
- Possibly affecting plant health (currently little known)

OANRP's current QUARANTINE & ERADICATION methodology:

- Above-ground plant parts, soil, and below-ground plant parts visually examined for snails weekly on all stock to be planted.
- If, following 8 weeks of visual examination, snails are never found, then plants are cleared for out-planting.
- If snails are found, infected plants are treated with methocarb sprays and metaldehyde baits (Hollingsworth & Armstrong, 2003).
- Greenhouse facilities are sprayed with metaldehyde, all equipment is power-washed, all cleaned stock is kept on benches seated in salt water.

If you can provide additional information about these snail species, methods for control in the greenhouse, or have seen them in the wild, please contact: Matt Keir, OANRP Rare Plant Program Manager (matthew.keir@us.army.mil)

References:

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Hollingsworth, R.G. & J.W. Armstrong, 2003. Effectiveness of products containing metaldehyde, copper or extracts of yucca or neem for control of *Zonitoides arboreus* (Say), a snail pest of orchid roots in Hawaii. Int. J. of Pest Mgmt. 49(2): 115-122.

Flyer distributed at the Hawaii Conservation Conference and to other colleagues regarding invasive snails in the greenhouse.

OUTREACH EVENTS:

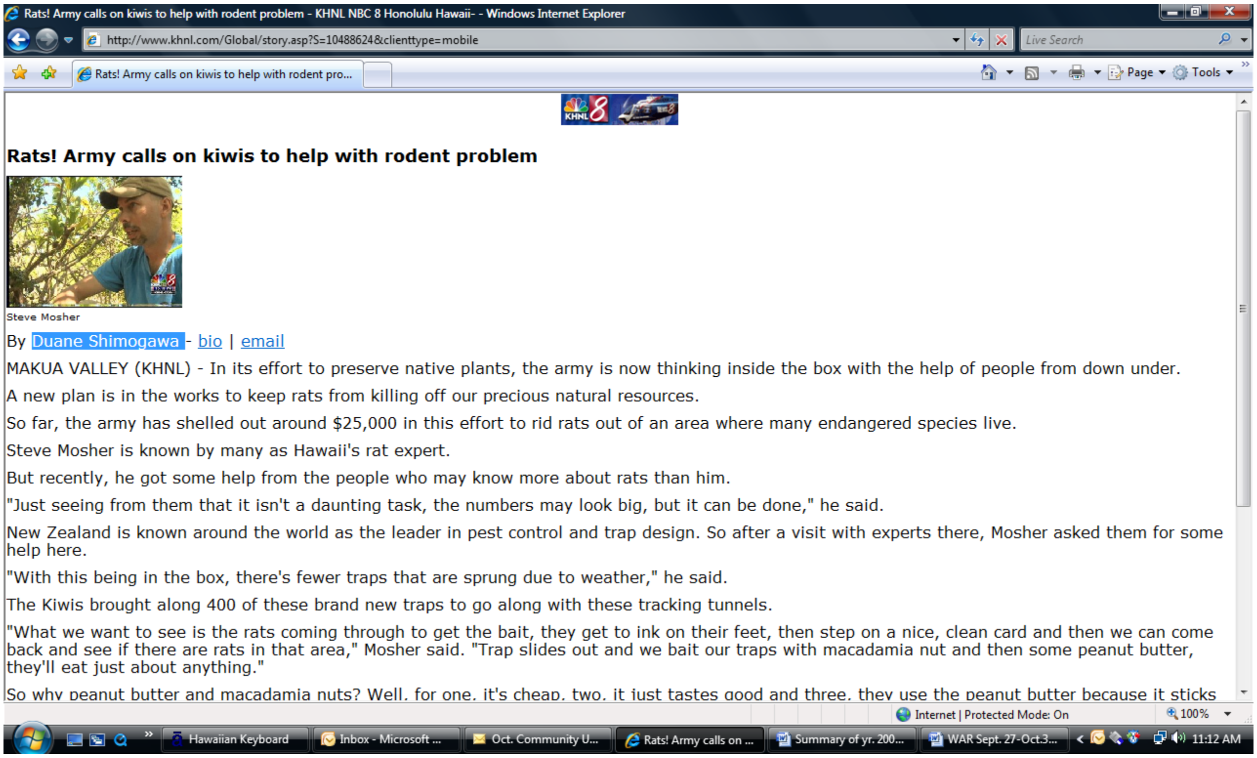
OANRP's booth at the Grow Hawaii Festival, April 2009.

Participants planted native Kookoolau seeds at the Bishop Museum's Family Sunday event, July 2009.

Guests tour the interpretive gardens at the new OANRP baseyard during the Earth Day Open House.

One of the OANRP's stellar volunteers, Jim Keenan, receives a volunteer appreciation award at the Earth Day Open House by Colonel Margotta; Army Natural Resources chief Michelle Mansker (center) announced the awards.

PUBLIC RELATIONS:



Screenshot of KHNL’s coverage of the rat-trap grid in Kahanahaiki.

Screenshot of KHON’s coverage of the story of *Cyanea superba,* “Rebuilding a Forest.”

EMP
Ecosystem Management Program Bulletin
Volume 46 Summer 2009

Endangered Waterbirds Discovered Nesting on Army Land

By Phil Taylor

Staff with the Army Natural Resources Program made an exciting discovery during their winter waterbird survey last February when two fluffy-feathered Hawaiian Coot chicks emerged from the tall grass with their parents in a flooded field on Dillingham Military Reservation (DMR), near Ka`ena Point.

Juvenile and adult `alae`ke`oke`o, or Hawaiian Coot. (Photo by Eric VanderWerf)

The Hawaiian Coot, or `alae ke`oke`o, is a duck-like bird found only in the Hawaiian Islands and is federally listed as an endangered species due to habitat loss, avian diseases, invasive predators and invasive plants. Coots, which are sometimes called "black ducks," have only partially webbed feet with lobed toes. They are typically seen in the open water of marshes and ponds. Adults display uniformly grayish-black plumage with a white bill and a bulbous white or sometimes red frontal shield. The young downy chicks are all black, except for a reddish-orange head and bill.

This sighting of the family flock marks the first time an endangered waterbird has been observed breeding on Army land in the state of Hawai`i. The Hawaiian Moorhen and Hawaiian Stilt have also been observed this year at DMR, but neither species has been seen nesting in the area. Both are also native to Hawai`i and listed as endangered species.

Previous surveys at DMR have revealed the presence of few to no waterbird species due to low water levels in the fields just south of Dillingham Airfield. The heavy rains during December and January allowed water levels to rise, providing adequate nesting habitat for the coots and other waterbirds.

Wetlands at Dillingham Military Reservation. (Photo by Phil Taylor, OANRP)

Inside this issue:

Endangered Waterbirds Discovered Nesting on Army Land, *by Phil Taylor*..... 1

Applications of Noninvasive Technologies in Cultural Resource Management, *by Jaime Raduenzel*.............................. 2

PTA Offers Environmental Tours to Celebrate Earth Day, *by Chicpaul Becerra*.. 3

New Tree Snail Population Encourages Conservationists, *by Vince Costello*...... 4

Wildfire Awareness - Help Spread the Word not the Flames!, *by Jane Reppun Beachy*.. 6

Front page from Summer 2009 EMP Bulletin.

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APPENDIX 1-2: WEED CONTROL PROGRAM FORMS AND GUIDANCE

List of inclusions:

1. How to Weed
2. Ginger Control: Field Efforts
3. Weed Control Effort Form
4. Weed Control Effort Form Guidelines
5. Common Reintroduction Form
6. How to Transplant
7. Weed Survey Form

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HOW TO WEED

The Holy Trinity of Weed Organization: WCAs, ICAs, and Surveys

Weed management activities are divided into three main categories: Weed Control Areas (WCAs), Incipient Control Areas (ICAs), and Surveys. Each has a different purpose and a different set of expectations. The MIP/OIP outlines all weed activities. The Ecosystem Restoration Management Unit Plans (ERMUPs) spell out specific weed control actions for each MU. These are currently being written.

Surveys: Surveys are conducted both on and off Army Training Areas. They are designed to proactively identify new weeds which the Army, OANRP, or something else (pigs, hikers) are moving into areas we are interested in. What areas are these? Army training areas, Management Units (MUs), and access points. Three basic types of surveys are conducted. Only presence of species is recorded, not number of occurrences. Each survey location is named with a unique code.

- **Roads:** Surveyed annually, in quarter 1, when all is wet and growing well. All roads in training areas are to be surveyed. Roads used by OANRP to access work sites, like the Pahole Road, are also surveyed. Code example: RS-Pahole-01
- **Landing Zones:** All military LZs are to be surveyed annually, in quarter 1. LZs used by NRS are to be surveyed whenever they are used, not to exceed once per quarter. Code ex: LZ-MMR-101
- **Transects:** generally these are 500m long and are monitored for ungulate sign as well. Monitoring interval varies for transects. Code example: WT-KLOA-14

Data from surveys is entered into The Database. Any species which could be a significant pest is evaluated, and if deemed feasible, controlled in an ICA.

Incipient Control Areas (ICA): ICAs are designed to facilitate control of incipient invasive weeds. They are geographic regions defined on the GIS. Only one species is the target at any one ICA. The goal of each ICA is to achieve eradication of the target species. ICAs are named according to region and species; for example, UpperKapuna-AngEve-03, refers to a particular Angiopteris infestation in the Upper Kapuna MU. Control efforts are recorded on Weed Control Effort Forms, WCEFs. It is important to record how many plants of mature, immature, and seedling age classes are removed on a given date. This can be hard to do, but the data is important in tracking efficacy. Data is stored in The Database.

Weed Control Areas (WCA): WCAs are designed to facilitate control of multiple weed species in restoration sites. WCAs are defined geographically, and are generally drawn around rare species sites, reintroduction sites, potential reintroduction sites, areas with patches of native-dominated forest, or sometimes weedy areas where we want to construct fuel breaks or conduct more in-depth restoration projects. The MIP/OIP state that within MUs we should strive to reach 50% or less alien cover, within 50m of rare species we should strive to reach 25% or less alien cover, and within 2m of a rare individual, we should strive to reach 0% alien cover. These broad goals inform individual WCA goals, which vary.

WCAs which include rare species are supposed to be managed to achieve 75% or greater native species cover. WCAs which include patches of native-dominated forest, but no rare species, should be managed to achieve at least 50% or less alien species cover. WCAs which include fuel breaks should be managed to keep fuels low. The goal of each WCA is/will be defined in the ERMUP. WCAs are generally drawn within MUs, but may also be located outside of MUs. Control efforts are recorded on the WCEF, and all data is stored in The Database.

The Database!

It's big, it's scary, and it's the best way to track our data and what we're doing. There are many sections to the database. The weed section of the database stores all survey, ICA, and WCA data. The scheduling section of the database lists all the weed related actions for each team, and helps us keep track of which actions have been done and which are pending.

- Weed section: each team has a 'weed tech' who enters survey and WCEF info into the database. Blue = Mandy, Green = Phil, Orange = Scott. Quality checks of this data are done by Jane. Hard copies of the WCEFs are kept in binders in the team offices.
- Scheduling section: Jane generates the list of actions, ideally with the help of everyone who has an opinion. Team coordinators put the actions on a calendar and carry them out. Then, they record time spent on each action in the scheduling database. This information can then be reviewed: How much time are we spending on weed control activities? Can we keep up? Are vital actions being missed? Should we re-prioritize? Are all data forms being entered?

Where? GIS/GPS/Maps

All weeded areas are recorded on GIS. Please refer to How to GPS. If you go to a NEW survey site, please GPS it. If you go to a new WCA or ICA, please GPS the perimeter. If you weed in a WCA, GPS the perimeter of the area weeded; this is vital for the WCEF. If you weed in an ICA, generally you don't need to GPS the perimeter of the area weeded, as it has already been defined as the ICA shape. There are some exceptions for very large ICAs, for example, Lepsco at Poamoho. GPS data goes to the weed tech.

Identifying your weeds, aka Know thine enemy:

There are a ton of weeds! Learning to identify the many weeds in Hawaii is a lifelong process. Focus on learning the primary weeds of the MUs you visit. Many weeds are ubiquitous, and you'll have a lot of opportunity to practice your identification skills. Conducting surveys is all about weed identification; LZ surveys are good practice! Weed control also requires that you know at least the most common weeds in an area. When in doubt, ask! Never control a plant if you are not 100% positive that it is a weed.

Resources

- **Books:** Manual of the Flowering Plants of Hawaii, Hawaii's Ferns and Fern Allies, A Tropical Garden Flora, Weeds of Hawaii's Pastures and Natural Areas, Wayside Plants of the Islands, Scott H's laminated booklet. Copies at each baseyard.
- **Picasa:** this program is loaded onto all the computers. It catalogues all of our photos, including weed photos. Open Picasa. Type keywords into the bar at the top of the screen. Some keywords to try include: weed, weeds, identification, incipient, the 6 letter abbreviation for the species name, ex. Schter for Schinus terebinthifolius. Note that you can search by more than one keyword by leaving a space between keywords.
- **Web:** www.hear.org/starr, check out the Plants of Hawaii images link, also a starting source for pics of reptiles, insects and birds, http://botany.si.edu/pacificislandbiodiversity/hawaiianflora/index.htm (Smithsonian), check out both the Checklist and Specimen links, http://www.bishopmuseum.org/research/natsci/botany/botdbhome.html, check out the

annotated checklist of cultivate plants link,
http://www2.bishopmuseum.org/natscidb/?w=PBIN&pt=t&lst=o&srch=b&cols=8&rpp=500&pge=1, check out all the links,
www.google.com, search by plant name via google web and images

- **People:** ask any field staff, especially when you are out in the field. Collect samples to bring back to the office (for weeds, big samples are ok, and flowers/fruit are very helpful). Some folks who know a lot of weeds are Julia, Michelle, Scott, Dan S, Joby, Kapua, and Jane. We send really puzzling stuff to Bishop Museum for identification. Directions for this are on the V drive, in the Bishop Museum Folder, 'submitting to Bishop process' powerpoint.

Herbicide

Almost all weed control involves using herbicide. Read the pesticide SOP, #7, prior to doing ANY weed control. ASK for direction and guidance from coworkers. You should always use PPE when dealing with herbicides, and should be vigilant in preventing your person, pack, or other gear from becoming contaminated with pesticides. FOLLOW the pesticide label: it is the law.

PPE includes: gloves, long sleeves, long pants, covered shoes, sometimes eye protection, and sometimes a respirator (for fine sprays).

A note on Long Sleeves: Ok, so we didn't really use long sleeves in the past. Why? We didn't realize we needed them. They are really hot; at some work sites, dangerously so. And we weren't vigilant. So, all the pictures in this brief have a glaring flaw: no one has proper PPE, as no one is wearing long sleeves. However, the Garlon label requires long-sleeves. Wear them! For those who get hot easily, try a thin, loose, 2nd-hand men's dress shirt over your regular t-shirt; wear it while weeding and take it off to hike.

A note on Gloves: Use the reusable, aqua-green nitrile gloves. These are first choice. Note that you can use the blue surgical style gloves for weeding, but risk of contamination is MUCH higher due to breakage and difficulty in removing surgical gloves to adjust your hair/glasses/talk on the radio/etc. You can wear surgical gloves under aqua gloves for maximum protection, but this is not required.

BEST!

OK

BAD!

Garlon 4: This is the workhorse of the arsenal. G4 in a 20% mix with either Forestry Crop Oil (FCO) or biodiesel is used on 90% of all weeds we kill. G4 is mixed with a red dye. Garlon is most effective on broadleaf weeds and is typically applied with an applicator bottle. G4 should only be used in a sprayer in very special circumstances. Leucaena leucocephala (haole koa) requires 40% G4 for good control.

Roundup/Ranger: This is effective on broadleaves and monocots. Typically, it is used for spraying grass in a 1% solution in water. Blue dye is added to make it easier to see where herbicide has been applied. Respirators are recommended but not required.

Fusilade: This is grass-specific, which makes it a very useful tool in minimizing non-target kill. However, it is most effective on actively growing grasses,and treatment has to be timed for this; flowering grasses are not actively growing. Very effective on Melinus minutiflora, molasses grass, less so on Panicum maximum (guinea grass). Fusilade is mixed with water (22mL Fus. /gal), a surfactant (15mL/gal), and blue dye. It is applied via spraying. Respirators are recommended but not required.

Escort: This is almost exclusively used on ginger. It is a granular formulation. Weigh 1 to 1.5g on the scale, and mix well with a liter of water in a sprayer. The spray is applied to the ginger rhizome; notching the rhizomes first improves uptake. No dye is added.

Oust: This is a pre-emergent herbicide. It is designed to kill germinating seeds, but does not kill seeds themselves. Seek guidance on when/where/how to use Oust; it is only used in select projects.

Dyes: Red dye (Bas-Oil Red, oil-based)should be used for G4 in biodiesel or FCO; do not use blue dye here as it will not mix properly. Blue dye (Turf Mark, water-based) should be used for water based applications, like Roundup and Fusillade.

Before Heading into the Field:

Gear : Assist field staff in preparing necessary gear. This may include herbicide gear, as well as other gear such as chainsaws or weedwhackers. ASK FOR SPECIFIC DIRECTION! When using herbicide, you will always need nitrile gloves (aqua green reusable), dry bags for carrying contaminated material, water for washing up, simple green for washing up, and at least one wash tub. Herbicide and herbicide equipment should always be carried in a dry bag. Place applicator bottles and herbicide transfer bottles in Ziplocs, then into dry bags. Herbicide shall always be carried in 'leakproof' hard plastic bottles. Herbicide equipment includes applicator bottles, hand sprayers, pump sprayers, and backpack sprayers.

Herbicide Mixing: have someone show you how to do this until you feel comfortable with the process and the gear. Wear PPE when mixing the juice! Roundup, Ranger, and Fusilade are generally mixed in the field. Be sure to take dye, surfactant (for Fusilade only), graduated cylinders, and a funnel into the field. Add a little water to the sprayer first, then the herbicide, then surfactant and dye, then top off with water to the fill line. Shake well prior to using. Use the mix rate cheat sheet (V drive, Forms) to help figure out how much product is needed. Garlon 4 is generally mixed at Base. Check to see if any G4 is already in transfer bottles: use these first. Garlon 4 is stored in carboys (large containers with spigots on the bottom). There is one carboy with mixed 20% G4 in FCO in the pesticide cabinet. Use this. If it is empty, ask for help from one of the weed techs in mixing a new batch. If you need a different dilution, use the carboys with 100% G4 and 100% FCO and a graduated cylinder to customize. Escort is weighed out and put into 1 or 1.5 g batches in whirlpacks. It is mixed with water in the field.

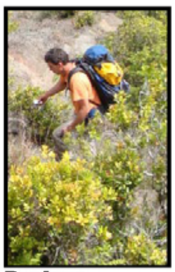
Mix Rates					
	24 oz	1 gal	3 gal	5 gal	25 gal
1%	7 ml	38 ml	115 ml	190 ml	950 ml
2%	14	75	225	375	1875
3%	22	118	345	575	2875
5%	35	190	575	950	4750
10%	70	380	1150	1900	9500
Fusilade Mix Rates Only					
	24 oz	1 gal	3 gal	5 gal	25 gal
Fusilade	4.2 ml	22 ml	66 ml	110 ml	550 ml
Surfactant	2.8 ml	15	45	75	375
Turf mark	2 ml	10	30	50	100-200

Tools to have: clippers, handsaw, hatchet (if girdling large trees). You should always carry clippers and handsaw in the field, even if you aren't planning on weeding. Tools should be sharp; hatchets can be sharpened (ask coworkers for help in how to do this correctly); handsaws blades can be replaced.

In the Field, Taking care of Business:

When conducting weed control, you should always have a GPS. GPS the boundaries of the area you weed – this is vital for tracking our effort and having productive, efficient weeding projects.

Transport: All pesticide gear should be carried in dry bags. You can put the dry bags in your pack, clip them to the outside of your pack, or just hand carry them. Make sure you tighten the lids of transport bottles well to avoid leakage. At the work site, stash herbicide gear in one location, and keep separate from day packs whenever possible. Herbicide stuff shouldn't be strewn around among daypacks and lunches. If pesticide gear is being flown into a remote location or campsite, put it in the sling whenever possible. Pesticide stuff in slings should be placed in puncture-resistant, leakproof, labeled containers, like buckets and action packers.



Dry bag

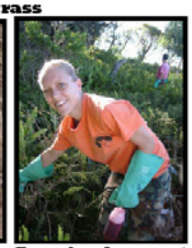
Separate prep area in field

Marked pesticide action packers

Garlon Prep: Pour mixed G4 into applicator bottles. Don't fill them to the brim! Tighten lids to avoid leaks. The applicator bottles have long tubes inside; dispense herbicide by squeezing the bottle. The tubes are useful in that they minimize spillage – if you fall and the bottle falls too, herbicide won't leak everywhere unless you squeeze the bottle as you fall. To prevent yourself from squeezing the bottle, carry it by the applicator spout. The tubes also allow you to apply herbicide really selectively , you don't have to turn the bottle upsidown to get juice out. If you can't get used to the tube, take it out, and SAVE IT. Lost tubes = bad. After emptying a transfer bottle, upend on weeds to let any residues drain out prior to washing.

Careful Pouring

¾ full applicator bottles, transfer bottles inverted on grass



Carrying by spout

Garlon Techniques: G4 should always be applied selectively. Basic techniques are illustrated here.

Clip and Drip: Good for small woody or herbaceous stuff like Clidemia, Rubus rosifolius, very young tree species. Cut the stem or stems close to the ground (within 3-4" at most). Treat cut stem with G4; entire stem should be covered, this may only take a drop. Benefit of this technique is that it is very easy to see what has been treated.

Cut Stump: same idea, but applies to large trees. Cut the tree down, leaving a very low stump; squirt G4 on entire cut surface. Cutting down large trees is labor intensive.

Basal: Good for small diameter woody trees and shrubs. Small diameter = 3" or less. Squirt a thin line (1" or less) of herbicide ALL the way around the basal bark about 2-3" from the ground. Uses more herbicide than clip and drip, and harder to see where has already been treated, but very fast. This technique is best for species that root from nodes, like Ageratina riparia and Ageratina adenophora. Squirt G4 at all places where these plants root into the ground, bases of all stems. This technique is also best for large diameter Schinus terebinthifolius (Christmas berry). Trials show that basal treatment of Schter is more effective than girdling; a thick line of herbicide is required, approx. 4-6"

Girdle: Best for large diameter (over 3") trees, excluding Schter. Use a hatchet or handsaw to cut through the cambium layer of the tree, all the way around the trunk or trunks. The cut doesn't need to be very wide, but it must be an unbroken ring, and must go all the way through the green/ white/ red cambium to the hardwood beneath. Squirt G4 on the cut ring, covering all cut surfaces. If you can cut in such a way so that the G4 is held in a pocket by the remaining bark, G4 uptake is improved.

Spray Techniques: Sprayers include hand sprayers, pump sprayers, hand-held wand sprayers, backpack sprayers, the 25gal skid sprayer, and the power sprayer. When spraying with backpack sprayers, the 25 gal skid sprayer, and the power sprayer, coveralls and respirators are needed. When spraying with hand, pump, or hand-held wand sprayers, coveralls and respirators generally aren't required. Wearing coveralls is hot! Drink lots of water! Spray grasses or other target weeds till all leaf surfaces are coated and herbicide just begins to drip from blades. Spray the same area from multiple angles to ensure that you get good coverage. Wearing respirators is strongly recommended for any application in which you will be exposed to spray drift for more than an hour.

Backpack sprayer

Skid sprayer

Hand-held wand sprayer

Backpack Sprayer notes: leaks happen. Minimize them by checking to make sure that all tubes are hooked up properly and are screwed on tightly, and grease the gasket on the lid with lube.
Non-grass targets: sometimes we spray Psicat seedling beds with sprayers and G4. The G4 is mixed with water in for this application. During roadside sprays, we often target both broadleaves and grasses. Use a mix of Roundup (1-2%) and Garlon (3%) for this type of application.

Ginger Control Techniques: Cut all stalks, leaving 1-2" stumps above the rhizome. Clear debris and mosses to expose the rhizome. Make cuts in the rhizome, scarifying it. Don't chop the rhizome up; any bits could develop in to new plants. Spray Escort solution on the rhizome, till covered; don't soak surrounding area, as Escort could kill surrounding vegetation. If you find any fruit, bag it and remove from the field. Put in the trash at Base.

Haole Koa Control Techniques: Haole koa is a survivor. For plants that have scarified, 'brain' trunks, cut off all stems, hack deep notches into the brain, and apply G4 40% liberally over entire brain and all cut surfaces.

Scarifying a 'brain', on left

Squirting a 'brain', on right

Piscat Control on the Summit Techniques: Summit environments are wet, saturated, high elevation. They include Ka'ala bog and most of summit region of the Ko'olau's, particularly 'Opaeula, Helemano, Poamoho, and Koloa. Psicat takes on a slightly different growth form at the summit: it tends to form shorter trees with multiple trunks, and does not fruit prolifically. Psicat slash often roots in these uber-wet environments. When treating Psicat, cut all trunks and squirt with G4 20% to get full coverage of cut surfaces and visible roots. Gather all slash together, squirt cut ends and aerial roots with G4, and pile slash off the ground. You will use more G4 than normal. Weeding on hot summer days also helps minimize slash sprouting.

End of the Field Day:

Washing up: All pesticide gear needs to be triple-rinsed, including ripped or punctured items (like Ziplocs or gloves) that are destined for the trash. Wash gear in the field, before heading back to Base. Use wash tubs, soap, and water; all staff should help. If you cannot wash gear in the field, be sure to apply rinsate to weeds or fencelines at base and be area of not contaminating areas that people need to use. Gear should be washed on the day of use, or, if camping, on the day it returns to base. Don't wash the inside of gloves with potentially contaminated water.

Triple Rinse

1. Water + Soap = fill containers at least ¼ full, agitate for 30 seconds, pour rinsate on nearby weeds, NOT on gravel, pavement. Wash outsides and insides of containers. Pump water through sprayer, if applicable.
2. Water + Soap = same thing as step 1
3. Water only = same process and disposal of rinsate. Rinse wash tubs after use.

Putting away gear: Put all gear out to dry on appropriate drying racks. Rinse the inside of the gloves with clean water before hanging up to dry. Toss any torn/punctured/cracked and otherwise unsafe gear. Make sure that any gear that is thrown away is rendered completely unusable by further puncturing/tearing it.

Filling out forms: Yep, that's right! If you weed, you need to fill out a Weed Control Effort Form! Only 1 WCA/ICA per WCEF. If you work in more than 1 WCA or ICA, keep track of time/area/herbicide used at each control area, and fill out separate forms. Please be as complete as possible – comments and sketch maps are good!!! GPS is great!! See the instructions for the WCEF for further guidance. The WCEF and WCEF Guidelines are on the V drive, in the Forms folder. To be a superstar, fill out WCEFs in the field or in the car on the way back to Base. Completed WCEFs go to the weed tech for each field team (Blue: Mandy, Green: Phil, Orange: Scott).

Ginger Control: Field Methods
Bog Flats, Kaala-01

Gear checklist:
- Spare escort packets and water for mixing
- Sprayer and glove clean-up bins and simple green
- Hip chain and spare line
- Compasses
- GPS unit and spare batteries if needed
- Spare pairs of nitrile gloves (green, thick gloves better than thin, blue, surgical style gloves)
- Blue, pink, and orange flagging for marking new sphagnum populations
-PPE (nitrile gloves, eye protection, long sleeve shirts, cammo jackets for thorn protection, leather or thick gloves)
-Kaala key
-pruners & handsaws

Mixing and Use of Herbicide:
Escort packets are already pre-made at West base, use 1 packet per 24 fl. oz (one grey spray bottle). This is one gram per 700 milliliters which gives a concentration of 0.14%. Probably only will need 1 bottle per participant, given the ginger at the flats are mainly small keikis. Pick up packets at your convenience. This chemical is only a suspension in water because it does not completely dissolve. Be sure to shake the mixture well if it has been sitting undisturbed for a while.

Escort also works on guava (for small guava cut at base and treat both stump and cut end).

Sweeps:
Use a copy of the last weed form to orient you for your sweeps. Usual bearing is 140° when sweeping from boardwalk to transect trail.

Mapping and Orienting Methods:
The phalanx method. The end person (should be staff) carries the hip chain on one end of the line (west side closest to Waianae), and should carry a GPS (on tracking mode to get the area), and take points at the start and end of the transect. All staff and volunteers should walk within sight of each other, about 1 person every 3-5 meters apart, to get good coverage in heavy brush. After reaching the end (boardwalk side or transect trail side), flip the line and follow the hip chain back the other way.

The people at the ends of the lines should agree on a compass bearing (140°, on a non-declinated compass) to follow along with the direction of hip chain lines. Participants also might find a compass useful as they orient in the brush. Note that the magnetic north of the compass and the true north from the printed maps differ by 11 degrees on Oahu, so ensure that everyone's compass is not declinated prior to starting

Herbicide Treatment Methods:
For really small ginger keikis, folks can just pull them out and pocket them for spraying in a pile at the end of a sweep.

For larger plants, first clear loose soil and debris away from the rhizome and roots. Then cut the stems above the pinkish red area where roots might resprout, wound the rhizome with a saw or clippers, and thoroughly spray to wet the rhizome and standing stalk. Herbicide sprayed on the soil will not seriously harm the ginger and would be wasted.

After spraying, cover the treated rhizome with the ginger leaves or other dead leaves if it is a rainy, drizzly day to prevent the chemicals from being washed off. Place cut branches so that others can see that the plant has been treated.

Guava is also normally killed when doing ginger sweeps. Escort should be sprayed on the cut stump and the end of the cut branch. Roots can sprout from any part of an untreated guava branch in very wet conditions. Perch the treated cut branches well above soil to prevent resprouting.

Counting of Controlled Plants:
Keep track of numbers of ginger found for reporting on the the weed form. Use the following size classes- Seedlings (2 tiny leaves, usually less than 10 cm); Immature are larger plants not showing signs of reproduction); Matures are plants with signs

1

of new or old flowers. Be sure to remind new folks that if several plants are connected by a rhizome that it is all considered a single individual, no matter how large the rhizome mass may be. This data on the weed form will tell us about the population structure and the efficacy of the weed control work in the long run.
We do not count the guava plants controlled because we assume that the numbers are low enough. Guava and other weeds should be noted on the form. Especially note large numbers or new/unusual species found, for example, Melaleuca quinqueveria.

Two rare endemic orchids grow on Ka'ala and should be described to new workers and they should be encouraged to ask if they are unclear what they are seeing.

Safety Precautions

General Precautions: Eye protection is required to avoid eye pokers in heavy brush. Blackberry thickets are difficult to work in without thick protective clothing. Give first aid as needed to prevent scratches and wounds from later infections. Glove liners like leather or cotton gloves can be worn under chemically resistant gloves if desired. Any damaged nitrile gloves should be replaced immediately to avoid chemical exposure.
Escort can be hazardous to humans. Reduce worker's exposure by spraying well away from your eyes and face and by setting the spray droplet size to avoid fine airborne mists. Hike to the site with the nozzle set to the closed setting until the sprayer is ready to use.

Chemical Safety:
The Material Safety Data Sheet is available in a binder in the truck for any worker or volunteer to see. You can see in the MSDS what the signs and symptoms of acute exposure are and what first aid measures should be. Escort has a Caution label and the PPE mentioned above is required for its use. *The active ingredient, Metsulfuron Methyl, causes eye and skin irritation and contact should be avoided.*

Snares and Pigs:
We are actively snaring and trapping along the blue transect and I did find one freshly caught keiki pig with the YCC group when there about 3 weeks ago. Please have folks watch out for the snares and not trip them (marked with orange flagging) on the blue transect. No snares are near the boardwalk. In the unlikely event a pig is seen stay well away from it.

Sphagnum

Sphagnum spreading:
With the YCC group, as we approached the sphagnum infestation we stopped just short of the boardwalk so we would not walk through any sphagnum at all. I highly recommend the same to prevent creating a wider infestation. While doing sweeps avoid walking through sphagnum and then out into the the forest without first cleaning footwear.

Mark and report new sphagnum:
If you find any new small satellite populations of sphagnum, please flag them well with triple blue and pink and orange flagging and GPS for future treatment.

Other Incipients

Mark and report new incipients:
If you find any new populations of an incipient weed, please flag them well with triple blue and pink and orange flagging and GPS. Incipient weeds to watch out for include: Juncus effusus, Leptospermum scoparium, Festuca arundinacea, Anthoxanthum odoratum.

2

DATA ENTRY (initial, date): GIS__________ Database__________ Filed__________

WCA/ICA

WEED CONTROL EFFORT FORM

Date ________ Crew ______________________ MU/area ______________

Land Owner (circle): Army, State, TNC, BWS, other______________________

Weather (circle one in each row):

Cloud Cover	Sunny	Partly Cloudy	Overcast
Rain	None	Mist/Occasional light	Rain
Wind	0-15mph	15-25mph	25+mph

(WCA) Treatment Type (circle): Ecosystem Weed Control, Grass Control

Code name______________ Common name______________________

(ICA) Incipient Taxon:______________________________

Directions to area______________________________

____

____

Area controlled on this date______________________________

____

____

Managed Taxa ______________________________

Target Weed Species (Most to Least found)______________________

____

Photopoint/GPS __________ Notes ______________________

Treatment Method	Quantity (L)	Pesticide	Mix Rate	Surfactant	Mix Rate	Area	People Hrs

Manual Control Technique/Scoping (NO CHEMICALS)	Area	People Hrs

For Single Species Targets (Numbers Found)

*Mature*__________ *Immature*__________ *Seedlings*__________ *Retreats*__________

Total Area Treated ______________ Total People Hours ______________

Comments ______________________________

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____

____

NextTime______________________________

____

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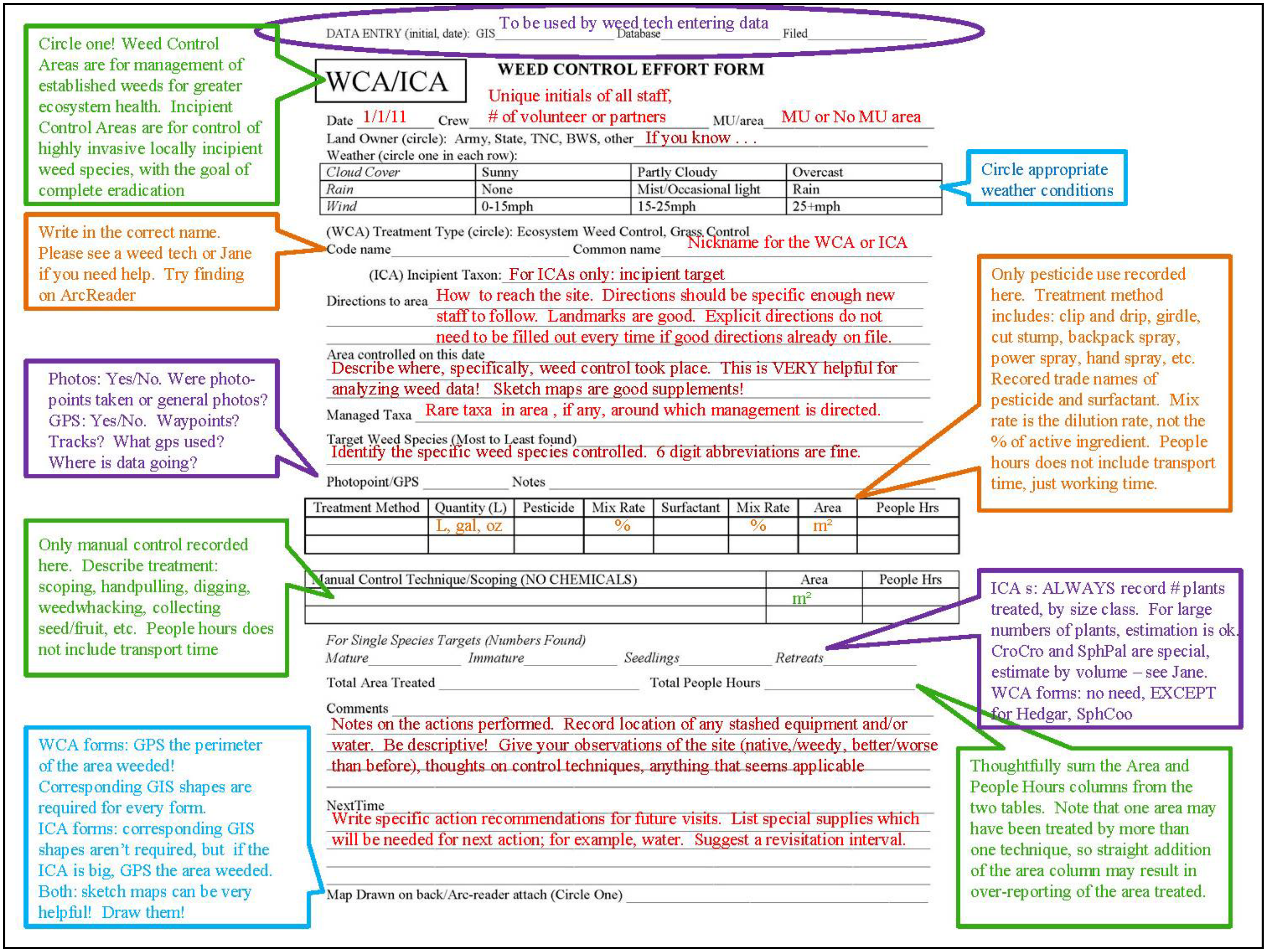
____

____

Map Drawn on back/Arc-reader attach (Circle One) ______________________



DATA ENTRY (initial, date): GIS ____ Database ____ Filed ____

To be used by weed tech entering data

Circle one! Weed Control Areas are for management of established weeds for greater ecosystem health. Incipient Control Areas are for control of highly invasive locally incipient weed species, with the goal of complete eradication

WCA/ICA

WEED CONTROL EFFORT FORM

Date 1/1/11 Crew Unique initials of all staff, # of volunteer or partners MU/area MU or No MU area

Land Owner (circle): Army, State, TNC, BWS, other If you know . . .

Weather (circle one in each row):

Cloud Cover	Sunny	Partly Cloudy	Overcast
Rain	None	Mist/Occasional light	Rain
Wind	0-15mph	15-25mph	25+mph

Circle appropriate weather conditions

Write in the correct name. Please see a weed tech or Jane if you need help. Try finding on ArcReader

(WCA) Treatment Type (circle): Ecosystem Weed Control, Grass Control

Code name ____ Common name Nickname for the WCA or ICA

(ICA) Incipient Taxon: For ICAs only: incipient target

Directions to area How to reach the site. Directions should be specific enough new staff to follow. Landmarks are good. Explicit directions do not need to be filled out every time if good directions already on file.

Area controlled on this date

Describe where, specifically, weed control took place. This is VERY helpful for analyzing weed data! Sketch maps are good supplements!

Managed Taxa Rare taxa in area , if any, around which management is directed.

Target Weed Species (Most to Least found)

Identify the specific weed species controlled. 6 digit abbreviations are fine.

Photos: Yes/No. Were photo-points taken or general photos? GPS: Yes/No. Waypoints? Tracks? What gps used? Where is data going?

Photopoint/GPS ____ Notes ____

Only pesticide use recorded here. Treatment method includes: clip and drip, girdle, cut stump, backpack spray, power spray, hand spray, etc. Recored trade names of pesticide and surfactant. Mix rate is the dilution rate, not the % of active ingredient. People hours does not include transport time, just working time.

Treatment Method	Quantity (L)	Pesticide	Mix Rate	Surfactant	Mix Rate	Area	People Hrs
	L, gal, oz		%		%	m^2	

Only manual control recorded here. Describe treatment: scoping, handpulling, digging, weedwhacking, collecting seed/fruit, etc. People hours does not include transport time

Manual Control Technique/Scoping (NO CHEMICALS)	Area	People Hrs
	m^2	

For Single Species Targets (Numbers Found)

Mature ____ *Immature* ____ *Seedlings* ____ *Retreats* ____

ICA s: ALWAYS record # plants treated, by size class. For large numbers of plants, estimation is ok. CroCro and SphPal are special, estimate by volume – see Jane. WCA forms: no need, EXCEPT for Hedgar, SphCoo

Total Area Treated ____ Total People Hours ____

Thoughtfully sum the Area and People Hours columns from the two tables. Note that one area may have been treated by more than one technique, so straight addition of the area column may result in over-reporting of the area treated.

Comments

Notes on the actions performed. Record location of any stashed equipment and/or water. Be descriptive! Give your observations of the site (native,/weedy, better/worse than before), thoughts on control techniques, anything that seems applicable

NextTime

Write specific action recommendations for future visits. List special supplies which will be needed for next action; for example, water. Suggest a revisitation interval.

Map Drawn on back/Arc-reader attach (Circle One) ____

WCA forms: GPS the perimeter of the area weeded! Corresponding GIS shapes are required for every form. ICA forms: corresponding GIS shapes aren't required, but if the ICA is big, GPS the area weeded. Both: sketch maps can be very helpful! Draw them!

COMMON REINTRODUCTION FORM

Date ___________ Crew_________________________________ MU/area________________________

Land Owner (circle): Army, State, TNC, BWS, other____

Weather (circle one in each row):

Cloud Cover	Sunny	Partly Cloudy	Overcast
Rain	None	Mist/Occasional light	Rain
Wind	0-15mph	15-25mph	25+mph

WCA Code name______________________ Common name__________________________________

Photo ___________________________________ GPS _______________________________________

Batch # (WCA-DatePlanted-Spp)____

Taxa Planted __________________________________ # Planted __________ # Monitored __________

Pot Size, Grower/Source ____

Directions/Area planted ____

____

____

if monitoring a subset of the planting, please note in comments below

Woody Species Monitoring

Vigor			Height				Maturity	
Healthy	Moderate	Dead	<20cm	20-50cm	50cm-1m	1m<	Vegetative	Reproductive

*for koa, note additional height categories, 1-2m _______________ and 2m< _____________________

Fern/Monocot Monitoring

Vigor			Coverage			Maturity	
Healthy	Moderate	Dead	Full, 75% ≤ x	Medium, 25%<x<75%	Sparse, x≤25%	Vegetative	Reproductive

*planted in groups; treat each group as 1 unit # Plants/Group and # of Groups ________________

*coverage: estimate within 1m ____

Comments ____

____

____

____

____

Map Drawn on back/Arc-reader attach (Circle One) ____

HOW TO TRANSPLANT

Know Thine Purpose

Common reintroductions, whether they are outplantings, transplantings, or seed sows, all are done to improve habitat quality for rare taxa. They seek to fulfill one/all of the following goals:

1. Provide native cover/shade to inhibit weed regeneration
2. Create native erosion control in heavily weeded areas
3. Improve habitat directly by increasing native taxa cover
4. Reduce cover of fire-ready grasses

Where to Where

In order to efficiently conduct a transplanting project, one needs to identify both a seedling source and a planting destination. A seedling source ideally is a large group of clustered seedlings of one species. The seedlings may form a chia pet or carpet, with a high likelihood of high natural mortality (sibling rivalry is brutal). The planting location should be relatively close by and should be appropriate habitat for the transplanting species. While planting locations abound, seedling sources tend to be more seasonal, less predictable, and widely distributed,

Appropriate Taxa

Not all species are good candidates of transplanting. Ideal characteristics include: relatively quick growth rate (likely to create cover quickly), hardiness (able to withstand the stress of transplanting), high germination rate (many seedlings present at once). As we have not done much transplanting, it is important to track transplanting efforts to determine which species are most successful. Possible candidates include:

Pipturus albidus	*Carex sp.*	*Nestigis sandwicensis*
Acacia koa	*Gahnia sp.*	*Raovulfia sandwicensis*
Pisonia sp.	*Dianella sandwicensis*	*Scaevola gaudichaudiai*
Pouteria sandwicensis	*Morinda trimera*	

Ideal Size: This depends on the taxa in question. For tree and shrub species, transplanting seedlings is most effective. Optimal seedling size varies for species. The seedling should be small enough to dig out the root ball with minimal damage, but not so small that the root ball is too poorly developed to survive the transition to a new location. For monocots like Carex or Gahnia, larger plants could be moved, as they tend to have smaller root balls.

Tools of the Trade

Trowels
Weeding forks (aka toad-stabbers
Shovels
Water jugs
Seedling containers – yogurt containers, buckets, trays . . . ?
Pin flags

Forced Migration

Considerations: to be fine-tuned, as we learn more

- Dig widely around seedlings to minimize root damage

- If seedlings are intertwined, dig out in clumps, gently loosen roots by shaking out dirt, or swishing in water, or . . . .
- Experiment with a variety of seedling sizes, if optimal size is not already known
- Keep seedlings damp; prevent them from drying out. Put a little water in transfer containers, make sure roots in water; this gives the roots a good soaking prior to planting too.
  Put water in bottom of transporting container
- Minimize time out of the ground for the seedlings
- Dig holes large enough to comfortably fit roots of the transplanting
- Tamp soil down firmly around seedling
- Create little moat around seedling to catch water, if possible
- Water generously
- Mark with pin flag, write date and species on flag. If planting densely, denote boundaries of planting area with pin flags or flagging, noting date, species, and number of plants on flag (this is harder to monitor).

Post-Planting Follow Through

Forms: Fill out a common reintroduction form. Be sure to note that it was a transplanting activity, where the stock was collected from, and where it was planted into. Note the number of plants in various size classes. To determine optimal size class, it would be valuable to note height on a finer scale than is notes on the form: <5cm, 5-10cm, 15-20cm, 20cm<.
Monitoring: The transplanting should be monitored quarterly for the first year, transitioning to every 6-12 months. If the transplanting was 100s of plants, only monitor a percentage (25%) of them. The monitored plants should be marked on the date of transplanting, should be spread across the planting area, and initial height/vigor should be recorded.

Weed Survey Sheet.

Similar sheets are printed from the database and used for LZ, Road, Transect, and Other (camps, quarry, fill sites) surveys.

Staff write in names and date at top and check off species seen. New species are written in at bottom.

SurveySiteCode ▾ **SurveySiteName** ▾ **SurveyDate** ▾ **Observers**

LZ-MMR-12

Ohikilolo Camp LZ

TaxonName ▾	2008/01/09 AH YJ VC JB + − TaxonObs ▾	2008/09/24 JG ME + − TaxonObs ▾	2009/04/27 ME JG AH KF KLA JH + − TaxonObs ▾	2009/07/21 AH KJW MV ME + − TaxonObs ▾
Ageratina riparia	X		X	
Ageratum conyzoides	X	X	X	
Andropogon virginicus		X		
Axonopus fissifolius	X	X	X	X
Castilleja arvensis			X	
Centaurium erythraea	X			
Conyza bonariensis	X	X	X	X
Cuphea carthagenesis		X		
Ehrharta stipoides	X	X	X	X
Emilia sonchifolia			X	X
Gamochaeta purpurea	X	X	X	X
Grevillea robusta	X	X		
Kalanchoe pinnata	X		X	
Kyllinga brevifolia			X	
Lantana camara	X	X	X	X
Linaria canadensis			X	
Melinis minutiflora	X	X		X
Pityrogramma austroamericana			X	X
Plantago lanceolata			X	
Rhynchelytrum repens			X	
Rubus rosifolius			X	X
Sacciolepis indica	X			
Schinus terebinthifolius	X	X	X	X
Setaria gracilis	X	X	X	X
Sporobolus indicus	X			
Stachytarpheta dichotoma	X	X	X	X
Triumfetta semitriloba	X	X	X	X
Vulpia bromoides	X		X	

<u>APPENDIX 1-3 OIL-BASED CARRIER HERBICIDE TRIALS</u>

Introduction

Natural resource work in Hawaii necessitates herbicide use for control and eradication of invasive plant species. Herbicides are usually diluted to the desired concentration with a carrier or adjuvant. A given carrier has two functions: (1) to dilute the herbicide to the correct concentration (adjuvant function), and (2) to assist in the uptake of the herbicide by the growing plant (carrier function). The type of carrier that is used depends on the type of herbicide used. In general there are two classes of commonly used herbicides for invasive weed control: (1) water-based herbicides such as glyphosate (the active ingredient in Roundup[1]), and (2) oil-based herbicides such as triclopyr butoxy ethyl ester (the active ingredient in Garlon 4a[2]). As their names suggest, water can be used as a carrier for water-based herbicides, while oil-based herbicides perform best with oil-based carriers.

The largest conservation management organization on O'ahu is the O'ahu Army Natural Resources program (OARNP). OARNP is mandated to mitigate impacts to endangered taxa from Army training. The Makua and Oahu Implementation Plans (MIP and OIP, respectively) outline goals and standards designed to bring rare taxa found on Army lands and in training impact areas to stability. To do this, OANRP conducts a variety of threat management both on and off Army land. Weeds and habitat loss pose a large threat to endangered species; OANRP spends considerable time and resources controlling invasive plants. Chemical treatment (via herbicides) often provides the most efficient and effective method for invasive plant control, thus OANRP uses significant amounts of herbicides and their carriers to accomplish management goals. Most weed control involves the use of 20% Garlon 4 mixed with Forestry Crop Oil[3] (FCO); previous trials and years of experience have shown this mix to be effective on an extremely wide range of target species and plant sizes.

In 2009 OANRP decided to test carrier alternatives to FCO. There were several reasons for this: (1) FCO is a petroleum product, and has become increasingly expensive, (2) FCO is no longer readily available for purchase, (3) staff were interested in finding a more environmentally friendly product, (4) a variety of other carriers are available, and some may be more effective than FCO, and (5) other agencies in Hawaii have already switched to using biodiesel as a carrier, with great success. OANRP conducted a series field trials test to test the effectiveness of treating invasive weeds with four different oil-based carriers combined with Garlon 4 herbicide.

Study Sites

Six different carrier trials were done in two different areas within Makua Valley, a 1760 ha military reservation fenced and managed by OANRP.

1) Lower Ohikilolo: two trials conducted on *Leucaena leucocephala*.

   Location: This study site is located at the mouth of Makua Valley, near the south firebreak road. The elevation is approximately 300 ft. The trial transect is located 3 meters to the south of the firebreak road and runs east for 200' paralleling the road.

   Vegetation: This dry, shrubland area is dominated by alien plants, particularly *Panicum maximum* and *Leucaena leucocephala*. Other alien taxa include: *Leonotis nepetipilum*, *Rhynceletrum repens*, *Macroptilium lathyroides*, and *Acacia farnesiana*. Native taxa include: *Hibiscus brackenridgii* subsp. *mokuleianus*, *Chamaesyce celastroides* var. *kaenana*, *Dodonea viscosa*, *Waltheria indica*, *Erythrina sandwicensis*, *Sida fallax*, and *Heteropogon contortus*.

   Physical characteristics: The substrate of Lower Ohikilolo site is rocky, with pockets of well draining soil nestled between rock outcroppings, small cliffs, and some rock talus. The area is hot and dry. Rainfall occurs primarily during winter months.

2) Kahanahaiki: four trials conducted, one each on *Clidemia hirta*, *Psidium cattleianum* (large trees), *Psidium cattleianum* (small trees) and *Schinus terebinthifolius*.

Location: Kahanahaiki is located on the northeastern rim of Makua Valley. It is easily accessed via the State Pahole access road. A 90 acre fence protects this management unit from pigs. Elevation ranges from 1400ft-2300ft.

Vegetation: This mesic forest area is home to a variety of rare and endangered plants and one endangered tree snail. Parts of Kahanahaiki are dominated by weeds, particularly *Psidium cattleianum* and *Schinus terebinthifolius*, but significant patches of native forest cover other portions of the area. Some of the native species found in Kahanahaiki include: *Metrosideros polymorpha*, *Acacia koa*, *Psychotria* spp., *Myrsine lessertiana*, *Pisonia* spp., *Nestigis sandwicensis*, *Cibotium* sp., *Maratia douglasii*, *Cyrtandra dentata*, and *Cyanea superba* subsp. *superba*. Three of the trial sites are located in the southern part of Kahanahaiki, while the fourth trial site is located in the middle part of the exclosure.

Physical characteristics: The substrate of Kahanahaiki is primarily well-draining soil, with loose rock found in the gulches. While summers in the area can be hot, winters generally bring cooler temperatures, rain, and some mist.

Methods

Setup and Application

The six trials were designed to test the efficacy of four carriers and a control treatment on four different alien species, using common weed control methods. A different species was used in each trial; ten plants were subjected to each of the five possible treatments in the trial, for a total of 50 test plants. Different herbicide application techniques were used, depending on the species being tested.

The carriers tested were:

1) MSO®[4]
2) PHASE®[5]
3) Forestry Crop Oil[3]
4) Biodiesel (B100)[6]
5) Control (no herbicide and no carrier)

The four weed species chosen were:

1) *Psidium cattleianum*, Strawberry Guava
2) *Schinus terebinthifolius*, Christmas Berry
3) *Clidemia hirta*, Koster's Curse
4) *Leucaena leucocephala*, Haole Koa

Psidium cattleianum, S. terebinthifolius and *C. hirta* were chosen because they are some of the most common weeds OANRP controls and all of them are susceptible to Garlon 4. *Leucaena leucocephala* was chosen because it is particularly hardy, it is susceptible to Garlon 4, and it requires slightly different control techniques than the other species chosen.

The application methods used were:

1) Thin line: Also known as basal treatement. The plant was not mechanically marred. A continuous ring of herbicide solution was applied directly to the bark around the diameter of the main trunk of the plant. For the control treatments, no solution was applied.

2) Girdle: A hatchet was used to chip/scrape off a 3-4” wide strip of cambium completely around the circumference of the plant. Then a continuous ring of solution was applied to the cut. For the control treatments, the plants were girdled, but no herbicide was applied.
3) Cut stump: The plant was cut down (as close to the ground as possible) and herbicide was applied to the entire surface of the resulting stump. For the control treatment, the plants were cut down, but no herbicide was applied to the stump.

For each trial, the size ranges of the weeds were pre-determined in an attempt to get a homogeneous pool of test individuals. Two size classes of *P. cattleianum* were chosen because different application methods are used for different size classes. Large trees require girdling and herbicide, while small trees require only thin line herbicide application.

- Trial #1: *C. hirta* with 20% Garlon 4. The plants chosen had to be at least 0.5cm in diameter and have brown woody stalks. Young plants have green fleshy stems.
- Trial #2: *P. cattleianum* (diameter<4”) with 20% Garlon 4. Each tree was chosen to have a diameter between 1” and 4”.
- Trial #3: *P. cattleianum* (diameter>10”) with 20% Garlon 4. Each tree was chosen to have a diameter greater than 10”.
- Trial #4: *S. terebinthifolius* with 20% Garlon 4. Each tree was chosen to have a diameter greater than 10”.
- Trial #5: *L. leucocephala* with 40% Garlon 4: Each tree was chosen to be between 1-3” in diameter.
- Trial #6: *L. leucocephala* with 20% Garlon 4: Each tree was chosen to be between 1-3” in diameter.

There were two trials using *L. leucocephala*. Trial #5 was performed using all five treatments and 40% Garlon 4. In previous trials, OANRP determined that 40% Garlon 4, coupled with cut stump application and stump scarification, resulted in effective control. Trial #6 was performed only using FCO and biodiesel, with 20% Garlon 4. This trial was done as a follow up to previous trials, to determine if a different carrier would dramatically improve the efficacy of 20% Garlon 4 on *L. leucocephala*.

Prior to treatment application, data collected on each plant included basal diameter (*cm*) and vigor. Each plant was labeled with a unique number. Using a number randomizer, each plant number was randomly assigned to one of the five treatment options.

Two plants were randomly selected from each treatment type to be used as photopoints, for a total of ten photopoints per trial. Photopoints were taken before treatment during monitoring.

Table 1 summarizes the species, number of individuals, treatment method and herbicide used for each trial.

Table 1: Summary of Trials

Carrier Trial	Species	Number of plants treated	Treatment method	Herbicide
Trial #1	*Clidemia hirta*	40	Thin line	20% Garlon4 in carrier (5 treatments)
Trial #2	*Psidium cattleianum* (diameter 1-3”)	40	Thin line	20% Garlon4 in carrier (5 treatments)
Trial #3	*Psidium cattleianum* (diameter > 10”)	40	Girdle	20% Garlon4 in carrier (5 treatments)
Trial #4	*Schinus terebinthifolius*	40	Thin line	20% Garlon4 in carrier (5 treatments)
Trial #5	*Leucaena leucocephala*	40	Cut stump	40% Garlon4 in carrier (5 treatments)

Trial #6*	*Leucaena leucocephala*	20	Cut stump	20% Garlon4 in carrier (2 treatments)

* *L. leucocephala* is normally treated with 40% Garlon 4 in FCO, however OANRP wanted to see if there would be a difference between FCO and biodeisel efficacy at 20% Garlon 4.

Monitoring

Table 2 indicates the times of treatment and monitoring for each trial. In some cases, more than one monitoring was conducted of the trial, but only the final monitoring results are shown here. A College of Tropical Agriculture (CTAHR) weed response table was used to measure the response of the treated plants to the test treatment (Table 3). In addition, the presence of wood boring insect damage (frass, holes) and fungi was noted, as these denoted dead wood. A cambium scrape was conducted, to see if any live cambium was still present, even if leaves were not.

Table 2: Monitoring timeline for each carrier trial.

Carrier Trial	Species	Treatment Date	Final Monitoring Date	Time Lapse (from treatment to monitoring)
Trial #1	*Clidemia hirta*	1/8/2009	7/20/2009	6 months
Trial #2	*Psidium cattleianum* (diameter 1-3")	2/17/2009	7/20/2009	5 months
Trial #3	*Psidium cattleianum* (diameter > 10")	2/11/2009	7/20/2009	5 months
Trial #4	*Schinus terebinthifolius*	2/19/2009	7/20/2009	5 months
Trial #5	*Leucaena leucocephala*	1/6/2009	10/27/2009	9 months
Trial #6	*Leucaena leucocephala*	1/6/2009	10/27/2009	9 months

Table 3: CTAHR Weed Response Table

Score	Description
0	No symptoms
10-30	Insignificant to poor weed control; little or no defoliation
40-60	Inadequate weed control; moderately severe symptoms; less than 70% defoliated
70	Adequate weed control; severe symptoms; all leaves chlorotic or more than 70% defoliated
80	Good weed control; very severe symptoms; 80% defoliated
90	Excellent weed control; very severe symptoms; 90% defoliation
100	Complete control; no sign of life

Results / Discussion

Preliminary data analysis of the carrier trials suggest that Biodiesel (B100) works just as well as FCO as a carrier. Phase and MSO, however, had varying results depending on the weed species treated. Each trial is summarized in a graph of the mortality of each plant treated using the different carriers (see Summary Graphs 1-6).

Further analysis is needed to confirm if there is any statistically significant difference in the treatment efficacy of the individual carriers. In addition, further analysis could be done to see if there is any correlation between treatment efficacy of the individual carriers and size of the plants treated (this data is not shown in the summary graphs).

Trial #1 *Clidemia hirta* with 20% Garlon 4. In this trial there does not appear to be any difference in the efficacy of the individual carriers. All of the shrubs treated (not including control) had complete death

(CTHAR = 100). The control had some partial mortality in a couple of plants, this is presumed to be due to natural variability.

Trial #2 *Psidium cattleianum* (diameter<4") with 20% Garlon 4. In this trial there does not appear to be any difference in the efficacy of the individual carriers. There is some variation with the mortality of one of trees treated with biodiesel (CTHAR =70) and one of the the trees treated with MSO (CTHAR =50). All of the other trees treated (not including control) had complete death (CTHAR = 100). This is presumed to be due to natural variability. One of the control trees was dead, it was presumed this was naturally occurring.

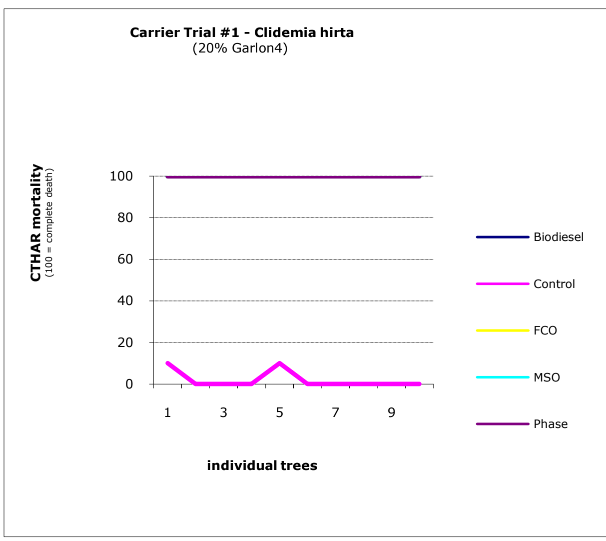
Trial #3 *Psidium cattleianum* (diameter>10") with 20% Garlon 4: In this trial there does not appear to be any difference in the efficacy of the individual carriers. Mortality in all of the trees treated was near 100% (CTHAR = 100. One of the control trees was dead; it appears this may have been treated accidentally.

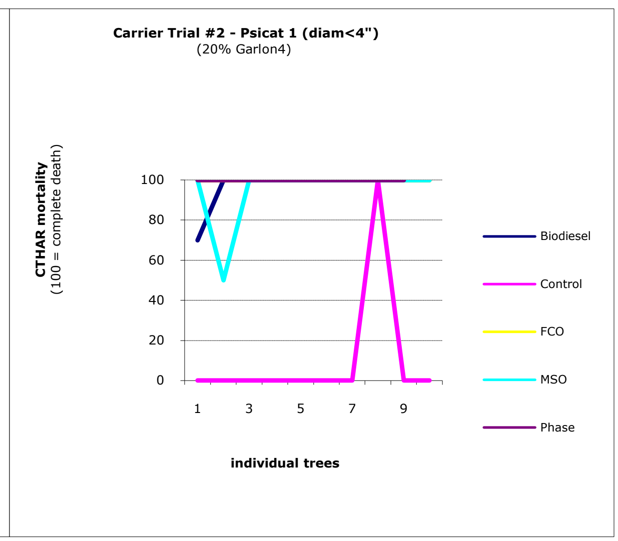
Trial #4 *Schinus terebinthifolius* with 20% Garlon 4: This trial had the most variability between the different carriers. The CTHAR score was nearly 100 for all of the individual trees treated with biodiesel and FCO. However the trees treated with MSO and Phase varied considerably in efficacy, CTHAR score ranging from 20 – 100. This suggests that these carriers did not perform as well. No significant mortality was observed in the control trees (CTHAR remained at or close to 0 for all control plants).

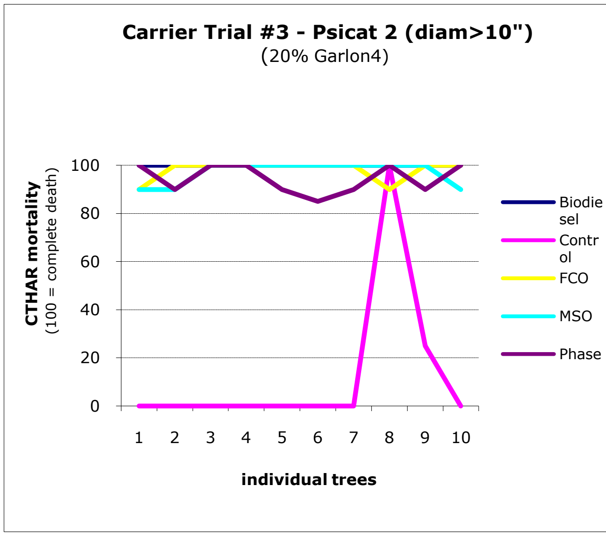
Trial #5 *Leucaena leucocephala* with 40% Garlon 4: In this trial there does not appear to be any difference in the efficacy of the individual carriers. All of the trees treated (not including control) had complete death (CTHAR = 100). There was no significant mortality observed in the control trees (CTHAR remained at or close to 0 for all the control plants)

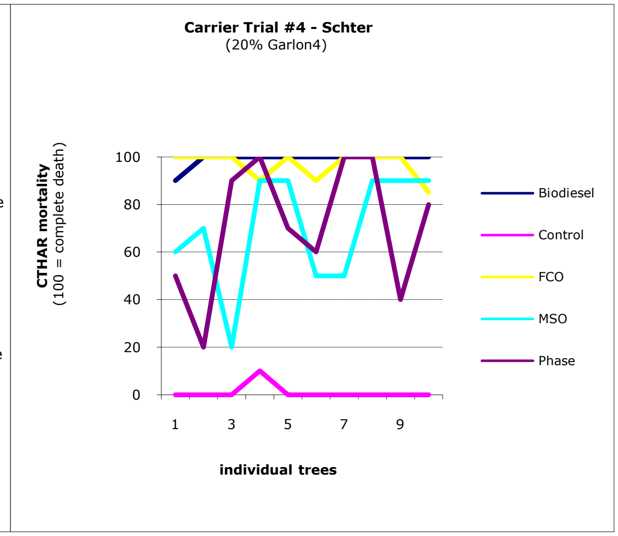
Trial #6 *Leucaena leucocephala* with 20% Garlon 4: This only tested FCO and biodiesel carriers, with no control except that installed for Trial #5 . All of the plants treated showed complete mortality (CTHAR = 100) with the exception of one of the plants treated with biodiesel, which showed no mortality. It is presumed that this may have been due to poor treatment technique.

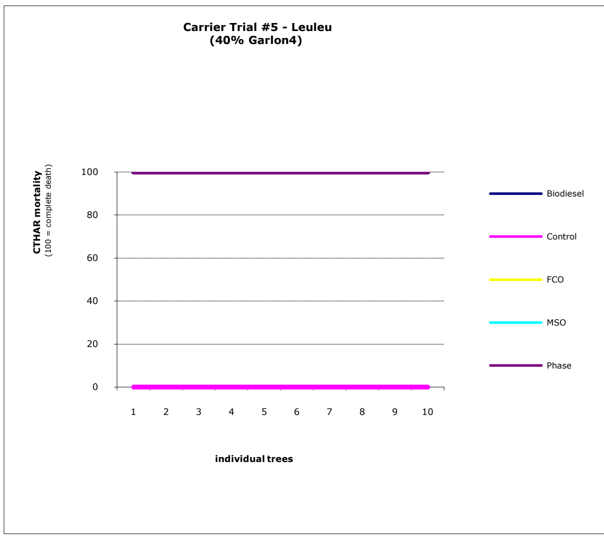
Summary Graphs 1-6

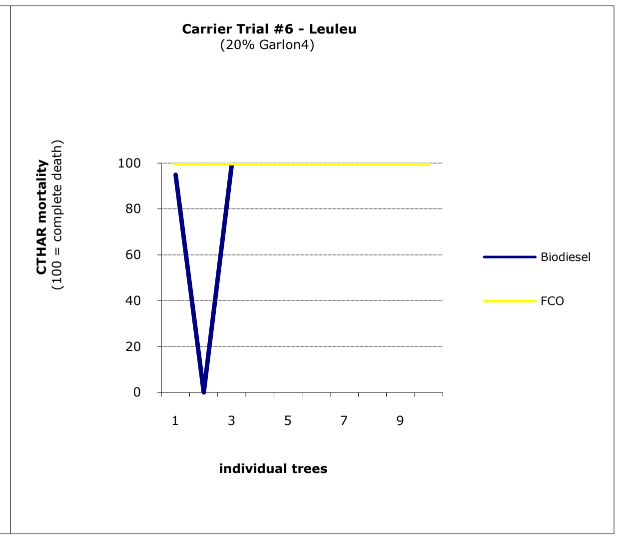












[1]Roundup: Produced by Monsanto. Active ingredients: Isopropylamine salt of N (phosphonomethyl) glycine; {Isopropylamine salt of glyphosate}

[2]Garlon 4: Produced by Dow Agrosciences : Active Ingredients: ((3,5,6-trichloro-2-pyridy1)oxy) acetic acid, buyoxy ethyl ester. Garlon is the most frequently used oil-based herbicide; used to control woody plants. Dilution rates range from 1.5 – 50% Garlon 4 with an oil-based carrier. Garlon is effective on a wide range of plants, particularly woody plants.

[3]Forestry crop oil (FCO): Produced by Loveland products. Ingredients: Petroleum Oil. FCO is the most commonly used oil-based carrier with Garlon 4.

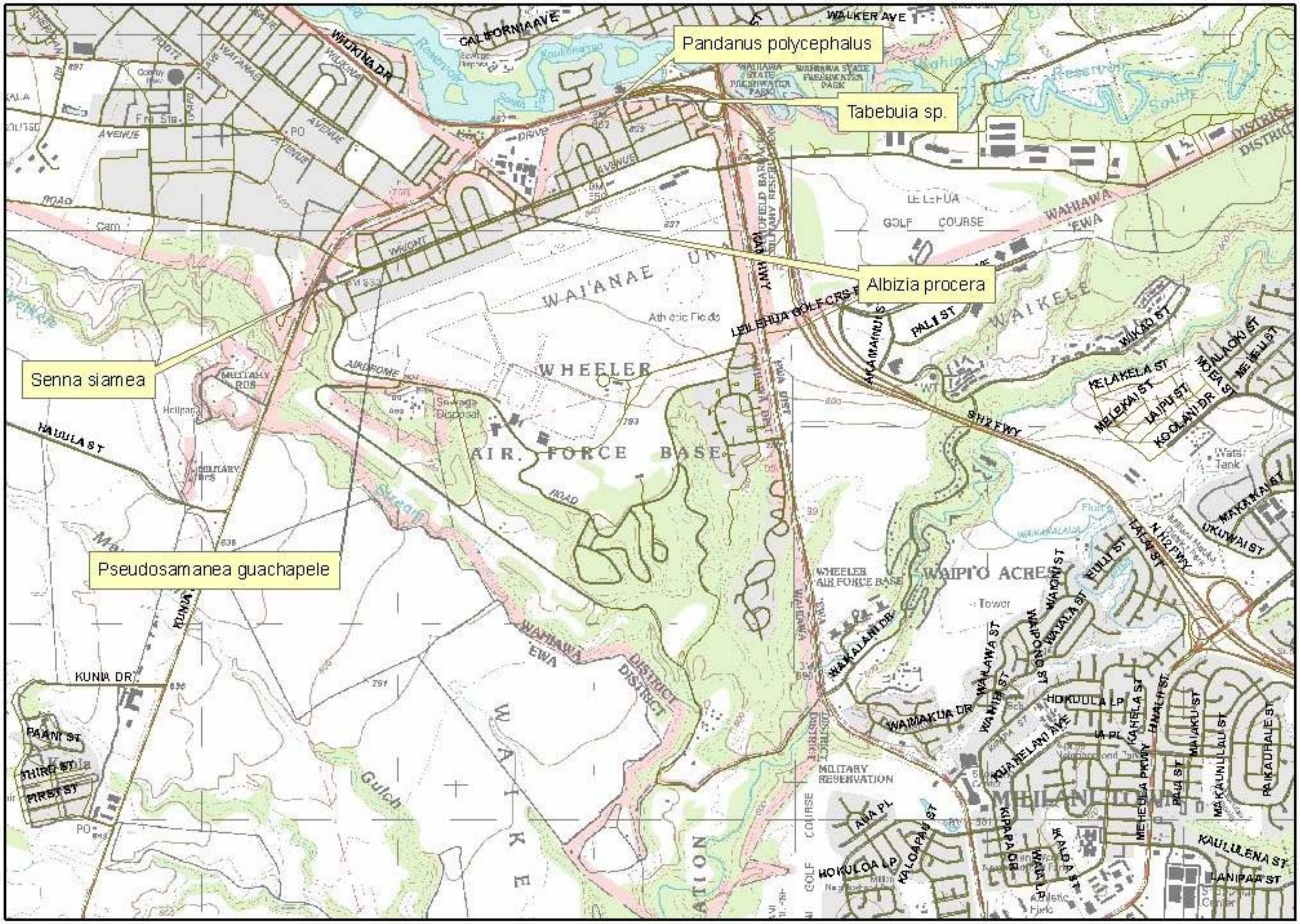
[4]MSO®: Produced by Loveland products. Concentrate with Leci-Tech. Ingredients: Methylated vegetable oil, Alcohol ethoxylate, and Phosphatidylcholine.

[5]PHASE®: Produced by Loveland products. Ingredients: Methylated esters of fatty acids, alkylpolyoxy-Ethylene ether and polyether modified polysiloxane.

