

## Appendix ES-1 Spelling of Hawaiian Names

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Place name	Hawaiian spelling
Aiea	‘Aiea
Aihualama	‘Aihualama
Aimuu	Aimuu
Alaiheihe	Alaiheihe
Alau	Alau
Ekahanui	‘Ēkahanui
Halawa	Hālawa
Haleauau	Hale‘au‘au
Halona	Hālona
Hawaii	Hawai‘i
Hawaii loa	Hawai‘iloa
Helemano/Halemano	Helemano/Halemano
Honolulu	Honolulu
Honouliuli	Honouliuli
Huliwai	Huliwai
Kaaikukai	Ka‘aikūka‘i
Kaala	Ka‘ala
Kaawa	Ka‘awa
Kaena	Ka‘ena
Kahaluu	Kahalu‘u
Kahana	Kahana
Kahanahaiki	Kahanahāiki
Kaimuhole	Kaimuhole
Kaipapau	Kaipāpa‘u
Kaiwikoele	Kaiwikō‘ele
Kalauao	Kalauao
Kaleleliki	Kaleleiki
Kalena	Kalena
Kaluaa	Kalua‘ā
Kaluakauila	Kaluakauila
Kaluanui	Kaluanui
Kamaileunu	Kamaile‘unu
Kamaili	Kamā‘ili
Kamananui	Kamananui
Kapakahi	Kapakahi
Kapuna	Kapuna
Kauai	Kaua‘i
Kauhiuhi	Kauhiuhi
Kaukonahua	Kaukonahua
Kaumoku Nui	Kaumoku Nui
Kaunala	Kaunala
Kawaihapai	Kawaihāpai
Kawaiiki	Kawaiiki
Kawailoa	Kawailoa
Kawainui	Kawainui
Kawai papa	Kawai papa
Kawaii	Kawaiū

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Keaau	Kea'au
Kealia	Keālia
Keawapilau	Keawapilau
Keawaula	Keawa'ula
Kihakapu	Kihakapu
Kipapa	Kīpapa
Koiahi	Ko'iahi
Koloa	Koloa
Konahuanui	Kōnāhuanui
Koolau	Ko'olau
Kuaokala	Kuaokalā
Laie	Lā'ie
Lanai	Lāna'i
Lualualei	Lualualei
Lulumahu	Lulumahu
Maakua	Ma'akua
Makaha	Mākaha
Makaleha	Makaleha
Makaua	Makaua
Makua	Mākua
Malaekahana	Mālaekahana
Manana	Mānana
Manini	Manini
Manoa	Mānoa
Manuka	Manukā
Manuwai	Manuwai
Maui	Maui
Maunauna	Maunauna
Maunawili	Maunawili
Mikilua	Mikilua
Moanalua	Moanalua
Mohiakea	Mohiākea
Mokuleia	Mokulei'a
Molokai	Moloka'i
Nanakuli	Nānākuli
Niu	Niu
Nuuanu	Nu'uanu
Oahu	O'ahu
Ohiaai	'Ōhi'a'ai
Ohikilolo	'Ōhikilolo
Oio	'Ō'io
Opaeula	'Ōpae'ula
Paalaa Uka	Pa'ala'a Uka
Pahipahialua	Pahipahi'ālua
Pahoa	Pāhoa
Pahole	Pahole
Palawai	Pālāwai
Palehua	Pālehua
Palikea	Palikea
Papali	Papali
Peahinaia	Pe'ahināi'a
Pohakea	Pōhākea
Puaakanoa	Puaakanoa*
Pualii	Puali'i

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Puhawai	Pūhāwai
Pukele	Pūkele
Pulee	Pule‘ē
Punapohaku	Punapōhaku
Puu Hapapa	Pu‘u Hāpapa
Puu Kailio	Pu‘u Ka‘ilio
Puu Kanehoa	Pu‘u Kānehoa
Puu Kaua	Pu‘u Kaua
Puu Kawiwi	Pu‘u Kawiwi
Puu Kumakalii	Pu‘u Kūmakali‘i
Puu Pane	Pu‘u Pane
Puuhapapa	Pu‘u Hāpapa
Puukaaumakua	Pu‘u Ka‘aumakua
Puukailio	Pu‘u Ka‘ilio
Puukainapuaa	Pu‘u Ka‘inapua‘a
Puukanehoa	Pu‘u Kānehoa
Puukaua	Pu‘u Kaua
Puukawiwi	Pu‘u Kawiwi
Puukeahiakahoe	Pu‘u Keahiakahoe
Puukumakalii	Pu‘u Kūmakali‘i
Puulu	Pū‘ulu
Puukona	Pu‘u o Kona
Puupane	Pu‘u Pane
Waahila	Wa‘ahila
Wahiawa	Wahiawā
Waialae Nui	Wai‘alae Nui
Waialua	Waialua
Waianae Kai	Wai‘anae Kai
Waiawa	Waiawa
Waieli	Wai‘eli
Waihee	Waihe‘e
Waikane	Waikāne
Wailupe	Wailupe
Waimalu	Waimalu
Waimano	Waimano
Waimea	Waimea
Waimea	Waimea
Wiliwiliinui	Wiliwiliinui

\*Diacriticals unknown

## Appendix ES-2

### Tutorial: Operating the OANRP Database (Distribute Version)

#### Overview

The Oahu Army Natural Resources Program Database (OANRP Database) is a multi-level database, coordinating diverse data from rare plant observations, reintroductions, rare snail monitoring, plant nursery propagation, and weed/ungulate management. The database files are developed with Microsoft Access. It is recommended that Access software versions 2007, 2010, or 2013 be used.

The database allows the Army staff to know which plant individual has been collected, matured, or died thus providing a better understanding of the genetic diversity that remains for any given rare species that the Army must manage. Using this database, the Army maintains consistent tracking and reporting for its managed rare species.

The APD is based upon the criteria established by the Hawaii Rare Plant Restoration Group (HRPRG). As part of the Makua and Oahu Implementation Plans, the Army Propagation database has been a 15 year effort in developing and coordinating the collection, propagation, management, and tracking of rare species.

The following appendix will briefly cover the database requirements and database procedures. Only important search criteria will be discussed. Most data fields are self-explanatory. This tutorial will be a guide to the database reports presented in previous OANRP status updates.

Several database reports may take a several minutes to compile within the database, thus pdf versions of the three major database reports (Population Unit Status, Threat Control Summary, and Genetic Storage Summary) have been created and may be found in the database reports subdirectory. Therefore, running the database may not be necessary unless more information is needed beyond the pdf version of the reports provided. Data provided is as of September 30, 2014.

Modification to the data and/or structure of the database is prohibited. The database version provided is read-only. It is intended for Implementation Team and collaborating agencies only. Distribution of the database structure and/or data is prohibited without the consent by the Oahu Army Natural Resources Program.

Questions may be directed to:

Roy Kam

Natural Resources Database Programmer Specialist

Oahu Army Natural Resources Program

Email: [rkam@hawaii.edu](mailto:rkam@hawaii.edu)

Linda Koch

Natural Resources GIS Specialist

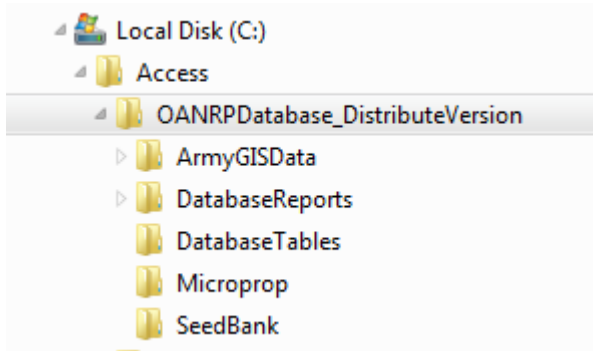
Oahu Army Natural Resources Program

Email: [lkoch@hawaii.edu](mailto:lkoch@hawaii.edu)

## I. Database Settings Setting Database Directories and Security Warning

### Database directories

The database must be placed under the following directories. Copy the following directories and data files from the data disc to the C: drive. Database path and GIS files must be within the following directories. All subdirectories should be under C:\



Descriptions of the files within each subdirectory are as follows under C:\Access\OANRPDatabase\_DistributeVersion:

#### OANRPDatabase\_DV.mdb

Front-End database file what most database users see, the database file manages the data forms, queries and reports. Data used in the OANRP Database is kept in the back-end data file (OANRPDataTables\_DV.mdb) located in the database tables subdirectory. Forms are locked and may only be used for viewing purposes.

C:\Access\OANRPDatabase\_DistributeVersion\ArmyGISData\

GIS shapefiles depicting the rare plant sites, managed areas, and fence lines.

C:\Access\OANRPDatabase\_DistributeVersion\DatabaseTables\OANRPDataTables\_DV.mdb

Back-End database file containing data for the Front-End database file.

C:\Access\OANRPDatabase\_DistributeVersion \Microprop\Microprop.mdb

Lyon Arboretum Micropropagation Database. Contact Nellie Sugii for more information.

C:\Access\OANRPDatabase\_DistributeVersion \SeedBank\SeedBankDatabase.mdb

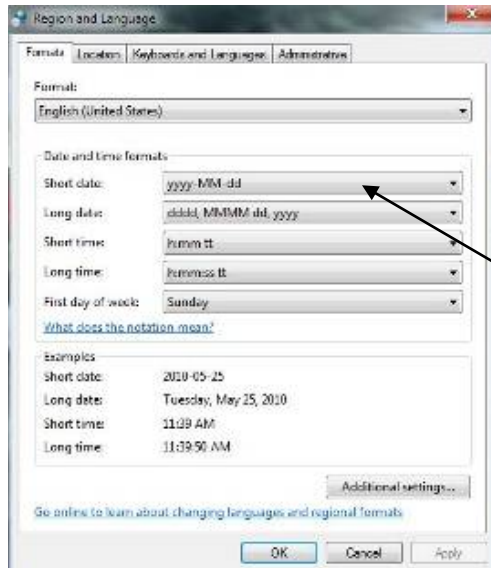
Army SeedLab Database. Contact Lauren Weisenberger for more information.


C:\Access\ OANRPDatabase\_DistributeVersion \TaxaDatabaseReports

Population Unit Status, Threat Control Summary, and Genetic Storage Summary PDF reports for each IP taxa.

## Setting Default Date Format

The default date format for most computers is normally set to mm/dd/yy. The format can be confusing and not sort properly for Access database records. Although, not required, the date format for computers using this Access database should be changed to yyyy-mm-dd.



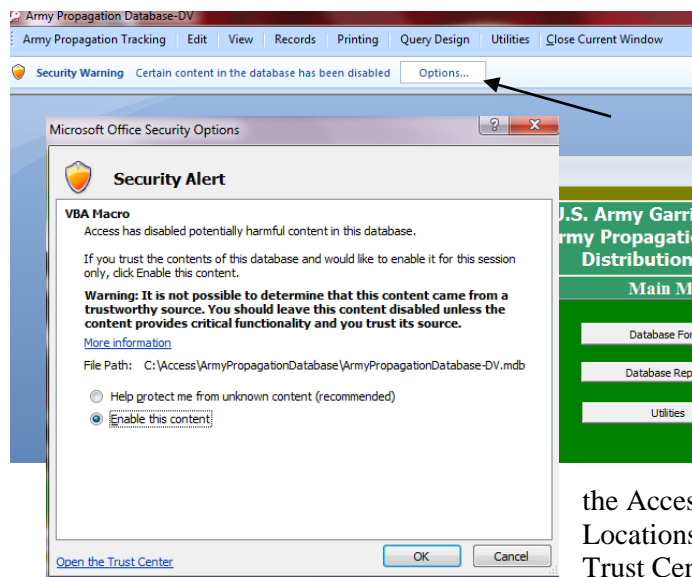
- Open Regional and Language Options by clicking the **Start** button , clicking **Control Panel**, clicking **Clock, Language, and Region**, and then clicking **Regional and Language**. Under the Formats, change the **Short Date** to **yyyy-MM-dd**.

Change to yyyy-MM-dd

## Security Warning

Security features in Microsoft Access 2007, 2010, and 2013 automatically disables any executable content. The Access database with customized, buttons, commands, etc. will have a warning and not work unless the following is set within your computer.

To help you manage how executable content behaves on your computer, Office Access 2007/2010/2013 database content must be enabled when the Security Warning appears.



After opening the OANRPDatabase\_DV.mdb file in Microsoft Access, click on Options when it appears at the top of your screen.

A window stating Security Alert will appear. Click on the button to select Enable this content, and click OK. Enabling the content will allow the database functions to operate.

Enabling content will have to be done every time the database file is opened. You may avoid having this Security Warning appear if the Access subdirectory is added to the Trust Center Locations. Contact Roy Kam if you need to establish a Trust Center Location.

## Data Search Methods

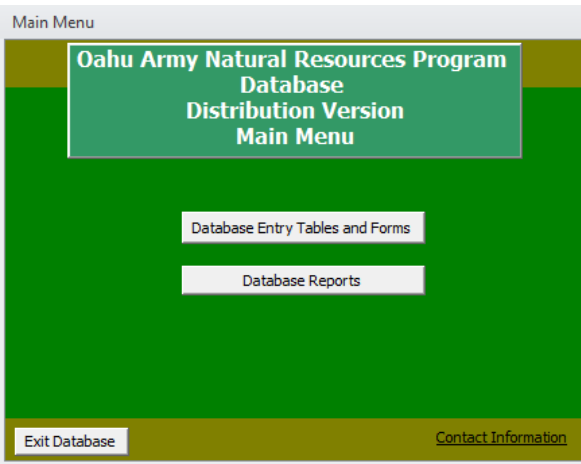
Most data form and report sections start with a Find Form. These Find Forms have drop downs that allow you to find an existing record. In the adjacent example, locating the Sources record for Alvin Yoshinaga.

Using the \* (asterisk), in a Find Form represents a wild card. Such as Organization \*= Search for all Sources with any Organization. In this case, we will just search for the Last Name = Yoshinaga.

On the bottom of each Data entry form (such as the Sources Form), there are a set of Navigation buttons. These buttons allow you to go to the previous or next record. Pressing the tab or enter keys moves from one data field to another.

**Short cuts:** *Shift + F2* in any text field (within a data entry form or datasheet) will bring up the Zoom window. The Zoom window will allow you to view the complete text entered in that data field. See example below.

## II. Main Menu



Open the **OARNPDatabase\_DV.mdb** either by double clicking the file, creating a shortcut on your desktop, or by opening MS Access and opening the file. The database will open to the Main Menu.

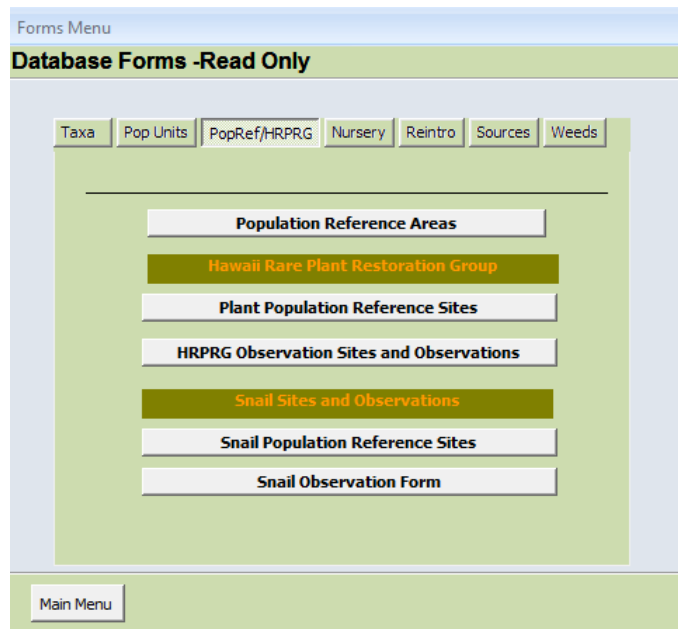
The database is broken up into 2 parts, Database Forms and Database Reports. We will primarily cover the Database reports. Database Forms are self-explanatory and is only for viewing purposes. The forms are provided for detailed review of individual observations. Only pertinent data fields will be discussed in detail.

## III. Database Forms

The **Database Forms menu** is broken up into several sections. They are Taxa, Pop Units, PopRef/HRPRG, Reintro, Sources, and Weeds.

Most buttons under each tab will open a “Find” form that will allow you to find existing database record.

For the purpose of this tutorial, we will discuss forms of the PopRef/HRPRG tab with comprise of the Population Reference and Population Reference Sites. All other sections are supplemental and self-explanatory.



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### **PopRef, Sites, and Observations**

Population information is broken up into three sections, Population Reference Areas (PopRef), Population Reference Sites (PopRefSite) and Observations. Both In situ and Reintro observations will be covered in this section.



## Population Reference Areas (PopRef)

Population Codes

**Population Reference**

PopCode: AKA

Population Ref Name: Makaua Gulch

Island: Oahu Region: Northern Koolau

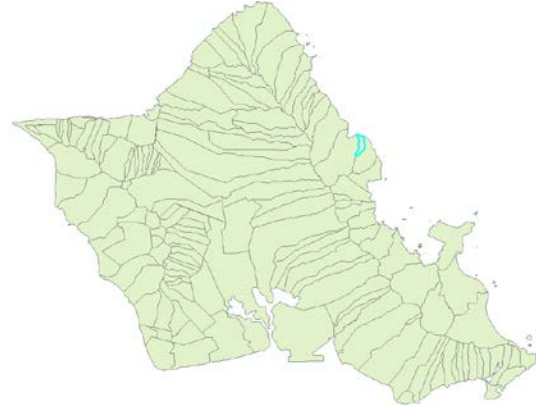
PopLocationDesc: Makaua Gulch Hidden valley above Kaawa on Kuoaloa Ranch land

Comments:

Exit

Record: 8 of 109 Filtered Search

Population Reference, also known as PopRef for short, is a boundary system that allows a consistent identification of plant or animal populations. The PopRef is normally valleys, summits, ahupuaa, bogs, or areas that biologists have continuously acknowledged within observations from past decades.



It should be noted that the Population Reference is not necessarily the name for any given population. It is only used as an identifier to compile different plant or animal populations within a given area. For example: Makaua on the Windward Koolau of Oahu (highlighted in blue). The GIS boundary is based upon Makaua's ahupuaa as AKA's PopRef. But a plant population within Makaua PopRef, its population name may be named something different like a puu, or other landmark within Makaua.

## Population Reference Site (PopRefSite)

The Population Reference Site (PopRefSite) is the primary data table in establishing plant or animal population sites. The PopRefSite identifies the Population Name, whether it is In situ, Ex situ or Reintro, and provides directions to the site, etc. The PopRefSite is only site information; observation information from various surveys is kept in the observation section discussed later.

Determining what is a population or Population Reference Site is always very difficult and can vary by taxon. Normally populations are determined by the botanist in the field. Population determination criteria normally used is topography, distance from one population to another (Army normally uses 1000 ft. buffer distance), genetic dispersal, geographic features (streams, veg. type changes), etc.

Find Population Reference Site Form

**Find Population Reference Site Record - Plants**

Select Multiple Criteria Reset Search Criteria \*=Select All Records

Population Reference\*: AKA

IP Mgmt Unit Name\*: \*

IP Pop Unit Name\*: \*

Population Reference Site ID\*: SchKaa.AKA-A

TaxonPopRefSiteID	PopRefSiteName	InExsitu
CyaAcu.AKA-A	Makaua Gulch	In situ
CyaCri.AKA-A	Makaua	In situ
SchKaa.AKA-A	Makaua Gulch fenced site	In situ
SchKaa.AKA-B	Reintro in the small fence with the wild plant	Reintro
SchKaa.AKA-C	Makaua mauka REINTRO	Reintro

Population Reference Site Datasheet Population Reference Site Form

Tables Menu

To view an existing PopRefSite record, from the menu click on the Population Reference Sites button, a Find Population Reference Site Record form will appear and select AKA under the PopRef drop down as in the example. From that, you could also see all of the AKA Populations under the Population Reference Site ID Drop down. Select SchKaa.AKA-A.

Within the PopRefSite record, **TaxonCode**, **PopRef**, and **PopRefSite (Site Letter)** are kept. All three data fields build the TaxonCodePopRefSiteID (aka PopRefSiteID or PopRef Code). The PopRefSiteID is found on the bottom of the form in this case SchKaa.AKA-A. The PopRefSiteID is the unique key field that provides consistent population identification. The format of the PopRefSiteID is always TaxonCode.PopRef-SiteLetter.

The screenshot shows a web form titled "Population Reference Sites". The form contains the following fields and data:

- TaxonCode:** SchKaa
- TaxonName:** Schiedea kaalae
- PopRef:** AKA
- PopRefName:** Makaua Gulch
- PopRefSite:** A
- PopRefSiteID:** AKA-A
- Population Reference Site Name:** Makaua Gulch fenced site
- IP Management Unit Name+:** Olona No MU
- IP Population Unit Name+:** Makaua (Koolaus)
- InExsitu:** In situ
- ArmyOnOffSite:** Off
- Directions to Site:** Up hidden valley trail to first sub-gulch on the right side above the big waterfall to fenced enclosure
- DiscontinuedDate:** (empty)
- Discontinued Reason:** (empty)
- SiteNorthing:** (empty)
- SiteEasting:** (empty)
- Elevation:** (empty)
- Comments:** (empty)
- Threat Status Table:**

ThreatType+	ThreatTaxon	ThreatManaged	ThreatComments
BTB	No	No	
Cattle	No	Yes	
Fire	No	No	
Goat	No	Yes	
Pig	Yes	Yes	
Rat	Yes	No	
Slug	Yes	No	
- EditDate:** 2005-09-08
- EditIn:** jmk
- TaxonCodePopRefSiteID:** SchKaa.AKA-A
- # of Observations:** 6
- Buttons:** Exit, Indiv Plants, Observations
- Footer:** Record: 14 | 1 of 1 | Filtered | Search

**Population Reference Site Name (PopRefSiteName)** is the name used to identify the population. It is normally be a brief descriptive name. Detailed directions or descriptions are entered in the Directions to Site field.

**IP Management Unit Name:** Management Unit commonly known from.

**IP Population Unit Name (PopUnit):** The PopUnit is used when several PopRefSites need to be tracked together. Such as a taxon with several sites throughout the Northern Waianae Mountains, Northern Waianae could be used as a PopUnit Name.

**InExsitu:** Identifies whether the PopRefSite is a naturally occurring wild (In situ), or Reintroduction (Reintro), etc.

**Directions to Site:** Detailed directions to locate the population.

**Threat Control Status:** What the threat control is being conducted (Yes, No, Partial)

## Observations

Clicking the Observations button on the bottom of the PopRefSite Form will open up the corresponding Observations.

### ObservationDate:

Observations of the Population Reference Site are entered by the ObservationDate.

Observation Date is normally the day that the Population Site was surveyed. If the individual(s) were not found during the survey, the observation date and record is still be filled out.

If the survey took several observation days, then the start date is entered in the ObservationDate.

**Observer Directions** may be entered if it is different from the PopRefSite Directions. Observer Directions may be a different route or situation that would represent the directions for that survey day.

HRPRG Observation Form 2

**HRPRG Observation Entry Form**

TaxonSite: SchKaa.AKA-A PopRefSiteName: Makaua Gulch fenced site ObsID: 7328  
 HRPRG Indiv Plant Summary Form InExsitu: In situ DisconDate: ObsDate: 2008-11-06

Observations Population Structure Habitat Characteristics Individual Plant Observations Collection

TaxonCodeSite: SchKaa.AKA-A PopRefSiteName: Makaua Gulch fenced site Observation ID: 7328  
 ObservationDate: 2008-11-06

Observer: 214 Full Name: Lauren Weisenberger Organiz: U.S. Army  
 ObserverAll: SCH, CM, BH (Brody Hartle)

Photo:  GPS:  SiteNorthing: SiteEasting:  
 SketchMap:  ObserverDirections: ObserverElevation:  
 Flagging Scheme:  
 ObsComments: plant lost tag but SCH knew it was number 1 so re-tagged today. never found number 2 and SCH knew where it had been. Looked all around and then made  
 VegetationType:  
 EditDate: 2009-02-17 EditIntr: LW

Exit Observation Form Population Ref Site All Current/Accurate Population Structure Observation Review Print Current Observation Record

Record: 1 of 6 Filtered Search

## Population Structure

The Population Structure should be always entered for any observations, even if the number of plants observed are incomplete (not all plants observed).

**Age Class** always is required, where **CountedNumIndiv** (Counted Number of Individuals) is considered a more accurate count of the number of plants.

**EstimatedNumIndiv** (Estimated Number of Individuals) may be entered only when the CountedNumIndiv is not entered. EstimatedNumIndiv is used when the number of plants is numerous. EstimatedNumIndiv should not be entered when the number of plants can be counted.

HRPRG Observation Form 2

**HRPRG Observation Entry Form**

TaxonSite: SchKaa.AKA-A PopRefSiteName: Makaua Gulch fenced site ObsID: 7328  
 HRPRG Indiv Plant Summary Form InExsitu: In situ DisconDate: ObsDate: 2008-11-06

Observations Population Structure Habitat Characteristics Individual Plant Observations Collection

**Observation Population Structure**

AgeClass	DefAgeClass	CountedNumIndiv	EstimatedNumIndiv	PopStructureComment
Mature		1		

Accurate Observation? **Population Structure Total**  
 Current Accurate Observation for Population Structure? TotalCounted: 1 TotalEstimated:  
 (Only ONE observation may be current per site)

**Population Information**

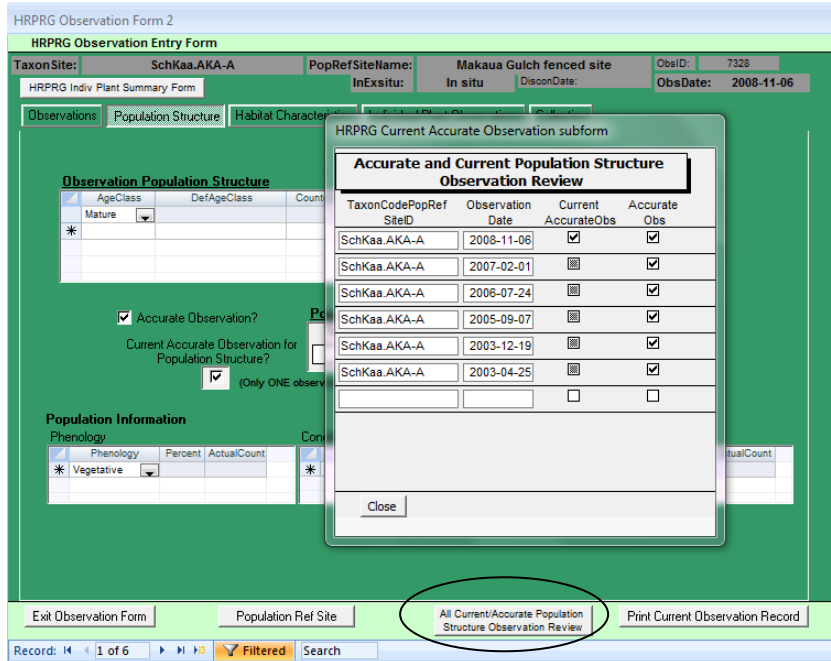
Phenology			Condition			Canopy Light Level		
Phenology	Percent	ActualCount	Condition	Percent	ActualCount	LightLevel	Percent	ActualCount
Vegetative								

Exit Observation Form Population Ref Site All Current/Accurate Population Structure Observation Review Print Current Observation Record

Record: 1 of 6 Filtered Search

EstimatedNumIndiv may not be a number range, if a range such as 100-200 is provided, the conservative number 100 is entered, and 100-200 may be entered in the PopStructureComment.

**Accurate Observation** is checked off when the Population Structure's Age Classes and CountedNumIndiv/ EstimateNumIndiv contain an accurate and representative count of the PopRefSite population. Many observations over different survey dates may have the Accurate Observation checked off.