[6]Biodiesel (B100). Ingredients: Methyl esters from lipid sources

Appendix 1-4
OED Survey Results for Schofield Barracks and Wheeler Army Airfield

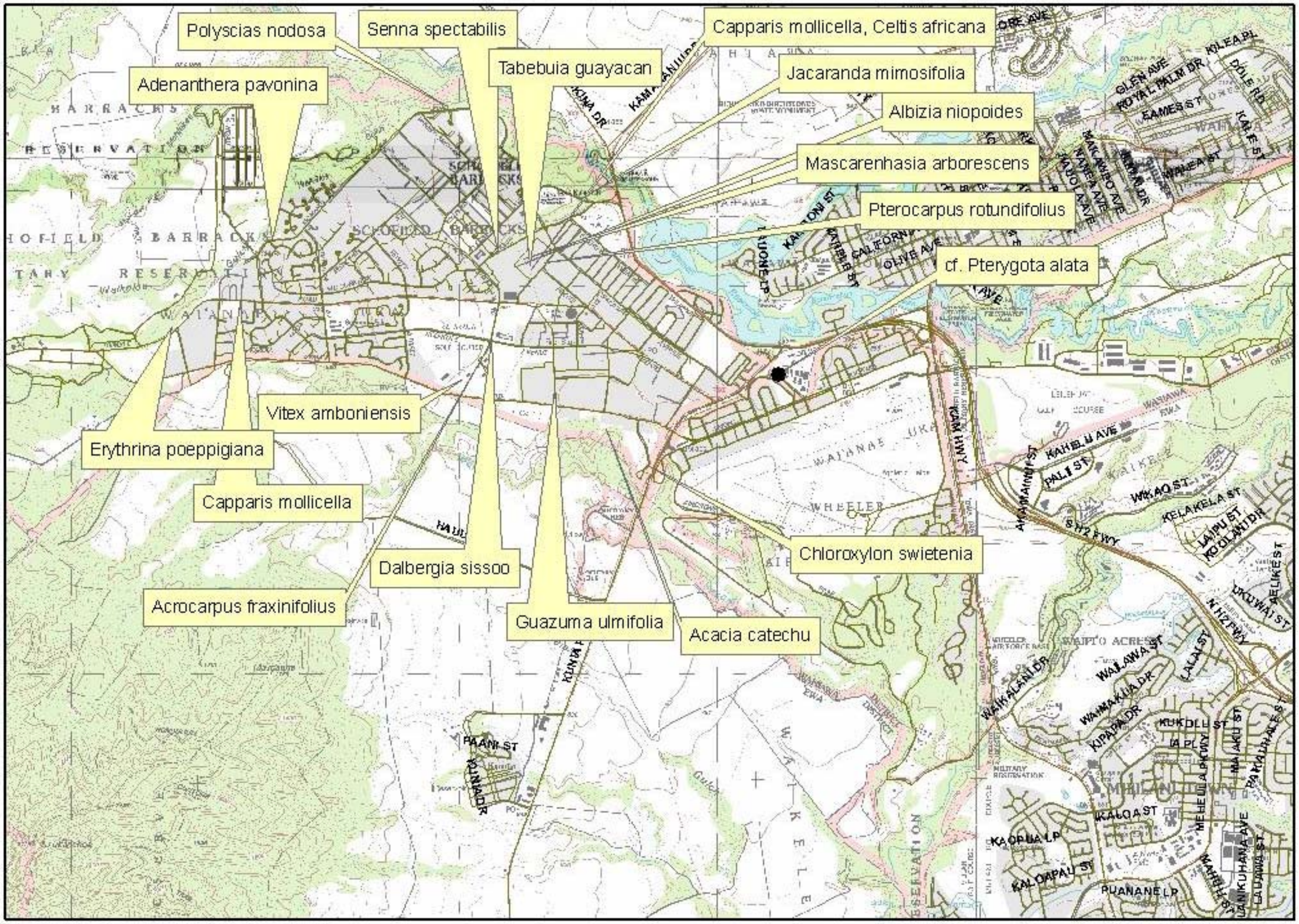
Wheeler	Notes	Oddities-Schofield/Wheeler only Oahu location	Commonly planted, fyi, look for spread	need ID, look for flowers/fruit	is it invasive in your natural areas?	consider removing	new record's, too widespread for OED
Albizia procera	Only known from Wheeler, where it is at least adventively spreading if not naturalized. It is a fast growing invasive elsewhere including Puerto Rico and South Africa. Would be great to remove but listed as some planted trees are listed Exceptional trees.	x			x		
Enterolobium cyclocarpum	Rather common on base, occasonal elsewhere on O'ahu. Rather large tree. The Global Compendium of Weeds lists this as invasive but a quick search for details turned up empty. OED has not seen this clearly spreading anywhere. Would be good to keep an eye out		x		x		
Erythrina sp.	Jane knows about this a bit. We need flowers or especially fruit to ID. Possibly imported from Samoa.			x			
Fraxinus cf. uhdei?	Fruits are a match for uhdei but seems to have a different look. We are less familiar with this species' variability and look. Would be interesting to hear what you guys think			x			
Pandanus polycephalus	Shrubby Pandanus with copius sticky fruits, looked inviting to birds though no spread was noted. Keep your eyes out! This is the first time we've come across this species.	x					
Pseudosamanea guachapele	A few large trees, no flowers seen but should be white. As the name suggests, it looks like monkeypod. No clear weed history from anywhere. Only known in the State from Wheeler	x					
Pterocarpus indicus	Very commonly planted on Schofield, invasive elsewhere but not documented as naturalized in Hawaii (yet). OED has observed seedlings. Would be good to look out for this in natural areas.		x		x		
Senna siamea	Rare elsewhere on O'ahu but commonly planted and sparingly naturalized on Schofield and Wheeler. Would be good to look out for it elsewhere. Invasive elsewhere, though the current WRA posted online accepted the species! Would be good to look out for, removal would be a large undertaking.		x		x		x
Tabebuia sp.	Need flowers for ID. Pretty sure we haven't come across this before. 2-3 small trees fruiting in residential area.	x		x			



Species of Interest: Wheeler

Scale 1:25,846

Schofield	Notes	Oddities- Schofield/Wheeler only Oahu location	Commonly planted, fyi, look for	need ID, look for flowers/fruit	is it invasive in your natural areas?	consider removing	new records, too widespread for OED
Acacia catechu	One naturalized individual noted on base. Planted in forest reserves and spreading, OED hasn't seen this in natural areas. Might want to keep an eye out.						
Acrocarpus fraxinifolius	Not in Global Compendium of Weeds. Not much known about biology. Only known specimen from HI is from Schofield.	x					
Adenanthera pavonina	Noxious weed, enviro weed in Global Compendium of Weeds. Serious weed elsewhere- look for spread.				x		
Albizia niopoides	Not in Global Compendium of Weeds. Seen spreading adventively from original planting to nearby shed and fence. Only known specimen from HI is from Schofield.	x				x	
Capparis mollicella	Distinctive flowers/fruit, OED found spreading off base. Didn't find any info on weed history elsewhere.	x			x		x?
Celtis africana	Not in Global Compendium of Weeds. Not much known about biology. Only 2 known locations from HI.	x					
Chloroxylon swietenia	Vulnerable species-IUCN. Not much known about biology. Only known specimen from Oahu is from Schofield.	x					
Dalbergia sissoo	Noxious, enviro weed in Global Compendium of Weeds. Problem species in Florida and N Australia.						
Erythrina poeppigiana	Cultivation escape, naturalized in Global Compendium of Weeds. Spreading from original planting in Schofield. Not a new record, but infrequently planted on Oahu.				x		
Ficus religiosa	Lots of saplings all around base. Especially at the base of gutters...		x		x		
Guazuma ulmifolia	One tree seen in Schofield, this species is occasional to rare elsewhere on O'ahu. It appears to have at least naturalized elsewhere but information on it being invasive was not found.						
Mascarenhasia arborescens	Not in Global Compendium of Weeds. Not much known about biology. Only known specimen from HI is from Schofield.	x					
Polyscias nodosa	Naturalized just over fence from base. Was sterile when we were there, but would be great to get a flowering/fruiting specimen.			x	x		
Pterocarpus rotundifolius	Agricultural weed in South Africa: Global Compendium of Weeds. Not much known about biology. Only known specimen from HI is from Schofield.	x					
Pterygota alata, c.f.	We're not sure of ID, would be great to get flowering/fruiting specimen.			x			
Senna spectabilis	Enviro weed in Global Compendium of Weeds. Collected naturalized at Schofield. Spreading to natural areas?						x
Swietenia macrophylla	not mapped in Schofield, but thought we'd mention it (it's included on the mapin the Exceptional Tree Guide) Invasive elsewhere including Hawaii. Was planted and is spreading in forest reserves here, but is rarely seen naturalizing from plantings in urban areas.						
Tabebuia guayacan	Not in Global Compendium of Weeds. Not much known about biology. Weedy congenerics. Only 2 known locations from HI.	x					
Tipuana tipu	In a few neighborhoods on base (not uncommon outside of Schofield), not noticed naturalizing but a weed elsewhere. Check for spreading to natural areas.				x		
Vitex amboniensis	Just an oddity, not encountered before on any of our surveys. No weed history elsewhere (but some other Vitex species are documented as invasive)						
Washingtonia robusta	A nasty weed in urban areas- check for spreading to natural areas.				x		



Species of Interest: Schofield

Scale 1:39,274

<u>APPENDIX 2: FIRE REPORTS</u>

Makua Cave Vicinity Fire Memorandum for Record

July 23, 2009

APVG-GWV (200-3) 8 September 2009

MEMORANDUM FOR RECORD

SUBJECT: Memorandum for record regarding Makua Cave vicinity fire, July 23.

<u>Background</u>

NRS is not currently approved to engage in fire fighting activities due to insurance issues at RCUH. These issues are currently actively being worked on by Dr. Cliff Smith, Joby Rohrer and Dan Sailer. Hopefully this will soon be resolved. As a result of this restriction, NRS involvement in fire response is restricted to working in an advisory capacity and supporting aerial operations. The fire was very small, 3.84 acres, not accounting for topography. It burned both makai and mauka of Farrington Highway, and was quickly contained. Staff involvement consisted of communicating with other agencies, specifically Army Wildland Fire, Makua Range Control, DPW Environmental, and Division of Forestry and Wildlife (DOFAW). NRS prepared to deploy to Makua to ensure that rare taxa were protected, but no assistance was needed. This was the second fire to occur in the week; a much larger fire burned portions of Kaena Point July 21, 22. Despite this, other agencies were quick to mobilize for the Makua Cave fire. It is unclear if any rare taxa were affected by the fire. There are several rare plants in the area, including populations of *Melanthera tenuifolia*, *Chamaesyce celastroides* var. *kaenana*, *Hibiscus brackenridgii* ssp. *mokuleianus*, and *Spermolepis hawaiiensis*. The *M. tenuifolia* population is located on a cliff; the fire burned up to this cliff, but did not impact the population. The *S. hawaiiensis* is located on the same cliff. The fire did burn within 150m of the *C. celastroides* and at least within 40m of the *M. tenuifolia*.

Map removed to protect rare resources

The fire threatened *M. tenuifolia*. The WCAs noted on the map are fuel breaks protecting *C. celastroides* and *H. brackenridgii*.

Thursday July 23, 2009

At approximately 12 pm, Mandy Hardman reported seeing smoke coming from the Makua/Keawaula region. She radioed base from Ohikilolo Ridge, Makua Valley, where she was in the process of hiking from camp to Range Control at the end of a three day camp trip. Base contacted Makua Range Control; Range Control staff said that they were aware of the fire, and noted that it was at Makua Cave. Base contacted Army Wildland Fire, who quickly mobilized and left Schofield for Makua. Base contacted Ryan Peralta of DOFAW, who was monitoring the Kaena Point fire (started on July 21). Mr. Peralta said that he would head towards Makua, as the fire location was in Zone 2 (DOFAW/HFD co-op response). Base also contacted Michelle Mansker (Army Natural Resources Manager) to update her on the situation. Ms. Mansker indicated that OANRP should hold off activating helicopter resources for the time being, as HFD was responding and OANRP paid for most of the helicopter time on the Kaena fire.

Meanwhile, the crew camped at Ohikilolo were preparing to end their 3-day trip. There was rainy, cloudy weather at the campsite, and the crew wanted to fly out as soon as possible. Ms. Hardman and Eli Kimmerle, who were hiking to Range Control, were told to wait at the Ohikilolo Mid LZ, the westernmost LZ on the ridge. Their route would have taken them very close to the fire. The irony of rainy weather on one side of Makua Valley and a fire on the other side was discussed.

Ms. Hardman radioed to Base and Ohikilolo Camp that she saw a helicopter dropping water on the fire; however, the transmission was not received by Base. This may have been due to difficulties with radio signal from Ohikilolo, or to multiple phone calls at Base. In any case, Base was not aware of the aggressive measures being implemented by HFD.

Base received a phone call from Army Wildland Fire, saying the HFD had contacted them, and that the fire was under control. Several Army Wildland Fire staff were going to turn around and head back to Schofield, sending 1 or 2 personnel on to monitor the fire. Base was concerned that no-one familiar with the rare taxa had yet seen the site.

Pacific Helicopters arrived at Ohikilolo to transport NR crews off the mountain at around 2pm, Lincoln Ishii pilot. The weather cleared, and Mr. Ishii was able to fly all personnel and gear from Ohikilolo to the Nike site. On the last load, Mr. Ishii flew over the fire with Kapua Kawelo and Mike Walker. They determined that the fire appeared to be out. Ms. Kawelo thought that the *M. tenuifolia* cliff had burned.

At 2:20pm, Base received a call from Army Wildland Fire that the fire was officially contained. This information was relayed on to Mr. Peralta and Ms. Mansker.

NRS Helicopter Resources

Company	Time	Total
Pacific (Lincoln)	2:00-2:10	10 min

NRS Personnel Resources

Personnel	Time	Total
KK, MW	2:00-2:10	10 min

To our knowledge, the HFD Fire Investigators were never called to the scene. The cause of the fire is officially unknown, but arson is suspected given the proximity to the road.

Post-Fire Survey, Thursday August 6, 2009

Jessica Hawkins conducted a survey of the fire to determine any possible damage to rare taxa and accurately GPS the perimeter of the burned area. The fire burned a small area makai of the highway, 0.16 acres, and a larger area mauka of the highway, 3.68 acres. The fire did not crest Ohikilolo ridge, and did not approach the fuel breaks maintained by OANRP to protect *C. celastroides* var. *kaenana*. However, it did sweep towards the cliffs east of the Makua Cave, towards a population of *M. tenuifolia*.

The following is a partial list of native and alien plant species surveyed in the burn area.

Native Plant Species	**Alien Plant Species**
Dodonaea viscosa	*Acacia farnesiana*
Myoporum sandwicense	*Cenchrus ciliaris*
Sida fallax	*Leucaena leucocephala*
Waltheria indica	*Panicum maximum*

Fire boundary close to Farrington Highway. Note small burned area makai of road. Note patchy burned areas

Map removed to protect rare resources

View towards the *M. tenuifolia* cliff. The fire burned to the base of the cliff.

Map removed to protect rare resources

View from Ohikilolo ridge, above the C. celastroides, looking towards Farrington.

Fuels were short, over rocky terrain

Post-Fire Survey, Thursday August 17, 2009

On August 17, 2009 Kaleo Wong and Joby Rohrer did a post fire survey to determine the impact of the fire on the *M. tenuifolia* at the Lowere Ohikilolo PU. The crew hiked in from Makua along the fence line with rappelling gear to access impacts to the plants one the cliff. The entire PU area in proximately to the fire was covered with multiple rappels. The fire never reached the area where *M. tenuifolia* had been seen in the past. There is a large, sheer, un-vegetated rock face just below the lowest extent of the PU. In fire did not breach this barrier as in previous years. However the fire edge got within tens of meters of the PU. Unfortunately despite the absence of a fire impact only a single plant was found on this day.

Map removed to protect rare resources

View of burn area form the *M. tenuifolia* PU, makai side of PU

Map removed to protect rare resources

View of burn area form the *M. tenuifolia* PU, Makua side of PU

Map removed to protect rare resources

View of lower portions of the *M. tenuifolia* cliff with burned area below

The single *M. tenuifolia* individual seen at PU

Lessons Learned and questions that need follow-up

- OANRP needs to work with PCSU to resolve insurance issues so staff can be involved in fire fighting activities. OANRP staff are a valuable resource in Wildland fires as most HFD crews are not familiar with wildland areas and native and endangered resources, and large numbers of trained personnel are needed for effective suppression operations.
- No OANRP, Army Wildland Fire, or DOFAW staff were at the scene of the fire. This made it difficult for OANRP to decide how to proceed in responding to the incident, since the *M. tenuifolia* was so close to the fire. HFD was on scene, but they do not have the same background in preserving rare taxa.
- Rare plants are located very close to Farrington Highway, the primary ignition point of most fires in this area. It is difficult to respond to fires quickly enough to prevent any damage to rare taxa.
- This area has a long history of wild fires. Proactive fuel reduction strategies should be utilized in the area.
- Helicopter support was critical in controlling the fire.
- NRS should work with Army Range Control to keep a binder of maps showing rare resource location so they can provide to the first responders.

Jane Beachy/Joby Rohrer

Ecosystem Restoration Program Manager

Oahu Army Natural Resources Program

Manini/Alau Vicinity Fire Memorandum for Record

July 21-22, 2009

APVG-GWV (200-3) 5 August 2009

MEMORANDUM FOR RECORD

SUBJECT: Memorandum for record regarding Manini/Alau vicinity fire, July 21-22.

Background

NRS is not currently approved to engage in fire fighting activities due to insurance issues at RCUH. These issues are currently actively being worked on by Dr. Cliff Smith, Joby Rohrer and Dan Sailer. Hopefully this will soon be resolved. As a result of this restriction, NRS involvement was minimal and restricted to working in an advisory role and supporting aerial operations. The response from other agencies was commendable as Army Wild Land Fire was there both days working late as well as a large DLNR crew and HFD resources including both fire helicopters on July 21. Luckily no endangered natural resources were directly impacted, although designated critical habitat for six species burned (*Chamaesyce celestroides var. kaenana, Sesbania tomentosum,Centaurium sebaeioides, Schiedea kealiae, Cyperus trachysanthos)*. The fire burned with 95 m of the East of Alau population of *Chamaesyce celestroides var. kaenana*. This endangered plant population is designated as a "Manage for Stability" population by the Makua Implementation Plan and is therefore intensively managed by the Oahu Army Natural Resource Program (OANRP). As calculated by GIS the fire burned a total of 61 acres not considering topography. OANRP estimates the fire to be about 200 acres given the very steep terrain. There was a similar fire in the area in August of 2007.

Map removed to protect rare resources

Tuesday July 21, 2009

At approximately 3:30 pm Mike Walker radioed in from Ohikilolo Ridge in Makua Valley where his team was on the first day of a three day camping trip. He reported seeing a plume of smoke rising from the Kaena vicinity. He could not tell precisely where the smoke was originating. From the Schofield Barracks Base yard OANRP staff notified DLNR staff, Ryan Peralta (Oahu Protection Forester), Jason Misaki (Oahu Wildlife Biologist), and Brent Leisemeyer (Natural Area Reserves Manager). The Army's Wild Land Fire Crew was also notified. Both Mr. Peralta and the Army Wild Land Fire followed up with HFD. Army Wildland Fire responded rapidly deploying from their Area X base yard within approximately twenty minutes from the initial conversation with OANRP. OANRP continued to get updates from Mr. Walker and reported the situation up the chain of command to Michelle Mansker (Army Natural Resource Manger) and PCSU (Pacific Cooperative Studies Unit). OANRP received permission to respond to the incident in an advisory mode to assist with resource maps and help determine the threat to recourses. At a little after 4 pm Senior Natural Resource Coordinator Mr. Joby Rohrer and Natural Resource Coordinator Mr. Dan Sailer responded to Kaena with maps to assist with efforts and help size up the fire.

Mr. Rohrer and Mr. Sailer arrived at the Manini/Alau vicinity around 5 pm. They tied in with Mr. Peralta and Mr. Scott Yamasaki (Army Wild Land Fire Section Supervisor) and got briefed by the HFD Incident Commander (IC). The fire had already completed its initial run through the hot flashy fuels in the area. Both HFD helicopters were already making bucket drops and continued until the end of the day. OANRP advised both the HFD and Wild Land crew of the fire's proximity to the *Chamaesyce* site. Crews focused on the area closest to the endangered plants to ensure that the fire would not begin to spread actively toward the plants. OANRP began to call helicopter resources to determine availability. There were no privately contracted helicopters available that afternoon and HFD had good coverage with their air resources.

OANRP stayed on site with crews until 9:30 pm. As the area darkened it became apparent that although there were no active flames there were numerous hot spots across the area and the chance of active fire behavior that night or the next day was good. The crew debriefed and made plans for the following day.

Personnel	Time	Total
JR, DKS	4:00-9:30	11 hours

C. celestroides var. kaenana at Kaena point

Wednesday July 22, 2009

On Wednesday July 22 OANRP were on scene at 6:15 am. Mr. Peralta was already conducting an aerial site assessment with HFD and two other DOFAW staff were also on site. A determination was made by Mr. Peralta and HFD that contract helicopter support would be called in and fire department helicopter support would be on standby. After the assessment Mr. Rohrer and DOFAW staff Mr. Mateo where assigned as lookouts on the road below the fire. DOFAW Oahu Division Supervisor Mr. Dave Smith also assumed supervision of all DOFAW staff on scene. Army Wildland Crews were soon on the scene and continued mop up activities initiated the previous afternoon. Mr. Yamasaki had split the crew and sent additional resources to manage the top perimeter of the fire given the close proximity to the FAA tracking station. DOFAW crews also came out in force with all branches represented (NARS, Forestry, Wildlife, Na Ala Hele, and OISC staff).

Pacific Helicopters arrived on scene at 8:35 am and did a short reconnaissance flight, then shut down to configure a Bambi fire bucket. At 9:30 am bucket drops began until 10:40 am when the ship left to refuel. Pacific returned at 11:35 and quickly continued to drop water. The pilot took a short lunch break around 12:30 pm then continued dropping until about 1:15 pm. Bucket drops were coordinated by on the ground spotters from both DOFAW and Army Wild Land Fire as well as OANRP staff on the road. At 2:10 pm Paradise Helicopters was on scene and began bucket drops. There was some difficulty with the helicopter's remote switch and the ship was switched out at 3:30 pm. Drops resumed at 3:40 pm and continued until 5:15 pm when an aerial recon was performed with DOFAW, Wild Land Fire, and OANRP staff.

OANRP staff on the fire included Mr. Rohrer who reported at 6:15 a.m., Mr. Sailer who reported at about 10:30 a.m. with additional hoses and supplies request by Wild Land Fire, and Mr. William

Weaver who reported at 8:45 a.m. with two DOFAW buckets from the Paradise Helicopters hanger. Mr. Sailer and Mr. Weaver stayed on scene until 3:30 pm. Mr. Rohrer stayed on scene until 6:00 pm.

Thanks to Mr. Yamasaki's and Mr. Peralta's aggressive aerial and ground attack, hot spots were quickly managed and monitored throughout the day and the fire never got a chance to become active again. All hotspots where managed efficiently and aggressively. Despite the steep terrain, the leading edge of the fire line was thoroughly checked by DOFAW staff and any hot spots were extinguished via mostly dry mop up methods. With heavy loads of light flashy fuels around and endangered plants extremely close OANRP fully supported the approach taken by the combined IC of Mr. Yamasaki and Mr. Peralta on July 22. It is OANRP's opinion that many times in the past fires were not attacked aggressively enough when they were in the mop up stage. Those fires were left to rekindle and rage again when effective management of latent hot spots is a much more effective strategy and in the long run saves effort and resources.

NRS Helicopter Resources

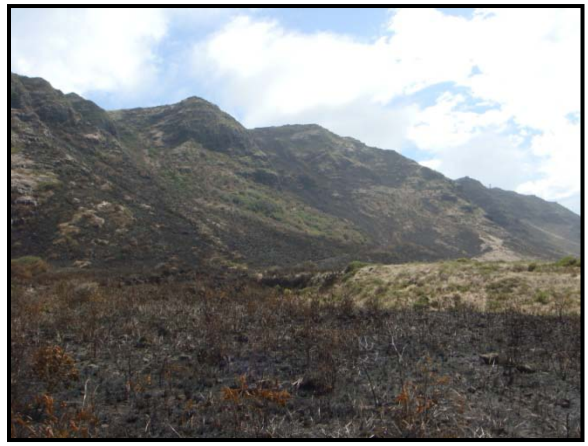
Company	Time	Total
Pacific (Howard)	8:35- 10:40 11:35-1:20	3 hours 40 minutes
Paradise (Calvin)	2:10 – 6:00 with some downtime	3 hours 30 minutes

NRS Personnel Resources

Personnel	Time	Total
JR	6:15-6:00	11 hours 45 minutes
DKS, WW	10:30/8:45	12 hours

Paradise Water drop

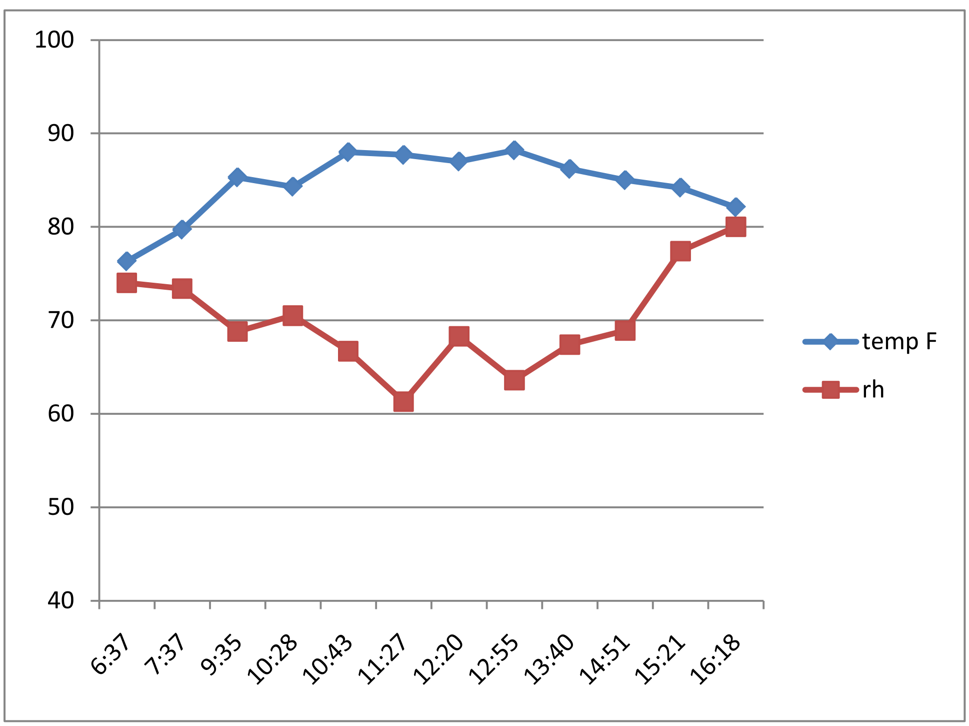
Suspected ignition point

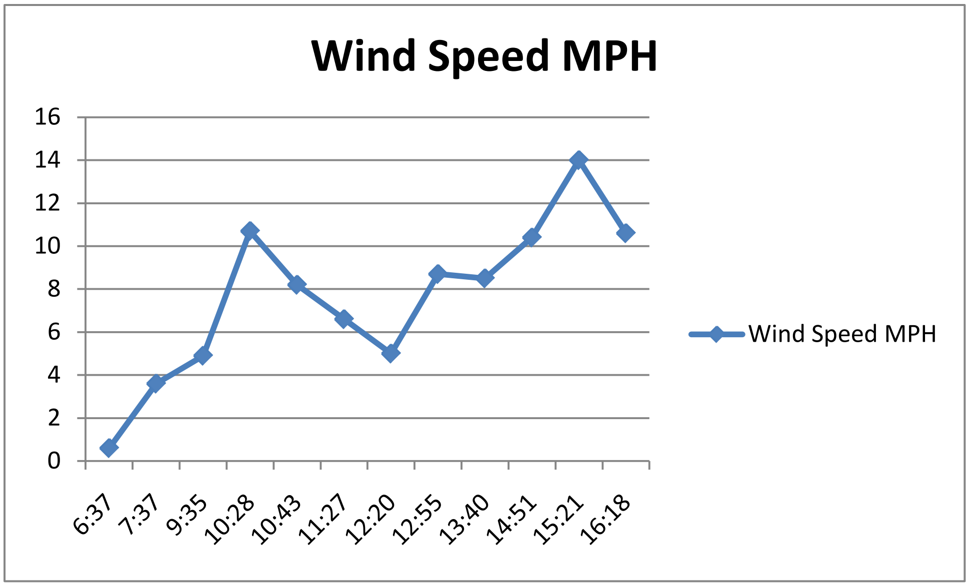


Burned area

To our knowledge, the HFD Fire Investigators were never called to the scene. The cause of the fire is officially unknown, but arson is suspected given the proximity to the road.

OANRP staff collected weather data as part of their lookout duties to advise the IC. The following graph depicts changes in relative humidity throughout the day.




Wind Speed MPH
16
14
12
10
8
6
4
2
0
6:37
7:37
9:35
10:28
10:43
11:27
12:20
12:55
13:40
14:51
15:21
16:18
Wind Speed MPH

The following is a partial list of Native and Alien plant species surveyed in the burn area.

Native Plant Species	Alien Plant Species
Dodonaea viscosa	*Acacia confusa*
Psydrax odoratum	*Andropogon virginicus*
Sida fallax	*Cenchrus ciliaris*
Waltheria indica	*Hyptis pectinata*
Erythrina sandwicense	Leucaena leucocephala
Myoporum sandwicense	*Melinus minutiflora*
Gossypium tomentosum	*Panicum maximum*
Plumbago zeylanica	*Pluchea symphytifolia*
Artemesia australis	*Rhynchelytrum repens*
Melanthera integrifolia	
Cocculus orbiculatus	

Lessons Learned and questions that need follow-up

- OANRP needs to work with PCSU to resolve insurance issues so staff can be involved in fire fighting activities. OANRP staff are a valuable resource in Wild land fires as most HFD crews are not familiar with wildland areas and native and endangered resources, and large numbers of trained personnel are needed for effective suppression operations.
- Kestral weather stations were extremely useful in tracking critical weather changes and predicting fire behavior.
- Operational fire buckets are essential during the peak fire season (April-October).
- Given the heavy recreational use of the Kaena Pt. area, fires can be expected in the area annually. Endangered species management plans may need to be changed to reflect this high fire frequency regime and the accompanying loss of native habitat.
- Contract helicopter support is critical to supplementing the efforts of HFD.
- The leadership under a joint IC of Mr. Yamasaki and Mr. Peralta is very efficient and effective.

Jobriath Rohrer

Senior Natural Resource Management Coordinator

Oahu Army Natural Resource Program

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<u>APPENDIX 3: FIRE MANAGEMENT NOTES</u>

<u>Dawn Greenlee Notes</u>

Waianae Mountains Kaluakauila, Waianae Kai, Honouliuli, Site Visits to Brainstorm New Fuelbreaks – March 11 and 12, 2009

All plans presented in these notes are preliminary and have, for the most part, not been discussed with landowners, action agencies, or regulatory partners

Site Visit Participants: Dawn Greenlee (USFWS), Andy Beavers (CEMML), Scott Yamasaki (Army FMO), and, on March 12, Ryan Peralta (DOFAW Oahu Protection Forester)

Kaluakauila: It may be possible to graze the guinea grass below Kaluakauila Management Unit on both the Keawaula and Makua sides (Figures 1 and 2). Areas with slopes less than 40 percent are targeted for grazing. If cattle were used, steep slopes may be sufficient to prevent cattle from impacting listed species. Strategic fences which may be necessary in less steep areas are shown in Figures 1 and 2. NRCS may be available to assist with fence and water source infrastructure design.

Figure 1. Targeted grazing areas to minimize fire threat to Kaluakauila MU

Map removed to protect rare resources

Figure 2. Kaluakauila – Keawaula Side

Approximate costs of Fuel Pre-suppression Actions (D. Greenlee notes)

Management Action	Priority	Cost	Annual cost?	Project type	Notes
Install fuel break along ridge line. Fuel break 20-30 ft wide depending on terrain.	P1	10,000	No	Fuel break	**$110/month per acre based on Makua Grass cutting contract DOC.**
Maintain fuel break between one peak north of 1737 and the peak at 1673 along the main ridge dividing KMU from Makua and Punapohaku via spraying with backpack sprayers.	P1	$2,500	Yes	Fuel break	**$110/month per acre based on Makua Grass cutting contract DOC.**
Develop helicopter landing zones along main Kaluakauila ridgeline	P1		No	Infrastructure	
Maintain helicopter landing zones	P2		Yes	Infrastructure	
Mark fenceline with cyperstakes on the western boundary where fires burn from Keawaula. with reflective tape so it is visible by helicopter crews from the air. Along chimney and above grassy bowl.	P1	$2,000	No	Infrastructure	
Construct chainlink fence to deter arsonists	P2	200K	No	Infrastructure	Based on two quotes from chainlink contractors
Install artificial surveillance cameras along chainlink fence at the base of Kaluakauila Drainage.		$20,000			
Control fuel along newly installed chainlink fenceline	P2	$4,000	Yes	Fuel modification	30 ft wide x .8 miles long=3 acres x $110/month/acre
Revegetation of grassy bowl with Mango	P3		No	Fuel modification	For FWS, very long term and costly!
Spray grassy bowl between upper and lower forest patches with herbicide via a helicopter ball sprayer in preparation for planting mango.	P3	100K	No	Fuel modification	For FWS, very long term and costly!
Maintain grass control in grassy bowl around plantings.	P4			Fuel modification	For FWS, very long term and costly!
Orient fire response crews to KMU and priority response areas.	P1	5,000	No	Infrastructure/ Communication	Helicopter time

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Appendix 4 Chapter 4 appendices

Appendix 4 contains supplemental information for Chapter 4. Contents of Appendix 4 include

- Appendix 4-1: Implementation Team Handout March 2009
- Appendix 4-2: Report to U.S. Army Garrison, Year 3, M. Meyer, July 2008
- Appendix 4-3: Black rat (*Rattus rattus*) predation on nonindigenous snails in Hawaii: Complex management implications, Meyer and Shiels, 2009
- Appendix 4-4: Application of harmonic radar technology to monitor tree snail dispersal, Hall and Hadfield 2009
- Appendix 4-5: Ecology of introduced rats (*Rattus* spp.) and their impacts on Hawaiian plants, A. Shiels 2009

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APPENDIX 4-1: IMPLEMENTATION TEAM HANDOUT MARCH 2009

Annual Army Tree-Snail Meeting
3/3/2009
Kevin Hall
kthall@hawaii.edu

Mark-Recapture Discussion Outline

- **Lincoln-Peterson estimators**
- **Practical example**
- **Assumptions of closed models**
- **Defining populations**
- **Full August 2008 protocol**
- **Deviations from protocol**
- **Marking: glue vs. paint**
- **Surveying: entire site vs. random quadrats**
- **Effort: 2 days vs. 3+ days**
- **Which deviations to use, and why**
- **Final notes & Discussion**

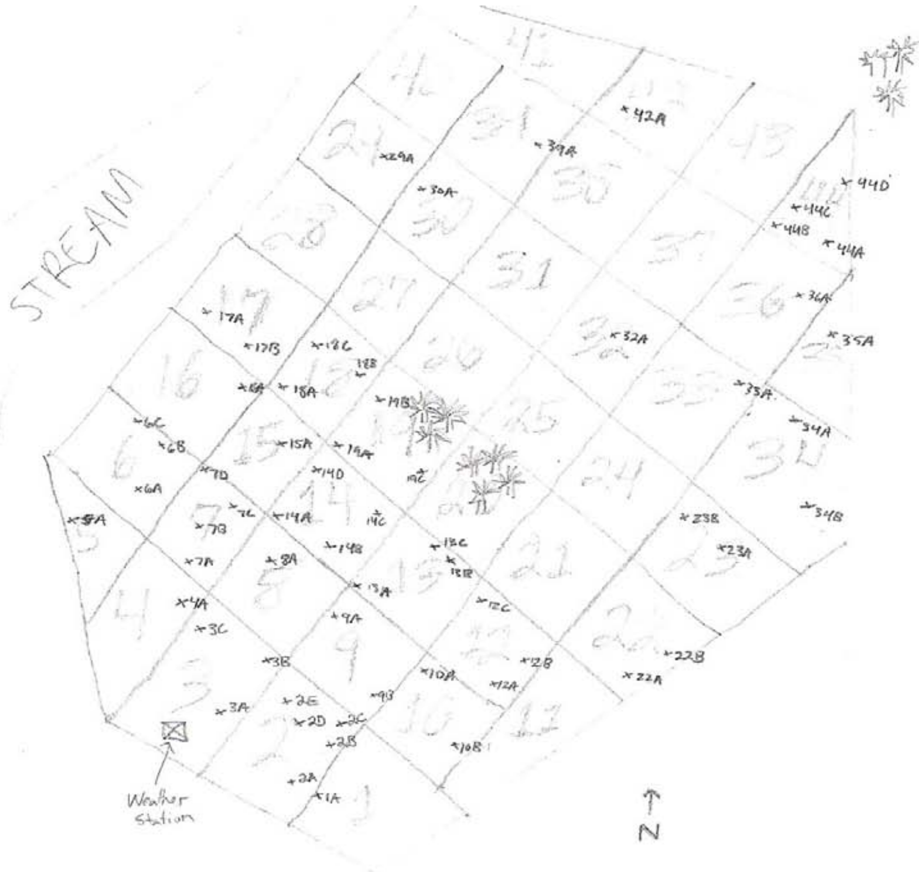
Table 1. Comparisons of deviations (*italics*) to various aspects of August 2008 protocol

	Variation	Advantages	Disadvantages
Marking	Glue method	Durability, additional data available	Time Consuming, training required, more snail handling
	Paint method	No training required, limited handling, fast	Mark deterioration, precludes long-term analyses
Surveying	Entire site	Consistency, fewer assumptions, tested method, easy planning	Understory impact can be high, lower capture probability
	Random quadrats	Understory impact reduced, higher capture probability	Lots of assumptions, protocol adaptive and untested
Effort	2 days	Less work, understory impact may be less	Lower statistical resolution, need more snails per survey
	3+ days	Greater statistical resolution, fewer snails required per survey	More work, understory impact may increase, lots of markings required (paint only)

Table 2. Snail site classification scheme and associated management recommendations

Understory	Terrain	Example site*	Recommendations
Absent	Easy	Kahanahaiki	No change from August 2008 protocol
Absent	Difficult	Poamoho	Add 3rd survey day
Present	Easy	Opaeula	Substitute random quadrats
Present	Difficult	Palikea	Add 3rd survey day, substitute random quadrats

-Difficult terrain results in lower capture probabilities, so additional data is needed.
-Understory presence requires minimizing impact, so random sampling is recommended.



1A: 40H	16A: 33H
2A: 64H	17A: 32H
2B: 51H	17B: 42H
2C: 62H	18A: 07H
2D: 18H	18B: 15H
2E: 61H	18C: 10H
3A: 17H	19A: 02H
3B: 55H	19B: 14H
3C: 05H	19C: 01H
4A: 04H	22A: 56H
5A: 47H	22B: 48H
6A: 58H	23A: 57H
6B: 08H	23B: 49H
6C: 13H	29A: 37H
7A: 19H	30A: 09H
7B: 38H	32A: 53H
7C: 11H	33A: 52H
7D: 12H	34A: 59H
8A: 60H	34B: 21H
9A: 46H	35A: 54H
9B: 06H	36A: 50H
10A: 65H	39A: 31H
10B: 20H	42A: 22H
12A: 45H	44A: 25H
12B: 16H	44B: 49H
12C: 36H	44C: 42H
13A: 39H	44D: 43H
13B: 28H	
13C: 27H	
14A: 29H	
14B: 38H	
14C: 41H	
14D: 03H	
15A: 63H	

Report to the U.S. Army Garrison Hawaii

Attn: Kapua Kawelo

Feeding ecology, microhabitat utilization, population size estimates, and possible control of the introduced predatory snail *Euglandina rosea* on Oahu, Hawaii

Year 3: Distribution, movement and micro-habitat utilization of the introduced predatory snail *Euglandina rosea* in the Waianae Mountains, Oahu: implications for management

Principal Investigator: Dr. Robert H. Cowie
Center for Conservation Research and Training
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3050 Maile Way, Gilmore 408
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Phone: (808) 956 0956
Fax: (808) 956 2647
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Project period (Year 3): 08/01/07 – 07/31/08

Introduction to research (Year 3)

The purposeful introduction of the land snail *Euglandina rosea*, which feeds exclusively on snails, has been implicated as a major factor influencing the decline of the native Hawaiian land snail fauna (Hadfield 1986, Cowie 2001). It was introduced to Hawaii in 1955 to control populations of another introduced snail, *Achatina fulica*, the giant African snail (Davis & Butler 1964, Simberloff 1995). However, *E. rosea* has not reduced *A. fulica* populations (Civeyrel & Simberloff 1996, Cowie 2001) but instead has been associated with the decline of many native land snail species not only in Hawaii but throughout the Pacific (Murray et al. 1988, Griffiths et al. 1993, Cowie 2001, Coote & Loève 2003).

The native Hawaiian land snail fauna used to be extremely diverse (over 750 species) and exhibited extremely high endemism (over 99 %) (Cowie et al. 1995), but the majority of these unique species are now extinct (Cowie 1998, 2005), with estimates of extinction ranging from 65-75 % (Solem 1990) to as much as 90 % (Cowie 2002, Lydeard et al. 2004). For example, extinction of the tree snail species in the sub-family Achatinellinae has been catastrophic (Hadfield & Mountain 1980, Hadfield 1986, Hadfield et al. 1993). All the species in the genus *Achatinella* are listed as endangered with many species already considered extinct (USFWS 1981). Decline of these species in particular is probably related to their slow growth, the long time they take to reach reproductive maturity (3-5 yr), and their slow reproductive rate, which make them highly vulnerable to unnaturally high levels of predation by the introduced predatory snail *Euglandina rosea*, in addition to other predators such as rats and human shell collectors (Hadfield & Mountain 1980, USFWS 1981, Hadfield 1986, Murray et al. 1988, Hadfield et al. 1993).

Despite its reputation for having a major effect on the land snail fauna of Hawaii and elsewhere, relatively little attention has been focused on the biology of *E. rosea*, with the exception of efforts to understand aspects of its feeding ecology (e.g., Cook 1985a, b, 1989a, b, Griffiths et al. 1993). A large effort has been focused on studying the biology of the endangered Hawaiian tree snails (e.g., USFWS 1981, Hadfield & Mountain 1980, Hadfield et al. 1993, Holland & Hadfield 2002), but there remains a need to understand the basic biology of *E. rosea* in Hawaii in order that natural resources managers may better design conservation strategies for the few extant native snail species left in the islands. Although the prognosis is rather gloomy, some land snail species are still extant, and control of *E. rosea* may be possible with adequate ecological information.

The objective of the work reported here was to understand the distribution, movement and microhabitat preference of *E. rosea* on a small spatial scale, i.e., within one gulch in the Waianae Mountain range on the island of Oahu. Abiotic (temperature and humidity) and biotic (prey densities) factors were monitored, and the distribution and movement patterns of *E. rosea* were determined from surveys and the use of two tracking techniques. The Waianae Mountains are of special conservation concern as they harbor many endangered and threatened land snail species, most of which are found at upper elevations near the ridges (Hadfield 1986, Hadfield et al. 1993, Holland and Hadfield 2002, Meyer 2006). Understanding how *E. rosea* is distributed across this landscape and how far it moves will help managers determine the scale on which control measures should be implemented, while understanding how *E. rosea* uses microhabitats within its range will help managers determine which snail species are likely to be the most threatened and where traps or searches that aim to trap/catch *E. rosea* as part of a control effort should be focused.

Methods

Study site

All work was conducted in Kahanaiki gulch starting on February 1, 2007 and ending June 16, 2008. Kahanahaiki gulch is on the north west side of the Waianae Mountains on Oahu (N 21^{o} 54.205′, W 158^{o} 19.646′). It has steep cliffs that rise roughly 80-150 m from the bottom of the gulch to the ridges either side. The two ridges have opposing aspects; one faces mostly northward and the other faces southward, and each are ~ 550 to 750 m in elevation above sea level. The vegetation is mixed with both native and invasive species present. The introduced strawberry guava (*Psidium cattleianum*) is the most abundant tree in the gulch, but native trees such as ohia (*Metrosideros polymorpha*) and koa (*Acacia koa*) are present. The climate in the gulch is tropical with wet winters and dry summers (Juvick & Juvick 1998).

Abiotic characterization of Kahanahaiki Gulch

To record the abiotic characteristics of Kanahaiki gulch and examine differences in temperature and humidity among the gulch and the two ridges six Log Tag HAXO-8 temperature and humidity loggers were placed at six sites, two in the gulch and two just below both the south and north facing ridges. They were placed approximately 400 m apart along the gulch transect and along each of the ridge transects (Figure 1) and hung 0.25 m above the ground on the base of a tree in shady areas. They were left in the field from March 13, 2007 to June 16, 2008 and recorded data every 30 min. Daily maximum temperature and minimum relative humidity were used to compare temperature and moisture conditions in the gulch to those on the ridges.

Patterns of prey density

To determine patterns of prey densities in the gulch, 18 sites were surveyed for snails on four occasions (March 8-12, 2007, May 10-14, 2007, November 15-19, 2007, July 26-30, 2008). Surveys involved timed searches of the trees/shrubs and the use of beer traps (88 ml glass jars, 5.0 cm tall and 5.0 cm in diameter with a 2.5 cm diameter opening in the top, filled with beer) to trap ground-dwelling snail/slug species. Six sites were in the gulch bottom and six were located 15 m below each of the north facing and south facing slopes (total 18 sites). At each site trees were surveyed for 10 min and ten beer traps were buried into the soil so the top was flush with the soil surface and were left for four days before collection. Each individual snail/slug collected was counted and identified to species except in the case of the 'tornatellinids' (small Achatinellidae in subfamilies other than Achatinellinae), which were just recorded collectively.

A two-factor ANOVA was used to test for differences in prey density among the gulch, south facing slope, and north facing slope sites. The fixed variable was location (gulch, south facing slope, north facing slope). The other, random variable was the four collection dates.

Movement patterns and microhabitat selection

Both movement patterns and microhabitat preference were characterized by attaching a bobbin to the snail's shell and the end of the line to a stationary object at the initial tracking point (see Murphy 2002). This technique allowed us to follow the trails of individuals as they moved through different microhabitats through time for the duration of this experiment (March 29, 2007 to July 17, 2007). Adult *E. rosea* were fitted with a size 40-8-20 nylon thread bobbin from Imperial Threads™. Each bobbin was wrapped in Parafilm© and enough line was pulled from the bobbin until it weighed less than 0.5 g (or < 10% of the weight of an adult *E. rosea*). Bobbins were glued to the shells using SuperGlue©. The end of the line was attached to a dowel in a cement base. The line was tied and taped to the dowel. Eight *E. rosea* were tracked successfully (> 14 days). Twelve *E. rosea* were not tracked successfully (< 14 days), mostly because the line was broken, and are not reported on here. Many of these failed attempts seemed to be caused by rat predation (see Meyer and Shiels in prep for an analysis of rat-snail interactions in this area). After the line breaks, as happens when rats prey on snails and if people step on the line, it is difficult to find the snail again. However, one snail was relocated after 21 days. The experimental sites were visited once a week following attachment of bobbins to the snails.

Movement Patterns: To describe movement patterns of *E. rosea*, five measurements related to their movement were recorded for each individual on each observation occasion: 1) linear distance from initial release point, 2) compass angle from initial release point, 3) linear distance from point at which snail was most recently previously recorded, 4) compass angle from point at which previously recorded, and 5) total distance traveled (the length of line pulled from the spool).

Microhabitat Preference: To determine microhabitat preferences, the microhabitat used by each snail was categorized (see below) at points every 0.75 m along the line left by the snail and compared to the relative prevalence of the different microhabitats overall, as assessed by taking measurements at 1 m intervals along four transects that were run on randomly chosen compass headings from the point of initial release for a distance corresponding to the furthest linear distance moved by the particular snail from its initial release point. If at least 24 points were not scored along these four transects, additional transects were surveyed until the number of microhabitat data points equaled or exceeded 24. Also, the microhabitat type in which the snails were found was recorded. Almost all snails were inactive when found suggesting that they move at night. When following the line left during the movement of each individual, at each point whether the snail was using arboreal or ground level habitats was first recorded. If this point was in an arboreal habitat (trees and shrubs), the height above ground and species of plant was recorded and the plant was searched for potential prey. If the point was on the ground, then the microhabitat was recorded as one of the following: 1) wood, consisting of downed logs greater that 10 cm in diameter, 2) open, consisting of all areas, including rock and open soil, where the snail could be easily seen, 3) shrub/fern, consisting of all habitat with low shrubs or ferns up to 0.5 m from the ground and blocking sight of the ground, and 4) leaf litter, consisting of areas with a thick covering of dead leaves and twigs without the cover of shrubs and ferns. When assessing the proportion of these microhabitats only ground level microhabitats were included.

To estimate habitat preference of *E. rosea*, Jacobs' selectivity indices (Jacobs 1974, and used by Sugiyama and Goto 2002) were calculated using the following formula:

$D_{ia} = (r_i - p_a) / (r_i + p_a - 2\, r_i\, p_a)$

where D_{ia} is the selectivity index of individual i for microhabitat a, r_i is the ratio of microhabitat type a use to all the other microhabitat types used by the individual, and p_a is the ratio of microhabitat a to all the other microhabitats available for the individual to use within the local area. As described above, r_i is determined for each snail by recording the microhabitat type at 0.75 m intervals along the path of each snail's trial, as determined from the line left from the bobbin, and p_a is determined from the data gathered at 1.0 m intervals along the four or more transects. If the individual preferentially uses a certain microhabitat the D_{ia} score will be positive, if it avoids a microhabitat the D_{ia} score will be negative.

In addition, the microhabitat at the point where each snail was found during the bobbin experiments (as opposed to the points 0.75 m apart along its trail, as recorded by the thread) was also recorded, and presumably reflects the snail's day time microhabitat preference. These preferences were also assessed using Jacobs' selectivity indices. For day time microhabitat preferences data recorded for all individuals were combined. There should be more than three times the number of observations than micro-habitats (Krebs 1999), and for most individuals (6 of 8) day time resting microhabitat type was recorded less than five times.

Distribution and population density (mark-recapture study)

Surveys for *E. rosea* in Kahanahaiki gulch combined with mark-recapture experiments were conducted from August 1, 2007 to June 16, 2008 to understand better the distribution and abundance of *E. rosea*. The seven transects (Figure 1)were surveyed twice monthly. A transect was surveyed through Kahanahaiki gulch (551 m), along each of the ridges (~ 570 m), and four transects from the bottom of the gulch to the ridge on both sides (north-facing: 88 and 150 m; south-facing 101 and 152m). On each transect the researcher moved slowly scanning an area extending roughly 2 m on either side. When a snail was found, it was individually marked by 1) writing an identifying number on the shell with a Deco-color© paint pen, and 2) printing a number on Rite in the Rain© paper and gluing it to the shell using Satellite City Super-t© glue. Shell length, measured to the nearest 0.1 mm, and the location of the snail were recorded. When a marked snail was recaptured the distance from the location at which it was last recorded was measured. Average weekly distance moved was calculated based on the number of days between each record for each snail.

A Mann-Whitney U test was used to assess if there were differences in the distance moved by snails tracked with bobbins and those tracked by mark-recapture. Potentially, the weight and extra size of the bobbins could have limited movements (H_o = average distance moved by snails tracked by mark-recapture methods were not greater than those moved by snails tracked using the bobbins).

Unfortunately, recapture rates were too low to permit an accurate estimate of the population density in the gulch. Only the data on distances moved could be used. A t-test was used to compare the linear distance moved per day by *E. rosea* with and without bobbins.

Results

Abiotic characterization

The gulches are typically cooler and more moist than either of the two ridges (Figure 2). However, the site located on the lower portion of the north-facing slope had similar temperatures and humidities to those at sites within the gulch.

Patterns of prey density

At least six possible prey species were collected during these surveys. These included four invasive species (*Limax maximus*, *Deroceras leave*, *Meghimatium striatum*, and *Paropeas achatinaceum*), and the native *Philonesia* sp. and the 'tornatellinids'. Most of the potential *E. rosea* prey snails were found at sites within the gulch (Table 1).

Movement patterns and microhabitat selection

Movement Patterns: Movement patterns were variable among individuals. Most snails (6 of 8) including the two snails tracked for over 60 days stayed within 10.0 m of the initial start point and had mean weakly linear distances moved from the initial starting point of less than 2.5 m(Table 2). The other two snails moved 13.5 and 41.0 m in linear distance from the initial starting point in 19 and 15 days respectively. Regardless of distances moved, all snails stayed in the gulch bottom.

Five of eight individuals tracked using the bobbin method climbed trees (up to 2 m above the ground). Eleven of the twelve trees climbed were strawberry guava (*Psidium cattleianum*) and there were snails ('tornatellinids') found in each strawberry guava tree climbed. The other tree/shrub climbed was an invasive *Melastoma*, and no potential prey snails were found in it.

Microhabitat Preference: The microhabitat preferences of the eight *E. rosea* tracked were estimated using the Jacobs' index of selectivity. In the leaf litter microhabitat, selectivity indices were positive for all individuals, suggesting that this microhabitat was preferred, since it was used more frequently than expected by random (Figure 3). Selectivity indices were negative in open and fern/shrub microhabitats for all individuals. Results for the wood microhabitat were mixed suggesting no overall preference.

Leaf litter was preferred during the day (Figure 4), as it was the only microhabitat that had a positive selectivity score.

Distribution and population density (mark-recapture study)

Twenty-nine live *E. rosea* (29.1 to 50.1 mm in shell length) and 56 shells (30.2 to 46.3 mm in shell length) were collected from August 1, 2007 to June 16, 2008. All but one of the live snails were collected along the gulch transect. The one other live snail was found near the north-facing ridge at the lower end of the gulch where temperature and humidity were similar to those in the gulch (Figure 2). Also, most of the shells were found in the gulch (46) and on the transect from the gulch to the lower north-facing slope (8). No live *E. rosea* or shells were found on either of the ridges.

Of the 29 snails that were marked, five were recaptured (one was recaptured twice) (Table 3). The low capture rate (many field trips resulted in no sightings) and few recaptures make estimating the population size within the gulch with any level of accuracy impossible.

Straight line distances moved ascertained from recaptured snails are similar to those determined by tracking snails using bobbins (Table 3). No significant differences were found between the movements of individuals tracked using mark-recapture and bobbin techniques ($z = -0.36$, $p = 0.64$).

Weekly growth (increase in shell length) of these five snails averaged 0.31 mm/week (range 0.0 – 0.55 mm) (Table 3).

Discussion

This is the first study in Hawaii of the distribution, movement, and habitat use of one of Hawaii's worst invasive species, *Euglandina rosea*. While land snail species had begun to disappear before 1900 (Burney et al. 2001), the rate of extinction accelerated greatly after the introduction of *Euglandina rosea* (Hadfield et al. 1993), and much of what remains of the unique Hawaiian land snail fauna is threatened (Solem 1990, Cowie 2002). As such, it is surprising that so little is known about the basic biology of *E. rosea*, other than its feeding ecology (Cook 1985a, b, 1989a, b, Griffiths et al. 1993).

Understanding how *E. rosea*, native snail species, and non-native prey species are distributed across a mountain range and at smaller scales, e.g. within a gulch, is important to understanding how *E. rosea* may impact the remaining native snail populations. Endangered native tree snails, *Achatinella* spp., are typically found on ridges (Holland and Hadfield 2002), as are other snails such as endodontids and helicinids that are less studied and are probably reduced to sparse isolated populations (Lydeard et al. 2004, Meyer 2006). Previously, some extant species, e.g., *Achatinella mustelina*, currently found on ridges, did extend to lower elevations (Hadfield et al. 1993). However, this study demonstrated that *E. rosea*, other non-native prey species, and native tornatellinids are found in much higher densities in the gulch than on the ridges. As such, gulches with dense non-native prey that seem to maintain populations despite *E. rosea* predation may act as reservoirs supporting thriving *E. rosea* populations. Occasionally an individual *E. rosea* may move to a ridge where they are more likely to interact with the endangered Hawaiian tree snails. This may be a consequence of random movement or a change in conditions. Any prolonged change in weather (ridges cooler or wetter) or prey abundance (increases on the ridge or decreases in the gulch) may facilitate the movement of *E. rosea* to the ridges. The only live *E. rosea* found outside the gulch was recaptured in the gulch and all snails tracked during the study using the bobbin technique stayed in the gulch bottom despite the distance moved suggesting that movements towards the ridge are rare.

Understanding the ecological factors that impact the distributions of organisms is important in determining the effect of a species across a landscape. Prey abundance (as described above) and abiotic conditions may be important factors influencing *E. rosea* populations. Both are strongly correlated here. In the gulch where it is cooler and more moist (Figure 1), higher densities of snails/slugs are present, including *E. rosea*. The one area outside the gulch (lower north-facing transect) where abiotic conditions were similar to those in the gulch also exhibited elevated densities of prey and evidence of *E. rosea* (one live snail and eight shells). Areas such as these may act as corridors permitting *E. rosea* to ascend the ridges and thereby connecting *E. rosea* populations in adjacent gulches. Conversely, since predators are known to move to areas with the highest prey densities (Fauchald & Tveraa 2006), areas with low prey densities may act as dispersal barriers since predators may remain in areas where food capture requires less effort. Visual recognition of these areas is difficult, but monitoring of abiotic conditions and prey densities could be used to identify these areas in the gulch.

The distance and direction a species moves influences the scale and areas where management will be the most effective. Movement patterns were variable among individuals, but were not related to the tracking technique used ($z = -0.36$, $p = 0.64$). Observations of movements over distances greater than 20 m were observed in three of the 13 individuals tracked, but in general this study indicates that most (10 of 13) *E. rosea* rarely move further than 10 m over a period of one month and less than 2.5 m in linear distance from initial starting point in a week (Table 2, 3). Regardless of the distance snails moved, snails stayed within the gulch. For instance, all snails tracked using the bobbin technique stayed in the gulch bottom. Four of the five individuals recaptured were marked and recaptured in the gulch bottom. The other snail recaptured during the mark recapture study was found near the north-facing ridge at the lower end of the gulch where temperature and humidity were similar to those in the gulch, but was recaptured in the gulch. These results indicate that efforts to control *E. rosea* in small areas near endangered snail species and in the adjacent gulch may successfully reduce *E. rosea* predation.

Understanding how a predator uses microhabitats within its range will help managers determine which species are likely to be the most threatened and where traps or searches that aim to trap/catch an alien predator as part of a control effort should be focused. The data indicate that *E. rosea* prefers dense leaf litter to open and fern/shrub microhabitats (Figure 3). Leaf litter was also the preferred microhabitat during the day (Figure 4). *Euglandina rosea* is generally most active during the night (personal observation) and these sites may represent day time shelters. The results for wood habitat are mixed. I often see slugs (potential prey items) in this microhabitat, but the distribution of slugs in downed wood may be patchy leading to varied preference indices for different individuals at different locations.. However, wood was not a preferred day time habitat (Figure 4). Leaf litter is more dense in the gulch than on the ridges, which may also contribute to the lower *E. rosea* densities on the ridges. These data suggest that litter dwelling snails are at the greatest risk of being preyed on by *E. rosea*. Many of the native snails associated with the litter, such as endodontids, are rare, and if not extinct, probably reduced to small isolated populations (Lydeard et al. 2004). In addition, the data suggest that leaf litter is the best place to focus search efforts for *E. rosea*, and that creating litter free barriers may reduce *E. rosea* intrusion into areas of high conservation concern.

Leaf litter may be preferred for many reasons, including 1) higher prey densities, 2) higher moisture retention, which reduces desiccation, and 3) avoidance of predators. Assessment of prey density according to microhabitat was attempted using the beer trap data from the different microhabitats at the various sites, but the variance was high and no significant pattern was detected. Desiccation is probably a major factor determining microhabitat selection (Cowie & Jones 1985, Arad et al. 1993, Copley 2000). However, the shrub/fern habitat was avoided (Figure 2, 3) despite the high likelihood that this microhabitat can retain substantial amounts of moisture. Visual predators can affect prey distributions (Cain & Sheppard 1952). In leaf litter, *E. rosea* is extremely difficult to see since the red/brown shell matches the color of dead leaves (personal observation). Therefore, visual predators may have a much harder time finding *E. rosea* in leaf litter habitats. Data on microhabitat use by *E. rosea*, rats, and other introduced mammal species in the same gulch (mammal data currently being collected by Aaron Shiels) may allow assessment of whether these species use different microhabitats. Rats will prey on *E. rosea* (Meyer and Shiels attached). Currently, the impact of rats and other predators (see Hadfield 1986 for a review of snail predators) on *E. rosea*'s microhabitat preference is unknown.

Our understanding of how *E. rosea* uses arboreal habitats is still limited. However, it is a major concern considering the only listed land snail species in Hawaii are arboreal (USFWS 1981). Five of the eight snails tracked climbed at least one tree while being tracked, and only one snail climbed a tree that did not have any snails on it. This demonstrates that trees and shrubs are used by *E. rosea*, but determining if *E. rosea* can ascertain that prey is present on the tree before it climbs it is difficult since a majority of the trees in the gulch have snails on them. However, considering *E. rosea* uses slime trails to locate prey (Cook 1985b), it seems likely that just one snail moving onto a tree from the forest floor may make all snails in that tree vulnerable to *E. rosea* predation for some period of time. Further work is needed to understand the trade-off of *E. rosea* choosing arboreal or ground habitats to search for prey. Of course, behavior may change depending on where *E. rosea* is found. For instance, do the lower prey densities on the ridges lead to *E. rosea* spending more time searching aboreal habitats for prey in such areas?

The data did not allow us to make population density estimates for *E. rosea*. Twenty-nine *E. rosea* were captured and new individuals were continuously being recaptured at the end of the research period. It is difficult to find and/or trap *E. rosea* in the field, and accurate assessments of the *E. rosea* populations may only be possible with new innovative techniques, such as the proposed method of using dogs to find snails by scent. However, it is clear that large populations probably exist in the gulches of the Waianae Mountains on Oahu as *E. rosea* is also much easier to find in other gulches (personal observation). Control of these populations requires focused effort in gulches adjacent to ridges where native snail populations are present.

Implications for management and control

This study indicates that efforts to control *E. rosea* in areas where small populations of native snails remain may be possible. Movements of *E. rosea* were variable, but generally the results suggest that *E. rosea* rarely moves more than 10.0 m per month. Therefore, if an effective method to locate or trap *E. rosea* was developed, then barriers ~ 10 to 20 m around areas with endangered land snails searched/trapped monthly would potentially limit encroachment of *E. rosea*. Additionally, effective control methods should be used in adjacent gulches where the highest densities of *E. rosea* are found. Prey densities and temperature/humidity data may be useful ways to predict corridors that *E. rosea* may use to move to ridges and thus where search efforts would be the most effective in preventing *E. rosea* from reaching the ridges. Leaf litter is the preferred microhabitat of *E. rosea*, and is a major component of Oahu mountain habitats and is extremely important for many ecosystem processes. However, degradation or removal of this key microhabitat may significantly alter the behavior of *E. rosea*. For instance, a litter free barrier may be effective in preventing encroachment of *E. rosea*, although, there are probably many other factors that may also have to be altered to make such a barrier effective.

Because of the consequences of the introduction of *E. rosea*, it is important to understand the biology of this species. Only through such studies can informed decisions be made regarding which control methods might be successful. It is our hope that this report provides impetus for other researchers to explore more aspects of *E. rosea* biology other than just the feeding ecology as it may provide insights into better control of this species and protect the remaining land snails in Hawaii and the Pacific.

Table 1: Numbers of possible prey items collected at six sites in each of three areas in Kahanahaiki gulch (NF = north facing ridge, SF = south facing ridge, G = within gulch) on four occasions. A two-factor ANOVA tested for differences in prey numbers among habitat types and on the four collection occasions.

Taxon	NF	SF	G	Source	p-value
'tornatellinids'*	17	12	343	location	< 0.001
				time	0.505
				location x time	0.129
Limax maximus	65	47	251	location	< 0.001
				time	0.610
				location x time	0.806
Deroceras leave	24	10	157	location	0.035
				time	< 0.001
				location x time	< 0.001
Meghimatium striatum	1	2	4	NA	
Paropeas achatinaceum	0	0	2	NA	
Philonesia* sp.	1	0	1	NA	

* indicates native

Table 2: Summary of movement patterns of the eight *E. rosea* tracked using the bobbin method.

	Date of Release	**No. of days tracked**	**Mean linear distance traveled/week (m) from start point (± 1SD)**	**Ratio of maximum linear distance (m) moved to total distance moved from start point (ratio in fraction)**	**No. trees climbed (No. trees with snails)**
***E. rosea* 1**	29-March-07	84	0.79 (± 1.25)	9.4 : 70.8 (0.13)	3(3)
***E. rosea* 2**	29-March-07	63	0.86 (± 2.21)	6.2 : 44.1 (0.14)	0
***E. rosea* 3**	11-April-07	15	0.94 (NA)	1.9 : 6.6 (0.28)	0
***E. rosea* 4**	3-May-07	28	0.10 (3.60)	3.1 : 28.2 (0.11)	2 (2)
***E. rosea* 5**	3-May-07	19	4.93 (1.90)	13.5 : 77.2 (0.17)	5 (5)
***E. rosea* 6**	17-May-07	27	1.63 (6.10)	6.1 : 24.3 (0.25)	1(0)
***E. rosea* 7**	2-July-07	22	2.18 (5.38)	9.6 : 30.5 (0.31)	0

***E. rosea* 8**	2-July-07	15	25.21 (18.39)	41.0 : 88.7 (0.46)	1(1)

Table 3: Summary of movement and growth patterns of the five *E. rosea* tracked using mark-recapture methods. One snail was recaptured twice.

	No. days between sightings	Linear distance (m) traveled	Linear distance (m) traveled / week	Increase in shell length (mm) / week
***E .rosea* 1**	56	68.0	8.5	0.45
***E. rosea* 2**	98	24.4	1.7	0.55
***E. rosea* 3**	25	2.5	0.7	0.36
***E. rosea* 4**	58	16.0	1.9	0.18
***E. rosea* 5**	7	0	0	0

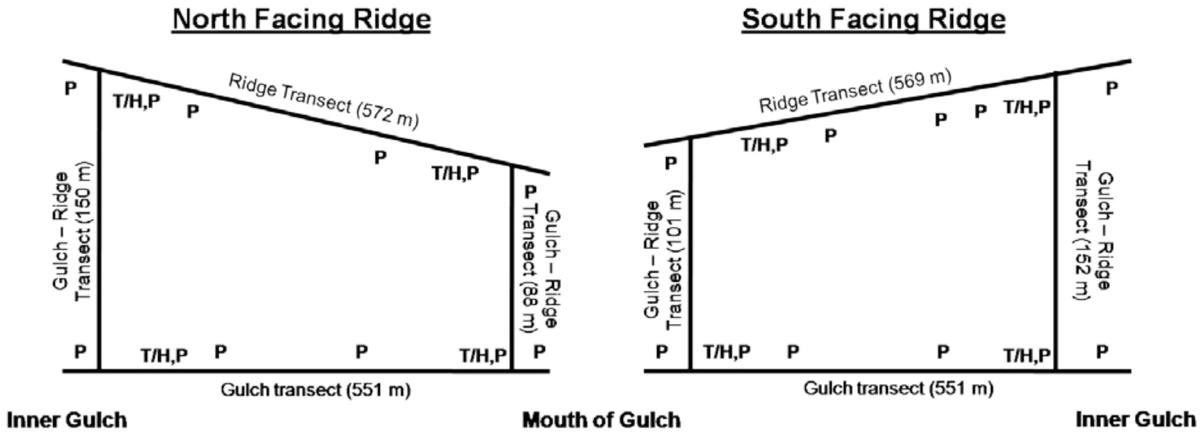

Figure 1: Schematic of research site in Kahanahaiki gulch, Oahu. Each line represents a transect. P represents locations surveyed for prey species and T/H represents locations where temperature and humidity data were collected.

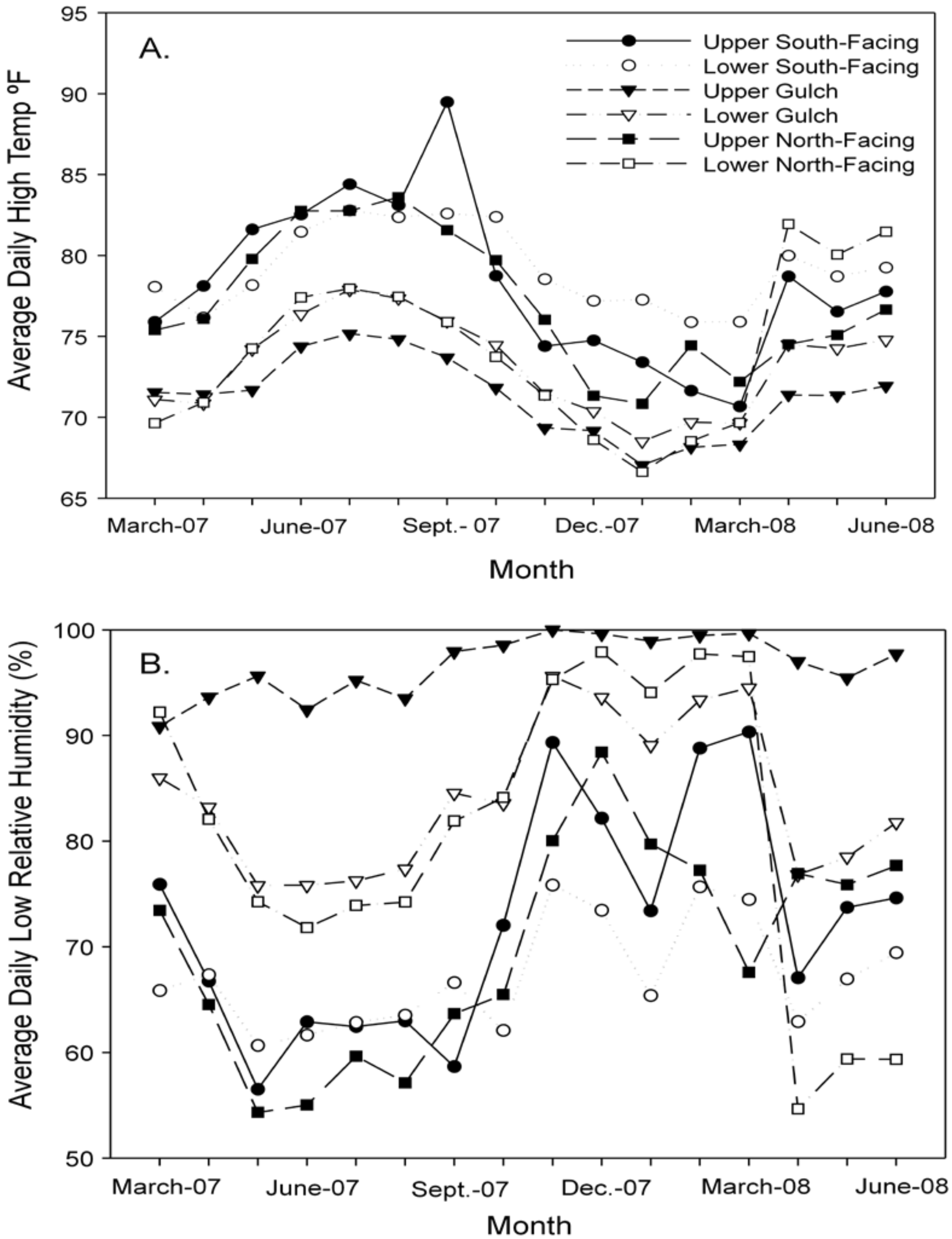

Figure 2: Average daily maximum temperatures and minimum relative humidity for six sites in Kahanahaiki gulch.

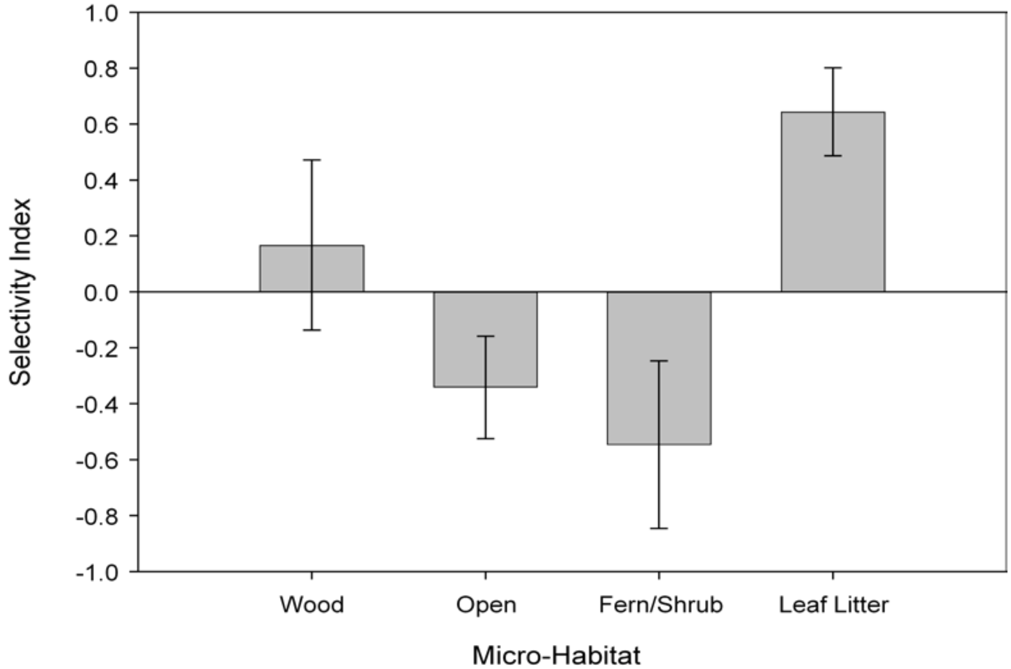

Figure 3: Microhabitat selection by eight adult *E. rosea* in Kahanahaiki gulch. Positive and negative values of the Jacobs' selectivity index indicate that different microhabitats were used more or less frequently, respectively, than expected by chance. Error bars equal ± 1 SD.

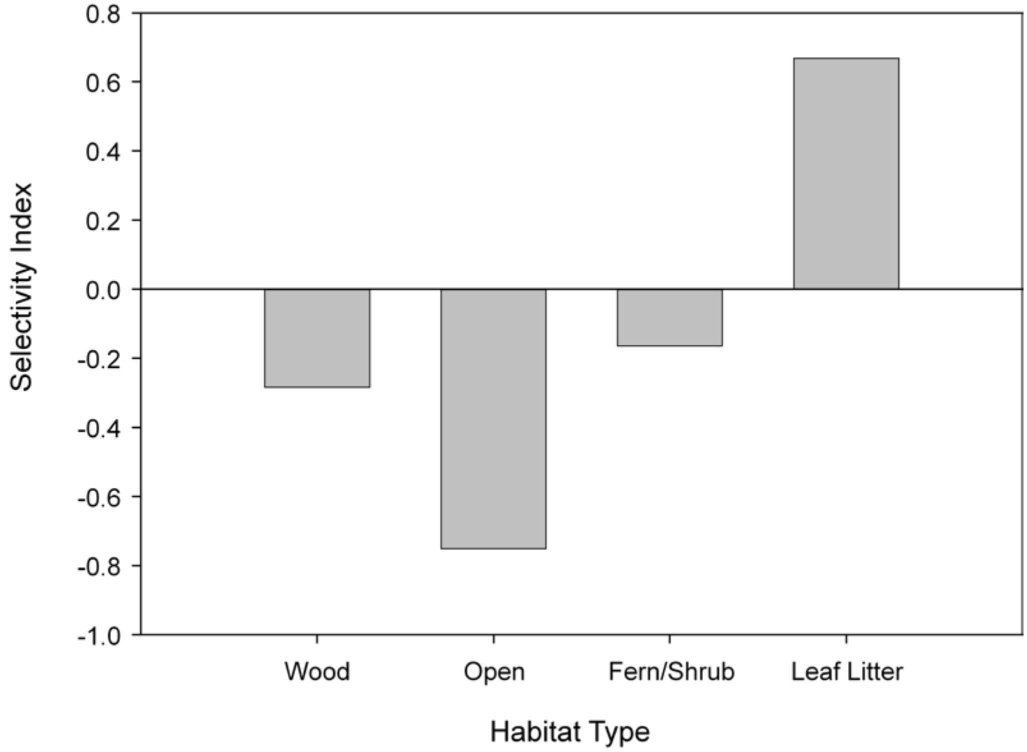

Figure 4: Day time habitat selection of eight adult *E. rosea* in Kahanahaiki gulch. Positive and negative values using the Jacobs' selectivity index indicate that different microhabitats were used more or less frequently, respectively, than expected by chance.

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APPENDIX 4-3: BLACK RAT (RATTUS RATTUS) PREDATION ON NONINDIGENOUS SNAILS IN HAWAII: COMPLEX MANAGEMENT IMPLICATIONS, MEYER AND SHIELS, 2009

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Black Rat (*Rattus rattus*) Predation on Nonindigenous Snails in Hawai'i: Complex Management Implications[1]

Wallace M. Meyer III[2,3] *and Aaron B. Shiels*[4]

Abstract: Understanding interactions among nonindigenous species that pose a threat to native species is crucial to effectively preserve native biodiversity. Captive feeding trials demonstrated that the black rat, *Rattus rattus*, will readily consume two of the most destructive nonindigenous snails, the giant African snail, *Achatina fulica* (100% predation), and the predatory snail *Euglandina rosea* (80% predation). Rats consumed snails from the entire size range offered (11.5 to 59.0 mm shell length), suggesting that there is no size refuge above which snails can escape rat predation. Damaged *E. rosea* shells from the captive feeding trials were compared with shells collected in the Wai'anae Mountains, O'ahu. This revealed evidence that *R. rattus* is responsible for at least 7%–20% of *E. rosea* mortality. However, this is likely a substantial underestimate because 67% of *E. rosea* shells in the captive feeding trials were damaged in such a way that they would not have been collected in the field. Therefore, we hypothesize that reduction or eradication of *R. rattus* populations may cause an ecological release of some nonindigenous snail species where these groups coexist. As such, effective restoration for native snails and plants may not be realized after *R. rattus* removal in forest ecosystems as a consequence of the complex interactions that currently exist among rats, nonindigenous snails, and the remaining food web.

Rapid population declines and species extinctions have been reported following the widespread introduction of nonindigenous species in Hawai'i (Burney et al. 2001, Athens et al. 2002). Human intervention is then often required for short-term recovery or maintenance of native biodiversity (Burney and Burney 2007). Unfortunately, insufficient understanding of both the magnitude of the threat that nonindigenous species pose to native biodiversity and the potentially complex interactions among the introduced species can lead to unexpected outcomes (Novacek and Cleland 2001, Doak et al. 2008). Given the large number of nonindigenous species that have altered Hawaiian ecosystems, understanding the interactions among nonindigenous species is crucial to effectively preserve the remaining native biodiversity.