As opposed to the Accurate Observation check box, the **Current Accurate Observation check off box** may only have one observation checked. The Current Accurate represents the population structure that is considered both current and accurate. The most recent observation may not always be the Current Accurate observation, thus the Current Accurate is used to identify the proper Population Structure numbers that currently represents the population in reports and queries.

Clicking on the button on the bottom “All Current/Accurate

PopStruc Obs Review” will pull up a review form to show all observations for the site and which ones were Accurate, and which one is tagged as the Current/Accurate.

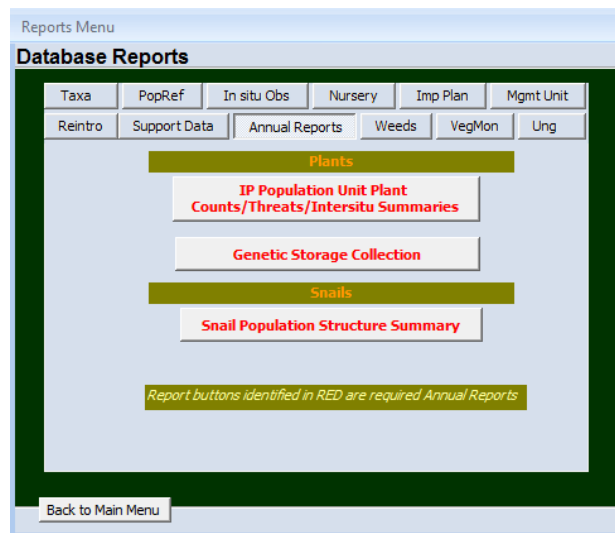
#### IV. Database Reports

Starting from the Main Menu, click on the Database Reports button. The Database Reports menu provides reports for various sections of the database.

Similar to the Database Entries, clicking on a button within the Database Reports will open a Find Form that will assist in selecting data records for the report.

For the purpose of this document, we will cover the reports normally generated for the Year-End Annual report.

There are three sections consisting of four reports that are normally printed annually. The sections are IP Populations, Genetic Storage, and Snail Population as shown in the figure to the right.



Find IP PU ex situ Summaries

**Population Unit ex situ Seed Storage/Micropropagation/Intersitu** Reset

Project/Plan: Makua Implementation Plan and TaxonCode\*: NerAng and PopulationUnitName\*: \*

IP PU Status Data  
Report Year: 2011

Management Designation (Exclude "No Management?")

Buttons: Population Unit Status-Exec. Summary, PU In situ-Ex situ Review, Population Unit Status w/ Orig IP Data, IP Population Unit Status with PopRefSites, IP PU Threats, PU Seed Storage, PU Founders in Outplanting, PU Micropropagation

Close

## Taxon Status and Threat Summaries

Under the IP Population Unit button, the menu has threat reports (in red) Exec. Summary, Taxon Status (Population Unit Status) and the Threat Summary (IP PU Threats). Buttons with red text will signify it is a report used in the year-end annual report. Project/Plan and Report Year must be selected for the reports to run. In the Report Year Field, select 2012. Report Year is defined below under Total Mature, Immature and Seedling 2012.

## Executive Summary

The Executive Summary database report combines data derived from the Taxon Status Summary Report, Genetic Summary Report and Threat Summary. See below for further details.

### Makua Implementation Plan - Executive Summary - Plants

# of Stable IP Population Units: 43 of 100

█ = Ungulate Threat to Taxon within Population Unit  
No Shading = Absence of Ungulate threat to Taxon within Population Unit

Plant Taxon	Target # Matures	Population Unit Name	Total Current Mat+Imm	Total Current Mature	Total Current Immature	Total Current Seedling	# Plants In 2012	# Plant In Original Report	Completed Genetic Storage Requirement %	% of Plants Protected from Ungulates	PU Met Goal?	# PU Met Goal
Neraudia angulata	100											
		Kalukauila	134	65	69	0	164	0	N/A	100%	No	
		Makua	133	117	16	1	39	29	46%	17%	Yes	
		Manuawai	57	52	5	0	0	12	100%	100%	No	
		Waianae Kai Mauka	65	27	38	0	20	46	26%	100%	No	
		<b>Neraudia angulata Total:</b>	<b>389</b>	<b>261</b>	<b>128</b>	<b>1</b>	<b>223</b>	<b>87</b>				1 of 4

## Taxon Status Summary

### Makua Implementation Plan - Population Unit Status

**Action Area: In**

TaxonName: Neraudia angulata Target# of Matures: 100 # MFS PU Met Goal: 1 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2012	Total Immature 2012	Total Seedling 2012	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU Last Obs Date	Population Trend Notes
Kalukauila	Manage reintroduction for stability				164	0	0	65	69	0	0	0	0	65	69	0	2013-05-21	Many of the outplants were observed dead in the last year and new immature plants were observed in the outplanting site
Kapuna	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2013-03-27	The last remaining plant was observed dead in the last year
Makua	Manage for stability	29	0	22	24	15	1	117	16	1	19	15	1	98	1	0	2013-07-11	Many plants were added to a new reintroduction site
Punapohaku	Genetic Storage				1	0	0	4	0	0	4	0	0	0	0	0	2013-09-04	New plants were discovered during surveys
<b>In Total:</b>		<b>30</b>	<b>0</b>	<b>22</b>	<b>189</b>	<b>15</b>	<b>1</b>	<b>186</b>	<b>85</b>	<b>1</b>	<b>23</b>	<b>15</b>	<b>1</b>	<b>163</b>	<b>70</b>	<b>0</b>		

**Action Area: Out**

TaxonName: Neraudia angulata Target# of Matures: 100 # MFS PU Met Goal: 1 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2012	Total Immature 2012	Total Seedling 2012	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU Last Obs Date	Population Trend Notes
Halona	Genetic Storage	15	0	0	30	4	0	30	4	0	30	4	0	0	0	0	2006-05-22	No monitoring in the last year
Leeward Puu Kaua	Genetic Storage	3	0	0	9	0	0	9	0	0	9	0	0	0	0	0	2006-11-21	No monitoring in the last year
Makaha	Genetic Storage	6	14	0	6	7	0	4	7	0	4	7	0	0	0	0	2012-12-18	Thorough monitoring

The Taxon Status Summary, shown above, displays the current status of the wild and outplanted plants for each PU next to the totals from the previous year for comparison. The report also depicts the original IP Totals for the different age classes. The PUs are grouped into those with plants that are located inside the MIP or OIP AA (In) and PUs where all plants are outside of both AAs (Out).

**Population Unit Name:** Groupings of Population Reference Sites. Only PUs designated to be ‘Manage for Stability’ (MFS), ‘Manage Reintroduction for Stability/Storage,’ or ‘Genetic Storage’ (GS) are shown in the table. Other PUs with ‘No Management’ designations are not managed and will not be reported. "No Management" PUs may be shown by not checking the "Exclude No Management" box on the report menu.

**Management Designation:** For PUs with naturally occurring (*in situ*) plants remaining, the designation is either ‘Manage for Stability’ or ‘Genetic Storage’. Some MFS PUs will be augmented with outplantings to reach stability goals. 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’.

**Total Original IP Mature, Immature, Seedling:** These first three columns display the original population numbers as noted in the first Implementation Plan reports of MIP (2005) and OIP (2008). When no numbers are displayed, the PU was not known at the time of the IPs

**Total Mature, Immature and Seedling 2012:** This displays the **SUM** of the number of *wild and outplanted* mature, immature plants and seedlings from the previous year’s report. These numbers should be compared to those in the next three columns to see the change observed over the last year.

**Total Current 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 last three columns can be compared with the NRS 2010 estimates to see the change observed over the last year.

**Wild Current Mature, Immature, Seedling:** These set of three columns display the most up to date population estimates of the wild (*in situ*) plants in each PU. These numbers are generated from OANRP monitoring data, data from the Oahu Plant Extinction Prevention Program (OPEP) and Oahu NARS staff. The estimates may have changed from last year if estimates were revised after new monitoring data was taken or if the PUs have been split or merged since the last reporting period. The most recent estimate is used for all PUs, but some have not been monitored in several years. Several PU have not been visited yet by OANRP and no plants are listed in the population estimates. As these sites are monitored, estimates will be revised.

**Outplanted Current Mature, Immature, Seedling:** The third set of three columns display the numbers of individuals OANRP and partner agencies have outplanted into each PU. This includes augmentations of *in situ* sites, reintroductions into nearby sites and introductions into new areas.

**PU LastObs Date:** Last Observation Date of the most recent Population Reference Site observed within a PU. Where thorough monitoring was done, the estimates were updated. Although, there are sites that may have been observed more recently, but a complete monitoring was not done.

**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 previous estimates, 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. When the PU has not been monitored, the same estimate from the previous year is repeated.

## Threat Control Summary

### Action Area: In

TaxonName: *Cenchrus agrimonioides* var. *agrimonioides*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	BTB Managed	Slugs Managed	Fire Managed
Kahanahaiki and Pahole	Manage for stability	320	Partial 100%	Partial 88%	Partial 30%	No	No	No
Kuaokala	Genetic Storage	1	No	No	No	No	No	No

### Action Area: Out

TaxonName: *Cenchrus agrimonioides* var. *agrimonioides*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	BTB Managed	Slugs Managed	Fire Managed
Central E Iahaniui	Manage for stability	161	Yes	Partial 100%	Yes	No	No	No
Maieha and Waianae Kai	Manage for stability	12	Partial 58%	Partial 100%	No	No	No	No
South Huliwai	Genetic Storage	17	No	No	No	No	No	No

[Shaded Box] = Threat to Taxon within Population Unit  
 No Shading = Absence of threat to Taxon within Population Unit  
 Ungulate Managed = Culmination of Cattle, Goats, and Pig threats  
 Yes=All PopReSites within Population Unit have threat controlled  
 No=All PopReSites within Population Unit have no threat control  
 Partial%=Percent of mature plants in Population Unit that have threat controlled  
 Partial 100%= All PopReSites within Population Unit have threat partially controlled

The Threat Control Summary summarizes the threat status for each Taxon Population Unit. Yes, No or Partial is used to indicate the level of threat management. Partial management has additional percentage based upon the number of mature plants being protected.

**Population Unit Name:** Groupings of Population Reference Sites. Only PUs designated to be ‘Manage for Stability’ (MFS), ‘Manage Reintroduction for Stability/Storage,’ or ‘Genetic Storage’ (GS) are shown in the table.

**Management Designation:** Designations for PUs with ongoing management are listed. Population Units that are MFS are the first priority for complete threat control. PUs that are managed in order to secure genetic storage collections receive the management needed for collection (ungulate and rodent control) as a priority but may be a lower priority for other threat control.

**# Mature Plants:** Number of Mature Plants within the Population Unit.

**Threat Columns:** The six most common threats are listed in the next columns. To indicate if the threat is noted at each PU, a shaded box is used. If the threat is not present at that PU, it is not shaded.

Threat control is defined as:

Yes = All sites within the PU have the threat controlled

No = All sites within the PU have no threat control

Partial % = Percent of mature plants in Population Unit that have threat controlled

Partial 100% = All PopRefSites within Population Unit have threat partially controlled

Partial (with no %) = All PopRefSites within Population Unit have threat partially controlled and only immature plants have been observed.

**Ungulates:** This threat is indicated if pigs, goats or cattle have been observed at any sites within the PU. This threat is controlled (Yes) if a fence has been completed and all ungulates removed from the site. Most PUs are threatened by pigs, but others are threatened by goats and cattle as well. The same type of fence is used to control for all three types of ungulates on Oahu. Partial indicates that the threat is controlled for some but not all plants in the PU.

**Weeds:** This threat is indicated at all PUs for all IP taxa. This threat is controlled if weed control has been conducted in the vicinity of the sites for each PU. If only some of the sites have had weed control, 'Partial' is used.

**Rats:** This threat is indicated for any PUs where damage from rodents has been confirmed by OANRP staff. This includes fruit predation and damage to stems or any part of the plant. The threat is controlled if the PU is protected by snap traps and bait stations. For some taxa, rats are not known to be a threat, but the sites are within rat control areas for other taxa so the threat is considered controlled. In these cases, the box is not shaded but control is 'Yes' or 'Partial.' Partial indicates that the threat is fully controlled over part of the PU.

**BTB:** BTB stands for the Coffee Black Twig Borer (*Xylosandrus compactus*). This threat is indicated for any PUs where damage from BTB has been confirmed by OANRP staff. This is known to be a threat for all *Alectryon macrococcus* var. *macrococcus* and *Flueggea neowawraea*. Other MIP/OIP taxa may be affected and will be monitored for damage. Effective control methods do not exist at this time.

**Slugs:** This threat is indicated for several IP taxa as confirmed by OANRP staff. Currently, slug control is conducted under an Experimental Use Permit from Hawaii State Department of Agriculture, which permits the use of Sluggo® around the recruiting seedlings of *Cyanea superba* subsp. *superba* in Kahanahaiki Gulch on Makua Military Reservation. Until the label is changed to allow for application in a forest setting, all applications must be conducted under this permit. Partial indicates that the threat is fully controlled over part of the PU.

**Fire:** This threat is indicated for PUs that occur on Army lands within the high fire threat area of the Makua AA, and some PUs within the Schofield West Range AA and Kahuku Training Area that have been threatened by fire within the last ten years. Similarly, PUs that are not on Army land were included if there is a history of fires in that area. This includes the PUs below the Honouliuli Contour Trail, the gulches above Waialua where the 2007 fire burned including Puulu, Kihakapu, Palikea, Kaimuhole, Alaiheihe, Manuwai, Kaomoku iki, Kaomoku nui and Kaawa and PUs in the Puu Palikea area that were threatened by the Nanakuli fire. Threat control conducted by OANRP includes removing fuel from the area with pesticides, marking the site with Seibert Stakes for water drops, and installing fuel-breaks in fallow agricultural areas along roads. 'Partial' means that the threat has been partially controlled to the whole PU, not that some plants are fully protected. Firebreaks and other control measures only partially block the threat of fire which could make it into the PU from other unprotected directions.



# Genetic Storage Summary

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >= 1 Microprop	# Plants >= 1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est Viable in SeedLab	# Plants >= 3 in Microprop	# Plants >= 3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement
<b>Action Area: In</b>														
<b>Neraudia angulata</b>														
Kapuna	Genetic Storage	0	0	2	2	2	0	2	2	0	0	2	2	100%
Makua	Manage for stability	19	15	71	2	2	0	23	1	0	0	23	23	46%
Punapohaku	Genetic Storage	4	0	0	0	0	0	2	0	0	0	1	1	25%
<b>Action Area: Out</b>														
<b>Neraudia angulata</b>														
Halona	Genetic Storage	30	4	0	0	0	0	7	0	0	0	7	7	21%
Leeward Puu Kaua	Genetic Storage	9	0	0	0	0	0	1	0	0	0	1	1	11%
Makaha	Genetic Storage	4	2	8	2	1	0	13	1	0	0	12	12	86%
Manuwai	Manage for stability	0	0	2	0	0	0	2	0	0	0	2	2	100%
Waianae Kai Makai	Genetic Storage	45	35	0	0	0	0	0	0	0	0	0	0	0%
Waianae Kai Mauka	Manage for stability	16	4	14	0	0	0	9	0	0	0	9	9	26%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		127	60	97	6	5	0	59	4	0	0	57	57	

The Genetic Storage Summary estimates of seeds remaining in genetic storage have been changed this year to account for the expected viability of the stored collections. The viability rates of a sample of most collections are measured prior to storage. These rates are used to estimate the number of viable seeds in the rest of the stored collection. If the product of (the total number of seeds stored) and (the initial percentage of viable seeds) is >50, that founder is considered secured in genetic storage. If each collection of a species is not tested, the initial viability is determined from the mean viability of (preference in descending order):

1. other founders in that collection
2. that founder from other collections
3. all founders in that population reference site
4. all founders of that species

**Number (#) of Potential Founders:** These first columns list the current number of live *in situ* immature and mature plants in each PU. These plants have been collected from already, or may be collected from in the future. The number of dead plants from which collections were made in the past is also included to show the total number of plants that could potentially be represented in genetic storage for each PU since collections began. Immature plants are included as founders for all taxa, but they can only serve as founders for some. For example, for *Hibiscus brackenridgei* subsp. *mokuleianus*, cuttings can be taken from immature plants for propagation. In comparison, for *Sanicula mariversa*, cuttings cannot be taken and seed is the only propagule used in collecting for genetic storage. Therefore, including immature plants in the number of potential founders for *S. mariversa* gives an over-estimate. The 'Manage reintroduction for stability/storage' PUs have no potential founders. The genetic storage status of the founder stock used for these reintroductions is listed under the source PU.

**Partial Storage Status:** To meet the IP genetic storage goal for each PU for taxa with seed storage as the preferred genetic storage method, at least 50 seeds must be stored from 50 plants. This year, the number of seeds needed for each plant (50) accounts for the original viability (Estimate Viability) of seed collections. 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, the Army nurseries or the State's Pahole Mid-elevation Nursery is required to meet stability goals. Plants with one or more representatives in either the Lyon Micropropagation Lab or a nursery are considered to partially meet storage goals. The number of plants that have met this goal at each location is displayed.

**# Plants that Met Goal:** 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 a 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 collection goals than last year. Also, as seeds age in storage, plants are outplanted, or explants contaminated, this number will drop. 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 extant in each PU. In some cases, plants that are being grown for reintroductions are also 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 securing 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.

**% Completed Genetic Storage Requirement:** Describes the percent of Founder Plants that have met Genetic Storage goals. Genetic storage of at least 50 seeds each from 50 individuals, or at least three clones each in propagation from 50 individuals, is required for each PU. If there are fewer than 50 founders for a PU, genetic storage is required from all available founders. For example, if there are at least 50 seeds from five individuals, or at least three clones in propagation from five individuals, then listed in the tables is 10%.

See Taxon Status Summary above for details on In/Out Action Area, Population Units, and Management Designation.

# Snail Population Status Summary

## Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control				
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina roses	Jackson's Chamaeleon

### Achatinella mustelina

E SU: A Pahole to Kahanahaiki													
MMR-A	Manage for stability	58	2013-05-13	32	12	14	0	Yes	Yes	Yes	Yes	No	
Kahanahaiki Exclosure													
MMR-C	Manage for stability	99	2012-05-17	68	23	8	0	Yes	Yes	Yes	No	No	
Maile Flats													
PAH-B	Manage for stability	42	2013-05-13	24	16	2	0	Yes	Yes	Yes	Yes	No	
Pahole Exclosure													
E SU Total:		199		124	51	24	0						

#### Size Class Definitions

SizeClass	DefSizeClass
Large	>18 mm
Medium	8-18 mm
Small	< 8 mm

= Threat to Taxon at Population Reference Site  
 No Shading = Absence of threat to Taxon at Population Reference Site  
 Yes=Threat is being controlled at PopRefSite  
 No=Threat is not being controlled at PopRefSite  
 Partial=Threat is being partially controlled at PopRefSite

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*.

The Snail Population Status Summary describes the current population size and threat control. Size Classes varies by snail taxon and definitions are listed on the lower left corner of the report. Threat Control consists of Yes, No, or Partial. Partial is where only some of the threat is being controlled at the site.

**Population Reference Site:** 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.

**Management Designation:** 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.

**Population Numbers:** 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.

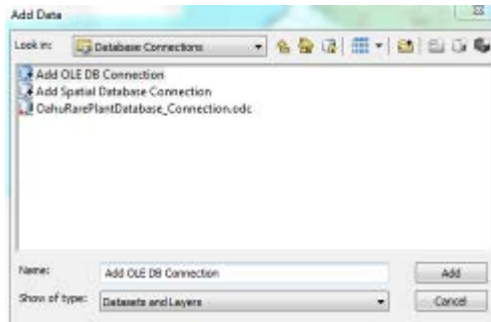
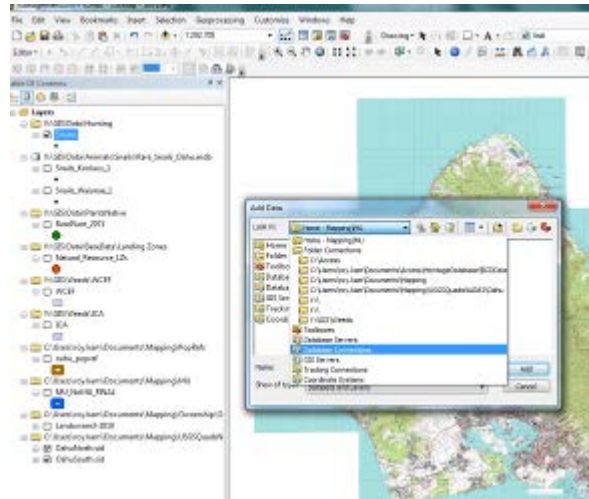
**Threat Control:** It is assumed that ungulate, weed, rat and *Euglandina* threats are problems at all the managed sites. If this is not true of a site, special discussion in the text will be included. If a threat is being managed at all in the vicinity of *A. mustelina* or affecting the habitat occupied by *A. mustelina* a "Yes" designation is assigned. The "No" designation is assigned when there is no ongoing threat control at the field site.

## Linking Access Database Query into ArcGIS –Distribution Database Version

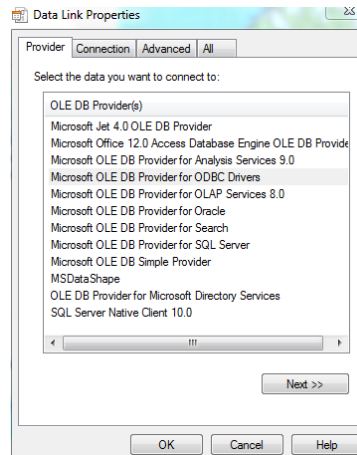
There may be times that information found in the Access database is needed in a GIS map. The following shows you how to link a query from Access into an ArcGIS project. The Population Reference Site query will be used as an example. Note there are several steps needed to bring in an Access Database query. If you don't feel comfortable in doing this, contact Roy Kam ([rkam@hawaii.edu](mailto:rkam@hawaii.edu)) and he will walk you through.

In your ArcGIS Project, make sure you have the Rare Plants or Rare Snails shapefile (or whatever shapefile you are linking) as one of your layers.

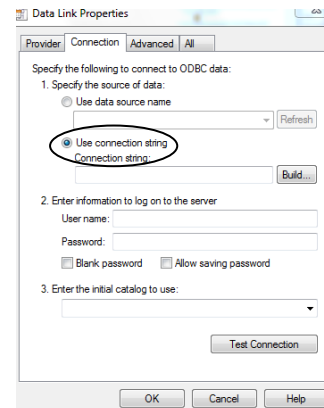
Click on the Add Button , and choose *Database Connections*.



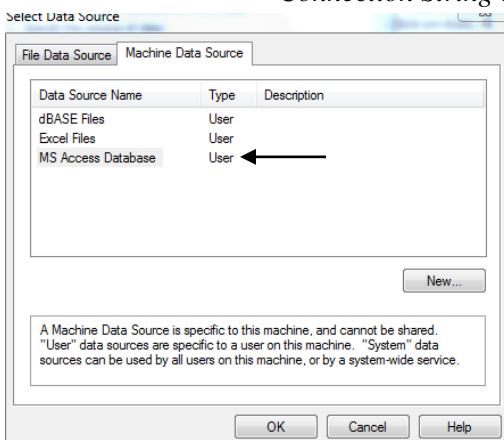
Then select *Add OLE Database Connection*, and click on *Add*.



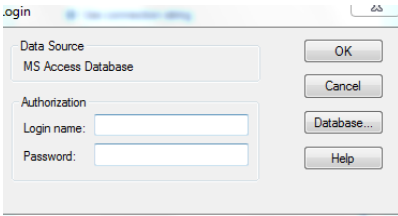
A Data Link Properties window will appear. Select *Microsoft OLE DB Provider for ODBC Drivers*.



Then in the Data Link Properties window, select the *Connection* tab. Under the Connection Tab, select *Use Connection String* and click on the button *Build*.



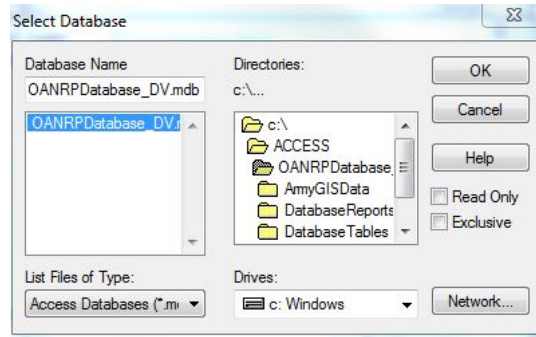
In the Select Data Source window, select the *Machine Data Source* tab, and select *MS Access Database* then click *OK*.



In the Login Window, Click on the *Database* button (leave Login Name and Password blank).

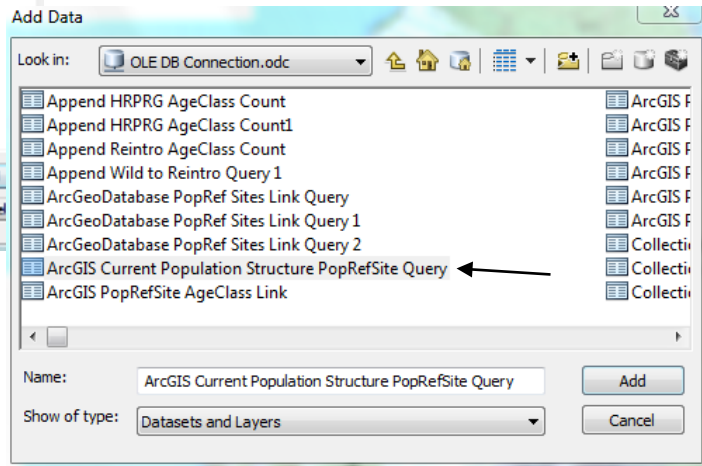
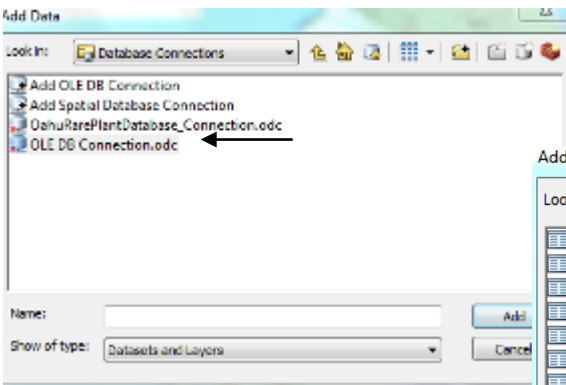
to C:\Access\OANRPDatabase\_DistributeVersion\OANRPDatabase\_DV.mdb

Click Ok to close the windows, until you are back at the Add Data window. You will now see a new OLE DB Connection.odc listed.



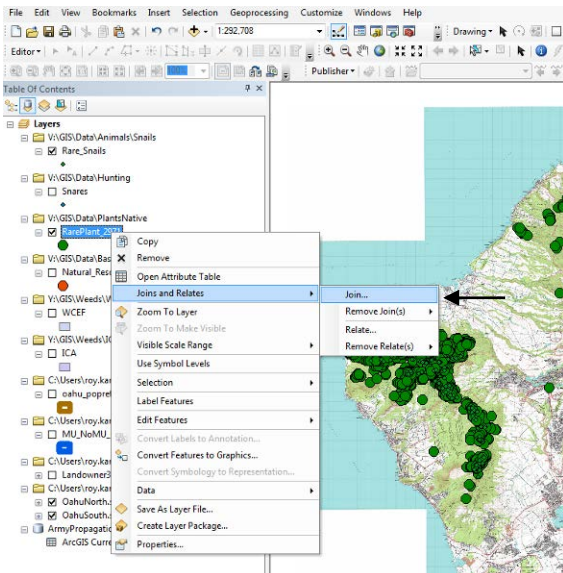
In the Select Database window, change the Drives to C: and browse

Double click on the OLE DB Connection.odc. The window will then open the Access Database and list all tables and queries.