Introductions of rats (*Rattus exulans* Peale, *R. norvegicus* Berkenhout, *R. rattus* L.) and terrestrial snails have been implicated in the decline of native Hawaiian flora and fauna (Hadfield 1986, Burney et al. 2001, Athens et al. 2002, Joe and Daehler 2008). All three rat species were introduced to the Hawaiian Islands by people and are among the most noxious invasive species on islands worldwide (Lowe et al. 2000, Russell and Clout 2004,

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Towns et al. 2006). The first rat species introduced to most islands in Polynesia, *Rattus exulans*, may have contributed to rapid forest decline and loss of animal species in Hawai'i (Burney et al. 2001, Athens et al. 2002). *Rattus rattus* and *R. norvegicus* became established in Hawai'i in the late 1700s after European arrival, and both *R. rattus* and *R. norvegicus* typically outcompete *R. exulans* (Lindsey et al. 1999, Russell and Clout 2004). *Rattus norvegicus* is more common in urban areas, and *R. rattus* is the most abundant rat species in conservation areas in the Hawaiian Islands (Lindsey et al. 1999; A.B.S., unpubl. data). Nonnative terrestrial snails were also brought to Hawai'i by humans and have established and spread in both urban and conservation areas (Cowie 1997). The giant African snail, *Achatina fulica* Bowdich, is one of the largest land snails in the world, reaching up to 19 cm in length (Peterson 1957). *Achatina fulica* has been recognized as one of the world's most damaging pests (Lowe et al. 2000). This designation is primarily a result of this species' large size, polyphagous diet, and ability to reach high population densities in areas where it has become established (Kekauoha 1966, Raut and Barker 2002, Meyer et al. 2008). *Euglandina rosea* (Férussac) was purposely introduced to Hawai'i in 1955 to control populations of *A. fulica* (Davis and Butler 1964, Civeyrel and Simberloff 1996, Cowie 2001). However, *E. rosea* has not reduced *A. fulica* populations (Civeyrel and Simberloff 1996, Cowie 2001) but has been associated with the decline and extinction of many of the endemic terrestrial snail species in Hawai'i and elsewhere in the Pacific where it has also been introduced (Clarke et al. 1984, Hadfield 1986, Murray et al. 1988, Cowie 2001, Coote and Loève 2003).

Rats and introduced snails have some diet overlap and therefore may have some similar environmental effects. For instance, both rats and many snail species introduced to Hawai'i eat various plant parts and reduce plant survival (Mead 1961, Cole et al. 2000, Joe and Daehler 2008, Pérez et al. 2008). Also, both rats and introduced predatory snails, most notably *E. rosea*, prey on native Hawaiian land snail species (Hadfield 1986, Hadfield et al. 1993, Cowie 2001). However, understanding the environmental impact of rats and snails is complicated by the fact that rats may feed on nonindigenous snails such as *E. rosea* (Hadfield et al. 1993). Therefore, rats may reduce the impacts of nonindigenous snails through predation (see Courchamp et al. [1999] for a discussion on mesopredator release).

It is unknown to what extent rats consume introduced snail species. Vulnerability to rat predation may be influenced by snail size. *Rattus rattus* is known to prey upon native snails, which are much smaller than *A. fulica* and *E. rosea* (Hadfield et al. 1993). However, to the best of our knowledge *R. rattus* predation on larger introduced snail species has not been addressed. This study addressed the following questions: (1) Will *R. rattus* feed on *A. fulica* and *E. rosea?* (2) Is there a size refuge above which snails are not vulnerable to *R. rattus?* (3) Can damage to *E. rosea* shells observed in feeding trials be matched to *E. rosea* shells (snails not alive) collected in the wild to allow estimation of rat predation on *E. rosea* in the wild? Because *R. rattus*, *A. fulica*, and *E. rosea* have become established and threaten native biodiversity on many other Pacific islands, understanding the interactions among these nonindigenous species can have wide-ranging utility for natural resource managers throughout much of the Pacific.

MATERIALS AND METHODS

Captive Feeding Trials

Ten adult *R. rattus* (six females and four males) were captured from wild populations in the Wai'anae Mountains, O'ahu, and taken to the University of Hawai'i Lyon Arboretum Rodent Housing Facility. Each rat was held in an individual 38 by 22 by 18 cm metal-mesh (8 mm) cage. Rats were allowed to acclimate for at least 1 week before beginning feeding trials, during which time the rats were fed a diet of mixed seeds (e.g., corn, sunflower, wheat, barley, oats, sorghum) and wedges of fruit (tangerine). Rats were checked daily to ensure that there was ample food and fresh water, and to clean urine/fecal trays.

Snail prey of various sizes, *A. fulica* (11.5–59.0 mm shell length) and *E. rosea* (32.3–45.7 mm shell length), were collected on O'ahu from conservation areas (Wai'anae Mountains) and urban areas (Honolulu), respectively, less than 1 week before the feeding trials.

Feeding trials were performed on 7 and 10 April 2008. Each trial lasted 24 hr and consisted of 10 experimental cages (each containing one rat and one prey snail) and 10 control cages (prey snail without rat). During each trial, five rats were offered *A. fulica* and five were offered *E. rosea*. Each rat was exposed to each prey species only once during the two feeding trials. Snails placed in cages without rats accounted for any incidence of mortality due to the laboratory conditions. The two trials were separated by a 48 hr period, during which the rats were fed their regular diet. After each trial, snail mortality was recorded, and shell fragments were recovered and photographed for later comparison with shells collected in the wild. Fisher's exact test (Sokal and Rohlf 1995) was used to assess differences in mortality between the experimental and control treatments for each prey species.

Snail Mortality in the Field

To estimate *E. rosea* mortality caused by *R. rattus* in the wild, shells of dead *E. rosea* from two sites (550–625 m elevation) on O'ahu (Kahanahāiki Management Unit, northern Wai'anae Mountains, 21° 32′ N, 158° 11′ W; Kalua'a Preserve, southern Wai'anae Mountains, 21° 28′ N, 158° 5′ W) were compared with *E. rosea* shells damaged in the captive feeding trials. Matching the damaged shells in the field with those specifically damaged by *R. rattus* in the captive feeding trials gave us confidence that the majority of the field-damaged shells were by *R. rattus* rather than other *Rattus* species. In addition, *R. rattus* is much more abundant than the other rat species in these conservation areas, as revealed by bimonthly relative abundance measures from these two sites using mark-and-recapture sampling during 2007–2008 (ratio of *R. rattus: R. exulans* is 12: 1 for Kahanahāiki and 135: 1 for Kalua'a; *R. norvegicus* was never captured at either site [A.B.S., unpubl. data]). The *E. rosea* shells were collected opportunistically between July 2005 and May 2008. All shells from the wild were categorized according to shell size and whether they were undamaged, damaged dorsally (i.e., opposite side of shell to aperture), or damaged at the aperture (see Figure 1). Shell fragments were not collected or recorded in the field because the shell fragments could not be confidently identified, and land managers often crush *E. rosea* if found. Fisher's exact test was used to assess if the frequency of damaged shells (aperture and dorsal damage combined) was significantly different between Kahanahāiki and Kalua'a.

FIGURE 1. Damage to *Euglandina rosea* shells by *R. rattus* in captive feeding trials: *A*, aperture damage; *B*, dorsal damage; *C*, shell apex remaining.

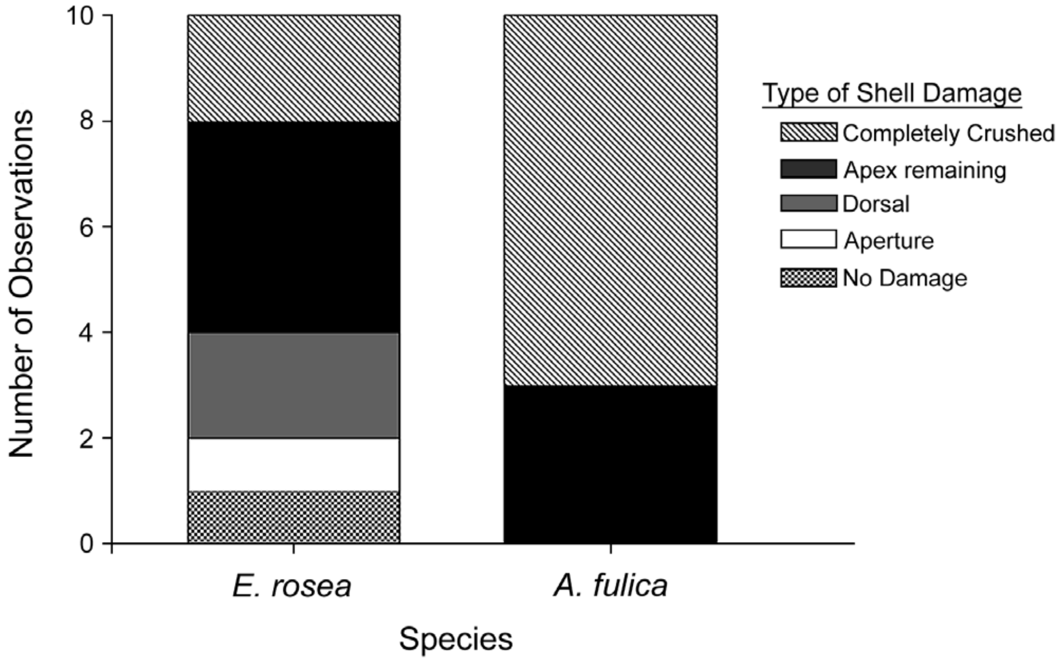

Figure 2. Frequency of shell damage categories in *Euglandina rosea* and *Achatina fulica* resulting from *R. rattus* predation in captive feeding trials.

RESULTS

Captive Feeding Trials

Rattus rattus consumed both snail species. All 10 *A. fulica* and eight of the 10 *E. rosea* were killed. There was no snail mortality in any control (rat-free) cages. The difference between experimental and control treatments for both snails was significant: *A. fulica* ($Z = 4.472$, $P < .001$) and *E. rosea* ($Z = 3.652$, $P = .007$).

Types of shell damage caused by *R. rattus* in the captive feeding trials included aperture damage (Figure 1*A*), dorsal damage (Figure 1*B*), anterior damage with the apex remaining intact (Figure 1*C*), and completely crushed shells. The two most common types of shell damage observed (combining data for both snail species) was the anterior portion damaged with the apex remaining intact (nine snails), and the shells being completely crushed into small pieces (seven snails) (Figure 2). Dorsal damage to the shell was observed in only two *E. rosea* that were killed (Figure 2). Aperture damage was observed in one *E. rosea* that survived the 24 hr rat exposure (Figure 1); it is not known if this damage impacts the survival or fitness of the snail. Among all snails offered, both the largest (59.0 mm shell length) and the five smallest (11.5, 19.6, 21.3, 24.0, and 24.1 mm) were completely crushed. The types of shell damage that we observed for the two snail species tended to differ: *A. fulica* shells were either completely crushed or partially crushed with the apex preserved, whereas *E. rosea* shells were either damaged dorsally or at the aperture, completely crushed, or partially crushed with the apex preserved (Figure 2).

Snail Mortality in the Field

In total, 166 *E. rosea* shells were collected from the two forest sites on Oʻahu: Kaluaʻa (96 shells) and Kahanahāiki (70 shells) (Figure 3). All shells were 25–55 mm in shell length. The absence of small shells (<25 mm) is probably not a result of collection bias because smaller shells of other snail species were noticed. Incidence of rat damage to shells was significantly higher ($Z = 2.025$, $P = .022$) in Kahanahāiki (24.5%) than in

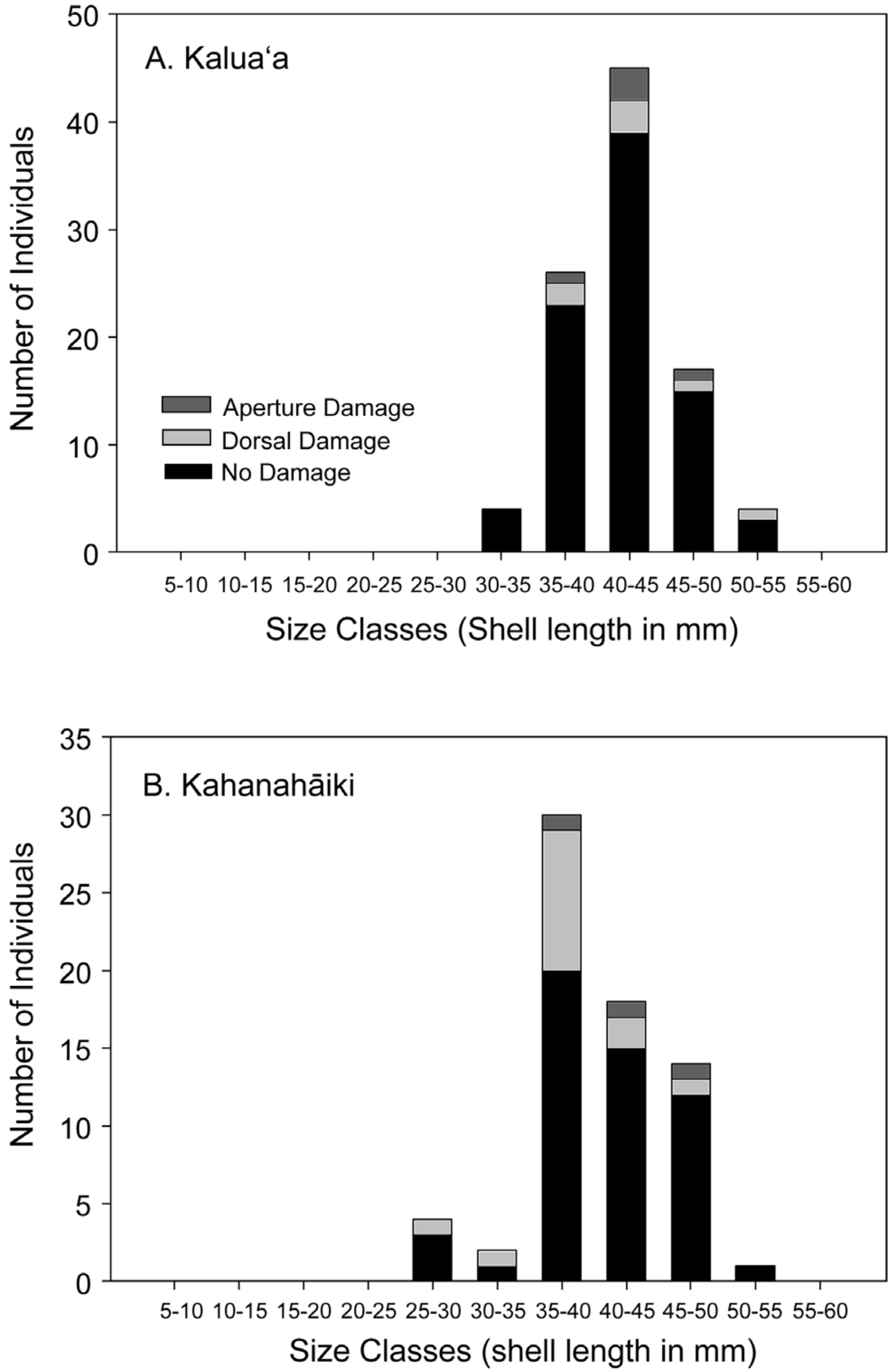

FIGURE 3. *Euglandina rosea* shell (dead snail) assemblage in two mesic forest sites on Oʻahu: *A*, Kaluaʻa Preserve, southern Waiʻanae Mountains; *B*, Kahanahāiki Management Unit, northern Waiʻanae Mountains. Dorsal and aperture shell damage is attributed to rats, based on matching shells with those used in captive feeding trials with *R. rattus*.

Kalua'a (12.5%). Dorsal shell damage tended to be much higher in Kahanahāiki (20.0%) compared to the dorsal shell damage in Kalua'a (7.3%) (Figure 3). Damage to the aperture was noticed on 4.5% and 5.2% of the shells collected from Kahanahāiki and Kalua'a, respectively. Although aperture damage may suggest interaction among rats and snails, it may not imply mortality based on the one observation made in the captive feeding trials. Alternatively, damage to the dorsal portion of the shell can be used to indicate mortality likely caused by *R. rattus*.

Crushed shells, which were rarely seen, and remnants of shells such as shell apexes that might have been preyed upon by *R. rattus* were not collected in the field because we presumed that most of those shells were intentionally crushed by land managers and conservationists who frequently visit the sites. However, in retrospect, on examining shell damage in the feeding trials, this was probably a false assumption and many of these shells may have been preyed upon by *R. rattus*. Therefore, our estimate of *R. rattus* predation on *E. rosea* is probably an underestimate.

DISCUSSION

Our captive feeding trials demonstrate that *R. rattus* can consume nonindigenous snails of various sizes (100% of *A. fulica* and 80% of *E. rosea* offered). The largest *A. fulica* (6 cm in shell length) and *E. rosea* (4.5 cm in shell length) offered were eaten, although we do not know whether very large *A. fulica*, which can reach 19.0 cm in shell length (Peterson 1957), would be preyed upon. Such large *A. fulica* are rarely observed in Hawai'i (W.M.M., pers. obs.). Comparison of rat damage to *E. rosea* in the captive feeding trials with shells of *E. rosea* from the wild showed that rats likely caused a minimum of 7%–20% of *E. rosea* mortality.

Rats crushed entire shells in 45% of the captive feeding trials (Figure 2). Unfortunately, it is unlikely that a high proportion of crushed shells could reliably be collected in the field. However, not accounting for completely crushed shells may result in an underestimate of the impact of *R. rattus* on snail populations and may therefore lead to inappropriate conclusions regarding predation levels. For example, no small *E. rosea* shells (<25 mm in shell length) were collected at the two field sites (Figure 3). This pattern might suggest very low juvenile mortality, but it seems more likely that juvenile mortality was not detected because shell fragments were not analyzed. Although rats crushed shells across the size range offered, smaller snails might be crushed more often, because this was the fate of the five smallest snails in the feeding trials. In addition, the shape of the shell may also influence the likelihood that the shell is crushed, because the more conically shaped shells of *E. rosea* were often damaged without completely crushing whereas the more rounded shells of *A. fulica* were most often crushed. In areas where native snails occur, presence of *E. rosea* shells and native snail shells with characteristic rat damage (Figure 4) are used to assess the predation risk from both predators and to initiate a rapid management response (V. Costello, pers. comm.). Rats crushing either *E. rosea* or native shells may limit the ability to adequately quantify the threat from either predator.

FIGURE 4. A shell of the endemic O'ahu tree snail *Achatinella mustelina* after *R. rattus* predation in a snail conservation area in the Wai'anae Mountains.

Predation levels on *E. rosea* of 7% and 20% at Kalua‘a and Kahanahāiki, respectively, correlate with *R. rattus* relative abundance, which was approximately 2.5 times greater at Kahanahāiki than at Kalua‘a based on bimonthly mark-and-recapture technique during 2007–2008 (A.B.S., unpubl. data). However, *E. rosea* mortality caused by *R. rattus* at those two sites is probably greater than that because only damage to the dorsal portion of the shell was used to indicate mortality. This potential underestimate is likely substantial, because 67% of *E. rosea* shells in the captive feeding trials were damaged in such a way that they would not have been collected in the field (Figure 2). As such, we suggest that *R. rattus* may substantially contribute to *E. rosea* mortality where they coexist. However, determining if *R. rattus* predation regulates *E. rosea* population densities requires a more in-depth understanding of *E. rosea* population dynamics.

Conservation of Hawai‘i's native forest ecosystems requires reducing or controlling the impacts of introduced plants and animals, including rodents and nonindigenous snails. Rats are increasingly being controlled in conservation areas on O‘ahu. Recent federal approval of aerial broadcast of rodenticide into conservation areas in Hawai‘i will probably lead to increased rat control efforts. However, the complex interactions among *R. rattus* and nonindigenous snail species, particularly *E. rosea*, suggest that managers should proceed cautiously with management and control efforts that involve these species. Removal of *R. rattus* in the Wai‘anae Mountains may result in *E. rosea* population increases. This may have negative effects on native snail populations, which may be irreversible because of the difficulty of controlling *E. rosea* while not harming other, native snail species. It is unknown if *E. rosea* predation on other mollusk species would equal or exceed that of *R. rattus*. In 85%–100% of rat stomachs examined on Maui, invertebrate material (including slugs, snails, and earthworms) was found (Sugihara 1997).

Rat predation on herbivorous nonindigenous snail species may also influence the preservation of Hawai‘i's native forest ecosystems. *Achatina fulica* is known to consume over 500 plant species (Mead 1961) and can reach densities of 7.75 snails per square meter in the low-elevation areas of Hawai‘i (Kekauoha 1966). Slugs (snails without shells) were specifically mentioned as threats or potential threats to 59 rare plant species (22% of all endangered and threatened plants) in Hawai‘i (Joe and Daehler 2008). Further experiments should examine rat prey preferences among various snail prey and the influence of rat predation on snail populations, especially those species that are widespread and are recognized as a threat to native ecosystems.

Until we understand how nonindigenous snail populations will respond to rat removal, it is difficult to predict the probability of success for native snail and plant recovery after *R. rattus* eradication. Prudent management will require precautionary and adaptive management approaches (Doak et al. 2008). Removal of species to help facilitate increases in other species can fail as a result of complex and unpredicted interactions (Doak et al. 2008 and references therein). However, our goal is not to impede rat control efforts in Hawai‘i. Instead, we hope that concurrent invertebrate and plant monitoring programs are established before and after such rat control efforts. Also, we suggest, as did Cole et al. (2000), that rodent exclusion studies are needed to evaluate the magnitude of impact of rats on various plant and animal populations and to provide a more in-depth understanding of both native and nonindigenous species in Hawaiian ecosystems.

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APPENDIX 4-4: APPLICATION OF HARMONIC RADAR TECHNOLOGY TO MONITOR TREE SNAIL DISPERSAL, HALL AND HADFIELD 2009

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Application of harmonic radar technology to monitor tree snail dispersal

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Abstract. Planned conservation efforts for tree snails of the endangered genus *Achatinella,* endemic to the island of O'ahu, Hawai'i, will include translocations among the remaining wild and captive-bred populations. In order to establish optimal levels of artificial migration among neighboring groups of snails within fragmented populations, efforts to determine natural dispersal rates through direct observation were initiated. Capture–mark–recapture (CMR) efforts have proved inadequate for obtaining the requisite dispersal estimates, due to low recapture probabilities. In addition, snail dispersal beyond the boundaries of a finite CMR study site was indistinguishable from mortality. In the preliminary study reported here, both the low recapture probability and dispersal detection problems of past CMR efforts were addressed by using harmonic radar tracking. This approach yielded rough dispersal estimates that were unattainable using CMR alone by providing 100% recapture rates even beyond the normal survey area boundaries. Extensive snail movements within clusters of connected trees were frequently observed after tracking for merely a few hours, although movements between unconnected trees were rare and recorded only after monthly survey intervals. Just 11 out of 40 tracked snails made between-tree movements (average distance of 4.94 ± 1.52 m) during the entire 7-month study, and provided the only data utilizable for inferring gene flow in and out of subpopulations. Meteorological data loggers were deployed when tracking began to look for an association between such snail movement and weather fluctuations. The resultant data indicate that increases in both wind gusts and humidity facilitate dispersal ($R^2 = 0.77$, p-value < 0.001), and that passive wind dispersal alone may be responsible for many snail movements ($R^2 = 0.59$, p-value $= 0.0014$). Despite having provided coarse estimates of short-term dispersal and corresponding wind influences, the limitations of the radar method can be substantial.

Additional key words: telemetry, mark–recapture, wind dispersal, Achatinella

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Tree snails of the genus *Achatinella* (Pulmonata: Achatinellidae), endemic to the island of O'ahu, Hawai'i, are rapidly disappearing and are all listed as Endangered by the United States Fish & Wildlife Service (USFWS 1992). Only ten species are extant out of the original 41 recognized by USFWS (based on synonymizations by Pilsbry & Cooke [1912–1914]). Initially common throughout native forests of both the Wai'anae and the Ko'olau mountains, *Achatinella* species can now be found only in scattered patches near the summits of these ranges. Following severe declines in number as a result of habitat loss and shell collecting in the 19th and 20th centuries, predation by introduced rats and the snail *Euglandina rosea* continue to decimate and fragment remnant snail populations (Hadfield 1986; USFWS 1992; Hadfield & Saufler 2008). The unusual life-history characteristics of these long-lived and late-maturing snails make any unaided recovery from invasive predator impacts extremely difficult (Hadfield et al. 1993). To assist in the preservation of the remaining wild populations, various governmental agencies have contributed to the initiation of both a captive-breeding program and building of predator-proof exclosures.

The intended goals of these conservation actions appear to have been achieved according to field and lab records (Hadfield et al. 2004), which show increases and/or stabilizations for some populations. However, the long-term consequences on the health

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of the gene pool from captivity, exclosures, and the fragmentation of subpopulations have yet to be addressed. There is growing concern that most of the remaining wild, enclosed, and captive populations of *Achatinella* spp. are increasingly at risk of the negative effects of inbreeding because of loss of genetic connectivity. Management strategies are being considered that will include translocation among neighboring subpopulations (residual fragments of historically continuous populations) to minimize the effects of excessive inbreeding, while being careful as to avoid any detrimental effects from unnatural levels of outbreeding. Storfer (1999) argued that only by first obtaining detailed observations of a species' natural gene flow can minimization of both these phenomena be accomplished. Microsatellite analyses using *Achatinella* spp. failed to reveal any structure on a subpopulation level (K.T. Hall, unpubl. data), rendering estimation of dispersal with modern genetic methods impossible. In light of this, a more direct approach was adopted to determine natural migration rates for two *Achatinella* spp.

Tree snails can be difficult to detect within dense vegetation, which makes obtaining direct dispersal-rate estimates difficult. Initial efforts using capture–mark–recapture (CMR) were hampered by low recapture rates, making any attempts at dispersal-rate estimation from those data imprecise (K.T. Hall, unpubl. data). Some snails were recaptured after not having been captured for several sampling intervals, most having returned to or never left their original trees, and others on neighboring or more distant trees. It is also often nearly impossible to distinguish between dispersal beyond a finite study site's boundaries and death (Koenig et al. 2000). This is especially true in animals such as small snails, whose remains are hard to locate. To increase the chances of recording more precise distances, frequencies, and timing of dispersal for *Achatinella* spp., harmonic radar tracking methods were adopted. The radar system includes a hand-held transmitter/receiver unit (Recco Inc., Lindingo, Sweden), which is used to detect small diode/wire combinations glued onto shells of live snails. With the expected 100% recapture rates, it was anticipated that preliminary estimates of short-term dispersal frequencies and distance could be obtained. Detection distances of up to 10 m were also readily possible with the radar, minimizing the reduced dispersal detection problems beyond the edges of a finite study site. However, the transponders receive and reflect a generic signal, and so individual identification must still rely on unique CMR codes.

Observations of dispersal during our pilot CMR surveys often varied following changes in observable weather conditions, implying that dispersal events may be a result of environmental factors. Prolonged periods of hot and dry conditions sometimes corresponded to an increased ratio of previously marked to unmarked adult snails in field surveys, as well as increased recapture rates (suggesting lower immigration). Similarly, stormy winter months sometimes led to an increase in the proportion of unmarked adults and reduced recapture rates (indicative of higher immigration). Therefore, it was hypothesized that any increases in snail movement detected with a harmonic radar would positively correlate with wind speed and humidity and/or negatively with temperature. Significant correlations would help determine whether dispersal is passive (i.e., positive correlation with wind gusts, which have been thought to blow snails out of trees [M.G. Hadfield, unpubl. data]) or active (i.e., positive correlation with high humidity, because some snails may be less active in the dry season [Cowie 1980]).

Methods

Transponder design

The results of successful studies using harmonic radar technology with a few land snail and insect taxa have already been published (e.g., Mascanzoni & Wallin 1986; Lovei et al. 1997; Stringer et al. 2004). O'Neal et al. (2004) conducted a study to optimize the trade-off between detection distance and transponder size to minimize any hindrance to the individual's natural movements, using a design very similar to the one adopted here for use with *Achatinella* spp. We tested many different kinds of transponders on captive individuals of *Achatinella* spp. before the current design was adopted. These transponders weigh <0.02 g, which is well below the conventionally accepted transmitter/body weight ratio (dubbed "the 5% rule") for having no adverse effects on the study organism. This rule, although informal, was adopted from studies on birds (Cochran 1980), small mammals (Aldridge & Brigham 1988), and fish (Claireaux & Lefrançois 1998). To determine snail weights, a series of living individuals of *Achatinella* spp. in the lab, all individuals ≥ 13 mm in shell length, were weighed and found to be >1 g. Therefore, only snails with shells ≥ 13 mm snails were fitted with transponders.

The transponders are passive and can theoretically function for several years without a power source. They are constructed from 6-cm lengths of a Teflon-coated, 0.08-mm-diameter copper wire (Omega Engineering Inc., Stamford, CT, USA) that were soldered

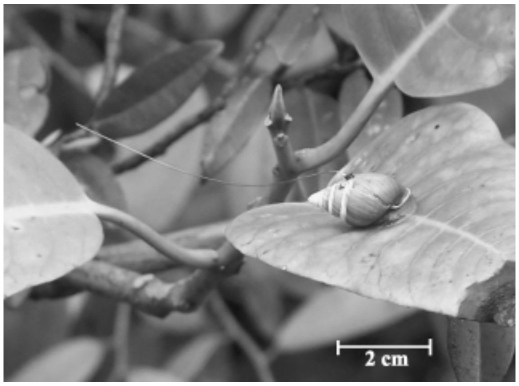

Fig. 1. Adult of *Achatinella mustelina* (21 mm in length from the apex to the bottom of the aperture) equipped with a harmonic radar transponder.

to small Schottky diodes (Mouser Electronics Inc., Mansfield, TX, USA) (e.g., Fig. 1). The solder bond is strengthened with a high-conductance epoxy resin, and the diode portion is glued with Satellite City Super T® to the body whorl of the snail's shell, oriented so that the wire drags behind the shell apex as the snail crawls. Transponders can be removed as needed by placing a drop of glue remover (Satellite City Super Solvent®) onto the glue bond, pushing away the resulting compound, and removing the transponder with slight pressure from tweezers.

Experimental approach

Achatinella mustelina Mighels 1845 (Wai'anae Mountains) and *Achatinella sowerbyana* Pfeiffer 1855 (Ko'olau Mountains) were used to monitor movement patterns. They are the only two remaining species of *Achatinella* with substantial numbers surviving in a fairly continuous habitat, providing the closest representation of gene flow in *Achatinella* before anthropogenic disturbances. The four field sites (Fig. 2) chosen include two replicates for each species, located at the extreme north/south ends of each species' known range to account for geographic and climatic variations. These are Palikea (in The Nature Conservancy's Honouliuli Preserve) and Kahanaha'iki (Makua Military Reservation) in the Wai'anae Mountains for *A. mustelina* (18 km apart), and north of the Poamoho monument (Ko'olau Summit Trail [KST]) and west of Opae'ula Cabin (Army leased land, leeward of the KST) in the Ko'olau Mountains for *A. sowerbyana* (2 km apart).

Fig. 2. O'ahu, Hawai'i. The four field sites used in this study are marked with squares.

For each site, perimeters were delineated by centering on the highest density area, with boundary extensions roughly corresponding to the maximum dispersal distances observed during CMR pilot studies. This is also the maximum amount of area that could be regularly searched with the manpower available. Within each site, a grid of $5\,m \times 5\,m$ quadrats was created. Individual quadrats were large enough to wholly contain most tree clusters. The actual number of quadrats at each site varied from 15 (Palikea) to 55 (Poamoho), due to each site's natural barriers (e.g., streams and cliffs). Ten of these quadrats were randomly selected (using a random number table to obtain individual quadrat numbers) at each of the four sites, and one snail $\geq$13 mm within each selected quadrat was fitted with a transponder (the maximum sample size allowed under USFWS permit TE826600). Daytime surveys were conducted at each site on a monthly basis to monitor dispersal (for $N = 40$ radar-equipped snails in total). In addition, two hourly overnight surveys were conducted at both Palikea and Kahanaha'iki to see whether any dispersal occurs during normal nocturnal foraging movements.

Weather/dispersal correlation

Weather data loggers from Onset Inc. (wind speed, humidity, and temperature, logging every 15 min) were deployed at three sites in early August 2006 to accumulate meteorological data (Poamoho snail tracking began in late August 2006). Radar-detected dispersal locations and weather data were recorded simultaneously at monthly intervals for a period of 7 months (through March 2007) to include both dry and wet seasons. The number of inter-tree dispersal events revealed with harmonic radar each month was recorded in addition to the corresponding weather values (minima, maxima, and averages) for that month to look for relationships (similar to Aubry et al. 2006). A best-subsets multiple regression procedure was used to select the model(s) that best explained the variation in monthly dispersal, based on Akaike's information criterion (Akaike 1974). This criterion provides a way to trade off the complexity of an estimated model against how well the model fits the data, preventing the appearance of a superior model that results from overfitting the data. All analyses were performed using R software (version 2.4.1, Ihaka & Gentleman 1996).

Results

Neither of the two hourly overnight surveys conducted at each Wai'anae site showed any movement of snails between unconnected trees, which would have required movement across the ground. Unconnected trees are defined as two clusters of vegetation that have no branches or leaves that come into contact with each other under normal weather conditions. Such between-tree movements were rare and only apparent after 1-month intervals. However, total linear movements as great as 3 m among connected trees were not uncommon in a single night. Based on the high frequency of movements throughout connected tree clusters, and the extreme rarity of finding live snails on the ground, inter-tree movement (between unconnected trees) became the focus of this study. As in other tree-snail studies exhibiting similar migration patterns (e.g., Schilthuizen et al. 2005), only these rare inter-tree movements have relevance to gene flow among subpopulations. Throughout this article, "dispersal" will refer only to movements between unconnected trees.

A list of all recorded snail dispersal and distances traveled by month is presented in Table 1. Inter-tree dispersal rates were between 0% and 20% per month, with more frequent dispersal occurring during the winter months when comparison was available (Wai'anae sites only). During this 7-month study, only 11 out of 40 snails were relocated outside of their original trees, providing a total of 17 between-tree movements. Dispersal distances were measured as the length between the two trees' bases at ground level, and resulted in an average of 4.94 ± 1.52 m.

For each month and site, the number of transponder-equipped snails (out of ten individuals) that dispersed between trees was determined and used as the response variable for the weather correlation analysis. No individual snail used in this regression contributed more than one movement to the analysis, meaning 11 different individuals' movements appear in Table 2. There were 12 potential meteorological predictor variables including maxima (max), minima (min), and averages (avg) for the four weather parameters measured (% relative humidity [RH], temperature in degrees Celsius [T, °C], wind speed [m/s], and wind gust speed [m/s]). Maximum RH was always 100% and both minimum wind measures (speed and gust) were 0 m/s, and so these three predictors were not included.

Temporary weather station malfunctions, and site/month combinations in which all ten transponder snails were not relocated, were responsible for excluding 14 monthly records in the weather correlation analysis. Of 28 possible monthly records (four sites, 7 months), only 14 were actually used in this analysis (Table 2). Regrettably, all four weather stations needed sensor replacement at least once during this study due to corrosion. Snail-tag loss per month varied substantially between sites and seemed to reflect the relative exposure to inclement weather at each site. In decreasing order from least exposure to greatest are Kahanaha'iki, Palikea, Opae'ula, and Poamoho. The numbers of tags lost by site are summarized in Table 3. When even a single snail remained undetected for more than 1 month, further radar monitoring was terminated at that site because dispersal could no longer be distinguished from tag loss or death. For most months involving tag loss, a subsequent intensive search of the area (sometimes requiring an additional day in the field) recovered snails with broken transponders that could be fixed before the next sampling interval.

The best-subsets regression model that outperformed all other models (using Akaike's information criterion, Akaike 1974) for explaining variation in dispersal (Table 2) contained only two predictor variables: maximum wind gust speed and average RH ($R^2 = 0.77$, $p < 0.001$). The estimates of these coefficients were both positive and significant at $\alpha = 0.05$. Of the single predictor models, maximum wind gust speed performed best ($R^2 = 0.59$, $p = 0.0014$). RH was the next best of the single predictor models, but did not perform nearly as well ($R^2 = 0.43$, $p = 0.011$).

Discussion

The initial goals of this project were to determine the short-term dispersal rates of two species of *Achatinella* and the effects weather may have on those rates. Use of harmonic radar methods provided rough estimates of dispersal, which are often difficult to separate from mortality or recapture probability in CMR analyses. The weak correlation of dispersal with wind gusts during winter months suggests that between-tree movements might be mostly passive rather than active, and that members of *Achatinella* spp. are blown out of their trees during violent wind storms. These findings agree with observations from January 1985 in which many snails from a previous CMR study of *Achatinella mustelina* were found far

Table 1. Distance traveled by individual snails (in meters) by month that moved between trees, measured as the distance between tree bases. Non-zero values are boldfaced. ?, snail never relocated; NA, not applicable.

Snail ID code	Site	August	September	October	November	December	January	February	March
A2	Palikea	0	0	0	0	0	0	0	0
A5	Palikea	0	0	0	0	0	**3**	0	0
A7	Palikea	0	0	0	0	0	0	0	0
A8	Palikea	0	0	0	0	0	0	0	0
B1	Palikea	0	0	0	0	0	0	0	0
B8	Palikea	0	0	**5**	0	0	0	0	0
B9	Palikea	0	0	0	0	0	0	0	0
H2	Palikea	0	0	0	0	0	0	0	?
H7	Palikea	0	0	0	0	**4**	**2**	0	0
J0	Palikea	0	0	0	**7**	0	0	0	0
B2	Kahanaha'iki	0	0	0	0	0	0	0	
D4	Kahanaha'iki	0	0	0	**6**	**6**	0	?	
G0	Kahanaha'iki	0	0	0	0	0	0	0	
G6	Kahanaha'iki	0	0	0	0	0	0	0	
J7	Kahanaha'iki	0	0	0	0	0	0	0	
K2	Kahanaha'iki	0	0	0	0	0	0	0	
Q0	Kahanaha'iki	0	0	0	0	0	0	?	
Q9	Kahanaha'iki	0	0	0	0	0	0	?	
R0	Kahanaha'iki	0	0	0	**3**	0	**7**	0	
T0	Kahanaha'iki	0	0	0	0	0	0	?	
A3	Poamoho	NA	0	0	0				
D3	Poamoho	NA	**6**	0	0				
E4	Poamoho	NA	0	0	0				
E5	Poamoho	NA	0	0	0				
H1	Poamoho	NA	0	**4**	?				
H9	Poamoho	NA	0	0	0				
J3	Poamoho	NA	0	0	?				
K1	Poamoho	NA	0	**5**	?				
K5	Poamoho	NA	**3**	0	0				
Q3	Poamoho	NA	0	0	?				
A3	Opae'ula	0	0	0	0				
A5	Opae'ula	0	0	0	?				
L5	Opae'ula	0	0	0	0				
M6	Opae'ula	0	0	0	0				
N4	Opae'ula	0	0	0	?				
N9	Opae'ula	0	0	0	0				
Q1	Opae'ula	0	0	0	?				
Q4	Opae'ula	**6**	0	0	?				
R5	Opae'ula	0	0	**5**	**5**				
R6	Opae'ula	0	0	0	**7**				

away from their origins following hurricane force winds during a severe winter storm (M.G. Hadfield, unpubl. data).

In the present study, a radar helped to relocate snails in vegetation that is not normally thought to be a prime host for snails. A common morph of the native tree *Metrosideros polymorpha* has a fuzzy leaf texture, which is usually avoided based on observations of captive and wild snails (unpubl. data). However, at least two snails were relocated with a radar on this particular tree morph. Some transponder-equipped snails have also been recaptured in dense foliage and/or on high branches that would have been challenging to search thoroughly. Use of the radar alone resulted in recapture rates $\geq 80\%$ at every site, which is more than double that of equivalent effort with CMR (K.T. Hall, unpubl. data).

Except where mentioned earlier, all non-recaptures can be attributed to breaks in the transponders at weak solder bonds. Most of these non-recaptured

Table 2. Meteorological predictor variables corresponding to the number of dispersing snails for each site/month combination. avg., average; max., maximum; min., minimum; RH, relative humidity; T, temperature; WS, wind speed; WG, wind gust.

Site, month	Dispersed snails (no.)	T (°C) (max.)	T (°C) (avg.)	T (°C) (min.)	RH% (avg.)	RH% (min.)	WS (avg.)	WS (max.)	WG (avg.)	WG (max.)
Palikea, August	0	25.2	18.5	16.0	95.5	60.3	1.8	4.2	4.0	9.5
Palikea, September	0	22.9	18.1	16.0	97.2	69.8	2.0	5.0	4.4	8.8
Palikea, October	1	25.2	18.8	16.0	97.9	70.3	1.3	4.2	3.2	9.1
Palikea, November	1	25.2	18.1	15.6	99.6	74.8	1.9	6.1	4.1	11.4
Palikea, December	1	24.0	16.2	13.3	97.1	68.3	1.7	5.3	4.0	10.7
Palikea, Feburary	0	23.2	15.7	12.9	98.0	45.3	1.6	5.0	3.8	8.8
Kahanaha'iki, August	0	32.3	21.1	15.6	97.0	45.3	1.0	4.6	3.6	9.9
Kahanaha'iki, September	0	30.7	20.8	17.1	96.0	48.3	1.3	3.1	4.8	10.3
Kahanaha'iki, November	2	31.5	20.0	14.9	99.0	46.3	2.0	5.0	5.0	12.0
Poamoho, September	2	26.7	19.2	16.8	98.5	72.8	2.4	6.5	5.9	13.7
Poamoho, October	2	26.0	19.3	16.8	98.6	81.8	1.4	5.7	3.9	13.7
Opae'ula, August	1	27.1	19.1	14.1	96.7	47.8	1.8	4.2	5.3	10.7
Opae'ula, September	0	24.0	18.7	16.4	95.8	58.3	1.9	4.2	5.7	11.8
Opae'ula, October	1	26.7	18.9	14.5	96.2	60.8	1.3	5.0	4.2	11.8

snails were eventually seen again during intensive searches with only the diode still attached. This is the major limitation of the transponders. Larger, more durable tags were tested, but affected natural snail behavior. Snails would sometimes come to rest without fully retracting into their shells, while others would have movement restricted by rigid wire kinks. In order to determine the fate of snails with failed transponders, considerable time was required to locate those individuals. Sometimes, this necessitated another trip to a field site specifically to find a lost snail.

Table 3. Number of transponder tags lost per month per site. *Weather station malfunctions. **At least one transponder snail never recaptured. Cells containing values without asterisks are the same site/month combinations found in Table 2.

	Kahanaha'iki	Palikea	Opae'ula	Poamoho
August	0	1	0	
September	0	2	1	2
October	0*	2	2	2
November	0	1	4**	3**
December	2*	1		
January	2*	1*		
February	4**	2		
March		3**		

Non-detection of dispersal is very problematic for CMR studies and was a major reason why a radar was used in this study. Despite dramatic improvements in detection ability, harmonic radar methods in their current form still cannot entirely eliminate non-detection of dispersal. For tree snail studies in which inclement weather is not a substantial factor, this method should suffice for monitoring purposes. However, further transponder modifications will be needed in study areas that are prone to severe weather and/or where regular access is limited. J. Kiriazi (UH Mānoa Electrical Engineering Department) is currently assisting the authors of this article with ways to increase the durability of transponders through more conformal designs that are less prone to wear and tear as snails forage through thick vegetation. These designs cover more of the shell's surface area, reducing the need for an antenna extension beyond the length of the snail. In addition, we are exploring ways to create transponders with unique frequencies by changing the length of the antennae. These approaches require a different transmitter and receiver with an adjustable frequency, a function not available with the Recco unit.

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APPENDIX 4-4 BACK PAGE

APPENDIX 4-5

Ecology of introduced rats (*Rattus* spp.) and their effects on Hawaiian plants

Army Environmental Annual Report (July 2008-August 2009)

Aaron Shiels

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University of Hawai`i at Mānoa

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I. Introduction & Project Objectives

Because most oceanic island ecosystems developed in the absence of terrestrial mammals, many island species are vulnerable to introduced mammalian predators. Rats (*Rattus* spp.) are among the most widespread and significant invasive mammals affecting islands. In many continental ecosystems, native rats provide an important ecological role, largely through seed dispersal, in maintaining native plant populations. Additionally, through hundreds of thousands of years of coexistence, most continental floras have developed defenses to protect against seed-eating mammals such as rats. On islands like Hawaii where rats have been recently introduced (in the last 1000 years), and have quickly become well established, the flora is particularly susceptible to the negative effects of rats (e.g., through seed predation and recruitment limitation). Additionally, the omnivorous diets of most rats, as well as their ability to maintain relatively high populations in most ecosystems, has likely resulted in widespread vulnerability of many different types of native flora and fauna to rats. A better understanding of these introduced rats (i.e., *Rattus* spp.) and their impact on both plants and animals in the Hawaiian Islands is needed.

The aim of this study is to increase our understanding of both the population ecology of rats (including relative abundances, seasonal fluctuations, habitat use, home-range, and diet) and the effects of introduced rats on native and non-native plants in Hawaii (particularly their susceptibility to seed predation and seed dispersal). Such information is critical to improving our understanding of contemporary island ecosystems that have been invaded by rats, as well as apply such findings to improve the conservation and restoration initiatives for native flora and fauna in Hawaii and other island where introduced rats are present.

II. Methods

Study Site

This research occurs at three study sites in the Wai`anae Mountains, Oahu: Kahanahāiki (KHI), Kalua`a at Honouliuli Preserve (HON), and Makaha (MAK). All three sites are in mesic, montane forest at 500-660 m a.s.l. Air temperature at 1 m height fluctuates seasonally, and generally range from 16-24^{o} Celsius (**Figure 1**). All three sites have a similar, mixed flora that includes both native and alien plant species. Detailed vegetation surveys were conducted at the focal study site, Kahanahāiki (see next section).

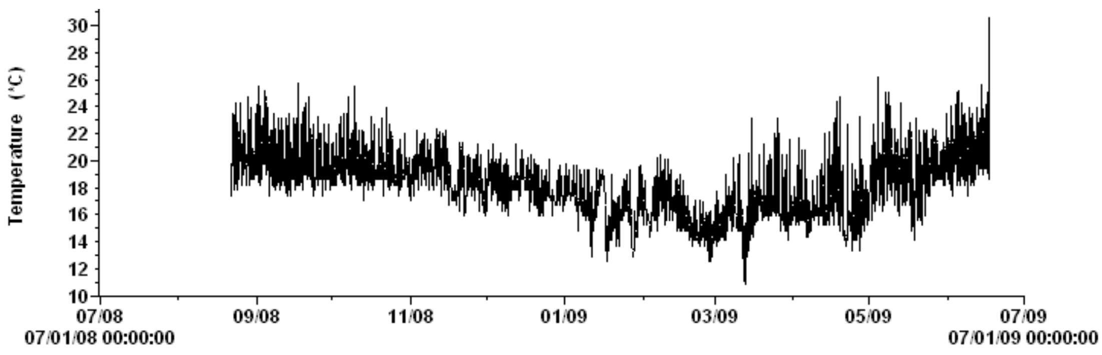

Figure 1. Seasonal fluctuation in air temperature (degrees Celsius) at Kahanahaiki, a mesic forest preserve on Oahu. Air temperature was measured four times a day at a height of 1 meter using Hobo® temperature dataloggers. The far right increasing line reflects the collection and download of the datalogger in Honolulu.

Plant composition and relative abundance at Kahanahaiki

Ten plots, each 15 x 15 m, were established in a stratified random design in Kahanahaiki gulch. Within each plot, all stems≥ 1 cm dbh (measured at 130 cm above ground) were ide ntified to species, mapped, marked with an aluminum tag and secured to the respective stem using grafting tape, and measured for height and diameter at dbh. This stem inventory followed the methods of the Center for Tropical Forest Sciences (Smithsonian Institution), which is a method used globally on long-term forest plots.

Field trials for vulnerability to rats of top 10 dominant woody plants

Thirty-two stations (4 treatments x 8 replicates), each placed 10 m apart, were established along transects at KHI to determine the vulnerability of fruit and seeds to rodents. Each station was randomly assigned one of the following treatments: 1) no-vertebrate-access, which consists of a wire metal mesh (1.2 cm aperture) open-bottom square box (30 x 30 x 30 cm; length x width x height) that excludes all potential vertebrate seed predators and dispersers (*e.g.,* rodents, pigs, cats, birds, mongoose) and acts as the control to compare subsequent treatments, 2) small-vertebrate-access, which is the same dimensions as the no-vertebrate-access but four holes (one on each of the side-walls; 10 x 10 cm each) allow small vertebrates (such as rodents) to access the interior but excludes the entry of other large animals (*i.e.,* pigs, cats, most birds), 3) open forest floor, where all vertebrates are able to freely access the station, and 4) cage control, where three sides (top and two walls) of metal mesh, allowing all animals access, were used to test the influence of the caging material on diaspore removal. Each mesh exclosure was pushed into the ground *ca.* 1 cm and held in place using 8 cm long turf staples. In order to determine the animal responsible for fruit/seed removal, motion-sensing cameras (Bushnell Sentry 2.1 MB or Multrie) were placed at a subset of these treatment stations. Ripe fruits and seeds of the 10 dominant woody plants (natives and aliens; based on plant census described above) were individually tested.

Laboratory trials: captive feeding, seed fate, and seed size threshold

Adult *Rattus rattus* captured from wild populations adjacent to HON, KHI, and MAK were utilized in captive feeding trials with fruits and seeds of Hawaiian plants. Once wild rats were captured in the field they were transported to the University of Hawaii Lyon Arboretum Rodent Housing Facility (LARHF). Each rat was held in individual 38 cm x 22 cm x 18 cm metal-mesh (8 mm) cages and allowed to acclimate for at least 1 week before beginning feeding trials with Hawaiian fruits and seeds. The proportion of fruit and seed eaten by each rat was quantified. Additionally, rat droppings were inspected for seeds that pass through the rat's digestive tracts, and passed seeds were recovered and assessed for germination by first sowing the seeds on agar Petri dishes and then comparing germination percentages to conspecific seeds that were not passed through rats. Between each feeding trial, rats were returned to their regular diets of mixed seeds (*e.g.,* corn, sunflower, wheat, barley, oats, sorghum) and wedges of fruit (tangerine, mango, kiwi). Rats were checked daily in order to ensure ample food and fresh water, and to clean urine/fecal trays. The regular number of rats that were held at LARHF was 10-12. Measurements of the seeds and fruits (e.g., length, mass, percent moisture) were recorded for the species used in the captive feeding trials in order to help determine which characteristics of the seeds may predict vulnerability to rat predation and dispersal.

Relative abundances of rats

Distribution and abundance of rats were assessed every two months from February 2007-April 2009 at HON and KHI, and quarterly from July 2008-April 2009 at MAK, using standard mark-and-recapture technique. Hagaruma live traps were set along transects at 25 m intervals. Four to six transects per site were established and each transect was approximately 35-50 m from adjacent transects. Steep topography did not allow for a symmetrical grid design. The total trapping area for each site was: 2.87 ha for HON, 2.81 ha for KHI, and 3.37 ha for MAK. Each trapping event consisted of four consecutive trap nights. Both KHI and HON had 60 traps (45 traps were on the ground, 15 were in trees up to 4 m height), and MAK had 50 traps (45 on ground, 5 were in trees). All traps were baited with fresh chunks of coconut, and pre-baiting with shredded coconut took place 2 days prior to opening traps. Mice (*Mus musculus*) were also prevalent at the study sites, and were marked and measured using the same methods as for rats.

Application of tracking tunnels to estimate rat abundance

At all three sites, tracking tunnels (The Black Trakka Gotcha Traps LTD) were deployed approximately 1 week after each live-trapping interval ended from May 2008-April 2009. Tracking tunnels consisted of a black plastic tunnel where a water resistant card containing ink and white surface was placed. Tunnels were baited with chunks of coconut and left for approximately 24 hours. Upon collection, each track card was inspected and the species of animal track was identified. During 2008-2009, tracking tunnels were deployed at six time periods for each of HON and KHI, and for three time periods for MAK. The proportion of tunnels that had rat tracks were matched with the live-capture rat abundances in order to determine if tracking tunnels could be used as a proxy for relative rat abundances in the Waianae Mountains.

Micro- and macro-habitat use of rats

In order to estimate *R. rattus* home-range and habitat use at KHI and MAK, a subset of the captured rats were fitted with radio collars. Each radio collar was <4% of the animal's body weight (mean ± SE collar mass: 3.86 ± 0.10 g). Radio telemetry provides a coarse-scale estimate of habitat use. Nighttime radio telemetry was conducted using triangulation. Finer scale habitat use (micro-habitat) was determined at all three sites using string bobbins attached to the backs of *R. rattus*.

Diets of introduced vertebrates at Kahanahaiki: rat, mouse, mongoose, cat, francolin

Diets of five common vertebrates at KHI were determined by analyzing stomach or fecal contents. Mice (*Mus musculus*) and black rats (*Rattus rattus*) were snap-trapped monthly during years 2007-2009 and kept frozen until stomach contents could be extracted. The majority of the mice samples were from May 2009. Scat of mongoose (*Herpestes auropunctatus*) and cats (*Felis catus*) were opportunistically collected by Steve Mosher at KHI during 2005-2007 and kept frozen until analysis. Droppings of Erckel's francolin (*Francolinus erckelii*), a common game bird at KHI, were also collected opportunistically during 2007-2009. A subset of francolin droppings were inspected for seeds passed through the bird's digestive tract and the seeds were immediately sown on Petri dishes to test for germination. All droppings were frozen until future analysis.

Rodent stomach contents were extracted from the stomach cavity, swirled for 5 min in water and mild detergent to separate contents, dissolve gastric juices and oils, and then sieved through a No. 35 US Standard sieve (0.5 mm mesh). Recovered contents were preserved in 95% ethanol and analyzed for 1) percent occurrence of each food type, and 2) relative abundance of each food type. A transparent grid (5 x 5 mm cells for rats; 3 x 3 mm cells for mice) was positioned beneath a Petri dish with stomach contents and examined under the dissecting microscope under 10x magnifications. Percent occurrence of each food type (i.e., vegetative material, seed, fruit, arthropod, hair) was calculated by the presence of each of the food types in a given sample divided by the total number of samples (N = 10 for *R. rattus*; N = 39 for *M. musculus*). Relative abundance of each food type was determined for each individual sample by scoring the number of grid-boxes containing a given food type and dividing by the total number of grid-boxes (i.e., 40 grid-boxes). If more than one food type was in a grid-box, the item closest to the microscope was recorded. When possible, the type/species of arthropod or plant was recorded. Student laboratory assistants/interns conducted these analyses (see Acknowledgements).

Scat (N = 31 mongoose; N = 13 cat) and droppings (N = 30 francolin) were analyzed in a similar fashion as rodent stomach contents. Scat/droppings were placed in centrifuge tubes, soaked and shaken in deionized water to break-up contents, and then sieved through a No. 35 sieve (0.5 mm mesh). Recovered contents were then dried at 45^{o} C and analysed for frequency of occurrence and relative abundance (using 5 x 5 mm grids) under the dissecting microscope

(10x magnification) in a similar fashion as rodent stomach contents. The food type categories used for scat and droppings included: plant (vegetative material, seed, fruit), arthropod, mollusk, reptile, mouse, rat, bird. When possible, the type/species of each food type was recorded. Student laboratory assistants/interns conducted these analyses (see Acknowledgements).

III. Summary Results & Interpretations – Plants and rat-plant interactions

Plant composition and relative abundance at Kahanahaiki

Thirty-five species of plants with stems ≥1 cm dbh from 20 families were present in the study plots at KHI. When the number of individuals (**Figure 2**) and the number of stems (**Figure 3**) were examined, *Psidium cattleianum* was the most common species, and *Schinus terebinthifolium* (also an alien) was among the top five most common trees. Eight of the 35 species were alien plants, and were represented by the following six families: Agavaceae, Anacardiaceae, Buddlejaceae, Euphorbiaceae, Myrtaceae, Proteaceae. The three most common native trees in the 2008 census were: *Diospyros hillebrandii*, *Psydrax odorata*, and *Sapindus oahuensis*. The majority of the 35 species were trees, yet there were a few shrubs and one liana (*Freycinetia arborea*). There were three endangered plant species and one species of concern in the 10 plots.

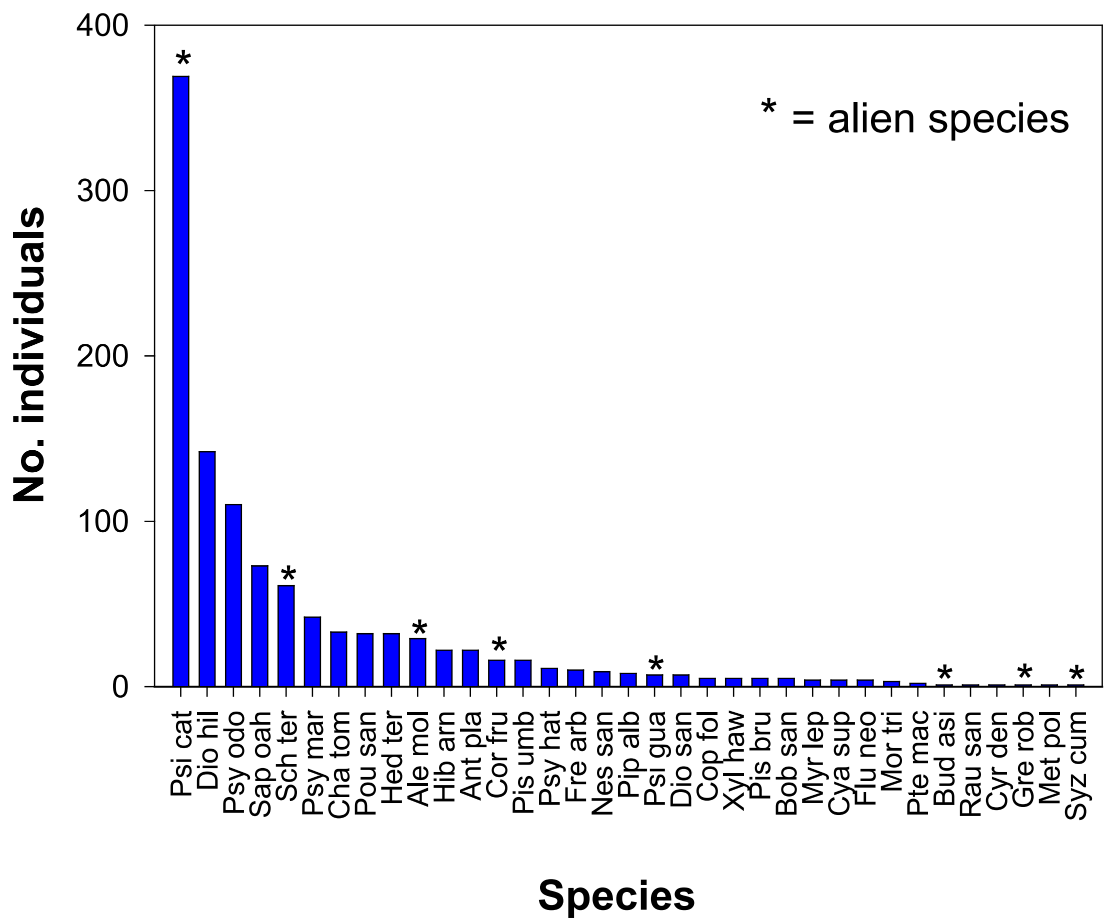

Figure 2. Relative abundance of the 35 species with stems ≥1 cm dbh at Kahanahaiki, Oahu. The top ten species listed corresponding to their six letter species codes are: 1- *Psidium cattleianum*, 2- *Diospyros*

hillebrandii, 3- *Psydrax odorata*, 4- *Sapindus oahuensis*, 5- *Schinus terebinthifolium**, 6- *Psychotria mariniana*, 7- *Charpentiera tomentosa*, 8- *Pouteria sandwicensis*, 9- *Hedyotis terminalis*, 10-*Aleurites moluccana**.

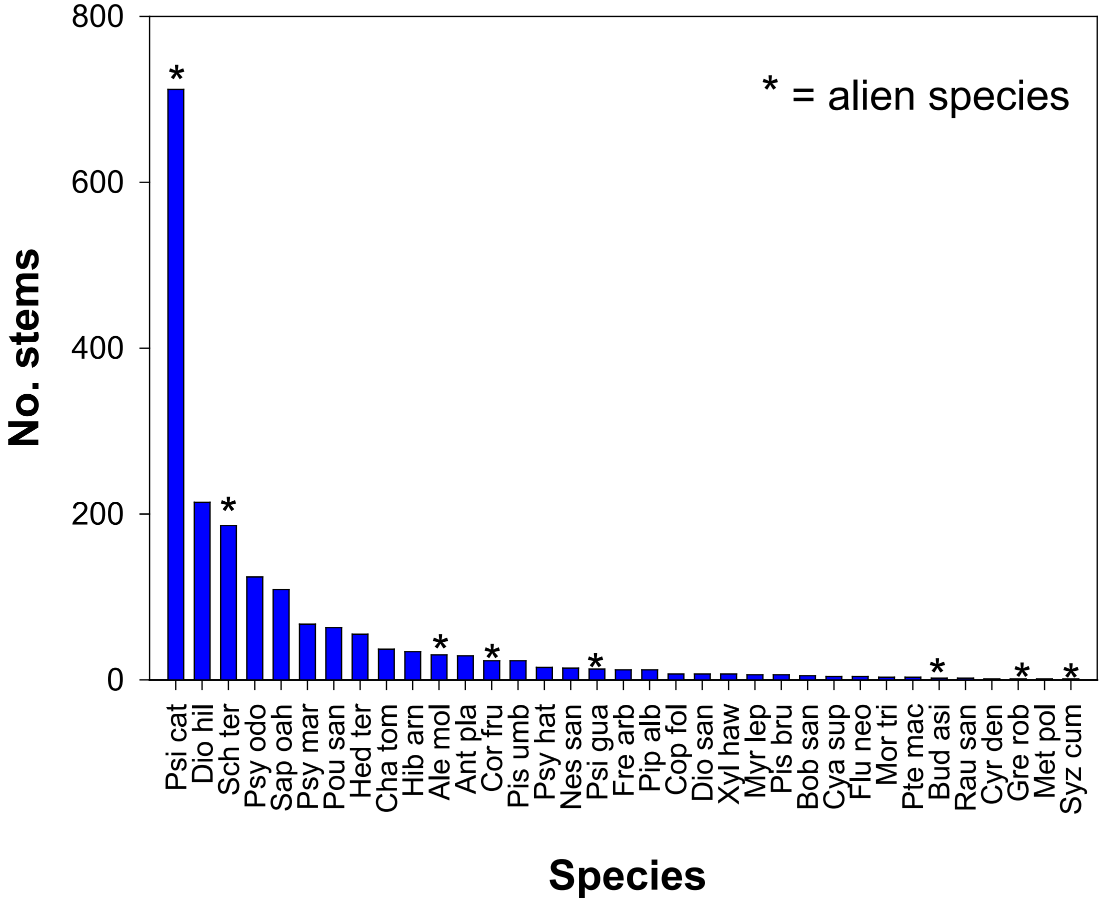

Figure 3. Relative abundance of the 35 species with stems ≥1 cm dbh at Kahanahaiki, Oahu. The top ten species with most abundant stems are listed corresponding to their six letter species codes are: 1- *Psidium cattleianum* (guava), 2- *Diospyros hillebrandii* (lama), 3- *Schinus terebinthifolia* (xmas berry)* , 4- *Psydrax odorata* (alahe‘e), 5- *Sapindus oahuensis* (lonomea), 6- *Psychotria mariniana* (kōpiko), 7- *Pouteria sandwicensis* (‘ala‘a), 8- *Hedyotis terminalis* (manono), 9- *Charpentiera tomentosa* (papala), 10- *Hibiscus arnottianus* (koki‘o)

Field trials for vulnerability to rats of top 10 dominant woody plants

When post-dispersal fruit/seed removal was assessed in the field at KHI, nine out of the top 10 dominant woody plant species were removed from the forest floor (**Table 1**). Motion-sensing cameras that were used to monitor a subset of the treatments and revealed that rats (probably *R. rattus*) was responsible for the majority, if not all, of removal of fruits/seeds of each of these nine species. *Psidium cattleianum* was highly vulnerable to rats as 100% of the available fruits/seeds were removed. Because *Psidium cattleianum* is the most common tree species at KHI (**Figure 1-2**) and produces a large amount of fruit/seed over a two-month period, a second trial during the peak fruiting was conducted which revealed just 12% fruit removal. This decreased proportion of trial fruit removed by rats was likely due to the higher abundance (during the peak) of fruit on the forest floor that surrounded the trial fruits. Despite the attractiveness of *Psidium cattleianum* to rats, the other two common alien trees (*Schinus* and *Aleurites*) were not attractive to rats as none of the fruit (*Aleurites*) or very little (2% for *Schinus*) was removed. The native trees assessed (i.e., 7 of 10) ranged in their proportion of fruit removed by rats from 21-79%, and four of the seven native species had >50% fruit removal (**Table 1**). *Diospyros sandwicensis* and *Pouteria sandwicensis* had very high fruit removal, indicating that these species are particularly attractive to rats.

Table 1. Results of the field trials where fruits/seeds of ten of the top woody plant species were assessed for attractiveness and removal by rats in Kahanahaiki forest, Oahu. *Psidium cattleianum* was assessed at two different time periods during its fruiting cycle. An asterix (*) signifies an alien species.

Species	% fruit removal (field)
Psidium cattleianum (guava)*	12-100
Diospyros sandwicensis (lama)	79
Pouteria sandwicensis (‘ala‘a)	79
Psydrax odorata (alahe‘e)	65
Coprosma foliosa (pilo)	56
Nestegis sandwicensis (olopua)	33
Hedyotis terminalis (manono)	29
Sapindus oahuensis (lonomea)	21
Schinus terebinthifolius (xmas berry)*	2
Aleurites moluccana (kukui)*	0

<u>Laboratory trials: captive feeding, seed fate, and seed size threshold</u>

An understanding of the vulnerability of seeds to rat predation can be determined by first assessing the removal of fruits/seed by rats in the field (e.g., KHI) and then assessing the degree by which rats (*R. rattus*) in the captive feeding trials damage and destroy seeds. Half of the dominant species that were first tested at KHI had at least 50% of their seeds damaged by *R. rattus* in captive feeding trials (**Table 2**). Higher seed damage indicates a higher likelihood that the seeds will be destroyed. *Nestegis sandwicensis* essentially had all of the offered seeds eaten and entirely damaged. Rats damaged approximately three-fourths of the available seeds of *Diospyros sandwicensis, Psidium cattleianum*, and *Coprosma foliosa* (**Table 2**). Despite the attractiveness of *Pouteria sandwicensis* in the field, the seeds were not damaged to a high degree. Furthermore, the pericarp (fruit portion) of the diaspore was most-commonly eaten by *R. rattus* in the captive feeding trials. Such a combination of high attractiveness in the field and low seed damage is indicative of dispersal potential by *R. rattus*. Despite being common alien trees, *Schinus* and *Aleurites* are not attractive or vulnerable to rats (**Table 2**).

Table 2. Results of the field and laboratory (captive feeding) trials for the top 10 woody plant species at Kahanahaiki forest, Oahu. *Psidium cattleianum* was assessed in the field at two different time periods during its fruiting cycle. An asterix (*) signifies an alien species.

Species	% fruit removal (field)	% seed damage (lab)
*Psidium cattleianum**	12-100	74
Diospyros sandwicensis	79	81
Pouteria sandwicensis	79	37
Psydrax odorata	65	56
Coprosma foliosa	56	73
Nestegis sandwicensis	33	99
Hedyotis terminalis	29	36
Sapindus oahuensis	21	23
*Schinus terebinthifolius**	2	3
*Aleurites moluccana**	0	<1

In addition to the 10 most common woody plants species at KHI, a wider suite of species were tested for vulnerability to *R. rattus* in captivity. Currently, more than 45 species from 28 plant families have been tested in the captive feeding trials for vulnerability to *R. rattus*. Other rodent species have not been utilized to a large degree in the feeding trials. In attempt to uncover particular characteristics of the seeds that predict vulnerability to rat predation, a seed size threshold has been determined (**Figure 4**). To date, seeds have been measured for their longest axial length. The majority of the seeds tested do not survive the interaction with *R. rattus*. However, the seeds that have the highest survival are the smallest seeds. Such small seeds that are below the threshold of 1.8 mm were consumed by *R. rattus* and most often passed intact through the rat's digestive tract. In order for small seeds to be swallowed and passed intact by *R. rattus*, they must have attractive fruit. Such small seeds are likely being dispersed by *R. rattus* in the wild.

There was no general (statistical) patterns uncovered when linear and non-linear relationships were tested between seed size and seed survival after rat interaction. The absence of significant pattern is probably reflective of the species specific characteristics of the seeds that do not fit the hypothesized pattern that larger seeds are more likely to be destroyed by *R. rattus*. As mentioned above, some of the large-seeded species such as *Pouteria* and *Sapindus* had few of their seeds damaged by *R. rattus*.

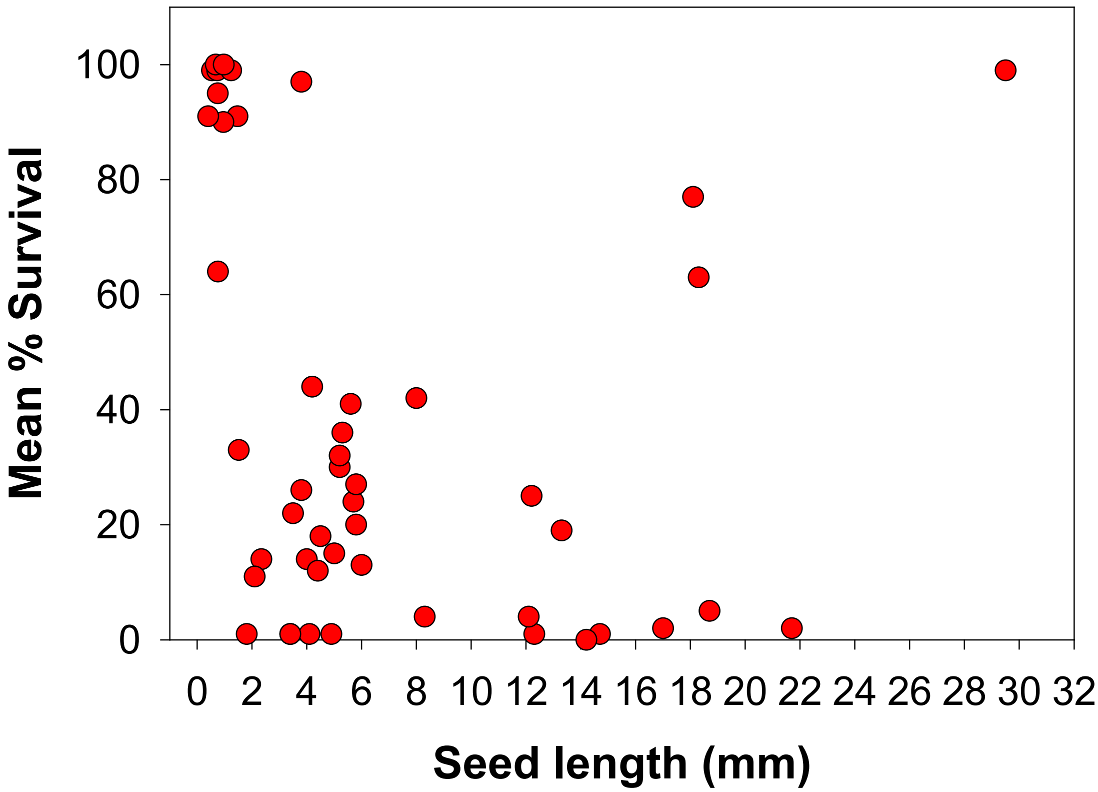

Figure 4. Mean seed survival of 45 plant species from 28 families after 24-48 hr interaction with *R. rattus*. Each point represents a species. Seed length (mm) was determined by the longest axis of the seed.

IV. Summary Results & Interpretations – Rat biology in the Waianae Mountains

Relative abundances of rats

Approximately 900 individuals of mice (*Mus musculus*) and rats (*R. rattus* and *R. exulans*) were captured, marked, measured, and released during the February 2007-April 2009 trapping season for all three sites (HON, KHI, MAK) combined. Few *R. exulans* were captured, but were present at all sites. *Rattus norvegicus* has never been captured at any of the study sites. There was a noticeable difference in rat captures between the two most intensely sampled sites (HON and KHI), as KHI rat abundances fluctuated more than HON (**Figure 5**). Additionally, *Rattus rattus* abundances at KHI were approximately 2-4 times greater than rat abundances at HON. The *R. rattus* abundances at MAK were more similar to HON than KHI (**Figure 5**). Rats were only active during the night, as no rats but several mice were captured during the daytime at each site.

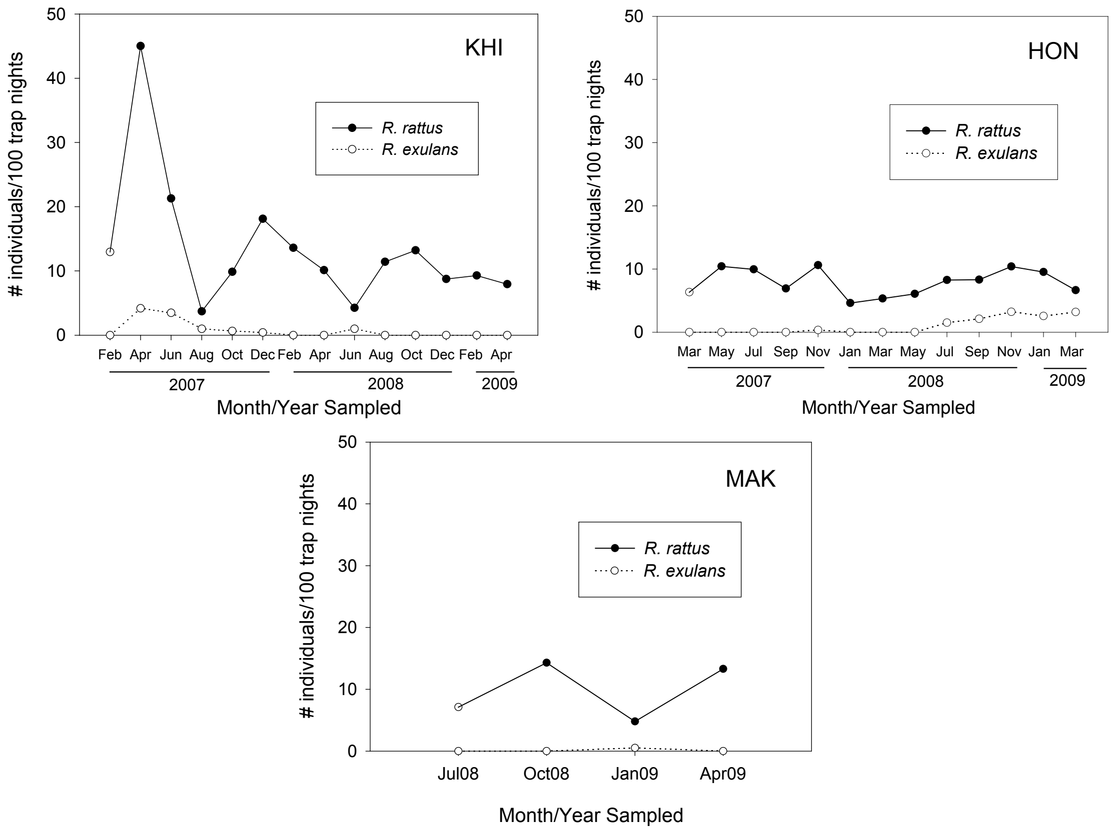

Figure 5. *Rattus* spp. abundances (No. indiv./100 trap nights) for three sites (KHI, HON, MAK) in the Waianae Mountains, Oahu.

Application of tracking tunnels to estimate rat abundance

In attempt to better predict rat abundance without utilizing the high-intensity, high-effort, live-trapping technique, tracking tunnels were deployed and the activity levels were matched with those of live-trapping. Both HON and KHI tracking tunnels were utilized on six occasions during 2008-2009, whereas MAK tracking tunnels were utilized on three occasions. There were no significant relationships when analyzed on a site-basis or collectively (all three sites combined), indicating that the tracking tunnels do not provide a reliable index of rat abundance at these sites (**Figure 6**). Future analyses will be conducted to determine if particular days in the 4 day trapping sequence (e.g., the first day), or if better rat abundance estimates utilizing program MARK, may provide a significant relationship with tracking tunnel activity.

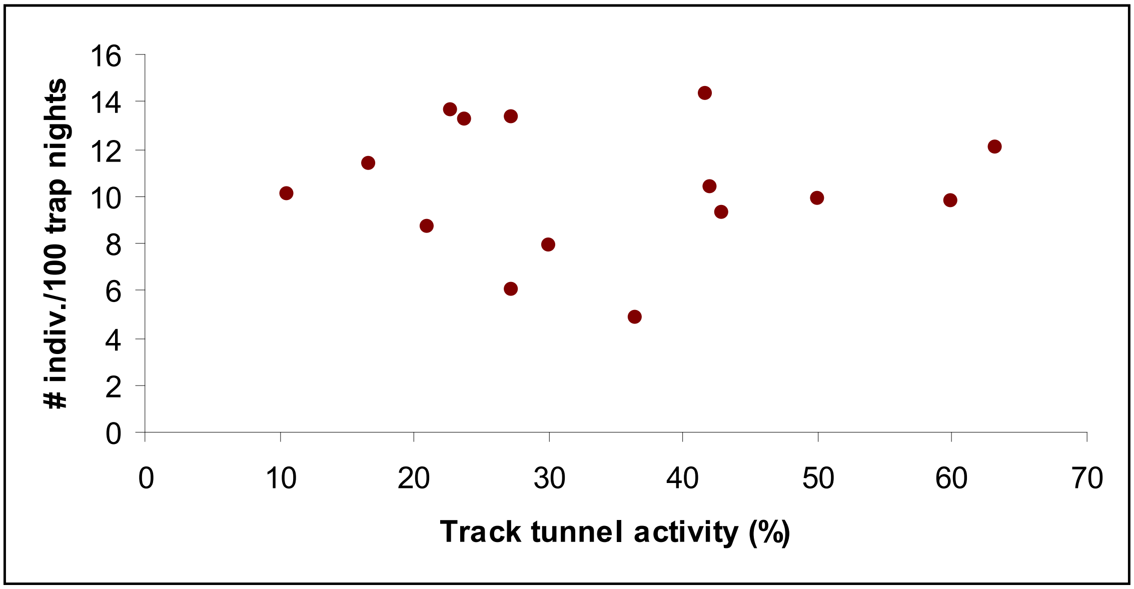

Figure 6. Scatterplot showing the rat (*R. rattus* + *R. exulans*) activity levels from the tracking tunnels matched with the rat abundance estimates (live-trapping) from the same sites (HON, KHI, MAK) and time periods (separated by 1 week). No significant relationships were present when analyzed on an individual site-basis or collectively.

Micro- and macro-habitat use of rats

Bobbins were attached to rats to provide an index of microhabitat use. For all individuals with bobbins attached, rats did not travel further than 50 m from the trap site in 24 hours before the 200-300 m of string in the bobbin ran out. There was not a clear partitioning of habitat for individuals of *R. rattus* that were caught in trees versus those that were caught on the ground. In other words, rats that were caught on the ground used tree and ground habitat, and likewise, rats that were caught in the trees used both trees and ground habitat. Overall, *R. rattus* appeared to use the ground habitat (79%) more than the trees (21%). When traveling above ground, rats were most often <1 m high, but in some cases they would climb to >12 m height (maximum was 22 m). A single *R. exulans* was caught in a tree (ca. 2.5 m height) at HON, but all other *R. exulans* at all sites were caught on the ground. Bobbins were attached to *M. musculus* that were caught on the ground at all three sites. Like *R. exulans*, mice used the ground habitat the most, but would often use habitat <2 m above ground. One mouse at KHI used tree habitat to 4.1 m above the ground.

Ten *R. rattus* were radio-collared and tracked at KHI from February through June 2007. The locations of collared rats were taken both during the daytime (inactive period) and nighttime (active period) approximately once a week. The home-ranges of each of the 10 rats are still being analyzed; however, all collared rats had home-ranges <1 ha, and movement distances appear to be relatively close to den sites (range: 7-145 m). Rat den sites were located both in the ground and in trees (live and dead). The most common trees for rat den sites were alien species (*Grevillea robusta, Psidium cattleianum, Aleurites moluccana*), although one female rat had a short-term (<1 week) den site in a cavity of the native *Santalum paniculatum*. All collared rats at KHI changed den sites multiple times (1-6 times) and only two rats returned to previously-used den sites after selecting a new den site during the life of the radio-collar. There were no occasions where two collared rats shared the same den site; however, home-ranges commonly overlapped. At least four of the 10 rats suffered predation, as rat collars were retrieved on the forest floor with only a rat stomach remaining or in one case only part of the pelt present. Stomachs from rats that were not collared were found on two occasions at KHI, suggesting that the collars did not cause the mortality of radio-collared rats. There are a suite of predators at KHI, as motion-sensing cameras revealed at least one feral cat (*Felis catus*) and several mongoose (*Herpestes auropunctatus*) at KHI. Barn owls (*Tyto alba*), another potential predator of rats, have been observed on several occasions during nighttime radio telemetry at KHI.

Ten *R. rattus* at MAK were radio-collared and tracked from July 2008 to May 2009. Compared to the collared rats at KHI, the MAK rats were not monitored as frequently. Den sites for MAK rats were both in the ground and in live and dead trees. At two different times (separated by nearly 6 months) a collared *R. rattus* denned in the same *Pouteria sandwicensis* tree, approximately 2 m above ground. Similarly two different rats denned in a large dead tree that was approximately 6 m tall. Large (living) trees of *Metrosideros polymorpha* and *Acacia koa* were also den sites of *R. rattus* at MAK. The highest den site was a female *R. rattus* in an *Aleurites moluccana* tree (20 m high). Beginning in April 2009, there was a male *R. rattus* that denned approximately 2 m above ground in a *Psidium guajava*, but this individual died of an unknown cause approximately one month later.

When compared to KHI, the collared rats at MAK did not appear to be depredated as frequently. One *R. rattus* at MAK died and had the majority of its carcass eaten, but it was unclear if the rat had died of 'natural' (non-predator) causes and was then scavenged, or if it was killed by a predator. In addition to a seemingly lower mortality of *R. rattus* at MAK, the rats at MAK appeared to have slightly larger home ranges (>1 ha) than those collared at KHI. This pattern supports past studies showing that rat home-ranges will increase with a decrease in rat abundance. Future analyses will determine if these apparent differences between rats at the two sites where radio collars were utilized are significant.

V. Summary Results & Interpretations – Diets of introduced vertebrates

Diets of Rattus rattus *and* Mus musculus

Dietary analyses of several of the most abundant introduced vertebrates at Kahanahaiki, Oahu, were determined during 2005-2009. Nearly 100 *R. rattus* stomachs have been collected from KHI, yet presently only 10 stomachs have been analyzed. In all ten of the *R. rattus* stomachs analyzed, both plant material and arthropods were present (**Table 3**). Similarly, mouse (*Mus musculus*) stomachs comprised of high proportions of both plants and arthropods (**Table 4**). The relative proportions of plant material tended to be higher in *R. rattus* than in *M. musculus*, and the proportion of arthropod in stomachs tended to be lower in *R. rattus* than *M. musculus* (**Table 3, 4**). A substantial portion of the stomach contents of rats was not identifiable. Intact seeds and fruit fragments of *Clidemia hirta* were found in one of the rat stomachs.

Table 3. Diet analysis of black rats (*Rattus rattus*) based on stomach content analysis. All rats were collected fresh (<24 hrs) from snap-traps set in Kahanahaiki forest, Oahu from 2007-2009 (N = 10).

	Plant	Arthropod	Fungi	Unknown
% Occurrence (% of droppings with each food type)	100%	100%	10%	40%
Mean relative abundance (% of 40 boxes with each food type)	92%	53%	2%	<1%

When the arthropod portion of mice were more closely examined, approximately 35% of the stomach content of each mouse was an unknown species of centipede, <1% was the ant *Solenopsis papuana* (P. Krushelnycky, *pers. comm.*), and the remaining 64% was comprised of spiders, beetles, and other unknown arthropods. The presence of mouse hair (**Table 4**) is most-likely a result of self-preening, as these rodents are not known to be cannibalistic.

Table 4. Diet analysis of mice (*Mus musculus*) based on stomach content analysis. All mice were collected fresh (<24 hrs) from snap-traps set at Kahanahaiki forest, Oahu.

	Plant	Arthropod	Mouse Hair
% Occurrence (% of droppings with each food type)	63%	94%	10%
Mean relative abundance (% of 40 boxes with each food type)	30%	65%	5%

Diets of Herpestes auropunctatus*,* Felis catus*, and* Francolinus erckelii

The main predators of mice and rats at KHI are mongoose (*Herpestes auropunctatus*) and cat (*Felis catus*), and this was confirmed through scat analysis (**Table 5**). Despite the carnivorous classification of cats and mongoose, their diets are largely omnivorous. Plant material was found in the majority of the samples, and some included seeds of *Psidium cattleianum*. The high frequency of reptile material in mongoose was probably the rainbow skink (*Lampropholis delicate*), which is commonly observed during the daytime on the ground in open-canopy areas at KHI. The mollusk observed in at least three of the mongoose scat (**Table 5**) was a native snail in the Tornatellidinae subfamily (family: Achatinellidae; J. Kim, *pers. comm.*). This snail is approximately 2 mm in length; this small size making it unlikely that the mongoose targets this snail and more likely that it was incidentally consumed (probably attached to a different food item). Bird feathers, bones, and egg shells were consumed by both mongoose and cat. It is unclear what species of birds were consumed, but there are very few native birds remaining at KHI.

Table 5. Percent occurrence of food types in scat from mongoose (*Herpestes auropunctatus*) and cat (*Felis catus*). All samples were collected in mesic forest in Kahanahaiki, Oahu.

	Rat	Mouse	Reptile	Plant	Arthropod	Mollusk	Bird
Mongoose (N = 31)	26%	77%	87%	84%	97%	10%	26%
Cat (N = 13)	100%	100%	31%	92%	100%	0%	23%

All samples of Erckel's francolin (*Francolinus erckelii*) contained both plant material and arthropod (**Table 6**). A few of the samples contained mollusk-looking organisms, and fewer contained reptile scales. Twenty-one of 30 samples contained intact seeds of *Rubus rosifolius* (thimbleberry), a noxious weed that appears to be spreading in KHI. Additionally, at least three of 30 droppings contained intact seeds of *Psidium cattleianum*. These findings reveal that this common introduced game bird is dispersing at least two of the highly invasive plants at these sites. Land managers need to be aware of this in order to best protect against their further spread and ecological damage.

Table 6. Diet analysis of Erckel's francolin (*Francolinus erckelii*) based on fresh droppings collected opportunistically (2007-2009) from Kahanahaiki forest, Oahu (N = 30 droppings).

	Plant	Arthropod	Mollusk	Reptile
% Occurrence (% of droppings with each food type)	100%	100%	27%	3%
Mean relative abundance (% of 40 boxes with each food type)	92%	53%	2%	<1%

VI. Conclusions

Rattus rattus is the most common rodent in all three study sites in the Waianae Mountains, and comprised >90% of the total rat captures during the 2-year census. Based on all rat studies that I am aware of in the Hawaiian Islands, *R. rattus* is presently the most common rat species to invade natural areas. Such high pervasiveness of *R. rattus* across the state clearly deserves attention in order to both establish a better understanding of the potential impacts of this invasive species on Hawaiian flora and fauna, and to apply these research findings to improve management efforts seeking to control introduced rats and their negative impacts on island biota.

Based on recapture and demography data to present, *R. rattus* appears to have a relatively high turnover rate in their populations in the Waianae Mountains, as few individuals have been recaptured after 6 months and only one individual has survived 1 year. Despite the presence of predators such as feral cats, mongoose, and barn owls, *R. rattus* appears to persist through periods of high predation (sometimes 40% mortality due to predation in a 4 month period at KHI; though much lower at MAK), variable fruit and seed availability (based on phenology data at KHI), and months of below-average temperatures (**Figure 1**) with little rainfall. These environmental factors may all contribute to the intra-annual fluctuations in rat populations observed at these sites. Additionally, disease has been little studied in rodent populations in natural areas in Hawaii but susceptibility to disease may also contribute to the fluctuating rat abundances observed.

Rats can affect the survival and reproduction of plants in several ways, yet seed predation and seed dispersal by rats appears particularly important to plant recruitment success in Hawaii. The combination of field and laboratory trials has enabled native and alien Hawaiian plants to be categorized according to their vulnerability to rats. Land management can use such species lists to help prioritize efforts to control and otherwise protect plant species that may be vulnerable to rats. While this current study is specific to Hawaii, generalities utilizing seed characteristics can help predict vulnerability of world-wide floras to rats (particularly *R. rattus*). Analyses to date suggest that there is a seed size threshold of 1.8 mm seed length for seed dispersal by *R. rattus*. This means that most seeds <1.8 mm that *R. rattus* consume will most-likely be dispersed (*i.e*., passed intact through the rat's digestive system), and otherwise not vulnerable to predation by *R. rattus*. Additionally, those species with seeds >1.8 mm that are attractive to rats are much more likely to be destroyed by *R. rattus*; however, the vulnerability of the larger seeds is also species-specific as some large-seeded species are not vulnerable to predation and some may alternatively be dispersed by rats. Currently there is a relatively high number of native plant species that are coexisting with the aggressive alien plants like *Psidium* and *Schinus*. Future integration of seed vulnerability measures, phenology, and seedling and size class structuring should enable better predictions of the extent by which introduced rats are altering Hawaiian forests.

The lack of relationship between tracking tunnel activity and rat abundance resulting from live-trapping was surprising. Additional analyses will be performed on these data in search of particular attributes that may support the usefulness of tracking tunnels as a proxy for live trapping. However, at this point it seems that tracking tunnels are best used to gain understanding of rat activity in particular habitat types rather than utilizing the tracking tunnels as indicators of rat abundance or density.

Rattus exulans, though present at all three study sites (HON, KHI, MAK), remains relatively uncommon and was not captured at all trapping sessions. Only one individual of *R. exulans* was captured during the 2008-2009 year at MAK. The few *R. exulans* individuals that were assessed for habitat use (by radio-collaring and bobbins) in KHI had slightly smaller homeranges than *R. rattus* and the type of habitat used by *R. exulans* was >80% ground, of which they seemed to utilize the dense cover of low-stature ferns (mainly the non-native *Blechnum appendiculatum*) when active. These apparent differences in habitat use, behavior, and density suggest that these two species of introduced rats may differ in the type and magnitude of threat that they pose to native biota and the present ecosystem.

In addition to *R. exulans* and *R. rattus*, several other introduced vertebrates have been observed at the study sites that may be competitors and/or predators of rats. Diet analyses of such species both provides a better understanding of the structure and food web in these forests, but also indicates the groups of organisms that are likely to be susceptible to each introduced vertebrate. Interestingly, all five of the introduced vertebrates (rats, mice, mongoose, cat, francolin) that have been studied have omnivorous diets. Although mice and rats are nocturnal, semi-arboreal, and have overlapping habitat uses, the diets of mice are approximately 65% arthropod and 30% plant, compared to *R. rattus* that has a diet of mostly plants and less arthropods. Additional analysis is needed to identify the types of species that are being consumed by these prominent rodents, yet the previously described plant trials provide some examples of such vulnerable species.

Mongoose and cat have diets consisting of wider groups of animals than the sampled rodents. Scat analysis reveals that mongoose preys heavily on reptiles, specifically skinks, as well as arthropods and plant material. Although both of these predators were not expected to eat plants, analysis of mongoose and cat scat shows that they not only eat plant material but they may also be dispersing some seeds during fruit consumption, which included the invasive species *Psidium cattleianum*. In addition to plant material, there was a wide variety of life forms that were consumed by both mongoose and cats (e.g., rodents, reptiles, plants, arthropods, mollusks, birds).

Analysis of Erckel's francolin diet revealed the large proportion of both arthropods and plant material. Although these francolins are able to fly, they only do so on rare occasions (usually when flushed). Therefore, the most vulnerable arthropods are those that are on the ground (in leaf litter and top soil) and perhaps on the lower portions (<1 m above ground) of vegetation. The high abundance of viable seeds of *Rubus rosifolius* (thimbleberry) and *Psidium cattleianum* that were found in many of the francolin droppings particularly deserves attention as these game birds are clearly dispersing these two noxious (and currently abundant) weeds and are likely accelerating the rates of spread. A more in-depth study of the impacts of Erckel's francolin and other common game birds on the current and future plant community is needed. Lastly, a better understanding of how these common introduced vertebrates are integrated into the food web in these forest preserves will provide a better understanding of the ecosystem and maintenance of biodiversity, as well as help avoid unexpected outcomes of future control or eradication efforts.

The findings from this study will help assess the pervasiveness, distribution, and habitat use of alien rats in Hawai`i, as well as the impacts of rats on Hawaiian plants. When strategizing rat control and eradication to protect native Hawaiian biota, it is important to understand which species are most vulnerable and how they are vulnerable. Most seeds that are attractive to rats in Hawaii are destroyed by the large incisor teeth of the rat. However, a small number of seeds will not be negatively affected, and may likely be dispersed, if eaten by rats. While the net effect of rats on seeds is largely negative, it is necessary to prioritize which species of native plants most need protection from rats. Additional understanding of how rats are integrated with the many other native and introduced species is needed to best manage natural areas in Hawaii. Because conservation efforts are restricted by cost and time, a greater knowledge in this area will hopefully assist in the preservation and/or restoration of native species in the Hawaiian Islands as well as additional island where introduced rats are present.

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VIII. Relevant products/publications from this research

Meyer, W.M., and A.B. Shiels. 2009. Black rat (*Rattus rattus*) predation on non-indigenous snails in Hawai`i: complex management implications. *Pacific Science* 63: 339-347.

Pérez, H.E., A.B. Shiels, H.M. Zaleski, and D.R. Drake. 2008. Germination after simulated rat damage in seeds of two endemic Hawaiian palm species. *Journal of Tropical Ecology* 24: 555-558.

Shiels, A.B, and D.R. Drake. 2007. *Fruit/seed vulnerability to introduced rats in Hawaiian forest. In*: Proceedings of the Seed Ecology II 2007 Conference, 9-13 September, Perth, Australia. Turner, S., D. Merritt, S. Clarke, L. Commander, and K. Dixon (Editors). Kings Park and Botanic Garden, Perth, Australia, pp. 81.

APPENDIX 5

TRANSLOCATION GUIDELINES FOR THE O‘AHU TREE SNAILS (*ACHATINELLA* SPECIES)

Prepared by

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EXECUTIVE SUMMARY

In light of continued declines in O‘ahu tree snail abundance, conservation managers are considering various types of translocation (see §1.1: Definitions) to supplement existing recovery efforts. The goals of translocation techniques are clear, but their long-term effects are widely unpredictable. In this report, the relative risks of five types of translocation are assessed using expert knowledge of *Achatinella* species, scientific literature, and the results of previous translocation attempts with other species.

Most of the techniques discussed have not previously been used with tree snails, hindering the ability to assess likely outcomes and evaluate alternatives. Basic biological risk-criteria are outlined, which are then used to rank the risk of various translocation scenarios. Priority goals for stabilizing these snails are re-defined, and risk levels are used to guide decisions on how to best achieve those goals with minimal risk. Three species' current statuses and management recommendations are discussed within this framework.

The complexity and variability of recommended actions for each species emphasize that any translocation should be preceded by extensive coordination with experts. This document provides only rough guidelines and should be amended whenever new information becomes available. Pre-translocation planning protocols are provided to optimize the use of these new approaches. Lastly, research needs are outlined together with possible experimental designs that may provide critical data on translocation effects.

1. BACKGROUND & CONTEXT

1.1 Definitions

Translocation: The capture, transport and release of a species from one location to another ("Translocation" 2009). This term makes no assumptions regarding the source of the individuals (captive-reared or wild), the characteristics of the destination habitat (occupied/unoccupied wild or captive location), or the number of individuals involved (whole/partial population or individual).

Population: A group of at least 5 animals (see §2.1) of a species whose ancestors may reasonably have interbred within the last 2 generations. This timeframe corresponds to a group of snails being separated by 30-50m from other snails, based on simulations of snail dispersal (Hall *in review*). In addition, analyses of microsatellite genetic data (using the markers of Erickson and Hadfield [2008]) have revealed population divergences at similar distances (Hall and Hadfield *in review*). Areas with high wind exposure and short vegetation correspond to longer separation requirements.

ESU: Evolutionarily significant unit. One or more populations of a species with a distinct, long-term evolutionary history that are genetically cohesive and have been isolated from other populations with regards to gene flow for hundreds of generations. This timeframe is based on the mutation rate of cytochrome oxidase I, the genetic marker that has been used to delineate all *Achatinella* species ESUs to date (Holland and Hadfield 2002). These mitochondrial markers take much more time than microsatellites to reveal major population divergence (Selkoe and Toonen 2006).

GU: Geographic Unit. A population or group of populations clearly separated geographically from other populations with regards to contemporary gene flow. These units are used to distinguish subdivisions within species in the absence of ESU designations.

1.2 Status of *Achatinella* Species

Tree snails of the genus *Achatinella* are endemic to the island of O‘ahu, Hawaii. These arboreal snails can reach over 20 mm in shell length and live primarily on native vegetation, feeding nocturnally on molds growing on the leaves and trunks of host plants. They are characterized by a late age at maturity (3+ years), long potential lifespan (10+ years), and low birth rate (4-5 offspring per year) (Hadfield et al 1993). O‘ahu tree snails are hermaphroditic, although self-fertilization has only thus far been confirmed for a closely related genus (*Partulina*) in the same subfamily (Kobayashi and Hadfield 1996).

The United States Fish and Wildlife Service (USFWS 1992) recognizes 41 species within this genus based upon taxonomic delineations by Pilsbry and Cooke (1912-1914). Only 10 of these species are thought to remain in the wild, and all are facing extinction pressure from invasive predators such as rats and predatory snails (Hadfield et al 1993). All 41 species were listed on January 13, 1981, as endangered under the single genus name *Achatinella* (46 FR 3178) (USFWS 1981).

As stated in §4(f) of the Endangered Species Act of 1973, USFWS is required to create a recovery plan for all listed taxa. The Service published the *Achatinella* species recovery plan in 1992, with the intended goal of stabilizing populations found in essential habitat areas (USFWS 1992). No goals for de-listing were set at that time because of uncertainty in the status of these species. Discussion of recovery and de-listing is still premature because predator threats have yet to be eliminated. The goals outlined in this document will be, as in 1992, to stabilize species while predator abatement research continues.

1.3 Management Goals Addressed

To stabilize an *Achatinella* species, USFWS (2003) recommended active management of 10 populations. In practice, management of only 6-8 populations has been approved for stabilizing some species (U.S. Army Garrison, 2008). For aquatic snails, USFWS (2005) had previously set a recovery target at only three stabilized populations. We recommend keeping the more conservative minimum of 6 populations for each *Achatinella* species, based on their extreme vulnerability to catastrophic decline from predation (Hadfield and Mountain 1980; Hadfield et al 1993). These 6 populations should include at least one population from every major GU of the species, or every ESU when genetic data are available. Up to 10 populations should be stabilized if more than 6 ESUs can be elucidated; additional populations should be managed less intensively, as outlined in §2.

All populations should number at least 300 individuals to be considered stabilized, which was the recorded size of a rapidly growing wild population in the Pahole NAR (Hadfield et al 1993). However, this population size is based on a single group of snails in a $25m^2$ area. In addition, this population was predated prior to reaching a stable population size and might have grown much larger. PVA analyses (see § 6.2) should thus be used to provide a more appropriate minimum number of individuals to achieve stabilization.

For the past two decades, active management has included various techniques such as captive propagation (one form of translocation), rat control, and the construction of two predator-proof exclosures. There has also been recent interest in employing additional translocation techniques to supplement ongoing conservation efforts. A total 5 types of translocation techniques are defined in §3, along with 8 types of populations for which they may be applied (§2). Although the usage of these 13 terms varies widely in the literature, they are defined here in the context in which they are likely to be proposed by conservation managers.

Unfortunately, most translocation approaches remain untested with tree snails, providing little information on which to base future decisions. The relative risks of these techniques are also outlined in §3, based on available literature and expert knowledge. Alternative techniques are then ranked by their risk levels, so that decision makers can prioritize their application towards fulfilling stabilization goals. Examples of designations and recommendations within this context are given in §4.

2. CLASSIFYING POPULATION TYPES

It should be noted that the population descriptions outlined in the next section are not permanent descriptors of a population. Additional data and/or changing realities can alter a population's status, although the basic requirements of §1.3 must remain satisfied by any changes in a population's classification. Populations are classified by size category (5 types) and conservation priority (3 types) in order to standardize management decisions in this document.

2.1 Definitions

<u>Defunct population:</u> Less than 5 adults. These populations are unlikely to recover unaided; 6 adults is the smallest recorded *Achatinella* species population size in which rapid growth has been confirmed (captive-reared *Achatinella lila*). Hadfield and Saufler (2009) recorded population-size increases from only 4 adults of *Partulina* snails (a closely related genus to *Achatinella*), although it is unclear whether *Achatinella* species are capable of similar recoveries. Defunct is thus defined as below 5 adults, the average of the *Achatinella* and *Partulina* thresholds where human-mediated population increases have occurred.

<u>Recoverable population:</u> Any population with 5 or more adults. This term is defined here strictly as an antonym to the above definition of defunct, and makes no assumptions as to the level of

human intervention required for recovery. Recoverable populations can be further classified as "small", "medium", or "large", all of which are defined below.

Small population: Between 5 and 20 adults. The upper bound of 20 was chosen because this is the number below which an entire wild population should be extracted for captive propagation (Tenhumberg et al 2004), and the minimal number of individuals recommended to establish a viable, re-introduced population (USFWS 1992, Stringer and Grant 2003). Although recovery from only 4 individuals appeared possible in Hadfield and Saufler's (2009) study, long-term success was unobservable due to rat predation.

Medium-sized population: Between 21 and 100 adults. This classification was created simply to define populations between "small" and "large" status.

Large population: Greater than 100 adults. A population of this size is considered "stabilized" if all age classes are also represented in the appropriate frequency (see Hadfield et al 1993), based on a total of 300 total individuals (USFWS 2003).

Primary population: These populations represent the minimum 6 populations of 300 individuals outlined in §1.3, characterizing the maximum genetic diversity or geographic range of the species. The appropriate minimum number of primary populations may exceed 6 (§1.3). The utmost priority for conservation managers is to designate and stabilize the appropriate number of primary populations, and protect them *in situ* with predator-proof exclosures. Captive populations are not considered primary populations; they cannot persist without constant human assistance. Within each GU or ESU, the largest and/or enclosed (predator-proof) population should be designated as its primary population. Only recoverable populations (see above) should be designated as primary populations, to increase recovery probability.

Secondary population: For species with populations in excess of the minimal number of primary populations, secondary populations should be designated. The purpose of a secondary population is to become a primary population should a primary population experience a catastrophic decline. One secondary population should be designated for each ESU or GU. High priority should be given to establishing secondary populations for GUs or ESUs represented by a single primary population. All captive populations are necessarily secondary populations, and should be used to restart a primary population as soon as possible if their wild source population is extirpated.

Tertiary population: These are populations in excess of secondary populations, and can become secondary populations if the secondary is lost or converted to primary status.

2.2 Designation Example: *Achatinella decipiens*

Most experts consider this species synonymous with *Achatinella byronii*, and both will be referred to collectively in this document as *A. decipiens*. Currently, "recoverable" (§2.1) applies to only 4 wild populations (U.S. Army Garrison 2008). All 4 are thus designated as primary populations and represent 3 GUs. One of these GUs is represented by both a wild and a captive population, which is considered a secondary population. At least 2 additional wild populations must be created in order to meet the minimum of six primary populations, and should come from under-represented GUs as outlined in §4.2.

2.3 Designation Example: *Achatinella lila*

Only 3 wild populations qualify as primary populations for this species, representing each of the 3 GUs (U.S. Army Garrison 2008). One secondary population is found in captivity and has been reproducing at an astonishing rate. To meet the minimum of six primary populations, this captive population will likely be used in the coming years to establish reintroduced populations.

2.4 Designation Example: *Achatinella sowerbyana*

Only 6 wild populations qualify as primary populations for this species, and all are thus designated as primary populations. Although 7 GUs have been defined for this species, only 3 of those are represented by the primary populations (U.S. Army Garrison 2008). One GU is represented solely by a secondary captive population, and the other 3 GUs are "defunct" (**§2.1)**. Future surveying efforts will hopefully reveal the existence of primary populations in the 4 under-represented GUs. For now, there are 3 primary populations in one GU, 2 in another GU, and a single primary population in a 3rd GU.

3. RISK CRITERIA FOR TRANLOCATION ALTERNATIVES

There are 5 types of translocation under consideration, (reintroduction, introduction, augmentation, combination, and extraction). Several of these approaches can be employed using an entire population, or by using a subset after splitting a larger population. It is assumed in all cases that such splitting does not reduce the original population to a "small" (§2.1) population. There are 3 levels of risk defined below, and a risk level is assigned to every translocation scenario likely to be proposed (captive stock to wild population, wild stock to captive population, etc.). Some definitions include terms defined in §2.1.

3.1 Definitions

Reintroduction: Translocation of a "large" or medium-sized" (§2.1) population to a locale within the historical range of the species where the species has been locally extirpated. This can be a whole population or a group of individuals split from a larger population. "Small" populations should be extracted, by definition (§2.1), and are not considered candidates for reintroduction.

<u>Introduction:</u> Translocation of a "large" or "medium-sized" population to a locale beyond the historical range of the species. This can be a whole population or a group of individuals split from a larger population.

<u>Augmentation:</u> Translocation of an individual or multiple individuals from a single source population (not a whole population) to another population. Mills & Allendorf (1996) note that augmentation should be from high diversity to low diversity; the reverse direction could actually decrease genetic variation. Populations in the center of a species range often retain more genetic variation (Schwartz et al 2002).

<u>Combination:</u> Translocation of a whole population into another population, resulting in the complete loss of unique genetic lineages. Such an irreversible loss highlights the need for caution with this approach.

<u>Extraction</u>: Translocation of individuals from a single wild population to a captive-rearing facility. This is done mainly to rapidly boost population sizes, although can be used as an emergency solution for populations facing impending extirpation. This latter purpose has been the prevailing justification for *Achatinella* species extractions to date.

<u>Low Risk</u>: No foreseeable detriment to the translocated species.

<u>Medium Risk:</u> One of the following criteria: 1) Unknown risk to the focal species (substantiated by relevant literature), 2) Unknown risk to other resident species (substantiated by relevant literature), or 3) Management action involving a blend of 2 untested translocation methods.

<u>High Risk:</u> An inevitable impact to the focal species is outlined; or at least 2 medium-risk criteria are met ("unknown risk to the focal species" can be counted twice if there are 2 clearly different sources of risk).

3.2 Reintroduction

Wild stock: If well-established transportation methods are used (§5.3), and the suitability of the recipient site is clearly supported, risks are considered minimal. ***Low Risk***

Captive stock: This option should not be considered until a captive population reaches 50 individuals (USFWS 1992), and reintroductions should not be used solely as a way to get rid of surplus captive stock (IUCN 1998). Surplus stock should be reintroduced only to meet stated recovery goals, or to experimentally test reintroduction effects so as to improve subsequent reintroductions. A review by Seddon et al (2007), spanning a broad array of both invertebrate and vertebrate taxa, indicated that reintroductions from wild stock are generally more successful that captive-reared individuals. This may stem from any number of causes including adaptation to unnatural captive environments or poor health resulting from pathogens in the captive facility (Cunningham 1996). However, these risks are associated with extraction and not reintroduction, and are intended to point out that wild stocks are preferable to captive stock for reintroductions, when the option is available. ***Low Risk***

3.3 Introduction

Wild Stock: Suitability of habitat outside of a species historical range is questionable, and may pose a risk to the focal species. Furthermore, adverse interactions with other resident species in new locals are also unknown. Introduced animals can serve as disease vector for resident species, or be exposed to new diseases themselves (Cunningham 1996). ***High Risk***

Captive Stock: In addition to the risks associated with introducing wild stock, captive stock can also introduce new diseases to resident species (Cunningham 1996). ***High Risk***

3.4 Augmentation

Wild stock to a wild population:

1) To an immediate neighbor population. An immediate neighbor population is one that has been separated from its origin by a predator-exclusion fence. The formulae to determine the appropriate number of migrants and frequency of release are given by Hall et al. (*in press*), and depend on the population size, dispersal rate (wind exposure), and dimensions of exclosure. ***Low Risk***
2) To a population in the same ESU or GU. The proper number of migrants and frequency of repetition is unknown (see §6.1: Research Needs). ***Medium Risk***
3) To a population in a different ESU or GU. In addition to number 2), there is potential for outbreeding depression under this scenario, whereby the offspring resulting from crossing distant lineages are less fit than either parent. This can occur via the break up of co-adapted gene complexes or as the result of maladapted intermediate phenotypes (Edmands 2007). ***High Risk***

Wild stock to a captive population:

1) To an immediate neighbor population. The number of adults to transfer should represent the emigration rate of the population, applied to the captive population size (see Hall et al. [*in press*] for calculation). The full, wild emigration rate could overwhelm captive capacity. Risks are attributed solely to the uncertainty of extraction (§3.6), a necessary component of this scenario. ***Low to High Risk***
2) To a population in the same ESU or GU. The risks from number 1) apply, and the proper number of migrants and frequency of repetition is unknown (§6.1). ***Medium to High Risk***

3) To a population in a different ESU or GU. In addition to number 2), there is potential for outbreeding depression here, as with wild populations. ***High Risk***

Captive stock to a wild population:

1) To an immediate neighbor population. There is a risk of introducing pathogens to the recipient population by using captive stock. The number and rate of adults to transfer can be approximated by applying emigration rates to the captive population (see Hall et al. [*in press*] for calculation). ***Medium Risk***
2) To a population in the same ESU or GU. In addition to risks from number 1), the proper number of migrants and rate of transfer are unknown. ***High Risk***
3) To a population in a different ESU or GU. In addition to the risks in number 2), there is the added potential for outbreeding depression. ***High Risk***

Captive stock to a captive population:

1) To an immediate neighbor population. Although any potential pathogens might be ubiquitous to the entire captive facility, there is still an unknown risk of spreading pathogens between captive populations. The proper number of migrants and rate of transfer is approximated as in with captive to wild augmentations. ***Medium risk***
2) To a population in the same ESU or GU. In addition to risks from number 1), the proper number of migrants and rate of transfer are unknown. ***High Risk***
3) To a population in a different ESU or GU. In addition to the risks listed in number 2), there is again potential for outbreeding depression. ***High Risk***

3.5 Combination

Wild stock ("defunct" population [§2.1]) to a wild population:

1) To a genetically identical population. Populations of fewer than 5 adults are not likely to recover independently (§2.1) and combination can boost recipient population numbers. ***Low Risk***
2) To a non-identical population in the same ESU or GU. Same as number 1), with added benefit of contributing new alleles to another troubled population. The lineage is likely lost already, so that risk is downplayed under this scenario. ***Low Risk***
3) To a population in a different ESU or GU. Same as number 2), but there is a possibility of outbreeding depression. ***Medium Risk***

Wild stock ("defunct" population) to a captive population:

1) To a genetically identical population. This is the equivalent of extracting a whole population (see §3.6). ***Low to High Risk***
2) To a non-identical population in the same ESU or GU. This involves extraction and combination, although the loss of the lineage is still downplayed for an already "defunct" population. There is added benefit of contributing new alleles to another troubled population; risks are from extraction (§3.6). ***Low to High Risk***
3) To a population in a different ESU or GU. Same as number 2), but there is a possibility of outbreeding depression. ***Medium to High Risk***

Captive stock ("defunct" population) to a wild population:

1) To a genetically identical population. Populations of fewer than 5 adults are not likely to recover independently (§2.1) and combination can boost recipient population numbers. Disease introduction is a concern. ***Medium Risk***

2) To a non-identical population in the same ESU or GU. Same as number 1), with added benefit of contributing new alleles to another troubled population. The lineage is likely lost already, so that risk is downplayed under this scenario. ***Medium Risk***

3) To a population in a different ESU or GU. Same as number 2), but there is a possibility of outbreeding depression. ***High Risk***

Captive stock ("defunct" population) to a captive population:

1) To a genetically identical population. Although any potential pathogens might be ubiquitous to the entire captive facility, there is still an unknown risk of spreading pathogens between captive populations. ***Medium Risk***

2) To a non-identical population in the same ESU or GU. Same as number 1), plus the lineage is likely lost already, so that risk is downplayed under this scenario. There is also added benefit of contributing new alleles to another troubled population. ***Medium Risk***

3) To a population in a different ESU or GU. Same as number 2), but there is a possibility of outbreeding depression. ***High Risk***

Combinations of 2 genetically identical "recoverable" (§2.1) populations:

1) Wild stock to a wild population. The ability of the destination habitat to support a large jump in population number is questionable. ***Medium Risk***
2) Wild stock to a captive population. The risks under this scenario are primarily from extraction (§3.6). ***Low to High Risk***
3) Captive stock to a wild population. In addition to the risks from number 1), there is the added risk of disease transmission. ***High Risk***
4) Captive stock to a captive population. Several "medium-sized" (§2.1) populations should be maintained in isolation (minimum size of 25 individuals, maintain F = 0.25), as opposed to a single larger population (Margan et al. 1998). These lines can then be crossed prior to reintroduction to provide the founder population with maximum genetic diversity. Disease transfer is also a concern. ***High Risk***

Combinations of 2 genetically non-identical "recoverable" (§2.1) populations: This will result in the complete loss of a unique lineage, which goes against the key goal of this document. By definition, populations of this size can be managed independently in the wild or in captivity. This is a clearly defined cost for the species. High Risk

3.6 Extraction

Species known to do well in captivity: Some species have done incredibly well in captivity, including a population of *A. lila* that has increased from 6 individuals to 600+ in the span of a decade. When fewer than 20 adults remain, the entire population should be captured and brought into captivity (Tenhumberg et al 2004). If there are more than 20, up to 20% should be extracted (minimum of 5 adults). There are minor risks of population loss due to equipment failure, but automated dialing systems are in place to alert caretakers if such failure occurs. In addition, most populations are divided into multiple terrariums in different incubators to further minimize this risk. ***Low Risk***

Species known to do poorly in captivity: This technique has been invaluable to preserving many species lineages that are now extirpated in the wild. However, while some *Achatinella* species have rapidly increased in number via captive propagation, others have gradually declined for unknown reasons. There is subsequently reason to doubt the viability of any offspring upon reintroduction. ***High Risk***

Species known to remain constant in captivity or with unknown captive prognosis: Facing heavy pressure in the wild could justify extraction (following the guidelines of species that do well in captivity), even if rapid population growth is unlikely. For species whose future in captivity cannot be predicted, the risk of doing poorly applies. Shabalina et al. (1997) noted that beneficial fitness traits in fruit flies can disappear as fast as 2% per generation under relaxed selection in captive conditions, and similar rates in excess of 40% have recorded in fish (Araki et al 2007). Studies on mice (e.g. Jiminez et al. 1994) have even shown that while deleterious inbreeding effects may not be noticeable in benign lab environments, the reduction in survival can be quite severe upon reintroduction to a harsher, natural environment. ***Medium Risk***

4. RECOMMENDATIONS

In general, none of the translocation techniques mentioned should be considered unless the population's destination location is a captive breeding facility or predator-proof exclosure with species-specific habitat. Not only does this allow for an increase in the chances of success, but also allows for an ease of monitoring to assess the effectiveness of these untested methods. Snails can scatter widely when placed in a new environment. Any wild releases of snails should occur during winter months with frequent rainfall (USFWS 1992). All individuals translocated should be adults, which should be marked with individual codes (see §A2) and transported according to protocols provided in §5.3. In addition, at least 10 snails from each population involved in a translocation should have already been sampled for DNA and analyzed (as outlined in §5.2).

4.1 Priority Actions

Level-1 priorities: These are critical activities, which are preferentially fulfilled by low-risk options when possible. Medium-risk options should be considered in the absence of low-risk possibilities, followed by high-risk alternatives as a last resort. These latter options will require additional planning (§5.1). Examples of fulfilling Level-1 priorities are given in §§4.2-4.4. Priority-determinations reflect the limited amount of resources that must be divided amongst all management actions.

1) Designate 6 primary populations for all species (as defined in §1.3), using the best available genetic data.
2) Establish new primary populations if fewer than 6 exist, preceded by the necessary predator exclosures/captive facilities to protect them.
3) Secure (with a predator-exclosure or captive breeding) any population that is the sole representative of a GU or ESU.

Level-2 priorities: The activities are of intermediate importance, and should be fulfilled using only low-risk options after Level 1 priorities have been initiated to the fullest extent possible. Medium-risk options may be considered after low-risk options are exhausted.

1) Designate secondary populations for each primary population.
2) Establish a secondary population for any population that is the sole representative of a GU or ESU.
3) Survey areas with recent (last 10 years) snail sightings that may provide an under-represented GU or ESU primary population; this may shift other populations' priority ratings.

Level-3 priorities: These activities are the least critical, and should be fulfilled on an opportunistic basis using only low-risk options.

1) Employ some form of translocation with all populations that show signs of excessive inbreeding. This can be determined genetically by comparing a population's inbreeding

coefficient with earlier samples from the same population (see §5.2) or through comparison with other populations in the same ESU or GU.

2) Survey existing tertiary populations.
3) Search for and establish new tertiary populations.

4.2 Level-1 Recommendation Example: *Achatinella decipiens*

Based on current designations (§2.2), top priority should be to intensely survey the 4 primary populations to obtain accurate abundance estimates (§A2). The GU represented by a single population should be extracted (in its entirety if < 20 adults remain) or secured with a predator exclosure. Any other "small" (§2.1) population discovered should be extracted in its entirety, while 20% should be removed from "medium-sized" (§2.1) populations to establish more primary or secondary populations (5 snails minimum, no action if removal lowers source population status to "small").

There are 3 out of 5 known GUs represented by the 4 primary population designations. Two more primary populations are needed, and would be most desired from the 2 other GUs. High priority should be given for a final search in these GUs because of recent snail sightings; any "small" population discovered will be temporarily extracted and later found a primary population. If all of the individuals within a GU can only meet the definition of a "small" (§2.1) population by being counted together, but no single source population exceeds 5 adults, extraction and combination should be initiated to create a primary population. If fewer than 5 adults remain in the GU, individuals should be considered for augmenting a neighboring GU; the potential benefit of salvaging a lineage outweighs outbreeding risks (§3.4).

4.3 Level-1 Recommendation Example: *Achatinella lila*

Primary populations are designated in §2.3, and top priority should be given to obtaining accurate abundance estimates for all 3 primary populations (§A2). The 2 GUs represented by single populations should be extracted (in their entirety if < 20 adults remain) or secured with a predator exclosure. The other GU has already been extracted to found a successful captive stock, and the wild source still persists as a "small" (§2.1) population. This wild population should also be extracted because population sizes increase faster in captivity. The numerous captive descendants of this source population should reintroduced to achieve the minimum of 6 primary populations.

4.4 Level-1 Recommendation Example: *Achatinella sowerbyana*

A total of 6 wild primary populations have already been designated for this relatively abundant species, and abundance levels should be confirmed (§A2). The GU represented by a single primary population should be secured with a predator exclosure, rather than extracted. This species has not reproduced well in captivity, so further use of extraction with this species should be only to protect against imminent extirpation. The GU represented solely by a captive population should receive priority for a predator exclosure, followed by a reintroduction. Another primary population is not required, but it would be desirable to re-assign a primary designation to under-represented GUs if possible.

5. PRE-TRANSLOCATION PLANNING

5.1 Expert Coordination

For low-risk options, the permit holder can carry out actions as needed, and must alert all relevant contacts (Table 1) after doing so. This alert must include a detailed description of the activity as well as a reasonable justification for the action. Failure to do so may result in revocation of the relevant permits. Medium-risk options require that a 6-week notice be given to all relevant contacts, again with details and justification. USFWS and DOFAW must give approval of medium-risk actions, and can request a meeting or additional information prior to approval. High-risk options require a meeting and thorough review by all contacts, and must also receive approval.

Affiliation	Contacts	Phone	Email
Army Natural Resources	Kawelo, Kapua	656-7641	kawelok@schofield.army.mil
Army Natural Resources	Costello, Vince	656-8341	costellv@schofield.army.mil
Army Natural Resources	Rohrer, Joby	656-8341	rohrerjl@schofield.army.mil
DOFAW Invertebrate permits	Gagne, Betsy	587-0063	betsy.h.gagne@hawaii.gov
DOFAW, O‘ahu NARS Manager	Liesemeyer, Brent	973-9783	brent.r.liesemeyer@hawaii.gov
UH Snail Lab Manager	Holland, Brenden	956-6176	bholland@hawaii.edu
University of Hawaii	Hadfield, Michael	539-7319	hadfield@hawaii.edu
USFWS, Species Lead	Browning, Joy	792-9400	Joy_Hiromasa@fws.gov
USFWS, Permitting	Nelson, Jay	792-9400	Jay_Nelson@fws.gov
USFWS, Science Advisor	Miller, Steve	792-9400	Stephen_E_Miller@fws.gov

Table 1. List of all parties to be contacted when translocation activities are conducted.

5.2 Genetic Data

At least 10 biopsied tissue samples from any populations being considered for translocation (both source and recipient populations) should first be analyzed following the methods of Holland et al (*in prep*), to determine their relationships to other populations using cytochrome oxidase I and microsatellites markers. Microsatellite data can then be used to assess the relative degree of inbreeding. In addition, this initial sample will serve as a baseline level of inbreeding to compare with future time intervals and other populations of the species.

Preliminary studies (Hall and Hadfield *in review*) have suggested that inbreeding levels can increase significantly in just ten years (~2 generations), even for populations in excess of 20 adults. For this reason, it is recommended that 10 additional samples be collected from each primary population every 5 years to monitor inbreeding. These additional samples may change the priority level of a population (§4.1), and allow researchers to assess the genetic effects of any conservation interventions.

5.3 Transporting Snails

It is important to make proper arrangements for the transport and release of translocated snails. While in transit, snails should be placed in containers with hard exteriors and a mesh-screen lid (for ventilation). Host-plant foliage (from snail's current tree) should be provided in containers for support and food, and a temperature below 80°F should be maintained. At the release site, snails should be placed into small, screened baskets hung from host trees, and leaves from the tree should be placed inside and moistened. Active snails can be released directly onto the host plant.

5.4 Evaluation and Monitoring

Initial monitoring: The first applications of new translocation techniques will be preceded by a full population count (§A2) and monitored daily for 1 week (USFWS 1992), then weekly for 1 month. If no unanticipated results are noted following 4 consecutive weeks, a quarterly schedule will be initiated. After 1 year, any translocated population will be monitored according to primary-level protocols (§A2).

Survival: With primary-level monitoring, 3 abundance estimates will be available after 1 year (6-month intervals). Ground shell surveys must also be conducted for translocated populations at these intervals (10 minutes search-time per quadrat [§A2]). Mortality trends should be carefully analyzed to assess initial success of the translocation, and management plans adapted accordingly.

Long-term success: To gauge success of a method, population trend analyses should be analyzed annually. Populations will be considered "recovering" if they exhibit an overall positive growth rate for 3 consecutive years, which will give confidence to the particular method employed and possibly lower its associated risk levels.

Revision to guidelines: Every 3 years, this document should be revised and updated to reflect new data and realities. Following initiation of any medium-risk population admixture scenarios (§§3.4-3.5), this timeframe should allow for any potential outbreeding depression effects to become apparent (Edmands 2007). Such methods should not be employed elsewhere until the 10-year evaluation has proven their merits.

6. RESEARCH NEEDS

6.1 Augmentation Intensity

The appropriate number of individuals for an initial augmentation is still unknown, with the exception of immediate neighbor populations (§3.4). The most widely used strategy is the one-migrant-per-generation rule (OMPG, Mills and Allendorf 1996), which has been interpreted literally in some USFWS recovery plans (USFWS 1988, 1993a, 1993b). Mills and Allendorf (1996) stress, however, that the true optimal number of migrants might be as high as 10 per generation. Daniels et al. (2000) found that for woodpeckers this number should be at least 4, although just a single migrant might be capable of recovering some inbred populations (Vilá et al 2003). A modified application of the OMPG rule was recommended in recovering the critically endangered Florida Panther, whereby one additional breeder would follow annually after a first generation of much higher gene flow to purge deleterious alleles from the population (Hedrick 1995). A range of initial augmentation levels should be tested experimentally, if possible.

Following an initial augmentation or reintroduction, Tenhumberg et al (2004) recommend releasing individuals over consecutive years to reduce any stochastic effects that may reduce success in poor-weather years. For augmentations, this would likely need to be a similar number of individuals as the initial augmentation so that the effects of that intensity level could be analyzed over time. For reintroductions, a range of between 1 and 10 individuals per generation is likely appropriate (see above), although this should also be determined using PVA (next section) whenever possible.

6.2 Population Viability Analysis (PVA)

Currently, population data are limiting or lacking. Therefore this report utilizes incredibly sparse information to determine the minimum number of individuals to found a captive or lab population. With PVA, it is possible to obtain a more accurate estimate of these numbers based on the demographic characteristics of the population (Bustamante 1998). To begin a PVA, observation-based estimates including survival, reproduction, and dispersal rates (all of which have already been obtained for some *Achatinella* species) are input into software packages such as VORTEX (Lindenmayer and Lacy 1995). These programs then simulate probabilities of extinction at specified future time intervals under various starting conditions (e.g., the number of individuals being used to found a population).

It may also be possible with PVA to determine the optimal number and source of migrants for augmentations, which is a major knowledge gap (§6.1). Lindemayer and Lacy (1995) note that measures such as gene diversity can be calculated for a hypothetical combined population, which then allows for an estimate of effective population size. PVA analyses can then be run to determine the probability of extinction before that particular augmentation level is approved, which could be invaluable in helping conservation managers choose between different courses of action.

Lastly, the stabilization target goal of 300 individuals is based on a single, randomly defined population (Hadfield et al 1993). A more accurate estimate of minimum viable population (MVP) size can be estimated using PVA. It should be noted that "viable", when referring to MVP, differs in meaning from other definitions in the literature. In PVA simulations, MVP is the minimum population size that will persist in the wild for 100+ years with at least 90% probability, accounting for genetic and environmental stochasticity. Traill et al (2007) show that across a broad spectrum of animal and plant taxa, the lowest MVP numbers were at least in the thousands of individuals. MVP estimates can also help determine the minimum population size above which a population can be harvested as a source population for reintroductions.

6.3 Potential Experiment

One *Achatinella* species is particularly well suited for furthering knowledge of translocation through experimentation, as recommended by Seddon et al (2007). *Achatinella lila* has been bred in captivity for over a decade, and a single source population of 6 individuals has exploded into over 600 individuals in the lab. This is well in excess of the 50-individual threshold established by USFWS (1992) for considering the reintroduction of a captive population. In the sprit of scientific investigation, it would be desirable to reintroduce snails from this captive population alongside a comparable reintroduction with snails translocated from genetically similar wild stock (control population).

It would be desirable to reintroduce several populations of varying sizes from this single captive stock to determine a minimum population size for a successful reintroduction. A side-by-side release of two different species could also shed light on the general effects of captivity. Regardless of the reintroduction parameters to be tested (minimum population size, captive vs. wild, geographic origin, etc.), experimental translocations should be conducted within protected exclosures in order to monitor the results of such experiments.

Two possible experimental designs are shown in Figure 1 for *Achatinella lila*, which are intended to simultaneously test several aspects of translocation and achieve specified management goals. As of this writing, there are three primary populations *Achatinella lila* representing all three GUs (§4.3). In accordance with the goals outlined in §1.3, three more primary populations should be established to meet the minimum of six. Both experimental designs would fulfill this goal as well as create one secondary population. The first design (left panel) would test the effects of captivity and optimal size of founder populations. The second design (right panel) would also test captivity effects and founder population size (to a lesser degree), as well as species differences.

Figure 1. Two possible experimental designs for *Achatinella lila* reintroduction. Outside and inside edges represent predator-proof exclosure fencing to prevent total loss in the event of a predator breaching any one quadrant. If the high cost of predator exclusion fencing precludes its use for all edges, inside edges may only represent barriers to *A. lila* dispersal. All stock of *A. lila* are from the same source population, and 10 wild adults may represent the entire remnant population. Wild stocks of *A. sowerbyana* are from the same geographic source as the *A. lila* stock, where the species live sympatrically. Captive *A. sowerbyana* are from a neighboring GU with 3 primary populations (see **§2.4**). This population is not performing well in captivity and is also well suited for reintroduction.

10 *A. lila* ALL WILD-STOCK	10 *A. lila* ALL CAPTIVE-STOCK
50 *A. lila* ALL CAPTIVE-STOCK	100 *A. lila* ALL CAPTIVE-STOCK

A. lila + 10 *A. sowerbyana* ALL CAPTIVE-STOCK	10 *A. lila* + 10 *A. sowerbyana* ALL WILD-STOCK
20 *A. lila* ALL CAPTIVE-STOCK	50 *A. lila* ALL CAPTIVE-STOCK

6.4 Climate Change Threats

If a species' historical range is no longer deemed adequate for persistence in the face of climate change, similar habitat elsewhere may be considered for introductions as a last resort (IUCN 1998). Such assisted colonization may be the only reasonable alternative for saving some imperiled species (Hoegh-Guldberg et al 2008). Extinctions from recent climate change have already been documented, and range-restricted mountaintop species such as the tree snails are the most vulnerable to climate extinction (Parmesan 2006).

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APPENDIX: MONITORING PROTOCOLS

A1. Summary

The level of monitoring required for each field population depends on its designation as a primary, secondary, or tertiary population. Primary populations are of highest priority for achieving stabilization, and thus require the most intensive monitoring (§A2). Accurate data on snail abundance must be obtained at regular intervals so that any changes in abundance can be addressed (e.g., extraction necessary). Secondary populations require an intermediate level of monitoring (§A3) to maintain their role as a safety net, should a primary population experience a catastrophic decline. Single-survey abundance estimates at less frequent (but regular) intervals will suffice for these purposes. Tertiary populations require a minimal amount of monitoring (§A4), limited to opportunistic surveys to determine presence/absence. This appendix will not address monitoring protocols for captive populations (which may be primary or secondary populations); those are discussed in Hadfield et al. (2004).

A2. Primary Populations

Field Site Delineation:

One must first delineate artificial boundaries for the population in the field, ensuring consistency between surveys and at least some level of comparability among abundance estimates. This process is best done with a team of surveyors over two full days prior to being geo-referenced, as follows:

1) Several experienced field biologists survey a known snail locale for a half-day.
2) Each surveyor has a unique color of flagging tape with which to mark trees with snails in them, and a unique code is written on each flag.
3) Information is recorded for each flagged tree regarding snail abundance, and each surveyor records relative tree locations with a basic illustration.
4) Surveyors combine information to determine areas of high density, and then spend the second half-day searching un-flagged trees in the vicinity of high-density areas.

5) On the 2nd day, site boundaries are agreed upon which include a majority of trees with recorded snail presence, and a buffer zone to include some emigration on subsequent surveys. Site dimensions should not be narrow at any point to reduce the chance of emigration bias between surveys. Sites must also be small enough to be sufficiently searched (see next section) by 4 people in one day
6) Perpendicular rows of transects are then delineated with field markings to create a grid of discernable 5m x 5m squares within the site's boundaries.
7) Lastly, the grid is mapped to show the layout of flagged trees, which are given permanent unique markings in the field and corresponding codes on the map.

Capture-Mark-Recapture:

The type of markings given to a snail depends on the survey type (see next section). The most informative markings will come from populations where individuals are assigned a unique and permanent alphanumeric code upon first capture, and individuals can be identified on subsequent surveys. This method is called the "glue method" and is superior to the "paint method", both of which are described below and summarized in Table A1.

Table A1. Comparisons of different marking types

Type of marking	Advantages	Disadvantages
Glue method	Durability, additional data available	Time Consuming, training required, more snail handling
6.1.1.1.1 Paint method	No training required, limited handling, fast	Mark deterioration, precludes long-term analyses

With the glue method, the type of shell marking a snail receives at first capture is determined by its size. Snails with shells over 7 mm in length are marked using letters and numbers printed on 2 paper punch-outs. Six-point font characters are printed onto waterproof paper (Rite-In-The-Rain), and cut out with a leather punch. It is preferable to use 2 separate punch-outs rather than a single punch-out with both characters on it, for 3 reasons: 1) many tags are often lost via wind gusts prior to application, which leads to erratic numbering, 2) a larger size punch-out is needed to fit 2 characters on it -that is less flush with the shell- leaving more of the rigid tag's underside exposed to deterioration, and 3) with 2 separate tags, loss of one tag allows for an estimate of tag-loss rate rather than mistaking all unmarked snails as "new".

In the field, the snail's shell is gently dried and cleaned, and then a small drop of cyanoacrylic glue (Satellite City 'Super T') is applied to it. The 2 punch-outs are then placed onto the glue, followed by another drop of the transparent glue to protect the marks from deterioration. When the glue dries, the snail is returned to its capture location. Snails less than 7 mm in length receive small circular dots using paint pens. These different colored paint dots must uniquely identify individuals in the field until they grow large enough to receive the paper marks, which can take up to one year. For a further description of marking techniques, see Hall et al (*in press*).

With the "paint method", all snails captured on a single day are marked with a single color of paint pen. These marks wear down substantially over the course of a year, and new marks of a different color can be applied on a subsequent survey. This generic coding scheme precludes the use of more sophisticated analyses to estimate survival rates and other demographic parameters, which can be obtained using the glue method. Abundance measures can still be obtained with both methods.

Survey Type:

The methods outlined in this section will be strictly aimed at determining abundance. Some methods will have the potential to estimate additional parameters such as survival, growth rate, and emigration, with some additional effort. These modifications are described in the next section. For all survey types, the location of all snails will be recorded on every survey. Unmarked snails will be marked and measured (shell length and width). Previously marked snails will be recorded, and length taken unless growth rates are known (see next section).

To determine abundance, the following site-specific methods must be completed in the exact same manner on at least 2 consecutive occasions in order to estimate abundance using the Lincoln-Peterson estimator (Chao and Huggins 2005). This method assumes that all marked individuals have a chance to randomly re-mix into the population prior to being surveyed again. In areas with low vegetation, this can happen in as little as 1 day (Hall and Hadfield 2009). However, in areas with taller vegetation, up to 1 month may be necessary to be confident that the population has re-mixed. Because the method also assumes no birth, death, emigration or immigration occur between intervals, in no circumstances should this interval be longer than 1 month (see Hadfield et al 1993).

The type of surveying method will depend on the habitat; some methods have been designed here exclusively to minimize impact to certain tree-snail habitat types. Sites are characterized as to whether they have an understory that is sensitive to trampling, and by the difficulty of the terrain to survey (e.g., steepness). This results in 4 permutations with which to classify a site. These permutations are outlined in Table A2, along with corresponding management recommendations that are described below.

Table A2. Snail site classification scheme and associated management recommendations

6.1.2 Understory	*6.1.2.1 Terrain*	*6.1.2.2 Surveying* *6.1.2.3 Recommendations*	*6.1.2.4 Marking Method*
Absent	Easy	2 survey days, full site survey	Glue
Absent	Difficult	3 survey days, full site survey	Glue
Present	Easy	2 survey days, random quadrat surveys	Paint
Present	Difficult	3 survey days, random quadrat surveys	Paint

For a site where trampling of the understory is not a concern, roughly 10-15 minutes of search time should be devoted to each quadrat. This should take a half-day to complete for sites between 500 and $1000m^2$ in area, and is best done with 4 observers dividing a site into 4 transects of quadrats (and at least 1 other person marking and releasing snails). The number of observers can be adjusted for sites with larger or smaller areas. For the second half of the day, the surveyor with the most recorded snails will then survey the transect of the observer with the fewest number of snails, and vice versa. The other two surveyors will also switch transects. This is to homogenize recapture rates at the site for a given day, so as not to violate a key Lincoln-Peterson estimator assumption. All unique captures for that day are compiled, and the same process is repeated the next day with the same surveyors doing the same transects. The "glue method" of marking should be used so that the maximum amount of data can be extracted from surveying efforts.

At sites with a substantial understory presence, fully surveying a site would cause excessive impact. For these sites, a random quadrat is selected and surveyed by all surveyors for 10-15 minutes total. The number of unique individuals is tallied, and then another random quadrat is surveyed. This iterative process continues until an adequate number of snails has been surveyed. To decide an adequate number of snails, a rough estimate of the population size is needed first (based on single day surveys, §A3).

Generally, an adequate sample size is between ¼ and ½ of the rough estimate and can be determined using tables in Robson and Reiger (1964). A few examples using 4 typical *Achatinella* species population sizes are provided in Table A3. Surveying ceases when an adequate sample size has been reached, and the exact same quadrats are surveyed on the following sampling occasion.

The "paint method" of marking is used only with understory-sensitive sites, since not surveying the whole site precludes analyses of variables other than abundance. A single color of paint pen is used by all surveyors to tally the number of unique snails on the first survey, and the process is repeated on the following survey with a different color. This 2nd marking is only to prevent a snail from the 1st day from being counted as recaptured more than once. Abundance is estimated as normal with the Lincoln-Peterson estimator, and then divided by the combined area of the quadrats surveyed. Finally, this density is multiplied by the area of the site to obtain an abundance estimate for that site.

Table A3. Minimum sample size needed using the random-quadrat method; examples are provided for range of population sizes that are typical of *Achatinella* species.

6.1.3 Rough Estimate of Population Size	*6.1.3.1 Snails Needed Each Day*
40	20
80	40
120	45
400	110

For sites with terrain that is easy to survey, only the minimum number (2) of survey days is required to achieve a reasonable rate of recapturing snails. Difficult terrain reduces this rate, and thus additional data are needed. Adding a 3rd consecutive survey occasion adequately accomplishes this goal (K. Hall, unpubl. data). Instead of using the Lincoln-Peterson estimator, multiple-recapture surveys require using the Schnabel method (Chao and Huggins 2005). Recommendations by site-type are summarized in Table A2.

Survey Intervals:

Primary sites need to be monitored at 6-month intervals to prevent emigration from influencing changes in abundance. If abundance drops are noted following analysis, an additional survey should be completed as soon as possible to determine the cause. This survey will be a combination of ground-shell surveys to rule out mortality, and surveys of the area around the site to rule out emigration. Site delineations and management should be adjusted accordingly. Great care should be taken to conduct all surveys at the same time of day to keep recapture probabilities constant (see Hall et al *in press*).

Sites where the "glue method" has been used can be further surveyed to obtain survival, emigration, and other important demographic estimates. This requires intensive monthly surveys of a high-density quadrat as in Hadfield et al (1993) to determine growth rates for 1 year. These data will be used to assign snails to different age-classes at every survey interval, even if not captured. Such data are necessary, as recapture probabilities and survival are known to vary with age (Hall et al *in press*). Program MARK (White and Burnham 1999) can then be used to obtain simultaneous estimates of all parameters of interest using likelihood-based model ranking.

A3. Secondary Populations

These populations require substantially less effort to monitor because of their lower priority level. For the initial survey, at least two surveyors search a known snail locale for several hours (day or night). The number of individual snails and search effort are recorded, along with shell measurements and any other pertinent data (e.g., weather observations). All trees with snails in them are then flagged with a blue and orange flagging combination for ease of relocation, the standard color scheme used by U.S. Army Environmental on Oʻahu.

Subsequent surveys must be done annually to ensure that such populations are still of sufficient size to fulfill their role as a safety net for primary populations. As with primary population surveys, effort should be made to keep search efforts consistent. However, due to the lack of rigor with these surveys (undefined population boundaries, inconsistent effort throughout site), it is not possible to analyze the population size trends over time. If such data are desired, the methods of §A2 must be used.

A4. Tertiary Populations

Tertiary populations need only have presence/absence data taken (although additional information is surely warranted when possible). These surveys should be done when time permits, and records should be available to all interested parties in an annual inventory of all populations. At a minimum, these populations should be surveyed every 5 years to determine their ability to serve as secondary populations if needed. As with secondary populations, analyses of population trends are precluded due to sparse data.

A5. Field equipment checklist (primary population surveys)

For each fieldworker

1) Relevant site maps
2) Notebooks
3) Snail collection containers (petri dishes)
4) Calipers for measurements
5) Orange and blue flagging tape
6) Watch or timer
7) Pens/Pencils/Markers

For the survey team:

1) Paper punch-outs (glue-method sites only)
2) Fine-point tweezers
3) Satellite city “super T” glue
4) Glue remover
5) Permanent tree tags
6) Paint pens of various colors

APPENDIX 6 CHAPTER 6 APPENDICES

Appendix 6 contains supplemental information for Chapter 6. Contents of Appendix 6 include:

- Appendix 6-1: Invasive Ant Monitoring Protocol
- Appendix 6-2: New Zealand Department of Conservation: Current Best Practices for Kill Trapping of Rats

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APPENDIX 6-1: INVASIVE ANT MONITORING PROTOCOL

Index cards (3 X 5 inches) containing SPAM, peanut butter and honey will be spaced along the edges of, or throughout, the area to be sampled. Each card will be placed so that it is halfway out of a ziplock "sandwich" bag. This maximizes your chances of capturing all ants present on the index card. Make sure all cards are separated by at least 15 meters. Only a small amount of each type of bait is necessary for each card. A minimum of 10 bait cards will be deployed at each site. Label each card with date, location, card # and collector name prior to placing cards in sampling areas. Target areas of increased human activity such as trails, campgrounds and picnic areas when possible. Always place cards in the shade. Deploy cards no earlier than 8:00 am in the morning and avoid sampling on rainy, blustery or cold days as both rain and low temperatures reduce ant activity. Should foraging ants be seen in the area prior to bait deployment, conditions are likely fine for sampling. Leave baits out for at least 1 hour. Pick up baits rapidly by slipping the card into its accompanying ziplock and immediately closing the ziplock. Make sure the bag is completely closed or you will have ants exploring your backpack. Place the bags in freezer for latter identification.

(With input from S. Plentovich and P. Krushelnycky (University of Hawaii at Manoa))

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<u>**APPENDIX 6-2: NEW ZEALAND DEPARTMENT OF CONSERVATION: CURRENT BEST PRACTICES FOR KILL TRAPPING OF RATS**</u>

KILL TRAPPING FOR RAT CONTROL

TECHNIQUE

Trap station layout

- Spacing no greater than 100x50m apart with perimeter traps 25m apart. In high density rat areas, the internal spacing of traps should be 100x25m.

  There should be at <u>least</u> one trap station within each rat's home range. Home ranges are generally reported by length. Ship rats have an average range length of 100-200m during the breeding season. Non-breeding ship rats have larger home ranges [1]. Norway rat home ranges are between 218-916m in length [2].

  At high rat densities, trap spacing may have to be reduced further to maximise capture rates.

- Laid out on grids by compass bearing or, in rough terrain, placed on ridges and spurs with additional lines located on 100 m contours using an altimeter. Spacing should be established as precisely as possible using compass and hip chain.

  Inaccurate location of lines will cause gaps in coverage where pockets of high rat numbers can persist.

- A good track infrastructure is important and each trap station numbered for ease of relocation and data collection.

  Reduces the risk of missing a trap during checking and allows capture data to be related to each trap site.

Timing of operations

- Timing is critical and depends on what is being protected.

  For ongoing ecosystem management, timing should be related to rat tracking indices and the vulnerable periods of those components in the system you are endeavouring to protect.

  For species protection, timing is dependant on when the species being protected is most vulnerable. E.g. To protect robins during the breeding season, rat indices must be low while the robins are on the nest until the chicks fledge. To protect invertebrates and skinks, rats should be controlled year round [1]

Effective use of traps

- Initially traps should be checked every 1-2 days. Once knockdown is achieved, as indicated by low catch rate and verified by tracking tunnel data (usually about 10-20 checks), traps only need to be checked once every 2-3 weeks. When rat numbers increase, trap checking frequency also needs to increase. Note: timing of checks will depend on.

  Traps need to be cleared regularly - frequency is dependant on site factors (e.g. area under protection and productivity) and the density of rodents present. A trap with a dead rat in it is not available to catch others.

EQUIPMENT

Trap type

Key elements are: catch effectively, kill humanely, easy to use and maintain, light weight, portable and cheap.

- Victor professional snapback is recommended.

  This trap has passed the National Animal Welfare Advisory Committee (NAWAC) kill trap guidelines (on Norway rats).

- DOC 150 & 200 have also passed the NAWAC guidelines and are suitable where mustelids are also being targeted.

Maintenance of traps

New Traps

- Standard Victor professional snapback traps should be treated with a preserving agent (e.g. paint or fence stain) as the wooden base is not treated.

  This will lengthen the life of the trap.

Traps in Use

- Should be cleaned regularly with a wire brush.

  Removes mould, fur and bits of dead animals and allows for identifying what has escaped from an empty sprung trap.

- Regular maintenance is essential, including checking for worn pivots, weakened springs & broken trigger mechanisms.
- When checking Victor snapback traps the trapper should carry spare traps, treadles and pegs.

  Treadles may be lost when the traps are sprung.

Tunnel/Cover

Kill traps must be set in a tunnel or under a cover. The tunnel has three functions: i) orientate the animal relative to the trap, ii) disguise and protect the trap and iii) keep out non-target species [3]. It must have the following:

- Minimum of 400mm long., width 105mm if using 'victor professional'

  Space for trap and prevent non-target animals (e.g. weka) accessing the trap.

- Single entry.

  Rats have access to right end of trap.

- Entry hole of 45mm x 45mm

  A larger entry hole will not exclude non-targets like weka.

- Easy access to check traps.
- Ability to fix to ground with a wire hoop.

  Prevent traps being disturbed by pigs and possums.

- Traps should be kept off ground.

  Keeps trap dryer, extends life of trap.

- Fully enclose the trap, *so the trap cannot be dragged out of the cover.*
- Stable, *so the trap doesn't move until triggered.*

Specification for tunnel/cover designs that meet these requirements are located at:

- docdm-103712 (Victor snap trap);
- docdm-29856 (DOC150); and
- docdm-29855 (DOC 200).

Bait and lures

Key elements are high palatability, field life aligned with the frequency of field checking, doesn't attract non-targets, easy to use and cheap.

- Suitable baits include chunky peanut butter, peanut butter mixed with rolled oats, white chocolate and Connovations margarine based prefeed.

  Peanut butter lasts 5-7 days in Te Urewera, peanut butter/rolled oats mix lasts up to 14 days at Rotoiti Mainland Island and white chocolate last up to 5 weeks in Te Urewera.

SKILLS REQUIRED

- Programme managers/Project managers need a good working knowledge of rat ecology and the prey ecology to manage operations effectively.
- Specific on job training of trappers in the use of rat traps and tunnel/covers is recommended.
- Trappers need sound bush navigational skills involving compass and map reading, and training in the relevant animal pest SOPs.

STANDARDS

Animal Welfare Act 1999

- Under the Animal Welfare Act 1999, the NAWAC developed draft guidelines for testing kill traps. It is recommended that only traps that have passed the NAWAC guidelines are used, because other traps that have not passed may be prohibited or restricted [4].

Health and Safety

- Health and safety resources http://docintranet/content/hro/healthsafety/healthsafety.htm
- See Risk Manager for examples of a safety plans.

Animal Pest Management SOP's

- Animal Pest SOP checklist HAMRO-83484

SUSTAINING CONTROL OVER THE LONG TERM

- Monitoring conservation outcomes is essential to judge effectiveness of the control programme.

  Control operations are useless unless outcomes are achieved.

- Rat tracking tunnels should be run concurrently with the trapping operation.

  To identify activity of animals not being trapped.

- Baits/lures may need to be alternated over the duration of control programmes.
- Good data collection helps operations to be more effective and efficient over the long term. What is recorded depends on what the project wants to know.

LIMITATIONS

- Constant re-invasion and rapid breeding means effective long term control must be ongoing.

  Rat numbers are likely to return to pre-control densities within weeks or months after control stops [1].

- Pig and possum interference with covers can be a problem.

- In beech forests during years with high mouse numbers, mice can make up the majority of captures. This severely reduces the number of traps available for rat control.
- No long life baits available, limiting the length of time between checks.
- High rat numbers can make initial knock down of the population difficult. More frequent checks have been shown to obtain rapid reduction in numbers.
- In years of very high rat numbers trapping may fail to achieve operational targets, so a toxin should be used to achieve an initial knockdown in rat numbers before trapping a starts.
- The technique is not good as an annual knockdown tool; it is better suited for maintaining rats at low densities.
- Mouse numbers may increase after rat control.
- Mice taking bait can severely reduce the effectiveness of traps

UNDER DEVELOPMENT

- Different cover designs to further reducing non-target captures (Lindsay Wilson – Opotiki AO, and Matt Maitland – St Arnaud AO).
- Alternative baits and long life baits (Lindsay Wilson and Matt Maitland)
- Periodic use of toxins in conjunction with trapping regime is being evaluated at Te Urewera national Park (Lindsay Wilson)

INFORMATION

DOC contacts

Trapping

- Your conservancy TSO.
- Darren Peters, Pest Section, Research, Development & Improvement Division, Wellington VPN 8256
- Ian McFadden, Pest Section, Research, Development & Improvement Division, Wellington VPN 8348

Rat ecology

- Craig Gillies, Scientific Officer Research, Development & Improvement, Hamilton VPN 6127
- Elaine Murphy, Research, Development & Improvement, Christchurch VPN 5413

Biodiversity Training Programme - Animal Pest Management Course

- Dale Williams, Programme Manager, Ecological Management Skills, R, D & I, Wellington, VPN 8218.
- Suzy Randall, Programme Manager, Ecological Management Skills, R, D & I, Wellington, VPN 8246.

Predator Dogs

- Scott Theobald, Ranger, Dogs for Conservation, Trounson Kauri Park, VPN 7381

Recommended reading

- Innes, J. G. 2005. Norway rat. *In* C. M. King (Ed.) The Handbook of New Zealand Mammals, 2nd edition. pp. 174-187. Oxford University Press, Melbourne.
- Innes, J. G. 2005. Ship rat. *In* C. M. King (Ed.) The Handbook of New Zealand Mammals, 2nd edition. pp. 187-203. Oxford University Press, Melbourne.

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1. Innes, J. G. 2005. Ship rat. Pages 187-203 *in* King, C. M., editor. *The Handbook of New Zealand Mammals*. Oxford University Press, Melbourne.

2. Innes, J. G. 2005. Norway rat. Pages 174-187 *in* King, C. M., editor. *The Handbook of New Zealand Mammals*. Oxford University Press, Melbourne.

3. King, C. M.; O'Donnell, C. F. J.; and Phillipson, S. M. 1994. *Monitoring and Control of mustelids on conservation lands. Part 2: Field and workshop guide*. DOC Technical Series 4, Department of Conservation, Wellington.

4. Warburton, B. 2001. Traps and trap-testing. *in* Walker, A., editor. *Proceedings of Mainland Island Hui, Omapere 20-23 August 2001*. Department of Conservation.

APPENDIX 1 CHAPTER 1 APPENDICES

Appendix 1 contains supplemental information for Chapter 1. Contents of Appendix 1 include:

- Appendix 1-1: Environmental Outreach 2009
- Appendix 1-2: Weed Control
- Appendix 1-3: Oil-Based Carrier Herbicide Trials
- Appendix 1-4: OED Survey Results for Schofield Barracks and Wheeler AAF

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APPENDIX 1-1: ENVIRONMENTAL OUTREACH 2009

VOLUNTEER SERVICE TRIPS:

Volunteers remove the incipient weed, *Juncus effusus,* from the summit of Kaala.