Browse through the list until you find *ArcGIS Current Population Structure PopRefSite Query*. This query in the Access Database lists all of the Rare Plants and Rare Snails with their current Population Structure and whether the site is In situ or Ex situ. Click Add. The query will now appear as a Layer in your map project.

Go to the shapefile, right click and select Join under the Joins and Relates.





OAHU ARMY NATURAL RESOURCES PROGRAM  
MONITORING PROGRAM

**RESULTS OF A WEEDING TRIAL AT LOWER OPAEULA  
MANAGEMENT UNIT**

A pilot study to identify the most effective weed control re-treatment interval for  
*Clidemia hirta*-dominated areas

**INTRODUCTION**

One of the primary threats to plant community health is the introduction and geographical expansion of non-native vegetation. It significantly disrupts ecosystem and population level dynamics and negatively affects rare species restoration and stabilization efforts. For these reasons, non-native weed control has become an integral component of the Oahu Army Natural Resources Program (OANRP) management strategy. While much of the vegetation in Opaepala Lower Management Unit (MU) is predominantly native, some areas contain dense *Clidemia hirta* in the understory. Because *C. hirta* is widely established throughout the MU, eradication is most likely not feasible. This species is targeted by OANRP for ecosystem level control across the MU due to its ecosystem altering characteristics and tendency to create thick monotypic stands if left uncontrolled.

The primary objective of this study was to guide weed control planning for *C. hirta* at Opaepala Lower MU, identifying the most effective re-treatment interval out of three predetermined intervals. Several questions were addressed pertaining to the effect of weeding *C. hirta*-dominated areas. To what extent does *C. hirta* and other weed taxa rebound if an area is not re-weeded for 6, 12 or 18 months? In the course of weeding areas that have dense weed cover, a certain degree of native understory vegetation trampling occurs. Is re-weeding at 6 months too soon? Is there a benefit to waiting 12 or more months before re-weeding without extensive resurgence of weeds? I.e., does re-weeding at 6 months cause further damage to native vegetation? How long does it take for small immature *C. hirta* plants [ $< 10$  centimeters (cm) tall, typically not treated during weeding] to become reproductive? How does species diversity change for native and non-native vegetation in response to weeding at different intervals? Does canopy cover change in response to understory weeding within 18 months?

Changes in native and non-native percent cover and species richness were examined among understory weed retreatment intervals of 6, 12, and 18 months, along with investigations of the minimum time for *C. hirta* maturation, to identify the weed control frequency required to minimize seed rain in a given area, and consequently limit seedling recruitment. The final results of this study will be used to help plan landscape level weed control actions for *C. hirta* and may be incorporated into the Opaepala Lower Ecosystem Restoration MU Plan.

**METHODOLOGY**

**Study site**

Opaepala Lower is a 25-acre MU located in the northern Koolau Mountain Range, on the island of Oahu. The plant community is classified as a montane wet forest and the habitat is predominantly native. The annual precipitation averages 3816 millimeters (mm) (Giambelluca 2013) and elevation ranges between 1920-2260 feet. The vegetation is comprised of a mixture of native and introduced species. The

dominant native species in the canopy include *Acacia koa*, *Metrosideros* spp., *Syzygium sandwicense*, *Cheirodendron* spp., *Cibotium* spp., *Ilex anomala*, *Psychotria* spp., and *Melicope* spp.. The most common native species in the understory include *Dicranopteris linearis*, *Freycinetia arborea*, *Alyxia stellata*, *Melicope* spp., *Psychotria* spp., and *Cibotium chamissoi*. The dominant introduced species in the canopy is *Psidium cattleianum*, while those most prevalent in the understory include *C. hirta*, *Lantana camara*, *Sphaeropteris cooperii*, *Citharexylum caudatum*, *Rubus rosifolius*, *Paspalum conjugatum*, *Blechnum appendiculatum*, *Erechtites valerianifolia*, *Urochloa maxima* and *Setaria palmifolia*. During plot monitoring in 2013 and 2014, 48 taxa (65% native) were identified in the understory and canopy (Table 1).

Table 1. Species identified in the understory and canopy during monitoring of plots at Opaepua Lower MU in 2013 and 2014. Native taxa are in boldface.

<i>Acacia koa</i>	<i>Deparia petersenii</i>	<b><i>Ophioderma pendulum</i> subsp. <i>falcatum</i></b>
<b><i>Adenophorus tamariscinus</i></b>	<b><i>Dryopteris glabra</i></b>	<i>Paspalum conjugatum</i>
<b><i>Adenophorus tenellus</i></b>	<b><i>Dryopteris sandwicensis</i></b>	<b><i>Peperomia tetraphylla</i></b>
<i>Ageratum conyzoides</i>	<b><i>Elaphoglossum alatum</i></b>	<i>Phlebodium aureum</i>
<b><i>Alyxia stellata</i></b>	<b><i>Elaphoglossum crassifolium</i></b>	<i>Polystachya concreta</i>
<b><i>Antidesma platyphyllum</i></b>	<i>Erechtites valerianifolia</i>	<i>Psidium cattleianum</i>
<b><i>Asplenium acuminatum</i></b>	<b><i>Freycinetia arborea</i></b>	<i>Psidium guajava</i>
<b><i>Asplenium contiguum</i></b>	<b><i>Gardenia mannii</i></b>	<b><i>Psilotum complanatum</i></b>
<b><i>Asplenium macraei</i></b>	<b><i>Gynochthodes trimera</i></b>	<b><i>Psychotria mariniana</i></b>
<i>Blechnum appendiculatum</i>	<b><i>Huperzia phyllantha</i></b>	<i>Pterolepis glomerata</i>
<b><i>Cibotium chamissoi</i></b>	<b><i>Hymenophyllaceae</i></b>	<i>Rubus rosifolius</i>
<b><i>Cibotium menziesii</i></b>	<i>Lantana camara</i>	<b><i>Selaginella arbuscula</i></b>
<i>Citharexylum caudatum</i>	<b><i>Lepisorus thunbergianus</i></b>	<i>Sphaeropteris cooperi</i>
<i>Clidemia hirta</i>	<b><i>Melicope oahuensis</i></b>	<b><i>Sphenomeris chinensis</i></b>
<i>Cyclosorus dentatus</i>	<b><i>Metrosideros polymorpha</i></b>	<b><i>Syzygium sandwicense</i></b>
<i>Cyclosorus parasiticus</i>	<b><i>Nephrolepis exaltata</i> subsp. <i>hawaiiensis</i></b>	<b><i>Wikstroemia oahuensis</i> var. <i>oahuensis</i></b>

## Field Methods

Plots were established within the Opaepua Lower MU for four weeding treatments (Figure 1):

- Plot 1: not weeded (control)
- Plot 2: weeded at 0 and 6 months.
- Plot 3: weeded at 0 and 12 months.
- Plot 4: weeded at 0 months.

Plots were spaced at a minimum of one meter (m) apart. Each plot measured 5 m wide by 21 m long.

Non-native and native percent cover were assessed using point intercept for each plot. Understory vegetation [ $< 2$  m above ground level (AGL)] intercepted by a 5 mm diameter, 6 foot tall pole at points every 0.5 m along each of 20 transects spaced 1m apart ( $n = 80$  points) was recorded. Percent cover was derived from the proportion of “hits” among all intercepts. Species richness was documented by quantifying species present within 2 quadrats ( $1 \text{ m}^2$ ) spaced 2.5 m apart along each of 10 transects spaced 2 m apart ( $n = 20$  quadrats). To assess how long it takes for small ( $< 10$  cm) immature *C. hirta* seedlings to transition into the reproductive stage class, a subset of fifty seedlings were tagged within a 5 x 5 m plot.

To determine if canopy changes occur in response to understory weeding within 18 months, and to assess if differences in light availability between plots should be taken into account when interpreting the trial results, data was also collected on canopy percent cover (using point intercept) and light



penetration to the forest understory strata (using photography). Canopy vegetation (> 2 m AGL) intercepted by laser (using a laser pointer aimed 180° from the forest floor) at 2 points spaced 2.5 m apart along each of 10 transects spaced 2 m apart (n = 20 points) was recorded. Hemispheric photographs were taken of the canopy at the same locations. Photographs were taken at breast height, aimed 180° from the forest floor.

Understory vegetation was weeded in Plots 2, 3 and 4 in May 2013 (which included all mature and immature plants and most of the seedlings, but not grasses), and baseline data for understory and canopy percent cover, species richness, and light availability was collected for all plots following weeding. Plots 2 and 3 were re-weeded at 6 and 12 months, respectively, in a similar manner as the initial weeding effort. After 18 months (November 2014), all plots were re-monitored. *Clidemia hirta* reproductive status was also monitored in May 2013 at the seedling plot, then every 6 months until the end of the trial in November 2014. Additionally, photopoints were taken at the beginning (post-weeding) and end of the trial from each corner towards the center of the plot, to document change in each of the plots.

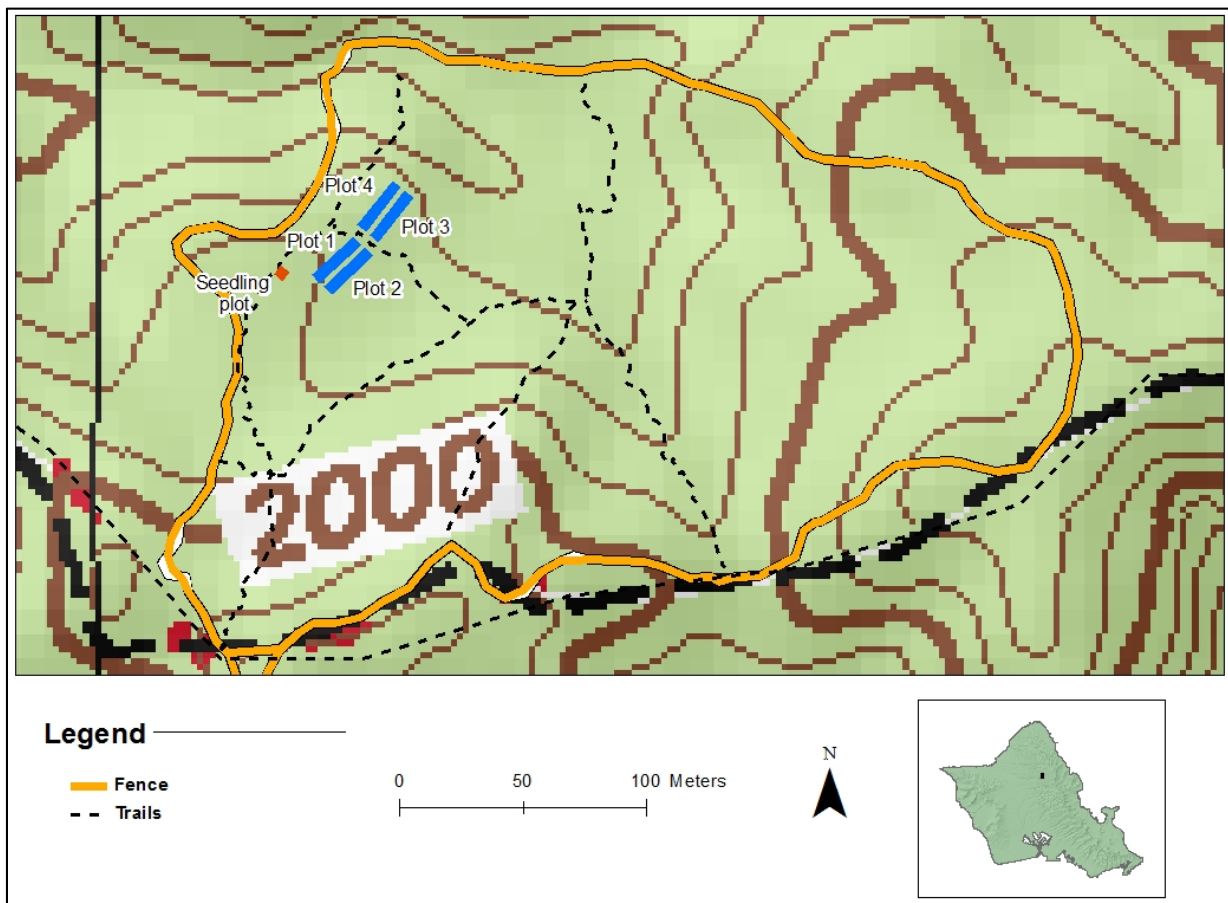


Figure 1. Locations of study plots at Lower Opaepa Management Unit

### Data Analysis

Chi-square and Fisher's exact tests were performed using point intercept data to examine change in understory and canopy cover within plots over time, and differences between plots at the end of the trial. Cover is described as very low to very high (Table 2). Within plot differences in species richness over time were analyzed using t-tests. Differences in species richness between plots at the end of the trial

were analyzed using ANOVA with Tukey's post-hoc comparisons. Gap Light Analyzer (GLA), Version 2.0 software (Frazer et al. 1999) was used to analyze percent canopy openness, using the hemispheric canopy photographs taken within each plot. Differences in canopy openness at the end of the trial were analyzed using ANOVA with Tukey's post-hoc comparisons.

Table 2. Percent cover categories used in describing trial results.

1-10	very low
11-25	low
26-40	moderately low
41-60	moderate
61-75	moderately high
76-90	high
91-100	very high

Analysis of change in weeds and non-vegetated area was based on initial weed cover in Plot 1, as Plots 2, 3 and 4 were weeded prior to baseline monitoring. *Clidemia hirta* cover was estimated to be similar among all 4 plots, as was the general weediness (cover and richness) of all other weeds combined (including grasses), based on anecdotal observations at the start of the trial. Although grasses were not weeded, they were likely trampled during weeding in Plots 2, 3 and 4. Because trampling likely affected grass cover estimates in the weeded plots, Plot 1 data was also used for comparison of grass cover change for all plots. Initial native cover estimates may also have been affected by trampling to a small degree.

## RESULTS

### Understory percent cover

#### *Non-Native*

Initial cover for total non-native taxa and *Clidemia hirta* was high, while non-native taxa excluding *C. hirta* was moderately low. There was a significant decrease in *C. hirta* and total weed cover, but a significant increase in total weed cover excluding *C. hirta*, among all weeded plots (Table 3 and Figure 2). The most commonly occurring grass, *Paspalum conjugatum*, also increased significantly from very low (Plots 2 and 4) and low (Plot 3) to moderately low in all weeded plots. There was no change in weed cover in the control plot.

At the end of the trial, *C. hirta* cover differed significantly among all plots ( $p < 0.001$ ), ranging from very low (Plot 3), to moderately low (Plot 2), to moderate (Plot 4) to high (Plot 1) in relation to the time elapsed since the last weeding effort (6, 12, and 18 months prior for Plots 3, 2 and 4, respectively, and Plot 1 never weeded). Total weed cover differed among plots except for Plots 2 and 3, ranging from moderate/moderately high (Plots 2 and 3), to high (Plot 4), to very high (Plot 1) ( $p < 0.001$ ), also in relation to time since weeding last occurred. Total weed cover excluding *C. hirta* differed among plots with the exception of plots 3 and 4, ranging from moderately low (Plot 1) to moderate (Plot 2) to moderately high/moderate (Plots 3 and 4) ( $p < 0.001$ ).

#### *Native*

There was a significant increase in native cover (from low to moderate) for the plots weeded twice (Plots 2 and 3), but no change in the control plot (Plot 1 - moderately low cover) or in the plot weeded only at month 0 (Plot 3 - low cover). Though initially absent in all plots, by the end of the trial, *Acacia koa* recruitment was present in all plots at very low cover, representing a very small but marginally significant increase in Plot 2 (weeded at months 0 and 6) and Plot 4 (weeded at month 0). *Cibotium chamissoi* was present in very low cover in all plots initially, and had a very small but

significant increase (to low cover) at the control plot, and a larger increase in the plots weeded twice (to low/moderately low cover), but no difference in the plot weeded once. *Nephrolepis exaltata* subsp. *hawaiiensis* was also present in very low cover initially in all plots, and had a significant increase (to low cover) in Plot 2 (weeded at months 0 and 6), but not in any other plots.

### *Non-vegetated*

Non-vegetated areas (including soil, rock, moss, and leaf litter) initially had very low cover. There was a very small significant increase (to low cover) in non-vegetated area in Plot 2 (weeded at months 0 and 6), but not in any other plots.

Table 3. Change in percent cover of native and non-native understory vegetation as well as non-vegetated areas after 18 months within plots weeded at months 0 and 6 (Plot 2), at months 0 and 12 (Plot 3), at month 0 (Plot 4), and not weeded (Plot 4 - control). Initial data for non-native taxa other than *Paspalum conjugatum* is derived from the control plot. Statistically significant results are in boldface. P-values derived from chi-square (\*) and Fisher's exact (\*\*) tests. Arrows indicate increase (↑) or decrease (↓) in cover.

	p			
	Plot 1	Plot 2	Plot 3	Plot 4
Non-native				
All non-native	0.374*	< <b>0.001*</b> ↓	< <b>0.001*</b> ↓	<b>0.010*</b> ↓
<i>Clidemia hirta</i>	0.771*	< <b>0.001*</b> ↓	< <b>0.001*</b> ↓	< <b>0.001*</b> ↓
Non-native excluding <i>Clidemia hirta</i>	0.483*	< <b>0.001*</b> ↑	< <b>0.001*</b> ↑	< <b>0.001*</b> ↑
<i>Paspalum conjugatum</i>	0.333*	< <b>0.001*</b> ↑	<b>0.002*</b> ↑	< <b>0.001*</b> ↑
Native				
All native	0.480*	< <b>0.001*</b> ↑	< <b>0.001*</b> ↑	1.000*
<i>Acacia koa</i>	1.000**	0.061**↑	0.499**	0.061**↑
<i>Cibotium chamissoi</i>	<b>0.044*</b> ↑	< <b>0.001*</b> ↑	< <b>0.001*</b> ↑	0.215**
<i>Nephrolepis exaltata</i> subsp. <i>hawaiiensis</i>	0.205*	< <b>0.001*</b> ↑	1.000*	0.562*
Non-vegetated	0.187*	<b>0.022*</b> ↑	0.280*	0.118*

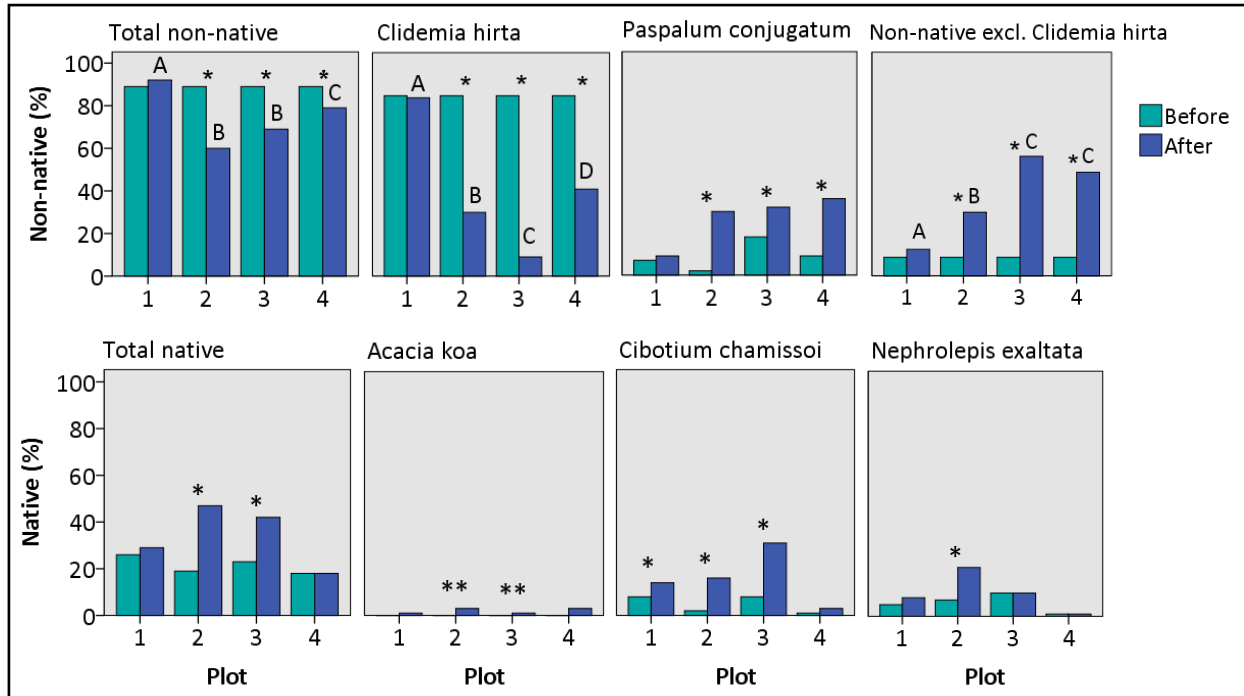


Figure 2. Percent cover of native and non-native understory at the start (before) and end (after) of the trial 18 later, among plots weeded at months 0 and 6 (Plot 2), at months 0 and 12 (Plot 3), at month 0 (Plot 4), and not weeded (Plot 1 - control). Initial data for non-native taxa except for *Paspalum conjugatum* is derived from the control plot. \*Significant, and \*\*marginally significant differences within plots. Letters denote significant differences between plots at the end of the trial.

### Photopoints

Though small differences were noticeable in photopoints of the control plot (not weeded - Plot 1) taken at the start and end of the project, the plot appeared similarly weed-dominated in the understory by the end of the trial (Figure 3). However, notable differences in the understory were apparent in the weeded plots, with the resurgence of weeds to varying degrees and the expansion of native fern cover following weeding at the start of the trial (Figure 4, 5 and 6). From the photopoints taken at the end of the trial, it was difficult to discern differences in non-native and native understory cover among the weeded plots.



Figure 3. Photopoints of Plot 1 (control – not weeded) from each plot corner towards center of plot, at the beginning and end of the trial.



Figure 4. Photopoints of Plot 2 (weeded at months 1 and 6) from each plot corner towards center of plot, at the beginning (after weeding) and end of the trial.



Figure 5. Photopoints of Plot 3 (weeded at months 1 and 12) from each plot corner towards center of plot, at the beginning (after weeding) and end of the trial.



Figure 6. Photopoints of Plot 4 (weeded at month 1) from each plot corner towards center of plot, at the beginning (after weeding) and end of the trial.



## Understorey species richness

Mean non-native species richness among quadrats increased significantly in the plots weeded at months 0 and 12 (Plot 3) and at month 0 (Plot 4) (Table 4 and Figure 7). At the end of the trial, there were significant differences in non-native species richness between plots (Anova:  $F = 6.003$ ,  $df = 3$ ,  $p = 0.001$ ), with pairwise differences between the control plot (not weeded) and the plots weeded at months 0 and 12 (Plot 3) and at month 0 (Plot 4) [Tukey's:  $p = 0.001$  (Plot 1 vs. 3);  $p = 0.049$  (Plot 1 vs. 4)]. There was no change in native species richness, with the exception of a marginally significant increase in the plot weeded at months 0 and 12 (Plot 3).

Table 4. Species richness change after 18 months within plots. Initial data for non-native taxa is derived from the control plot (not weeded) ( $n = 20$ ). Statistically significant results are in boldface. Arrows indicate increase ( $\uparrow$ ) or decrease ( $\downarrow$ ) in cover.

Plot	p*	
	Non-native	Native
1	0.689	0.907
2	0.081	0.116
3	<b>&lt; 0.001</b> $\uparrow$	0.057 $\uparrow$
4	<b>0.001</b> $\uparrow$	0.101

\*Significance derived from t tests.

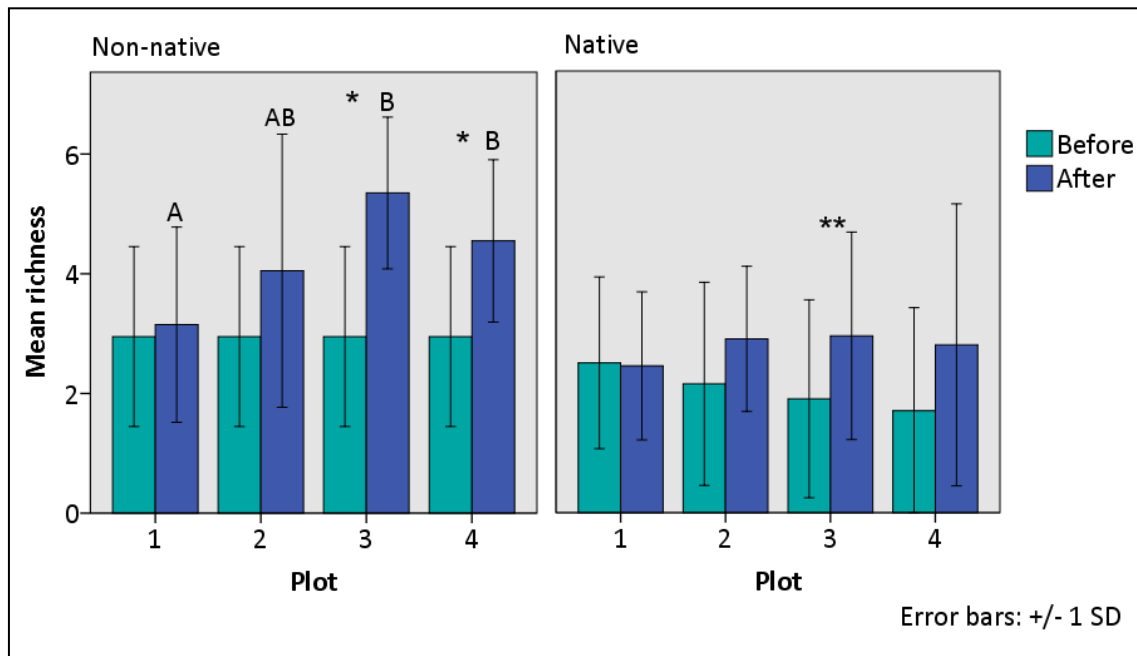


Figure 7. Bar graphs of mean non-native and native species richness among quadrats ( $n = 20$ ) at the start (before) and end (after) of the trial 18 months later, among plots weeded at months 0 and 6 (Plot 2), at months 0 and 12 (Plot 3), at month 0 (Plot 4), and not weeded (Plot 1 - control). Initial data for non-native taxa is derived from the control plot. \*Significant, and \*\*marginally significant differences within plots. Letters denote significant differences between plots at the end of the trial.

## Maturation time

Among the 50 tagged small immature *C. hirta* in the seedling plot, one individual was mature by 12 months, and 43% of the remaining live plants ( $n = 28$ ) were mature by 18 months. Mature plants ranged from approximately 1 to 1.5 m tall. Many of the immature plants were still very small, and were located beneath dense *C. chamissoi* cover. Nearly half of the tagged plants were dead or missing by 18 months, many of which may have been lost as a result of a *M. polymorpha* treefall that occurred within the plot (Figure 8). The treefall occurred between months 12 and 18, and created a light gap that may have prompted the growth and maturation of tagged immature *C. hirta*. At the end of the trial, all plots had mature *C. hirta*, including Plot 3, which was weeded only six months prior.

Figure 8. Photograph of *Clidemia hirta* seedling plot, showing large shady



*Cibotium chamissoi*, and uprooted *Metrosideros polymorpha* tree.

## Canopy percent cover and openness

There was no significant change in canopy cover (using point intercept data) during the course of the trial in response to weeding in understory (Figure 9). However, there were differences in canopy cover between plots (as measured at the end of the trial), with significantly higher cover in Plot 4 vs. Plot 2 (Fisher's exact  $p = 0.020$ ).

Similarly, there was no significant change in canopy openness (using GLA data) between years for the weeded plots (Figure 10), yet, there were significant differences among plots (as measured at the end of the trial) (ANOVA:  $p < 0.001$ ,  $F = 12.81$ ). Plot 2 was more open than all other plots, while Plot 4 was the least open.

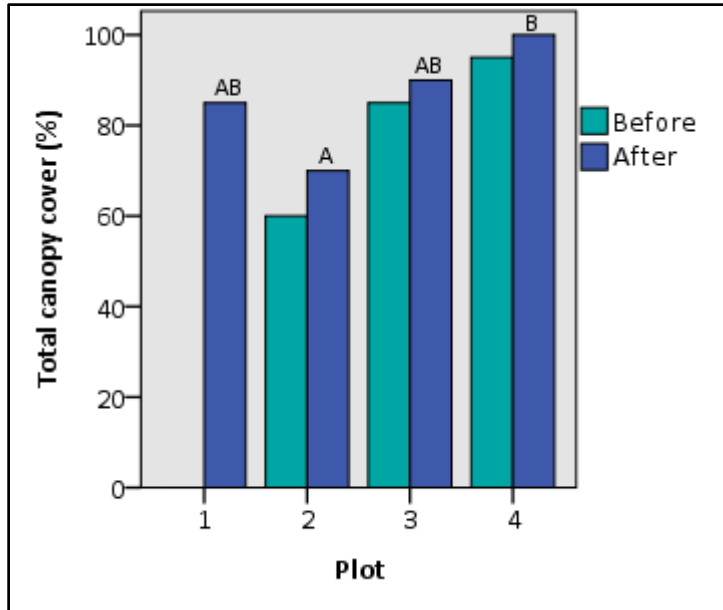


Figure 9. Bar graph of total canopy percent cover ( $n = 20$ ) before and 18 months after plots were weeded at months 0 and 6 (Plot 2), at months 0 and 12 (Plot 3), at month 0 (Plot 4), and not weeded (control – Plot 1). Initial data for the control plot (not weeded) was not recorded. Letters denote significant differences between plots at the end of the trial.

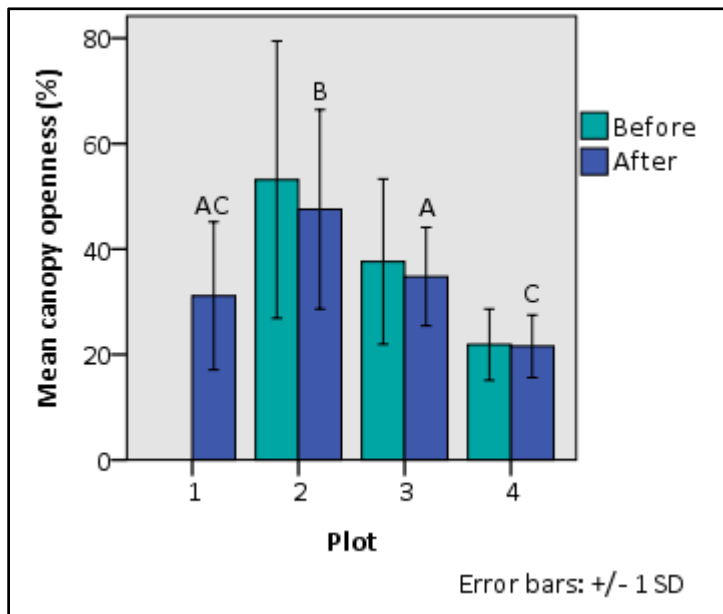


Figure 10. Bar graph of mean percent canopy openness ( $n = 20$ ) before and 18 months after plots were weeded at months 0 and 6 (Plot 2), at months 0 and 12 (Plot 3), at month 0 (Plot 4), and not weeded (control – Plot 1). Initial data for the control plot was not recorded. Letters denote significant differences among plots at the end of the trial (Tukey's pairwise comparisons).

## DISCUSSION

### Understory cover

The results of the trial suggest that weeding *C. hirta*-dominated understory at Lower Opaeula produces reduced *C. hirta* cover paired with an increase in native cover after 18 months if initial weeding is followed by additional weeding 6 or 12 months later. However, substantial increased cover of non-native weeds other than *C. hirta* occurred, particularly *P. conjugatum*. The best results occurred weeding at months 0 and 6 with respect to a reduction in total weed cover paired with increased total native cover. Weeding at months 0 and 12 had nearly as good of a result, with slightly less native cover, and slightly more non-native cover. The plot weeded only once had very poor results after 18 months, with no change in native cover, and a resurgence of non-native cover to nearly as high as it was prior to weeding. The most notable response in native cover was the increase in *C. chamissoi* cover in the plots weeded twice. Little change in cover occurred during this time interval in the unweeded plot, suggesting that the rate of degradation in unweeded areas is slow.

The trial results should be interpreted with caution, as initial data was recorded only after Plots 2, 3, and 4 were weeded. Native plants and *P. conjugatum* may have been trampled in the course of weeding, which could have resulted in exaggerated changes in cover. Weed cover and richness may have differed in the weeded plots from Plot 1, which could have introduced error in estimates of non-native change.

### Photopoints

While the photopoints were effective in revealing either little change (in the control plot) or more dramatic change (in the weeded plots) over time following initial weeding efforts at the start of the trial, differences among the weeded plots at the end of the trial were difficult to discern. By supplementing photopoints with percent cover and species richness data, a better understanding of the extent of change over time and differences among treatments was obtained.

### Species richness

The increased cover in non-native weeds other than *C. hirta* was paired with an increase in weed species richness among quadrats in the weeded plots. Dense *C. hirta* cover may outcompete and/or may prevent the establishment of other understory weeds. As native species richness did not change substantially, the increase in native cover that occurred in the plots weeded twice was largely an expansion of species already present. The plots weeded twice had the best outcome with respect to unchanged weed richness (Plot 2 – weeded at months 0 and 6), and a marginally significant increase in native richness (Plot 3 – weeded at months 0 and 12). The plot weeded only once had the worst result, with an increase in weed richness, and no increase in native richness. Similar to the limited change in cover, no change in richness occurred in the control plot, further suggesting that the rate of decline is slower than can be detected in an 18 month time interval.

### Maturation time

Though the minimum time for *C. hirta* maturation from the small immature stage was 12 to 18 months in the seedling plot, the presence of mature plants in a plot weeded only 6 month prior to the end of the trial suggests that the minimum time to maturation of small immature plants is less than six months. Growth and maturation of *C. hirta* may be influenced by light availability, as suggested by the limited maturation that occurred by 12 months in the seedling plot, during which time the plants were shaded by a large *M. polymorpha* tree, followed by substantial growth and maturation following the falling of the tree.

The occurrence of dense *C. chamissoi* atop tagged *C. hirta* that remained small at the end of the trial further suggests limited growth under shady conditions.

### **Canopy cover and light availability**

As no change in canopy cover or openness occurred within weeded plots over time, the time in which canopy cover may change in response to understory weeding is likely greater than 18 months. Differences in understory change over time among plots may have been influenced by differences in light availability, as canopy cover and openness differed among plots. This is of particular concern for interpreting the results in Plot 4, which was more open than the other plots, and had the worst results. Overall results were similar between the two methods of assessing light availability, with Plot 2 being least canopied/most open, and Plot 4 having the highest canopy cover/least openness in comparison with the other plots. GLA data is likely less influenced by human error or bias than the point intercept data, due to point intercept challenges with maintaining an exact 180° vertical projection with a laser pointer, particularly in association with assessing intercepts with high sparse canopy.

### **RECOMMENDATIONS**

- Re-weeding should occur within 6 to 12 months, in order to allow native cover to expand, and prevent weed cover from returning to near prior levels. Because change is slow in unweeded areas, it is not urgent to weed expansively across the MU in the immediate future, particularly if re-weeding within the recommended time interval is not feasible for all weeded areas.
- Weeding of *C. hirta*-dominated areas should focus first in areas with high canopy cover, as young plants will likely grow and mature less quickly.
- Weeding should be paired with grass control, to prevent expansion of non-native grasses, and possibly allow for further expansion of native cover.
- Because *C. hirta*-dominated areas are partially replaced by other weed taxa, care should be taken to ensure that more problematic weeds do not become established.
- Clearcutting *P. cattleianum* in this area is not advised unless there are resources to follow up and prevent *C. hirta* from becoming established. Or, *P. cattleianum* removal should be limited to the understory only, and limit all canopy removal.
- If there is an impetus to deplete the *C. hirta* seed bank, weeding should occur more frequently than 6 months, particularly in areas with greater light availability. Additionally, weeding must be ongoing, as *C. hirta* forms a long lived seed bank (Brooks and Setter, 2012). However, such a high frequency of weeding will limit the total area that is feasible to weed. Additionally, there will likely be a continual influx of *C. hirta* seeds from the surrounding areas. Depletion of the *C. hirta* seed bank is likely an impractical endeavor.
- Further investigations of the effects of light availability on *C. hirta* growth should be done.
- While this trial provided useful information for *C. hirta*-dominated understory at Lower Opaepala, expectations for similar results in other locations should be applied cautiously.

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**Annual Progress Report for “Kahanahaiki Vegetation Mapping Analysis”**  
**Project Update: October 1, 2014 – September 30<sup>th</sup>, 2015**

**Evaluation of Three Very High Resolution Remote Sensing Technologies for Vegetation Monitoring in Makaha and Kahanahaiki Valleys**

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Summary

This report serves to update the progress of this project from October, 2014 through September 30<sup>th</sup>, 2015. Support of this project was made possible by the Oahu Army Natural Resources Program, Research Corporation of the University of Hawaii, Pacific Cooperative Studies Unit, the Natural Resources and Environmental Management program at the University of Hawaii at Manoa, Resource Mapping Hawaii, Pacific GPS, USGS, Apollo Mapping and the support staff within these organizations.

The project study location was switched from Makaha to Kahanahaiki in upper Makua Valley for easier site access. Kahanahaiki has served as a model research site for a host of research. It is representative of many resources and challenges faced for management in the Waianae Mountain range of Oahu. Progress was made with respect to gear rentals, testing, field data collection, UAS exploration, imagery acquisition and classification training. Four aerial image missions were conducted under contract by ReMap HI and 3 UAS missions were conducted for research and development purposes. Weather was limiting and the missions served to be partially successful, capturing a portion of the desired image dataset. Imagery data was obtained from satellite, aerial and gigapan imaging platforms. Suitable World View 3 satellite imagery was collected for the study area and preliminary image processing occurred. Survey tools were used to collect field data during the Summer of 2015.

### Study Site

A site visit was conducted in Makaha Valley in early April and it became clear that the site is too remote for the scope of the project. Kahanahaiki in upper Makua Valley was chosen as an alternative study location and was approved by OANRP staff.

### High Resolution Aerial

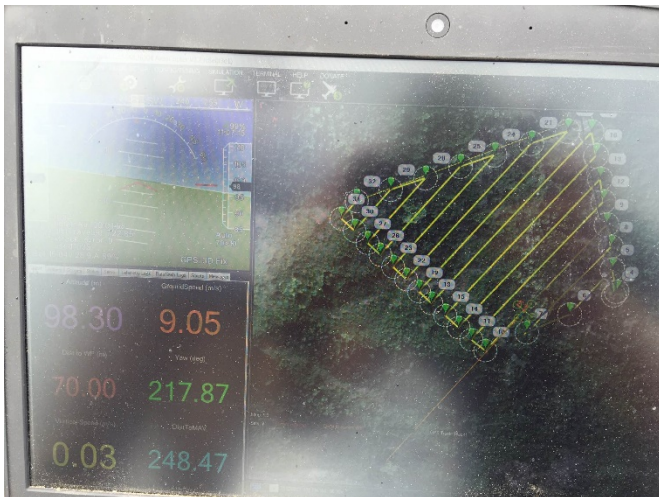
Under contract, Remap Hawaii flew on four occasions with the Cessna 206 fixed wing plane to capture high resolution imagery of Kahanahaiki and Makaha but faced challenges due to the difficult nature of weather in the area. Data collection was attempted after 10 a.m. in an attempt to capture imagery of the MUs when the sun was overhead and casting the least amount of shadowing. Incidentally, there were significant low level clouds during the flights and several missions were deemed to be unsafe to the pilot and crew. Partial imagery of upper Makaha was obtained and delivered (See Figure 1). Image resolution is high with significant potential for assessment and tracking change over time of vegetation.



Figure 1: Makaha subunit II image sample. The Kumaipo LZ and MU fence.



After four attempted flights the focus switched to an Unmanned Aerial System (UAS) and several site visits were conducted. UH Manoa Geography graduate, Charles Devaney was brought on for the UAS phase. Benefits of UAS include but is not limited to: cost effectiveness while delivering a quality sweet of image data products, reduction of risk, easier mobilization and the capability of flying safely below the cloud ceiling. A test flight was conducted with a DJI Phantom and GoPro Hero 3 camera. Resulting imagery showed potential. The flight mission was preplanned by Mr. Devaney to image Kahanahaiki subunits I and II and a flight was coordinated with favorable weather conditions. A Y-6 rotary Unmanned Aerial Vehicle (UAV) was prepped and flown by Mr. Devaney. It flew 3 out of 5 preplanned flight segments on autopilot after the initial launch (See Figures 2 and 3). Battery life was a limiting factor with 10 minute flights. The Y-6 mission was ended short due to significant compass errors and potential firmware issues complicated by possible interference from nearby communication towers at the Nike facility. It was safely returned to the launch point.



Figures 2 and 3: Flight mission while the flight was underway and the Y-6 rotary UAV being prepped for launch.

A fixed wing, Newskywalker UAV was identified as potentially a more suitable UAV for the mission. A launch and land location was identified and Troubleshooting and equipment testing were conducted. It was flown under conditions that started optimally with light winds and a high cloud ceiling. Weather moved into Kahanahaiki from the south with a low cloud ceiling. An entire MU dataset was collected and the fixed wing performed well on autopilot staying true to the planned flight. Line of site was followed, however approximately 50% of the image dataset of Kahanahaiki Subunits I and II was partially obstructed by low clouds. If a safe landing is achievable the fixed wing UAS shows great potential as battery life is expanded significantly. The Newskywalker flew on a single battery for 107 minutes with approximately 50% usage. The rotor and fixed wing UAVs were flown with a Sony Mirrorless camera delivering sharp, high resolution images. Two image deliverables were obtained from the Newskywalker, a 3-D image mosaic of subunit II and orthorectified tiles of the cloud free southern portion of the MU (See Figures 3 and 4).

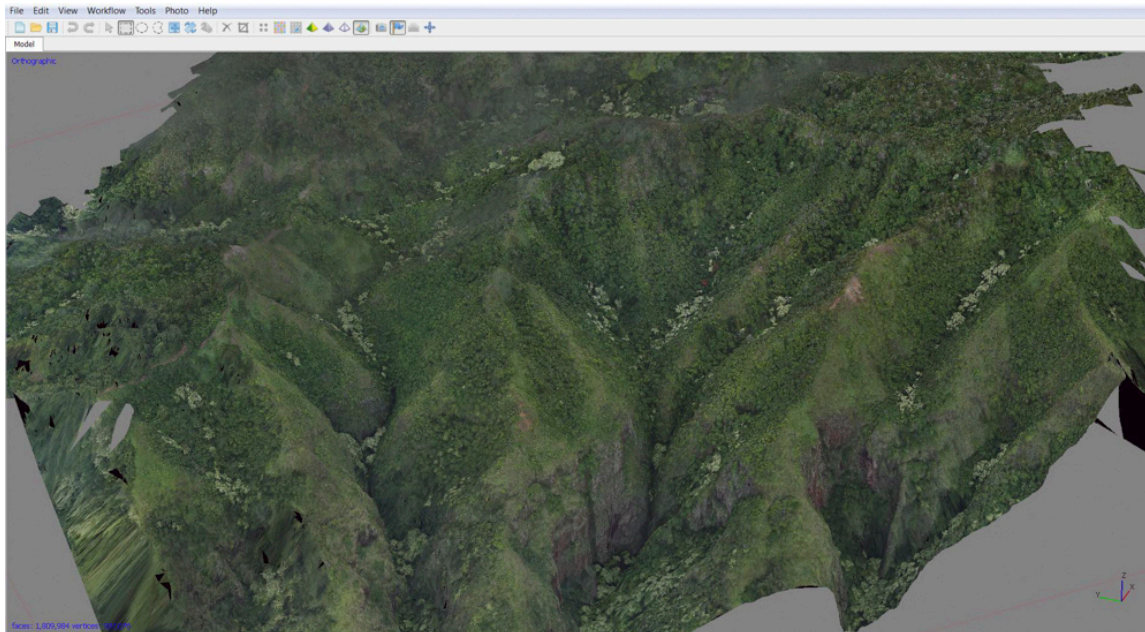


Figure 3: Screenshot of the 3D image data product of Kahanahaiki subunit II looking east.



Figure 4: Sample image tile of Kahanahaiki subunit II.

#### World View 3 Satellite Imagery

In June 2015, Apollo Imaging delivered the first data set of 175km<sup>2</sup> capturing target MUs in the Waianae Mountains collected on May of 2015. The imagery of the leeward portion of the northwestern data set was cloud free. Much of the remaining target area was obstructed by cloud cover. Apollo mapping was contacted and agreed to continue to collect imagery of the area until an acceptable deliverable may be obtained. Data processing of the cloud free portion of the May data set was undertaken by Apollo Imaging, however the geoprocessing needs further work.

Orthorectification will be conducted to align Kahanahaiki and Makua with an accurate known base layer data set.

### Gigapan

An effective protocol was developed for obtaining sharp, effective mosaics using a Gigapan Epic Pro mount, Canon 60D and Canon 100-400mm f4L lens. A 900 image mosaic was gathered from one of the main gulch vantage points to be used in the accuracy assessment (See Figure 5). Two other ridgeline locations were imaged in addition.

Test classification using an object based approach and visual classification of a gigapixel image of upper Makaha collected in the previous reporting year was conducted in ArcGIS 10.0 (see Appendix 1).



Fig. 5: Mosaic of the east facing northern portion of Kahanahaiki subunit II.

### Other Work

A Trimble Geo7XH was rented from Pacific GPS for a shared 6 week duration with OANRP. Karen Knowlen conducted an introductory training for this researcher and select OANRP staff. Training data of target species locations throughout subunit I of Kahanahaiki. Locations of ground markers to facilitate orthorectification of aerial imagery were also collected. The Truepulse 360 R laser rangefinder was integrated with the Trimble for obtaining GPS offsets. Early tests show error from 1-20m partially due to magnetic interference. Further investigation is required to develop a working protocol, however this combination of data collection shows much potential for mapping and rapid assessments from suitable vantage points (See Figures 6, 7 & 8)



Figures 6,7,8: Training data collection, orthorectification ground marker data collection and GPS offset exploration.

Appendix 1.

**Object Based Image Classification of Gigapixel Imagery of a Mixed Mesic Forest**

William Weaver

Geography 762

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Term Project Paper

## **Abstract**

Tropical island ecosystems are typically very vulnerable to invasive species due to high net resource availability and the poor ability of native species to compete for those resources. The invasion of Strawberry Guava (*Psidium cattleianum*) may have significant effects on Hawaii's water resources. Mapping the extent of Strawberry Guava in Hawaiian watersheds and monitoring landscape change is a key component to watershed restoration efforts. The Gigapan robotic unit allows a user to capture very high resolution digital images (<1cm) with billions of pixels from suitable ground locations. It is gaining use by researchers across many fields of science to capture site information from geology to ecology to complement field work; however it has yet to be fully utilized for vegetation mapping. Analysis of imagery has been limited to visual classification of imagery. Object based classification with eCognition was used to classify Gigapan imagery to separate *P. cattleianum* from a target area in Makaha Valley, Oahu, Hawaii. User's accuracy was low at 47% (n=30) due to a host of factors including the lack of a fourth NIR band, shadowing due to the sensor view angle, homogenous nature of the vegetation, spectral similarities among vegetation, and changes in the light levels during the image collection process. Object based classification may not serve to be the most optimal pairing with Gigapan imagery, however visual analysis and classification may serve to be an effective classification method to classify to the species level due to the very high spatial resolution of the imagery (0.8cm).

## **Introduction**

The Hawaiian Islands are a prime example of ecological diversity and host an array of unique and rare species that have evolved within a myriad of environments (Gon, 2003; Sailer, 2003). A key ecosystem within the islands is the mesic forest, an area found in coastal, lowland, and montane areas of Hawaii that receives 1200 mm to 1500 mm rainfall annually (Wagner et al.,

1998; Sailer, 2003). Although wet forests are credited with capturing the bulk of rain water, mesic forests significantly supplement groundwater recharge and buffer wet forested areas from degradation by land use change, ungulate damage, and fires (Sailer, 2003; Juvik and Juvik, 1998).

The mixed mesic forest of upper Makaha valley is an area of significant groundwater recharge (Mair and Fares, 2009). Unfortunately, much of the upper valley has been severely impacted by an array of human activities and the subsequent introduction of many invasive plant species (Juvik and Juvik, 1998; Takahashi et al., 2010; Mair and Fares, 2009). In addition to ecological impacts, non-native tree species threaten to negatively affect the hydrological services provided by native forests (Mair and Fares, 2009; Vitousek et al., 1987). Invasive plants such as *Psidium cattleianum* alter local water balances by changing vegetation structure, water storage characteristics, and rates of transpiration (Takahashi et al., 2010).

Vegetation monitoring provides the basis for understanding the intricate composition of an area on a forest to watershed scale. It can allow us to capture current forest dynamics and can be used to track changes in an area over time. The baseline data provided by vegetation monitoring can be very useful especially in areas that receive management through ecosystem restoration. Tracking changes over time can give natural resource managers insight on the forest composition and resource inventory and provide a means to assess the effectiveness of conservation practices and a measure for success of their efforts. Unfortunately, traditional “on the ground” vegetation monitoring techniques can be time consuming and costly and may vary in accuracy and consistency depending on observer bias (Congalton, 1991). Ground monitoring can also be damaging to sensitive ecosystems and difficult to accomplish in steep terrain.

New technology is changing the face of vegetation mapping and its efficacy in the form of remote sensing and GIS. Analysis of remote imagery can provide accurate and timely assessments



of vegetation on a large scale at a set point in time (Bunting and Lucas, 2006). Remote imagery can easily be replicated and can provide an accurate visual key of an area (Bunting and Lucas, 2006).

### Object of Study

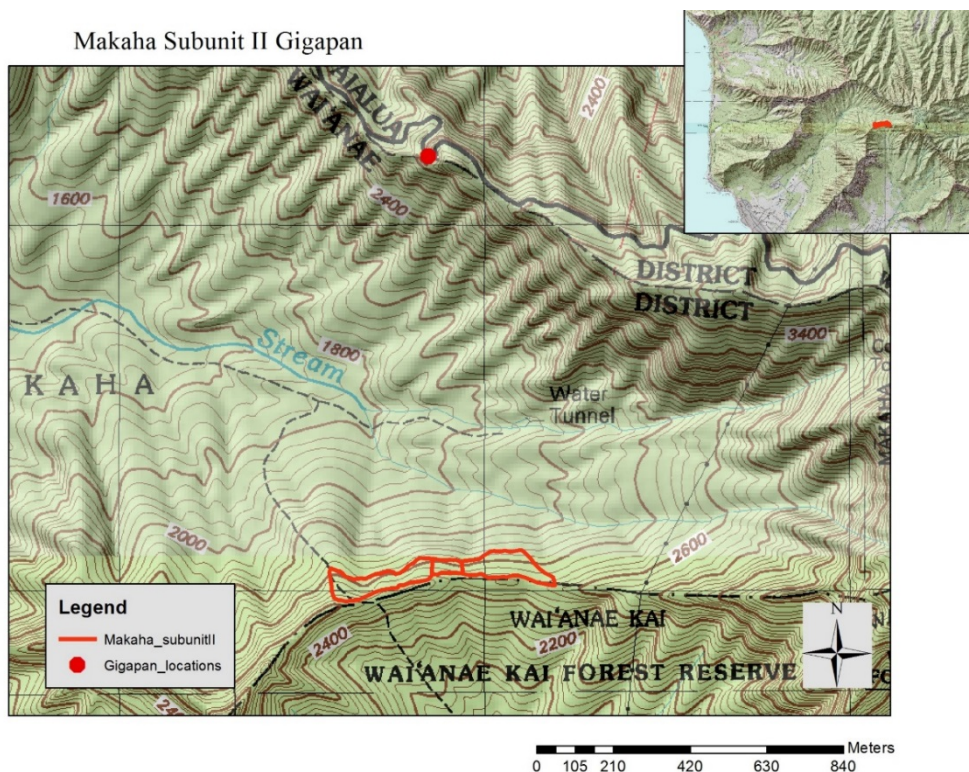
Accurate and timely classification of remote sensing imagery is vital to the adaptive management process. Little work has been conducted with supervised classification of Gigapan imagery. The objectives of this research were:

1. To investigate the use of object based classification to classify *P. cattleianum* from gigapixel Gigapan imagery in subunit II of Makaha Valley.
2. Conduct a visual classification of the imagery for comparison
3. Assess the accuracy of the object based classification

### Study Site

Upper Makaha valley is located on the leeward side of the Northern Waianae Mountain Range of Oahu. It is owned by the Honolulu Board of Water Supply (BWS) and is one of their key watersheds. Makaha valley has a diverse history of land management and some of the land use practices within the valley continue to have impacts on the forest community to this day (OANRP et al., 2010). Maintaining and improving the function of this watershed is of utmost importance for groundwater recharge and protected habitat of endangered native plants and animals (Townscape, 2009). Vegetation communities within Makaha valley have been described by Harmon (2006) and Suzuki (2006), who utilized fine resolution satellite imagery to document the highly invasive *P. cattleianum* throughout much of the valley. Native to Brazil, *P. cattleianum* was first introduced to Hawaii in 1825 and is now a dominant component of many Hawaiian

environments from sea level to 1300m (Smith, 1985; Takahashi et al., 2010). Remnant native forest tree species including *Metrosideros polymorpha*, *Acacia koa*, and *Diospyros sandwicensis* are found within a portion of the upper Makaha valley (Harman, 2006). The most intact native areas within the valley were fenced with the recent completion of two subunits. Subunit I is about 85 acres and subunit II is about 35 acres in size (see Figure 1). Ground vegetation monitoring in subunit II was conducted in 2014 with the use of belt transects and survey plots (Oahu Army Natural Resource Program status report, 2014).



**Figure 1.** Topographic map portraying the back of Makaha Valley with Subunit II and the Gigapan location on the Ka'ala road.

### Object Based Image Analysis

Traditionally, aerial photography has been used to obtain very fine (<1m) spatial resolution, however other platforms are becoming available (Bunting and Lucas, 2006). The

advancement of hyperspectral satellite sensors has lent the opportunity for many studies of digital image analysis. The pixel based image analysis was the accepted methodology since the launch of Landsat-1 in 1972 (Blaschke et al. 2014). However there are limitations to this pixel based approach. Blaschke et al. (2014) point out, that once the spatial resolution is finer than the object of interest, objects are made up of multiple pixels so focus should be on the patterns that are created. A per-pixel approach with new high resolution sensors may decrease the accuracy of within class spectral variability (Blaschke et al. 2014, Hay et. al. 1996). Research in the 2000s started developing object based image analysis focusing on the color, tone, texture, patterns, shape, shadow and context of groups of pixel objects; development of these techniques represents a new paradigm in image analysis (Blaschke et al. 2014).

There have been multiple challenges that researchers have faced when seeking to map tree crown and canopy cover or tree density, including the understanding gap dynamics, and/or discriminating and classifying species (Bunting and Lucas, 2006). Canopy reflectance can be influenced by shadowing between crowns, reflectance contributions from non-photosynthetic material (e.g., primary branches) in the crown and the underlying soils and vegetation, and variations within and between species and growth stages as a function of foliar biochemistry, moisture content, internal structure and age of leaves (Bunting and Lucas, 2006).