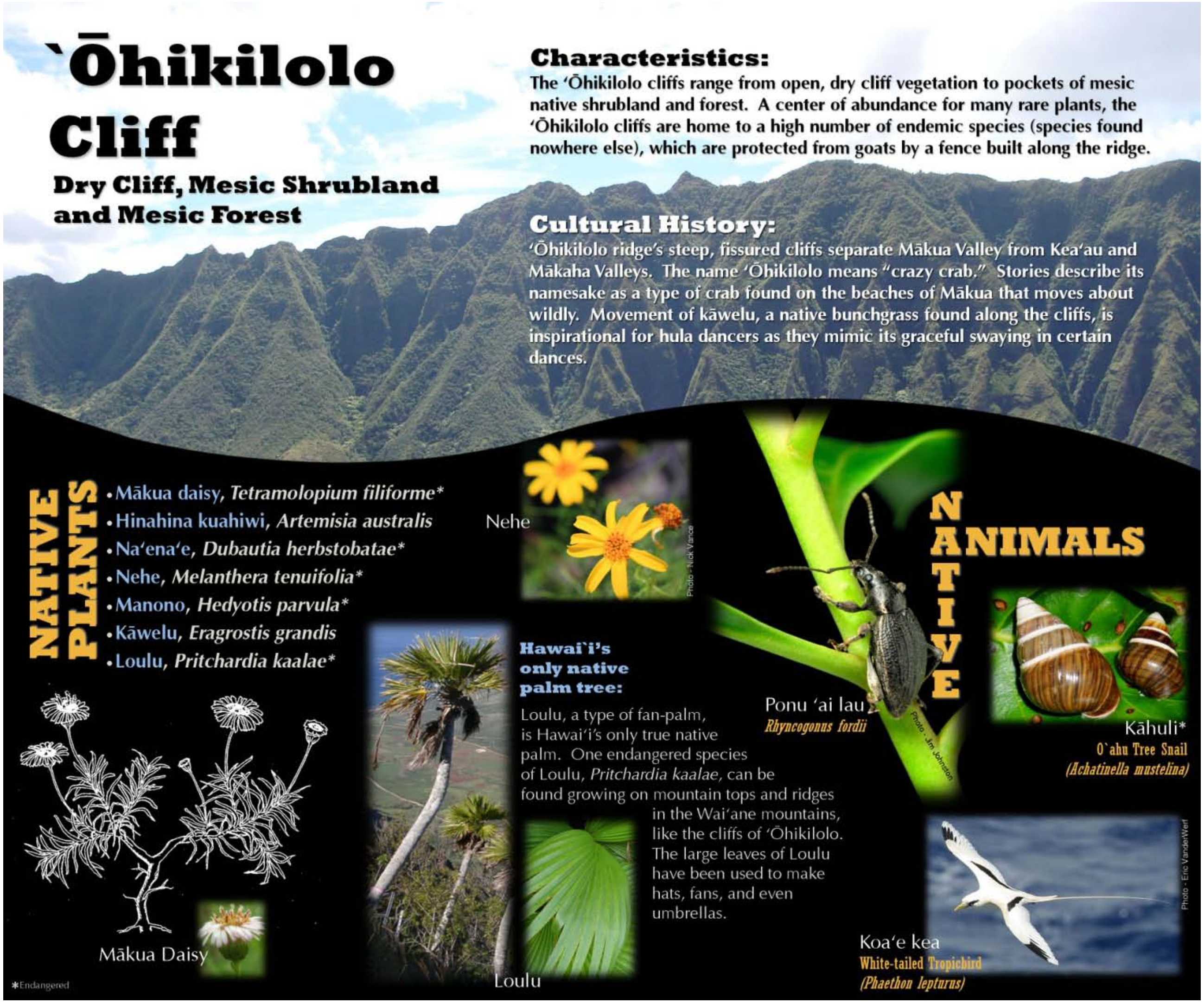
Scouts carry supplies to construct a water catchment, trail steps, and fence crossings.

Volunteers help clear invasive weeds around the site of a future field nursery for National Public Lands Day 2009.

Members of the Hawaii Youth Conservation Corps help remove invasive strawberry guava in the forest at Kahanahaiki.

Volunteers endure muddy conditions while removing the incipient weed, *Crocosmia* x *crocosmiifolia* at Kaala.

EDUCATIONAL MATERIALS:



Example of one of the interpretive signs designed for the OANRP's new baseyard interpretive garden.

Alien Snails Found in Greenhouses - Can We Keep Them Out of Our Native Forests?

O'ahu Army Natural Resources Program

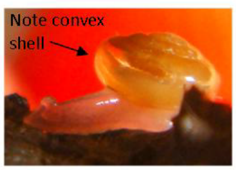
The O`ahu Army Natural Resources Program (OANRP) maintains two endangered plant nurseries where propagules are raised for genetic storage and to be out-planted back into the wild. Within the last several months, it has been discovered that much of the nursery stock are harboring multiple species of alien snails. It has been shown that horticultural facilities act as critical vectors for many alien snail and slug species, highlighting the need for greater awareness about these species (Cowie et al., 2008). The purpose of this informational flyer is threefold: 1) to provide additional information for any agencies/organizations conducting out-plantings in the wild by highlighting the species found in OANRP nurseries; 2) to garner any information that the horticultural, botanical, and conservation community may have regarding quarantine and eradication methods; and 3) to garner any information the horticultural, botanical, and conservation community may have regarding known distribution of these alien snail species in the wild.

Five snails of concern:

Zonitoides arboreus

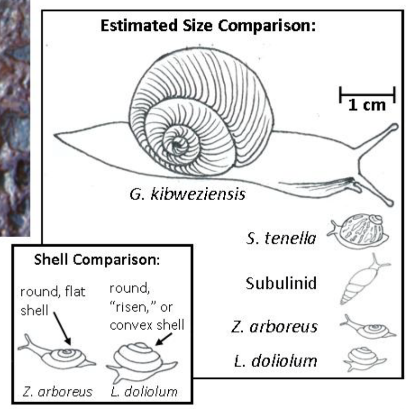
Subulinid

Gonaxis kibweziensis



Liardetia doliolum

Succinea tenella



RISKS associated with accidental forest introduction:

- Competition with native snails for food
- Increased prey for snail predators
- Potential to transmit diseases to native snails (currently little known)
- Possibly affecting plant health (currently little known)

OANRP's current QUARANTINE & ERADICATION methodology:

- Above-ground plant parts, soil, and below-ground plant parts visually examined for snails weekly on all stock to be planted.
- If, following 8 weeks of visual examination, snails are never found, then plants are cleared for out-planting.
- If snails are found, infected plants are treated with methocarb sprays and metaldehyde baits (Hollingsworth & Armstrong, 2003).
- Greenhouse facilities are sprayed with metaldehyde, all equipment is power-washed, all cleaned stock is kept on benches seated in salt water.

If you can provide additional information about these snail species, methods for control in the greenhouse, or have seen them in the wild, please contact: Matt Keir, OANRP Rare Plant Program Manager (matthew.keir@us.army.mil)

References:

Cowie, R.H., K.A. Hayes, C.T. Tran, and W.M. Meyer III, 2008. The horticultural industry as a vector of alien snails and slugs: widespread invasions in Hawaii. Int. J. of Pest Mgmt. 54(4): 267-276.

Hollingsworth, R.G. & J.W. Armstrong, 2003. Effectiveness of products containing metaldehyde, copper or extracts of yucca or neem for control of *Zonitoides arboreus* (Say), a snail pest of orchid roots in Hawaii. Int. J. of Pest Mgmt. 49(2): 115-122.

Flyer distributed at the Hawaii Conservation Conference and to other colleagues regarding invasive snails in the greenhouse.

OUTREACH EVENTS:

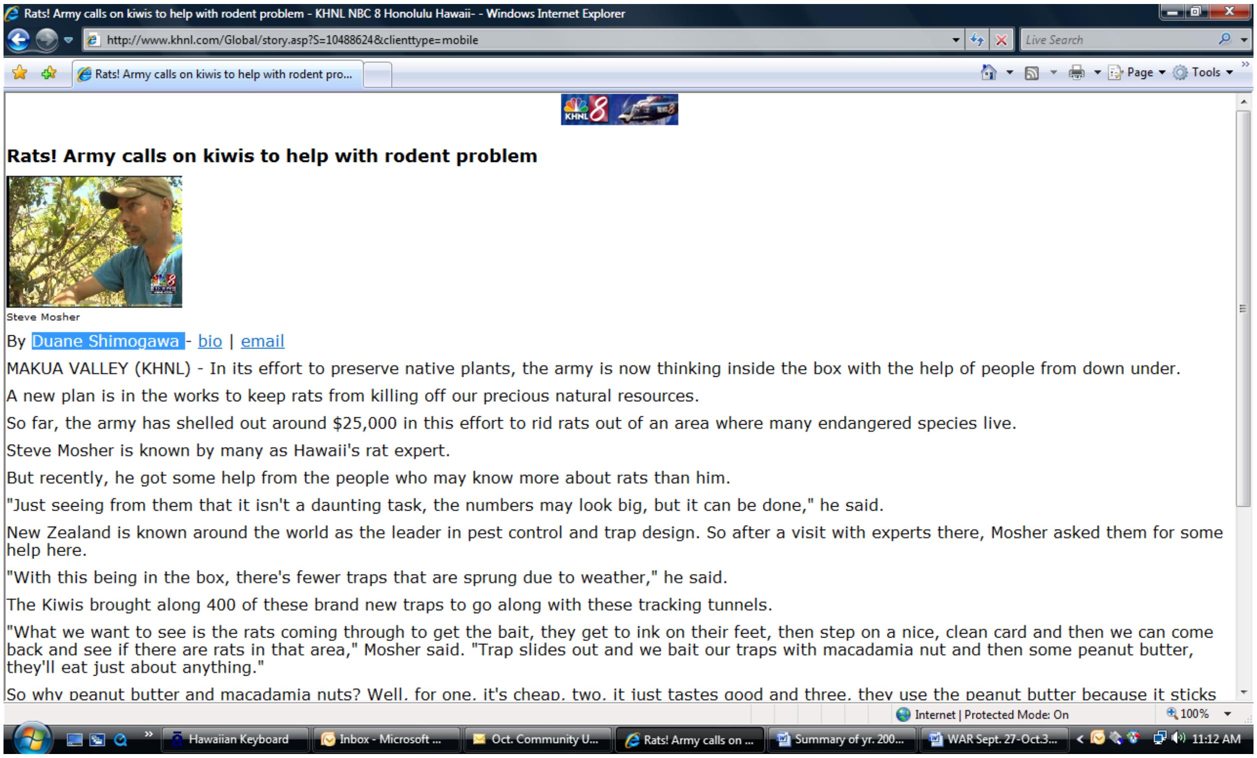
OANRP's booth at the Grow Hawaii Festival, April 2009.

Participants planted native Kookoolau seeds at the Bishop Museum's Family Sunday event, July 2009.

Guests tour the interpretive gardens at the new OANRP baseyard during the Earth Day Open House.

One of the OANRP's stellar volunteers, Jim Keenan, receives a volunteer appreciation award at the Earth Day Open House by Colonel Margotta; Army Natural Resources chief Michelle Mansker (center) announced the awards.

PUBLIC RELATIONS:



Rats! Army calls on kiwis to help with rodent problem

Steve Mosher

By Duane Shimogawa - bio | email

MAKUA VALLEY (KHNL) - In its effort to preserve native plants, the army is now thinking inside the box with the help of people from down under.

A new plan is in the works to keep rats from killing off our precious natural resources.

So far, the army has shelled out around $25,000 in this effort to rid rats out of an area where many endangered species live.

Steve Mosher is known by many as Hawaii's rat expert.

But recently, he got some help from the people who may know more about rats than him.

"Just seeing from them that it isn't a daunting task, the numbers may look big, but it can be done," he said.

New Zealand is known around the world as the leader in pest control and trap design. So after a visit with experts there, Mosher asked them for some help here.

"With this being in the box, there's fewer traps that are sprung due to weather," he said.

The Kiwis brought along 400 of these brand new traps to go along with these tracking tunnels.

"What we want to see is the rats coming through to get the bait, they get to ink on their feet, then step on a nice, clean card and then we can come back and see if there are rats in that area," Mosher said. "Trap slides out and we bait our traps with macadamia nut and then some peanut butter, they'll eat just about anything."

So why peanut butter and macadamia nuts? Well, for one, it's cheap, two, it just tastes good and three, they use the peanut butter because it sticks

Screenshot of KHNL's coverage of the rat-trap grid in Kahanahaiki.

Rebuilding A Forest

Reported by: Ron Mizutani
Email: rmizutani@khon2.com
Last Update: 3/24 6:19 pm

The U.S. Army gave mother nature a helping hand today returning a native tree that was once extinct from the wild -- back to the wild.

Members from the Oahu Army Natural Resources Program begin the long hike into Makua Valley. Their final destination is Kahanahaiki, where they'll rendezvous with a helicopter,carrying very special cargo.

The Cyanea Superba is a beautiful palm found only in the Waianae Mountains. At one time its population was down to a single tree.

"There were no seedlings and no keiki below them," said Matt Keir, UH Rare Plant Program Manager.

In 1996 a total of 10 plants existed, by 1998 it was down to five. The threatened

Screenshot of KHON's coverage of the story of *Cyanea superba,* "Rebuilding a Forest."

EMP
Ecosystem Management Program Bulletin
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Endangered Waterbirds Discovered Nesting on Army Land

By Phil Taylor

Staff with the Army Natural Resources Program made an exciting discovery during their winter waterbird survey last February when two fluffy-feathered Hawaiian Coot chicks emerged from the tall grass with their parents in a flooded field on Dillingham Military Reservation (DMR), near Ka`ena Point.

Juvenile and adult `alae`ke`oke`o, or Hawaiian Coot. (Photo by Eric VanderWerf)

The Hawaiian Coot, or `alae ke`oke`o, is a duck-like bird found only in the Hawaiian Islands and is federally listed as an endangered species due to habitat loss, avian diseases, invasive predators and invasive plants. Coots, which are sometimes called "black ducks," have only partially webbed feet with lobed toes. They are typically seen in the open water of marshes and ponds. Adults display uniformly grayish-black plumage with a white bill and a bulbous white or sometimes red frontal shield. The young downy chicks are all black, except for a reddish-orange head and bill.

This sighting of the family flock marks the first time an endangered waterbird has been observed breeding on Army land in the state of Hawai`i. The Hawaiian Moorhen and Hawaiian Stilt have also been observed this year at DMR, but neither species has been seen nesting in the area. Both are also native to Hawai`i and listed as endangered species.

Previous surveys at DMR have revealed the presence of few to no waterbird species due to low water levels in the fields just south of Dillingham Airfield. The heavy rains during December and January allowed water levels to rise, providing adequate nesting habitat for the coots and other waterbirds.

Wetlands at Dillingham Military Reservation. (Photo by Phil Taylor, OANRP)

Front page from Summer 2009 EMP Bulletin.

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APPENDIX 1-2: WEED CONTROL PROGRAM FORMS AND GUIDANCE

List of inclusions:

1. How to Weed
2. Ginger Control: Field Efforts
3. Weed Control Effort Form
4. Weed Control Effort Form Guidelines
5. Common Reintroduction Form
6. How to Transplant
7. Weed Survey Form

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HOW TO WEED

The Holy Trinity of Weed Organization: WCAs, ICAs, and Surveys

Weed management activities are divided into three main categories: Weed Control Areas (WCAs), Incipient Control Areas (ICAs), and Surveys. Each has a different purpose and a different set of expectations. The MIP/OIP outlines all weed activities. The Ecosystem Restoration Management Unit Plans (ERMUPs) spell out specific weed control actions for each MU. These are currently being written.

Surveys: Surveys are conducted both on and off Army Training Areas. They are designed to proactively identify new weeds which the Army, OANRP, or something else (pigs, hikers) are moving into areas we are interested in. What areas are these? Army training areas, Management Units (MUs), and access points. Three basic types of surveys are conducted. Only presence of species is recorded, not number of occurrences. Each survey location is named with a unique code.

- **Roads:** Surveyed annually, in quarter 1, when all is wet and growing well. All roads in training areas are to be surveyed. Roads used by OANRP to access work sites, like the Pahole Road, are also surveyed. Code example: RS-Pahole-01
- **Landing Zones:** All military LZs are to be surveyed annually, in quarter 1. LZs used by NRS are to be surveyed whenever they are used, not to exceed once per quarter. Code ex: LZ-MMR-101
- **Transects:** generally these are 500m long and are monitored for ungulate sign as well. Monitoring interval varies for transects. Code example: WT-KLOA-14

Data from surveys is entered into The Database. Any species which could be a significant pest is evaluated, and if deemed feasible, controlled in an ICA.

Incipient Control Areas (ICA): ICAs are designed to facilitate control of incipient invasive weeds. They are geographic regions defined on the GIS. Only one species is the target at any one ICA. The goal of each ICA is to achieve eradication of the target species. ICAs are named according to region and species; for example, UpperKapuna-AngEve-03, refers to a particular Angiopteris infestation in the Upper Kapuna MU. Control efforts are recorded on Weed Control Effort Forms, WCEFs. It is important to record how many plants of mature, immature, and seedling age classes are removed on a given date. This can be hard to do, but the data is important in tracking efficacy. Data is stored in The Database.

Weed Control Areas (WCA): WCAs are designed to facilitate control of multiple weed species in restoration sites. WCAs are defined geographically, and are generally drawn around rare species sites, reintroduction sites, potential reintroduction sites, areas with patches of native-dominated forest, or sometimes weedy areas where we want to construct fuel breaks or conduct more in-depth restoration projects. The MIP/OIP state that within MUs we should strive to reach 50% or less alien cover, within 50m of rare species we should strive to reach 25% or less alien cover, and within 2m of a rare individual, we should strive to reach 0% alien cover. These broad goals inform individual WCA goals, which vary.

WCAs which include rare species are supposed to be managed to achieve 75% or greater native species cover. WCAs which include patches of native-dominated forest, but no rare species, should be managed to achieve at least 50% or less alien species cover. WCAs which include fuel breaks should be managed to keep fuels low. The goal of each WCA is/will be defined in the ERMUP. WCAs are generally drawn within MUs, but may also be located outside of MUs. Control efforts are recorded on the WCEF, and all data is stored in The Database.

The Database!

It's big, it's scary, and it's the best way to track our data and what we're doing. There are many sections to the database. The weed section of the database stores all survey, ICA, and WCA data. The scheduling section of the database lists all the weed related actions for each team, and helps us keep track of which actions have been done and which are pending.

- Weed section: each team has a 'weed tech' who enters survey and WCEF info into the database. Blue = Mandy, Green = Phil, Orange = Scott. Quality checks of this data are done by Jane. Hard copies of the WCEFs are kept in binders in the team offices.
- Scheduling section: Jane generates the list of actions, ideally with the help of everyone who has an opinion. Team coordinators put the actions on a calendar and carry them out. Then, they record time spent on each action in the scheduling database. This information can then be reviewed: How much time are we spending on weed control activities? Can we keep up? Are vital actions being missed? Should we re-prioritize? Are all data forms being entered?

Where? GIS/GPS/Maps

All weeded areas are recorded on GIS. Please refer to How to GPS. If you go to a NEW survey site, please GPS it. If you go to a new WCA or ICA, please GPS the perimeter. If you weed in a WCA, GPS the perimeter of the area weeded; this is vital for the WCEF. If you weed in an ICA, generally you don't need to GPS the perimeter of the area weeded, as it has already been defined as the ICA shape. There are some exceptions for very large ICAs, for example, Lepsco at Poamoho. GPS data goes to the weed tech.

Identifying your weeds, aka Know thine enemy:

There are a ton of weeds! Learning to identify the many weeds in Hawaii is a lifelong process. Focus on learning the primary weeds of the MUs you visit. Many weeds are ubiquitous, and you'll have a lot of opportunity to practice your identification skills. Conducting surveys is all about weed identification; LZ surveys are good practice! Weed control also requires that you know at least the most common weeds in an area. When in doubt, ask! Never control a plant if you are not 100% positive that it is a weed.

Resources

- **Books:** Manual of the Flowering Plants of Hawaii, Hawaii's Ferns and Fern Allies, A Tropical Garden Flora, Weeds of Hawaii's Pastures and Natural Areas, Wayside Plants of the Islands, Scott H's laminated booklet. Copies at each baseyard.
- **Picasa:** this program is loaded onto all the computers. It catalogues all of our photos, including weed photos. Open Picasa. Type keywords into the bar at the top of the screen. Some keywords to try include: weed, weeds, identification, incipient, the 6 letter abbreviation for the species name, ex. Schter for Schinus terebinthifolius. Note that you can search by more than one keyword by leaving a space between keywords.
- **Web:** www.hear.org/starr, check out the Plants of Hawaii images link, also a starting source for pics of reptiles, insects and birds, http://botany.si.edu/pacificislandbiodiversity/hawaiianflora/index.htm (Smithsonian), check out both the Checklist and Specimen links, http://www.bishopmuseum.org/research/natsci/botany/botdbhome.html, check out the

annotated checklist of cultivate plants link,
http://www2.bishopmuseum.org/natscidb/?w=PBIN&pt=t&lst=o&srch=b&cols=8&rpp=500&pge=1, check out all the links,
www.google.com, search by plant name via google web and images

- **People:** ask any field staff, especially when you are out in the field. Collect samples to bring back to the office (for weeds, big samples are ok, and flowers/fruit are very helpful). Some folks who know a lot of weeds are Julia, Michelle, Scott, Dan S, Joby, Kapua, and Jane. We send really puzzling stuff to Bishop Museum for identification. Directions for this are on the V drive, in the Bishop Museum Folder, 'submitting to Bishop process' powerpoint.

Herbicide

Almost all weed control involves using herbicide. Read the pesticide SOP, #7, prior to doing ANY weed control. ASK for direction and guidance from coworkers. You should always use PPE when dealing with herbicides, and should be vigilant in preventing your person, pack, or other gear from becoming contaminated with pesticides. FOLLOW the pesticide label: it is the law.

PPE includes: gloves, long sleeves, long pants, covered shoes, sometimes eye protection, and sometimes a respirator (for fine sprays).

A note on Long Sleeves: Ok, so we didn't really use long sleeves in the past. Why? We didn't realize we needed them. They are really hot; at some work sites, dangerously so. And we weren't vigilant. So, all the pictures in this brief have a glaring flaw: no one has proper PPE, as no one is wearing long sleeves. However, the Garlon label requires long-sleeves. Wear them! For those who get hot easily, try a thin, loose, 2nd-hand men's dress shirt over your regular t-shirt; wear it while weeding and take it off to hike.

A note on Gloves: Use the reusable, aqua-green nitrile gloves. These are first choice. Note that you can use the blue surgical style gloves for weeding, but risk of contamination is MUCH higher due to breakage and difficulty in removing surgical gloves to adjust your hair/glasses/talk on the radio/etc. You can wear surgical gloves under aqua gloves for maximum protection, but this is not required.

BEST!

OK

BAD!

Garlon 4: This is the workhorse of the arsenal. G4 in a 20% mix with either Forestry Crop Oil (FCO) or biodiesel is used on 90% of all weeds we kill. G4 is mixed with a red dye. Garlon is most effective on broadleaf weeds and is typically applied with an applicator bottle. G4 should only be used in a sprayer in very special circumstances. Leucaena leucocephala (haole koa) requires 40% G4 for good control.

Roundup/Ranger: This is effective on broadleaves and monocots. Typically, it is used for spraying grass in a 1% solution in water. Blue dye is added to make it easier to see where herbicide has been applied. Respirators are recommended but not required.

Fusilade: This is grass-specific, which makes it a very useful tool in minimizing non-target kill. However, it is most effective on actively growing grasses,and treatment has to be timed for this; flowering grasses are not actively growing. Very effective on Melinus minutiflora, molasses grass, less so on Panicum maximum (guinea grass). Fusilade is mixed with water (22mL Fus. /gal), a surfactant (15mL/gal), and blue dye. It is applied via spraying. Respirators are recommended but not required.

Escort: This is almost exclusively used on ginger. It is a granular formulation. Weigh 1 to 1.5g on the scale, and mix well with a liter of water in a sprayer. The spray is applied to the ginger rhizome; notching the rhizomes first improves uptake. No dye is added.

Oust: This is a pre-emergent herbicide. It is designed to kill germinating seeds, but does not kill seeds themselves. Seek guidance on when/where/how to use Oust; it is only used in select projects.

Dyes: Red dye (Bas-Oil Red, oil-based)should be used for G4 in biodiesel or FCO; do not use blue dye here as it will not mix properly. Blue dye (Turf Mark, water-based) should be used for water based applications, like Roundup and Fusillade.

Before Heading into the Field:

Gear : Assist field staff in preparing necessary gear. This may include herbicide gear, as well as other gear such as chainsaws or weedwhackers. ASK FOR SPECIFIC DIRECTION! When using herbicide, you will always need nitrile gloves (aqua green reusable), dry bags for carrying contaminated material, water for washing up, simple green for washing up, and at least one wash tub. Herbicide and herbicide equipment should always be carried in a dry bag. Place applicator bottles and herbicide transfer bottles in Ziplocs, then into dry bags. Herbicide shall always be carried in 'leakproof' hard plastic bottles. Herbicide equipment includes applicator bottles, hand sprayers, pump sprayers, and backpack sprayers.

Herbicide Mixing: have someone show you how to do this until you feel comfortable with the process and the gear. Wear PPE when mixing the juice! Roundup, Ranger, and Fusilade are generally mixed in the field. Be sure to take dye, surfactant (for Fusilade only), graduated cylinders, and a funnel into the field. Add a little water to the sprayer first, then the herbicide, then surfactant and dye, then top off with water to the fill line. Shake well prior to using. Use the mix rate cheat sheet (V drive, Forms) to help figure out how much product is needed. Garlon 4 is generally mixed at Base. Check to see if any G4 is already in transfer bottles: use these first. Garlon 4 is stored in carboys (large containers with spigots on the bottom). There is one carboy with mixed 20% G4 in FCO in the pesticide cabinet. Use this. If it is empty, ask for help from one of the weed techs in mixing a new batch. If you need a different dilution, use the carboys with 100% G4 and 100% FCO and a graduated cylinder to customize. Escort is weighed out and put into 1 or 1.5 g batches in whirlpacks. It is mixed with water in the field.

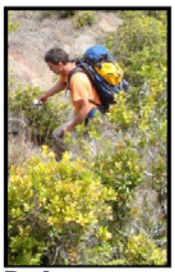
Mix Rates					
	24 oz	1 gal	3 gal	5 gal	25 gal
1%	7 ml	38 ml	115 ml	190 ml	950 ml
2%	14	75	225	375	1875
3%	22	118	345	575	2875
5%	35	190	575	950	4750
10%	70	380	1150	1900	9500
Fusilade Mix Rates Only					
	24 oz	1 gal	3 gal	5 gal	25 gal
Fusilade	4.2 ml	22 ml	66 ml	110 ml	550 ml
Surfactant	2.8 ml	15	45	75	375
Turf mark	2 ml	10	30	50	100-200

Tools to have: clippers, handsaw, hatchet (if girdling large trees). You should always carry clippers and handsaw in the field, even if you aren't planning on weeding. Tools should be sharp; hatchets can be sharpened (ask coworkers for help in how to do this correctly); handsaws blades can be replaced.

In the Field, Taking care of Business:

When conducting weed control, you should always have a GPS. GPS the boundaries of the area you weed – this is vital for tracking our effort and having productive, efficient weeding projects.

Transport: All pesticide gear should be carried in dry bags. You can put the dry bags in your pack, clip them to the outside of your pack, or just hand carry them. Make sure you tighten the lids of transport bottles well to avoid leakage. At the work site, stash herbicide gear in one location, and keep separate from day packs whenever possible. Herbicide stuff shouldn't be strewn around among daypacks and lunches. If pesticide gear is being flown into a remote location or campsite, put it in the sling whenever possible. Pesticide stuff in slings should be placed in puncture-resistant, leakproof, labeled containers, like buckets and action packers.



Dry bag

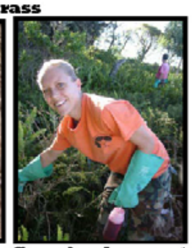
Separate prep area in field

Marked pesticide action packers

Garlon Prep: Pour mixed G4 into applicator bottles. Don't fill them to the brim! Tighten lids to avoid leaks. The applicator bottles have long tubes inside; dispense herbicide by squeezing the bottle. The tubes are useful in that they minimize spillage – if you fall and the bottle falls too, herbicide won't leak everywhere unless you squeeze the bottle as you fall. To prevent yourself from squeezing the bottle, carry it by the applicator spout. The tubes also allow you to apply herbicide really selectively , you don't have to turn the bottle upsidown to get juice out. If you can't get used to the tube, take it out, and SAVE IT. Lost tubes = bad. After emptying a transfer bottle, upend on weeds to let any residues drain out prior to washing.

Careful Pouring

¾ full applicator bottles, transfer bottles inverted on grass



Carrying by spout

Garlon Techniques: G4 should always be applied selectively. Basic techniques are illustrated here.

Clip and Drip: Good for small woody or herbaceous stuff like Clidemia, Rubus rosifolius, very young tree species. Cut the stem or stems close to the ground (within 3-4" at most). Treat cut stem with G4; entire stem should be covered, this may only take a drop. Benefit of this technique is that it is very easy to see what has been treated.

Cut Stump: same idea, but applies to large trees. Cut the tree down, leaving a very low stump; squirt G4 on entire cut surface. Cutting down large trees is labor intensive.

Basal: Good for small diameter woody trees and shrubs. Small diameter = 3" or less. Squirt a thin line (1" or less) of herbicide ALL the way around the basal bark about 2-3" from the ground. Uses more herbicide than clip and drip, and harder to see where has already been treated, but very fast. This technique is best for species that root from nodes, like Ageratina riparia and Ageratina adenophora. Squirt G4 at all places where these plants root into the ground, bases of all stems. This technique is also best for large diameter Schinus terebinthifolius (Christmas berry). Trials show that basal treatment of Schter is more effective than girdling; a thick line of herbicide is required, approx. 4-6"

Girdle: Best for large diameter (over 3") trees, excluding Schter. Use a hatchet or handsaw to cut through the cambium layer of the tree, all the way around the trunk or trunks. The cut doesn't need to be very wide, but it must be an unbroken ring, and must go all the way through the green/ white/ red cambium to the hardwood beneath. Squirt G4 on the cut ring, covering all cut surfaces. If you can cut in such a way so that the G4 is held in a pocket by the remaining bark, G4 uptake is improved.

Spray Techniques: Sprayers include hand sprayers, pump sprayers, hand-held wand sprayers, backpack sprayers, the 25gal skid sprayer, and the power sprayer. When spraying with backpack sprayers, the 25 gal skid sprayer, and the power sprayer, coveralls and respirators are needed. When spraying with hand, pump, or hand-held wand sprayers, coveralls and respirators generally aren't required. Wearing coveralls is hot! Drink lots of water! Spray grasses or other target weeds till all leaf surfaces are coated and herbicide just begins to drip from blades. Spray the same area from multiple angles to ensure that you get good coverage. Wearing respirators is strongly recommended for any application in which you will be exposed to spray drift for more than an hour.


Backpack sprayer


Skid sprayer


Hand-held wand sprayer

Backpack Sprayer notes: leaks happen. Minimize them by checking to make sure that all tubes are hooked up properly and are screwed on tightly, and grease the gasket on the lid with lube.
Non-grass targets: sometimes we spray Psicat seedling beds with sprayers and G4. The G4 is mixed with water in for this application. During roadside sprays, we often target both broadleaves and grasses. Use a mix of Roundup (1-2%) and Garlon (3%) for this type of application.

Ginger Control Techniques: Cut all stalks, leaving 1-2" stumps above the rhizome. Clear debris and mosses to expose the rhizome. Make cuts in the rhizome, scarifying it. Don't chop the rhizome up; any bits could develop in to new plants. Spray Escort solution on the rhizome, till covered; don't soak surrounding area, as Escort could kill surrounding vegetation. If you find any fruit, bag it and remove from the field. Put in the trash at Base.

Haole Koa Control Techniques: Haole koa is a survivor. For plants that have scarified, 'brain' trunks, cut off all stems, hack deep notches into the brain, and apply G4 40% liberally over entire brain and all cut surfaces.

Scarifying a 'brain', on left

Squirting a 'brain', on right

Piscat Control on the Summit Techniques: Summit environments are wet, saturated, high elevation. They include Ka'ala bog and most of summit region of the Ko'olau's, particularly 'Opaeula, Helemano, Poamoho, and Koloa. Psicat takes on a slightly different growth form at the summit: it tends to form shorter trees with multiple trunks, and does not fruit prolifically. Psicat slash often roots in these uber-wet environments. When treating Psicat, cut all trunks and squirt with G4 20% to get full coverage of cut surfaces and visible roots. Gather all slash together, squirt cut ends and aerial roots with G4, and pile slash off the ground. You will use more G4 than normal. Weeding on hot summer days also helps minimize slash sprouting.

End of the Field Day:

Washing up: All pesticide gear needs to be triple-rinsed, including ripped or punctured items (like Ziplocs or gloves) that are destined for the trash. Wash gear in the field, before heading back to Base. Use wash tubs, soap, and water; all staff should help. If you cannot wash gear in the field, be sure to apply rinsate to weeds or fencelines at base and be area of not contaminating areas that people need to use. Gear should be washed on the day of use, or, if camping, on the day it returns to base. Don't wash the inside of gloves with potentially contaminated water.

Triple Rinse

1. Water + Soap = fill containers at least ¼ full, agitate for 30 seconds, pour rinsate on nearby weeds, NOT on gravel, pavement. Wash outsides and insides of containers. Pump water through sprayer, if applicable.
2. Water + Soap = same thing as step 1
3. Water only = same process and disposal of rinsate. Rinse wash tubs after use.

Putting away gear: Put all gear out to dry on appropriate drying racks. Rinse the inside of the gloves with clean water before hanging up to dry. Toss any torn/punctured/cracked and otherwise unsafe gear. Make sure that any gear that is thrown away is rendered completely unusable by further puncturing/tearing it.

Filling out forms: Yep, that's right! If you weed, you need to fill out a Weed Control Effort Form! Only 1 WCA/ICA per WCEF. If you work in more than 1 WCA or ICA, keep track of time/area/herbicide used at each control area, and fill out separate forms. Please be as complete as possible – comments and sketch maps are good!!! GPS is great!! See the instructions for the WCEF for further guidance. The WCEF and WCEF Guidelines are on the V drive, in the Forms folder. To be a superstar, fill out WCEFs in the field or in the car on the way back to Base. Completed WCEFs go to the weed tech for each field team (Blue: Mandy, Green: Phil, Orange: Scott).

Ginger Control: Field Methods
Bog Flats, Kaala-01

Gear checklist:
- Spare escort packets and water for mixing
- Sprayer and glove clean-up bins and simple green
- Hip chain and spare line
- Compasses
- GPS unit and spare batteries if needed
- Spare pairs of nitrile gloves (green, thick gloves better than thin, blue, surgical style gloves)
- Blue, pink, and orange flagging for marking new sphagnum populations
-PPE (nitrile gloves, eye protection, long sleeve shirts, cammo jackets for thorn protection, leather or thick gloves)
-Kaala key
-pruners & handsaws

Mixing and Use of Herbicide:
Escort packets are already pre-made at West base, use 1 packet per 24 fl. oz (one grey spray bottle). This is one gram per 700 milliliters which gives a concentration of 0.14%. Probably only will need 1 bottle per participant, given the ginger at the flats are mainly small keikis. Pick up packets at your convenience. This chemical is only a suspension in water because it does not completely dissolve. Be sure to shake the mixture well if it has been sitting undisturbed for a while.

Escort also works on guava (for small guava cut at base and treat both stump and cut end).

Sweeps:
Use a copy of the last weed form to orient you for your sweeps. Usual bearing is 140° when sweeping from boardwalk to transect trail.

Mapping and Orienting Methods:
The phalanx method. The end person (should be staff) carries the hip chain on one end of the line (west side closest to Waianae), and should carry a GPS (on tracking mode to get the area), and take points at the start and end of the transect. All staff and volunteers should walk within sight of each other, about 1 person every 3-5 meters apart, to get good coverage in heavy brush. After reaching the end (boardwalk side or transect trail side), flip the line and follow the hip chain back the other way.

The people at the ends of the lines should agree on a compass bearing (140°, on a non-declinated compass) to follow along with the direction of hip chain lines. Participants also might find a compass useful as they orient in the brush. Note that the magnetic north of the compass and the true north from the printed maps differ by 11 degrees on Oahu, so ensure that everyone's compass is not declinated prior to starting

Herbicide Treatment Methods:
For really small ginger keikis, folks can just pull them out and pocket them for spraying in a pile at the end of a sweep.

For larger plants, first clear loose soil and debris away from the rhizome and roots. Then cut the stems above the pinkish red area where roots might resprout, wound the rhizome with a saw or clippers, and thoroughly spray to wet the rhizome and standing stalk. Herbicide sprayed on the soil will not seriously harm the ginger and would be wasted.

After spraying, cover the treated rhizome with the ginger leaves or other dead leaves if it is a rainy, drizzly day to prevent the chemicals from being washed off. Place cut branches so that others can see that the plant has been treated.

Guava is also normally killed when doing ginger sweeps. Escort should be sprayed on the cut stump and the end of the cut branch. Roots can sprout from any part of an untreated guava branch in very wet conditions. Perch the treated cut branches well above soil to prevent resprouting.

Counting of Controlled Plants:
Keep track of numbers of ginger found for reporting on the the weed form. Use the following size classes- Seedlings (2 tiny leaves, usually less than 10 cm); Immature are larger plants not showing signs of reproduction); Matures are plants with signs

1

of new or old flowers. Be sure to remind new folks that if several plants are connected by a rhizome that it is all considered a single individual, no matter how large the rhizome mass may be. This data on the weed form will tell us about the population structure and the efficacy of the weed control work in the long run.
We do not count the guava plants controlled because we assume that the numbers are low enough. Guava and other weeds should be noted on the form. Especially note large numbers or new/unusual species found, for example, Melaleuca quinqueveria.

Two rare endemic orchids grow on Ka'ala and should be described to new workers and they should be encouraged to ask if they are unclear what they are seeing.

Safety Precautions

General Precautions: Eye protection is required to avoid eye pokers in heavy brush. Blackberry thickets are difficult to work in without thick protective clothing. Give first aid as needed to prevent scratches and wounds from later infections. Glove liners like leather or cotton gloves can be worn under chemically resistant gloves if desired. Any damaged nitrile gloves should be replaced immediately to avoid chemical exposure.
Escort can be hazardous to humans. Reduce worker's exposure by spraying well away from your eyes and face and by setting the spray droplet size to avoid fine airborne mists. Hike to the site with the nozzle set to the closed setting until the sprayer is ready to use.

Chemical Safety:
The Material Safety Data Sheet is available in a binder in the truck for any worker or volunteer to see. You can see in the MSDS what the signs and symptoms of acute exposure are and what first aid measures should be. Escort has a Caution label and the PPE mentioned above is required for its use. *The active ingredient, Metsulfuron Methyl, causes eye and skin irritation and contact should be avoided.*

Snares and Pigs:
We are actively snaring and trapping along the blue transect and I did find one freshly caught keiki pig with the YCC group when there about 3 weeks ago. Please have folks watch out for the snares and not trip them (marked with orange flagging) on the blue transect. No snares are near the boardwalk. In the unlikely event a pig is seen stay well away from it.

Sphagnum

Sphagnum spreading:
With the YCC group, as we approached the sphagnum infestation we stopped just short of the boardwalk so we would not walk through any sphagnum at all. I highly recommend the same to prevent creating a wider infestation. While doing sweeps avoid walking through sphagnum and then out into the the forest without first cleaning footwear.

Mark and report new sphagnum:
If you find any new small satellite populations of sphagnum, please flag them well with triple blue and pink and orange flagging and GPS for future treatment.

Other Incipients

Mark and report new incipients:
If you find any new populations of an incipient weed, please flag them well with triple blue and pink and orange flagging and GPS. Incipient weeds to watch out for include: Juncus effusus, Leptospermum scoparium, Festuca arundinacea, Anthoxanthum odoratum.

DATA ENTRY (initial, date): GIS___________ Database___________ Filed___________

WCA/ICA

WEED CONTROL EFFORT FORM

Date ________ Crew ______________________ MU/area______________

Land Owner (circle): Army, State, TNC, BWS, other______________________

Weather (circle one in each row):

Cloud Cover	Sunny	Partly Cloudy	Overcast
Rain	None	Mist/Occasional light	Rain
Wind	0-15mph	15-25mph	25+mph

(WCA) Treatment Type (circle): Ecosystem Weed Control, Grass Control

Code name______________ Common name______________________

(ICA) Incipient Taxon:______________________________

Directions to area______________________________

____

____

Area controlled on this date______________________________

____

____

Managed Taxa ______________________________

Target Weed Species (Most to Least found)______________________

____

Photopoint/GPS ________ Notes ______________________

Treatment Method	Quantity (L)	Pesticide	Mix Rate	Surfactant	Mix Rate	Area	People Hrs

Manual Control Technique/Scoping (NO CHEMICALS)	Area	People Hrs

For Single Species Targets (Numbers Found)

*Mature*________ *Immature*________ *Seedlings*________ *Retreats*________

Total Area Treated ______________ Total People Hours ______________

Comments ______________________________

____

____

____

____

NextTime______________________________

____

____

____

____

Map Drawn on back/Arc-reader attach (Circle One) ______________________

DATA ENTRY (initial, date): GIS__________ Database__________ Filed__________

To be used by weed tech entering data

Circle one! Weed Control Areas are for management of established weeds for greater ecosystem health. Incipient Control Areas are for control of highly invasive locally incipient weed species, with the goal of complete eradication

WCA/ICA

WEED CONTROL EFFORT FORM

Date 1/1/11 Crew Unique initials of all staff, # of volunteer or partners MU/area MU or No MU area

Land Owner (circle): Army, State, TNC, BWS, other If you know . . .

Weather (circle one in each row):

Cloud Cover	Sunny	Partly Cloudy	Overcast
Rain	None	Mist/Occasional light	Rain
Wind	0-15mph	15-25mph	25+mph

Circle appropriate weather conditions

Write in the correct name. Please see a weed tech or Jane if you need help. Try finding on ArcReader

(WCA) Treatment Type (circle): Ecosystem Weed Control, Grass Control

Code name__________ Common name Nickname for the WCA or ICA

(ICA) Incipient Taxon: For ICAs only: incipient target

Directions to area How to reach the site. Directions should be specific enough new staff to follow. Landmarks are good. Explicit directions do not need to be filled out every time if good directions already on file.

Area controlled on this date

Describe where, specifically, weed control took place. This is VERY helpful for analyzing weed data! Sketch maps are good supplements!

Managed Taxa Rare taxa in area , if any, around which management is directed.

Target Weed Species (Most to Least found)

Identify the specific weed species controlled. 6 digit abbreviations are fine.

Photos: Yes/No. Were photo-points taken or general photos? GPS: Yes/No. Waypoints? Tracks? What gps used? Where is data going?

Photopoint/GPS __________ Notes __________

Only pesticide use recorded here. Treatment method includes: clip and drip, girdle, cut stump, backpack spray, power spray, hand spray, etc. Recored trade names of pesticide and surfactant. Mix rate is the dilution rate, not the % of active ingredient. People hours does not include transport time, just working time.

Treatment Method	Quantity (L)	Pesticide	Mix Rate	Surfactant	Mix Rate	Area	People Hrs
	L, gal, oz		%		%	m²	

Only manual control recorded here. Describe treatment: scoping, handpulling, digging, weedwhacking, collecting seed/fruit, etc. People hours does not include transport time

Manual Control Technique/Scoping (NO CHEMICALS)	Area	People Hrs
	m²	

ICA s: ALWAYS record # plants treated, by size class. For large numbers of plants, estimation is ok. CroCro and SphPal are special, estimate by volume – see Jane. WCA forms: no need, EXCEPT for Hedgar, SphCoo

For Single Species Targets (Numbers Found)

*Mature*__________ *Immature*__________ *Seedlings*__________ *Retreats*__________

Total Area Treated __________ Total People Hours __________

Thoughtfully sum the Area and People Hours columns from the two tables. Note that one area may have been treated by more than one technique, so straight addition of the area column may result in over-reporting of the area treated.

Comments

Notes on the actions performed. Record location of any stashed equipment and/or water. Be descriptive! Give your observations of the site (native,/weedy, better/worse than before), thoughts on control techniques, anything that seems applicable

NextTime

Write specific action recommendations for future visits. List special supplies which will be needed for next action; for example, water. Suggest a revisitation interval.

WCA forms: GPS the perimeter of the area weeded! Corresponding GIS shapes are required for every form. ICA forms: corresponding GIS shapes aren't required, but if the ICA is big, GPS the area weeded. Both: sketch maps can be very helpful! Draw them!

Map Drawn on back/Arc-reader attach (Circle One) __________

COMMON REINTRODUCTION FORM

Date __________ Crew ______________________________ MU/area ______________________

Land Owner (circle): Army, State, TNC, BWS, other ______________________________

Weather (circle one in each row):

Cloud Cover	Sunny	Partly Cloudy	Overcast
Rain	None	Mist/Occasional light	Rain
Wind	0-15mph	15-25mph	25+mph

WCA Code name ____________________ Common name ________________________

Photo ________________________________ GPS ____________________________

Batch # (WCA-DatePlanted-Spp) ____

Taxa Planted ______________________________ # Planted _________ # Monitored _________

Pot Size, Grower/Source ____

Directions/Area planted ____

____

____

if monitoring a subset of the planting, please note in comments below

Woody Species Monitoring

Vigor			Height				Maturity	
Healthy	Moderate	Dead	<20cm	20-50cm	50cm-1m	1m<	Vegetative	Reproductive

*for koa, note additional height categories, 1-2m ______________ and 2m< __________________

Fern/Monocot Monitoring

Vigor			Coverage			Maturity	
Healthy	Moderate	Dead	Full, 75% ≤ x	Medium, 25%<x<75%	Sparse, x≤25%	Vegetative	Reproductive

*planted in groups; treat each group as 1 unit # Plants/Group and # of Groups ______________

*coverage: estimate within 1m ______________________________________

Comments ____

____

____

____

____

Map Drawn on back/Arc-reader attach (Circle One) ______________________________

HOW TO TRANSPLANT

Know Thine Purpose

Common reintroductions, whether they are outplantings, transplantings, or seed sows, all are done to improve habitat quality for rare taxa. They seek to fulfill one/all of the following goals:

1. Provide native cover/shade to inhibit weed regeneration
2. Create native erosion control in heavily weeded areas
3. Improve habitat directly by increasing native taxa cover
4. Reduce cover of fire-ready grasses

Where to Where

In order to efficiently conduct a transplanting project, one needs to identify both a seedling source and a planting destination. A seedling source ideally is a large group of clustered seedlings of one species. The seedlings may form a chia pet or carpet, with a high likelihood of high natural mortality (sibling rivalry is brutal). The planting location should be relatively close by and should be appropriate habitat for the transplanting species. While planting locations abound, seedling sources tend to be more seasonal, less predictable, and widely distributed,

Appropriate Taxa

Not all species are good candidates of transplanting. Ideal characteristics include: relatively quick growth rate (likely to create cover quickly), hardiness (able to withstand the stress of transplanting), high germination rate (many seedlings present at once). As we have not done much transplanting, it is important to track transplanting efforts to determine which species are most successful. Possible candidates include:

Pipturus albidus	*Carex sp.*	*Nestigis sandwicensis*
Acacia koa	*Gahnia sp.*	*Raovulfia sandwicensis*
Pisonia sp.	*Dianella sandwicensis*	*Scaevola gaudichaudiai*
Pouteria sandwicensis	*Morinda trimera*	

Ideal Size: This depends on the taxa in question. For tree and shrub species, transplanting seedlings is most effective. Optimal seedling size varies for species. The seedling should be small enough to dig out the root ball with minimal damage, but not so small that the root ball is too poorly developed to survive the transition to a new location. For monocots like Carex or Gahnia, larger plants could be moved, as they tend to have smaller root balls.

Tools of the Trade

Trowels
Weeding forks (aka toad-stabbers
Shovels
Water jugs
Seedling containers – yogurt containers, buckets, trays . . . ?
Pin flags

Forced Migration

Considerations: to be fine-tuned, as we learn more

- Dig widely around seedlings to minimize root damage

- If seedlings are intertwined, dig out in clumps, gently loosen roots by shaking out dirt, or swishing in water, or . . . .
- Experiment with a variety of seedling sizes, if optimal size is not already known
- Keep seedlings damp; prevent them from drying out. Put a little water in transfer containers, make sure roots in water; this gives the roots a good soaking prior to planting too.
  Put water in bottom of transporting container
- Minimize time out of the ground for the seedlings
- Dig holes large enough to comfortably fit roots of the transplanting
- Tamp soil down firmly around seedling
- Create little moat around seedling to catch water, if possible
- Water generously
- Mark with pin flag, write date and species on flag. If planting densely, denote boundaries of planting area with pin flags or flagging, noting date, species, and number of plants on flag (this is harder to monitor).

Post-Planting Follow Through

Forms: Fill out a common reintroduction form. Be sure to note that it was a transplanting activity, where the stock was collected from, and where it was planted into. Note the number of plants in various size classes. To determine optimal size class, it would be valuable to note height on a finer scale than is notes on the form: <5cm, 5-10cm, 15-20cm, 20cm<.
Monitoring: The transplanting should be monitored quarterly for the first year, transitioning to every 6-12 months. If the transplanting was 100s of plants, only monitor a percentage (25%) of them. The monitored plants should be marked on the date of transplanting, should be spread across the planting area, and initial height/vigor should be recorded.

Weed Survey Sheet.

Similar sheets are printed from the database and used for LZ, Road, Transect, and Other (camps, quarry, fill sites) surveys.

SurveySiteCode **SurveySiteName** **SurveyDate** **Observers**

LZ-MMR-12

Ohikilolo Camp LZ

TaxonName	2008/01/09 AH YJ VC JB TaxonObs	2008/09/24 JG ME TaxonObs	2009/04/27 ME JG AH KF KLA JH TaxonObs	2009/07/21 AH KJW MV ME TaxonObs
Ageratina riparia	X		X	
Ageratum conyzoides	X	X	X	
Andropogon virginicus		X		
Axonopus fissifolius	X	X	X	X
Castilleja arvensis			X	
Centaurium erythraea	X			
Conyza bonariensis	X	X	X	X
Cuphea carthagenesis		X		
Ehrharta stipoides	X	X	X	X
Emilia sonchifolia			X	X
Gamochaeta purpurea	X	X	X	X
Grevillea robusta	X	X		
Kalanchoe pinnata	X		X	
Kyllinga brevifolia			X	
Lantana camara	X	X	X	X
Linaria canadensis			X	
Melinis minutiflora	X	X		X
Pityrogramma austroamericana			X	X
Plantago lanceolata			X	
Rhynchelytrum repens			X	
Rubus rosifolius			X	X
Sacciolepis indica	X			
Schinus terebinthifolius	X	X	X	X
Setaria gracilis	X	X	X	X
Sporobolus indicus	X			
Stachytarpheta dichotoma	X	X	X	X
Triumfetta semitriloba	X	X	X	X
Vulpia bromoides	X		X	

Staff write in names and date at top and check off species seen. New species are written in at bottom.

Appendix 1-3 Oil-Based Carrier Herbicide Trials

Introduction

Natural resource work in Hawaii necessitates herbicide use for control and eradication of invasive plant species. Herbicides are usually diluted to the desired concentration with a carrier or adjuvant. A given carrier has two functions: (1) to dilute the herbicide to the correct concentration (adjuvant function), and (2) to assist in the uptake of the herbicide by the growing plant (carrier function). The type of carrier that is used depends on the type of herbicide used. In general there are two classes of commonly used herbicides for invasive weed control: (1) water-based herbicides such as glyphosate (the active ingredient in Roundup[1]), and (2) oil-based herbicides such as triclopyr butoxy ethyl ester (the active ingredient in Garlon 4a[2]). As their names suggest, water can be used as a carrier for water-based herbicides, while oil-based herbicides perform best with oil-based carriers.

The largest conservation management organization on O'ahu is the O'ahu Army Natural Resources program (OARNP). OARNP is mandated to mitigate impacts to endangered taxa from Army training. The Makua and Oahu Implementation Plans (MIP and OIP, respectively) outline goals and standards designed to bring rare taxa found on Army lands and in training impact areas to stability. To do this, OANRP conducts a variety of threat management both on and off Army land. Weeds and habitat loss pose a large threat to endangered species; OANRP spends considerable time and resources controlling invasive plants. Chemical treatment (via herbicides) often provides the most efficient and effective method for invasive plant control, thus OANRP uses significant amounts of herbicides and their carriers to accomplish management goals. Most weed control involves the use of 20% Garlon 4 mixed with Forestry Crop Oil[3] (FCO); previous trials and years of experience have shown this mix to be effective on an extremely wide range of target species and plant sizes.

In 2009 OANRP decided to test carrier alternatives to FCO. There were several reasons for this: (1) FCO is a petroleum product, and has become increasingly expensive, (2) FCO is no longer readily available for purchase, (3) staff were interested in finding a more environmentally friendly product, (4) a variety of other carriers are available, and some may be more effective than FCO, and (5) other agencies in Hawaii have already switched to using biodiesel as a carrier, with great success. OANRP conducted a series field trials test to test the effectiveness of treating invasive weeds with four different oil-based carriers combined with Garlon 4 herbicide.

Study Sites

Six different carrier trials were done in two different areas within Makua Valley, a 1760 ha military reservation fenced and managed by OANRP.

1) Lower Ohikilolo: two trials conducted on *Leucaena leucocephala*.

   Location: This study site is located at the mouth of Makua Valley, near the south firebreak road. The elevation is approximately 300 ft. The trial transect is located 3 meters to the south of the firebreak road and runs east for 200' paralleling the road.

   Vegetation: This dry, shrubland area is dominated by alien plants, particularly *Panicum maximum* and *Leucaena leucocephala*. Other alien taxa include: *Leonotis nepetipilum*, *Rhynceletrum repens*, *Macroptilium lathyroides*, and *Acacia farnesiana*. Native taxa include: *Hibiscus brackenridgii* subsp. *mokuleianus*, *Chamaesyce celastroides* var. *kaenana*, *Dodonea viscosa*, *Waltheria indica*, *Erythrina sandwicensis*, *Sida fallax*, and *Heteropogon contortus*.

   Physical characteristics: The substrate of Lower Ohikilolo site is rocky, with pockets of well draining soil nestled between rock outcroppings, small cliffs, and some rock talus. The area is hot and dry. Rainfall occurs primarily during winter months.

2) Kahanahaiki: four trials conducted, one each on *Clidemia hirta*, *Psidium cattleianum* (large trees), *Psidium cattleianum* (small trees) and *Schinus terebinthifolius*.

Location: Kahanahaiki is located on the northeastern rim of Makua Valley. It is easily accessed via the State Pahole access road. A 90 acre fence protects this management unit from pigs. Elevation ranges from 1400ft-2300ft.

Vegetation: This mesic forest area is home to a variety of rare and endangered plants and one endangered tree snail. Parts of Kahanahaiki are dominated by weeds, particularly *Psidium cattleianum* and *Schinus terebinthifolius*, but significant patches of native forest cover other portions of the area. Some of the native species found in Kahanahaiki include: *Metrosideros polymorpha*, *Acacia koa*, *Psychotria* spp., *Myrsine lessertiana*, *Pisonia* spp., *Nestigis sandwicensis*, *Cibotium* sp., *Maratia douglasii*, *Cyrtandra dentata*, and *Cyanea superba* subsp. *superba*. Three of the trial sites are located in the southern part of Kahanahaiki, while the fourth trial site is located in the middle part of the exclosure.

Physical characteristics: The substrate of Kahanahaiki is primarily well-draining soil, with loose rock found in the gulches. While summers in the area can be hot, winters generally bring cooler temperatures, rain, and some mist.

Methods

Setup and Application

The six trials were designed to test the efficacy of four carriers and a control treatment on four different alien species, using common weed control methods. A different species was used in each trial; ten plants were subjected to each of the five possible treatments in the trial, for a total of 50 test plants. Different herbicide application techniques were used, depending on the species being tested.

The carriers tested were:

1) MSO®[4]
2) PHASE®[5]
3) Forestry Crop Oil[3]
4) Biodiesel (B100)[6]
5) Control (no herbicide and no carrier)

The four weed species chosen were:

1) *Psidium cattleianum*, Strawberry Guava
2) *Schinus terebinthifolius*, Christmas Berry
3) *Clidemia hirta*, Koster's Curse
4) *Leucaena leucocephala*, Haole Koa

Psidium cattleianum, S. terebinthifolius and *C. hirta* were chosen because they are some of the most common weeds OANRP controls and all of them are susceptible to Garlon 4. *Leucaena leucocephala* was chosen because it is particularly hardy, it is susceptible to Garlon 4, and it requires slightly different control techniques than the other species chosen.

The application methods used were:

1) Thin line: Also known as basal treatement. The plant was not mechanically marred. A continuous ring of herbicide solution was applied directly to the bark around the diameter of the main trunk of the plant. For the control treatments, no solution was applied.

2) Girdle: A hatchet was used to chip/scrape off a 3-4" wide strip of cambium completely around the circumference of the plant. Then a continuous ring of solution was applied to the cut. For the control treatments, the plants were girdled, but no herbicide was applied.
3) Cut stump: The plant was cut down (as close to the ground as possible) and herbicide was applied to the entire surface of the resulting stump. For the control treatment, the plants were cut down, but no herbicide was applied to the stump.

For each trial, the size ranges of the weeds were pre-determined in an attempt to get a homogeneous pool of test individuals. Two size classes of *P. cattleianum* were chosen because different application methods are used for different size classes. Large trees require girdling and herbicide, while small trees require only thin line herbicide application.

- Trial #1: *C. hirta* with 20% Garlon 4. The plants chosen had to be at least 0.5cm in diameter and have brown woody stalks. Young plants have green fleshy stems.
- Trial #2: *P. cattleianum* (diameter<4") with 20% Garlon 4. Each tree was chosen to have a diameter between 1" and 4".
- Trial #3: *P. cattleianum* (diameter>10") with 20% Garlon 4. Each tree was chosen to have a diameter greater than 10".
- Trial #4: *S. terebinthifolius* with 20% Garlon 4. Each tree was chosen to have a diameter greater than 10".
- Trial #5: *L. leucocephala* with 40% Garlon 4: Each tree was chosen to be between 1-3" in diameter.
- Trial #6: *L. leucocephala* with 20% Garlon 4: Each tree was chosen to be between 1-3" in diameter.

There were two trials using *L. leucocephala*. Trial #5 was performed using all five treatments and 40% Garlon 4. In previous trials, OANRP determined that 40% Garlon 4, coupled with cut stump application and stump scarification, resulted in effective control. Trial #6 was performed only using FCO and biodiesel, with 20% Garlon 4. This trial was done as a follow up to previous trials, to determine if a different carrier would dramatically improve the efficacy of 20% Garlon 4 on *L. leucocephala*.

Prior to treatment application, data collected on each plant included basal diameter (*cm*) and vigor. Each plant was labeled with a unique number. Using a number randomizer, each plant number was randomly assigned to one of the five treatment options.

Two plants were randomly selected from each treatment type to be used as photopoints, for a total of ten photopoints per trial. Photopoints were taken before treatment during monitoring.

Table 1 summarizes the species, number of individuals, treatment method and herbicide used for each trial.

Table 1: Summary of Trials

Carrier Trial	Species	Number of plants treated	Treatment method	Herbicide
Trial #1	*Clidemia hirta*	40	Thin line	20% Garlon4 in carrier (5 treatments)
Trial #2	*Psidium cattleianum* (diameter 1-3")	40	Thin line	20% Garlon4 in carrier (5 treatments)
Trial #3	*Psidium cattleianum* (diameter > 10")	40	Girdle	20% Garlon4 in carrier (5 treatments)
Trial #4	*Schinus terebinthifolius*	40	Thin line	20% Garlon4 in carrier (5 treatments)
Trial #5	*Leucaena leucocephala*	40	Cut stump	40% Garlon4 in carrier (5 treatments)

Trial #6*	*Leucaena leucocephala*	20	Cut stump	20% Garlon4 in carrier (2 treatments)

* *L. leucocephala* is normally treated with 40% Garlon 4 in FCO, however OANRP wanted to see if there would be a difference between FCO and biodeisel efficacy at 20% Garlon 4.

Monitoring

Table 2 indicates the times of treatment and monitoring for each trial. In some cases, more than one monitoring was conducted of the trial, but only the final monitoring results are shown here. A College of Tropical Agriculture (CTAHR) weed response table was used to measure the response of the treated plants to the test treatment (Table 3). In addition, the presence of wood boring insect damage (frass, holes) and fungi was noted, as these denoted dead wood. A cambium scrape was conducted, to see if any live cambium was still present, even if leaves were not.

Table 2: Monitoring timeline for each carrier trial.

Carrier Trial	Species	Treatment Date	Final Monitoring Date	Time Lapse (from treatment to monitoring)
Trial #1	*Clidemia hirta*	1/8/2009	7/20/2009	6 months
Trial #2	*Psidium cattleianum* (diameter 1-3")	2/17/2009	7/20/2009	5 months
Trial #3	*Psidium cattleianum* (diameter > 10")	2/11/2009	7/20/2009	5 months
Trial #4	*Schinus terebinthifolius*	2/19/2009	7/20/2009	5 months
Trial #5	*Leucaena leucocephala*	1/6/2009	10/27/2009	9 months
Trial #6	*Leucaena leucocephala*	1/6/2009	10/27/2009	9 months

Table 3: CTAHR Weed Response Table

Score	Description
0	No symptoms
10-30	Insignificant to poor weed control; little or no defoliation
40-60	Inadequate weed control; moderately severe symptoms; less than 70% defoliated
70	Adequate weed control; severe symptoms; all leaves chlorotic or more than 70% defoliated
80	Good weed control; very severe symptoms; 80% defoliated
90	Excellent weed control; very severe symptoms; 90% defoliation
100	Complete control; no sign of life

Results / Discussion

Preliminary data analysis of the carrier trials suggest that Biodiesel (B100) works just as well as FCO as a carrier. Phase and MSO, however, had varying results depending on the weed species treated. Each trial is summarized in a graph of the mortality of each plant treated using the different carriers (see Summary Graphs 1-6).

Further analysis is needed to confirm if there is any statistically significant difference in the treatment efficacy of the individual carriers. In addition, further analysis could be done to see if there is any correlation between treatment efficacy of the individual carriers and size of the plants treated (this data is not shown in the summary graphs).

Trial #1 *Clidemia hirta* with 20% Garlon 4. In this trial there does not appear to be any difference in the efficacy of the individual carriers. All of the shrubs treated (not including control) had complete death

(CTHAR = 100). The control had some partial mortality in a couple of plants, this is presumed to be due to natural variability.

Trial #2 *Psidium cattleianum* (diameter<4") with 20% Garlon 4. In this trial there does not appear to be any difference in the efficacy of the individual carriers. There is some variation with the mortality of one of trees treated with biodiesel (CTHAR =70) and one of the the trees treated with MSO (CTHAR =50). All of the other trees treated (not including control) had complete death (CTHAR = 100). This is presumed to be due to natural variability. One of the control trees was dead, it was presumed this was naturally occurring.

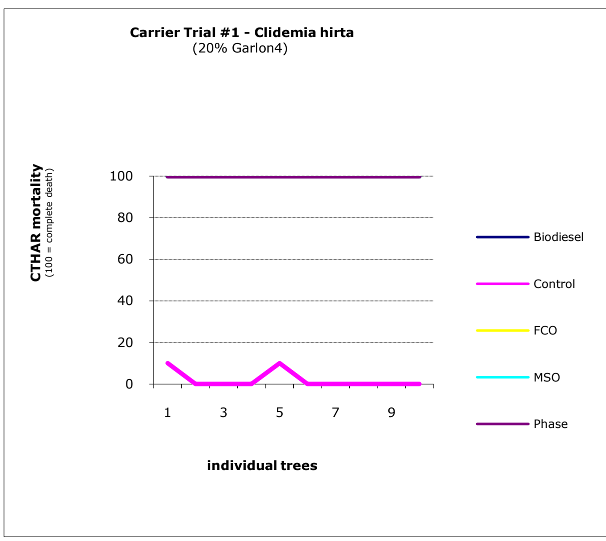
Trial #3 *Psidium cattleianum* (diameter>10") with 20% Garlon 4: In this trial there does not appear to be any difference in the efficacy of the individual carriers. Mortality in all of the trees treated was near 100% (CTHAR = 100. One of the control trees was dead; it appears this may have been treated accidentally.

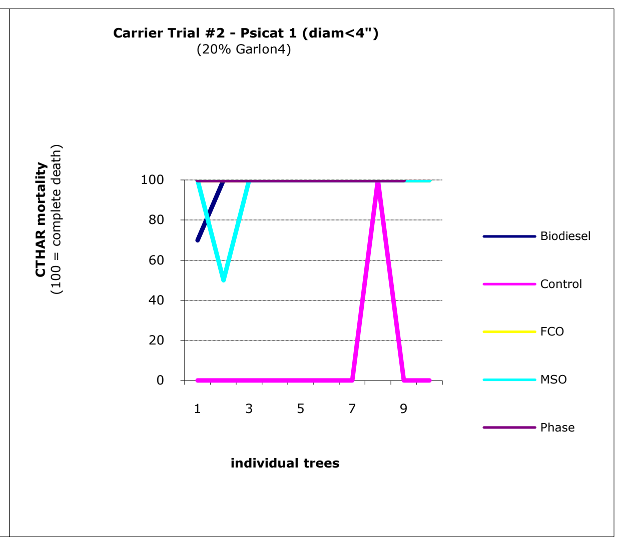
Trial #4 *Schinus terebinthifolius* with 20% Garlon 4: This trial had the most variability between the different carriers. The CTHAR score was nearly 100 for all of the individual trees treated with biodiesel and FCO. However the trees treated with MSO and Phase varied considerably in efficacy, CTHAR score ranging from 20 – 100. This suggests that these carriers did not perform as well. No significant mortality was observed in the control trees (CTHAR remained at or close to 0 for all control plants).

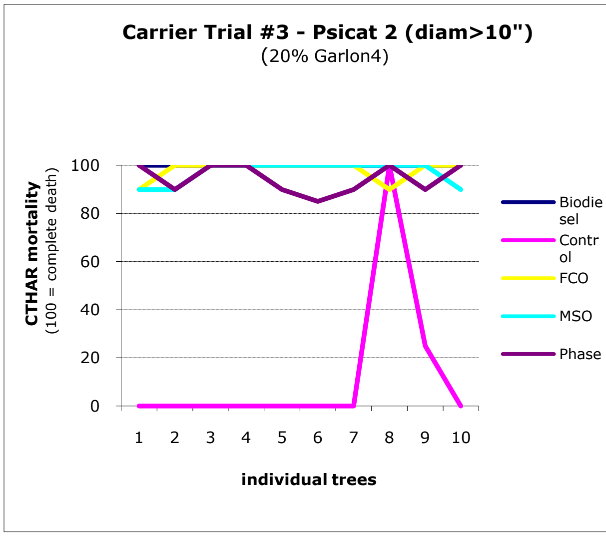
Trial #5 *Leucaena leucocephala* with 40% Garlon 4: In this trial there does not appear to be any difference in the efficacy of the individual carriers. All of the trees treated (not including control) had complete death (CTHAR = 100). There was no significant mortality observed in the control trees (CTHAR remained at or close to 0 for all the control plants)

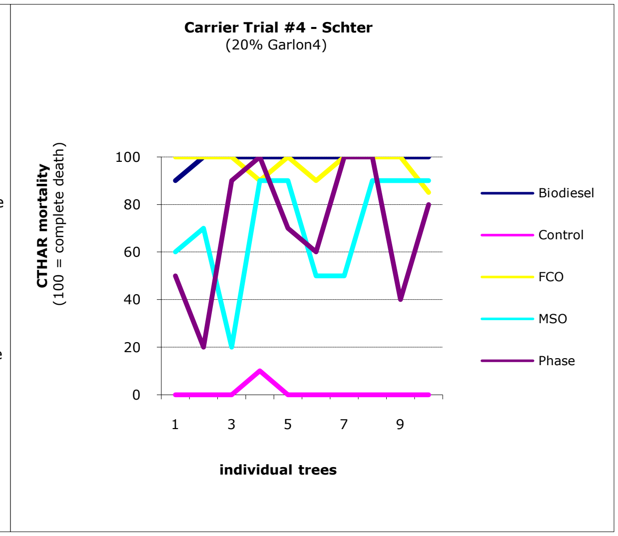
Trial #6 *Leucaena leucocephala* with 20% Garlon 4: This only tested FCO and biodiesel carriers, with no control except that installed for Trial #5 . All of the plants treated showed complete mortality (CTHAR = 100) with the exception of one of the plants treated with biodiesel, which showed no mortality. It is presumed that this may have been due to poor treatment technique.

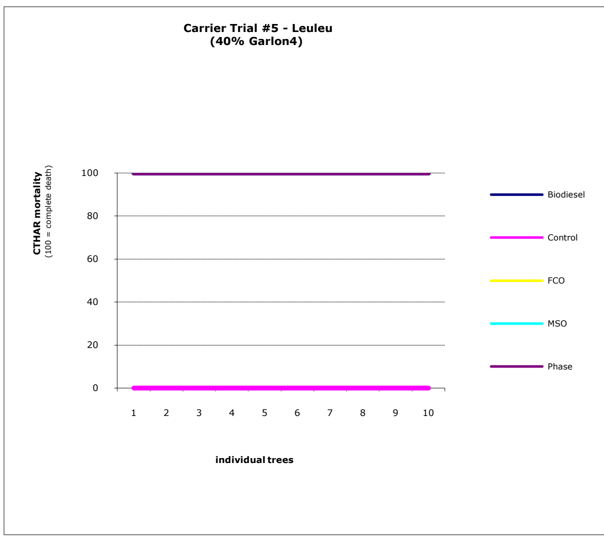
Summary Graphs 1-6

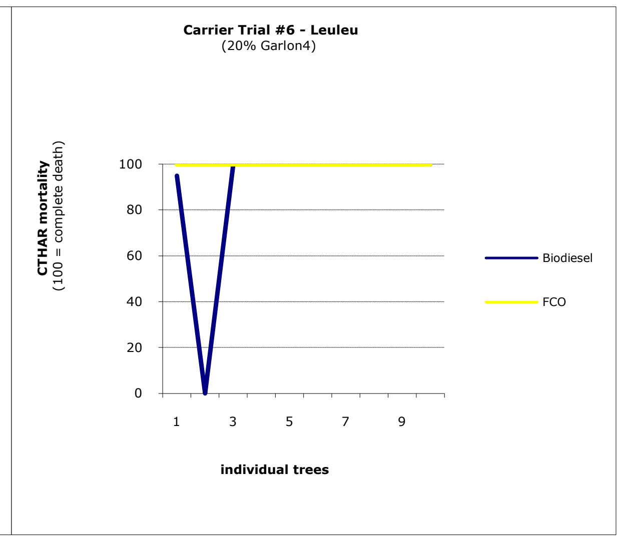












[1]Roundup: Produced by Monsanto. Active ingredients: Isopropylamine salt of N (phosphonomethyl) glycine; {Isopropylamine salt of glyphosate}

[2]Garlon 4: Produced by Dow Agrosciences : Active Ingredients: ((3,5,6-trichloro-2-pyrid1)oxy) acetic acid, buyoxy ethyl ester. Garlon is the most frequently used oil-based herbicide; used to control woody plants. Dilution rates range from 1.5 – 50% Garlon 4 with an oil-based carrier. Garlon is effective on a wide range of plants, particularly woody plants.

[3]Forestry crop oil (FCO): Produced by Loveland products. Ingredients: Petroleum Oil. FCO is the most commonly used oil-based carrier with Garlon 4.

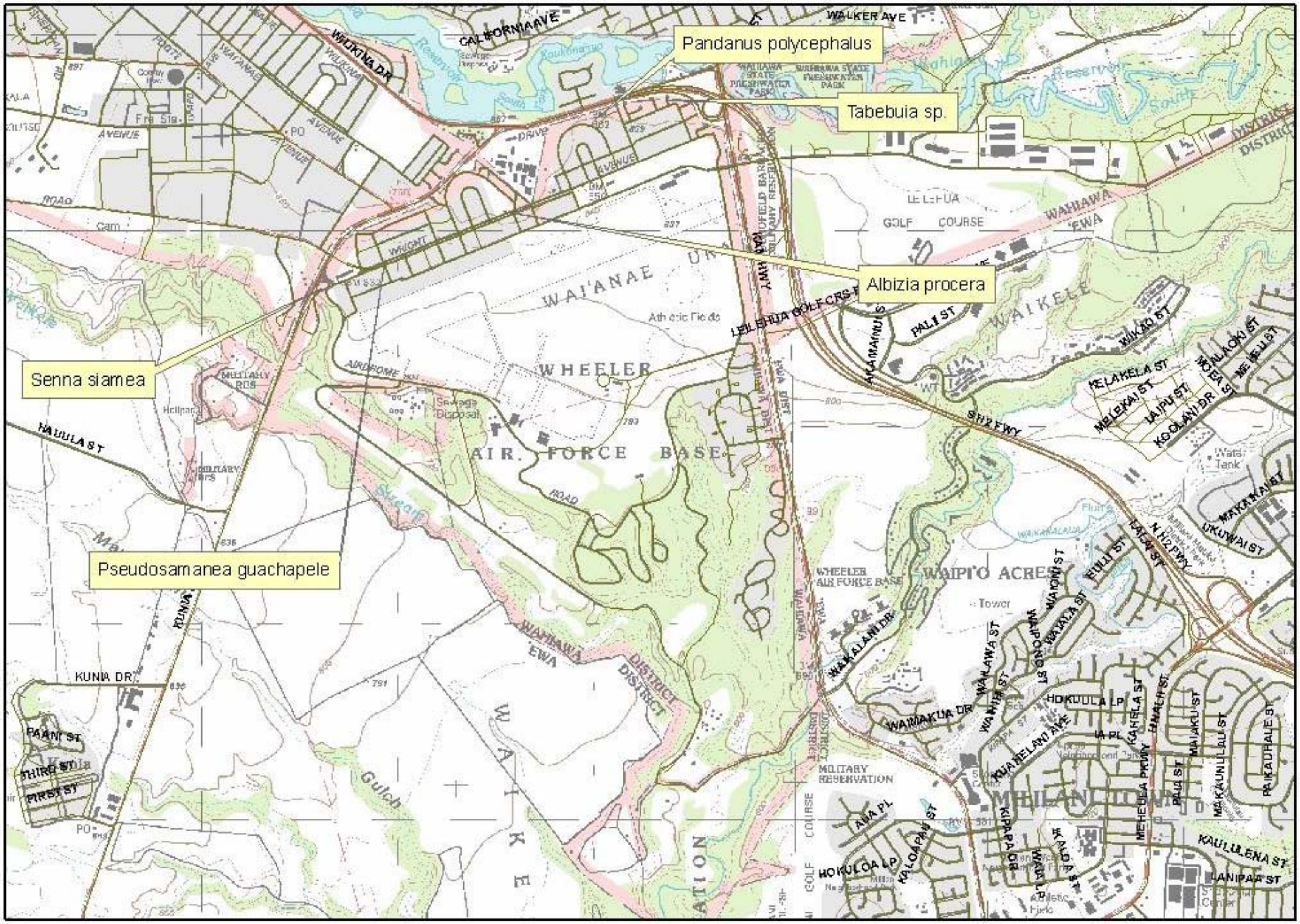
[4]MSO®: Produced by Loveland products. Concentrate with Leci-Tech. Ingredients: Methylated vegetable oil, Alcohol ethoxylate, and Phosphatidylcholine.

[5]PHASE®: Produced by Loveland products. Ingredients: Methylated esters of fatty acids, alkylpolyoxy-Ethylene ether and polyether modified polysiloxane.