### Gigapan System

Little work has been done mapping vegetation with the Gigapan system. This project will represent the first attempt to couple the Gigapan system with a laser rangefinder GPS and run through object based classification vegetation analysis. The Gigapan robotic unit allows a user to capture very high resolution digital images (<1cm) with billions of pixels (gigapan.com, Sargent et al. 2010, Stock et al., 2010). The technology utilized by the Gigapan robotic unit was developed

by Carnegie Mellon for the Mars Rovers, Spirit and Opportunity to capture images of the red planet (gigapan.com). It is gaining use by researchers across many other fields of science to capture site information from geology to ecology to complement field work (Sargent R., Bartley C., Dille, P., Keller, J., Nourbakhsh, LeGrand, R., 2010). The TruePulse 360R is a laser rangefinder that can link to a GPS to obtain GPS offsets from up to 1,000m from its target location for non-reflective surfaces and 2,000m for reflective surfaces. The laser rangefinder will be mounted on the camera via the hotshoe and fired at each image location in the Gigapan mosaic allowing for georeferencing of the Gigapan mosaic.



**Figure 2.** The Gigapan Epic Pro, Canon 60D, and TruePulse 360R rangefinder setup used for image acquisition

## Methods

Imagery was obtained of Makaha Subunit II on April 5<sup>th</sup>, 2015, between 12 and 1p.m. from a turnout on the Federal Aviation access road leading up to the summit of Mount Ka'ala. The vantage point has an elevation of approximately 850 meters, (see Figure 1) and is located at the UTM coordinates 04Q0586840, 2379164. The exact setup location is marked with pink surveyors flagging to allow for return to the same location. The Gigapan Epic Pro was mounted on a sturdy tripod and levelled using the bubble level on the device. A Canon 60D and a Canon 300mm f2.8L lens with a Canon 2x extender were mounted to the Gigapan unit and zoomed to its full extent (see Fig. 2). A Truepulse 360R laser rangefinder GPS was mounted to the camera on the hotshoe attachment oriented at the center of the scene.

The camera was set to aperture priority, ISO400, F5.6 with a shutter speed of 1/800. Focus was made with autofocus at the center of the scene then the lens was switched to manual focus. The top left and bottom right corners of the panorama were selected. The Gigapan unit was initiated to take the images of the study area starting at the top left corner panning from top to bottom. Once the unit had taken the images in a certain column it moved up to the adjacent row with a 30% overlap in between images. The unit took approximately 40 minutes to complete the panorama image capture.

Image post processing was conducted with Adobe LightRoom 5.0. A 10% level increase was applied to contrast, vibrance, clarity, saturation, sharpening and noise reduction of each image. The gigapixel panorama of the study site was put together using GigaPan Stitch 2.3.0307. Visual classification of a subset of the image was undertaken to be used for the classification accuracy assessment using visual cues, such as canopy shape, canopy size, canopy color, texture, bark and stem color and relationship to other objects (Jensen, 2007) (See Table 1). The Gigapan image was

imported into ArcMap 10.1 and a subset of the panorama was selected and delineated by a polygon feature class. Ten vegetation species classes were identified by zooming and exploring the image and delineating polygon shapes, each with a separate feature class.

**Table 1.** Examples of visual cues used for visual classification of the imagery

	<b>Visual Attributes</b>					
<b><u>Species</u></b>	<b><u>Canopy shape</u></b>	<b><u>Canopy size</u></b>	<b><u>Canopy color</u></b>	<b><u>Canopy texture</u></b>	<b><u>Bark/ stem color</u></b>	<b><u>Relationship to other canopy objects</u></b>
Strawberry guava	Uniform relatively flat canopy surface	small	dark green	uniform texture	dark bark	Large monotypic stands
Ohia	irregular canopy with light dead branches	medium	dark green	irregular texture	grey bark with many dead branches	solitary well-spaced
Koa	Irregular canopy	large	light green	irregular texture	greyish white bark	solitary to clumped

An object based classification approach was applied to a subset of the imagery with eCognition Developer 9.0. The imagery was initially segmented at a relative scale of 120, shape 0.2 and compactness of 0.8 in order to create segments smaller than canopy objects. The image subset was then classified into a broad classification of two separate classes, Strawberry Guava and the other canopy components. This was achieved by applying various layer values from the Feature selection to the classification process tree. Levels were set for the Mean Brightness for

Layer 3 and Max diff. in addition to the Standard deviation level of Layers 1, 2, and 3. A nearest neighbor supervised classification was also run (see Fig. 6).

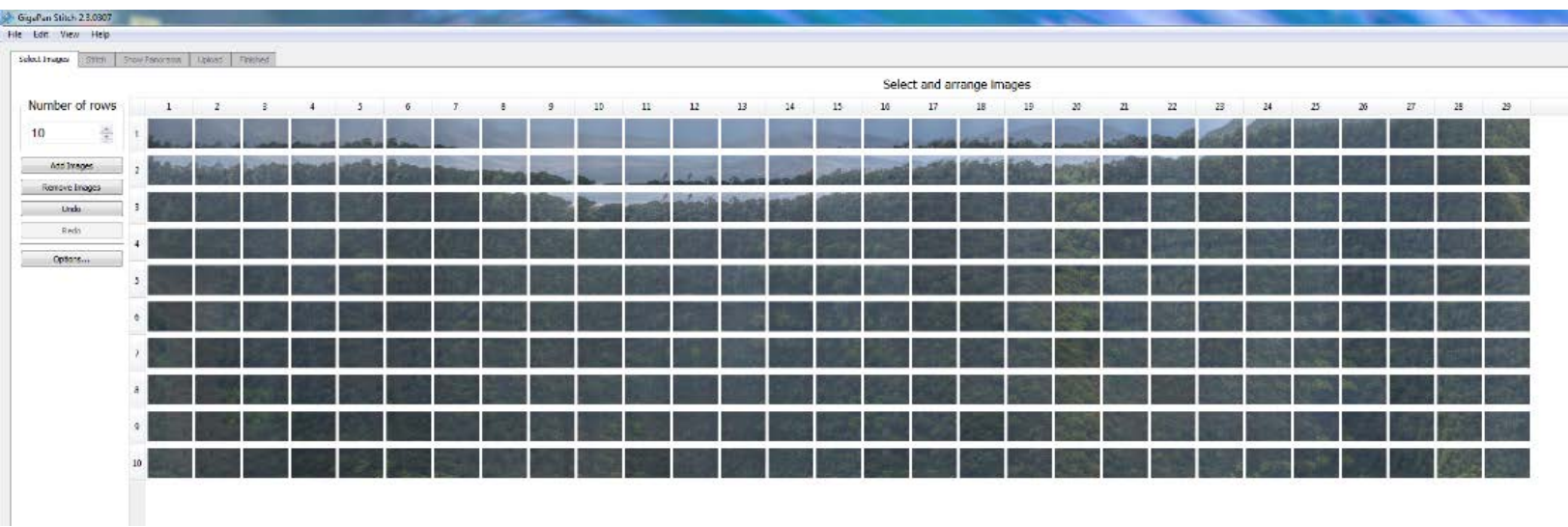
An accuracy assessment was conducted comparing the visually classified image with the object based classified image. This was executed by first exporting the classified eCognition data into jpg. format. A grid was laid over the image in Microsoft Powerpoint and 30 random points were generated with a random point generator tool. The points were plotted on the grid and inserted on the image (see Fig. 7). The two classified images were overlaid in Powerpoint and each random point was assessed to determine if the classification of Strawberry Guava was accurate by visual comparison.

## **Results**

The TruePulse 360R laser rangefinder would not pick up readings at the survey location of the study site. The Gigapan Epic Pro and digital single lens reflex camera captured a subset of the area of interest as a panoramic image stitched together from 290 images, resulting in a single file 2.1GB in size (See Figure 3 and Figure 4). The distance from the vantage point to the center of Subunit II was measured using the ArcMap 10.1 measuring tool and determined to be approximately 1100m. The resulting gigapixel image had a spatial resolution of 0.8cm. This was determined using the following formula:

$$GSD = \text{distance} / \text{focal length} \times \text{CCD pixel size}$$

Where GSD is the ground surface distance, the distance is measured from the camera to the survey location, the focal length is the length of the lens and **CCD** pixel size is the size of the camera sensor.



**Figure 3.** Individual 290 images prior to the stitching process

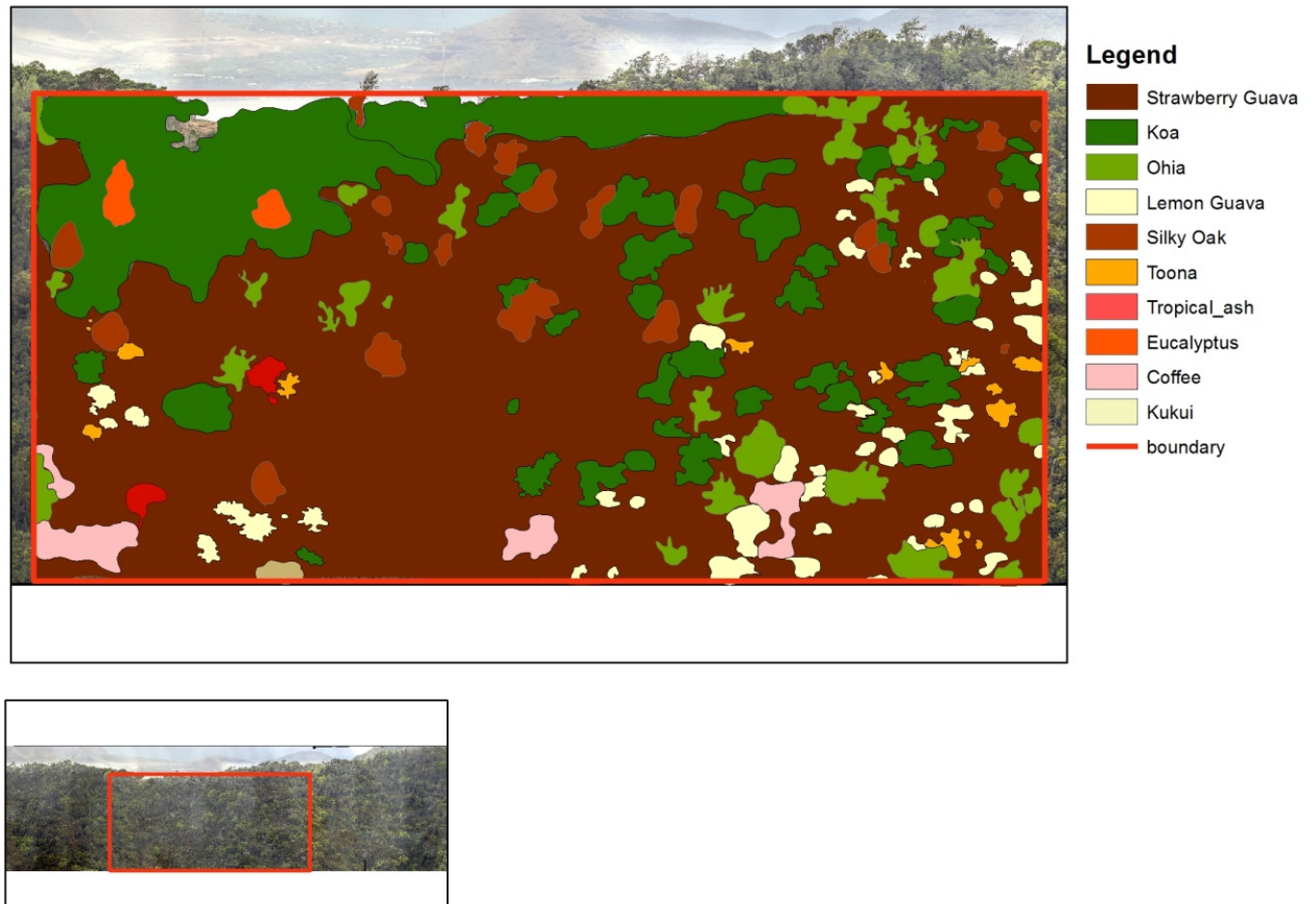


**Figure 4.** Gigapixel Gigapan mosaic of stitched images of the study site.



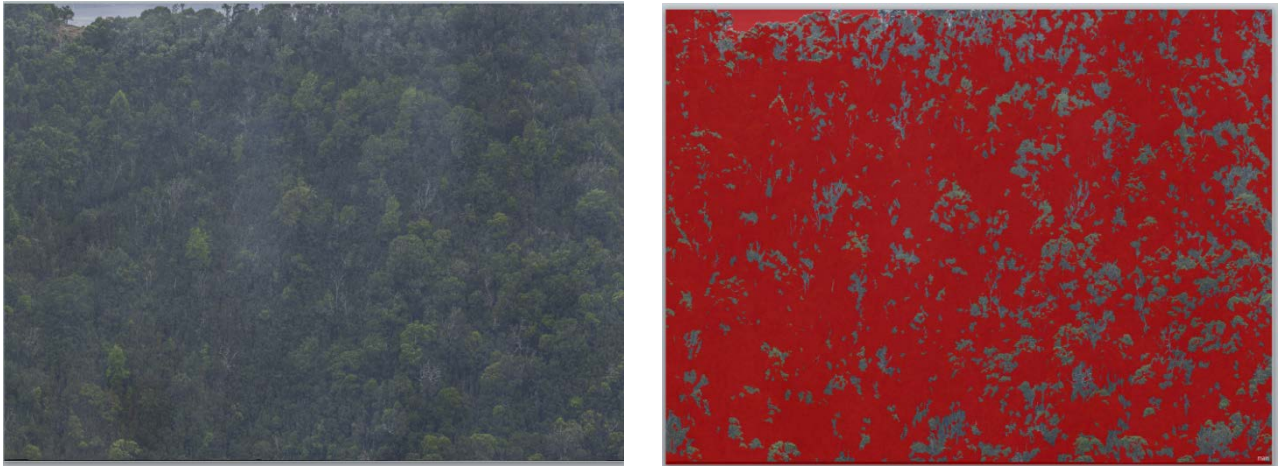
Visual classification of a subset of the target imagery was achieved for 10 canopy species due to the very high spatial resolution of the imagery. In order of abundance these included: Strawberry Guava, Koa, Ohia, Lemon Guava, Silky Oak, Toona, Tropical Ash, Eucalyptus, Coffee and Kukui (See Fig. 5).

#### Upper Makaha Kumaipo Ridge Visual Vegetation Classification

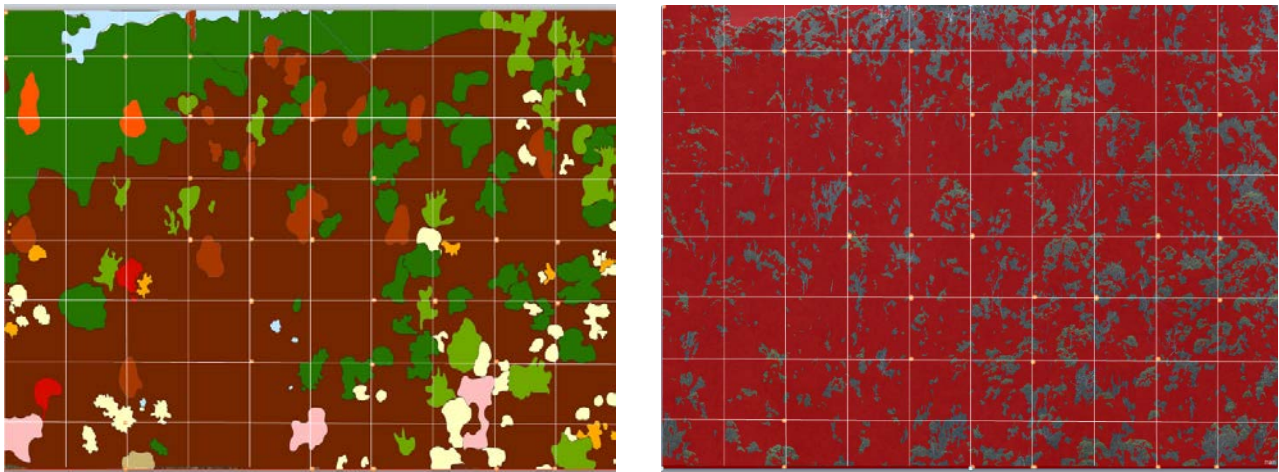


**Figure 5.** The classification of 10 species by visual classification in ArcMap 10.1

Object based classification of a subset of the scene yielded the image as seen in Fig. 7. The classification of Strawberry Guava is displayed in red and the other opaque polygons classified as not Strawberry Guava.



**Figure 6.** The subset image selected from the panorama for object based classification and the result of the supervised classification process to classify Strawberry Guava in eCognition with Guava as the red color.



**Figure 7.** Grid overlay and random points used for the accuracy assessment of the image set

The overall user's accuracy was determined to be 47% accurate for classifying Strawberry Guava with object based classification. Visual classification was assumed to be 100% accurate.

**Table 2.** The accuracy matrix of assessment results.

	Producer (Visual)					
	Class	Psicat	Other	Total	%	
User (eCognition)	Psicat	8	5	13	43%	
	Other	11	6	17	57%	
	Total	19	11	30		
	%	63%	37%		47%	

## Discussion

The TruePulse 360R laser rangefinder was meant to enable georeferenced points for the center of the images taken during the panorama, however the distance was greater than the 1,000m range and would not register at the survey location. It may have been even greater than the estimated 1,100m determined with the ArcMap measuring tool due to a difference in elevation from the vantage point to the study location. This tool may serve to be a very useful compliment to the Gigapan system under 1,000m but needs further testing. The ability to have georeferenced points for each image in the mosaic would be a great benefit to assist in incipient species location for management as a process to orthorectify this type of very high oblique imagery has yet to be determined.

Initially, the goal was to capture the entire subunit II in a mosaic of images to be created into a gigapixel panorama. However a subset of the unit was chosen to create a manageable dataset. This served to be an effective and efficient method that allowed for a workable dataset.

The low accuracy of the object based classification method may be attributed to a host of factors with the first being the nature of the image incident view angle. It is a very high oblique and the image may be subject to substantial shadowing that complicates the classification process. The high resolution is a benefit for visual classification and serves to be useful during the object based process, however this is a result of the combination of hundreds of images that may take a while to capture. In this case it took nearly 40 minutes to cover just half of the scene of upper Makaha Valley. The cloud cover was relatively uniform which was beneficial however the light levels did fluctuate during the data collection and the scene was brighter as the sun emerged from behind the clouds. This complicated and led to errors in classification as much of the preliminary segmentation was based on reflectance values. The file size is also effectively quite large as a gigapixel file making for time consuming post processing.

Perhaps the greatest drawback to Gigapan imagery and the specific equipment used for this study was the limiting factor of only three available bands, RGB. The lack of a fourth NIR band was a hindrance in the object based classification process as several of the classification algorithm rely on this NIR band to run a NDVI vegetation index sequence. eCognition offers manual classification techniques that allows for a higher classification accuracy but this lends to the question, at what point is it simply more effective to conduct visual classification?

Visual classification of the Gigapan image served to be very effective even to the incipient invasive species level. The very high spatial resolution and this researcher's familiarity with the region and its associated species helped to facilitate this. There were two tropical ash trees that

were easily identified within the scene and have high potential to spread throughout the area, potentially causing further detriment to the Makaha watershed. This highlights perhaps the greatest utility of the Gigapan system with vegetation mapping and monitoring for managers to detect incipient invasive species in target areas and visually track landscape changes over time. It has strong potential as a watershed management tool but classification may serve to be limited to visual analysis. The Gigapan system will serve to be a very useful tool if images can be georeferenced with the TruePulse system incorporated with a Trimble GPS unit to assist in ground location of these problematic incipient invasives. The assumption that the visual classification of the imagery was 100% needs to be made clear and may not be 100% accurate. An assessment of this accuracy needs to be conducted with the incorporation of a compliment of ground control plots.

## **Conclusion**

Object based classification and high oblique Gigapan imagery may not be an optimal pairing as displayed by the low accuracy (47%) to map the simple classification of Strawberry Guava in upper Makaha Valley, Oahu. Visual Classification may serve to be more reliable to the trained observer but this is not quantifiable without ground control points. Gigapan may not be a suitable tool for quantitative mapping but has potential for monitoring change and has high potential to assist in incipient invasive species detection. A methodology for locating specific points in the image on the ground needs to be developed.

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## **APPENDIX ES-5: HYLAEUS ANTHRACINUS REINTRODUCTION**

### **ES-5.1 BACKGROUND**

*Hylaeus anthracinus* is an endemic bee, one of 63 known bee species native to Hawaii. It is found on all islands from Oahu to Hawaii, though there are no recent collections from Lanai and it may be extirpated there (Daly and Magnacca, 2003). The island populations segregate into three strongly divergent genetic clusters (Hawaii, Maui + Kahoolawe, and Molokai + Oahu) that may represent cryptic species (Magnacca and Brown, 2010). It is a candidate for listing as endangered, and will likely be proposed for listing soon (U.S. Fish and Wildlife Service, 2011).

*Hylaeus anthracinus* occurs primarily in the coastal zone. Like other coastal species, it extends into lowland dry forest and rarely montane dry forest. Historically, *H. anthracinus* was widespread along most of the leeward and dry coasts of the islands it inhabits. Between 1930 (when collections of *Hylaeus* largely ended) and the 1990s, the distribution of coastal *Hylaeus* species contracted dramatically (Magnacca, 2007a). On Oahu, Molokai, and Maui, *H. anthracinus* is found in only a few locations. On Oahu, it has been found at a few widely scattered sites, including Ka Iwi in the southeast, Malaekahana and Kahuku in the northeast, and Kaena and Dillingham Military Reservation in the northwest. On Hawaii, it still occurs in several long strips of coastline in South Kohala and North Kona. These populations may reach extremely high densities, but are still restricted to a narrow strip of vegetation consisting of mixed native species and tree heliotrope (*Heliotropium foertherianum*=*Tournefortia argentea*), typically less than 20 m wide, between the ocean and kiawe scrub or fountain grass inland. Elsewhere on the island, only a single very small and vulnerable population is known, at Ka Lae (South Point). There is one record from Pohakuloa Training Area in 2004, but it is a male (Magnacca, 2007b), and it is uncertain if a breeding population exists there or if it may have been a vagrant from the coast.

Several *Hylaeus* species may soon be under management by OANRP, and new techniques will be required for them. The combination of overall rarity and high population density at certain sites makes *H. anthracinus* an ideal species for studying practical conservation techniques. Often 100-300 bees or more may be found flying around a single heliotrope tree in South Kohala, the highest density of any native bee species. This allows for collection of relatively large numbers of individuals without negatively impacting the source population. For this project, we tested the ability to establish new populations of *H. anthracinus* at suitable sites using simple translocation. Establishment of new populations is highly desirable because despite their large numbers of individuals, all existing ones are within a relatively small area and occupy a narrow strip of coastal strand. Stochastic events such as tsunami, fire, or even landscaping changes by shoreline landowners could devastate the populations quickly. The destination site selected was Puuhonua O Honaunau National Historic Park (PUHO), close to historic collection records of *H. anthracinus* at Kealakekua Bay. Although established and primarily managed for its cultural value, the park contains significant areas of native coastal vegetation including a restoration site at Alahaka Bay. In addition, the range of habitat quality available allows for testing of suitability.

### **ES-5.2 METHODS**

The translocation was conducted in January 2015. *Hylaeus anthracinus* were collected from *Heliotropium foertherianum* trees at Puako and Waikoloa (approximately 110 and 150 respectively). Those at Waikoloa in particular were heavily male-biased, and extensive catches were made in order to achieve at least a 60-40 male-female ratio among the translocated bees. *Hylaeus* were held in plastic snap-cap vials (approximately 30-50 individuals each) in a cooler bag with ice, and driven to PUHO. Alien bees (mainly *Ceratina* spp. and *Lasioglossum* spp.) were excluded from the catch in the net, and any accidentally included were killed while cooled. Transit time was about 1.5 hours.



Table 1. Release site characteristics.

Site	Alahaka Bay	coastal trail	royal grounds
No. <i>Hylaeus</i> Released	100	85	50
Ant Species	<i>Ochetellus glaber</i> <i>Tetramorium insolens</i> <i>Tapinoma melanocephalum</i>	<i>Pheidole megacephala</i>	<i>Pheidole megacephala</i>
Plant Species	<i>Heliotropium foertherianum</i> <i>Scaevola taccada</i> <i>Waltheria indica</i> <i>Sesbania tomentosa</i> <i>Jacquemontia ovalifolia</i> <i>Sida fallax</i> <i>Cordia subcordata</i>	<i>Scaevola taccada</i> <i>Waltheria indica</i> <i>Sesbania tomentosa</i> <i>Myoporum sandwicense</i> <i>Cordia subcordata</i>	<i>Scaevola taccada</i> <i>Waltheria indica</i> <i>Morinda citrifolia</i>

*Map removed to protect rare resources. Available upon request*

Figure 1. Left: source sites in South Kohala. Right: release sites at Puuhonua O Honaunau NHP in South Kona.

Bees were released at three sites at PUHO. These differed in habitat quality; all three are dominated by native plants, but diversity varies widely. In addition, the important introduced floral host *Heliotropium foertherianum* occurs only at the most diverse site. The sites also varied in the ants present (sampled using corn syrup and salmon cat food baits left out for 1 hour, 10 at each site) – two had *Pheidole megacephala*, while the third had three species, all of which are considered much less serious threats to native arthropods. Details of the three sites are shown in Table 1. Releases were conducted by simply opening vials and allowing the bees to walk or fly off as they warmed up. Total time from the beginning of collections to the final release was 4.5 hours (10:30 AM – 3:00 PM). The sites were monitored every three months for establishment and abundance. At the coastal trail and royal grounds sites, no bees were seen at the first monitoring period in April, so a second release of 50 bees at each site was conducted then.

### ES-5.3 RESULTS

The sites were monitored for establishment success in April and July 2015. The weather in April became overcast shortly after arriving and was therefore not conducive to comprehensive monitoring. At least five *H. anthracinus* (three male and two female) were observed on *Scaevola* and *Heliotropium* at Alahaka Bay before clouds moved in, but none were seen at the other two sites. During the second release at the royal grounds site, *Pheidole* were observed attacking cold-stunned bees en masse within seconds of them being placed on the ground (Figure 2D). Bees were unable to fend off ants or fly away even after warming up, although they appeared to be unharmed when the ants were removed after being observed for about 10 minutes.

Conditions were better for observation in July, and *H. anthracinus* were seen on *Scaevola*, *Sida* and *Heliotropium* at Alahaka Bay (Figure 2A, B). The last had large numbers (five-minute count: 152), while the others have only a few individuals visiting flowers. Nesting was also observed in coral rock, indicating that the population is established and reproducing (Figure 2C). No bees were seen at the other two sites, but they were found about 150 m north of the Alahaka Bay release site, indicating that they are spreading on their own.

## ES-5.4 CONCLUSIONS

*Hylaeus anthracinus* is successfully established at PUHO following a single introduction at Alahaka Bay. This is the first time the species has been present in South Kona in about 80 years. A major high surf and high tide event occurred two weeks after the first release, flooding the release sites with several feet of water and causing serious damage to the park. Nevertheless, while this may have affected early nest success, it clearly did not prevent establishment at Alahaka Bay. The primary limiting factor on their distribution in this area appears to be ants – while the middle side (coastal trail) has good quality floral resources, it also has *Pheidole* present. The presence of tree heliotrope (*Heliotropium foertherianum*) may be an important secondary factor. The two cannot be definitively separated, since the current range of *H. anthracinus* extends to the northernmost heliotrope which is close to the southern end of the *Pheidole* population. Nevertheless, it is clear that *Pheidole* excludes bees entirely, and *Heliotropium* is the floral host that supports by far the largest number of *Hylaeus*.