[6]Biodiesel (B100). Ingredients: Methyl esters from lipid sources

Appendix 1-4
OED Survey Results for Schofield Barracks and Wheeler Army Airfield

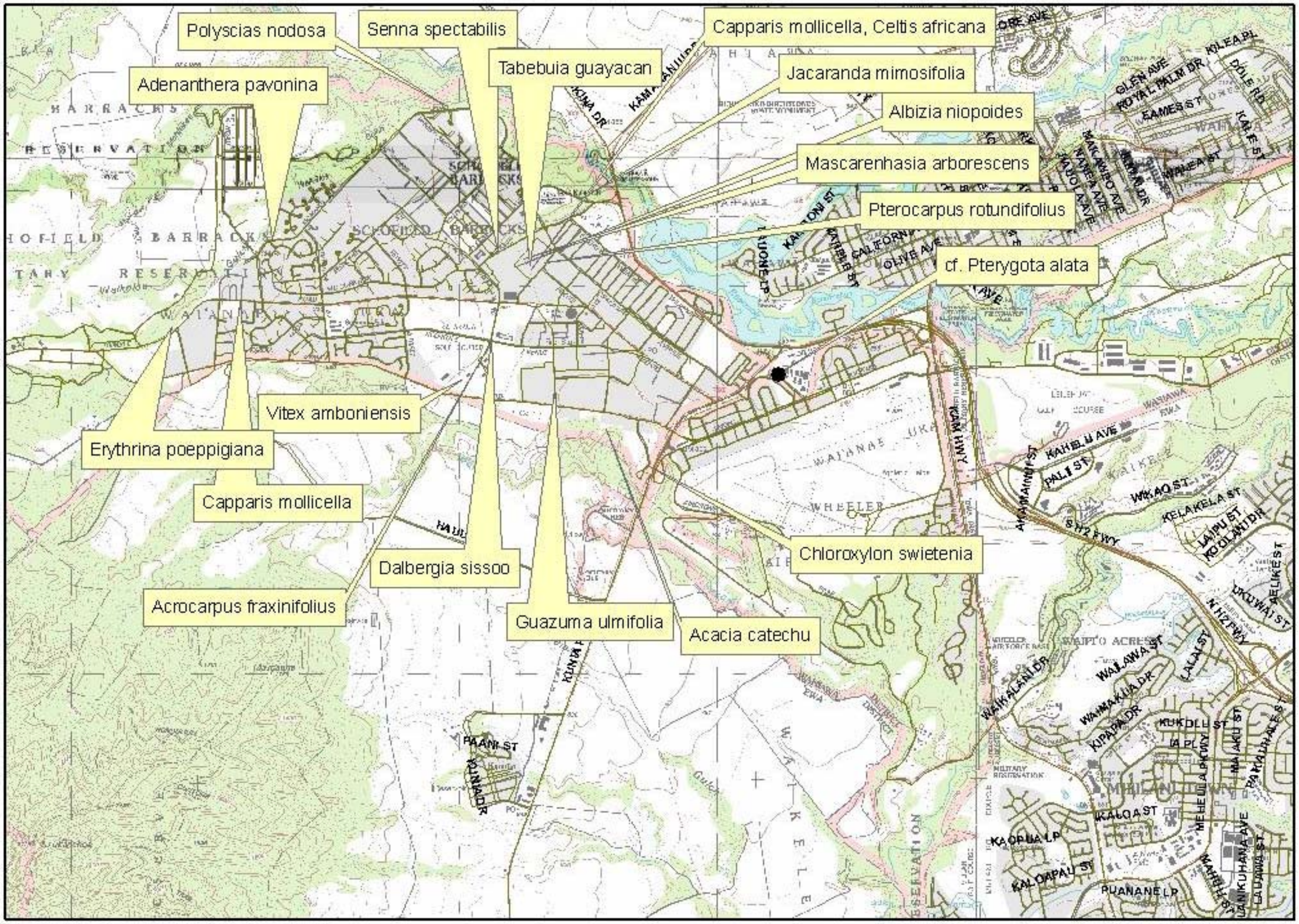
Wheeler	Notes	Oddities-Schofield/Wheeler only Oahu location	Commonly planted, fyi, look for spread	need ID, look for flowers/fruit	is it invasive in your natural areas?	consider removing	new record's, too widespread for OED
Albizia procera	Only known from Wheeler, where it is at least adventively spreading if not naturalized. It is a fast growing invasive elsewhere including Puerto Rico and South Africa. Would be great to remove but listed as some planted trees are listed Exceptional trees.	x			x		
Enterolobium cyclocarpum	Rather common on base, occasonal elsewhere on O'ahu. Rather large tree. The Global Compendium of Weeds lists this as invasive but a quick search for details turned up empty. OED has not seen this clearly spreading anywhere. Would be good to keep an eye out		x		x		
Erythrina sp.	Jane knows about this a bit. We need flowers or especially fruit to ID. Possibly imported from Samoa.			x			
Fraxinus cf. uhdei?	Fruits are a match for uhdei but seems to have a different look. We are less familiar with this species' variability and look. Would be interesting to hear what you guys think			x			
Pandanus polycephalus	Shrubby Pandanus with copius sticky fruits, looked inviting to birds though no spread was noted. Keep your eyes out! This is the first time we've come across this species.	x					
Pseudosamanea guachapele	A few large trees, no flowers seen but should be white. As the name suggests, it looks like monkeypod. No clear weed history from anywhere. Only known in the State from Wheeler	x					
Pterocarpus indicus	Very commonly planted on Schofield, invasive elsewhere but not documented as naturalized in Hawaii (yet). OED has observed seedlings. Would be good to look out for this in natural areas.		x		x		
Senna siamea	Rare elsewhere on O'ahu but commonly planted and sparingly naturalized on Schofield and Wheeler. Would be good to look out for it elsewhere. Invasive elsewhere, though the current WRA posted online accepted the species! Would be good to look out for, removal would be a large undertaking.		x		x		x
Tabebuia sp.	Need flowers for ID. Pretty sure we haven't come across this before. 2-3 small trees fruiting in residential area.	x		x			



Species of Interest: Wheeler

Scale 1:25,846

Schofield	Notes	Oddities-Schofield/Wheeler only Oahu location	Commonly planted, fyi, look for	need ID, look for flowers/fruit	is it invasive in your natural areas?	consider removing	new records, too widespread for OED
Acacia catechu	One naturalized individual noted on base. Planted in forest reserves and spreading, OED hasn't seen this in natural areas. Might want to keep an eye out.						
Acrocarpus fraxinifolius	Not in Global Compendium of Weeds. Not much known about biology. Only known specimen from HI is from Schofield.	x					
Adenanthera pavonina	Noxious weed, enviro weed in Global Compendium of Weeds. Serious weed elsewhere- look for spread.				x		
Albizia niopoides	Not in Global Compendium of Weeds. Seen spreading adventively from original planting to nearby shed and fence. Only known specimen from HI is from Schofield.	x				x	
Capparis mollicella	Distinctive flowers/fruit, OED found spreading off base. Didn't find any info on weed history elsewhere.	x			x		x?
Celtis africana	Not in Global Compendium of Weeds. Not much known about biology. Only 2 known locations from HI.	x					
Chloroxylon swietenia	Vulnerable species-IUCN. Not much known about biology. Only known specimen from Oahu is from Schofield.	x					
Dalbergia sissoo	Noxious, enviro weed in Global Compendium of Weeds. Problem species in Florida and N Australia.						
Erythrina poeppigiana	Cultivation escape, naturalized in Global Compendium of Weeds. Spreading from original planting in Schofield. Not a new record, but infrequently planted on Oahu.				x		
Ficus religiosa	Lots of saplings all around base. Especially at the base of gutters...		x		x		
Guazuma ulmifolia	One tree seen in Schofield, this species is occasional to rare elsewhere on O'ahu. It appears to have at least naturalized elsewhere but information on it being invasive was not found.						
Mascarenhasia arborescens	Not in Global Compendium of Weeds. Not much known about biology. Only known specimen from HI is from Schofield.	x					
Polyscias nodosa	Naturalized just over fence from base. Was sterile when we were there, but would be great to get a flowering/fruiting specimen.			x	x		
Pterocarpus rotundifolius	Agricultural weed in South Africa: Global Compendium of Weeds. Not much known about biology. Only known specimen from HI is from Schofield.	x					
Pterygota alata, c.f.	We're not sure of ID, would be great to get flowering/fruiting specimen.			x			
Senna spectabilis	Enviro weed in Global Compendium of Weeds. Collected naturalized at Schofield. Spreading to natural areas?						x
Swietenia macrophylla	not mapped in Schofield, but thought we'd mention it (it's included on the mapin the Exceptional Tree Guide) Invasive elsewhere including Hawaii. Was planted and is spreading in forest reserves here, but is rarely seen naturalizing from plantings in urban areas.						
Tabebuia guayacan	Not in Global Compendium of Weeds. Not much known about biology. Weedy congenerics. Only 2 known locations from HI.	x					
Tipuana tipu	In a few neighborhoods on base (not uncommon outside of Schofield), not noticed naturalizing but a weed elsewhere. Check for spreading to natural areas.				x		
Vitex amboniensis	Just an oddity, not encountered before on any of our surveys. No weed history elsewhere (but some other Vitex species are documented as invasive)						
Washingtonia robusta	A nasty weed in urban areas- check for spreading to natural areas.				x		



Species of Interest: Schofield

N

Scale 1:39,274

APPENDIX 2: FIRE REPORTS

Makua Cave Vicinity Fire Memorandum for Record

July 23, 2009

APVG-GWV (200-3) 8 September 2009

MEMORANDUM FOR RECORD

SUBJECT: Memorandum for record regarding Makua Cave vicinity fire, July 23.

Background

NRS is not currently approved to engage in fire fighting activities due to insurance issues at RCUH. These issues are currently actively being worked on by Dr. Cliff Smith, Joby Rohrer and Dan Sailer. Hopefully this will soon be resolved. As a result of this restriction, NRS involvement in fire response is restricted to working in an advisory capacity and supporting aerial operations. The fire was very small, 3.84 acres, not accounting for topography. It burned both makai and mauka of Farrington Highway, and was quickly contained. Staff involvement consisted of communicating with other agencies, specifically Army Wildland Fire, Makua Range Control, DPW Environmental, and Division of Forestry and Wildlife (DOFAW). NRS prepared to deploy to Makua to ensure that rare taxa were protected, but no assistance was needed. This was the second fire to occur in the week; a much larger fire burned portions of Kaena Point July 21, 22. Despite this, other agencies were quick to mobilize for the Makua Cave fire. It is unclear if any rare taxa were affected by the fire. There are several rare plants in the area, including populations of *Melanthera tenuifolia*, *Chamaesyce celastroides* var. *kaenana*, *Hibiscus brackenridgii* ssp. *mokuleianus*, and *Spermolepis hawaiiensis*. The *M. tenuifolia* population is located on a cliff; the fire burned up to this cliff, but did not impact the population. The *S. hawaiiensis* is located on the same cliff. The fire did burn within 150m of the *C. celastroides* and at least within 40m of the *M. tenuifolia*.

The fire threatened *M. tenuifolia*. The WCAs noted on the map are fuel breaks protecting *C. celastroides* and *H. brackenridgii*.

Thursday July 23, 2009

At approximately 12 pm, Mandy Hardman reported seeing smoke coming from the Makua/Keawaula region. She radioed base from Ohikilolo Ridge, Makua Valley, where she was in the process of hiking from camp to Range Control at the end of a three day camp trip. Base contacted Makua Range Control; Range Control staff said that they were aware of the fire, and noted that it was at Makua Cave. Base contacted Army Wildland Fire, who quickly mobilized and left Schofield for Makua. Base contacted Ryan Peralta of DOFAW, who was monitoring the Kaena Point fire (started on July 21). Mr. Peralta said that he would head towards Makua, as the fire location was in Zone 2 (DOFAW/HFD co-op response). Base also contacted Michelle Mansker (Army Natural Resources Manager) to update her on the situation. Ms. Mansker indicated that OANRP should hold off activating helicopter resources for the time being, as HFD was responding and OANRP paid for most of the helicopter time on the Kaena fire.

Meanwhile, the crew camped at Ohikilolo were preparing to end their 3-day trip. There was rainy, cloudy weather at the campsite, and the crew wanted to fly out as soon as possible. Ms. Hardman and Eli Kimmerle, who were hiking to Range Control, were told to wait at the Ohikilolo Mid LZ, the westernmost LZ on the ridge. Their route would have taken them very close to the fire. The irony of rainy weather on one side of Makua Valley and a fire on the other side was discussed.

Ms. Hardman radioed to Base and Ohikilolo Camp that she saw a helicopter dropping water on the fire; however, the transmission was not received by Base. This may have been due to difficulties with radio signal from Ohikilolo, or to multiple phone calls at Base. In any case, Base was not aware of the aggressive measures being implemented by HFD.

Base received a phone call from Army Wildland Fire, saying the HFD had contacted them, and that the fire was under control. Several Army Wildland Fire staff were going to turn around and head back to Schofield, sending 1 or 2 personnel on to monitor the fire. Base was concerned that no-one familiar with the rare taxa had yet seen the site.

Pacific Helicopters arrived at Ohikilolo to transport NR crews off the mountain at around 2pm, Lincoln Ishii pilot. The weather cleared, and Mr. Ishii was able to fly all personnel and gear from Ohikilolo to the Nike site. On the last load, Mr. Ishii flew over the fire with Kapua Kawelo and Mike Walker. They determined that the fire appeared to be out. Ms. Kawelo thought that the *M. tenuifolia* cliff had burned.

At 2:20pm, Base received a call from Army Wildland Fire that the fire was officially contained. This information was relayed on to Mr. Peralta and Ms. Mansker.

NRS Helicopter Resources

Company	Time	Total
Pacific (Lincoln)	2:00-2:10	10 min

NRS Personnel Resources

Personnel	Time	Total
KK, MW	2:00-2:10	10 min

To our knowledge, the HFD Fire Investigators were never called to the scene. The cause of the fire is officially unknown, but arson is suspected given the proximity to the road.

Post-Fire Survey, Thursday August 6, 2009

Jessica Hawkins conducted a survey of the fire to determine any possible damage to rare taxa and accurately GPS the perimeter of the burned area. The fire burned a small area makai of the highway, 0.16 acres, and a larger area mauka of the highway, 3.68 acres. The fire did not crest Ohikilolo ridge, and did not approach the fuel breaks maintained by OANRP to protect *C. celastroides* var. *kaenana*. However, it did sweep towards the cliffs east of the Makua Cave, towards a population of *M. tenuifolia*.

The following is a partial list of native and alien plant species surveyed in the burn area.

Native Plant Species	**Alien Plant Species**
Dodonaea viscosa	*Acacia farnesiana*
Myoporum sandwicense	*Cenchrus ciliaris*
Sida fallax	*Leucaena leucocephala*
Waltheria indica	*Panicum maximum*

Fire boundary close to Farrington Highway. Note small burned area makai of road. Note patchy burned areas

Map removed to protect rare resources

View towards the *M. tenuifolia* cliff. The fire burned to the base of the cliff.

Map removed to protect rare resources

View from Ohikilolo ridge, above the C. celastroides, looking towards Farrington.

Fuels were short, over rocky terrain

Post-Fire Survey, Thursday August 17, 2009

On August 17, 2009 Kaleo Wong and Joby Rohrer did a post fire survey to determine the impact of the fire on the *M. tenuifolia* at the Lowere Ohikilolo PU. The crew hiked in from Makua along the fence line with rappelling gear to access impacts to the plants one the cliff. The entire PU area in proximately to the fire was covered with multiple rappels. The fire never reached the area where *M. tenuifolia* had been seen in the past. There is a large, sheer, un-vegetated rock face just below the lowest extent of the PU. In fire did not breach this barrier as in previous years. However the fire edge got within tens of meters of the PU. Unfortunately despite the absence of a fire impact only a single plant was found on this day.

Map removed to protect rare resources

View of burn area form the *M. tenuifolia* PU, makai side of PU

View of burn area form the *M. tenuifolia* PU, Makua side of PU

Map removed to protect rare resources

View of lower portions of the *M. tenuifolia* cliff with burned area below

The single *M. tenuifolia* individual seen at PU

Lessons Learned and questions that need follow-up

- OANRP needs to work with PCSU to resolve insurance issues so staff can be involved in fire fighting activities. OANRP staff are a valuable resource in Wildland fires as most HFD crews are not familiar with wildland areas and native and endangered resources, and large numbers of trained personnel are needed for effective suppression operations.
- No OANRP, Army Wildland Fire, or DOFAW staff were at the scene of the fire. This made it difficult for OANRP to decide how to proceed in responding to the incident, since the *M. tenuifolia* was so close to the fire. HFD was on scene, but they do not have the same background in preserving rare taxa.
- Rare plants are located very close to Farrington Highway, the primary ignition point of most fires in this area. It is difficult to respond to fires quickly enough to prevent any damage to rare taxa.
- This area has a long history of wild fires. Proactive fuel reduction strategies should be utilized in the area.
- Helicopter support was critical in controlling the fire.
- NRS should work with Army Range Control to keep a binder of maps showing rare resource location so they can provide to the first responders.

Jane Beachy/Joby Rohrer

Ecosystem Restoration Program Manager

Oahu Army Natural Resources Program

Manini/Alau Vicinity Fire Memorandum for Record

July 21-22, 2009

APVG-GWV (200-3) 5 August 2009

MEMORANDUM FOR RECORD

SUBJECT: Memorandum for record regarding Manini/Alau vicinity fire, July 21-22.

Background

NRS is not currently approved to engage in fire fighting activities due to insurance issues at RCUH. These issues are currently actively being worked on by Dr. Cliff Smith, Joby Rohrer and Dan Sailer. Hopefully this will soon be resolved. As a result of this restriction, NRS involvement was minimal and restricted to working in an advisory role and supporting aerial operations. The response from other agencies was commendable as Army Wild Land Fire was there both days working late as well as a large DLNR crew and HFD resources including both fire helicopters on July 21. Luckily no endangered natural resources were directly impacted, although designated critical habitat for six species burned (*Chamaesyce celestroides var. kaenana, Sesbania tomentosum,Centaurium sebaeioides, Schiedea kealiae, Cyperus trachysanthos)*. The fire burned with 95 m of the East of Alau population of *Chamaesyce celestroides var. kaenana*. This endangered plant population is designated as a “Manage for Stability” population by the Makua Implementation Plan and is therefore intensively managed by the Oahu Army Natural Resource Program (OANRP). As calculated by GIS the fire burned a total of 61 acres not considering topography. OANRP estimates the fire to be about 200 acres given the very steep terrain. There was a similar fire in the area in August of 2007.

Map removed to protect rare resources

Tuesday July 21, 2009

At approximately 3:30 pm Mike Walker radioed in from Ohikilolo Ridge in Makua Valley where his team was on the first day of a three day camping trip. He reported seeing a plume of smoke rising from the Kaena vicinity. He could not tell precisely where the smoke was originating. From the Schofield Barracks Base yard OANRP staff notified DLNR staff, Ryan Peralta (Oahu Protection Forester), Jason Misaki (Oahu Wildlife Biologist), and Brent Leisemeyer (Natural Area Reserves Manager). The Army's Wild Land Fire Crew was also notified. Both Mr. Peralta and the Army Wild Land Fire followed up with HFD. Army Wildland Fire responded rapidly deploying from their Area X base yard within approximately twenty minutes from the initial conversation with OANRP. OANRP continued to get updates from Mr. Walker and reported the situation up the chain of command to Michelle Mansker (Army Natural Resource Manger) and PCSU (Pacific Cooperative Studies Unit). OANRP received permission to respond to the incident in an advisory mode to assist with resource maps and help determine the threat to recourses. At a little after 4 pm Senior Natural Resource Coordinator Mr. Joby Rohrer and Natural Resource Coordinator Mr. Dan Sailer responded to Kaena with maps to assist with efforts and help size up the fire.

Mr. Rohrer and Mr. Sailer arrived at the Manini/Alau vicinity around 5 pm. They tied in with Mr. Peralta and Mr. Scott Yamasaki (Army Wild Land Fire Section Supervisor) and got briefed by the HFD Incident Commander (IC). The fire had already completed its initial run through the hot flashy fuels in the area. Both HFD helicopters were already making bucket drops and continued until the end of the day. OANRP advised both the HFD and Wild Land crew of the fire's proximity to the *Chamaesyce* site. Crews focused on the area closest to the endangered plants to ensure that the fire would not begin to spread actively toward the plants. OANRP began to call helicopter resources to determine availability. There were no privately contracted helicopters available that afternoon and HFD had good coverage with their air resources.

OANRP stayed on site with crews until 9:30 pm. As the area darkened it became apparent that although there were no active flames there were numerous hot spots across the area and the chance of active fire behavior that night or the next day was good. The crew debriefed and made plans for the following day.

Personnel	Time	Total
JR, DKS	4:00-9:30	11 hours

C. celestroides var. kaenana at Kaena point

Wednesday July 22, 2009

On Wednesday July 22 OANRP were on scene at 6:15 am. Mr. Peralta was already conducting an aerial site assessment with HFD and two other DOFAW staff were also on site. A determination was made by Mr. Peralta and HFD that contract helicopter support would be called in and fire department helicopter support would be on standby. After the assessment Mr. Rohrer and DOFAW staff Mr. Mateo where assigned as lookouts on the road below the fire. DOFAW Oahu Division Supervisor Mr. Dave Smith also assumed supervision of all DOFAW staff on scene. Army Wildland Crews were soon on the scene and continued mop up activities initiated the previous afternoon. Mr. Yamasaki had split the crew and sent additional resources to manage the top perimeter of the fire given the close proximity to the FAA tracking station. DOFAW crews also came out in force with all branches represented (NARS, Forestry, Wildlife, Na Ala Hele, and OISC staff).

Pacific Helicopters arrived on scene at 8:35 am and did a short reconnaissance flight, then shut down to configure a Bambi fire bucket. At 9:30 am bucket drops began until 10:40 am when the ship left to refuel. Pacific returned at 11:35 and quickly continued to drop water. The pilot took a short lunch break around 12:30 pm then continued dropping until about 1:15 pm. Bucket drops were coordinated by on the ground spotters from both DOFAW and Army Wild Land Fire as well as OANRP staff on the road. At 2:10 pm Paradise Helicopters was on scene and began bucket drops. There was some difficulty with the helicopter's remote switch and the ship was switched out at 3:30 pm. Drops resumed at 3:40 pm and continued until 5:15 pm when an aerial recon was performed with DOFAW, Wild Land Fire, and OANRP staff.

OANRP staff on the fire included Mr. Rohrer who reported at 6:15 a.m., Mr. Sailer who reported at about 10:30 a.m. with additional hoses and supplies request by Wild Land Fire, and Mr. William

Weaver who reported at 8:45 a.m. with two DOFAW buckets from the Paradise Helicopters hanger. Mr. Sailer and Mr. Weaver stayed on scene until 3:30 pm. Mr. Rohrer stayed on scene until 6:00 pm.

Thanks to Mr. Yamasaki's and Mr. Peralta's aggressive aerial and ground attack, hot spots were quickly managed and monitored throughout the day and the fire never got a chance to become active again. All hotspots where managed efficiently and aggressively. Despite the steep terrain, the leading edge of the fire line was thoroughly checked by DOFAW staff and any hot spots were extinguished via mostly dry mop up methods. With heavy loads of light flashy fuels around and endangered plants extremely close OANRP fully supported the approach taken by the combined IC of Mr. Yamasaki and Mr. Peralta on July 22. It is OANRP's opinion that many times in the past fires were not attacked aggressively enough when they were in the mop up stage. Those fires were left to rekindle and rage again when effective management of latent hot spots is a much more effective strategy and in the long run saves effort and resources.

NRS Helicopter Resources

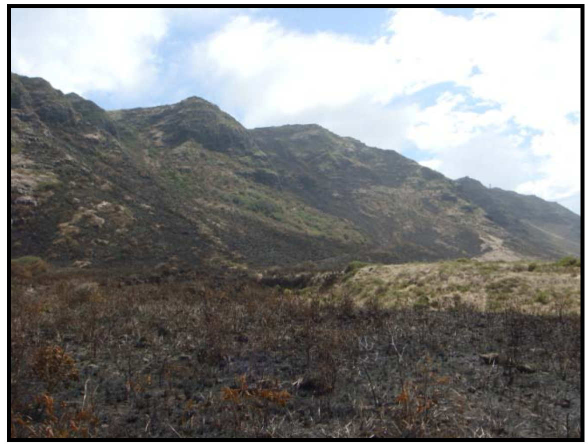
Company	Time	Total
Pacific (Howard)	8:35- 10:40 11:35-1:20	3 hours 40 minutes
Paradise (Calvin)	2:10 – 6:00 with some downtime	3 hours 30 minutes

NRS Personnel Resources

Personnel	Time	Total
JR	6:15-6:00	11 hours 45 minutes
DKS, WW	10:30/8:45	12 hours

Paradise Water drop

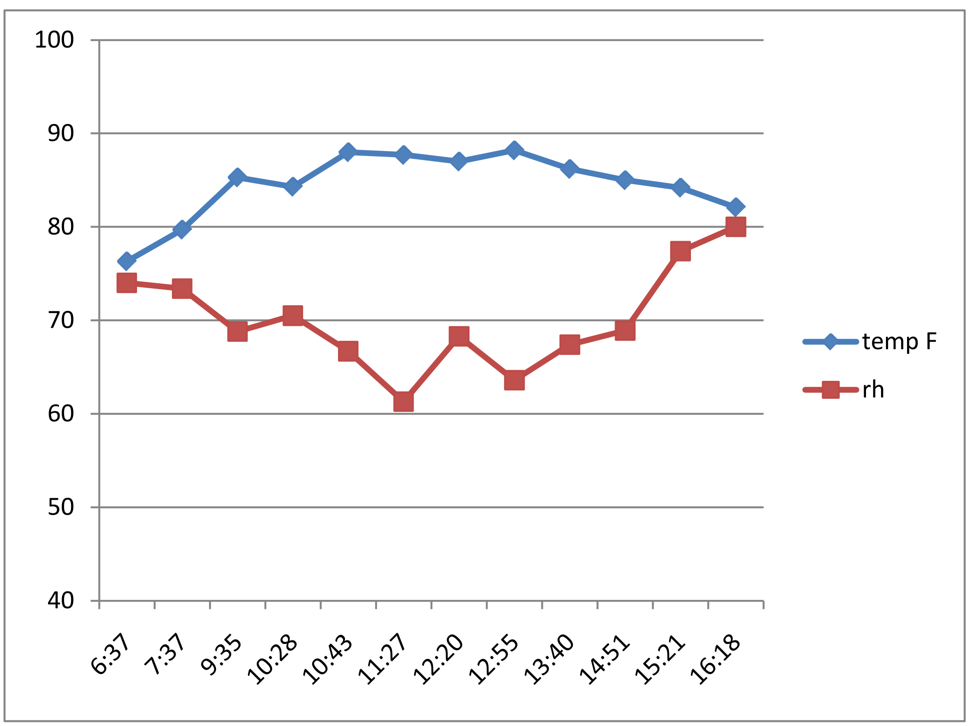
Suspected ignition point

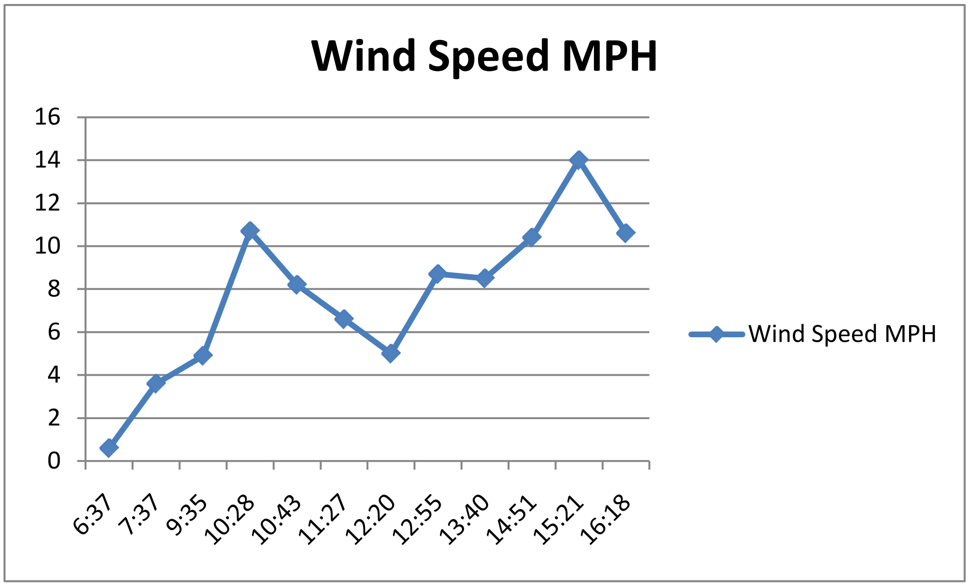


Burned area

To our knowledge, the HFD Fire Investigators were never called to the scene. The cause of the fire is officially unknown, but arson is suspected given the proximity to the road.

OANRP staff collected weather data as part of their lookout duties to advise the IC. The following graph depicts changes in relative humidity throughout the day.




Wind Speed MPH
16
14
12
10
8
6
4
2
0
6:37
7:37
9:35
10:28
10:43
11:27
12:20
12:55
13:40
14:51
15:21
16:18
Wind Speed MPH

The following is a partial list of Native and Alien plant species surveyed in the burn area.

Native Plant Species	Alien Plant Species
Dodonaea viscosa	*Acacia confusa*
Psydrax odoratum	*Andropogon virginicus*
Sida fallax	*Cenchrus ciliaris*
Waltheria indica	*Hyptis pectinata*
Erythrina sandwicense	Leucaena leucocephala
Myoporum sandwicense	*Melinus minutiflora*
Gossypium tomentosum	*Panicum maximum*
Plumbago zeylanica	*Pluchea symphytifolia*
Artemesia australis	*Rhynchelytrum repens*
Melanthera integrifolia	
Cocculus orbiculatus	

Lessons Learned and questions that need follow-up

- OANRP needs to work with PCSU to resolve insurance issues so staff can be involved in fire fighting activities. OANRP staff are a valuable resource in Wild land fires as most HFD crews are not familiar with wildland areas and native and endangered resources, and large numbers of trained personnel are needed for effective suppression operations.
- Kestral weather stations were extremely useful in tracking critical weather changes and predicting fire behavior.
- Operational fire buckets are essential during the peak fire season (April-October).
- Given the heavy recreational use of the Kaena Pt. area, fires can be expected in the area annually. Endangered species management plans may need to be changed to reflect this high fire frequency regime and the accompanying loss of native habitat.
- Contract helicopter support is critical to supplementing the efforts of HFD.
- The leadership under a joint IC of Mr. Yamasaki and Mr. Peralta is very efficient and effective.

Jobriath Rohrer

Senior Natural Resource Management Coordinator

Oahu Army Natural Resource Program

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<u>APPENDIX 3: FIRE MANAGEMENT NOTES</u>

<u>Dawn Greenlee Notes</u>

Waianae Mountains Kaluakauila, Waianae Kai, Honouliuli, Site Visits to Brainstorm New Fuelbreaks – March 11 and 12, 2009

All plans presented in these notes are preliminary and have, for the most part, not been discussed with landowners, action agencies, or regulatory partners

Site Visit Participants: Dawn Greenlee (USFWS), Andy Beavers (CEMML), Scott Yamasaki (Army FMO), and, on March 12, Ryan Peralta (DOFAW Oahu Protection Forester)

Kaluakauila: It may be possible to graze the guinea grass below Kaluakauila Management Unit on both the Keawaula and Makua sides (Figures 1 and 2). Areas with slopes less than 40 percent are targeted for grazing. If cattle were used, steep slopes may be sufficient to prevent cattle from impacting listed species. Strategic fences which may be necessary in less steep areas are shown in Figures 1 and 2. NRCS may be available to assist with fence and water source infrastructure design.

Figure 1. Targeted grazing areas to minimize fire threat to Kaluakauila MU

Figure 2. Kaluakauila – Keawaula Side

Map removed to
protect rare resources

Approximate costs of Fuel Pre-suppression Actions (D. Greenlee notes)

Management Action	Priority	Cost	Annual cost?	Project type	Notes
Install fuel break along ridge line. Fuel break 20-30 ft wide depending on terrain.	P1	10,000	No	Fuel break	**$110/month per acre based on Makua Grass cutting contract DOC.**
Maintain fuel break between one peak north of 1737 and the peak at 1673 along the main ridge dividing KMU from Makua and Punapohaku via spraying with backpack sprayers.	P1	$2,500	Yes	Fuel break	**$110/month per acre based on Makua Grass cutting contract DOC.**
Develop helicopter landing zones along main Kaluakauila ridgeline	P1		No	Infrastructure	
Maintain helicopter landing zones	P2		Yes	Infrastructure	
Mark fenceline with cyperstakes on the western boundary where fires burn from Keawaula. with reflective tape so it is visible by helicopter crews from the air. Along chimney and above grassy bowl.	P1	$2,000	No	Infrastructure	
Construct chainlink fence to deter arsonists	P2	200K	No	Infrastructure	Based on two quotes from chainlink contractors
Install artificial surveillance cameras along chainlink fence at the base of Kaluakauila Drainage.		$20,000			
Control fuel along newly installed chainlink fenceline	P2	$4,000	Yes	Fuel modification	30 ft wide x .8 miles long=3 acres x $110/month/acre
Revegetation of grassy bowl with Mango	P3		No	Fuel modification	For FWS, very long term and costly!
Spray grassy bowl between upper and lower forest patches with herbicide via a helicopter ball sprayer in preparation for planting mango.	P3	100K	No	Fuel modification	For FWS, very long term and costly!
Maintain grass control in grassy bowl around plantings.	P4			Fuel modification	For FWS, very long term and costly!
Orient fire response crews to KMU and priority response areas.	P1	5,000	No	Infrastructure/ Communication	Helicopter time

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APPENDIX 4 CHAPTER 4 APPENDICES

Appendix 4 contains supplemental information for Chapter 4. Contents of Appendix 4 include

- Appendix 4-1: Implementation Team Handout March 2009
- Appendix 4-2: Report to U.S. Army Garrison, Year 3, M. Meyer, July 2008
- Appendix 4-3: Black rat (*Rattus rattus*) predation on nonindigenous snails in Hawaii: Complex management implications, Meyer and Shiels, 2009
- Appendix 4-4: Application of harmonic radar technology to monitor tree snail dispersal, Hall and Hadfield 2009
- Appendix 4-5: Ecology of introduced rats (*Rattus* spp.) and their impacts on Hawaiian plants, A. Shiels 2009

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APPENDIX 4-1: IMPLEMENTATION TEAM HANDOUT MARCH 2009

Annual Army Tree-Snail Meeting
3/3/2009
Kevin Hall
kthall@hawaii.edu

Mark-Recapture Discussion Outline

- **Lincoln-Peterson estimators**
- **Practical example**
- **Assumptions of closed models**
- **Defining populations**
- **Full August 2008 protocol**
- **Deviations from protocol**
- **Marking: glue vs. paint**
- **Surveying: entire site vs. random quadrats**
- **Effort: 2 days vs. 3+ days**
- **Which deviations to use, and why**
- **Final notes & Discussion**

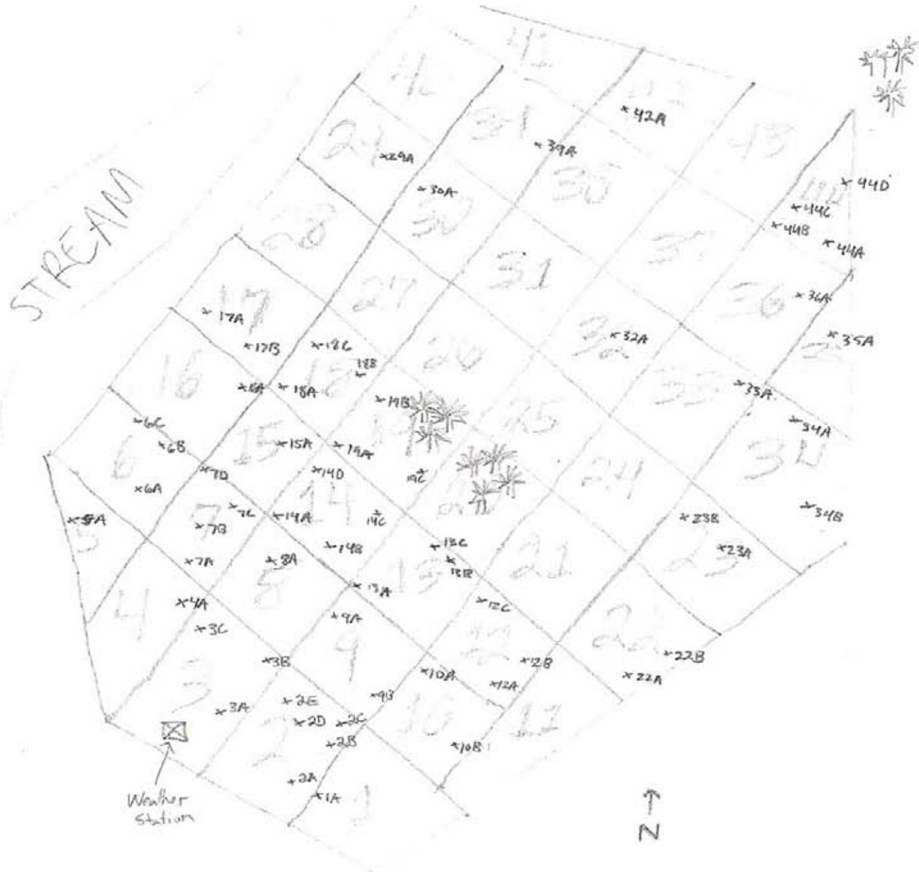
Table 1. Comparisons of deviations (*italics*) to various aspects of August 2008 protocol

	Variation	Advantages	Disadvantages
Marking	Glue method	Durability, additional data available	Time Consuming, training required, more snail handling
	Paint method	No training required, limited handling, fast	Mark deterioration, precludes long-term analyses
Surveying	Entire site	Consistency, fewer assumptions, tested method, easy planning	Understory impact can be high, lower capture probability
	Random quadrats	Understory impact reduced, higher capture probability	Lots of assumptions, protocol adaptive and untested
Effort	2 days	Less work, understory impact may be less	Lower statistical resolution, need more snails per survey
	3+ days	Greater statistical resolution, fewer snails required per survey	More work, understory impact may increase, lots of markings required (paint only)

Table 2. Snail site classification scheme and associated management recommendations

Understory	Terrain	Example site*	Recommendations
Absent	Easy	Kahanahaiki	No change from August 2008 protocol
Absent	Difficult	Poamoho	Add 3rd survey day
Present	Easy	Opaeula	Substitute random quadrats
Present	Difficult	Palikea	Add 3rd survey day, substitute random quadrats

-Difficult terrain results in lower capture probabilities, so additional data is needed.
-Understory presence requires minimizing impact, so random sampling is recommended.



1A: 40H
2A: 64H
2B: 51H
2C: 62H
2D: 18H
2E: 61H
3A: 17H
3B: 55H
3C: 05H
4A: 04H
5A: 47H
6A: 58H
6B: 08H
6C: 13H
7A: 19H
7B: 38H
7C: 11H
7D: 12H
8A: 60H
9A: 46H
9B: 06H
10A: 65H
10B: 20H
12A: 45H
12B: 16H
12C: 36H
13A: 39H
13B: 28H
13C: 27H
14A: 29H
14B: 38H
14C: 41H
14D- 03H
15A: 63H

16A: 33H
17A: 32H
17B: 42H
18A: 07H
18B: 15H
18C: 10H
19A: 02H
19B: 14H
19C: 01H
22A: 56H
22B: 48H
23A: 57H
23B: 49H
29A: 37H
30A: 09H
32A: 53H
33A: 52H
34A: 59H
34B: 21H
35A: 54H
36A: 50H
39A: 31H
42A: 22H
44A: 25H
44B: 44H
44C: 42H
44D: 43H

Report to the U.S. Army Garrison Hawaii

Attn: Kapua Kawelo

Feeding ecology, microhabitat utilization, population size estimates, and possible control of the introduced predatory snail *Euglandina rosea* on Oahu, Hawaii

Year 3: Distribution, movement and micro-habitat utilization of the introduced predatory snail *Euglandina rosea* in the Waianae Mountains, Oahu: implications for management

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Project period (Year 3): 08/01/07 – 07/31/08

Introduction to research (Year 3)

The purposeful introduction of the land snail *Euglandina rosea*, which feeds exclusively on snails, has been implicated as a major factor influencing the decline of the native Hawaiian land snail fauna (Hadfield 1986, Cowie 2001). It was introduced to Hawaii in 1955 to control populations of another introduced snail, *Achatina fulica*, the giant African snail (Davis & Butler 1964, Simberloff 1995). However, *E. rosea* has not reduced *A. fulica* populations (Civeyrel & Simberloff 1996, Cowie 2001) but instead has been associated with the decline of many native land snail species not only in Hawaii but throughout the Pacific (Murray et al. 1988, Griffiths et al. 1993, Cowie 2001, Coote & Loève 2003).

The native Hawaiian land snail fauna used to be extremely diverse (over 750 species) and exhibited extremely high endemism (over 99 %) (Cowie et al. 1995), but the majority of these unique species are now extinct (Cowie 1998, 2005), with estimates of extinction ranging from 65-75 % (Solem 1990) to as much as 90 % (Cowie 2002, Lydeard et al. 2004). For example, extinction of the tree snail species in the sub-family Achatinellinae has been catastrophic (Hadfield & Mountain 1980, Hadfield 1986, Hadfield et al. 1993). All the species in the genus *Achatinella* are listed as endangered with many species already considered extinct (USFWS 1981). Decline of these species in particular is probably related to their slow growth, the long time they take to reach reproductive maturity (3-5 yr), and their slow reproductive rate, which make them highly vulnerable to unnaturally high levels of predation by the introduced predatory snail *Euglandina rosea*, in addition to other predators such as rats and human shell collectors (Hadfield & Mountain 1980, USFWS 1981, Hadfield 1986, Murray et al. 1988, Hadfield et al. 1993).

Despite its reputation for having a major effect on the land snail fauna of Hawaii and elsewhere, relatively little attention has been focused on the biology of *E. rosea*, with the exception of efforts to understand aspects of its feeding ecology (e.g., Cook 1985a, b, 1989a, b, Griffiths et al. 1993). A large effort has been focused on studying the biology of the endangered Hawaiian tree snails (e.g., USFWS 1981, Hadfield & Mountain 1980, Hadfield et al. 1993, Holland & Hadfield 2002), but there remains a need to understand the basic biology of *E. rosea* in Hawaii in order that natural resources managers may better design conservation strategies for the few extant native snail species left in the islands. Although the prognosis is rather gloomy, some land snail species are still extant, and control of *E. rosea* may be possible with adequate ecological information.

The objective of the work reported here was to understand the distribution, movement and microhabitat preference of *E. rosea* on a small spatial scale, i.e., within one gulch in the Waianae Mountain range on the island of Oahu. Abiotic (temperature and humidity) and biotic (prey densities) factors were monitored, and the distribution and movement patterns of *E. rosea* were determined from surveys and the use of two tracking techniques. The Waianae Mountains are of special conservation concern as they harbor many endangered and threatened land snail species, most of which are found at upper elevations near the ridges (Hadfield 1986, Hadfield et al. 1993, Holland and Hadfield 2002, Meyer 2006). Understanding how *E. rosea* is distributed across this landscape and how far it moves will help managers determine the scale on which control measures should be implemented, while understanding how *E. rosea* uses microhabitats within its range will help managers determine which snail species are likely to be the most threatened and where traps or searches that aim to trap/catch *E. rosea* as part of a control effort should be focused.

Methods

Study site

All work was conducted in Kahanaiki gulch starting on February 1, 2007 and ending June 16, 2008. Kahanahaiki gulch is on the north west side of the Waianae Mountains on Oahu (N 21^{o} 54.205′, W 158^{o} 19.646′). It has steep cliffs that rise roughly 80-150 m from the bottom of the gulch to the ridges either side. The two ridges have opposing aspects; one faces mostly northward and the other faces southward, and each are ~ 550 to 750 m in elevation above sea level. The vegetation is mixed with both native and invasive species present. The introduced strawberry guava (*Psidium cattleianum*) is the most abundant tree in the gulch, but native trees such as ohia (*Metrosideros polymorpha*) and koa (*Acacia koa*) are present. The climate in the gulch is tropical with wet winters and dry summers (Juvick & Juvick 1998).

Abiotic characterization of Kahanahaiki Gulch

To record the abiotic characteristics of Kanahaiki gulch and examine differences in temperature and humidity among the gulch and the two ridges six Log Tag HAXO-8 temperature and humidity loggers were placed at six sites, two in the gulch and two just below both the south and north facing ridges. They were placed approximately 400 m apart along the gulch transect and along each of the ridge transects (Figure 1) and hung 0.25 m above the ground on the base of a tree in shady areas. They were left in the field from March 13, 2007 to June 16, 2008 and recorded data every 30 min. Daily maximum temperature and minimum relative humidity were used to compare temperature and moisture conditions in the gulch to those on the ridges.

Patterns of prey density

To determine patterns of prey densities in the gulch, 18 sites were surveyed for snails on four occasions (March 8-12, 2007, May 10-14, 2007, November 15-19, 2007, July 26-30, 2008). Surveys involved timed searches of the trees/shrubs and the use of beer traps (88 ml glass jars, 5.0 cm tall and 5.0 cm in diameter with a 2.5 cm diameter opening in the top, filled with beer) to trap ground-dwelling snail/slug species. Six sites were in the gulch bottom and six were located 15 m below each of the north facing and south facing slopes (total 18 sites). At each site trees were surveyed for 10 min and ten beer traps were buried into the soil so the top was flush with the soil surface and were left for four days before collection. Each individual snail/slug collected was counted and identified to species except in the case of the ‘tornatellinids’ (small Achatinellidae in subfamilies other than Achatinellinae), which were just recorded collectively.

A two-factor ANOVA was used to test for differences in prey density among the gulch, south facing slope, and north facing slope sites. The fixed variable was location (gulch, south facing slope, north facing slope). The other, random variable was the four collection dates.

Movement patterns and microhabitat selection

Both movement patterns and microhabitat preference were characterized by attaching a bobbin to the snail’s shell and the end of the line to a stationary object at the initial tracking point (see Murphy 2002). This technique allowed us to follow the trails of individuals as they moved through different microhabitats through time for the duration of this experiment (March 29, 2007 to July 17, 2007). Adult *E. rosea* were fitted with a size 40-8-20 nylon thread bobbin from Imperial Threads™. Each bobbin was wrapped in Parafilm© and enough line was pulled from the bobbin until it weighed less than 0.5 g (or < 10% of the weight of an adult *E. rosea*). Bobbins were glued to the shells using SuperGlue©. The end of the line was attached to a dowel in a cement base. The line was tied and taped to the dowel. Eight *E. rosea* were tracked successfully (> 14 days). Twelve *E. rosea* were not tracked successfully (< 14 days), mostly because the line was broken, and are not reported on here. Many of these failed attempts seemed to be caused by rat predation (see Meyer and Shiels in prep for an analysis of rat-snail interactions in this area). After the line breaks, as happens when rats prey on snails and if people step on the line, it is difficult to find the snail again. However, one snail was relocated after 21 days. The experimental sites were visited once a week following attachment of bobbins to the snails.

Movement Patterns: To describe movement patterns of *E. rosea*, five measurements related to their movement were recorded for each individual on each observation occasion: 1) linear distance from initial release point, 2) compass angle from initial release point, 3) linear distance from point at which snail was most recently previously recorded, 4) compass angle from point at which previously recorded, and 5) total distance traveled (the length of line pulled from the spool).

Microhabitat Preference: To determine microhabitat preferences, the microhabitat used by each snail was categorized (see below) at points every 0.75 m along the line left by the snail and compared to the relative prevalence of the different microhabitats overall, as assessed by taking measurements at 1 m intervals along four transects that were run on randomly chosen compass headings from the point of initial release for a distance corresponding to the furthest linear distance moved by the particular snail from its initial release point. If at least 24 points were not scored along these four transects, additional transects were surveyed until the number of microhabitat data points equaled or exceeded 24. Also, the microhabitat type in which the snails were found was recorded. Almost all snails were inactive when found suggesting that they move at night. When following the line left during the movement of each individual, at each point whether the snail was using arboreal or ground level habitats was first recorded. If this point was in an arboreal habitat (trees and shrubs), the height above ground and species of plant was recorded and the plant was searched for potential prey. If the point was on the ground, then the microhabitat was recorded as one of the following: 1) wood, consisting of downed logs greater that 10 cm in diameter, 2) open, consisting of all areas, including rock and open soil, where the snail could be easily seen, 3) shrub/fern, consisting of all habitat with low shrubs or ferns up to 0.5 m from the ground and blocking sight of the ground, and 4) leaf litter, consisting of areas with a thick covering of dead leaves and twigs without the cover of shrubs and ferns. When assessing the proportion of these microhabitats only ground level microhabitats were included.

To estimate habitat preference of *E. rosea*, Jacobs' selectivity indices (Jacobs 1974, and used by Sugiyama and Goto 2002) were calculated using the following formula:

$D_{ia} = (r_i - p_a) / (r_i + p_a - 2\, r_i\, p_a)$

where D_{ia} is the selectivity index of individual i for microhabitat a, r_i is the ratio of microhabitat type a use to all the other microhabitat types used by the individual, and p_a is the ratio of microhabitat a to all the other microhabitats available for the individual to use within the local area. As described above, r_i is determined for each snail by recording the microhabitat type at 0.75 m intervals along the path of each snail's trial, as determined from the line left from the bobbin, and p_a is determined from the data gathered at 1.0 m intervals along the four or more transects. If the individual preferentially uses a certain microhabitat the D_{ia} score will be positive, if it avoids a microhabitat the D_{ia} score will be negative.

In addition, the microhabitat at the point where each snail was found during the bobbin experiments (as opposed to the points 0.75 m apart along its trail, as recorded by the thread) was also recorded, and presumably reflects the snail's day time microhabitat preference. These preferences were also assessed using Jacobs' selectivity indices. For day time microhabitat preferences data recorded for all individuals were combined. There should be more than three times the number of observations than micro-habitats (Krebs 1999), and for most individuals (6 of 8) day time resting microhabitat type was recorded less than five times.

Distribution and population density (mark-recapture study)

Surveys for *E. rosea* in Kahanahaiki gulch combined with mark-recapture experiments were conducted from August 1, 2007 to June 16, 2008 to understand better the distribution and abundance of *E. rosea*. The seven transects (Figure 1)were surveyed twice monthly. A transect was surveyed through Kahanahaiki gulch (551 m), along each of the ridges (~ 570 m), and four transects from the bottom of the gulch to the ridge on both sides (north-facing: 88 and 150 m; south-facing 101 and 152m). On each transect the researcher moved slowly scanning an area extending roughly 2 m on either side. When a snail was found, it was individually marked by 1) writing an identifying number on the shell with a Deco-color© paint pen, and 2) printing a number on Rite in the Rain© paper and gluing it to the shell using Satellite City Super-t© glue. Shell length, measured to the nearest 0.1 mm, and the location of the snail were recorded. When a marked snail was recaptured the distance from the location at which it was last recorded was measured. Average weekly distance moved was calculated based on the number of days between each record for each snail.

A Mann-Whitney U test was used to assess if there were differences in the distance moved by snails tracked with bobbins and those tracked by mark-recapture. Potentially, the weight and extra size of the bobbins could have limited movements (H_o = average distance moved by snails tracked by mark-recapture methods were not greater than those moved by snails tracked using the bobbins).

Unfortunately, recapture rates were too low to permit an accurate estimate of the population density in the gulch. Only the data on distances moved could be used. A t-test was used to compare the linear distance moved per day by *E. rosea* with and without bobbins.

Results

Abiotic characterization

The gulches are typically cooler and more moist than either of the two ridges (Figure 2). However, the site located on the lower portion of the north-facing slope had similar temperatures and humidities to those at sites within the gulch.

Patterns of prey density

At least six possible prey species were collected during these surveys. These included four invasive species (*Limax maximus*, *Deroceras leave*, *Meghimatium striatum*, and *Paropeas achatinaceum*), and the native *Philonesia* sp. and the 'tornatellinids'. Most of the potential *E. rosea* prey snails were found at sites within the gulch (Table 1).

Movement patterns and microhabitat selection

Movement Patterns: Movement patterns were variable among individuals. Most snails (6 of 8) including the two snails tracked for over 60 days stayed within 10.0 m of the initial start point and had mean weakly linear distances moved from the initial starting point of less than 2.5 m(Table 2). The other two snails moved 13.5 and 41.0 m in linear distance from the initial starting point in 19 and 15 days respectively. Regardless of distances moved, all snails stayed in the gulch bottom.

Five of eight individuals tracked using the bobbin method climbed trees (up to 2 m above the ground). Eleven of the twelve trees climbed were strawberry guava (*Psidium cattleianum*) and there were snails ('tornatellinids') found in each strawberry guava tree climbed. The other tree/shrub climbed was an invasive *Melastoma*, and no potential prey snails were found in it.

Microhabitat Preference: The microhabitat preferences of the eight *E. rosea* tracked were estimated using the Jacobs' index of selectivity. In the leaf litter microhabitat, selectivity indices were positive for all individuals, suggesting that this microhabitat was preferred, since it was used more frequently than expected by random (Figure 3). Selectivity indices were negative in open and fern/shrub microhabitats for all individuals. Results for the wood microhabitat were mixed suggesting no overall preference.

Leaf litter was preferred during the day (Figure 4), as it was the only microhabitat that had a positive selectivity score.

Distribution and population density (mark-recapture study)

Twenty-nine live *E. rosea* (29.1 to 50.1 mm in shell length) and 56 shells (30.2 to 46.3 mm in shell length) were collected from August 1, 2007 to June 16, 2008. All but one of the live snails were collected along the gulch transect. The one other live snail was found near the north-facing ridge at the lower end of the gulch where temperature and humidity were similar to those in the gulch (Figure 2). Also, most of the shells were found in the gulch (46) and on the transect from the gulch to the lower north-facing slope (8). No live *E. rosea* or shells were found on either of the ridges.

Of the 29 snails that were marked, five were recaptured (one was recaptured twice) (Table 3). The low capture rate (many field trips resulted in no sightings) and few recaptures make estimating the population size within the gulch with any level of accuracy impossible.

Straight line distances moved ascertained from recaptured snails are similar to those determined by tracking snails using bobbins (Table 3). No significant differences were found between the movements of individuals tracked using mark-recapture and bobbin techniques ($z = -0.36$, $p = 0.64$).

Weekly growth (increase in shell length) of these five snails averaged 0.31 mm/week (range 0.0 – 0.55 mm) (Table 3).

Discussion

This is the first study in Hawaii of the distribution, movement, and habitat use of one of Hawaii's worst invasive species, *Euglandina rosea*. While land snail species had begun to disappear before 1900 (Burney et al. 2001), the rate of extinction accelerated greatly after the introduction of *Euglandina rosea* (Hadfield et al. 1993), and much of what remains of the unique Hawaiian land snail fauna is threatened (Solem 1990, Cowie 2002). As such, it is surprising that so little is known about the basic biology of *E. rosea*, other than its feeding ecology (Cook 1985a, b, 1989a, b, Griffiths et al. 1993).

Understanding how *E. rosea*, native snail species, and non-native prey species are distributed across a mountain range and at smaller scales, e.g. within a gulch, is important to understanding how *E. rosea* may impact the remaining native snail populations. Endangered native tree snails, *Achatinella* spp., are typically found on ridges (Holland and Hadfield 2002), as are other snails such as endodontids and helicinids that are less studied and are probably reduced to sparse isolated populations (Lydeard et al. 2004, Meyer 2006). Previously, some extant species, e.g., *Achatinella mustelina*, currently found on ridges, did extend to lower elevations (Hadfield et al. 1993). However, this study demonstrated that *E. rosea*, other non-native prey species, and native tornatellinids are found in much higher densities in the gulch than on the ridges. As such, gulches with dense non-native prey that seem to maintain populations despite *E. rosea* predation may act as reservoirs supporting thriving *E. rosea* populations. Occasionally an individual *E. rosea* may move to a ridge where they are more likely to interact with the endangered Hawaiian tree snails. This may be a consequence of random movement or a change in conditions. Any prolonged change in weather (ridges cooler or wetter) or prey abundance (increases on the ridge or decreases in the gulch) may facilitate the movement of *E. rosea* to the ridges. The only live *E. rosea* found outside the gulch was recaptured in the gulch and all snails tracked during the study using the bobbin technique stayed in the gulch bottom despite the distance moved suggesting that movements towards the ridge are rare.

Understanding the ecological factors that impact the distributions of organisms is important in determining the effect of a species across a landscape. Prey abundance (as described above) and abiotic conditions may be important factors influencing *E. rosea* populations. Both are strongly correlated here. In the gulch where it is cooler and more moist (Figure 1), higher densities of snails/slugs are present, including *E. rosea*. The one area outside the gulch (lower north-facing transect) where abiotic conditions were similar to those in the gulch also exhibited elevated densities of prey and evidence of *E. rosea* (one live snail and eight shells). Areas such as these may act as corridors permitting *E. rosea* to ascend the ridges and thereby connecting *E. rosea* populations in adjacent gulches. Conversely, since predators are known to move to areas with the highest prey densities (Fauchald & Tveraa 2006), areas with low prey densities may act as dispersal barriers since predators may remain in areas where food capture requires less effort. Visual recognition of these areas is difficult, but monitoring of abiotic conditions and prey densities could be used to identify these areas in the gulch.

The distance and direction a species moves influences the scale and areas where management will be the most effective. Movement patterns were variable among individuals, but were not related to the tracking technique used ($z = -0.36$, $p = 0.64$). Observations of movements over distances greater than 20 m were observed in three of the 13 individuals tracked, but in general this study indicates that most (10 of 13) *E. rosea* rarely move further than 10 m over a period of one month and less than 2.5 m in linear distance from initial starting point in a week (Table 2, 3). Regardless of the distance snails moved, snails stayed within the gulch. For instance, all snails tracked using the bobbin technique stayed in the gulch bottom. Four of the five individuals recaptured were marked and recaptured in the gulch bottom. The other snail recaptured during the mark recapture study was found near the north-facing ridge at the lower end of the gulch where temperature and humidity were similar to those in the gulch, but was recaptured in the gulch. These results indicate that efforts to control *E. rosea* in small areas near endangered snail species and in the adjacent gulch may successfully reduce *E. rosea* predation.

Understanding how a predator uses microhabitats within its range will help managers determine which species are likely to be the most threatened and where traps or searches that aim to trap/catch an alien predator as part of a control effort should be focused. The data indicate that *E. rosea* prefers dense leaf litter to open and fern/shrub microhabitats (Figure 3). Leaf litter was also the preferred microhabitat during the day (Figure 4). *Euglandina rosea* is generally most active during the night (personal observation) and these sites may represent day time shelters. The results for wood habitat are mixed. I often see slugs (potential prey items) in this microhabitat, but the distribution of slugs in downed wood may be patchy leading to varied preference indices for different individuals at different locations.. However, wood was not a preferred day time habitat (Figure 4). Leaf litter is more dense in the gulch than on the ridges, which may also contribute to the lower *E. rosea* densities on the ridges. These data suggest that litter dwelling snails are at the greatest risk of being preyed on by *E. rosea*. Many of the native snails associated with the litter, such as endodontids, are rare, and if not extinct, probably reduced to small isolated populations (Lydeard et al. 2004). In addition, the data suggest that leaf litter is the best place to focus search efforts for *E. rosea*, and that creating litter free barriers may reduce *E. rosea* intrusion into areas of high conservation concern.

Leaf litter may be preferred for many reasons, including 1) higher prey densities, 2) higher moisture retention, which reduces desiccation, and 3) avoidance of predators. Assessment of prey density according to microhabitat was attempted using the beer trap data from the different microhabitats at the various sites, but the variance was high and no significant pattern was detected. Desiccation is probably a major factor determining microhabitat selection (Cowie & Jones 1985, Arad et al. 1993, Copley 2000). However, the shrub/fern habitat was avoided (Figure 2, 3) despite the high likelihood that this microhabitat can retain substantial amounts of moisture. Visual predators can affect prey distributions (Cain & Sheppard 1952). In leaf litter, *E. rosea* is extremely difficult to see since the red/brown shell matches the color of dead leaves (personal observation). Therefore, visual predators may have a much harder time finding *E. rosea* in leaf litter habitats. Data on microhabitat use by *E. rosea*, rats, and other introduced mammal species in the same gulch (mammal data currently being collected by Aaron Shiels) may allow assessment of whether these species use different microhabitats. Rats will prey on *E. rosea* (Meyer and Shiels attached). Currently, the impact of rats and other predators (see Hadfield 1986 for a review of snail predators) on *E. rosea*'s microhabitat preference is unknown.

Our understanding of how *E. rosea* uses arboreal habitats is still limited. However, it is a major concern considering the only listed land snail species in Hawaii are arboreal (USFWS 1981). Five of the eight snails tracked climbed at least one tree while being tracked, and only one snail climbed a tree that did not have any snails on it. This demonstrates that trees and shrubs are used by *E. rosea*, but determining if *E. rosea* can ascertain that prey is present on the tree before it climbs it is difficult since a majority of the trees in the gulch have snails on them. However, considering *E. rosea* uses slime trails to locate prey (Cook 1985b), it seems likely that just one snail moving onto a tree from the forest floor may make all snails in that tree vulnerable to *E. rosea* predation for some period of time. Further work is needed to understand the trade-off of *E. rosea* choosing arboreal or ground habitats to search for prey. Of course, behavior may change depending on where *E. rosea* is found. For instance, do the lower prey densities on the ridges lead to *E. rosea* spending more time searching aboreal habitats for prey in such areas?

The data did not allow us to make population density estimates for *E. rosea*. Twenty-nine *E. rosea* were captured and new individuals were continuously being recaptured at the end of the research period. It is difficult to find and/or trap *E. rosea* in the field, and accurate assessments of the *E. rosea* populations may only be possible with new innovative techniques, such as the proposed method of using dogs to find snails by scent. However, it is clear that large populations probably exist in the gulches of the Waianae Mountains on Oahu as *E. rosea* is also much easier to find in other gulches (personal observation). Control of these populations requires focused effort in gulches adjacent to ridges where native snail populations are present.

Implications for management and control

This study indicates that efforts to control *E. rosea* in areas where small populations of native snails remain may be possible. Movements of *E. rosea* were variable, but generally the results suggest that *E. rosea* rarely moves more than 10.0 m per month. Therefore, if an effective method to locate or trap *E. rosea* was developed, then barriers ~ 10 to 20 m around areas with endangered land snails searched/trapped monthly would potentially limit encroachment of *E. rosea*. Additionally, effective control methods should be used in adjacent gulches where the highest densities of *E. rosea* are found. Prey densities and temperature/humidity data may be useful ways to predict corridors that *E. rosea* may use to move to ridges and thus where search efforts would be the most effective in preventing *E. rosea* from reaching the ridges. Leaf litter is the preferred microhabitat of *E. rosea*, and is a major component of Oahu mountain habitats and is extremely important for many ecosystem processes. However, degradation or removal of this key microhabitat may significantly alter the behavior of *E. rosea*. For instance, a litter free barrier may be effective in preventing encroachment of *E. rosea*, although, there are probably many other factors that may also have to be altered to make such a barrier effective.

Because of the consequences of the introduction of *E. rosea*, it is important to understand the biology of this species. Only through such studies can informed decisions be made regarding which control methods might be successful. It is our hope that this report provides impetus for other researchers to explore more aspects of *E. rosea* biology other than just the feeding ecology as it may provide insights into better control of this species and protect the remaining land snails in Hawaii and the Pacific.

Table 1: Numbers of possible prey items collected at six sites in each of three areas in Kahanahaiki gulch (NF = north facing ridge, SF = south facing ridge, G = within gulch) on four occasions. A two-factor ANOVA tested for differences in prey numbers among habitat types and on the four collection occasions.

Taxon	NF	SF	G	Source	p-value
‘tornatellinids’*	17	12	343	location	< 0.001
				time	0.505
				location x time	0.129
Limax maximus	65	47	251	location	< 0.001
				time	0.610
				location x time	0.806
Deroceras leave	24	10	157	location	0.035
				time	< 0.001
				location x time	< 0.001
Meghimatium striatum	1	2	4	NA	
Paropeas achatinaceum	0	0	2	NA	
Philonesia* sp.	1	0	1	NA	

* indicates native

Table 2: Summary of movement patterns of the eight *E. rosea* tracked using the bobbin method.

	Date of Release	No. of days tracked	Mean linear distance traveled/week (m) from start point (± 1SD)	Ratio of maximum linear distance (m) moved to total distance moved from start point (ratio in fraction)	No. trees climbed (No. trees with snails)
***E. rosea* 1**	29-March-07	84	0.79 (± 1.25)	9.4 : 70.8 (0.13)	3(3)
***E. rosea* 2**	29-March-07	63	0.86 (± 2.21)	6.2 : 44.1 (0.14)	0
***E. rosea* 3**	11-April-07	15	0.94 (NA)	1.9 : 6.6 (0.28)	0
***E. rosea* 4**	3-May-07	28	0.10 (3.60)	3.1 : 28.2 (0.11)	2 (2)
***E. rosea* 5**	3-May-07	19	4.93 (1.90)	13.5 : 77.2 (0.17)	5 (5)
***E. rosea* 6**	17-May-07	27	1.63 (6.10)	6.1 : 24.3 (0.25)	1(0)
***E. rosea* 7**	2-July-07	22	2.18 (5.38)	9.6 : 30.5 (0.31)	0

E. rosea **8**	2-July-07	15	25.21 (18.39)	41.0 : 88.7 (0.46)	1(1)

Table 3: Summary of movement and growth patterns of the five *E. rosea* tracked using mark-recapture methods. One snail was recaptured twice.

	No. days between sightings	**Linear distance (m) traveled**	**Linear distance (m) traveled / week**	**Increase in shell length (mm) / week**
***E .rosea* 1**	56	68.0	8.5	0.45
***E. rosea* 2**	98	24.4	1.7	0.55
***E. rosea* 3**	25	2.5	0.7	0.36
***E. rosea* 4**	58	16.0	1.9	0.18
***E. rosea* 5**	7	0	0	0

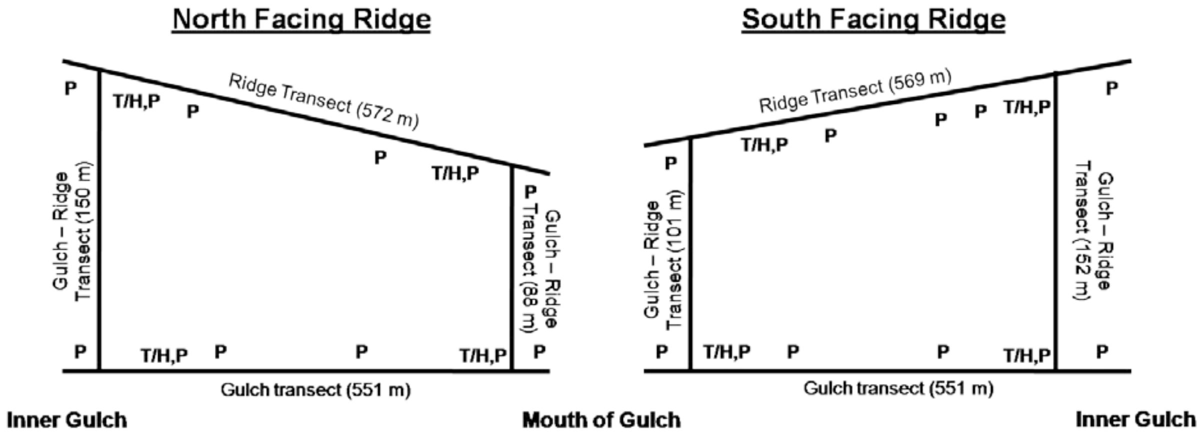

Figure 1: Schematic of research site in Kahanahaiki gulch, Oahu. Each line represents a transect. P represents locations surveyed for prey species and T/H represents locations where temperature and humidity data were collected.

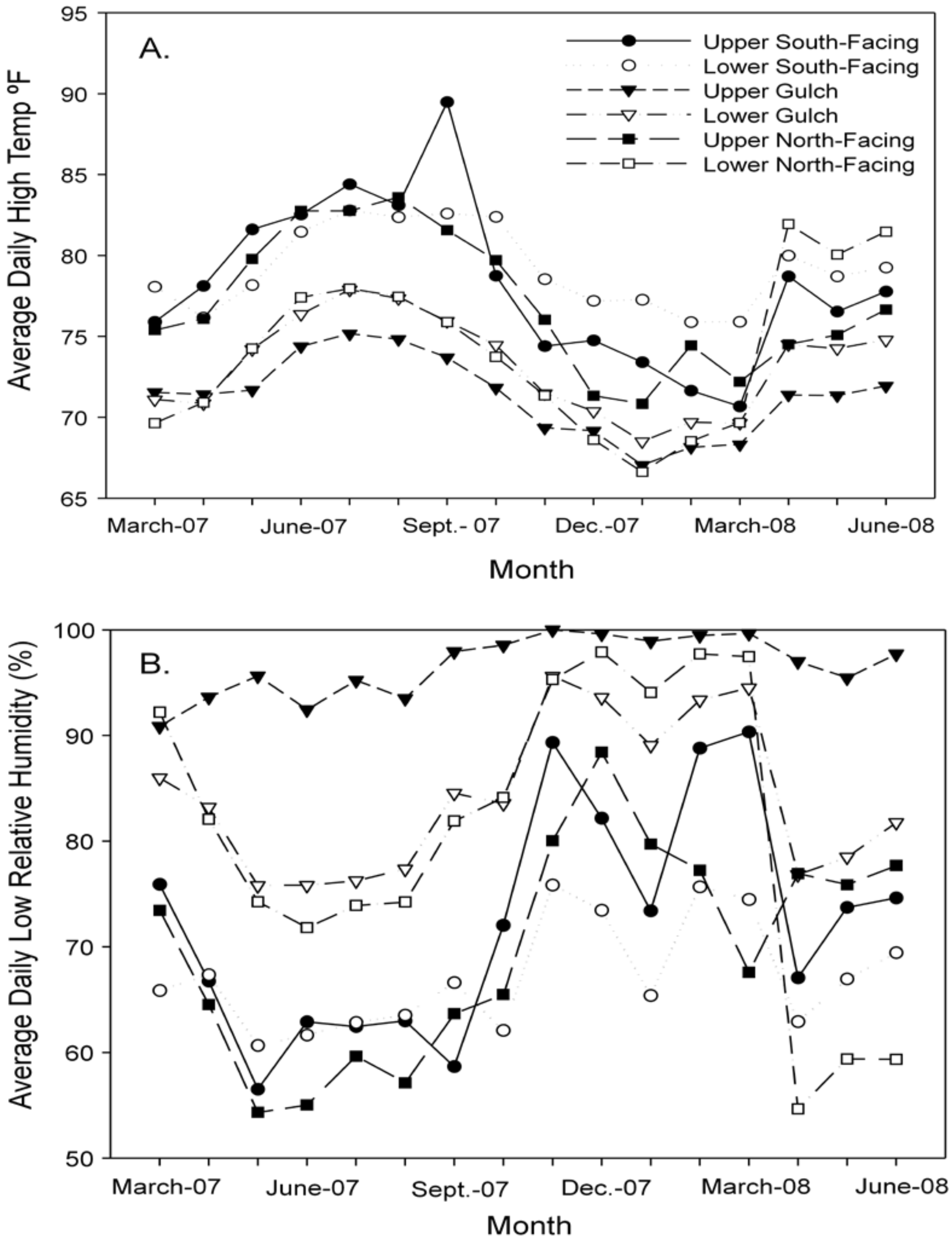

Figure 2: Average daily maximum temperatures and minimum relative humidity for six sites in Kahanahaiki gulch.

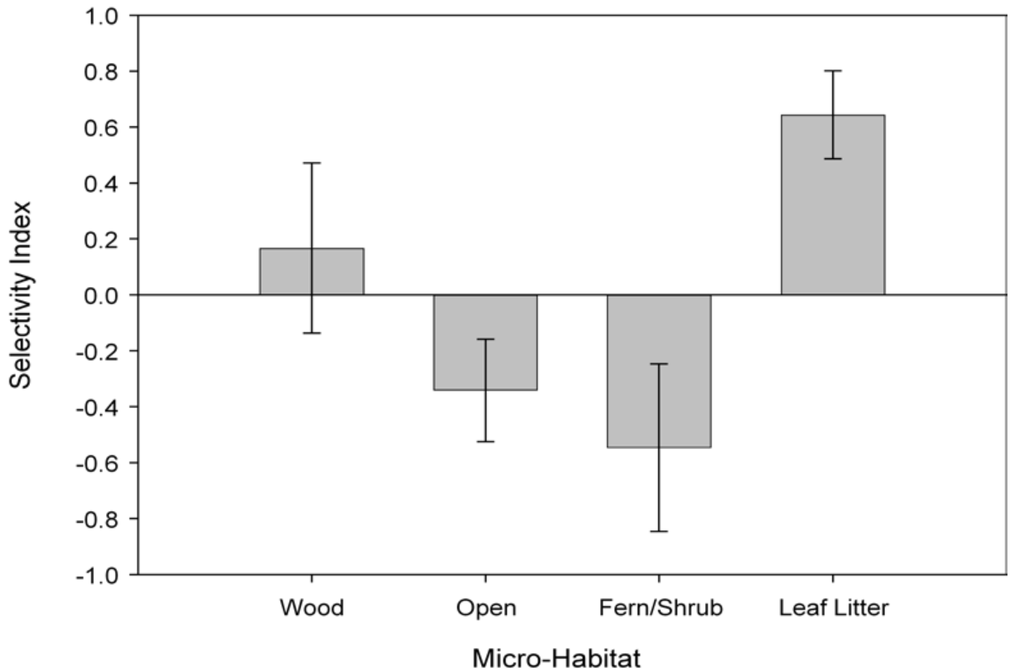

Figure 3: Microhabitat selection by eight adult *E. rosea* in Kahanahaiki gulch. Positive and negative values of the Jacobs' selectivity index indicate that different microhabitats were used more or less frequently, respectively, than expected by chance. Error bars equal ± 1 SD.

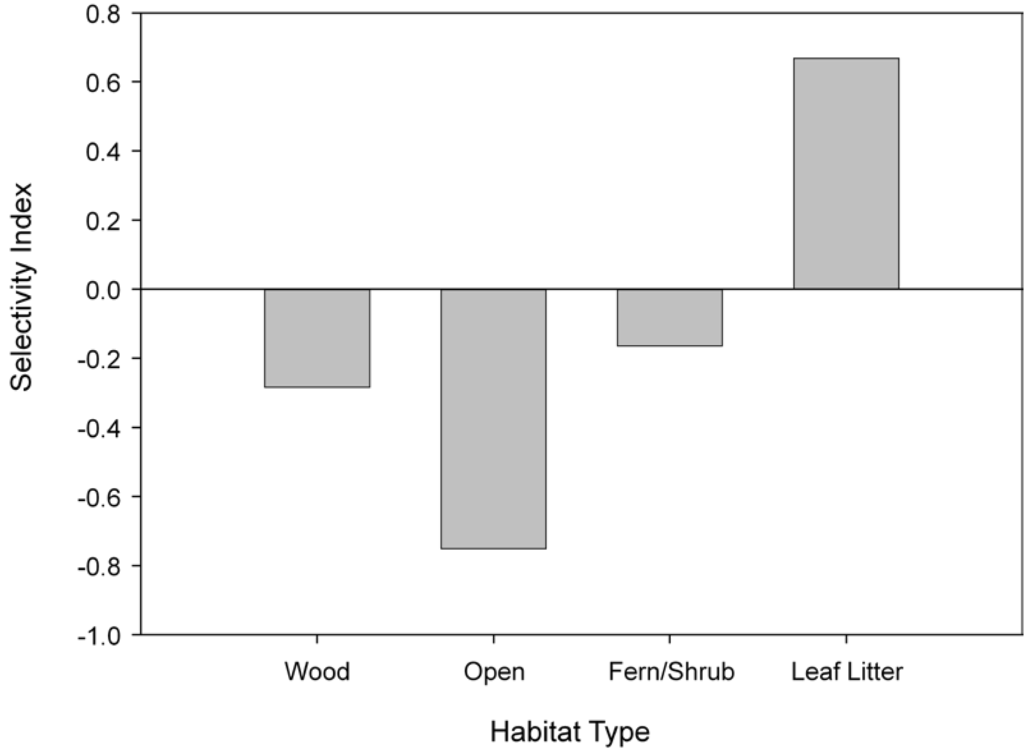

Figure 4: Day time habitat selection of eight adult *E. rosea* in Kahanahaiki gulch. Positive and negative values using the Jacobs' selectivity index indicate that different microhabitats were used more or less frequently, respectively, than expected by chance.