While introduced small carpenter bees, *Ceratina smaragdula* and *C. dentipes*, are present at PUHO, they are not particularly abundant. As at the larger populations in North Kona and South Kohala, *H. anthracinus* appears capable of successfully competing against them in the absence of ants or other aggravating factors. The alien *Hylaeus* recently introduced to Oahu and Kauai, *H. strenuus*, may be another matter; it is nearly identical in size and habit to *H. anthracinus*, which has declined dramatically on Oahu since it became widespread there. Prevention of its spread to Hawaii is therefore of critical importance.

## ES-5.5 REFERENCES

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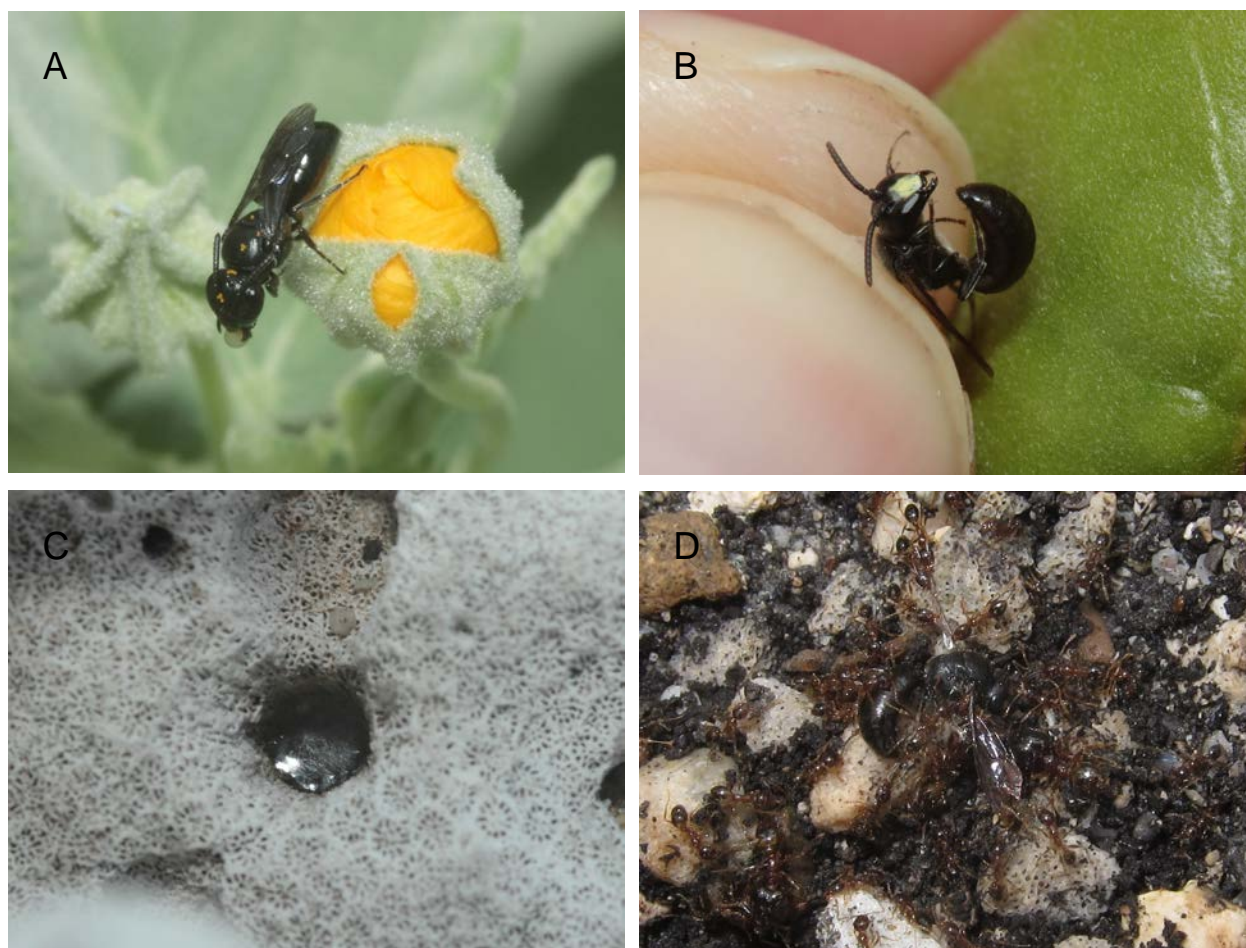


Figure 2. *Hylaeus anthracinus* at Puuhonua O Honaunau NHP. (A) female on *Sida*, concentrating a drop of nectar. (B) Male caught flying around *Scaevola*. (C) Nest entrance in coral rock sealed with cellophane-like secretion. (D) Attacked by *Pheidole megacephala* at the royal grounds site.

## **APPENDIX ES-6: MEGALAGRION XANTHOMELAS CONSERVATION**

### **ES-6.1 BACKGROUND**

*Megalagrion xanthomelas* (Fig. 1) is one of 25 damselflies endemic to the Hawaiian Islands, all derived from a single radiation. Known as the orangeblack Hawaiian damselfly, it breeds in a wide variety of lentic aquatic habitats, including basal spring wetlands, brackish anchialine ponds, slow-moving streams, and various types of ponds, including taro loi and other artificial water bodies. Once widespread in the lowlands of all the main islands except Kauai, it has declined severely as wetlands have been disrupted and particularly due to the introduction of mosquitofish and other alien predatory fish. It was designated as a candidate for listing as endangered in 1994; it has not yet been listed, but is expected to be formally proposed soon. Five other *Megalagrion* damselflies are currently listed as endangered, including three endemic to Oahu.

Although it occurs widely in scattered locations on Hawaii, *M. xanthomelas* was thought to be extirpated from Oahu until 1995. At that time, it was rediscovered on the grounds of Tripler Army Medical Center (TAMC) in a spring-fed stream that flowed permanently but only for a short distance, preventing fish from lower elevations from reaching it. The natural stream flow was later disrupted by construction at TAMC, and the population is now maintained as an artificial “stream” from a hose that is always kept on. The population has been monitored monthly by OANRP staff since October 2013; previously it was monitored weekly or biweekly from 2012-2013, and periodically prior to that, by Bishop Museum personnel under contract. During this time the population has stayed relatively stable, though the number observed fluctuates widely between visits (Fig. 2).

They have survived in this situation for nearly 20 years, but since this is the only remaining Oahu population, it has long been considered a priority to establish at least one additional population elsewhere,



Figure 1. Male *Megalagrion xanthomelas*, the orangeblack Hawaiian damselfly, at Tripler Army Medical Center.

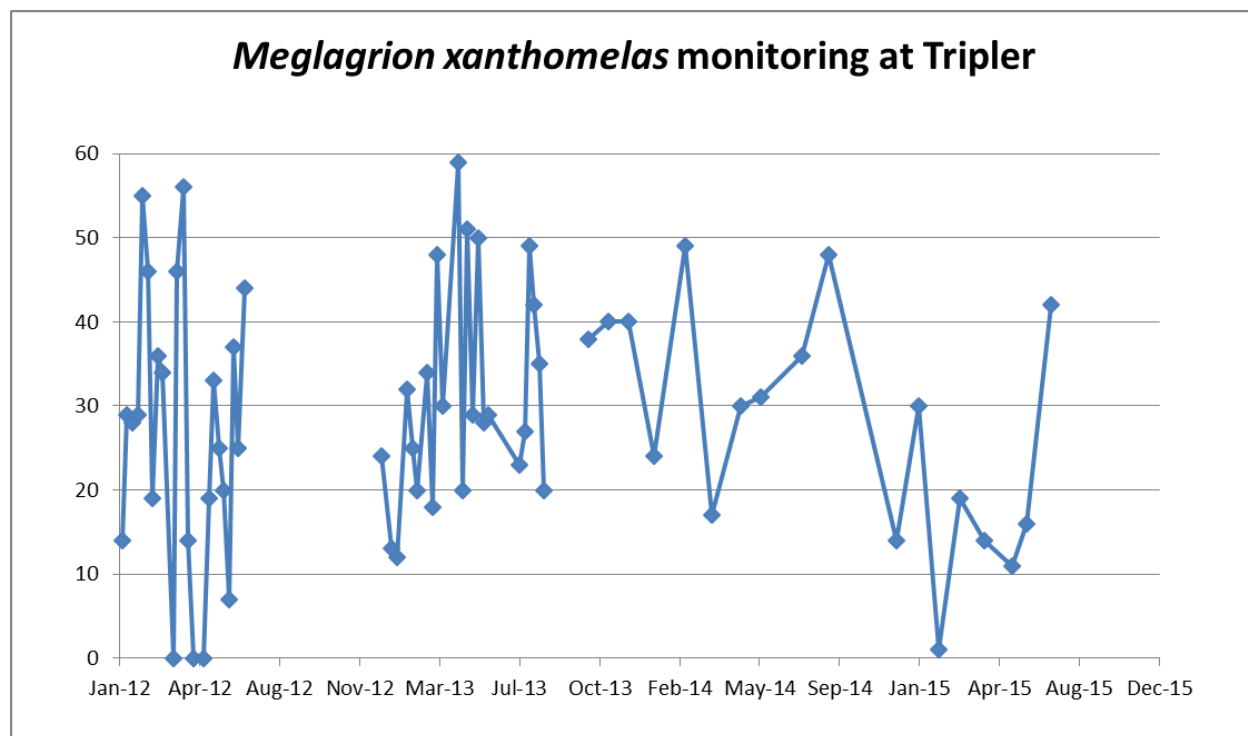


Figure 2. *Megalagrion xanthomelas* observations at TAMC over time.

particularly in a more natural area managed for conservation. Translocations were attempted at Dillingham Military Reservation (1998), Makiki Stream (2003), Kalaeloa (2010), and Waimea Botanical Garden (2012), but all have failed so far for various reasons. All these sites are currently considered not suitable for long-term habitation by *M. xanthomelas* due to the presence of predators or degradation of the aquatic habitat. Therefore, we are still looking for a good reintroduction site.

To this end, several potential reintroduction sites were visited by a group consisting of representatives from OANRP, DOFAW, USFWS, Honolulu Board of Water Supply, and the Bishop Museum. Sites were selected based on the collected knowledge of the group members and assessed for appropriateness of various characteristics, including water flow and depth, shade cover, lowest permanent reach, proximity to other water bodies, aquatic vegetation, abundance of potential prey items, and presence of alien aquatic predators. Land ownership and public accessibility were also secondary factors.

## ES-6.2 RESULTS

Nine potential release sites were visited in Nov.–Dec. 2014 and Feb. 2015. A brief summary of the results are in Table 1. The two windward Koolau sites were both permanent streams extending to the ocean, close to other water bodies, contained bullfrogs and mosquitofish (at least in the lower reaches), and are subject to frequent high-flow events during periods of high rainfall (one of which occurred during a visit). It is likely that all windward sites are similar, and thus no others were considered in this area. Still, some sites with isolated water features or slow side pools similar to the Onomea Bay streams of Hawaii may yet be found.

The remaining sites were in the Waianae range. The previous reintroduction site above Dillingham airfield was revisited, as it had been considered to be one of the best locations. However, it was found to have significantly degraded over the past several years. Previously the presence of introduced crayfish and dense vegetation were thought to have been factors in the failure of *M. xanthomelas* to establish; now

*Map removed to protect rare resources. Available upon request*

Figure 3. Potential reintroduction sites for *Megalagrion xanthomelas* in the Waianae (left) and Koolau (right) ranges visited during the current survey year.

Table 1. Site characteristics.

Site	Water Type	Predators	Habitat
Waihee	permanent flowing stream	bullfrogs, fish	heavily shaded, subject to frequent flash flooding
Ahuimanu	permanent flowing stream	bullfrogs, fish	heavily shaded, subject to frequent flash flooding
Punanaula	spring-fed slow stream	wrinkled frogs	small, narrow stream, confined by guinea grass; may be restored for taro production
Honua	permanent flowing stream	none observed	stream is relatively fast-flowing
Makaha - Glover	permanent flowing stream	bullfrogs?	may be restored for taro production
Makaha stream	intermittent with perm. pools	bullfrogs	
Kapuna seep	spring-fed slow stream	bullfrogs	<i>M. hawaiiense</i> present at seep, stream below very small
Kapuna stream	intermittent with perm. pools	bullfrogs	shady, moderately deep gulch
Dillingham	spring-fed slow stream	none	highly degraded, stream channel disrupted by pig digging

extensive pig digging has levelled the stream channel into a flat, muddy bed, and no aquatic animals and little vegetation are present.

Two sites were visited in Makaha Valley, in the upper valley above the bend and lower at Glover tunnel. The former had bullfrog tadpoles present and the streambed appeared relatively bare, suggesting few food resources. The latter appeared more suitable but is slated to be restored to taro production, and likely contains bullfrogs if the upper area does.



Figure 4. Drainage ditch around the Tripler heating/cooling plant, inhabited by *M. xanthomelas*.

Punanaula spring on the west side of Waianae Valley produces a small permanent stream that flows for a relatively short distance, and has only small wrinkled frogs present.

However, it too is likely to be restored to taro production, and the area of available habitat is extremely small. Honua Stream on the east side is much larger but flows through a steep area, resulting in a high flow rate. While no predators were observed, it appears to flow continuously to low elevations so frogs may be present.

At Kapuna Gulch in Pahole NAR, a seep feeds a small permanent stream that flows for a short distance above Mokuleia Trail. *Megalagrion hawaiiense* is found breeding at the seep itself, but bullfrog tadpoles were found in the stream pools below. Further down the gulch, the stream is intermittent but groundwater keeps at least some pools permanent, and bullfrogs were again present.

### ES-6.3 CONCLUSIONS

All of the sites found so far were not high quality habitat for reintroduction of *M. xanthomelas*. Most had bullfrog tadpoles present, which are known to be predators of naiads though it is uncertain if they completely exclude *Megalagrion*, as they apparently formerly occurred at Tripler. The best site in terms of physical and biological environment was Punanaula, but the available area was very small and reservation of the site for agricultural use will likely result in increased disturbance. There may be additional sites available in Waianae Valley, including in the branches of Honua and Hiu streams, that have not yet been investigated. Portions of these are diverted for human use, but excess flow or even leakage from water pipes may provide sufficient habitat for damselflies. Historically it was recorded breeding in sugar plantation reservoirs in Waianae.

The ideal site, where predators are not present or could be eliminated, would be something similar to the pre-disturbance state of the Tripler stream – a spring-fed stream that originates in a relatively dry lowland area, flows a relatively short distance, and then usually dries up before connecting to any permanent water

body. It would be extremely surprising if there were no other examples on Oahu, but we have been unable to find any. This may be due in part to the long history of hydrological alteration, including stream diversion and tunnel boring that has lowered perched aquifers.

The recent discovery of *M. xanthomelas* breeding in a drainage ditch around a building at TAMC (Fig. 4) suggests that another solution may be to establish populations in relatively small, artificial sites. This was previously done at TAMC during construction, and the damselflies have essentially already done this themselves on other islands. On Lanai, there were no historic records of *M. xanthomelas*, but they were discovered on the island in 1993 breeding in golf course water traps and a leaking water pipe. Given its known adaptability – *M. xanthomelas* was described as being “a common insect in Honolulu gardens” and “very numerous under conditions changed from the natural” by Perkins in 1913, prior to the introduction of most alien aquatic predators – “restoring” it to formerly abundant artificial habitats may be the best option for increasing the population.





UNIVERSITY  
of HAWAI'I  
MĀNOA

**Hawaiian Tree Snail Conservation Laboratory  
Pacific Biosciences Research Center**

*PI: Brenden Holland  
Annual Report – October 2015*

**TREE SNAIL PROPAGATION SUMMARY**

The UH Tree Snail Conservation Lab currently houses and cares for about 400 snails in 10 endemic Hawaiian achatinelline species, all of which are listed as federally endangered. The tree snails are housed in 28 cages of three different sizes, maintained in environmental chambers. Conditions in chambers are intended to mimic natural conditions of mid-elevation Hawaiian rain forest. Chambers have temperature and light control, on a 12 hour cycle. Temperatures are held at 20 or 21°C for during daylight, and 16°C or 17 during the night. Sprinkler timers are set to water cages each 8 hours, 6 days per week. There has historically been a one day no water period, again to mimic natural conditions.

Tasks for lab personnel include weekly scheduled cage changes, removal of old leaves and branches and replacing with fresh leaves of native tree and plant species. We also count births, measure newborn snails and remove, measure and preserve any dead individuals, and note percent cultured fungus consumed.

Following removal of old leaves, cages are cleaned with hot water and detergent, sterilized with ethanol, air-dried, and snails are replaced along with fresh foliage. Members of our group hike Oahu trails weekly to collect fresh leaves, providing food for the snails in the form of surface growing arboreal fungus from leaves and tree bark.

In addition culture medium is autoclaved weekly, and 45 plates are poured and inoculated with lab stock fungus. Cultured fungus has been used as a dietary supplement in the lab for a number of years.

**Table A.** Population status summary for the Waianae species, *Achatinella mustelina* from most recent cycle (period ending July 1, 2015).

Population source	# of snails	Juvenile	Subadult	Adult
Peacock Flats	3	1	2	0
Bornhorst	1	0	1	0
Ekahanui Honouliuli	11	11	0	0
Palikea Gulch	2	0	0	2
Makaha	1	1	0	0
Schofield West	7	6	1	0
Makaleha	11	9	1	1
Totals	36	28	5	3

**Table B.** Population status summary for the Koolau species, *Achatinella lila* from most recent cycle (period ending July 1, 2015).

Species	Cage	Births	Deaths	# of snails	Juvenile	Subadult	Adult
<i>A. lila</i>	Pop 1	1	0	25	9	11	5
	Pop 2	1	0	38	16	16	6
	Pop 3	0	0	35	20	5	10
	Pop 4	0	0	33	20	6	7
	Pop 5	3	2	35	22	5	8
	Pop 6	0	0	25	14	5	6
	Pop 7	0	1	15	12	0	3
	Pop 8	2	0	21	14	3	4
Totals		7	3	227	127	51	49

There is a long-standing plan to release a subsample of the total 227 *Achatinella lila* currently housed in the lab, into a recently constructed predator exclusion fence in the central Koolau Mountains at a site called Poamoho. This translocation effort has been delayed due first to climatic conditions leading to complete destruction, due to high wind velocity, of the first steel walled structure. The structure was then completely redesigned

and replaced with a wooden version by OANRP staff. Currently the fence structure itself is intake and completed, but the persistence of predatory rodents (rats) in the interior, and uncertainty as to whether rats are able to gain access from outside of the fence has delayed this action.

### **Chamber temperature calibrations**

During this period we tested all internal chamber temperatures using Hobo data-loggers and analog thermometers. We found that three of the chambers were operating a few degrees (average 2.3° C) below the control panel settings. Therefore we have adjusted panel setting to maintain internal temperatures within day/night target ranges. It is our hope that keeping more precise chamber temperatures might help stabilize reproductive rates and survival for captive species.



**Figure A.** Electronic and analog means to monitor temperatures in environmental chambers.

### **New Tree Snail Population Data Entry System**

Together with SEPP staff, USFWS, and intern Ryan Pe'a, we have implemented a new data entry system. The new system uses a Weekly Master Update, and will improve data recording consistency, legibility, ability to share, and will be contiguous.

### **HAWAIIAN SNAIL PREDATOR STUDIES**

This section of the draft report includes summaries of ongoing and recently completed efforts aimed at obtaining management relevant biological data during this funding cycle. The projects summarized share the objective of understanding and ultimately controlling invasive predators that are known or suspected to impact endangered species on Army lands, including two projects (sections **D & E**) that were recently submitted for peer-reviewed publication.

Recent OANRP-funded studies conducted in our lab over the past few years have resulted a number of scientific publications concerning:

- 1.) The first detection of impacts on endemic fauna, including the Oahu tree snail *Achatinella mustelina* (Holland, Costello & Montgomery 2010).
- 2.) Impact projections, estimates and overall threat assessment via gut content analyses and ingestion frequency (Chiaverano & Holland 2014).
- 3.) We have characterized movement behavior and establishment of home range in various forest habitats (Chiaverano, Wright & Holland 2014) using radio-transmitter tracking studies in the field.
- 4.) We discovered consistent, statistically significant differences in head morphology (size) and invertebrate prey utilization among different Hawaiian islands correlated with differences in bite force due to diet differences and rainfall (Van Kleeck, Chiaverano & Holland in press, summarized below).

For the predatory invasive wrinkled frog, we have submitted our findings for publication (summarized in section **D** below).

**A) Chameleon dissection results:**

We euthanized and dissected 21 adult field collected Jackson's chameleons during this period, all cleared from the Puu Hapapa site, outside of the snail enclosure in the native forest. The most significant result was one large male was found to have consumed 16 native helicarionid snails, all present in its gut, of various sizes, presumably all were the same species *Philonesia harmanni*. Jackson's chameleons continue to pose an immediate threat to the persistence of native Hawaiian invertebrates on Army managed lands. No additional *A. mustelina* have been observed in chameleon stomachs.

**B) Jackson's Chameleon control feasibility trial based on comparison to Brown Tree Snake management on Guam**

Ecosystem damage by the introduction of the Brown Tree Snake (BTS) (*Boiga irregularis*) in the 1950's on the island of Guam (US Territory) has resulted in the devastation of the island wildlife, particularly the native and naturalized avifauna. In fact 11 of the 18 native birds have been extirpated and all of the remaining taxa severely depleted (by over 90%), and 12 resident species have been extirpated. Following introduction of very few specimens (1998) the BTS spread rapidly, within a few years reaching densities of 12,000 per square mile, resulting in thousands of hospitalizations due to bites in the past two decades, and regular, electrical outages caused by BTS (about 1.5 hrs every other day) (Burnett et al 2008). Several decades and millions of dollars have been invested in attempted control, and have proven largely unsuccessful. Targeted management efforts to date have mainly consisted of baited minnow traps that use live mice, and are placed along residential fence lines and around utilities and power generating stations. There has been a concerted effort both on Guam and at Honolulu International Airport, to prevent transfer of this devastating invasive reptile to the Hawaiian Islands.

Although Hawaii has no invasive snakes, at the present time, there are 26 established predatory invasive reptiles and amphibians in the islands. The Jackson's chameleon

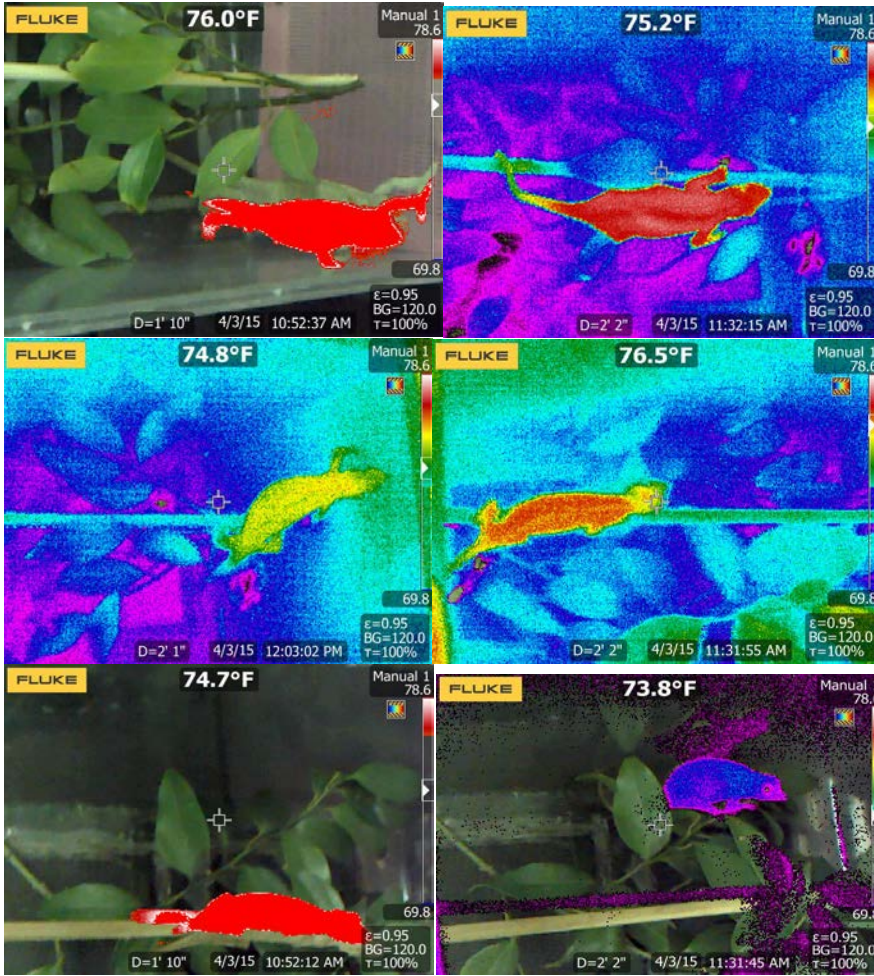
(*Trioceros jacksoni xantholophus*) is the most ecologically damaging species of invasive herpetofauna in Hawaii, for which the threat and impact has been characterized to date. Relative to the density recorded for BTS, of 12,000 snakes per mi<sup>2</sup>, Jackson's chameleons have been observed at a density of six times this, or 72,000 per mi<sup>2</sup> (45 per 0.4 acres = 72,000 per mi<sup>2</sup>). Our concern is that predatory activity of Jackson's chameleons on Oahu could cause the extinction of tree snails in areas where the species overlap in habitat, as has occurred on Guam with the invasive BTS and native birds. In a sense, the Jackson's chameleon could be considered Hawaii's BTS, and it warrants immediate control efforts.

Recent innovative field trials on the island of Guam, aimed at control of BTS conducted by the USGS and USDA, appear to be having the desired impact, namely a reduction of the population density of snakes. In this trial the commercially available analgesic Tylenol®, or generic name acetaminophen, is delivered via placement in the esophagus of a dead mouse, at a dosage of 80 mg/kg. This dose has been tested in the laboratory and shown to be lethal to all size classes, even the largest adult snakes, with little or no secondary or non-target impacts. We are interested in investigating the possibility of adopting this strategy for Jackson's chameleons in Hawaii. We have recently received IACUC protocol approval to test acetaminophen on chameleons in the laboratory.

Once approval was received for lab testing, we started trials immediately, and preliminary results are definitive: this product is toxic to Jackson's chameleons at same dosage as used for BTS in Guam (80 mg acetaminophen/kg body weight). We will continue to test the same dosages per body weight as were done with BTS lab trials. Once lethal dose for chameleons is optimized we have various ideas in terms of how to deploy the pill fragments in the field, which will also be evaluated in the laboratory setting prior to scaling up for field trials. However this work will require a small amount of funding plus permits. Part of the regulatory requirement to field deployment of acetaminophen addition to IACUC protocol approval, will be meeting the EPA labeling regulations, since acetaminophen is not labeled as a reptile control product.

### **C) Improving Chameleon Detection Methods**

There is a need to devise an improved method of field detection of Jackson's chameleons in the field. In collaboration with HECO we have been experimenting with a thermal imaging device, called a Fluke, which is the property of HECO, and we are working with their Environmental staff. We have tried this equipment in the lab and in the field and are continuing to investigate whether this technology imparts a detection advantage when searching for chameleons in the forest canopy by eye. Thus far this technology seems to hold some promise under certain environmental conditions. Trials will continue (Figure C-1).



**Figure C-1.** Thermal images recorded with Fluke technology in the laboratory, when chameleon body temperature differs even by less than one degree from ambient or background temp, this technology is a substantial help in detecting chameleons in the tree. The question we now have is, how frequently does this situation occur, where chameleon and background differ. Device was provided and tested courtesy of HECO Environmental office. Trials are ongoing.