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APPENDIX 4-3: BLACK RAT (RATTUS RATTUS) PREDATION ON NONINDIGENOUS SNAILS IN HAWAII: COMPLEX MANAGEMENT IMPLICATIONS, MEYER AND SHIELS, 2009

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Black Rat (*Rattus rattus*) Predation on Nonindigenous Snails in Hawai'i: Complex Management Implications[1]

Wallace M. Meyer III[2,3] *and Aaron B. Shiels*[4]

Abstract: Understanding interactions among nonindigenous species that pose a threat to native species is crucial to effectively preserve native biodiversity. Captive feeding trials demonstrated that the black rat, *Rattus rattus*, will readily consume two of the most destructive nonindigenous snails, the giant African snail, *Achatina fulica* (100% predation), and the predatory snail *Euglandina rosea* (80% predation). Rats consumed snails from the entire size range offered (11.5 to 59.0 mm shell length), suggesting that there is no size refuge above which snails can escape rat predation. Damaged *E. rosea* shells from the captive feeding trials were compared with shells collected in the Wai'anae Mountains, O'ahu. This revealed evidence that *R. rattus* is responsible for at least 7%–20% of *E. rosea* mortality. However, this is likely a substantial underestimate because 67% of *E. rosea* shells in the captive feeding trials were damaged in such a way that they would not have been collected in the field. Therefore, we hypothesize that reduction or eradication of *R. rattus* populations may cause an ecological release of some nonindigenous snail species where these groups coexist. As such, effective restoration for native snails and plants may not be realized after *R. rattus* removal in forest ecosystems as a consequence of the complex interactions that currently exist among rats, nonindigenous snails, and the remaining food web.

Rapid population declines and species extinctions have been reported following the widespread introduction of nonindigenous species in Hawai'i (Burney et al. 2001, Athens et al. 2002). Human intervention is then often required for short-term recovery or maintenance of native biodiversity (Burney and Burney 2007). Unfortunately, insufficient understanding of both the magnitude of the threat that nonindigenous species pose to native biodiversity and the potentially complex interactions among the introduced species can lead to unexpected outcomes (Novacek and Cleland 2001, Doak et al. 2008). Given the large number of nonindigenous species that have altered Hawaiian ecosystems, understanding the interactions among nonindigenous species is crucial to effectively preserve the remaining native biodiversity.

Introductions of rats (*Rattus exulans* Peale, *R. norvegicus* Berkenhout, *R. rattus* L.) and terrestrial snails have been implicated in the decline of native Hawaiian flora and fauna (Hadfield 1986, Burney et al. 2001, Athens et al. 2002, Joe and Daehler 2008). All three rat species were introduced to the Hawaiian Islands by people and are among the most noxious invasive species on islands worldwide (Lowe et al. 2000, Russell and Clout 2004,

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Towns et al. 2006). The first rat species introduced to most islands in Polynesia, *Rattus exulans*, may have contributed to rapid forest decline and loss of animal species in Hawai'i (Burney et al. 2001, Athens et al. 2002). *Rattus rattus* and *R. norvegicus* became established in Hawai'i in the late 1700s after European arrival, and both *R. rattus* and *R. norvegicus* typically outcompete *R. exulans* (Lindsey et al. 1999, Russell and Clout 2004). *Rattus norvegicus* is more common in urban areas, and *R. rattus* is the most abundant rat species in conservation areas in the Hawaiian Islands (Lindsey et al. 1999; A.B.S., unpubl. data). Nonnative terrestrial snails were also brought to Hawai'i by humans and have established and spread in both urban and conservation areas (Cowie 1997). The giant African snail, *Achatina fulica* Bowdich, is one of the largest land snails in the world, reaching up to 19 cm in length (Peterson 1957). *Achatina fulica* has been recognized as one of the world's most damaging pests (Lowe et al. 2000). This designation is primarily a result of this species' large size, polyphagous diet, and ability to reach high population densities in areas where it has become established (Kekauoha 1966, Raut and Barker 2002, Meyer et al. 2008). *Euglandina rosea* (Férussac) was purposely introduced to Hawai'i in 1955 to control populations of *A. fulica* (Davis and Butler 1964, Civeyrel and Simberloff 1996, Cowie 2001). However, *E. rosea* has not reduced *A. fulica* populations (Civeyrel and Simberloff 1996, Cowie 2001) but has been associated with the decline and extinction of many of the endemic terrestrial snail species in Hawai'i and elsewhere in the Pacific where it has also been introduced (Clarke et al. 1984, Hadfield 1986, Murray et al. 1988, Cowie 2001, Coote and Loève 2003).

Rats and introduced snails have some diet overlap and therefore may have some similar environmental effects. For instance, both rats and many snail species introduced to Hawai'i eat various plant parts and reduce plant survival (Mead 1961, Cole et al. 2000, Joe and Daehler 2008, Pérez et al. 2008). Also, both rats and introduced predatory snails, most notably *E. rosea*, prey on native Hawaiian land snail species (Hadfield 1986, Hadfield et al. 1993, Cowie 2001). However, understanding the environmental impact of rats and snails is complicated by the fact that rats may feed on nonindigenous snails such as *E. rosea* (Hadfield et al. 1993). Therefore, rats may reduce the impacts of nonindigenous snails through predation (see Courchamp et al. [1999] for a discussion on mesopredator release).

It is unknown to what extent rats consume introduced snail species. Vulnerability to rat predation may be influenced by snail size. *Rattus rattus* is known to prey upon native snails, which are much smaller than *A. fulica* and *E. rosea* (Hadfield et al. 1993). However, to the best of our knowledge *R. rattus* predation on larger introduced snail species has not been addressed. This study addressed the following questions: (1) Will *R. rattus* feed on *A. fulica* and *E. rosea?* (2) Is there a size refuge above which snails are not vulnerable to *R. rattus?* (3) Can damage to *E. rosea* shells observed in feeding trials be matched to *E. rosea* shells (snails not alive) collected in the wild to allow estimation of rat predation on *E. rosea* in the wild? Because *R. rattus*, *A. fulica*, and *E. rosea* have become established and threaten native biodiversity on many other Pacific islands, understanding the interactions among these nonindigenous species can have wide-ranging utility for natural resource managers throughout much of the Pacific.

MATERIALS AND METHODS

Captive Feeding Trials

Ten adult *R. rattus* (six females and four males) were captured from wild populations in the Wai'anae Mountains, O'ahu, and taken to the University of Hawai'i Lyon Arboretum Rodent Housing Facility. Each rat was held in an individual 38 by 22 by 18 cm metal-mesh (8 mm) cage. Rats were allowed to acclimate for at least 1 week before beginning feeding trials, during which time the rats were fed a diet of mixed seeds (e.g., corn, sunflower, wheat, barley, oats, sorghum) and wedges of fruit (tangerine). Rats were checked daily to ensure that there was ample food and fresh water, and to clean urine/fecal trays.

Snail prey of various sizes, *A. fulica* (11.5–59.0 mm shell length) and *E. rosea* (32.3–45.7 mm shell length), were collected on O'ahu from conservation areas (Wai'anae Mountains) and urban areas (Honolulu), respectively, less than 1 week before the feeding trials.

Feeding trials were performed on 7 and 10 April 2008. Each trial lasted 24 hr and consisted of 10 experimental cages (each containing one rat and one prey snail) and 10 control cages (prey snail without rat). During each trial, five rats were offered *A. fulica* and five were offered *E. rosea*. Each rat was exposed to each prey species only once during the two feeding trials. Snails placed in cages without rats accounted for any incidence of mortality due to the laboratory conditions. The two trials were separated by a 48 hr period, during which the rats were fed their regular diet. After each trial, snail mortality was recorded, and shell fragments were recovered and photographed for later comparison with shells collected in the wild. Fisher's exact test (Sokal and Rohlf 1995) was used to assess differences in mortality between the experimental and control treatments for each prey species.

Snail Mortality in the Field

To estimate *E. rosea* mortality caused by *R. rattus* in the wild, shells of dead *E. rosea* from two sites (550–625 m elevation) on O'ahu (Kahanahāiki Management Unit, northern Wai'anae Mountains, 21° 32′ N, 158° 11′ W; Kalua'a Preserve, southern Wai'anae Mountains, 21° 28′ N, 158° 5′ W) were compared with *E. rosea* shells damaged in the captive feeding trials. Matching the damaged shells in the field with those specifically damaged by *R. rattus* in the captive feeding trials gave us confidence that the majority of the field-damaged shells were by *R. rattus* rather than other *Rattus* species. In addition, *R. rattus* is much more abundant than the other rat species in these conservation areas, as revealed by bimonthly relative abundance measures from these two sites using mark-and-recapture sampling during 2007–2008 (ratio of *R. rattus: R. exulans* is 12: 1 for Kahanahāiki and 135: 1 for Kalua'a; *R. norvegicus* was never captured at either site [A.B.S., unpubl. data]). The *E. rosea* shells were collected opportunistically between July 2005 and May 2008. All shells from the wild were categorized according to shell size and whether they were undamaged, damaged dorsally (i.e., opposite side of shell to aperture), or damaged at the aperture (see Figure 1). Shell fragments were not collected or recorded in the field because the shell fragments could not be confidently identified, and land managers often crush *E. rosea* if found. Fisher's exact test was used to assess if the frequency of damaged shells (aperture and dorsal damage combined) was significantly different between Kahanahāiki and Kalua'a.

Figure 1. Damage to *Euglandina rosea* shells by *R. rattus* in captive feeding trials: *A*, aperture damage; *B*, dorsal damage; *C*, shell apex remaining.

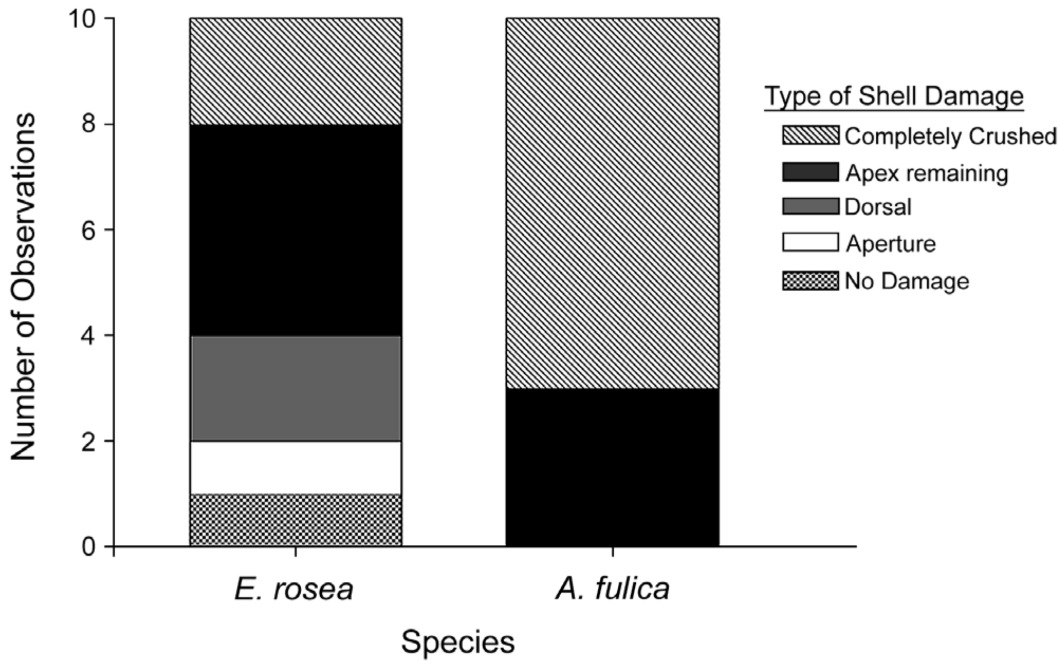

Figure 2. Frequency of shell damage categories in *Euglandina rosea* and *Achatina fulica* resulting from *R. rattus* predation in captive feeding trials.

RESULTS

Captive Feeding Trials

Rattus rattus consumed both snail species. All 10 *A. fulica* and eight of the 10 *E. rosea* were killed. There was no snail mortality in any control (rat-free) cages. The difference between experimental and control treatments for both snails was significant: *A. fulica* ($Z = 4.472$, $P < .001$) and *E. rosea* ($Z = 3.652$, $P = .007$).

Types of shell damage caused by *R. rattus* in the captive feeding trials included aperture damage (Figure 1*A*), dorsal damage (Figure 1*B*), anterior damage with the apex remaining intact (Figure 1*C*), and completely crushed shells. The two most common types of shell damage observed (combining data for both snail species) was the anterior portion damaged with the apex remaining intact (nine snails), and the shells being completely crushed into small pieces (seven snails) (Figure 2). Dorsal damage to the shell was observed in only two *E. rosea* that were killed (Figure 2). Aperture damage was observed in one *E. rosea* that survived the 24 hr rat exposure (Figure 1); it is not known if this damage impacts the survival or fitness of the snail. Among all snails offered, both the largest (59.0 mm shell length) and the five smallest (11.5, 19.6, 21.3, 24.0, and 24.1 mm) were completely crushed. The types of shell damage that we observed for the two snail species tended to differ: *A. fulica* shells were either completely crushed or partially crushed with the apex preserved, whereas *E. rosea* shells were either damaged dorsally or at the aperture, completely crushed, or partially crushed with the apex preserved (Figure 2).

Snail Mortality in the Field

In total, 166 *E. rosea* shells were collected from the two forest sites on O‘ahu: Kalua‘a (96 shells) and Kahanahāiki (70 shells) (Figure 3). All shells were 25–55 mm in shell length. The absence of small shells (<25 mm) is probably not a result of collection bias because smaller shells of other snail species were noticed. Incidence of rat damage to shells was significantly higher ($Z = 2.025$, $P = .022$) in Kahanahāiki (24.5%) than in

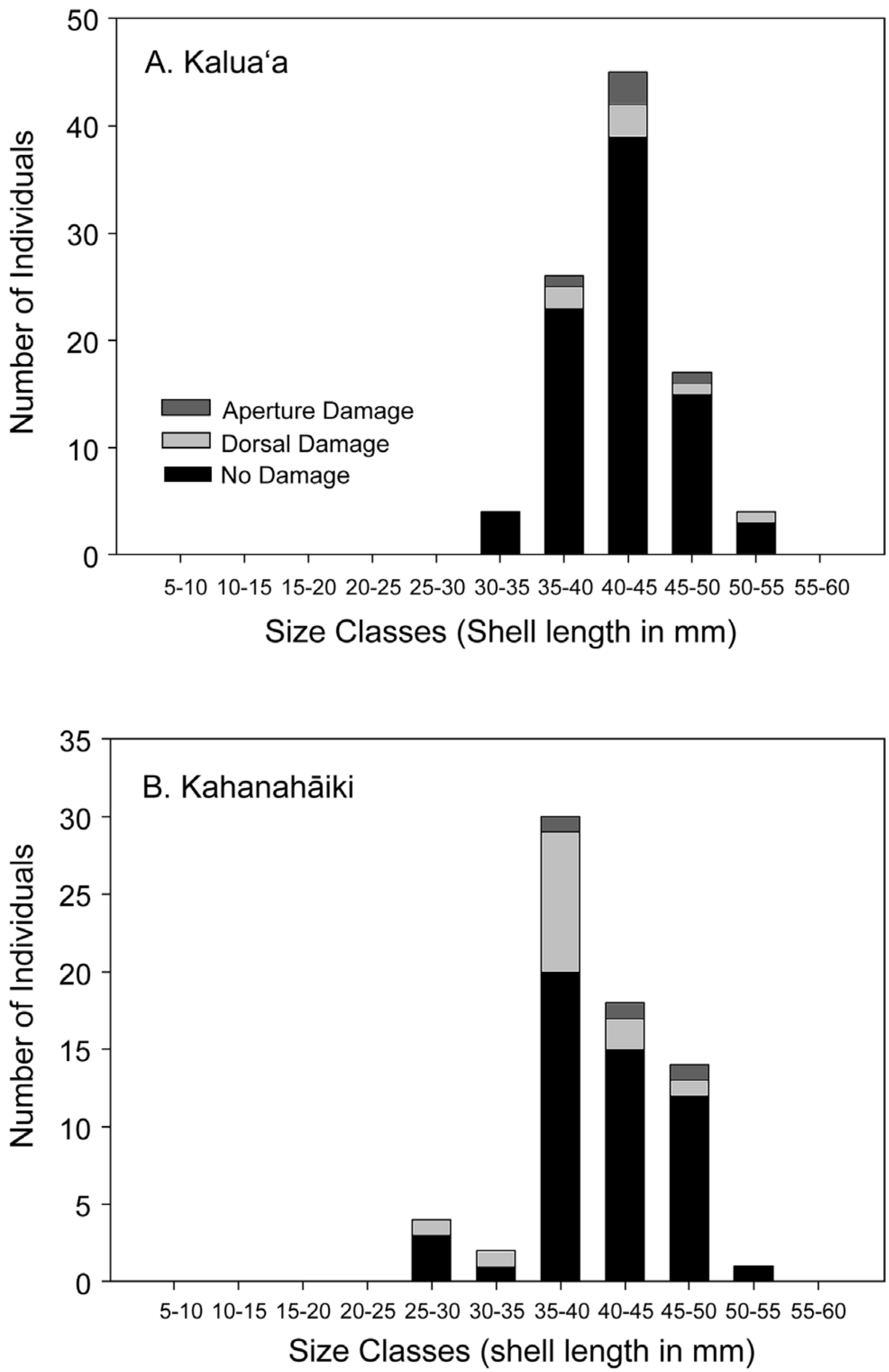

Figure 3. *Euglandina rosea* shell (dead snail) assemblage in two mesic forest sites on O'ahu: *A*, Kalua'a Preserve, southern Wai'anae Mountains; *B*, Kahanahāiki Management Unit, northern Wai'anae Mountains. Dorsal and aperture shell damage is attributed to rats, based on matching shells with those used in captive feeding trials with *R. rattus*.

Kalua'a (12.5%). Dorsal shell damage tended to be much higher in Kahanahāiki (20.0%) compared to the dorsal shell damage in Kalua'a (7.3%) (Figure 3). Damage to the aperture was noticed on 4.5% and 5.2% of the shells collected from Kahanahāiki and Kalua'a, respectively. Although aperture damage may suggest interaction among rats and snails, it may not imply mortality based on the one observation made in the captive feeding trials. Alternatively, damage to the dorsal portion of the shell can be used to indicate mortality likely caused by *R. rattus*.

Crushed shells, which were rarely seen, and remnants of shells such as shell apexes that might have been preyed upon by *R. rattus* were not collected in the field because we presumed that most of those shells were intentionally crushed by land managers and conservationists who frequently visit the sites. However, in retrospect, on examining shell damage in the feeding trials, this was probably a false assumption and many of these shells may have been preyed upon by *R. rattus*. Therefore, our estimate of *R. rattus* predation on *E. rosea* is probably an underestimate.

DISCUSSION

Our captive feeding trials demonstrate that *R. rattus* can consume nonindigenous snails of various sizes (100% of *A. fulica* and 80% of *E. rosea* offered). The largest *A. fulica* (6 cm in shell length) and *E. rosea* (4.5 cm in shell length) offered were eaten, although we do not know whether very large *A. fulica*, which can reach 19.0 cm in shell length (Peterson 1957), would be preyed upon. Such large *A. fulica* are rarely observed in Hawai'i (W.M.M., pers. obs.). Comparison of rat damage to *E. rosea* in the captive feeding trials with shells of *E. rosea* from the wild showed that rats likely caused a minimum of 7%–20% of *E. rosea* mortality.

Rats crushed entire shells in 45% of the captive feeding trials (Figure 2). Unfortunately, it is unlikely that a high proportion of crushed shells could reliably be collected in the field. However, not accounting for completely crushed shells may result in an underestimate of the impact of *R. rattus* on snail populations and may therefore lead to inappropriate conclusions regarding predation levels. For example, no small *E. rosea* shells (<25 mm in shell length) were collected at the two field sites (Figure 3). This pattern might suggest very low juvenile mortality, but it seems more likely that juvenile mortality was not detected because shell fragments were not analyzed. Although rats crushed shells across the size range offered, smaller snails might be crushed more often, because this was the fate of the five smallest snails in the feeding trials. In addition, the shape of the shell may also influence the likelihood that the shell is crushed, because the more conically shaped shells of *E. rosea* were often damaged without completely crushing whereas the more rounded shells of *A. fulica* were most often crushed. In areas where native snails occur, presence of *E. rosea* shells and native snail shells with characteristic rat damage (Figure 4) are used to assess the predation risk from both predators and to initiate a rapid management response (V. Costello, pers. comm.). Rats crushing either *E. rosea* or native shells may limit the ability to adequately quantify the threat from either predator.

FIGURE 4. A shell of the endemic O'ahu tree snail *Achatinella mustelina* after *R. rattus* predation in a snail conservation area in the Wai'anae Mountains.

Predation levels on *E. rosea* of 7% and 20% at Kalua‘a and Kahanahāiki, respectively, correlate with *R. rattus* relative abundance, which was approximately 2.5 times greater at Kahanahāiki than at Kalua‘a based on bimonthly mark-and-recapture technique during 2007–2008 (A.B.S., unpubl. data). However, *E. rosea* mortality caused by *R. rattus* at those two sites is probably greater than that because only damage to the dorsal portion of the shell was used to indicate mortality. This potential underestimate is likely substantial, because 67% of *E. rosea* shells in the captive feeding trials were damaged in such a way that they would not have been collected in the field (Figure 2). As such, we suggest that *R. rattus* may substantially contribute to *E. rosea* mortality where they coexist. However, determining if *R. rattus* predation regulates *E. rosea* population densities requires a more in-depth understanding of *E. rosea* population dynamics.

Conservation of Hawai‘i's native forest ecosystems requires reducing or controlling the impacts of introduced plants and animals, including rodents and nonindigenous snails. Rats are increasingly being controlled in conservation areas on O‘ahu. Recent federal approval of aerial broadcast of rodenticide into conservation areas in Hawai‘i will probably lead to increased rat control efforts. However, the complex interactions among *R. rattus* and nonindigenous snail species, particularly *E. rosea*, suggest that managers should proceed cautiously with management and control efforts that involve these species. Removal of *R. rattus* in the Wai‘anae Mountains may result in *E. rosea* population increases. This may have negative effects on native snail populations, which may be irreversible because of the difficulty of controlling *E. rosea* while not harming other, native snail species. It is unknown if *E. rosea* predation on other mollusk species would equal or exceed that of *R. rattus*. In 85%–100% of rat stomachs examined on Maui, invertebrate material (including slugs, snails, and earthworms) was found (Sugihara 1997).

Rat predation on herbivorous nonindigenous snail species may also influence the preservation of Hawai‘i's native forest ecosystems. *Achatina fulica* is known to consume over 500 plant species (Mead 1961) and can reach densities of 7.75 snails per square meter in the low-elevation areas of Hawai‘i (Kekauoha 1966). Slugs (snails without shells) were specifically mentioned as threats or potential threats to 59 rare plant species (22% of all endangered and threatened plants) in Hawai‘i (Joe and Daehler 2008). Further experiments should examine rat prey preferences among various snail prey and the influence of rat predation on snail populations, especially those species that are widespread and are recognized as a threat to native ecosystems.

Until we understand how nonindigenous snail populations will respond to rat removal, it is difficult to predict the probability of success for native snail and plant recovery after *R. rattus* eradication. Prudent management will require precautionary and adaptive management approaches (Doak et al. 2008). Removal of species to help facilitate increases in other species can fail as a result of complex and unpredicted interactions (Doak et al. 2008 and references therein). However, our goal is not to impede rat control efforts in Hawai‘i. Instead, we hope that concurrent invertebrate and plant monitoring programs are established before and after such rat control efforts. Also, we suggest, as did Cole et al. (2000), that rodent exclusion studies are needed to evaluate the magnitude of impact of rats on various plant and animal populations and to provide a more in-depth understanding of both native and nonindigenous species in Hawaiian ecosystems.

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APPENDIX 4-4: APPLICATION OF HARMONIC RADAR TECHNOLOGY TO MONITOR TREE SNAIL DISPERSAL, HALL AND HADFIELD 2009

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Application of harmonic radar technology to monitor tree snail dispersal

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Abstract. Planned conservation efforts for tree snails of the endangered genus *Achatinella,* endemic to the island of O'ahu, Hawai'i, will include translocations among the remaining wild and captive-bred populations. In order to establish optimal levels of artificial migration among neighboring groups of snails within fragmented populations, efforts to determine natural dispersal rates through direct observation were initiated. Capture–mark–recapture (CMR) efforts have proved inadequate for obtaining the requisite dispersal estimates, due to low recapture probabilities. In addition, snail dispersal beyond the boundaries of a finite CMR study site was indistinguishable from mortality. In the preliminary study reported here, both the low recapture probability and dispersal detection problems of past CMR efforts were addressed by using harmonic radar tracking. This approach yielded rough dispersal estimates that were unattainable using CMR alone by providing 100% recapture rates even beyond the normal survey area boundaries. Extensive snail movements within clusters of connected trees were frequently observed after tracking for merely a few hours, although movements between unconnected trees were rare and recorded only after monthly survey intervals. Just 11 out of 40 tracked snails made between-tree movements (average distance of 4.94 ± 1.52 m) during the entire 7-month study, and provided the only data utilizable for inferring gene flow in and out of subpopulations. Meteorological data loggers were deployed when tracking began to look for an association between such snail movement and weather fluctuations. The resultant data indicate that increases in both wind gusts and humidity facilitate dispersal ($R^2 = 0.77$, p-value < 0.001), and that passive wind dispersal alone may be responsible for many snail movements ($R^2 = 0.59$, p-value $= 0.0014$). Despite having provided coarse estimates of short-term dispersal and corresponding wind influences, the limitations of the radar method can be substantial.

Additional key words: telemetry, mark–recapture, wind dispersal, Achatinella

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Tree snails of the genus *Achatinella* (Pulmonata: Achatinellidae), endemic to the island of O'ahu, Hawai'i, are rapidly disappearing and are all listed as Endangered by the United States Fish & Wildlife Service (USFWS 1992). Only ten species are extant out of the original 41 recognized by USFWS (based on synonymizations by Pilsbry & Cooke [1912–1914]). Initially common throughout native forests of both the Wai'anae and the Ko'olau mountains, *Achatinella* species can now be found only in scattered patches near the summits of these ranges. Following severe declines in number as a result of habitat loss and shell collecting in the 19th and 20th centuries, predation by introduced rats and the snail *Euglandina rosea* continue to decimate and fragment remnant snail populations (Hadfield 1986; USFWS 1992; Hadfield & Saufler 2008). The unusual life-history characteristics of these long-lived and late-maturing snails make any unaided recovery from invasive predator impacts extremely difficult (Hadfield et al. 1993). To assist in the preservation of the remaining wild populations, various governmental agencies have contributed to the initiation of both a captive-breeding program and building of predator-proof exclosures.

The intended goals of these conservation actions appear to have been achieved according to field and lab records (Hadfield et al. 2004), which show increases and/or stabilizations for some populations. However, the long-term consequences on the health

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of the gene pool from captivity, exclosures, and the fragmentation of subpopulations have yet to be addressed. There is growing concern that most of the remaining wild, enclosed, and captive populations of *Achatinella* spp. are increasingly at risk of the negative effects of inbreeding because of loss of genetic connectivity. Management strategies are being considered that will include translocation among neighboring subpopulations (residual fragments of historically continuous populations) to minimize the effects of excessive inbreeding, while being careful as to avoid any detrimental effects from unnatural levels of outbreeding. Storfer (1999) argued that only by first obtaining detailed observations of a species' natural gene flow can minimization of both these phenomena be accomplished. Microsatellite analyses using *Achatinella* spp. failed to reveal any structure on a subpopulation level (K.T. Hall, unpubl. data), rendering estimation of dispersal with modern genetic methods impossible. In light of this, a more direct approach was adopted to determine natural migration rates for two *Achatinella* spp.

Tree snails can be difficult to detect within dense vegetation, which makes obtaining direct dispersal-rate estimates difficult. Initial efforts using capture–mark–recapture (CMR) were hampered by low recapture rates, making any attempts at dispersal-rate estimation from those data imprecise (K.T. Hall, unpubl. data). Some snails were recaptured after not having been captured for several sampling intervals, most having returned to or never left their original trees, and others on neighboring or more distant trees. It is also often nearly impossible to distinguish between dispersal beyond a finite study site's boundaries and death (Koenig et al. 2000). This is especially true in animals such as small snails, whose remains are hard to locate. To increase the chances of recording more precise distances, frequencies, and timing of dispersal for *Achatinella* spp., harmonic radar tracking methods were adopted. The radar system includes a hand-held transmitter/receiver unit (Recco Inc., Lindingo, Sweden), which is used to detect small diode/wire combinations glued onto shells of live snails. With the expected 100% recapture rates, it was anticipated that preliminary estimates of short-term dispersal frequencies and distance could be obtained. Detection distances of up to 10 m were also readily possible with the radar, minimizing the reduced dispersal detection problems beyond the edges of a finite study site. However, the transponders receive and reflect a generic signal, and so individual identification must still rely on unique CMR codes.

Observations of dispersal during our pilot CMR surveys often varied following changes in observable weather conditions, implying that dispersal events may be a result of environmental factors. Prolonged periods of hot and dry conditions sometimes corresponded to an increased ratio of previously marked to unmarked adult snails in field surveys, as well as increased recapture rates (suggesting lower immigration). Similarly, stormy winter months sometimes led to an increase in the proportion of unmarked adults and reduced recapture rates (indicative of higher immigration). Therefore, it was hypothesized that any increases in snail movement detected with a harmonic radar would positively correlate with wind speed and humidity and/or negatively with temperature. Significant correlations would help determine whether dispersal is passive (i.e., positive correlation with wind gusts, which have been thought to blow snails out of trees [M.G. Hadfield, unpubl. data]) or active (i.e., positive correlation with high humidity, because some snails may be less active in the dry season [Cowie 1980]).

Methods

Transponder design

The results of successful studies using harmonic radar technology with a few land snail and insect taxa have already been published (e.g., Mascanzoni & Wallin 1986; Lovei et al. 1997; Stringer et al. 2004). O'Neal et al. (2004) conducted a study to optimize the trade-off between detection distance and transponder size to minimize any hindrance to the individual's natural movements, using a design very similar to the one adopted here for use with *Achatinella* spp. We tested many different kinds of transponders on captive individuals of *Achatinella* spp. before the current design was adopted. These transponders weigh <0.02 g, which is well below the conventionally accepted transmitter/body weight ratio (dubbed "the 5% rule") for having no adverse effects on the study organism. This rule, although informal, was adopted from studies on birds (Cochran 1980), small mammals (Aldridge & Brigham 1988), and fish (Claireaux & Lefrançois 1998). To determine snail weights, a series of living individuals of *Achatinella* spp. in the lab, all individuals ≥ 13 mm in shell length, were weighed and found to be >1 g. Therefore, only snails with shells ≥ 13 mm snails were fitted with transponders.

The transponders are passive and can theoretically function for several years without a power source. They are constructed from 6-cm lengths of a Teflon-coated, 0.08-mm-diameter copper wire (Omega Engineering Inc., Stamford, CT, USA) that were soldered

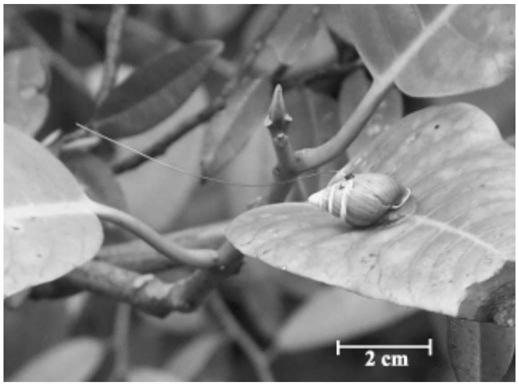

Fig. 1. Adult of *Achatinella mustelina* (21 mm in length from the apex to the bottom of the aperture) equipped with a harmonic radar transponder.

to small Schottky diodes (Mouser Electronics Inc., Mansfield, TX, USA) (e.g., Fig. 1). The solder bond is strengthened with a high-conductance epoxy resin, and the diode portion is glued with Satellite City Super T® to the body whorl of the snail's shell, oriented so that the wire drags behind the shell apex as the snail crawls. Transponders can be removed as needed by placing a drop of glue remover (Satellite City Super Solvent®) onto the glue bond, pushing away the resulting compound, and removing the transponder with slight pressure from tweezers.

Experimental approach

Achatinella mustelina Mighels 1845 (Wai'anae Mountains) and *Achatinella sowerbyana* Pfeiffer 1855 (Ko'olau Mountains) were used to monitor movement patterns. They are the only two remaining species of *Achatinella* with substantial numbers surviving in a fairly continuous habitat, providing the closest representation of gene flow in *Achatinella* before anthropogenic disturbances. The four field sites (Fig. 2) chosen include two replicates for each species, located at the extreme north/south ends of each species' known range to account for geographic and climatic variations. These are Palikea (in The Nature Conservancy's Honouliuli Preserve) and Kahanaha'iki (Makua Military Reservation) in the Wai'anae Mountains for *A. mustelina* (18 km apart), and north of the Poamoho monument (Ko'olau Summit Trail [KST]) and west of Opae'ula Cabin (Army leased land, leeward of the KST) in the Ko'olau Mountains for *A. sowerbyana* (2 km apart).

Fig. 2. O'ahu, Hawai'i. The four field sites used in this study are marked with squares.

For each site, perimeters were delineated by centering on the highest density area, with boundary extensions roughly corresponding to the maximum dispersal distances observed during CMR pilot studies. This is also the maximum amount of area that could be regularly searched with the manpower available. Within each site, a grid of $5\,m \times 5\,m$ quadrats was created. Individual quadrats were large enough to wholly contain most tree clusters. The actual number of quadrats at each site varied from 15 (Palikea) to 55 (Poamoho), due to each site's natural barriers (e.g., streams and cliffs). Ten of these quadrats were randomly selected (using a random number table to obtain individual quadrat numbers) at each of the four sites, and one snail $\geq$13 mm within each selected quadrat was fitted with a transponder (the maximum sample size allowed under USFWS permit TE826600). Daytime surveys were conducted at each site on a monthly basis to monitor dispersal (for $N = 40$ radar-equipped snails in total). In addition, two hourly overnight surveys were conducted at both Palikea and Kahanaha'iki to see whether any dispersal occurs during normal nocturnal foraging movements.

Weather/dispersal correlation

Weather data loggers from Onset Inc. (wind speed, humidity, and temperature, logging every 15 min) were deployed at three sites in early August 2006 to accumulate meteorological data (Poamoho snail tracking began in late August 2006). Radar-detected dispersal locations and weather data were recorded simultaneously at monthly intervals for a period of 7 months (through March 2007) to include both dry and wet seasons. The number of inter-tree dispersal events revealed with harmonic radar each month was recorded in addition to the corresponding weather values (minima, maxima, and averages) for that month to look for relationships (similar to Aubry et al. 2006). A best-subsets multiple regression procedure was used to select the model(s) that best explained the variation in monthly dispersal, based on Akaike's information criterion (Akaike 1974). This criterion provides a way to trade off the complexity of an estimated model against how well the model fits the data, preventing the appearance of a superior model that results from overfitting the data. All analyses were performed using R software (version 2.4.1, Ihaka & Gentleman 1996).

Results

Neither of the two hourly overnight surveys conducted at each Wai'anae site showed any movement of snails between unconnected trees, which would have required movement across the ground. Unconnected trees are defined as two clusters of vegetation that have no branches or leaves that come into contact with each other under normal weather conditions. Such between-tree movements were rare and only apparent after 1-month intervals. However, total linear movements as great as 3 m among connected trees were not uncommon in a single night. Based on the high frequency of movements throughout connected tree clusters, and the extreme rarity of finding live snails on the ground, inter-tree movement (between unconnected trees) became the focus of this study. As in other tree-snail studies exhibiting similar migration patterns (e.g., Schilthuizen et al. 2005), only these rare inter-tree movements have relevance to gene flow among subpopulations. Throughout this article, "dispersal" will refer only to movements between unconnected trees.

A list of all recorded snail dispersal and distances traveled by month is presented in Table 1. Inter-tree dispersal rates were between 0% and 20% per month, with more frequent dispersal occurring during the winter months when comparison was available (Wai'anae sites only). During this 7-month study, only 11 out of 40 snails were relocated outside of their original trees, providing a total of 17 between-tree movements. Dispersal distances were measured as the length between the two trees' bases at ground level, and resulted in an average of 4.94 ± 1.52 m.

For each month and site, the number of transponder-equipped snails (out of ten individuals) that dispersed between trees was determined and used as the response variable for the weather correlation analysis. No individual snail used in this regression contributed more than one movement to the analysis, meaning 11 different individuals' movements appear in Table 2. There were 12 potential meteorological predictor variables including maxima (max), minima (min), and averages (avg) for the four weather parameters measured (% relative humidity [RH], temperature in degrees Celsius [T, °C], wind speed [m/s], and wind gust speed [m/s]). Maximum RH was always 100% and both minimum wind measures (speed and gust) were 0 m/s, and so these three predictors were not included.

Temporary weather station malfunctions, and site/month combinations in which all ten transponder snails were not relocated, were responsible for excluding 14 monthly records in the weather correlation analysis. Of 28 possible monthly records (four sites, 7 months), only 14 were actually used in this analysis (Table 2). Regrettably, all four weather stations needed sensor replacement at least once during this study due to corrosion. Snail-tag loss per month varied substantially between sites and seemed to reflect the relative exposure to inclement weather at each site. In decreasing order from least exposure to greatest are Kahanaha'iki, Palikea, Opae'ula, and Poamoho. The numbers of tags lost by site are summarized in Table 3. When even a single snail remained undetected for more than 1 month, further radar monitoring was terminated at that site because dispersal could no longer be distinguished from tag loss or death. For most months involving tag loss, a subsequent intensive search of the area (sometimes requiring an additional day in the field) recovered snails with broken transponders that could be fixed before the next sampling interval.

The best-subsets regression model that outperformed all other models (using Akaike's information criterion, Akaike 1974) for explaining variation in dispersal (Table 2) contained only two predictor variables: maximum wind gust speed and average RH ($R^2 = 0.77$, $p < 0.001$). The estimates of these coefficients were both positive and significant at $\alpha = 0.05$. Of the single predictor models, maximum wind gust speed performed best ($R^2 = 0.59$, $p = 0.0014$). RH was the next best of the single predictor models, but did not perform nearly as well ($R^2 = 0.43$, $p = 0.011$).

Discussion

The initial goals of this project were to determine the short-term dispersal rates of two species of *Achatinella* and the effects weather may have on those rates. Use of harmonic radar methods provided rough estimates of dispersal, which are often difficult to separate from mortality or recapture probability in CMR analyses. The weak correlation of dispersal with wind gusts during winter months suggests that between-tree movements might be mostly passive rather than active, and that members of *Achatinella* spp. are blown out of their trees during violent wind storms. These findings agree with observations from January 1985 in which many snails from a previous CMR study of *Achatinella mustelina* were found far

Table 1. Distance traveled by individual snails (in meters) by month that moved between trees, measured as the distance between tree bases. Non-zero values are boldfaced. ?, snail never relocated; NA, not applicable.

Snail ID code	Site	August	September	October	November	December	January	February	March
A2	Palikea	0	0	0	0	0	0	0	0
A5	Palikea	0	0	0	0	0	**3**	0	0
A7	Palikea	0	0	0	0	0	0	0	0
A8	Palikea	0	0	0	0	0	0	0	0
B1	Palikea	0	0	0	0	0	0	0	0
B8	Palikea	0	0	**5**	0	0	0	0	0
B9	Palikea	0	0	0	0	0	0	0	0
H2	Palikea	0	0	0	0	0	0	0	?
H7	Palikea	0	0	0	0	**4**	**2**	0	0
J0	Palikea	0	0	0	**7**	0	0	0	0
B2	Kahanaha'iki	0	0	0	0	0	0	0	
D4	Kahanaha'iki	0	0	0	**6**	**6**	0	?	
G0	Kahanaha'iki	0	0	0	0	0	0	0	
G6	Kahanaha'iki	0	0	0	0	0	0	0	
J7	Kahanaha'iki	0	0	0	0	0	0	0	
K2	Kahanaha'iki	0	0	0	0	0	0	0	
Q0	Kahanaha'iki	0	0	0	0	0	0	?	
Q9	Kahanaha'iki	0	0	0	0	0	0	?	
R0	Kahanaha'iki	0	0	0	**3**	0	**7**	0	
T0	Kahanaha'iki	0	0	0	0	0	0	?	
A3	Poamoho	NA	0	0	0				
D3	Poamoho	NA	**6**	0	0				
E4	Poamoho	NA	0	0	0				
E5	Poamoho	NA	0	0	0				
H1	Poamoho	NA	0	**4**	?				
H9	Poamoho	NA	0	0	0				
J3	Poamoho	NA	0	0	?				
K1	Poamoho	NA	0	**5**	?				
K5	Poamoho	NA	**3**	0	0				
Q3	Poamoho	NA	0	0	?				
A3	Opae'ula	0	0	0	0				
A5	Opae'ula	0	0	0	?				
L5	Opae'ula	0	0	0	0				
M6	Opae'ula	0	0	0	0				
N4	Opae'ula	0	0	0	?				
N9	Opae'ula	0	0	0	0				
Q1	Opae'ula	0	0	0	?				
Q4	Opae'ula	**6**	0	0	?				
R5	Opae'ula	0	0	**5**	**5**				
R6	Opae'ula	0	0	0	**7**				

away from their origins following hurricane force winds during a severe winter storm (M.G. Hadfield, unpubl. data).

In the present study, a radar helped to relocate snails in vegetation that is not normally thought to be a prime host for snails. A common morph of the native tree *Metrosideros polymorpha* has a fuzzy leaf texture, which is usually avoided based on observations of captive and wild snails (unpubl. data). However, at least two snails were relocated with a radar on this particular tree morph. Some transponder-equipped snails have also been recaptured in dense foliage and/or on high branches that would have been challenging to search thoroughly. Use of the radar alone resulted in recapture rates $\geq 80\%$ at every site, which is more than double that of equivalent effort with CMR (K.T. Hall, unpubl. data).

Except where mentioned earlier, all non-recaptures can be attributed to breaks in the transponders at weak solder bonds. Most of these non-recaptured

Table 2. Meteorological predictor variables corresponding to the number of dispersing snails for each site/month combination. avg., average; max., maximum; min., minimum; RH, relative humidity; T, temperature; WS, wind speed; WG, wind gust.

Site, month	Dispersed snails (no.)	T (°C) (max.)	T (°C) (avg.)	T (°C) (min.)	RH% (avg.)	RH% (min.)	WS (avg.)	WS (max.)	WG (avg.)	WG (max.)
Palikea, August	0	25.2	18.5	16.0	95.5	60.3	1.8	4.2	4.0	9.5
Palikea, September	0	22.9	18.1	16.0	97.2	69.8	2.0	5.0	4.4	8.8
Palikea, October	1	25.2	18.8	16.0	97.9	70.3	1.3	4.2	3.2	9.1
Palikea, November	1	25.2	18.1	15.6	99.6	74.8	1.9	6.1	4.1	11.4
Palikea, December	1	24.0	16.2	13.3	97.1	68.3	1.7	5.3	4.0	10.7
Palikea, Feburary	0	23.2	15.7	12.9	98.0	45.3	1.6	5.0	3.8	8.8
Kahanaha'iki, August	0	32.3	21.1	15.6	97.0	45.3	1.0	4.6	3.6	9.9
Kahanaha'iki, September	0	30.7	20.8	17.1	96.0	48.3	1.3	3.1	4.8	10.3
Kahanaha'iki, November	2	31.5	20.0	14.9	99.0	46.3	2.0	5.0	5.0	12.0
Poamoho, September	2	26.7	19.2	16.8	98.5	72.8	2.4	6.5	5.9	13.7
Poamoho, October	2	26.0	19.3	16.8	98.6	81.8	1.4	5.7	3.9	13.7
Opae'ula, August	1	27.1	19.1	14.1	96.7	47.8	1.8	4.2	5.3	10.7
Opae'ula, September	0	24.0	18.7	16.4	95.8	58.3	1.9	4.2	5.7	11.8
Opae'ula, October	1	26.7	18.9	14.5	96.2	60.8	1.3	5.0	4.2	11.8

snails were eventually seen again during intensive searches with only the diode still attached. This is the major limitation of the transponders. Larger, more durable tags were tested, but affected natural snail behavior. Snails would sometimes come to rest without fully retracting into their shells, while others would have movement restricted by rigid wire kinks. In order to determine the fate of snails with failed transponders, considerable time was required to locate those individuals. Sometimes, this necessitated another trip to a field site specifically to find a lost snail.

Table 3. Number of transponder tags lost per month per site. *Weather station malfunctions. **At least one transponder snail never recaptured. Cells containing values without asterisks are the same site/month combinations found in Table 2.

	Kahanaha'iki	Palikea	Opae'ula	Poamoho
August	0	1	0	
September	0	2	1	2
October	0*	2	2	2
November	0	1	4**	3**
December	2*	1		
January	2*	1*		
February	4**	2		
March		3**		

Non-detection of dispersal is very problematic for CMR studies and was a major reason why a radar was used in this study. Despite dramatic improvements in detection ability, harmonic radar methods in their current form still cannot entirely eliminate non-detection of dispersal. For tree snail studies in which inclement weather is not a substantial factor, this method should suffice for monitoring purposes. However, further transponder modifications will be needed in study areas that are prone to severe weather and/or where regular access is limited. J. Kiriazi (UH Mānoa Electrical Engineering Department) is currently assisting the authors of this article with ways to increase the durability of transponders through more conformal designs that are less prone to wear and tear as snails forage through thick vegetation. These designs cover more of the shell's surface area, reducing the need for an antenna extension beyond the length of the snail. In addition, we are exploring ways to create transponders with unique frequencies by changing the length of the antennae. These approaches require a different transmitter and receiver with an adjustable frequency, a function not available with the Recco unit.

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Stringer, and Victor Lubecke provided technical advice. Funding was provided by Unitas Malacologica, Conchologists of America, the University of Hawai'i Ecology, Evolution, and Conservation Biology Program (NSF GK-12 grant DGE02-32016, P.I. KY Kaneshiro), USFWS, and the US Army Garrison, Environmental Division, which also provided some site access. Many volunteers assisted with data collection. We thank Menno Schilthuizen, Mike Hart, and two anonymous reviewers for a helpful commentary on revising this manuscript.

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APPENDIX 4-4 BACK PAGE

APPENDIX 4-5

Ecology of introduced rats (*Rattus* spp.) and their effects on Hawaiian plants

Army Environmental Annual Report (July 2008-August 2009)

Aaron Shiels

PhD Student, Department of Botany

University of Hawai`i at Mānoa

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I. Introduction & Project Objectives

Because most oceanic island ecosystems developed in the absence of terrestrial mammals, many island species are vulnerable to introduced mammalian predators. Rats (*Rattus* spp.) are among the most widespread and significant invasive mammals affecting islands. In many continental ecosystems, native rats provide an important ecological role, largely through seed dispersal, in maintaining native plant populations. Additionally, through hundreds of thousands of years of coexistence, most continental floras have developed defenses to protect against seed-eating mammals such as rats. On islands like Hawaii where rats have been recently introduced (in the last 1000 years), and have quickly become well established, the flora is particularly susceptible to the negative effects of rats (e.g., through seed predation and recruitment limitation). Additionally, the omnivorous diets of most rats, as well as their ability to maintain relatively high populations in most ecosystems, has likely resulted in widespread vulnerability of many different types of native flora and fauna to rats. A better understanding of these introduced rats (i.e., *Rattus* spp.) and their impact on both plants and animals in the Hawaiian Islands is needed.

The aim of this study is to increase our understanding of both the population ecology of rats (including relative abundances, seasonal fluctuations, habitat use, home-range, and diet) and the effects of introduced rats on native and non-native plants in Hawaii (particularly their susceptibility to seed predation and seed dispersal). Such information is critical to improving our understanding of contemporary island ecosystems that have been invaded by rats, as well as apply such findings to improve the conservation and restoration initiatives for native flora and fauna in Hawaii and other island where introduced rats are present.

II. Methods

Study Site

This research occurs at three study sites in the Wai`anae Mountains, Oahu: Kahanahāiki (KHI), Kalua`a at Honouliuli Preserve (HON), and Makaha (MAK). All three sites are in mesic, montane forest at 500-660 m a.s.l. Air temperature at 1 m height fluctuates seasonally, and generally range from 16-24^{o} Celsius (**Figure 1**). All three sites have a similar, mixed flora that includes both native and alien plant species. Detailed vegetation surveys were conducted at the focal study site, Kahanahāiki (see next section).

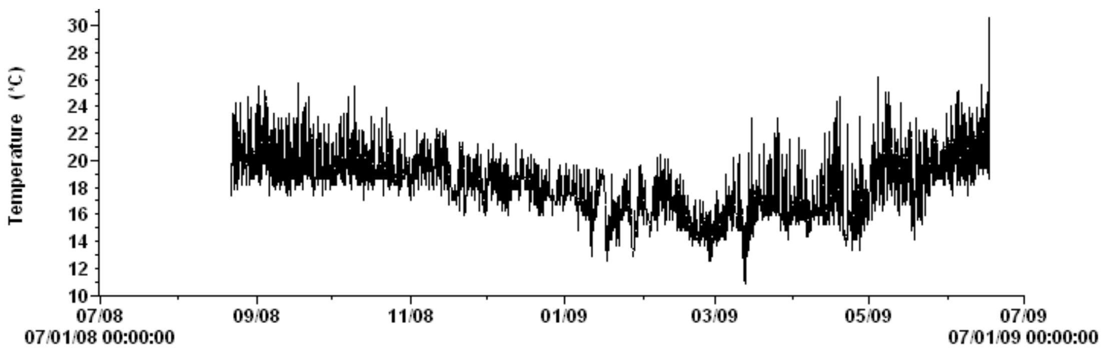

Figure 1. Seasonal fluctuation in air temperature (degrees Celsius) at Kahanahaiki, a mesic forest preserve on Oahu. Air temperature was measured four times a day at a height of 1 meter using Hobo® temperature dataloggers. The far right increasing line reflects the collection and download of the datalogger in Honolulu.

Plant composition and relative abundance at Kahanahaiki

Ten plots, each 15 x 15 m, were established in a stratified random design in Kahanahaiki gulch. Within each plot, all stems≥ 1 cm dbh (measured at 130 cm above ground) were ide ntified to species, mapped, marked with an aluminum tag and secured to the respective stem using grafting tape, and measured for height and diameter at dbh. This stem inventory followed the methods of the Center for Tropical Forest Sciences (Smithsonian Institution), which is a method used globally on long-term forest plots.

Field trials for vulnerability to rats of top 10 dominant woody plants

Thirty-two stations (4 treatments x 8 replicates), each placed 10 m apart, were established along transects at KHI to determine the vulnerability of fruit and seeds to rodents. Each station was randomly assigned one of the following treatments: 1) no-vertebrate-access, which consists of a wire metal mesh (1.2 cm aperture) open-bottom square box (30 x 30 x 30 cm; length x width x height) that excludes all potential vertebrate seed predators and dispersers (*e.g.,* rodents, pigs, cats, birds, mongoose) and acts as the control to compare subsequent treatments, 2) small-vertebrate-access, which is the same dimensions as the no-vertebrate-access but four holes (one on each of the side-walls; 10 x 10 cm each) allow small vertebrates (such as rodents) to access the interior but excludes the entry of other large animals (*i.e.,* pigs, cats, most birds), 3) open forest floor, where all vertebrates are able to freely access the station, and 4) cage control, where three sides (top and two walls) of metal mesh, allowing all animals access, were used to test the influence of the caging material on diaspore removal. Each mesh exclosure was pushed into the ground *ca.* 1 cm and held in place using 8 cm long turf staples. In order to determine the animal responsible for fruit/seed removal, motion-sensing cameras (Bushnell Sentry 2.1 MB or Multrie) were placed at a subset of these treatment stations. Ripe fruits and seeds of the 10 dominant woody plants (natives and aliens; based on plant census described above) were individually tested.

Laboratory trials: captive feeding, seed fate, and seed size threshold

Adult *Rattus rattus* captured from wild populations adjacent to HON, KHI, and MAK were utilized in captive feeding trials with fruits and seeds of Hawaiian plants. Once wild rats were captured in the field they were transported to the University of Hawaii Lyon Arboretum Rodent Housing Facility (LARHF). Each rat was held in individual 38 cm x 22 cm x 18 cm metal-mesh (8 mm) cages and allowed to acclimate for at least 1 week before beginning feeding trials with Hawaiian fruits and seeds. The proportion of fruit and seed eaten by each rat was quantified. Additionally, rat droppings were inspected for seeds that pass through the rat's digestive tracts, and passed seeds were recovered and assessed for germination by first sowing the seeds on agar Petri dishes and then comparing germination percentages to conspecific seeds that were not passed through rats. Between each feeding trial, rats were returned to their regular diets of mixed seeds (*e.g.,* corn, sunflower, wheat, barley, oats, sorghum) and wedges of fruit (tangerine, mango, kiwi). Rats were checked daily in order to ensure ample food and fresh water, and to clean urine/fecal trays. The regular number of rats that were held at LARHF was 10-12. Measurements of the seeds and fruits (e.g., length, mass, percent moisture) were recorded for the species used in the captive feeding trials in order to help determine which characteristics of the seeds may predict vulnerability to rat predation and dispersal.

Relative abundances of rats

Distribution and abundance of rats were assessed every two months from February 2007-April 2009 at HON and KHI, and quarterly from July 2008-April 2009 at MAK, using standard mark-and-recapture technique. Hagaruma live traps were set along transects at 25 m intervals. Four to six transects per site were established and each transect was approximately 35-50 m from adjacent transects. Steep topography did not allow for a symmetrical grid design. The total trapping area for each site was: 2.87 ha for HON, 2.81 ha for KHI, and 3.37 ha for MAK. Each trapping event consisted of four consecutive trap nights. Both KHI and HON had 60 traps (45 traps were on the ground, 15 were in trees up to 4 m height), and MAK had 50 traps (45 on ground, 5 were in trees). All traps were baited with fresh chunks of coconut, and pre-baiting with shredded coconut took place 2 days prior to opening traps. Mice (*Mus musculus*) were also prevalent at the study sites, and were marked and measured using the same methods as for rats.

Application of tracking tunnels to estimate rat abundance

At all three sites, tracking tunnels (The Black Trakka Gotcha Traps LTD) were deployed approximately 1 week after each live-trapping interval ended from May 2008-April 2009. Tracking tunnels consisted of a black plastic tunnel where a water resistant card containing ink and white surface was placed. Tunnels were baited with chunks of coconut and left for approximately 24 hours. Upon collection, each track card was inspected and the species of animal track was identified. During 2008-2009, tracking tunnels were deployed at six time periods for each of HON and KHI, and for three time periods for MAK. The proportion of tunnels that had rat tracks were matched with the live-capture rat abundances in order to determine if tracking tunnels could be used as a proxy for relative rat abundances in the Waianae Mountains.

Micro- and macro-habitat use of rats

In order to estimate *R. rattus* home-range and habitat use at KHI and MAK, a subset of the captured rats were fitted with radio collars. Each radio collar was <4% of the animal's body weight (mean ± SE collar mass: 3.86 ± 0.10 g). Radio telemetry provides a coarse-scale estimate of habitat use. Nighttime radio telemetry was conducted using triangulation. Finer scale habitat use (micro-habitat) was determined at all three sites using string bobbins attached to the backs of *R. rattus*.

Diets of introduced vertebrates at Kahanahaiki: rat, mouse, mongoose, cat, francolin

Diets of five common vertebrates at KHI were determined by analyzing stomach or fecal contents. Mice (*Mus musculus*) and black rats (*Rattus rattus*) were snap-trapped monthly during years 2007-2009 and kept frozen until stomach contents could be extracted. The majority of the mice samples were from May 2009. Scat of mongoose (*Herpestes auropunctatus*) and cats (*Felis catus*) were opportunistically collected by Steve Mosher at KHI during 2005-2007 and kept frozen until analysis. Droppings of Erckel's francolin (*Francolinus erckelii*), a common game bird at KHI, were also collected opportunistically during 2007-2009. A subset of francolin droppings were inspected for seeds passed through the bird's digestive tract and the seeds were immediately sown on Petri dishes to test for germination. All droppings were frozen until future analysis.

Rodent stomach contents were extracted from the stomach cavity, swirled for 5 min in water and mild detergent to separate contents, dissolve gastric juices and oils, and then sieved through a No. 35 US Standard sieve (0.5 mm mesh). Recovered contents were preserved in 95% ethanol and analyzed for 1) percent occurrence of each food type, and 2) relative abundance of each food type. A transparent grid (5 x 5 mm cells for rats; 3 x 3 mm cells for mice) was positioned beneath a Petri dish with stomach contents and examined under the dissecting microscope under 10x magnifications. Percent occurrence of each food type (i.e., vegetative material, seed, fruit, arthropod, hair) was calculated by the presence of each of the food types in a given sample divided by the total number of samples (N = 10 for *R. rattus*; N = 39 for *M. musculus*). Relative abundance of each food type was determined for each individual sample by scoring the number of grid-boxes containing a given food type and dividing by the total number of grid-boxes (i.e., 40 grid-boxes). If more than one food type was in a grid-box, the item closest to the microscope was recorded. When possible, the type/species of arthropod or plant was recorded. Student laboratory assistants/interns conducted these analyses (see Acknowledgements).

Scat (N = 31 mongoose; N = 13 cat) and droppings (N = 30 francolin) were analyzed in a similar fashion as rodent stomach contents. Scat/droppings were placed in centrifuge tubes, soaked and shaken in deionized water to break-up contents, and then sieved through a No. 35 sieve (0.5 mm mesh). Recovered contents were then dried at 45^{o} C and analysed for frequency of occurrence and relative abundance (using 5 x 5 mm grids) under the dissecting microscope

(10x magnification) in a similar fashion as rodent stomach contents. The food type categories used for scat and droppings included: plant (vegetative material, seed, fruit), arthropod, mollusk, reptile, mouse, rat, bird. When possible, the type/species of each food type was recorded. Student laboratory assistants/interns conducted these analyses (see Acknowledgements).

III. Summary Results & Interpretations – Plants and rat-plant interactions

Plant composition and relative abundance at Kahanahaiki

Thirty-five species of plants with stems ≥1 cm dbh from 20 families were present in the study plots at KHI. When the number of individuals (**Figure 2**) and the number of stems (**Figure 3**) were examined, *Psidium cattleianum* was the most common species, and *Schinus terebinthifolium* (also an alien) was among the top five most common trees. Eight of the 35 species were alien plants, and were represented by the following six families: Agavaceae, Anacardiaceae, Buddlejaceae, Euphorbiaceae, Myrtaceae, Proteaceae. The three most common native trees in the 2008 census were: *Diospyros hillebrandii*, *Psydrax odorata*, and *Sapindus oahuensis*. The majority of the 35 species were trees, yet there were a few shrubs and one liana (*Freycinetia arborea*). There were three endangered plant species and one species of concern in the 10 plots.

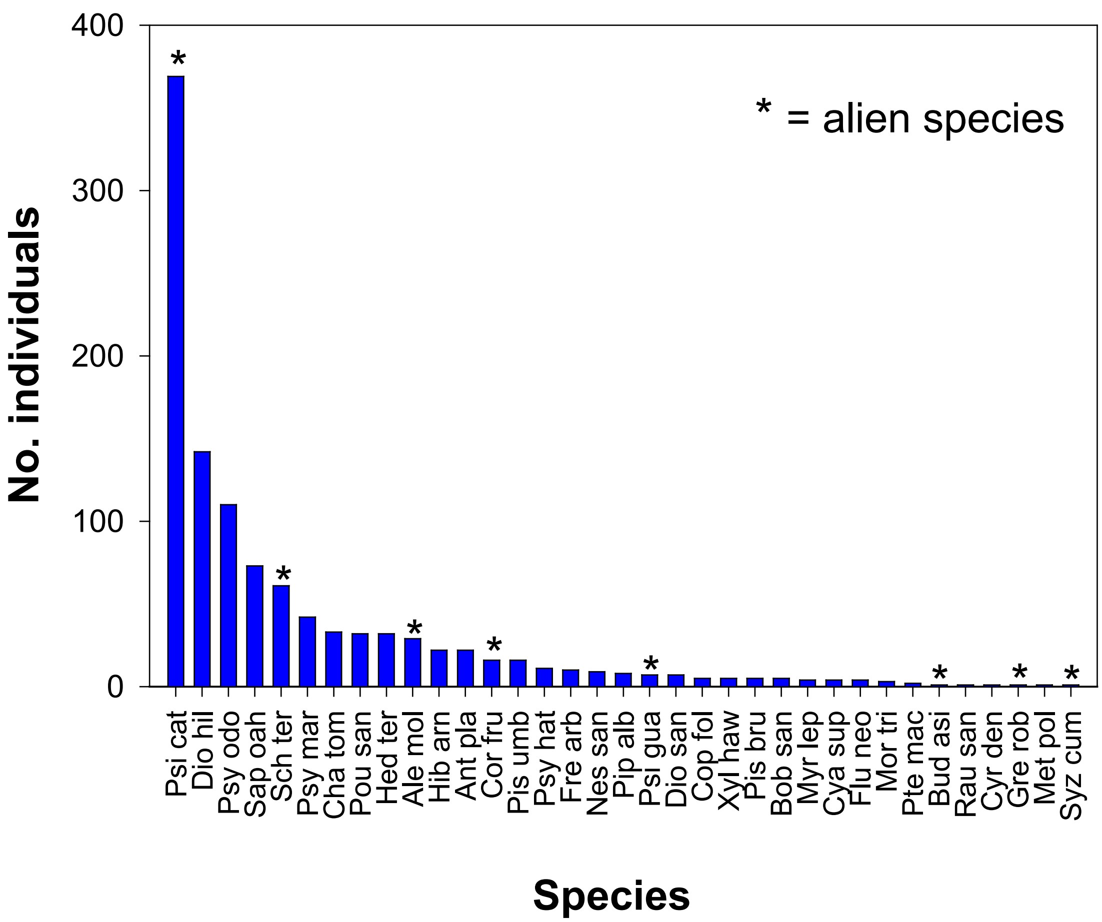

Figure 2. Relative abundance of the 35 species with stems ≥1 cm dbh at Kahanahaiki, Oahu. The top ten species listed corresponding to their six letter species codes are: 1- *Psidium cattleianum*, 2- *Diospyros*

hillebrandii, 3- *Psydrax odorata*, 4- *Sapindus oahuensis*, 5- *Schinus terebinthifolium**, 6- *Psychotria mariniana*, 7- *Charpentiera tomentosa*, 8- *Pouteria sandwicensis*, 9- *Hedyotis terminalis*, 10-*Aleurites moluccana**.

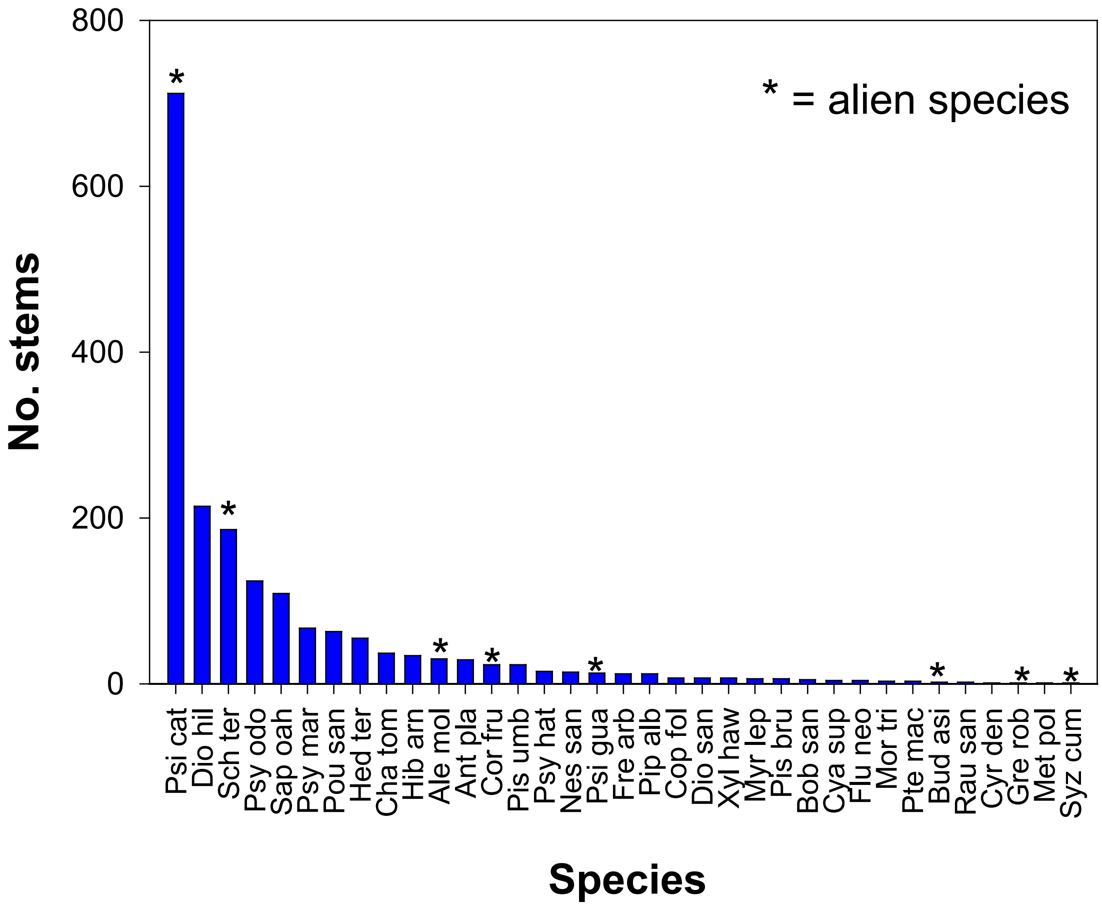

Figure 3. Relative abundance of the 35 species with stems ≥1 cm dbh at Kahanahaiki, Oahu. The top ten species with most abundant stems are listed corresponding to their six letter species codes are: 1- *Psidium cattleianum* (guava), 2- *Diospyros hillebrandii* (lama), 3- *Schinus terebinthifolia* (xmas berry)* , 4- *Psydrax odorata* (alaheʻe), 5- *Sapindus oahuensis* (lonomea), 6- *Psychotria mariniana* (kōpiko), 7- *Pouteria sandwicensis* (ʻalaʻa), 8- *Hedyotis terminalis* (manono), 9- *Charpentiera tomentosa* (papala), 10- *Hibiscus arnottianus* (kokiʻo)

Field trials for vulnerability to rats of top 10 dominant woody plants

When post-dispersal fruit/seed removal was assessed in the field at KHI, nine out of the top 10 dominant woody plant species were removed from the forest floor (**Table 1**). Motion-sensing cameras that were used to monitor a subset of the treatments and revealed that rats (probably *R. rattus*) was responsible for the majority, if not all, of removal of fruits/seeds of each of these nine species. *Psidium cattleianum* was highly vulnerable to rats as 100% of the available fruits/seeds were removed. Because *Psidium cattleianum* is the most common tree species at KHI (**Figure 1-2**) and produces a large amount of fruit/seed over a two-month period, a second trial during the peak fruiting was conducted which revealed just 12% fruit removal. This decreased proportion of trial fruit removed by rats was likely due to the higher abundance (during the peak) of fruit on the forest floor that surrounded the trial fruits. Despite the attractiveness of *Psidium cattleianum* to rats, the other two common alien trees (*Schinus* and *Aleurites*) were not attractive to rats as none of the fruit (*Aleurites*) or very little (2% for *Schinus*) was removed. The native trees assessed (i.e., 7 of 10) ranged in their proportion of fruit removed by rats from 21-79%, and four of the seven native species had >50% fruit removal (**Table 1**). *Diospyros sandwicensis* and *Pouteria sandwicensis* had very high fruit removal, indicating that these species are particularly attractive to rats.

Table 1. Results of the field trials where fruits/seeds of ten of the top woody plant species were assessed for attractiveness and removal by rats in Kahanahaiki forest, Oahu. *Psidium cattleianum* was assessed at two different time periods during its fruiting cycle. An asterix (*) signifies an alien species.

Species	% fruit removal (field)
Psidium cattleianum (guava)*	12-100
Diospyros sandwicensis (lama)	79
Pouteria sandwicensis (‘ala‘a)	79
Psydrax odorata (alahe‘e)	65
Coprosma foliosa (pilo)	56
Nestegis sandwicensis (olopua)	33
Hedyotis terminalis (manono)	29
Sapindus oahuensis (lonomea)	21
Schinus terebinthifolius (xmas berry)*	2
Aleurites moluccana (kukui)*	0

Laboratory trials: captive feeding, seed fate, and seed size threshold

An understanding of the vulnerability of seeds to rat predation can be determined by first assessing the removal of fruits/seed by rats in the field (e.g., KHI) and then assessing the degree by which rats (*R. rattus*) in the captive feeding trials damage and destroy seeds. Half of the dominant species that were first tested at KHI had at least 50% of their seeds damaged by *R. rattus* in captive feeding trials (**Table 2**). Higher seed damage indicates a higher likelihood that the seeds will be destroyed. *Nestegis sandwicensis* essentially had all of the offered seeds eaten and entirely damaged. Rats damaged approximately three-fourths of the available seeds of *Diospyros sandwicensis, Psidium cattleianum*, and *Coprosma foliosa* (**Table 2**). Despite the attractiveness of *Pouteria sandwicensis* in the field, the seeds were not damaged to a high degree. Furthermore, the pericarp (fruit portion) of the diaspore was most-commonly eaten by *R. rattus* in the captive feeding trials. Such a combination of high attractiveness in the field and low seed damage is indicative of dispersal potential by *R. rattus*. Despite being common alien trees, *Schinus* and *Aleurites* are not attractive or vulnerable to rats (**Table 2**).

Table 2. Results of the field and laboratory (captive feeding) trials for the top 10 woody plant species at Kahanahaiki forest, Oahu. *Psidium cattleianum* was assessed in the field at two different time periods during its fruiting cycle. An asterix (*) signifies an alien species.

Species	**% fruit removal (field)**	**% seed damage (lab)**
*Psidium cattleianum**	12-100	74
Diospyros sandwicensis	79	81
Pouteria sandwicensis	79	37
Psydrax odorata	65	56
Coprosma foliosa	56	73
Nestegis sandwicensis	33	99
Hedyotis terminalis	29	36
Sapindus oahuensis	21	23
*Schinus terebinthifolius**	2	3
*Aleurites moluccana**	0	<1

In addition to the 10 most common woody plants species at KHI, a wider suite of species were tested for vulnerability to *R. rattus* in captivity. Currently, more than 45 species from 28 plant families have been tested in the captive feeding trials for vulnerability to *R. rattus*. Other rodent species have not been utilized to a large degree in the feeding trials. In attempt to uncover particular characteristics of the seeds that predict vulnerability to rat predation, a seed size threshold has been determined (**Figure 4**). To date, seeds have been measured for their longest axial length. The majority of the seeds tested do not survive the interaction with *R. rattus*. However, the seeds that have the highest survival are the smallest seeds. Such small seeds that are below the threshold of 1.8 mm were consumed by *R. rattus* and most often passed intact through the rat's digestive tract. In order for small seeds to be swallowed and passed intact by *R. rattus*, they must have attractive fruit. Such small seeds are likely being dispersed by *R. rattus* in the wild.

There was no general (statistical) patterns uncovered when linear and non-linear relationships were tested between seed size and seed survival after rat interaction. The absence of significant pattern is probably reflective of the species specific characteristics of the seeds that do not fit the hypothesized pattern that larger seeds are more likely to be destroyed by *R. rattus*. As mentioned above, some of the large-seeded species such as *Pouteria* and *Sapindus* had few of their seeds damaged by *R. rattus*.

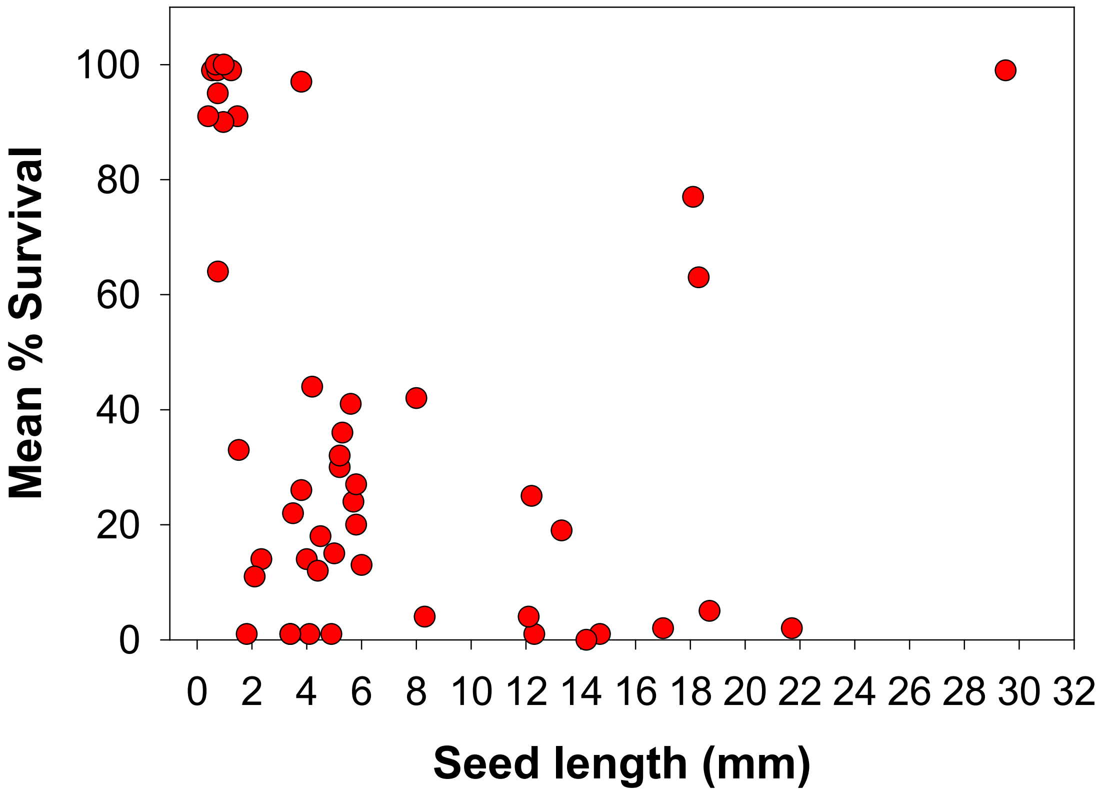

Figure 4. Mean seed survival of 45 plant species from 28 families after 24-48 hr interaction with *R. rattus*. Each point represents a species. Seed length (mm) was determined by the longest axis of the seed.

IV. Summary Results & Interpretations – Rat biology in the Waianae Mountains

Relative abundances of rats

Approximately 900 individuals of mice (*Mus musculus*) and rats (*R. rattus* and *R. exulans*) were captured, marked, measured, and released during the February 2007-April 2009 trapping season for all three sites (HON, KHI, MAK) combined. Few *R. exulans* were captured, but were present at all sites. *Rattus norvegicus* has never been captured at any of the study sites. There was a noticeable difference in rat captures between the two most intensely sampled sites (HON and KHI), as KHI rat abundances fluctuated more than HON (**Figure 5**). Additionally, *Rattus rattus* abundances at KHI were approximately 2-4 times greater than rat abundances at HON. The *R. rattus* abundances at MAK were more similar to HON than KHI (**Figure 5**). Rats were only active during the night, as no rats but several mice were captured during the daytime at each site.