**D) Prey-associated head-size variation in an invasive lizard (*Trioceros jacksoni xantholophus*) in the Hawaiian Islands**

(this study was conducted during the funding period, and has been accepted for publication in the *Biological Journal of the Linnean Society*, the following is a summary, OANRP support was acknowledged)

Biological invasions are recognized as a primary driver of large-scale changes in global ecosystems. This study addresses ecomorphological variation in head size within and among populations of an ecologically destructive invasive predator, and evaluates the potential roles of environmental components in phenotypic differentiation. We used four size-corrected measurements of head morphology in Jackson's chameleons (*Trioceros jacksonii xantholophus*) ( $n=319$ ) collected from three Hawaiian Islands to assess phenotypic variation among and within islands. Head size (PC1) was compared among islands using ANOVA, and its association with factors such as rainfall and exploited prey hardness was assessed by Pearson correlation analysis and Mann-Whitney U-tests. Differences in prey exploitation among islands were tested using Chi-square analysis, revealing head size differences among islands (mean difference >5%), and these differences were found to be correlated with variation in hardness of prey consumed. These results suggest that morphological differences among introduced island populations of the Jackson's chameleon may be due to ecomorphological adaptation to differences in exploited prey hardness, whether due to prey choice or availability.

Spatial distribution of different environmental factors results in distinct selective pressures on functionally important anatomical characters, such as head size in reptiles. We proposed that, following several dozen generations of reproductive isolation in different environments, head differentiation may be evident among island populations. In order to address this hypothesis we collected morphological data using four size-standardized skull measurements in chameleons from three islands (Hawaii, Maui and Oahu) and tested for correlation among these measurements and environmental factors, such as rainfall and exploited arthropod prey hardness (based on prey type) from gut content data. Our objectives were to 1) quantify the extent of intra-specific skull size variation within and among multiple populations of *T.j. xantholophus* from three islands

and 2) conduct and evaluate correlation analyses of morphometric patterns and potential environmental drivers of phenotypic variation in this species.

## Results

*Head morphology comparison among islands* - ANOVA detected no significant differences in SVL among islands (ANOVA:  $F_{(2,312)} = 0.46$ ,  $p = 0.63$ ), but indicated significant differences in PC1 among islands (ANOVA:  $F_{(2,312)} = 5.7$ ,  $p = 0.02$ ).

Chameleons from Oahu had significantly smaller heads than those of their counterparts from Hawaii (*Tukey's*,  $p < 0.001$ ), while no significant differences in head size were detected between Maui and other islands (*Tukey's*,  $p > 0.05$ ).

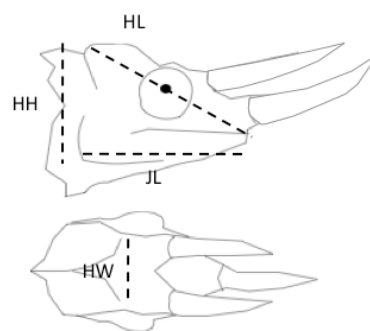
*Environmental effects* - Chameleon diet composition in terms of prey hardness varied significantly among islands ( $\chi^2 = 7.69$ ,  $df = 2$ ,  $p = 0.02$ ). Individuals from Hawaii showed an exploitation pattern with the highest percentage of hard prey items (62.5%), while in the diet of chameleons from Oahu, the lowest percentage of hard prey items was observed (37.3%). Intermediate percentage values (52.5%) were found in individuals from Maui. Significant differences in PC1 were observed between low and high rainfall sites on both Maui ( $Z = -2.89$ ,  $p < 0.005$ ) and Oahu ( $Z = -2.08$ ,  $p < 0.05$ ).

In various reptile taxa, prey hardness is an important factor driving head size variation including chameleons. In this study, larger heads of *T.j. xantholophus* were associated with a significantly higher proportion of hard prey consumed based on gut content analysis, suggesting that inter-island geographic variation in head size could be due to local adaptation to differences in composition of prey exploited (i.e., hard versus soft prey items). Geographically isolated populations are likely to diverge morphologically from one another given time as they approach local fitness optima, especially in the presence of distinct environmental and prey assemblage differences. In cases where gene flow is absent, divergent selection has been shown to drive local adaptation over short ecological time-scales.

Relative head size of Jackson's chameleons was significantly smaller at high rainfall locations on Oahu and Maui. Although rainfall is not likely to directly impinge on morphological variation, ecological factors correlated with rainfall, such as resource availability and quality, may drive variation in functional features such as head size,

among others. For example, prey type and availability have been shown to vary with precipitation levels, and food abundance has been shown to be higher with higher rainfall in a seasonal tropical ecosystem. Arthropods are the main food source for Jackson's chameleons in the Hawaiian Islands, and these taxa tend to have thickened cuticles in more arid environments to counteract desiccation, while in wetter environments arthropods had thinner cuticles, and softer body types. Higher rainfall has been shown to translate to increased availability of softer prey, requiring relatively lower bite force and smaller predator head size. In fact Measey et al. (2011) showed that Cape dwarf chameleons exhibited a preference for smaller, softer arthropod prey where available.

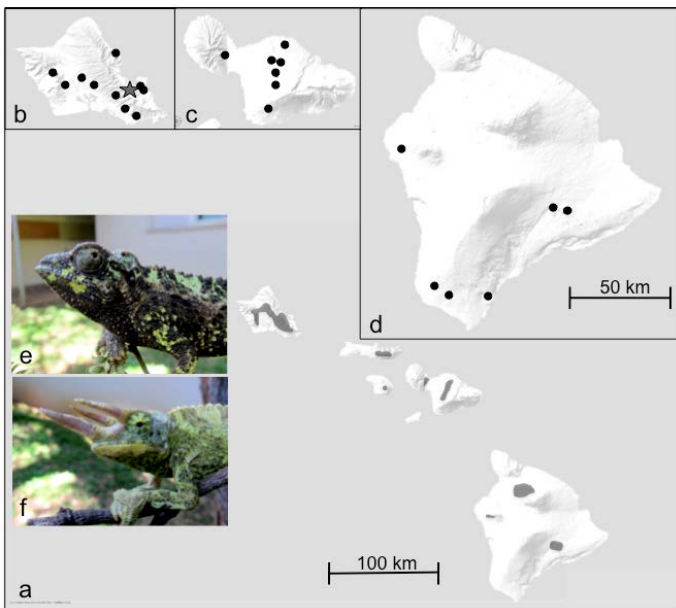
**Figure D-1.** Dotted lines show measurements recorded from the heads of each individual *T. j. xantholophus*: head length (HL), head height (HH), jaw length (JL) and head width (HW). Male chameleon depicted (three prominent horns shown).



The results of this study suggest that local adaptation to environmental conditions, i.e. exploitation of different dietary resources, whether due to availability or selective preference, may be driving evolutionary divergence in head size of Jackson's chameleon populations on different islands. It is possible that the observed differences among islands are a result of neutral variation due, for example, to multiple founder events and genetic drift, where small numbers of chameleons likely established each sampled population, and sampling bias has resulted in the phenotypes exhibited by those small populations.

Strict enforcement of regulations prohibiting inter-island transport has effectively eliminated the possibility of interisland gene flow. Assuming that the larger head ecomorph and its concomitant enhanced bite force is an optimal phenotype under the lower precipitation/harder prey habitat scenario observed on the island of Hawaii, this phenotype likely evolved on a relatively short ecological time scale. Therefore, we may have documented insipient adaptive divergence of Oahu and Hawaii chameleon populations.

Successful establishment of anthropogenically released non-native taxa is one factor that is dramatically altering our island ecosystems, but it can also provide opportunities to investigate the pace and process of micro-evolutionary change. In such instances where lineages with reduced genetic diversity are placed into varied, novel environments, the primary drivers, whether plasticity or adaptation, can be addressed and potentially elucidated. In further studies, integrated genomic, ecomorphological and behavioral approaches will be useful in elucidating relative genetic versus environmental contributions to evolutionary change in established non-native populations. Such studies that take place during contemporary invasion and range expansion events can detect biological change as it plays out, on ecological time scales, and therefore hold potential to provide real-time insights into the ability of species to adapt in the face of changing global ecosystems, and may provide important biological data that can be informative for management and control of invasive pests.



**Figure D-2.** Distribution of *Trioceros jacksonii xantholophus* in Hawaii, based on museum collections, live specimens captured for this study. a.) Map of known distributions main islands. Collection localities are indicated by black dots on the islands b.) Oahu, c.) Maui, and d.) Hawaii. This species exhibits sexual dimorphism in horn morphology, where e.) females lack, and f.) males have horns. Star symbol on map b.) indicates the approximate original location of release of *T.j. xantholophus* in 1972.

(References and reprints available on request)

## **E) Characterization of impacts of the wrinkled frog, *Glandirana rugosa*, on Hawaii's native invertebrate fauna**

(this study was conducted during the funding period, and has been submitted for publication to *Biological Invasions*, the following is a summary, OANRP support was acknowledged)

### **Introduction**

Invertebrates constitute the most diverse animal lineages on Pacific Islands, and have experienced the most significant extinction rates. Recent losses of biodiversity, particularly in the form of gastropod extinctions in the Hawaiian Islands have been driven largely by ecosystem changes brought about by direct predation by introduced predators. Although Hawaii notably lacks native terrestrial reptiles and amphibians, anthropogenic releases of herpetofauna have resulted in the establishment of frogs, toads, turtles and lizards, among which are some of the most conspicuous faunal groups in the islands today (e.g. coqui frog, green day gecko, brown anole). Many of these taxa overlap in their distributions with native Hawaiian forests. However, despite establishment of more than two-dozen predatory reptile species in Hawaii, ecological impacts remain unknown for 24 of 26 species.

In this investigation, we conducted surveys, collected specimens and used museum collections of the wrinkled frog, *Glandirana rugosa*, an established species intentionally released in the late 19<sup>th</sup> century, from three main Hawaiian Islands (Kauai, Maui, Oahu). The significance of this species distribution lies in the fact that it overlaps in several locations with endemic snails. We conducted comparative gut content analyses from two islands in an effort to assess impacts and enable prioritization of management decisions. Our results suggest that diet composition in the Hawaiian Islands is significantly different from that in its native Japan, where the dominant taxonomic groups by volume were Coleoptera (beetles), Lepidoptera (moths, butterflies) and Formicidae (ants). Invasive frogs in Hawaii exploited mostly Dermaptera (earwigs), Amphipoda (landhoppers) and Hemiptera (true bugs). In Hawaii this species also exploited endemic insects (~5% total volume, 7 genera) and snails (14 snails in 3 endemic genera).

The Japanese wrinkled frog, *Glandirana rugosa* (Jiang and Zhou 2005), was intentionally released on Oahu from Japan intended for agricultural pest control in 1896 by entomologists employed by the Republic of Hawaii with a small number of additional releases between 1900 and 1940 (Bryan 1932; Funasaki et al. 1988). In their native range, *G. rugosa* inhabits rice paddies and feeds on a variety of invertebrates, including snails and insects (Hirai and Matsui 2000). However, despite having been established across the Hawaiian Islands for nearly 120 years, no previous effort has been made to characterize the threat posed by *G. rugosa* to native ecosystems. Additionally, since the range *G. rugosa* and a number of endemic terrestrial invertebrates, including numerous endangered species on Oahu, overlap (Englund 2002; Englund et al., 2003; Englund and Arakaki, 2004; Preston et al. 2007) assessment of the threat posed is warranted. The objectives of this study were to: 1) examine diet of *G. rugosa* and begin to characterize threats to native invertebrate fauna in a comparative framework by examining diet in its native range; 2) investigate seasonality of reproduction; 3) assess uniformity of exploited taxa among male versus female frogs; 4) report observed recent range expansions using GPS positions of collections of this predatory species.

## Methods

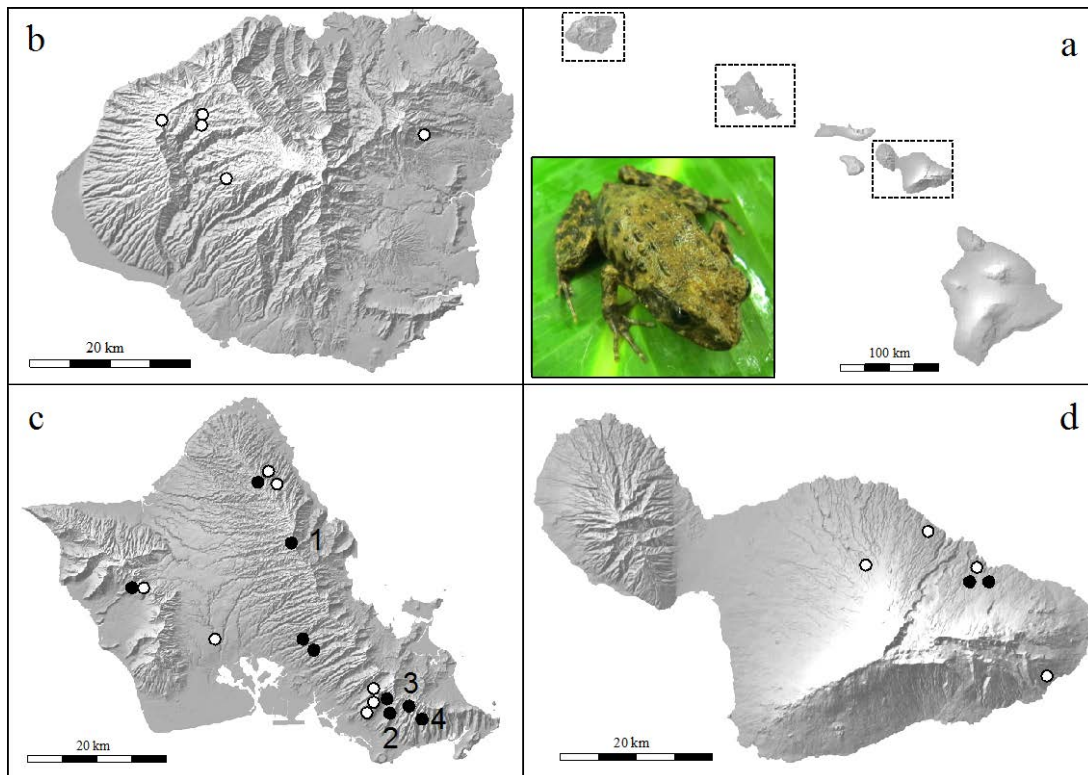
### *Data collection*

Locality, gender, reproductive status and body size information were documented from the collections in the Bishop Museum from three islands (12 sites Oahu, 5 Kauai, 6 Maui) and from specimens collected by hand in the Koolau Mountains on Oahu (5 sites)(Figure 1). Stomach contents were microscopically examined from nine sites on Oahu and two on Maui, and prey were identified to family, and genus / species where possible. Most dietary items were intact individual prey, but for those that were disarticulated due to mastication and or digestive processes, prey items were identified by diagnostic morphological features of hard body parts (such as wing venation in Diptera). Length, width, and height of prey items were measured to the nearest 0.01 mm from either specimens removed from the stomach if whole, or averaged from 3-5 identified preserved specimens (Kraus and Preston 2012). Prey volumes were calculated using the ellipsoid equation  $V=4/3\pi (abc)$  where a, b and c are the body axes (Kraus and Preston,

2012; Kraus et al., 2012). In addition, snout-vent-length (SVL) of all specimens was measured using digital calipers to the nearest 0.01mm and exact collection locality was recorded.

### *Data analysis*

To test whether frogs show gender-correlated differences in exploited prey size, total prey volume was calculated for each individual and differences in average prey volume between males and females were analyzed using Mann-Whitney U tests. Additionally, the relationship between total prey volume and SVL was analyzed using Linear regression, to determine the relationship between prey size and frog body size.



**Figure E-1.** Map of collection localities; a) Hawaiian Islands, inset photo of *Glandirana rugosa*, b) Kauai, c) Oahu and d) Maui. Closed circles are sites where gut contents were collected, open circles represent collection localities where only size and reproductive data were collected. Numbers (1-4) on Oahu map shown in **c** indicate sites where wrinkled frogs had not previously been documented.

## Results

Locality, gender, reproductive status and body size data were collected from 102 individuals, 41 live caught and 61 preserved specimens, from three islands: Kauai ( $n = 7$ ), Maui ( $n = 27$ ), and Oahu ( $n = 68$ ). A total of 447 prey items were identified from a subset of 52 individuals from nine locations on Oahu and two on Maui (Figure E-1). Female biased sexual size (SVL) dimorphism is known for this species (Khonsue et al. 2001): average female body size ( $n=41$ ) was  $45.64 \pm 0.93$  mm, and average male body size ( $n=46$ ) is  $37.2 \pm 0.66$  mm. However, despite body size differences, no differences were detected in total prey volume between males and females (Mann-Whitney U test:  $Z=0.041$ ;  $df=46$ ;  $p=0.97$ ) and there was no relationship between SVL and total prey volume (Linear regression:  $R^2=0.015$ ;  $F_{(1,47)}=.69$ ;  $p=0.41$ ). Preliminary reproductive status analysis suggests that there is seasonality in the cycle, where the peak number of gravid females was observed in January (rainy season) and the highest observed numbers of juvenile frogs were observed in July (dry season).



Order	Family	Genus/species	Year introduced	Current status	Reference
Anura	Ranidae	<i>Glandirana rugosa</i>	1896	Est.	Bryan 1932
		<i>Lithobates clamitans</i>	1935	Rel.	Tinker 1938
		<i>Lithobates pipiens</i>	?	Rel.	Bryan 1932; Tinker 1938
		<i>Lithobates catesbeiana</i>	1899-1902	Est.	Bryan 1932
		<i>Rana nigromaculata</i>	? 1925	Rel.	Tinker 1938
	Dendrobatidae	<i>Dendrobates auratus</i>	1932	Est.	Tinker 1938
	Hylidae	<i>Osteopilys septentrionalis</i>	1980s	Era.	McKeown 1996
		<i>Litoria aurea</i>	1929	Rel.	Bryan 1932
	Bufonidae	<i>Rhinella marina</i>	1931	Est.	Tinker 1938
		<i>Bufo bufo</i>	? 1933	Rel.	Tinker 1938
		<i>Bufo boreas</i>	? 1857	Rel.	Bryan 1932
		<i>Bufo americanus</i>	1892-93	Rel.	Bryan 1932
	Leptodactylidae	<i>Eleutherodactylus planirostris</i>	1980s	Est.	Kraus et al. 1999
		<i>Eleutherodactylus coqui</i>	1980s	Est.	Kraus et al. 1999
Squamata	Iguanidae	<i>Iguana iguana</i>	1950s	Unkn.	McKeown 1996
	Dactyloidae	<i>Anolis carolinensis</i>	1950s	Est.	Oliver and Shaw 1953
		<i>Anolis sagrei</i>	1980	Est.	McKeown 1996
		<i>Anolis equestris</i>	1981	Est.	McKeown 1996
	Phrynosomatidae	<i>Phrynosoma cornutum</i>	1950	Rel.	Shaw and Breese 1951; Hunsaker and Breese 1967
	Chameleonicidae	<i>Trioceros jacksonii xantholophus</i>	1972	Est.	McKeown 1996
		<i>Chamaeleo calyptratus</i>	2002	Era.	Main Invasive Species Council 2008
	Gekkonidae	<i>Lepidodactylus lugubris</i>	?	Est.	Stejneger 1899
		<i>Gehra mutilata</i>	?	Est.	Stejneger 1899
		<i>Hemiphyllodactylus typus</i>	?	Est.	Stejneger 1899
		<i>Hemidactylus garnotii</i>	?	Est.	Stejneger 1899
		<i>Hemidactylus frenatus</i>	1940s	Est.	Tinker 1938
		<i>Phelsuma guimbecae guibecae</i>	1980s	Est.	McKeown 1996
		<i>Phelsuma laticauda laticauda</i>	1974	Est.	McKeown 1996
		<i>Phelsuma madagascarensis grandis</i>	1996	Est.	Kraus 2002
		<i>Gekko gekko</i>	1960s	Era.	McKeown 1996
		Scincidae	<i>Lampropholis delicata</i>	1917	Est.
	<i>Cryptoblepharus poecilopleurus</i>		?	Unkn.	Stejneger 1899
	<i>Lipinia noctua noctua</i>		?	Est.	Hallowell 1860; Stejneger 1899
	<i>Emoia cyanura</i>		?	Est.	Stejneger, 1899
	<i>Emoia impar</i>		?	Unkn.	Fisher and Ineich 2012
	Typhlopidae	<i>Ramphotyphlops braminus</i>	--1930	Est.	Hunsaker and Breese 1967
Testudines	Emyidae	<i>Trachemys scripta elegans</i>	1900s	Est.	Tinker 1938
		<i>Graptemys pulchra</i>	1900s	Rel.	Tinker 1938
		<i>Graptemys geographica</i>	1900s	Rel.	Tinker 1938
		<i>Terrapene spp</i>	1900s	Unkn.	Lovich 1989
	Trionychidae	<i>Pala steindachneri</i>	1947	Est.	Oliver and Shaw 1953; McKeown 1996
		<i>Pelodiscus sinensis</i>	1947	Est.	Oliver and Shaw 1953; McKeown 1996
		<i>Pelodiscus maackii</i>	1947	Est.	Dong et al. 2015

**Table E-1.** Summary of introduced reptile and amphibians in the Hawaiian Islands, including date of release and current status. Abbreviations for current status are: “Rel.” = Released but not established; “Est” = Established; “Era” = Eradicated following release; “Unkn” = Unknown status following release. Totals by group are: Anura = 14; Squamata = 22; Testudines = 7. Total 43 species, 4 are of uncertain status, 26 are established. Note also that the focus of this study, the wrinkled frog *Glandirana rugosa*, along with *Bufo americanus* are the earliest documented herpetofaunal releases in Hawaii, although *B. americanus* did not become established, leaving *G. rugosa* as the longest standing herpetofaunal introduction.

Historical release date and current status, i.e. whether established, eradicated, or unknown, for all herpetofaunal taxa (total 43 species) was compiled and summarized for the Hawaiian Islands (Table E-1). Of the two anuran species that were intentionally released as attempted biocontrol in the late 1800’s, *Bufo americanus* and *G. rugosa*, only the wrinkled frog remains, although additional releases of this species are also documented as occurring subsequent to the initial release (Bryan 1932). Total releases by group are 14 species of frogs and toads (Anura), 22 lizards (Squamata), and seven turtles (Testudines). Of the total 43 species released in Hawaii, four are currently of uncertain

status, in some cases still periodically observed and occasionally documented but not unambiguously naturalized. A total of 26 herpetofaunal taxa are currently established in the Hawaiian Islands.

Frogs examined for exploited prey species analysis were collected at elevations ranging from 100-800 m (Table 2) in Hawaii. In terms of comparison of predatory behavior between introduced and native ranges, the three most common prey item categories in frogs collected in the Hawaiian Islands by number consisted of Amphipoda (22.15%), Hemiptera (13.20%) and Hymenoptera (11.63%), whereas dominant prey groups by counts in Japan were Hymenoptera (59.07%), Diptera (13.60%) and Coleoptera (12.23%) (Hirai & Matsui 2000). Analysis of prey composition by volume for the Hawaii samples revealed that the top groups were Dermaptera (59.42%), Amphipoda (10.92%) and Hemiptera (9.59%). Dominant prey groups by volume for Japan were Coleoptera (28.23%), Lepidoptera (21.27%) and Hymenoptera (12.00%). The only group shared was Hymenoptera, the third most common prey item by number of specimens in Hawaii, and the top prey group by number and third category by volume in Japan. In its native range, *G. rugosa* consumed a lot of ants, as these individuals are very small in volume, yet still occupied 12% of the relative volume of prey but only 1% by volume in Hawaii.

Identified native fauna comprised ~4% of prey items by counts, and 5% of total prey volume and were found in frogs from all collection localities, including both native and non-native forest sites on both islands we sampled. However it should be noted that these values are likely to be underestimates due to the challenge associated with positively identifying gut contents to species, coupled with the fact that we only recorded those species for which we were most confident. Yet, 52 and 77% of prey items by count and volume, respectively, belong to families with diverse endemic lineages (Table E-4).

There were 17 collection localities on the island of Oahu, we collected *G. rugosa* from five localities, four of which were new recorded sites, suggesting ongoing range expansion (Figure E-1).

**Table E-2.** Summary of stomach contents by family from 52 individuals of *Glandirana rugosa* from Oahu and Maui.

Order/ Taxa	Family	# Prey items	% Relative abundance	% Relative volume
Acari		3	0.67	0.00
Amphipoda		99	22.15	10.92
Araneae	Dysderidae	2	0.45	0.04
	Pholcidae	1	0.22	0.02
	Salcidae	3	0.67	0.85
	Thomisidae	2	0.45	0.15
	Unknown	12	2.68	0.93
Chilopoda		44	9.84	2.65
Coleoptera	Carabidae	13	2.91	0.43
	Coccinellidae	2	0.45	0.03
	Curetoniidae	14	3.13	0.51
	Hydrophilidae	1	0.22	0.08
	Pythidae	1	0.22	0.47
	Staphylinidae	3	0.67	0.44
	Tenebrionoidea	2	0.45	0.07
	Unknown Larvae	3	0.67	0.21
Dermaptera		25	5.59	59.42
Diplopoda		4	0.89	0.06
Diptera	Dolichopodidae	9	2.01	0.03
	Ephryidae	11	2.46	0.04
	Phoridae	3	0.67	0.01
	Sciariidae	1	0.22	0.00
	Tipulidae	34	7.61	0.72
	Unknown	4	0.89	0.01
Gastropoda	Achatinellidae	12	2.68	2.96
	Helicarionidae	2	0.45	1.48
	Subulinidae	5	1.12	0.58
	Oxychilidae	2	0.45	0.49
Hemiptera	Cydnidae	37	8.28	9.22
	Largidae	1	0.22	0.02
	Miridae	15	3.36	0.07
	Nabidae	3	0.67	0.27
	Unknown	3	0.67	0.01
Hymenoptera	Apidae	1	0.22	1.45
	Chalcidoidea	2	0.45	0.00
	Formicidae	49	10.96	1.06
Isopoda		3	0.67	0.26
Lepidoptera	Cosmopterygii	1	0.22	0.03
	Unknown larvae	4	0.89	1.55
Neuroptera	Hemeroptidae	1	0.22	0.24
Oligochaeta		2	0.45	1.43
Orthoptera	Gryllidae	7	1.57	0.67
Psocoptera	Psocidae	1	0.22	0.10
<b>Total</b>		<b>447</b>	<b>100</b>	<b>100</b>

## Discussion

This study is the first to examine *Glandirana rugosa* impact in Hawaii despite its establishment in the islands for about 120 years. The presence of small snails was recently documented in the diet of coqui frogs in Hawaii (Beard 2009), although taxonomic composition of these snails not reported, 12 species were categorized as “possibly endemic”. The results of this investigation reveal the first confirmed case of an invasive amphibian preying on endemic land snails.

**Table E-3.** Summary of diet contents by order, comparing relative abundance and volume of prey items in introduced range (Hawaiian Islands, n=52) and native range (Japan, n=139; Hirai and Matsui 2000). The three most dominant exploited prey items by number and volume from native and introduced ranges are in bold. Prey items present in gut contents of frogs in their native range but not in introduced range, and are not included in this table are: Collembola, Decapoda, Odonata, Plecoptera, Protura, Thysanoptera and Tricoptera.