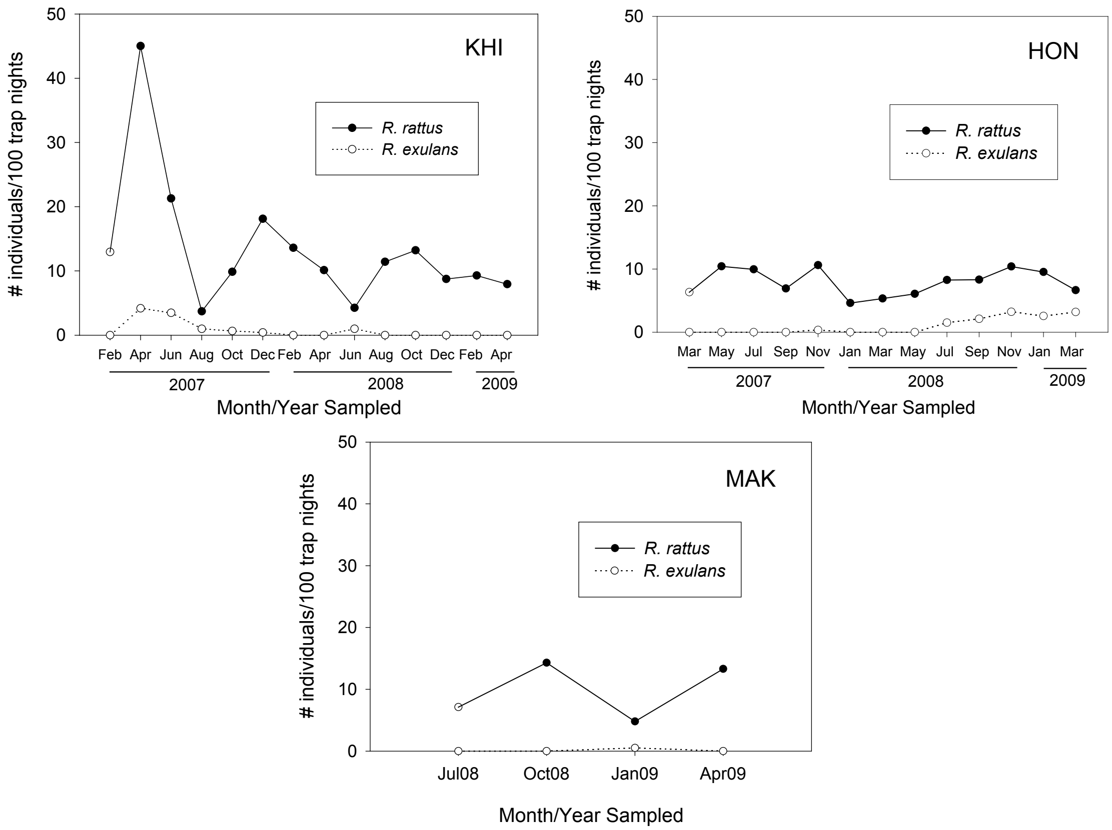

Figure 5. *Rattus* spp. abundances (No. indiv./100 trap nights) for three sites (KHI, HON, MAK) in the Waianae Mountains, Oahu.

Application of tracking tunnels to estimate rat abundance

In attempt to better predict rat abundance without utilizing the high-intensity, high-effort, live-trapping technique, tracking tunnels were deployed and the activity levels were matched with those of live-trapping. Both HON and KHI tracking tunnels were utilized on six occasions during 2008-2009, whereas MAK tracking tunnels were utilized on three occasions. There were no significant relationships when analyzed on a site-basis or collectively (all three sites combined), indicating that the tracking tunnels do not provide a reliable index of rat abundance at these sites (**Figure 6**). Future analyses will be conducted to determine if particular days in the 4 day trapping sequence (e.g., the first day), or if better rat abundance estimates utilizing program MARK, may provide a significant relationship with tracking tunnel activity.

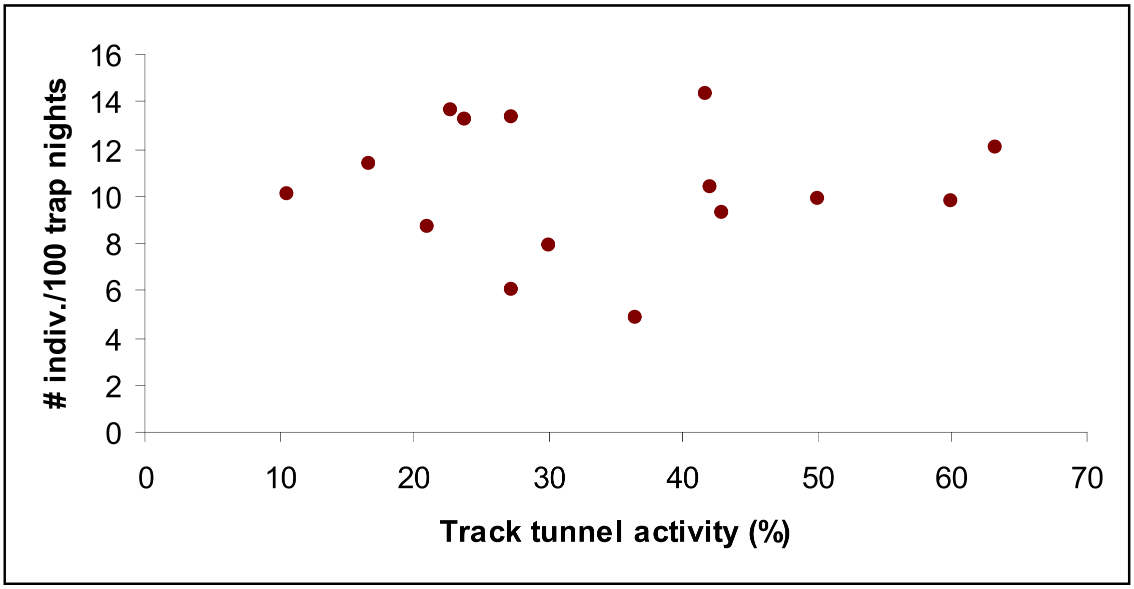

Figure 6. Scatterplot showing the rat (*R. rattus* + *R. exulans*) activity levels from the tracking tunnels matched with the rat abundance estimates (live-trapping) from the same sites (HON, KHI, MAK) and time periods (separated by 1 week). No significant relationships were present when analyzed on an individual site-basis or collectively.

Micro- and macro-habitat use of rats

Bobbins were attached to rats to provide an index of microhabitat use. For all individuals with bobbins attached, rats did not travel further than 50 m from the trap site in 24 hours before the 200-300 m of string in the bobbin ran out. There was not a clear partitioning of habitat for individuals of *R. rattus* that were caught in trees versus those that were caught on the ground. In other words, rats that were caught on the ground used tree and ground habitat, and likewise, rats that were caught in the trees used both trees and ground habitat. Overall, *R. rattus* appeared to use the ground habitat (79%) more than the trees (21%). When traveling above ground, rats were most often <1 m high, but in some cases they would climb to >12 m height (maximum was 22 m). A single *R. exulans* was caught in a tree (ca. 2.5 m height) at HON, but all other *R. exulans* at all sites were caught on the ground. Bobbins were attached to *M. musculus* that were caught on the ground at all three sites. Like *R. exulans*, mice used the ground habitat the most, but would often use habitat <2 m above ground. One mouse at KHI used tree habitat to 4.1 m above the ground.

Ten *R. rattus* were radio-collared and tracked at KHI from February through June 2007. The locations of collared rats were taken both during the daytime (inactive period) and nighttime (active period) approximately once a week. The home-ranges of each of the 10 rats are still being analyzed; however, all collared rats had home-ranges <1 ha, and movement distances appear to be relatively close to den sites (range: 7-145 m). Rat den sites were located both in the ground and in trees (live and dead). The most common trees for rat den sites were alien species (*Grevillea robusta, Psidium cattleianum, Aleurites moluccana*), although one female rat had a short-term (<1 week) den site in a cavity of the native *Santalum paniculatum*. All collared rats at KHI changed den sites multiple times (1-6 times) and only two rats returned to previously-used den sites after selecting a new den site during the life of the radio-collar. There were no occasions where two collared rats shared the same den site; however, home-ranges commonly overlapped. At least four of the 10 rats suffered predation, as rat collars were retrieved on the forest floor with only a rat stomach remaining or in one case only part of the pelt present. Stomachs from rats that were not collared were found on two occasions at KHI, suggesting that the collars did not cause the mortality of radio-collared rats. There are a suite of predators at KHI, as motion-sensing cameras revealed at least one feral cat (*Felis catus*) and several mongoose (*Herpestes auropunctatus*) at KHI. Barn owls (*Tyto alba*), another potential predator of rats, have been observed on several occasions during nighttime radio telemetry at KHI.

Ten *R. rattus* at MAK were radio-collared and tracked from July 2008 to May 2009. Compared to the collared rats at KHI, the MAK rats were not monitored as frequently. Den sites for MAK rats were both in the ground and in live and dead trees. At two different times (separated by nearly 6 months) a collared *R. rattus* denned in the same *Pouteria sandwicensis* tree, approximately 2 m above ground. Similarly two different rats denned in a large dead tree that was approximately 6 m tall. Large (living) trees of *Metrosideros polymorpha* and *Acacia koa* were also den sites of *R. rattus* at MAK. The highest den site was a female *R. rattus* in an *Aleurites moluccana* tree (20 m high). Beginning in April 2009, there was a male *R. rattus* that denned approximately 2 m above ground in a *Psidium guajava*, but this individual died of an unknown cause approximately one month later.

When compared to KHI, the collared rats at MAK did not appear to be depredated as frequently. One *R. rattus* at MAK died and had the majority of its carcass eaten, but it was unclear if the rat had died of 'natural' (non-predator) causes and was then scavenged, or if it was killed by a predator. In addition to a seemingly lower mortality of *R. rattus* at MAK, the rats at MAK appeared to have slightly larger home ranges (>1 ha) than those collared at KHI. This pattern supports past studies showing that rat home-ranges will increase with a decrease in rat abundance. Future analyses will determine if these apparent differences between rats at the two sites where radio collars were utilized are significant.

V. Summary Results & Interpretations – Diets of introduced vertebrates

Diets of Rattus rattus *and* Mus musculus

Dietary analyses of several of the most abundant introduced vertebrates at Kahanahaiki, Oahu, were determined during 2005-2009. Nearly 100 *R. rattus* stomachs have been collected from KHI, yet presently only 10 stomachs have been analyzed. In all ten of the *R. rattus* stomachs analyzed, both plant material and arthropods were present (**Table 3**). Similarly, mouse (*Mus musculus*) stomachs comprised of high proportions of both plants and arthropods (**Table 4**). The relative proportions of plant material tended to be higher in *R. rattus* than in *M. musculus*, and the proportion of arthropod in stomachs tended to be lower in *R. rattus* than *M. musculus* (**Table 3, 4**). A substantial portion of the stomach contents of rats was not identifiable. Intact seeds and fruit fragments of *Clidemia hirta* were found in one of the rat stomachs.

Table 3. Diet analysis of black rats (*Rattus rattus*) based on stomach content analysis. All rats were collected fresh (<24 hrs) from snap-traps set in Kahanahaiki forest, Oahu from 2007-2009 (N = 10).

	Plant	Arthropod	Fungi	Unknown
% Occurrence (% of droppings with each food type)	100%	100%	10%	40%
Mean relative abundance (% of 40 boxes with each food type)	92%	53%	2%	<1%

When the arthropod portion of mice were more closely examined, approximately 35% of the stomach content of each mouse was an unknown species of centipede, <1% was the ant *Solenopsis papuana* (P. Krushelnycky, *pers. comm*.), and the remaining 64% was comprised of spiders, beetles, and other unknown arthropods. The presence of mouse hair (**Table 4**) is most-likely a result of self-preening, as these rodents are not known to be cannibalistic.

Table 4. Diet analysis of mice (*Mus musculus*) based on stomach content analysis. All mice were collected fresh (<24 hrs) from snap-traps set at Kahanahaiki forest, Oahu.

	Plant	Arthropod	Mouse Hair
% Occurrence (% of droppings with each food type)	63%	94%	10%
Mean relative abundance (% of 40 boxes with each food type)	30%	65%	5%

Diets of Herpestes auropunctatus*,* Felis catus*, and* Francolinus erckelii

The main predators of mice and rats at KHI are mongoose (*Herpestes auropunctatus*) and cat (*Felis catus*), and this was confirmed through scat analysis (**Table 5**). Despite the carnivorous classification of cats and mongoose, their diets are largely omnivorous. Plant material was found in the majority of the samples, and some included seeds of *Psidium cattleianum*. The high frequency of reptile material in mongoose was probably the rainbow skink (*Lampropholis delicate*), which is commonly observed during the daytime on the ground in open-canopy areas at KHI. The mollusk observed in at least three of the mongoose scat (**Table 5**) was a native snail in the Tornatellidinae subfamily (family: Achatinellidae; J. Kim, *pers. comm*.). This snail is approximately 2 mm in length; this small size making it unlikely that the mongoose targets this snail and more likely that it was incidentally consumed (probably attached to a different food item). Bird feathers, bones, and egg shells were consumed by both mongoose and cat. It is unclear what species of birds were consumed, but there are very few native birds remaining at KHI.

Table 5. Percent occurrence of food types in scat from mongoose (*Herpestes auropunctatus*) and cat (*Felis catus*). All samples were collected in mesic forest in Kahanahaiki, Oahu.

	Rat	Mouse	Reptile	Plant	Arthropod	Mollusk	Bird
Mongoose (N = 31)	26%	77%	87%	84%	97%	10%	26%
Cat (N = 13)	100%	100%	31%	92%	100%	0%	23%

All samples of Erckel's francolin (*Francolinus erckelii*) contained both plant material and arthropod (**Table 6**). A few of the samples contained mollusk-looking organisms, and fewer contained reptile scales. Twenty-one of 30 samples contained intact seeds of *Rubus rosifolius* (thimbleberry), a noxious weed that appears to be spreading in KHI. Additionally, at least three of 30 droppings contained intact seeds of *Psidium cattleianum*. These findings reveal that this common introduced game bird is dispersing at least two of the highly invasive plants at these sites. Land managers need to be aware of this in order to best protect against their further spread and ecological damage.

Table 6. Diet analysis of Erckel's francolin (*Francolinus erckelii*) based on fresh droppings collected opportunistically (2007-2009) from Kahanahaiki forest, Oahu (N = 30 droppings).

	Plant	Arthropod	Mollusk	Reptile
% Occurrence (% of droppings with each food type)	100%	100%	27%	3%
Mean relative abundance (% of 40 boxes with each food type)	92%	53%	2%	<1%

VI. Conclusions

Rattus rattus is the most common rodent in all three study sites in the Waianae Mountains, and comprised >90% of the total rat captures during the 2-year census. Based on all rat studies that I am aware of in the Hawaiian Islands, *R. rattus* is presently the most common rat species to invade natural areas. Such high pervasiveness of *R. rattus* across the state clearly deserves attention in order to both establish a better understanding of the potential impacts of this invasive species on Hawaiian flora and fauna, and to apply these research findings to improve management efforts seeking to control introduced rats and their negative impacts on island biota.

Based on recapture and demography data to present, *R. rattus* appears to have a relatively high turnover rate in their populations in the Waianae Mountains, as few individuals have been recaptured after 6 months and only one individual has survived 1 year. Despite the presence of predators such as feral cats, mongoose, and barn owls, *R. rattus* appears to persist through periods of high predation (sometimes 40% mortality due to predation in a 4 month period at KHI; though much lower at MAK), variable fruit and seed availability (based on phenology data at KHI), and months of below-average temperatures (**Figure 1**) with little rainfall. These environmental factors may all contribute to the intra-annual fluctuations in rat populations observed at these sites. Additionally, disease has been little studied in rodent populations in natural areas in Hawaii but susceptibility to disease may also contribute to the fluctuating rat abundances observed.

Rats can affect the survival and reproduction of plants in several ways, yet seed predation and seed dispersal by rats appears particularly important to plant recruitment success in Hawaii. The combination of field and laboratory trials has enabled native and alien Hawaiian plants to be categorized according to their vulnerability to rats. Land management can use such species lists to help prioritize efforts to control and otherwise protect plant species that may be vulnerable to rats. While this current study is specific to Hawaii, generalities utilizing seed characteristics can help predict vulnerability of world-wide floras to rats (particularly *R. rattus*). Analyses to date suggest that there is a seed size threshold of 1.8 mm seed length for seed dispersal by *R. rattus*. This means that most seeds <1.8 mm that *R. rattus* consume will most-likely be dispersed (*i.e*., passed intact through the rat's digestive system), and otherwise not vulnerable to predation by *R. rattus*. Additionally, those species with seeds >1.8 mm that are attractive to rats are much more likely to be destroyed by *R. rattus*; however, the vulnerability of the larger seeds is also species-specific as some large-seeded species are not vulnerable to predation and some may alternatively be dispersed by rats. Currently there is a relatively high number of native plant species that are coexisting with the aggressive alien plants like *Psidium* and *Schinus*. Future integration of seed vulnerability measures, phenology, and seedling and size class structuring should enable better predictions of the extent by which introduced rats are altering Hawaiian forests.

The lack of relationship between tracking tunnel activity and rat abundance resulting from live-trapping was surprising. Additional analyses will be performed on these data in search of particular attributes that may support the usefulness of tracking tunnels as a proxy for live trapping. However, at this point it seems that tracking tunnels are best used to gain understanding of rat activity in particular habitat types rather than utilizing the tracking tunnels as indicators of rat abundance or density.

Rattus exulans, though present at all three study sites (HON, KHI, MAK), remains relatively uncommon and was not captured at all trapping sessions. Only one individual of *R. exulans* was captured during the 2008-2009 year at MAK. The few *R. exulans* individuals that were assessed for habitat use (by radio-collaring and bobbins) in KHI had slightly smaller homeranges than *R. rattus* and the type of habitat used by *R. exulans* was >80% ground, of which they seemed to utilize the dense cover of low-stature ferns (mainly the non-native *Blechnum appendiculatum*) when active. These apparent differences in habitat use, behavior, and density suggest that these two species of introduced rats may differ in the type and magnitude of threat that they pose to native biota and the present ecosystem.

In addition to *R. exulans* and *R. rattus*, several other introduced vertebrates have been observed at the study sites that may be competitors and/or predators of rats. Diet analyses of such species both provides a better understanding of the structure and food web in these forests, but also indicates the groups of organisms that are likely to be susceptible to each introduced vertebrate. Interestingly, all five of the introduced vertebrates (rats, mice, mongoose, cat, francolin) that have been studied have omnivorous diets. Although mice and rats are nocturnal, semi-arboreal, and have overlapping habitat uses, the diets of mice are approximately 65% arthropod and 30% plant, compared to *R. rattus* that has a diet of mostly plants and less arthropods. Additional analysis is needed to identify the types of species that are being consumed by these prominent rodents, yet the previously described plant trials provide some examples of such vulnerable species.

Mongoose and cat have diets consisting of wider groups of animals than the sampled rodents. Scat analysis reveals that mongoose preys heavily on reptiles, specifically skinks, as well as arthropods and plant material. Although both of these predators were not expected to eat plants, analysis of mongoose and cat scat shows that they not only eat plant material but they may also be dispersing some seeds during fruit consumption, which included the invasive species *Psidium cattleianum*. In addition to plant material, there was a wide variety of life forms that were consumed by both mongoose and cats (e.g., rodents, reptiles, plants, arthropods, mollusks, birds).

Analysis of Erckel's francolin diet revealed the large proportion of both arthropods and plant material. Although these francolins are able to fly, they only do so on rare occasions (usually when flushed). Therefore, the most vulnerable arthropods are those that are on the ground (in leaf litter and top soil) and perhaps on the lower portions (<1 m above ground) of vegetation. The high abundance of viable seeds of *Rubus rosifolius* (thimbleberry) and *Psidium cattleianum* that were found in many of the francolin droppings particularly deserves attention as these game birds are clearly dispersing these two noxious (and currently abundant) weeds and are likely accelerating the rates of spread. A more in-depth study of the impacts of Erckel's francolin and other common game birds on the current and future plant community is needed. Lastly, a better understanding of how these common introduced vertebrates are integrated into the food web in these forest preserves will provide a better understanding of the ecosystem and maintenance of biodiversity, as well as help avoid unexpected outcomes of future control or eradication efforts.

The findings from this study will help assess the pervasiveness, distribution, and habitat use of alien rats in Hawai`i, as well as the impacts of rats on Hawaiian plants. When strategizing rat control and eradication to protect native Hawaiian biota, it is important to understand which species are most vulnerable and how they are vulnerable. Most seeds that are attractive to rats in Hawaii are destroyed by the large incisor teeth of the rat. However, a small number of seeds will not be negatively affected, and may likely be dispersed, if eaten by rats. While the net effect of rats on seeds is largely negative, it is necessary to prioritize which species of native plants most need protection from rats. Additional understanding of how rats are integrated with the many other native and introduced species is needed to best manage natural areas in Hawaii. Because conservation efforts are restricted by cost and time, a greater knowledge in this area will hopefully assist in the preservation and/or restoration of native species in the Hawaiian Islands as well as additional island where introduced rats are present.

VII. Acknowledgements

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VIII. Relevant products/publications from this research

Meyer, W.M., and A.B. Shiels. 2009. Black rat (*Rattus rattus*) predation on non-indigenous snails in Hawai`i: complex management implications. *Pacific Science* 63: 339-347.

Pérez, H.E., A.B. Shiels, H.M. Zaleski, and D.R. Drake. 2008. Germination after simulated rat damage in seeds of two endemic Hawaiian palm species. *Journal of Tropical Ecology* 24: 555-558.

Shiels, A.B, and D.R. Drake. 2007. *Fruit/seed vulnerability to introduced rats in Hawaiian forest. In*: Proceedings of the Seed Ecology II 2007 Conference, 9-13 September, Perth, Australia. Turner, S., D. Merritt, S. Clarke, L. Commander, and K. Dixon (Editors). Kings Park and Botanic Garden, Perth, Australia, pp. 81.

APPENDIX 5

TRANSLOCATION GUIDELINES FOR THE O‘AHU TREE SNAILS (*ACHATINELLA* SPECIES)

Prepared by

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Honolulu, Hawaii

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EXECUTIVE SUMMARY

In light of continued declines in O‘ahu tree snail abundance, conservation managers are considering various types of translocation (see §1.1: Definitions) to supplement existing recovery efforts. The goals of translocation techniques are clear, but their long-term effects are widely unpredictable. In this report, the relative risks of five types of translocation are assessed using expert knowledge of *Achatinella* species, scientific literature, and the results of previous translocation attempts with other species.

Most of the techniques discussed have not previously been used with tree snails, hindering the ability to assess likely outcomes and evaluate alternatives. Basic biological risk-criteria are outlined, which are then used to rank the risk of various translocation scenarios. Priority goals for stabilizing these snails are re-defined, and risk levels are used to guide decisions on how to best achieve those goals with minimal risk. Three species’ current statuses and management recommendations are discussed within this framework.

The complexity and variability of recommended actions for each species emphasize that any translocation should be preceded by extensive coordination with experts. This document provides only rough guidelines and should be amended whenever new information becomes available. Pre-translocation planning protocols are provided to optimize the use of these new approaches. Lastly, research needs are outlined together with possible experimental designs that may provide critical data on translocation effects.

1. BACKGROUND & CONTEXT

1.1 Definitions

Translocation: The capture, transport and release of a species from one location to another ("Translocation" 2009). This term makes no assumptions regarding the source of the individuals (captive-reared or wild), the characteristics of the destination habitat (occupied/unoccupied wild or captive location), or the number of individuals involved (whole/partial population or individual).

Population: A group of at least 5 animals (see §2.1) of a species whose ancestors may reasonably have interbred within the last 2 generations. This timeframe corresponds to a group of snails being separated by 30-50m from other snails, based on simulations of snail dispersal (Hall *in review*). In addition, analyses of microsatellite genetic data (using the markers of Erickson and Hadfield [2008]) have revealed population divergences at similar distances (Hall and Hadfield *in review*). Areas with high wind exposure and short vegetation correspond to longer separation requirements.

ESU: Evolutionarily significant unit. One or more populations of a species with a distinct, long-term evolutionary history that are genetically cohesive and have been isolated from other populations with regards to gene flow for hundreds of generations. This timeframe is based on the mutation rate of cytochrome oxidase I, the genetic marker that has been used to delineate all *Achatinella* species ESUs to date (Holland and Hadfield 2002). These mitochondrial markers take much more time than microsatellites to reveal major population divergence (Selkoe and Toonen 2006).

GU: Geographic Unit. A population or group of populations clearly separated geographically from other populations with regards to contemporary gene flow. These units are used to distinguish subdivisions within species in the absence of ESU designations.

1.2 Status of *Achatinella* Species

Tree snails of the genus *Achatinella* are endemic to the island of O'ahu, Hawaii. These arboreal snails can reach over 20 mm in shell length and live primarily on native vegetation, feeding nocturnally on molds growing on the leaves and trunks of host plants. They are characterized by a late age at maturity (3+ years), long potential lifespan (10+ years), and low birth rate (4-5 offspring per year) (Hadfield et al 1993). O'ahu tree snails are hermaphroditic, although self-fertilization has only thus far been confirmed for a closely related genus (*Partulina*) in the same subfamily (Kobayashi and Hadfield 1996).

The United States Fish and Wildlife Service (USFWS 1992) recognizes 41 species within this genus based upon taxonomic delineations by Pilsbry and Cooke (1912-1914). Only 10 of these species are thought to remain in the wild, and all are facing extinction pressure from invasive predators such as rats and predatory snails (Hadfield et al 1993). All 41 species were listed on January 13, 1981, as endangered under the single genus name *Achatinella* (46 FR 3178) (USFWS 1981).

As stated in §4(f) of the Endangered Species Act of 1973, USFWS is required to create a recovery plan for all listed taxa. The Service published the *Achatinella* species recovery plan in 1992, with the intended goal of stabilizing populations found in essential habitat areas (USFWS 1992). No goals for de-listing were set at that time because of uncertainty in the status of these species. Discussion of recovery and de-listing is still premature because predator threats have yet to be eliminated. The goals outlined in this document will be, as in 1992, to stabilize species while predator abatement research continues.

1.3 Management Goals Addressed

To stabilize an *Achatinella* species, USFWS (2003) recommended active management of 10 populations. In practice, management of only 6-8 populations has been approved for stabilizing some species (U.S. Army Garrison, 2008). For aquatic snails, USFWS (2005) had previously set a recovery target at only three stabilized populations. We recommend keeping the more conservative minimum of 6 populations for each *Achatinella* species, based on their extreme vulnerability to catastrophic decline from predation (Hadfield and Mountain 1980; Hadfield et al 1993). These 6 populations should include at least one population from every major GU of the species, or every ESU when genetic data are available. Up to 10 populations should be stabilized if more than 6 ESUs can be elucidated; additional populations should be managed less intensively, as outlined in §2.

All populations should number at least 300 individuals to be considered stabilized, which was the recorded size of a rapidly growing wild population in the Pahole NAR (Hadfield et al 1993). However, this population size is based on a single group of snails in a $25m^2$ area. In addition, this population was predated prior to reaching a stable population size and might have grown much larger. PVA analyses (see § 6.2) should thus be used to provide a more appropriate minimum number of individuals to achieve stabilization.

For the past two decades, active management has included various techniques such as captive propagation (one form of translocation), rat control, and the construction of two predator-proof exclosures. There has also been recent interest in employing additional translocation techniques to supplement ongoing conservation efforts. A total 5 types of translocation techniques are defined in §3, along with 8 types of populations for which they may be applied (§2). Although the usage of these 13 terms varies widely in the literature, they are defined here in the context in which they are likely to be proposed by conservation managers.

Unfortunately, most translocation approaches remain untested with tree snails, providing little information on which to base future decisions. The relative risks of these techniques are also outlined in §3, based on available literature and expert knowledge. Alternative techniques are then ranked by their risk levels, so that decision makers can prioritize their application towards fulfilling stabilization goals. Examples of designations and recommendations within this context are given in §4.

2. CLASSIFYING POPULATION TYPES

It should be noted that the population descriptions outlined in the next section are not permanent descriptors of a population. Additional data and/or changing realities can alter a population's status, although the basic requirements of §1.3 must remain satisfied by any changes in a population's classification. Populations are classified by size category (5 types) and conservation priority (3 types) in order to standardize management decisions in this document.

2.1 Definitions

Defunct population: Less than 5 adults. These populations are unlikely to recover unaided; 6 adults is the smallest recorded *Achatinella* species population size in which rapid growth has been confirmed (captive-reared *Achatinella lila*). Hadfield and Saufler (2009) recorded population-size increases from only 4 adults of *Partulina* snails (a closely related genus to *Achatinella*), although it is unclear whether *Achatinella* species are capable of similar recoveries. Defunct is thus defined as below 5 adults, the average of the *Achatinella* and *Partulina* thresholds where human-mediated population increases have occurred.

Recoverable population: Any population with 5 or more adults. This term is defined here strictly as an antonym to the above definition of defunct, and makes no assumptions as to the level of human intervention required for recovery. Recoverable populations can be further classified as "small", "medium", or "large", all of which are defined below.

Small population: Between 5 and 20 adults. The upper bound of 20 was chosen because this is the number below which an entire wild population should be extracted for captive propagation (Tenhumberg et al 2004), and the minimal number of individuals recommended to establish a viable, re-introduced population (USFWS 1992, Stringer and Grant 2003). Although recovery from only 4 individuals appeared possible in Hadfield and Saufler's (2009) study, long-term success was unobservable due to rat predation.

Medium-sized population: Between 21 and 100 adults. This classification was created simply to define populations between "small" and "large" status.

Large population: Greater than 100 adults. A population of this size is considered "stabilized" if all age classes are also represented in the appropriate frequency (see Hadfield et al 1993), based on a total of 300 total individuals (USFWS 2003).

Primary population: These populations represent the minimum 6 populations of 300 individuals outlined in §1.3, characterizing the maximum genetic diversity or geographic range of the species. The appropriate minimum number of primary populations may exceed 6 (§1.3). The utmost priority for conservation managers is to designate and stabilize the appropriate number of primary populations, and protect them *in situ* with predator-proof exclosures. Captive populations are not considered primary populations; they cannot persist without constant human assistance. Within each GU or ESU, the largest and/or enclosed (predator-proof) population should be designated as its primary population. Only recoverable populations (see above) should be designated as primary populations, to increase recovery probability.

Secondary population: For species with populations in excess of the minimal number of primary populations, secondary populations should be designated. The purpose of a secondary population is to become a primary population should a primary population experience a catastrophic decline. One secondary population should be designated for each ESU or GU. High priority should be given to establishing secondary populations for GUs or ESUs represented by a single primary population. All captive populations are necessarily secondary populations, and should be used to restart a primary population as soon as possible if their wild source population is extirpated.

Tertiary population: These are populations in excess of secondary populations, and can become secondary populations if the secondary is lost or converted to primary status.

2.2 Designation Example: *Achatinella decipiens*

Most experts consider this species synonymous with *Achatinella byronii*, and both will be referred to collectively in this document as *A. decipiens*. Currently, "recoverable" (§2.1) applies to only 4 wild populations (U.S. Army Garrison 2008). All 4 are thus designated as primary populations and represent 3 GUs. One of these GUs is represented by both a wild and a captive population, which is considered a secondary population. At least 2 additional wild populations must be created in order to meet the minimum of six primary populations, and should come from under-represented GUs as outlined in §4.2.

2.3 Designation Example: *Achatinella lila*

Only 3 wild populations qualify as primary populations for this species, representing each of the 3 GUs (U.S. Army Garrison 2008). One secondary population is found in captivity and has been reproducing at an astonishing rate. To meet the minimum of six primary populations, this captive population will likely be used in the coming years to establish reintroduced populations.

2.4 Designation Example: *Achatinella sowerbyana*

Only 6 wild populations qualify as primary populations for this species, and all are thus designated as primary populations. Although 7 GUs have been defined for this species, only 3 of those are represented by the primary populations (U.S. Army Garrison 2008). One GU is represented solely by a secondary captive population, and the other 3 GUs are "defunct" (**§2.1)**. Future surveying efforts will hopefully reveal the existence of primary populations in the 4 under-represented GUs. For now, there are 3 primary populations in one GU, 2 in another GU, and a single primary population in a 3rd GU.

3. RISK CRITERIA FOR TRANLOCATION ALTERNATIVES

There are 5 types of translocation under consideration, (reintroduction, introduction, augmentation, combination, and extraction). Several of these approaches can be employed using an entire population, or by using a subset after splitting a larger population. It is assumed in all cases that such splitting does not reduce the original population to a "small" (§2.1) population. There are 3 levels of risk defined below, and a risk level is assigned to every translocation scenario likely to be proposed (captive stock to wild population, wild stock to captive population, etc.). Some definitions include terms defined in §2.1.

3.1 Definitions

Reintroduction: Translocation of a "large" or medium-sized" (§2.1) population to a locale within the historical range of the species where the species has been locally extirpated. This can be a whole population or a group of individuals split from a larger population. "Small" populations should be extracted, by definition (§2.1), and are not considered candidates for reintroduction.

<u>Introduction:</u> Translocation of a "large" or "medium-sized" population to a locale beyond the historical range of the species. This can be a whole population or a group of individuals split from a larger population.

<u>Augmentation:</u> Translocation of an individual or multiple individuals from a single source population (not a whole population) to another population. Mills & Allendorf (1996) note that augmentation should be from high diversity to low diversity; the reverse direction could actually decrease genetic variation. Populations in the center of a species range often retain more genetic variation (Schwartz et al 2002).

<u>Combination:</u> Translocation of a whole population into another population, resulting in the complete loss of unique genetic lineages. Such an irreversible loss highlights the need for caution with this approach.

<u>Extraction</u>: Translocation of individuals from a single wild population to a captive-rearing facility. This is done mainly to rapidly boost population sizes, although can be used as an emergency solution for populations facing impending extirpation. This latter purpose has been the prevailing justification for *Achatinella* species extractions to date.

<u>Low Risk</u>: No foreseeable detriment to the translocated species.

<u>Medium Risk:</u> One of the following criteria: 1) Unknown risk to the focal species (substantiated by relevant literature), 2) Unknown risk to other resident species (substantiated by relevant literature), or 3) Management action involving a blend of 2 untested translocation methods.

<u>High Risk:</u> An inevitable impact to the focal species is outlined; or at least 2 medium-risk criteria are met ("unknown risk to the focal species" can be counted twice if there are 2 clearly different sources of risk).

3.2 Reintroduction

Wild stock: If well-established transportation methods are used (§5.3), and the suitability of the recipient site is clearly supported, risks are considered minimal. ***Low Risk***

Captive stock: This option should not be considered until a captive population reaches 50 individuals (USFWS 1992), and reintroductions should not be used solely as a way to get rid of surplus captive stock (IUCN 1998). Surplus stock should be reintroduced only to meet stated recovery goals, or to experimentally test reintroduction effects so as to improve subsequent reintroductions. A review by Seddon et al (2007), spanning a broad array of both invertebrate and vertebrate taxa, indicated that reintroductions from wild stock are generally more successful that captive-reared individuals. This may stem from any number of causes including adaptation to unnatural captive environments or poor health resulting from pathogens in the captive facility (Cunningham 1996). However, these risks are associated with extraction and not reintroduction, and are intended to point out that wild stocks are preferable to captive stock for reintroductions, when the option is available. ***Low Risk***

3.3 Introduction

Wild Stock: Suitability of habitat outside of a species historical range is questionable, and may pose a risk to the focal species. Furthermore, adverse interactions with other resident species in new locals are also unknown. Introduced animals can serve as disease vector for resident species, or be exposed to new diseases themselves (Cunningham 1996). ***High Risk***

Captive Stock: In addition to the risks associated with introducing wild stock, captive stock can also introduce new diseases to resident species (Cunningham 1996). ***High Risk***

3.4 Augmentation

Wild stock to a wild population:

1) To an immediate neighbor population. An immediate neighbor population is one that has been separated from its origin by a predator-exclusion fence. The formulae to determine the appropriate number of migrants and frequency of release are given by Hall et al. (*in press*), and depend on the population size, dispersal rate (wind exposure), and dimensions of exclosure. ***Low Risk***
2) To a population in the same ESU or GU. The proper number of migrants and frequency of repetition is unknown (see §6.1: Research Needs). ***Medium Risk***
3) To a population in a different ESU or GU. In addition to number 2), there is potential for outbreeding depression under this scenario, whereby the offspring resulting from crossing distant lineages are less fit than either parent. This can occur via the break up of co-adapted gene complexes or as the result of maladapted intermediate phenotypes (Edmands 2007). ***High Risk***

Wild stock to a captive population:

1) To an immediate neighbor population. The number of adults to transfer should represent the emigration rate of the population, applied to the captive population size (see Hall et al. [*in press*] for calculation). The full, wild emigration rate could overwhelm captive capacity. Risks are attributed solely to the uncertainty of extraction (§3.6), a necessary component of this scenario. ***Low to High Risk***
2) To a population in the same ESU or GU. The risks from number 1) apply, and the proper number of migrants and frequency of repetition is unknown (§6.1). ***Medium to High Risk***

3) To a population in a different ESU or GU. In addition to number 2), there is potential for outbreeding depression here, as with wild populations. ***High Risk***

Captive stock to a wild population:

1) To an immediate neighbor population. There is a risk of introducing pathogens to the recipient population by using captive stock. The number and rate of adults to transfer can be approximated by applying emigration rates to the captive population (see Hall et al. [*in press*] for calculation). ***Medium Risk***
2) To a population in the same ESU or GU. In addition to risks from number 1), the proper number of migrants and rate of transfer are unknown. ***High Risk***
3) To a population in a different ESU or GU. In addition to the risks in number 2), there is the added potential for outbreeding depression. ***High Risk***

Captive stock to a captive population:

1) To an immediate neighbor population. Although any potential pathogens might be ubiquitous to the entire captive facility, there is still an unknown risk of spreading pathogens between captive populations. The proper number of migrants and rate of transfer is approximated as in with captive to wild augmentations. ***Medium risk***
2) To a population in the same ESU or GU. In addition to risks from number 1), the proper number of migrants and rate of transfer are unknown. ***High Risk***
3) To a population in a different ESU or GU. In addition to the risks listed in number 2), there is again potential for outbreeding depression. ***High Risk***

3.5 Combination

Wild stock ("defunct" population [§2.1]) to a wild population:

1) To a genetically identical population. Populations of fewer than 5 adults are not likely to recover independently (§2.1) and combination can boost recipient population numbers. ***Low Risk***
2) To a non-identical population in the same ESU or GU. Same as number 1), with added benefit of contributing new alleles to another troubled population. The lineage is likely lost already, so that risk is downplayed under this scenario. ***Low Risk***
3) To a population in a different ESU or GU. Same as number 2), but there is a possibility of outbreeding depression. ***Medium Risk***

Wild stock ("defunct" population) to a captive population:

1) To a genetically identical population. This is the equivalent of extracting a whole population (see §3.6). ***Low to High Risk***
2) To a non-identical population in the same ESU or GU. This involves extraction and combination, although the loss of the lineage is still downplayed for an already "defunct" population. There is added benefit of contributing new alleles to another troubled population; risks are from extraction (§3.6). ***Low to High Risk***
3) To a population in a different ESU or GU. Same as number 2), but there is a possibility of outbreeding depression. ***Medium to High Risk***

Captive stock ("defunct" population) to a wild population:

1) To a genetically identical population. Populations of fewer than 5 adults are not likely to recover independently (§2.1) and combination can boost recipient population numbers. Disease introduction is a concern. ***Medium Risk***

2) To a non-identical population in the same ESU or GU. Same as number 1), with added benefit of contributing new alleles to another troubled population. The lineage is likely lost already, so that risk is downplayed under this scenario. ***Medium Risk***

3) To a population in a different ESU or GU. Same as number 2), but there is a possibility of outbreeding depression. ***High Risk***

Captive stock ("defunct" population) to a captive population:

1) To a genetically identical population. Although any potential pathogens might be ubiquitous to the entire captive facility, there is still an unknown risk of spreading pathogens between captive populations. ***Medium Risk***

2) To a non-identical population in the same ESU or GU. Same as number 1), plus the lineage is likely lost already, so that risk is downplayed under this scenario. There is also added benefit of contributing new alleles to another troubled population. ***Medium Risk***

3) To a population in a different ESU or GU. Same as number 2), but there is a possibility of outbreeding depression. ***High Risk***

Combinations of 2 genetically identical "recoverable" (§2.1) populations:

1) Wild stock to a wild population. The ability of the destination habitat to support a large jump in population number is questionable. ***Medium Risk***
2) Wild stock to a captive population. The risks under this scenario are primarily from extraction (§3.6). ***Low to High Risk***
3) Captive stock to a wild population. In addition to the risks from number 1), there is the added risk of disease transmission. ***High Risk***
4) Captive stock to a captive population. Several "medium-sized" (§2.1) populations should be maintained in isolation (minimum size of 25 individuals, maintain F = 0.25), as opposed to a single larger population (Margan et al. 1998). These lines can then be crossed prior to reintroduction to provide the founder population with maximum genetic diversity. Disease transfer is also a concern. ***High Risk***

Combinations of 2 genetically non-identical "recoverable" (§2.1) populations: This will result in the complete loss of a unique lineage, which goes against the key goal of this document. By definition, populations of this size can be managed independently in the wild or in captivity. This is a clearly defined cost for the species. High Risk

3.6 Extraction

Species known to do well in captivity: Some species have done incredibly well in captivity, including a population of *A. lila* that has increased from 6 individuals to 600+ in the span of a decade. When fewer than 20 adults remain, the entire population should be captured and brought into captivity (Tenhumberg et al 2004). If there are more than 20, up to 20% should be extracted (minimum of 5 adults). There are minor risks of population loss due to equipment failure, but automated dialing systems are in place to alert caretakers if such failure occurs. In addition, most populations are divided into multiple terrariums in different incubators to further minimize this risk. ***Low Risk***

Species known to do poorly in captivity: This technique has been invaluable to preserving many species lineages that are now extirpated in the wild. However, while some *Achatinella* species have rapidly increased in number via captive propagation, others have gradually declined for unknown reasons. There is subsequently reason to doubt the viability of any offspring upon reintroduction. ***High Risk***

Species known to remain constant in captivity or with unknown captive prognosis: Facing heavy pressure in the wild could justify extraction (following the guidelines of species that do well in captivity), even if rapid population growth is unlikely. For species whose future in captivity cannot be predicted, the risk of doing poorly applies. Shabalina et al. (1997) noted that beneficial fitness traits in fruit flies can disappear as fast as 2% per generation under relaxed selection in captive conditions, and similar rates in excess of 40% have recorded in fish (Araki et al 2007). Studies on mice (e.g. Jiminez et al. 1994) have even shown that while deleterious inbreeding effects may not be noticeable in benign lab environments, the reduction in survival can be quite severe upon reintroduction to a harsher, natural environment. ***Medium Risk***

4. RECOMMENDATIONS

In general, none of the translocation techniques mentioned should be considered unless the population's destination location is a captive breeding facility or predator-proof exclosure with species-specific habitat. Not only does this allow for an increase in the chances of success, but also allows for an ease of monitoring to assess the effectiveness of these untested methods. Snails can scatter widely when placed in a new environment. Any wild releases of snails should occur during winter months with frequent rainfall (USFWS 1992). All individuals translocated should be adults, which should be marked with individual codes (see §A2) and transported according to protocols provided in §5.3. In addition, at least 10 snails from each population involved in a translocation should have already been sampled for DNA and analyzed (as outlined in §5.2).

4.1 Priority Actions

Level-1 priorities: These are critical activities, which are preferentially fulfilled by low-risk options when possible. Medium-risk options should be considered in the absence of low-risk possibilities, followed by high-risk alternatives as a last resort. These latter options will require additional planning (§5.1). Examples of fulfilling Level-1 priorities are given in §§4.2-4.4. Priority-determinations reflect the limited amount of resources that must be divided amongst all management actions.

1) Designate 6 primary populations for all species (as defined in §1.3), using the best available genetic data.
2) Establish new primary populations if fewer than 6 exist, preceded by the necessary predator exclosures/captive facilities to protect them.
3) Secure (with a predator-exclosure or captive breeding) any population that is the sole representative of a GU or ESU.

Level-2 priorities: The activities are of intermediate importance, and should be fulfilled using only low-risk options after Level 1 priorities have been initiated to the fullest extent possible. Medium-risk options may be considered after low-risk options are exhausted.

1) Designate secondary populations for each primary population.
2) Establish a secondary population for any population that is the sole representative of a GU or ESU.
3) Survey areas with recent (last 10 years) snail sightings that may provide an under-represented GU or ESU primary population; this may shift other populations' priority ratings.

Level-3 priorities: These activities are the least critical, and should be fulfilled on an opportunistic basis using only low-risk options.

1) Employ some form of translocation with all populations that show signs of excessive inbreeding. This can be determined genetically by comparing a population's inbreeding

coefficient with earlier samples from the same population (see §5.2) or through comparison with other populations in the same ESU or GU.

2) Survey existing tertiary populations.
3) Search for and establish new tertiary populations.

4.2 Level-1 Recommendation Example: *Achatinella decipiens*

Based on current designations (§2.2), top priority should be to intensely survey the 4 primary populations to obtain accurate abundance estimates (§A2). The GU represented by a single population should be extracted (in its entirety if < 20 adults remain) or secured with a predator exclosure. Any other "small" (§2.1) population discovered should be extracted in its entirety, while 20% should be removed from "medium-sized" (§2.1) populations to establish more primary or secondary populations (5 snails minimum, no action if removal lowers source population status to "small").

There are 3 out of 5 known GUs represented by the 4 primary population designations. Two more primary populations are needed, and would be most desired from the 2 other GUs. High priority should be given for a final search in these GUs because of recent snail sightings; any "small" population discovered will be temporarily extracted and later found a primary population. If all of the individuals within a GU can only meet the definition of a "small" (§2.1) population by being counted together, but no single source population exceeds 5 adults, extraction and combination should be initiated to create a primary population. If fewer than 5 adults remain in the GU, individuals should be considered for augmenting a neighboring GU; the potential benefit of salvaging a lineage outweighs outbreeding risks (§3.4).

4.3 Level-1 Recommendation Example: *Achatinella lila*

Primary populations are designated in §2.3, and top priority should be given to obtaining accurate abundance estimates for all 3 primary populations (§A2). The 2 GUs represented by single populations should be extracted (in their entirety if < 20 adults remain) or secured with a predator exclosure. The other GU has already been extracted to found a successful captive stock, and the wild source still persists as a "small" (§2.1) population. This wild population should also be extracted because population sizes increase faster in captivity. The numerous captive descendants of this source population should reintroduced to achieve the minimum of 6 primary populations.

4.4 Level-1 Recommendation Example: *Achatinella sowerbyana*

A total of 6 wild primary populations have already been designated for this relatively abundant species, and abundance levels should be confirmed (§A2). The GU represented by a single primary population should be secured with a predator exclosure, rather than extracted. This species has not reproduced well in captivity, so further use of extraction with this species should be only to protect against imminent extirpation. The GU represented solely by a captive population should receive priority for a predator exclosure, followed by a reintroduction. Another primary population is not required, but it would be desirable to re-assign a primary designation to under-represented GUs if possible.

5. PRE-TRANSLOCATION PLANNING

5.1 Expert Coordination

For low-risk options, the permit holder can carry out actions as needed, and must alert all relevant contacts (Table 1) after doing so. This alert must include a detailed description of the activity as well as a reasonable justification for the action. Failure to do so may result in revocation of the relevant permits. Medium-risk options require that a 6-week notice be given to all relevant contacts, again with details and justification. USFWS and DOFAW must give approval of medium-risk actions, and can request a meeting or additional information prior to approval. High-risk options require a meeting and thorough review by all contacts, and must also receive approval.

Affiliation	Contacts	Phone	Email
Army Natural Resources	Kawelo, Kapua	656-7641	kawelok@schofield.army.mil
Army Natural Resources	Costello, Vince	656-8341	costellv@schofield.army.mil
Army Natural Resources	Rohrer, Joby	656-8341	rohrerjl@schofield.army.mil
DOFAW Invertebrate permits	Gagne, Betsy	587-0063	betsy.h.gagne@hawaii.gov
DOFAW, O‘ahu NARS Manager	Liesemeyer, Brent	973-9783	brent.r.liesemeyer@hawaii.gov
UH Snail Lab Manager	Holland, Brenden	956-6176	bholland@hawaii.edu
University of Hawaii	Hadfield, Michael	539-7319	hadfield@hawaii.edu
USFWS, Species Lead	Browning, Joy	792-9400	Joy_Hiromasa@fws.gov
USFWS, Permitting	Nelson, Jay	792-9400	Jay_Nelson@fws.gov
USFWS, Science Advisor	Miller, Steve	792-9400	Stephen_E_Miller@fws.gov

Table 1. List of all parties to be contacted when translocation activities are conducted.

5.2 Genetic Data

At least 10 biopsied tissue samples from any populations being considered for translocation (both source and recipient populations) should first be analyzed following the methods of Holland et al (*in prep*), to determine their relationships to other populations using cytochrome oxidase I and microsatellites markers. Microsatellite data can then be used to assess the relative degree of inbreeding. In addition, this initial sample will serve as a baseline level of inbreeding to compare with future time intervals and other populations of the species.

Preliminary studies (Hall and Hadfield *in review*) have suggested that inbreeding levels can increase significantly in just ten years (~2 generations), even for populations in excess of 20 adults. For this reason, it is recommended that 10 additional samples be collected from each primary population every 5 years to monitor inbreeding. These additional samples may change the priority level of a population (§4.1), and allow researchers to assess the genetic effects of any conservation interventions.

5.3 Transporting Snails

It is important to make proper arrangements for the transport and release of translocated snails. While in transit, snails should be placed in containers with hard exteriors and a mesh-screen lid (for ventilation). Host-plant foliage (from snail's current tree) should be provided in containers for support and food, and a temperature below 80°F should be maintained. At the release site, snails should be placed into small, screened baskets hung from host trees, and leaves from the tree should be placed inside and moistened. Active snails can be released directly onto the host plant.

5.4 Evaluation and Monitoring

Initial monitoring: The first applications of new translocation techniques will be preceded by a full population count (§A2) and monitored daily for 1 week (USFWS 1992), then weekly for 1 month. If no unanticipated results are noted following 4 consecutive weeks, a quarterly schedule will be initiated. After 1 year, any translocated population will be monitored according to primary-level protocols (§A2).

Survival: With primary-level monitoring, 3 abundance estimates will be available after 1 year (6-month intervals). Ground shell surveys must also be conducted for translocated populations at these intervals (10 minutes search-time per quadrat [§A2]). Mortality trends should be carefully analyzed to assess initial success of the translocation, and management plans adapted accordingly.

Long-term success: To gauge success of a method, population trend analyses should be analyzed annually. Populations will be considered "recovering" if they exhibit an overall positive growth rate for 3 consecutive years, which will give confidence to the particular method employed and possibly lower its associated risk levels.

Revision to guidelines: Every 3 years, this document should be revised and updated to reflect new data and realities. Following initiation of any medium-risk population admixture scenarios (§§3.4-3.5), this timeframe should allow for any potential outbreeding depression effects to become apparent (Edmands 2007). Such methods should not be employed elsewhere until the 10-year evaluation has proven their merits.

6. RESEARCH NEEDS

6.1 Augmentation Intensity

The appropriate number of individuals for an initial augmentation is still unknown, with the exception of immediate neighbor populations (§3.4). The most widely used strategy is the one-migrant-per-generation rule (OMPG, Mills and Allendorf 1996), which has been interpreted literally in some USFWS recovery plans (USFWS 1988, 1993a, 1993b). Mills and Allendorf (1996) stress, however, that the true optimal number of migrants might be as high as 10 per generation. Daniels et al. (2000) found that for woodpeckers this number should be at least 4, although just a single migrant might be capable of recovering some inbred populations (Vilá et al 2003). A modified application of the OMPG rule was recommended in recovering the critically endangered Florida Panther, whereby one additional breeder would follow annually after a first generation of much higher gene flow to purge deleterious alleles from the population (Hedrick 1995). A range of initial augmentation levels should be tested experimentally, if possible.

Following an initial augmentation or reintroduction, Tenhumberg et al (2004) recommend releasing individuals over consecutive years to reduce any stochastic effects that may reduce success in poor-weather years. For augmentations, this would likely need to be a similar number of individuals as the initial augmentation so that the effects of that intensity level could be analyzed over time. For reintroductions, a range of between 1 and 10 individuals per generation is likely appropriate (see above), although this should also be determined using PVA (next section) whenever possible.

6.2 Population Viability Analysis (PVA)

Currently, population data are limiting or lacking. Therefore this report utilizes incredibly sparse information to determine the minimum number of individuals to found a captive or lab population. With PVA, it is possible to obtain a more accurate estimate of these numbers based on the demographic characteristics of the population (Bustamante 1998). To begin a PVA, observation-based estimates including survival, reproduction, and dispersal rates (all of which have already been obtained for some *Achatinella* species) are input into software packages such as VORTEX (Lindenmayer and Lacy 1995). These programs then simulate probabilities of extinction at specified future time intervals under various starting conditions (e.g., the number of individuals being used to found a population).

It may also be possible with PVA to determine the optimal number and source of migrants for augmentations, which is a major knowledge gap (§6.1). Lindemayer and Lacy (1995) note that measures such as gene diversity can be calculated for a hypothetical combined population, which then allows for an estimate of effective population size. PVA analyses can then be run to determine the probability of extinction before that particular augmentation level is approved, which could be invaluable in helping conservation managers choose between different courses of action.

Lastly, the stabilization target goal of 300 individuals is based on a single, randomly defined population (Hadfield et al 1993). A more accurate estimate of minimum viable population (MVP) size can be estimated using PVA. It should be noted that "viable", when referring to MVP, differs in meaning from other definitions in the literature. In PVA simulations, MVP is the minimum population size that will persist in the wild for 100+ years with at least 90% probability, accounting for genetic and environmental stochasticity. Traill et al (2007) show that across a broad spectrum of animal and plant taxa, the lowest MVP numbers were at least in the thousands of individuals. MVP estimates can also help determine the minimum population size above which a population can be harvested as a source population for reintroductions.

6.3 Potential Experiment

One *Achatinella* species is particularly well suited for furthering knowledge of translocation through experimentation, as recommended by Seddon et al (2007). *Achatinella lila* has been bred in captivity for over a decade, and a single source population of 6 individuals has exploded into over 600 individuals in the lab. This is well in excess of the 50-individual threshold established by USFWS (1992) for considering the reintroduction of a captive population. In the sprit of scientific investigation, it would be desirable to reintroduce snails from this captive population alongside a comparable reintroduction with snails translocated from genetically similar wild stock (control population).

It would be desirable to reintroduce several populations of varying sizes from this single captive stock to determine a minimum population size for a successful reintroduction. A side-by-side release of two different species could also shed light on the general effects of captivity. Regardless of the reintroduction parameters to be tested (minimum population size, captive vs. wild, geographic origin, etc.), experimental translocations should be conducted within protected exclosures in order to monitor the results of such experiments.

Two possible experimental designs are shown in Figure 1 for *Achatinella lila*, which are intended to simultaneously test several aspects of translocation and achieve specified management goals. As of this writing, there are three primary populations *Achatinella lila* representing all three GUs (§4.3). In accordance with the goals outlined in §1.3, three more primary populations should be established to meet the minimum of six. Both experimental designs would fulfill this goal as well as create one secondary population. The first design (left panel) would test the effects of captivity and optimal size of founder populations. The second design (right panel) would also test captivity effects and founder population size (to a lesser degree), as well as species differences.

Figure 1. Two possible experimental designs for *Achatinella lila* reintroduction. Outside and inside edges represent predator-proof exclosure fencing to prevent total loss in the event of a predator breaching any one quadrant. If the high cost of predator exclusion fencing precludes its use for all edges, inside edges may only represent barriers to *A. lila* dispersal. All stock of *A. lila* are from the same source population, and 10 wild adults may represent the entire remnant population. Wild stocks of *A. sowerbyana* are from the same geographic source as the *A. lila* stock, where the species live sympatrically. Captive *A. sowerbyana* are from a neighboring GU with 3 primary populations (see **§2.4**). This population is not performing well in captivity and is also well suited for reintroduction.

10 *A. lila* ALL WILD-STOCK	10 *A. lila* ALL CAPTIVE-STOCK
50 *A. lila* ALL CAPTIVE-STOCK	100 *A. lila* ALL CAPTIVE-STOCK

A. lila + 10 *A. sowerbyana* ALL CAPTIVE-STOCK	10 *A. lila* + 10 *A. sowerbyana* ALL WILD-STOCK
20 *A. lila* ALL CAPTIVE-STOCK	50 *A. lila* ALL CAPTIVE-STOCK

6.4 Climate Change Threats

If a species' historical range is no longer deemed adequate for persistence in the face of climate change, similar habitat elsewhere may be considered for introductions as a last resort (IUCN 1998). Such assisted colonization may be the only reasonable alternative for saving some imperiled species (Hoegh-Guldberg et al 2008). Extinctions from recent climate change have already been documented, and range-restricted mountaintop species such as the tree snails are the most vulnerable to climate extinction (Parmesan 2006).

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APPENDIX: MONITORING PROTOCOLS

A1. Summary

The level of monitoring required for each field population depends on its designation as a primary, secondary, or tertiary population. Primary populations are of highest priority for achieving stabilization, and thus require the most intensive monitoring (§A2). Accurate data on snail abundance must be obtained at regular intervals so that any changes in abundance can be addressed (e.g., extraction necessary). Secondary populations require an intermediate level of monitoring (§A3) to maintain their role as a safety net, should a primary population experience a catastrophic decline. Single-survey abundance estimates at less frequent (but regular) intervals will suffice for these purposes. Tertiary populations require a minimal amount of monitoring (§A4), limited to opportunistic surveys to determine presence/absence. This appendix will not address monitoring protocols for captive populations (which may be primary or secondary populations); those are discussed in Hadfield et al. (2004).

A2. Primary Populations

Field Site Delineation:

One must first delineate artificial boundaries for the population in the field, ensuring consistency between surveys and at least some level of comparability among abundance estimates. This process is best done with a team of surveyors over two full days prior to being geo-referenced, as follows:

1) Several experienced field biologists survey a known snail locale for a half-day.
2) Each surveyor has a unique color of flagging tape with which to mark trees with snails in them, and a unique code is written on each flag.
3) Information is recorded for each flagged tree regarding snail abundance, and each surveyor records relative tree locations with a basic illustration.
4) Surveyors combine information to determine areas of high density, and then spend the second half-day searching un-flagged trees in the vicinity of high-density areas.

5) On the 2nd day, site boundaries are agreed upon which include a majority of trees with recorded snail presence, and a buffer zone to include some emigration on subsequent surveys. Site dimensions should not be narrow at any point to reduce the chance of emigration bias between surveys. Sites must also be small enough to be sufficiently searched (see next section) by 4 people in one day
6) Perpendicular rows of transects are then delineated with field markings to create a grid of discernable 5m x 5m squares within the site's boundaries.
7) Lastly, the grid is mapped to show the layout of flagged trees, which are given permanent unique markings in the field and corresponding codes on the map.

Capture-Mark-Recapture:

The type of markings given to a snail depends on the survey type (see next section). The most informative markings will come from populations where individuals are assigned a unique and permanent alphanumeric code upon first capture, and individuals can be identified on subsequent surveys. This method is called the "glue method" and is superior to the "paint method", both of which are described below and summarized in Table A1.

Table A1. Comparisons of different marking types

Type of marking	Advantages	Disadvantages
Glue method	Durability, additional data available	Time Consuming, training required, more snail handling
6.1.1.1.1 Paint method	No training required, limited handling, fast	Mark deterioration, precludes long-term analyses

With the glue method, the type of shell marking a snail receives at first capture is determined by its size. Snails with shells over 7 mm in length are marked using letters and numbers printed on 2 paper punch-outs. Six-point font characters are printed onto waterproof paper (Rite-In-The-Rain), and cut out with a leather punch. It is preferable to use 2 separate punch-outs rather than a single punch-out with both characters on it, for 3 reasons: 1) many tags are often lost via wind gusts prior to application, which leads to erratic numbering, 2) a larger size punch-out is needed to fit 2 characters on it -that is less flush with the shell- leaving more of the rigid tag's underside exposed to deterioration, and 3) with 2 separate tags, loss of one tag allows for an estimate of tag-loss rate rather than mistaking all unmarked snails as "new".

In the field, the snail's shell is gently dried and cleaned, and then a small drop of cyanoacrylic glue (Satellite City 'Super T') is applied to it. The 2 punch-outs are then placed onto the glue, followed by another drop of the transparent glue to protect the marks from deterioration. When the glue dries, the snail is returned to its capture location. Snails less than 7 mm in length receive small circular dots using paint pens. These different colored paint dots must uniquely identify individuals in the field until they grow large enough to receive the paper marks, which can take up to one year. For a further description of marking techniques, see Hall et al (*in press*).

With the "paint method", all snails captured on a single day are marked with a single color of paint pen. These marks wear down substantially over the course of a year, and new marks of a different color can be applied on a subsequent survey. This generic coding scheme precludes the use of more sophisticated analyses to estimate survival rates and other demographic parameters, which can be obtained using the glue method. Abundance measures can still be obtained with both methods.

Survey Type:

The methods outlined in this section will be strictly aimed at determining abundance. Some methods will have the potential to estimate additional parameters such as survival, growth rate, and emigration, with some additional effort. These modifications are described in the next section. For all survey types, the location of all snails will be recorded on every survey. Unmarked snails will be marked and measured (shell length and width). Previously marked snails will be recorded, and length taken unless growth rates are known (see next section).

To determine abundance, the following site-specific methods must be completed in the exact same manner on at least 2 consecutive occasions in order to estimate abundance using the Lincoln-Peterson estimator (Chao and Huggins 2005). This method assumes that all marked individuals have a chance to randomly re-mix into the population prior to being surveyed again. In areas with low vegetation, this can happen in as little as 1 day (Hall and Hadfield 2009). However, in areas with taller vegetation, up to 1 month may be necessary to be confident that the population has re-mixed. Because the method also assumes no birth, death, emigration or immigration occur between intervals, in no circumstances should this interval be longer than 1 month (see Hadfield et al 1993).

The type of surveying method will depend on the habitat; some methods have been designed here exclusively to minimize impact to certain tree-snail habitat types. Sites are characterized as to whether they have an understory that is sensitive to trampling, and by the difficulty of the terrain to survey (e.g., steepness). This results in 4 permutations with which to classify a site. These permutations are outlined in Table A2, along with corresponding management recommendations that are described below.

Table A2. Snail site classification scheme and associated management recommendations

6.1.2 Understory	*6.1.2.1 Terrain*	*6.1.2.2 Surveying 6.1.2.3 Recommendations*	*6.1.2.4 Marking Method*
Absent	Easy	2 survey days, full site survey	Glue
Absent	Difficult	3 survey days, full site survey	Glue
Present	Easy	2 survey days, random quadrat surveys	Paint
Present	Difficult	3 survey days, random quadrat surveys	Paint

For a site where trampling of the understory is not a concern, roughly 10-15 minutes of search time should be devoted to each quadrat. This should take a half-day to complete for sites between 500 and $1000m^2$ in area, and is best done with 4 observers dividing a site into 4 transects of quadrats (and at least 1 other person marking and releasing snails). The number of observers can be adjusted for sites with larger or smaller areas. For the second half of the day, the surveyor with the most recorded snails will then survey the transect of the observer with the fewest number of snails, and vice versa. The other two surveyors will also switch transects. This is to homogenize recapture rates at the site for a given day, so as not to violate a key Lincoln-Peterson estimator assumption. All unique captures for that day are compiled, and the same process is repeated the next day with the same surveyors doing the same transects. The "glue method" of marking should be used so that the maximum amount of data can be extracted from surveying efforts.

At sites with a substantial understory presence, fully surveying a site would cause excessive impact. For these sites, a random quadrat is selected and surveyed by all surveyors for 10-15 minutes total. The number of unique individuals is tallied, and then another random quadrat is surveyed. This iterative process continues until an adequate number of snails has been surveyed. To decide an adequate number of snails, a rough estimate of the population size is needed first (based on single day surveys, §A3).

Generally, an adequate sample size is between ¼ and ½ of the rough estimate and can be determined using tables in Robson and Reiger (1964). A few examples using 4 typical *Achatinella* species population sizes are provided in Table A3. Surveying ceases when an adequate sample size has been reached, and the exact same quadrats are surveyed on the following sampling occasion.

The “paint method” of marking is used only with understory-sensitive sites, since not surveying the whole site precludes analyses of variables other than abundance. A single color of paint pen is used by all surveyors to tally the number of unique snails on the first survey, and the process is repeated on the following survey with a different color. This 2nd marking is only to prevent a snail from the 1st day from being counted as recaptured more than once. Abundance is estimated as normal with the Lincoln-Peterson estimator, and then divided by the combined area of the quadrats surveyed. Finally, this density is multiplied by the area of the site to obtain an abundance estimate for that site.

Table A3. Minimum sample size needed using the random-quadrat method; examples are provided for range of population sizes that are typical of *Achatinella* species.

6.1.3 Rough Estimate of Population Size	*6.1.3.1 Snails Needed Each Day*
40	20
80	40
120	45
400	110

For sites with terrain that is easy to survey, only the minimum number (2) of survey days is required to achieve a reasonable rate of recapturing snails. Difficult terrain reduces this rate, and thus additional data are needed. Adding a 3rd consecutive survey occasion adequately accomplishes this goal (K. Hall, unpubl. data). Instead of using the Lincoln-Peterson estimator, multiple-recapture surveys require using the Schnabel method (Chao and Huggins 2005). Recommendations by site-type are summarized in Table A2.

Survey Intervals:

Primary sites need to be monitored at 6-month intervals to prevent emigration from influencing changes in abundance. If abundance drops are noted following analysis, an additional survey should be completed as soon as possible to determine the cause. This survey will be a combination of ground-shell surveys to rule out mortality, and surveys of the area around the site to rule out emigration. Site delineations and management should be adjusted accordingly. Great care should be taken to conduct all surveys at the same time of day to keep recapture probabilities constant (see Hall et al *in press*).

Sites where the “glue method” has been used can be further surveyed to obtain survival, emigration, and other important demographic estimates. This requires intensive monthly surveys of a high-density quadrat as in Hadfield et al (1993) to determine growth rates for 1 year. These data will be used to assign snails to different age-classes at every survey interval, even if not captured. Such data are necessary, as recapture probabilities and survival are known to vary with age (Hall et al *in press*). Program MARK (White and Burnham 1999) can then be used to obtain simultaneous estimates of all parameters of interest using likelihood-based model ranking.

A3. Secondary Populations

These populations require substantially less effort to monitor because of their lower priority level. For the initial survey, at least two surveyors search a known snail locale for several hours (day or night). The number of individual snails and search effort are recorded, along with shell measurements and any other pertinent data (e.g., weather observations). All trees with snails in them are then flagged with a blue and orange flagging combination for ease of relocation, the standard color scheme used by U.S. Army Environmental on O‘ahu.

Subsequent surveys must be done annually to ensure that such populations are still of sufficient size to fulfill their role as a safety net for primary populations. As with primary population surveys, effort should be made to keep search efforts consistent. However, due to the lack of rigor with these surveys (undefined population boundaries, inconsistent effort throughout site), it is not possible to analyze the population size trends over time. If such data are desired, the methods of §A2 must be used.

A4. Tertiary Populations

Tertiary populations need only have presence/absence data taken (although additional information is surely warranted when possible). These surveys should be done when time permits, and records should be available to all interested parties in an annual inventory of all populations. At a minimum, these populations should be surveyed every 5 years to determine their ability to serve as secondary populations if needed. As with secondary populations, analyses of population trends are precluded due to sparse data.

A5. Field equipment checklist (primary population surveys)

For each fieldworker

1) Relevant site maps
2) Notebooks
3) Snail collection containers (petri dishes)
4) Calipers for measurements
5) Orange and blue flagging tape
6) Watch or timer
7) Pens/Pencils/Markers

For the survey team:

1) Paper punch-outs (glue-method sites only)
2) Fine-point tweezers
3) Satellite city “super T” glue
4) Glue remover
5) Permanent tree tags
6) Paint pens of various colors

APPENDIX 6 CHAPTER 6 APPENDICES

Appendix 6 contains supplemental information for Chapter 6. Contents of Appendix 6 include:

- Appendix 6-1: Invasive Ant Monitoring Protocol
- Appendix 6-2: New Zealand Department of Conservation: Current Best Practices for Kill Trapping of Rats

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APPENDIX 6-1: INVASIVE ANT MONITORING PROTOCOL

Index cards (3 X 5 inches) containing SPAM, peanut butter and honey will be spaced along the edges of, or throughout, the area to be sampled. Each card will be placed so that it is halfway out of a ziplock "sandwich" bag. This maximizes your chances of capturing all ants present on the index card. Make sure all cards are separated by at least 15 meters. Only a small amount of each type of bait is necessary for each card. A minimum of 10 bait cards will be deployed at each site. Label each card with date, location, card # and collector name prior to placing cards in sampling areas. Target areas of increased human activity such as trails, campgrounds and picnic areas when possible. Always place cards in the shade. Deploy cards no earlier than 8:00 am in the morning and avoid sampling on rainy, blustery or cold days as both rain and low temperatures reduce ant activity. Should foraging ants be seen in the area prior to bait deployment, conditions are likely fine for sampling. Leave baits out for at least 1 hour. Pick up baits rapidly by slipping the card into its accompanying ziplock and immediately closing the ziplock. Make sure the bag is completely closed or you will have ants exploring your backpack. Place the bags in freezer for latter identification.

(With input from S. Plentovich and P. Krushelnycky (University of Hawaii at Manoa))

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APPENDIX 6-2: NEW ZEALAND DEPARTMENT OF CONSERVATION: CURRENT BEST PRACTICES FOR KILL TRAPPING OF RATS

KILL TRAPPING FOR RAT CONTROL

TECHNIQUE

Trap station layout

- Spacing no greater than 100x50m apart with perimeter traps 25m apart. In high density rat areas, the internal spacing of traps should be 100x25m.

  There should be at least one trap station within each rat's home range. Home ranges are generally reported by length. Ship rats have an average range length of 100-200m during the breeding season. Non-breeding ship rats have larger home ranges [1]. Norway rat home ranges are between 218-916m in length [2].

  At high rat densities, trap spacing may have to be reduced further to maximise capture rates.

- Laid out on grids by compass bearing or, in rough terrain, placed on ridges and spurs with additional lines located on 100 m contours using an altimeter. Spacing should be established as precisely as possible using compass and hip chain.

  Inaccurate location of lines will cause gaps in coverage where pockets of high rat numbers can persist.

- A good track infrastructure is important and each trap station numbered for ease of relocation and data collection.

  Reduces the risk of missing a trap during checking and allows capture data to be related to each trap site.

Timing of operations

- Timing is critical and depends on what is being protected.

  For ongoing ecosystem management, timing should be related to rat tracking indices and the vulnerable periods of those components in the system you are endeavouring to protect.

  For species protection, timing is dependant on when the species being protected is most vulnerable. E.g. To protect robins during the breeding season, rat indices must be low while the robins are on the nest until the chicks fledge. To protect invertebrates and skinks, rats should be controlled year round [1]

Effective use of traps

- Initially traps should be checked every 1-2 days. Once knockdown is achieved, as indicated by low catch rate and verified by tracking tunnel data (usually about 10-20 checks), traps only need to be checked once every 2-3 weeks. When rat numbers increase, trap checking frequency also needs to increase. Note: timing of checks will depend on.

  Traps need to be cleared regularly - frequency is dependant on site factors (e.g. area under protection and productivity) and the density of rodents present. A trap with a dead rat in it is not available to catch others.

EQUIPMENT

Trap type

Key elements are: catch effectively, kill humanely, easy to use and maintain, light weight, portable and cheap.

- Victor professional snapback is recommended.

  This trap has passed the National Animal Welfare Advisory Committee (NAWAC) kill trap guidelines (on Norway rats).

- DOC 150 & 200 have also passed the NAWAC guidelines and are suitable where mustelids are also being targeted.

Maintenance of traps

New Traps

- Standard Victor professional snapback traps should be treated with a preserving agent (e.g. paint or fence stain) as the wooden base is not treated.

  This will lengthen the life of the trap.

Traps in Use

- Should be cleaned regularly with a wire brush.

  Removes mould, fur and bits of dead animals and allows for identifying what has escaped from an empty sprung trap.

- Regular maintenance is essential, including checking for worn pivots, weakened springs & broken trigger mechanisms.
- When checking Victor snapback traps the trapper should carry spare traps, treadles and pegs.

  Treadles may be lost when the traps are sprung.

Tunnel/Cover

Kill traps must be set in a tunnel or under a cover. The tunnel has three functions: i) orientate the animal relative to the trap, ii) disguise and protect the trap and iii) keep out non-target species [3]. It must have the following:

- Minimum of 400mm long., width 105mm if using 'victor professional'

  Space for trap and prevent non-target animals (e.g. weka) accessing the trap.

- Single entry.

  Rats have access to right end of trap.

- Entry hole of 45mm x 45mm

  A larger entry hole will not exclude non-targets like weka.

- Easy access to check traps.
- Ability to fix to ground with a wire hoop.

  Prevent traps being disturbed by pigs and possums.

- Traps should be kept off ground.

  Keeps trap dryer, extends life of trap.

- Fully enclose the trap, *so the trap cannot be dragged out of the cover.*
- Stable, *so the trap doesn't move until triggered.*

Specification for tunnel/cover designs that meet these requirements are located at:

- docdm-103712 (Victor snap trap);
- docdm-29856 (DOC150); and
- docdm-29855 (DOC 200).

Bait and lures

Key elements are high palatability, field life aligned with the frequency of field checking, doesn't attract non-targets, easy to use and cheap.

- Suitable baits include chunky peanut butter, peanut butter mixed with rolled oats, white chocolate and Connovations margarine based prefeed.

  Peanut butter lasts 5-7 days in Te Urewera, peanut butter/rolled oats mix lasts up to 14 days at Rotoiti Mainland Island and white chocolate last up to 5 weeks in Te Urewera.

SKILLS REQUIRED

- Programme managers/Project managers need a good working knowledge of rat ecology and the prey ecology to manage operations effectively.
- Specific on job training of trappers in the use of rat traps and tunnel/covers is recommended.
- Trappers need sound bush navigational skills involving compass and map reading, and training in the relevant animal pest SOPs.

STANDARDS

Animal Welfare Act 1999

- Under the Animal Welfare Act 1999, the NAWAC developed draft guidelines for testing kill traps. It is recommended that only traps that have passed the NAWAC guidelines are used, because other traps that have not passed may be prohibited or restricted [4].

Health and Safety

- Health and safety resources http://docintranet/content/hro/healthsafety/healthsafety.htm
- See Risk Manager for examples of a safety plans.

Animal Pest Management SOP's

- Animal Pest SOP checklist HAMRO-83484

SUSTAINING CONTROL OVER THE LONG TERM

- Monitoring conservation outcomes is essential to judge effectiveness of the control programme.

  Control operations are useless unless outcomes are achieved.

- Rat tracking tunnels should be run concurrently with the trapping operation.

  To identify activity of animals not being trapped.

- Baits/lures may need to be alternated over the duration of control programmes.
- Good data collection helps operations to be more effective and efficient over the long term. What is recorded depends on what the project wants to know.

LIMITATIONS

- Constant re-invasion and rapid breeding means effective long term control must be ongoing.

  Rat numbers are likely to return to pre-control densities within weeks or months after control stops [1].

- Pig and possum interference with covers can be a problem.

- In beech forests during years with high mouse numbers, mice can make up the majority of captures. This severely reduces the number of traps available for rat control.
- No long life baits available, limiting the length of time between checks.
- High rat numbers can make initial knock down of the population difficult. More frequent checks have been shown to obtain rapid reduction in numbers.
- In years of very high rat numbers trapping may fail to achieve operational targets, so a toxin should be used to achieve an initial knockdown in rat numbers before trapping a starts.
- The technique is not good as an annual knockdown tool; it is better suited for maintaining rats at low densities.
- Mouse numbers may increase after rat control.
- Mice taking bait can severely reduce the effectiveness of traps

UNDER DEVELOPMENT

- Different cover designs to further reducing non-target captures (Lindsay Wilson – Opotiki AO, and Matt Maitland – St Arnaud AO).
- Alternative baits and long life baits (Lindsay Wilson and Matt Maitland)
- Periodic use of toxins in conjunction with trapping regime is being evaluated at Te Urewera national Park (Lindsay Wilson)

INFORMATION

DOC contacts

Trapping

- Your conservancy TSO.
- Darren Peters, Pest Section, Research, Development & Improvement Division, Wellington VPN 8256
- Ian McFadden, Pest Section, Research, Development & Improvement Division, Wellington VPN 8348

Rat ecology

- Craig Gillies, Scientific Officer Research, Development & Improvement, Hamilton VPN 6127
- Elaine Murphy, Research, Development & Improvement, Christchurch VPN 5413

Biodiversity Training Programme - Animal Pest Management Course

- Dale Williams, Programme Manager, Ecological Management Skills, R, D & I, Wellington, VPN 8218.
- Suzy Randall, Programme Manager, Ecological Management Skills, R, D & I, Wellington, VPN 8246.

Predator Dogs

- Scott Theobald, Ranger, Dogs for Conservation, Trounson Kauri Park, VPN 7381

Recommended reading

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