Order/Prey taxa	Hawaii			Japan	
	# Prey items	% Relative abundance	% Relative volume	% Relative abundance	% Relative volume
Acari	3	0.67	0.00	0.07	0.03
Amphipoda	99	<b>22.15</b>	<b>10.92</b>	0.17	0.13
Araneae	20	4.47	2.00	2.07	2.00
Chilopoda	44	9.84	2.65	0.03	0.10
Coleoptera	39	8.72	2.24	<b>12.23</b>	<b>28.23</b>
Dermoptera	25	5.59	<b>59.42</b>	0.07	0.37
Diplopoda	4	0.89	0.06	1.97	4.37
Diptera	62	<b>13.87</b>	0.82	<b>13.60</b>	6.10
Gastropoda	21	4.70	5.52	1.37	1.43
Hemiptera	59	<b>13.20</b>	<b>9.59</b>	3.07	4.67
Hymenoptera	52	11.63	2.51	<b>59.07</b>	<b>12.00</b>
Isopoda	3	0.67	0.26	0.87	4.60
Lepidoptera	5	1.12	1.58	1.90	<b>21.27</b>
Neuroptera	1	0.22	0.24	1.00	0.97
Oligochaeta	2	0.45	1.43	0.50	7.73
Orthoptera	7	1.57	0.67	0.33	1.30
Psocoptera	1	0.22	0.10	0.00	0.00
<b>Total</b>	<b>447</b>	<b>100</b>	<b>100</b>	<b>98</b>	<b>95</b>

Though *G. rugosa* was released as an attempted biological control for taro pests, known pest species of any group comprised only ~1% of *G. rugosa*'s diet by volume, consisting of invasive ants, which do not feed on taro. Compared to this tiny fraction of total prey volume, nearly 6% was native endemic invertebrates. The introduction of *G. rugosa* to control pests has been a dramatic failure.

Amphipods, which comprised the largest prey item by number, play an important ecological role in leaf litter decomposition in the Hawaiian forest ecosystem, and comprise diverse endemic lineages, with 11 species on Oahu (Hurley 1959). Additionally, arthropod abundance surveys from nearby sites of similar elevation, rainfall, and forest composition suggest that amphipods are the most commonly available prey item in the leaf litter (Van Kleeck et al. unpub) as reflected in the number observed in stomach contents. The order Dermaptera, the earwigs, was most dominant prey group by volume observed in *G. rugosa* diet, and there are ten native Hawaiian species (one indigenous and nine endemic) (Hawaiian Arthropod Checklist 2004). Although the endemic dermapteran species are not common, the frog's ongoing range expansion (Figure E-1) into native forest observed during this study, will likely increase overlap and interaction of this frog with these and other important endemic species.

Frogs are known as generalist predators that can reach extremely high densities (Beard 2009). Of particular concern is the new observation that Hawaii's endemic land snails, a group that on the whole is in dire conservation state, were specifically targeted by this frog. Of 21 snails observed in frog guts, 14 individuals (67%) were members of three genera with endemic species on Oahu (*Elasmias*, *Tornatellides*, and *Philonesia*). Geographic spread by the wrinkled frog from low-elevation agricultural land where it was released in taro patches, into native watersheds up to 800 m elevation warrants concern in terms of impacts on rare and threatened native invertebrate fauna which have experienced unprecedented declines due the introduction of predatory invasive species (Solem 1991) in recent decades (Holland 2009; Holland et al. 2008).

Snails comprised 5% and 6% of dietary items in number and in volume respectively, in this study (Table E-2). Gastropods were also documented in the diet of *G. rugosa* in the native range (Hirai and Matsui 2000), though at far lower frequencies, and in invasive coqui frogs in Hawaii (Beard 2009). Small land snails are a documented prey item in other ranid frogs as well (e.g. Tyler and Hoestenbach 1979). Of the 10 families with endemic Hawaiian land snail species, one genus (*Achatinella*) the Oahu tree snails, has been afforded endangered status under the U.S. Endangered Species Act (USFWS 1981). Partly because Hawaiian land snail endemism exists at multiple hierarchical levels, including species, genus, subfamily and family levels (Solem 1990), this fauna makes attractive scientific models for the study of biogeography and evolutionary radiations (Cowie and Holland 2008; Holland and Cowie 2009). However the Hawaiian land snail fauna has suffered extinction rates estimated at 65-90% (Solem 1990; Cowie 2001) because of collection, habitat loss, and in recent decades predation by invasive species. Rats, *Rattus rattus*, and the rosy wolf snail, *Euglandina rosea*, (Hadfield 1986) have traditionally been considered the primary threats to Hawaiian snails, with the Jackson's chameleon recently entering the realm of conservation concern (Holland et al. 2010; Chiaverano and Holland 2014). These invasive predators have devastated multiple species, and the threat of extinction persists for extant snail taxa, failing intervention. This study reveals the second herpetofaunal species documented as preying on endemic Hawaiian land snails. However, the wrinkled frog has been shown to occupy primarily riparian leaf litter rather than arboreal habitat, so it is unlikely that this species poses a threat to the endangered tree snails. But leaf litter dwelling snail lineages such as the extremely rare Amastridae and Endodontidae share overlapping habitat with *G. rugosa*.

Frogs hold the potential to alter ecosystems due to their high population densities and generalist feeding habits. Although ranid frogs are generalist predators, and their diet is known to vary with habitat (e.g. Elliot and Karunakaran 1974; Tyler and Hoestenbach 1979), in its native range, *G. rugosa* exhibits a similar level of preference for ants as other known ant specialists (Hirai and Matsui 2000). Ants were consumed at relatively high frequency by frogs in Hawaii (11% by count), and all ant lineages are invasive in the islands, but without prey availability data from the collection sites, it is uncertain whether *G. rugosa* displays selectivity for these species.

Predatory behavior patterns did not vary with frog body size, developmental stage, or with sex suggesting that frogs of both genders and all life stages are potential predators to native arthropod species. Although Tinker (1938) stated that all life stages can be found throughout the year in Hawaii, during this study more juveniles were collected between May and September and gravid females from November to February, suggesting possible seasonality in reproduction. Ranid frogs exhibit high levels of variation length and period of metamorphosis, as a result of varying climates and food availability (Riha and Berven 1991; Merilä et al. 2000). In fact, in our studies, *G. rugosa* completes metamorphosis in as little as seven weeks in Hawaii (pers observ), as opposed to 12 to 52 weeks in their native range, with longest delays seen where over-wintering is common (Khonsue et al. 2001). Despite its association with agricultural areas such as rice paddies in its native range (Hirai and Matsui 2000), in Hawaii *G. rugosa* is currently undergoing range expansion into native forest sites and areas of conservation concern (pers observ).

Dramatic differences between predatory patterns observed in frogs from Japan versus Hawaii may reflect differences in prey availability in these different habitats based on forest complexity, plant community structure and invertebrate communities therein. On the other hand, we are beginning to see that adaptation of invasive herpetofauna to Hawaii's novel and highly diverse microhabitats can be rapid (Van Kleeck et al. in press). It is possible that the accelerated rates of metamorphosis and differences in predatory patterns observed between native and introduced ranges of this frog reflect changes due to adaptation of development rate and prey preference, though further studies will be needed to confirm this possibility.

Impact and threat assessment studies of invasive herpetofaunal species in Hawaii remain few relative to the numerous (26) known established predatory amphibians and reptiles in the islands. Likewise there is a need for additional studies of native and endemic invertebrate diversity, ecosystem services, and changes in areas where new predatory species are established. Studies of declines in native biodiversity are useful, but do not address indirect effects of loss of invertebrate taxa in terms of ecosystem processes such as pollination, leaf litter breakdown, and nutrient cycling. Only once changes in native community structure, alteration of ecosystems and ecology of invasive

species are reconciled, can we begin to effectively address the loss of native biodiversity by counteracting the spread and controlling the activity of nonnative lineages. Further in-depth assessment of impacts on endemic ecosystems are warranted to improve our ability to manage and ultimately restore diverse island ecosystems.

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(References and reprints available on request)



**Table E-4.** Summary of number and volume of arthropods comprising stomach contents, in comparison to the species diversity (total number) of endemic and introduced taxa in each of the families that occur in the Hawaiian Islands. Known Hawaiian endemic lineages are in bold.

Order	Family	Genus	# Prey items	% Relative abundance	% Relative volume	# Endemic	# Introduced	References
Amphipoda			99	22.15	10.92	11	5	Hawaiian Terrestrial Arthropod Checklist
Araneae	<b>Thomisidae</b>		2	<b>0.45</b>	<b>0.15</b>	20	0	Hawaiian Terrestrial Arthropod Checklist
Coleoptera	Carabidae		13	2.91	0.43	236	46	Hawaiian Terrestrial Arthropod Checklist
	Staphalynidae		3	0.67	0.44	99	45	Hawaiian Terrestrial Arthropod Checklist
Dermoptera			25	5.59	59.42	9	2	Hawaiian Terrestrial Arthropod Checklist
Diptera	Dolichopodidae		9	2.01	0.03	208	14	Hawaiian Terrestrial Arthropod Checklist
	Ephydriidae		11	2.46	0.04	20	23	Hawaiian Terrestrial Arthropod Checklist
	Sciaridae		1	0.22	0.00	12	9	Hawaiian Terrestrial Arthropod Checklist
	Tipulidae		34	7.61	0.72	17	3	Hawaiian Terrestrial Arthropod Checklist
<b>Gastropoda</b>	<b>Achatinellidae:</b>	<i><b>Elasmus</b></i>	7	<b>1.57</b>	<b>1.73</b>	106	0	Solem, 1990
	<b>Tornatillininae</b>	<i><b>Tornatilledes</b></i>	5	<b>1.12</b>	<b>1.23</b>			
	<b>Helicarionidae</b>	<i><b>Philonesia</b></i>	2	<b>0.45</b>	<b>1.48</b>	60	0	Cowie et al., 1995
Hemiptera	Miridae		15	3.36	0.07	127	20	Hawaiian Terrestrial Arthropod Checklist
	Nabidae		3	0.67	0.27	26	2	Hawaiian Terrestrial Arthropod Checklist
<b>Lepidoptera</b>	<b>Cosmopterygii</b>	<i><b>Hyposmocoma</b></i>	1	<b>0.22</b>	<b>0.03</b>	345	4	Hawaiian Terrestrial Arthropod Checklist
Neuroptera	Hemerobiidae		1	0.22	0.24	25	4	Hawaiian Terrestrial Arthropod Checklist
Psocoptera	Psocidae		1	0.22	0.10	63	1	Hawaiian Terrestrial Arthropod Checklist
<b>Total</b>			<b>447</b>	<b>51.90</b>	<b>77.31</b>	<b>1384</b>	<b>178</b>	

## **Molecular assessment of wild *Achatinella mustelina* diet**

### Annual Report - September, 2015

Geoffrey Zahn and Anthony Amend  
Department of Botany, University of Hawaii at Manoa, amend@hawaii.edu

#### **Status of the Project and Personnel**

Dr. Richard O'Rorke left the project in June to pursue an opportunity in Australia. Dr. Geoff Zahn joined us in August to oversee the experiments.

#### **Food Similarity Between Proposed Donor and Enclosure Snail Sites**

If populations of *Achatinella mustelina* in difficult-to-access areas are to be successfully relocated to enclosures at sites more amenable to conservation efforts, it must be assured that conditions at the proposed sites are similar to those where the snails currently reside. One factor that may be important is the availability of preferred snail food sources. We plan to determine whether epiphytic microbial communities are similar between donor and proposed enclosure sites by sequencing DNA amplicons of material swabbed from the surface of leaves at each location.

At each current snail site, leaves from at least 10 plants containing snails were recorded, collected and returned to the lab. In the lab, leaf surfaces were swabbed and these swabs will be subjected to DNA sequencing to determine species composition. The same sampling strategy is being carried out for plants (same species as current snail plants) at the proposed enclosure sites. If leaf-surface microbial communities are similar between current and proposed sites, it is an indication that food source and availability will not be limiting factors in snail health at proposed sites following translocation. If microbial communities are dissimilar, further work will be done to determine whether these differences are functionally meaningful and/or whether it is possible to inoculate plant surfaces at the proposed sites with microbial food sources from the current sites to ease any potential snail relocation shock.

<b>Donor Site</b>	<b>Proposed Enclosure Site</b>
Skeeter Pass	Ka'ala Bog
Culvert 69	Three Points/ Makaleha
Ekahanui	Palikea Area

#### **Snail Food "Farming" for Improved Captive Breeding**

Previous work (see Annual Report 2014 and attached manuscript draft) demonstrated that the diet of captive snails differs from that of snails in the wild. We propose an experiment to test whether and how to cultivate preferred snail food on more accessible and convenient host plants and locations. Using a controlled experiment in a growth chamber we plan to assess the extent to which

plant identity, community membership, environment and leaf surface pre-treatments enable cultivation of target snail food fungi. Results from this experiment should provide insight into captive breeding programs proposed by SEP and other stake-holders, as well as potential site remediation for future translocations in the field.

## Snail Transplant Studies

In preparation for potential snail transplant to novel enclosures, we assessed whether snail introductions impact microbial community composition. *Auriculella ambusta* snails, serving as a proxy for *Achatinella* were transplanted from ginger and jasmine onto *Metrosideros polymorpha* at a restoration site on Mt. Tantalus. Snail enclosures were maintained using window-screen bags, and non-snail controls were established on the same trees as blocked experimental replicates. Using DNA sequencing as in previous studies, we determined the extent to which phyllosphere fungi and bacteria, with and without snails, resemble prior snail habitat, snail feces, snail mucus, or the contemporary environment. The experiment was sampled weekly and maintained for 6 weeks.

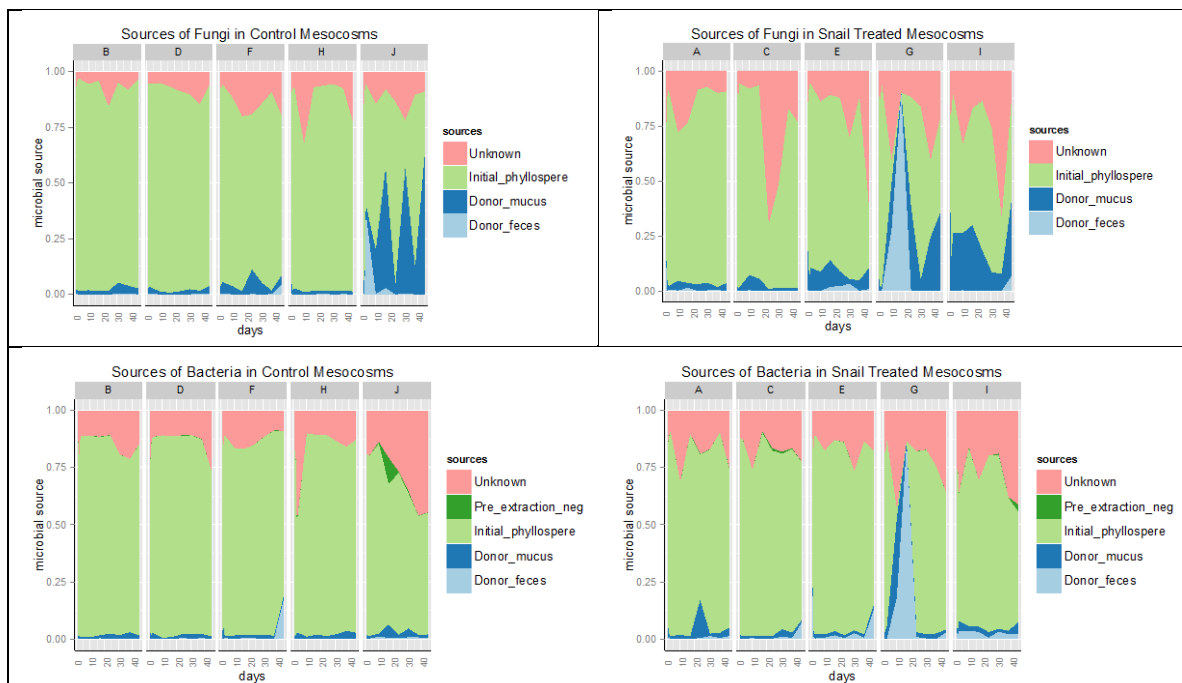


Figure 1. “Source” of microbial community composition on leaves. Clockwise from upper left: Fungal No-Snail, Fungal Snail, Bacteria No-Snail, Bacteria Snail. “Unknown” contribution to community composition is presumed to be aerial deposition from the environment.

Abundance of microbes on the leaf surface was assessed using scanning electron microscopic (SEM) imagery.

## Results

Initial analysis of our data suggests that snails transport their own microbes (the farming hypothesis) only briefly, and that this influence is relatively minor and attenuates after two weeks. Instead, snails appear to disrupt intact phyllosphere communities, increasing the contribution of aerial microbes over time (Figure 1). This does not lead to a single stable snail-like community, but instead contributes to communities of microbes that differ considerably from each other and from non-snail controls, which are more homogenous (Figure 2). That is to say, the presence of snails appears to tip the balance between a deterministic and stochastic microbial community assembly process.

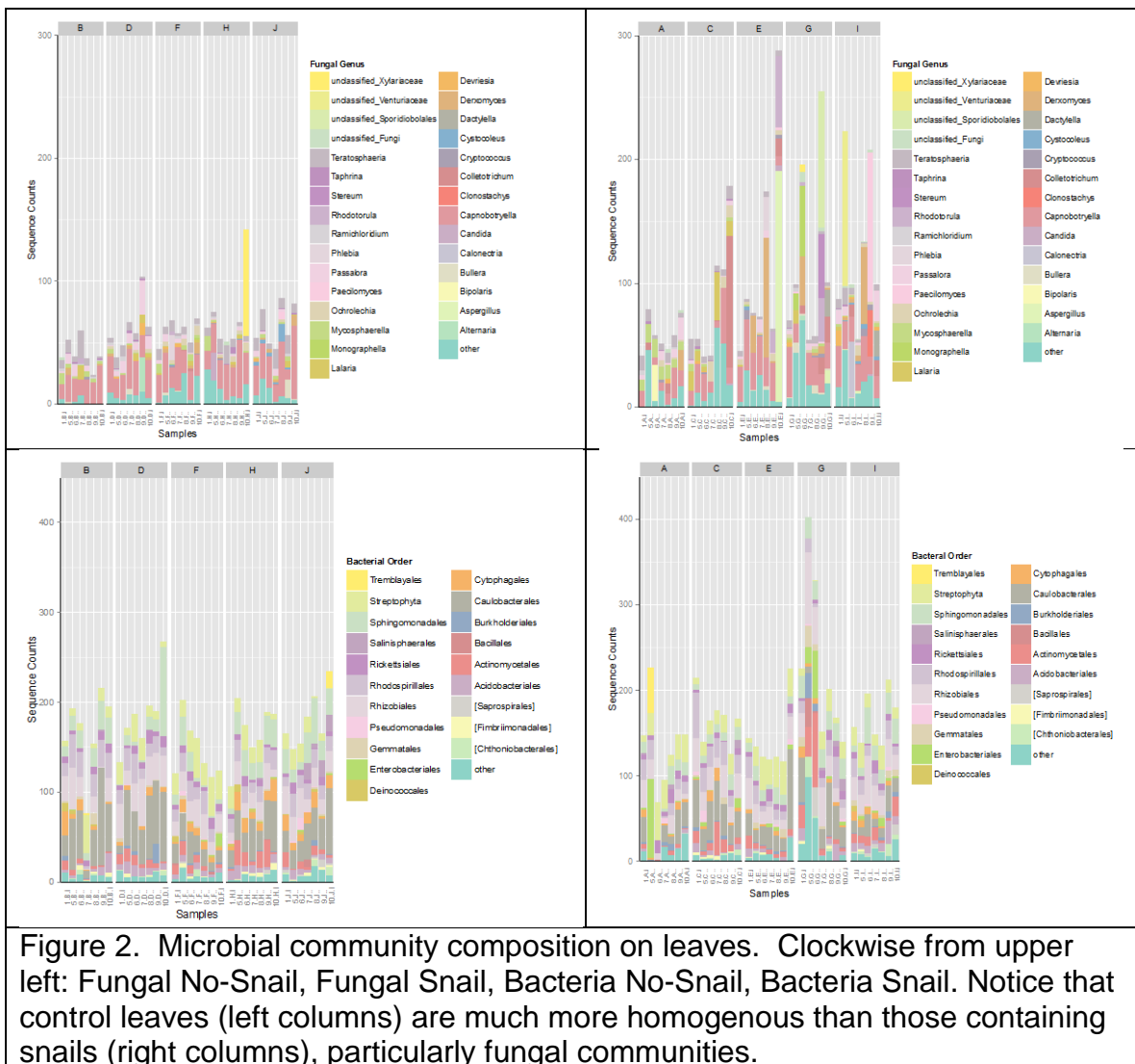


Figure 2. Microbial community composition on leaves. Clockwise from upper left: Fungal No-Snail, Fungal Snail, Bacteria No-Snail, Bacteria Snail. Notice that control leaves (left columns) are much more homogenous than those containing snails (right columns), particularly fungal communities.

Analysis of SEM images demonstrated, unsurprisingly, that snails significantly reduce the abundance of surface microbes.

## Significance

Experimental results suggest that, at least for transplanted *Auriculella ambusta*, microbial input from source locations is rapidly swamped by contemporary phyllosphere and aerial microbes. Transplanting, snails, therefore, is insufficient for simultaneous transplanting of snail food.

That snails significantly reduce the abundance and stability of phyllosphere microbes, however, suggests that a synergistic approach may abet transplantation of food sources. Because grazed leaves are more receptive to aerial-dispersed microbes, repeated applications of preferred food items (via spray bottle slurries for example) may enable us to grow snail food in novel habitats. This dynamic is the subject of our next experiment.

### **Snail Feeding Trials**

The results of our feeding trials are under review in *Biological Conservation*. The draft manuscript is attached and the title page/abstract are appended below:

#### **Escaping the captive diet: enhancing captive breeding of endangered species by determining dietary preferences**

**O'Rorke, Holland, Cobian, Gaughen, Amend**

##### **Abstract**

Endangered species can be safeguarded against extinction by raising subpopulations in *ex situ* facilities that mimic their wild habitats. This is difficult when the endangered animal's diet is cryptic. We present a combined molecular and behavioral approach to assess the *ex situ* diet of *Achatinella*, a critically endangered genus of tree snail, to determine how diet of captive snails differs from wild snails. *Ex situ* snails are currently fed biofilms growing on the surface of leaves, as well as a cultured fungus isolated from this same habitat. Amplicon sequencing of DNA extracted from feces of cultured snails confirms that this cultured fungus is abundant in the wild, but that it dominates the diet of the *ex situ* snail diet (comprising ~38% of sequences). The diet of captive snails is significantly less diverse compared to wild snails. To test the hypothesis that snails have diet preferences, we conducted feeding trials. These used a surrogate snail species, *Auriculella diaphana*, which is a confamilial Oahu endemic, though non-federally listed. Contrary to our expectations we found that snails do have feeding preferences. Furthermore, our feeding preference trials show that over all other feeding options snails most preferred the "no-microbe" control, which consisted only of potato dextrose agar (PDA). PDA is rich in simple carbohydrates, which is in contrast to the wild environment of tree-snails, which is oligotrophic. These results suggest further research should focus on calorie budgets of snails and on devising new approaches to supplementing their *ex situ* diet.

## Escaping the captive diet: enhancing captive breeding of endangered species by determining dietary preferences

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### Abstract

Endangered species can be safeguarded against extinction by raising subpopulations in *ex situ* facilities that mimic their wild habitats. This is difficult when the endangered animal's diet is cryptic. We present a combined molecular and behavioral approach to assess the *ex situ* diet of *Achatinella*, a critically endangered genus of tree snail, to determine how diet of captive snails differs from wild snails. *Ex situ* snails are currently fed biofilms growing on the surface of leaves, as well as a cultured fungus isolated from this same habitat. Amplicon sequencing of DNA extracted from feces of cultured snails confirms that this cultured fungus is abundant in the wild, but that it dominates the diet of the *ex situ* snail diet (comprising ~38% of sequences). The diet of captive snails is significantly less diverse compared to wild snails. To test the hypothesis that snails have diet preferences, we conducted feeding trials. These used a surrogate snail species, *Auriculella diaphana*, which is a confamilial Oahu endemic, though non-federally listed. Contrary to our expectations we found that snails do have feeding preferences. Furthermore, our feeding preference trials show that over all other feeding options snails most preferred the "no-microbe" control, which consisted only of potato dextrose agar (PDA). PDA is rich in simple carbohydrates, in contrast to the oligotrophic environment of wild tree-snails. These results suggest further research should focus on calorie budgets of snails and on devising new approaches to supplementing their *ex situ* diet.

## Introduction

All of the species of the endemic O'ahu tree snail genus *Achatinella* (family Achatinellidae) have been listed under the U.S. Endangered Species Act since 1981 (USFWS, 1981), and all remaining genera and species from throughout the Hawaiian Archipelago are considered either species of concern or critically threatened. Extinctions caused by habitat loss, shell collectors and especially, invasive predators have reduced approximately 41 species of *Achatinella* to just ten species (Holland & Cowie 2009) with only a single individual remaining in the species *A. apexfulva* and less than ten known individuals of *A. fulgens* in the wild. To safeguard the genetic stocks of surviving species, an *ex situ* breeding facility, the Hawaiian Tree Snail Conservation Laboratory (HTSCL) has maintained subpopulations of the snails since the late nineteen-eighties. However, these *ex situ* populations are prone to episodes of high mortality and have not flourished despite the absence of predators. Because wild stocks of these unique animals are quickly declining, managers are anxious to improve lab conservation strategies. The present study examines the use of non-invasive methods and surrogate species to explore how the *ex situ* diet of a critically endangered species can be improved in order to improve their fitness.

The *ex situ* culture facility is modeled on the snails' natural ecosystem (Hadfield et al. 2004), but while temperature and humidity can be monitored *in situ* and simulated in incubators, the diet of wild snails has not been artificially replicated because the composition of their wild diet was not characterized until recently (O'Rorke et al. 2014; Price et al. n.d.). *Achatinella* graze microbes from leaf surfaces, and so, every two weeks their cages in the *ex situ* facility are provisioned with a supply of leaves collected from the wild. This wild "sourced" diet is supplemented by a cultured *Cladosporium* fungus that was isolated around 1989 from a native *ohia* tree (*Metrosideros polymorpha*), which is a common host plant for the snails (Kobayashi & Hadfield 1996). Observations of *ex situ* snails suggest that they will consume almost any microbe that they encounter, but the hypothesis that snails do not have a preference for food items has not been tested in a controlled experiment. Wild populations of tree snails have a very diverse microbial diet (O'Rorke et al. 2014; Price et al. n.d.), but it is not clear if this is because they indiscriminately consume food from any surface they happen to be on, or if they are targeting particular microbes but accidentally consume non-target diet items as well. Determining snail preferences provides a potential conservation opportunity, because it will indicate whether captive snails should be provisioned with particular foods.

To determine whether the *Cladosporium* isolate that is used to supplement the *ex situ* snail diet is a large component of their diet we sequenced fungal DNA from their feces. This also enabled us to determine the degree to which *ex situ* diet overlaps that of the wild populations. We also determined whether snails prefer particular diet items by conducting feeding trials in which isolated fungus and bacteria strains were offered to the tree snail *Auriculella diaphana*. This snail was used as a model for *Achatinella* because although it is of conservation concern, it is more fecund and is not listed as endangered. *Auriculella* are an excellent surrogate for *Achatinella* because they are often sympatric and cohabit the same leaves (Pilsbry et al. 1912) and the dietary remnants in the fecal

contents of sympatric *Auriculella* and *Achatinella* are similar, even when sampled almost a year apart (O'Rorke et al. 2014). In addition, both species are members of endemic Hawaiian subfamilies of achatinellid tree snails, the Auriculellinae and the Achatinellinae, which are phylogenetically closely related sister groups (Holland & Hadfield 2004).

## Methods

Snails and microbial isolates

*Achatinella* snails are housed at the snail culture facility at the HTSCL at the University of Hawaii in Manoa (Table 1). *Auriculella diaphana* used for the feeding trial were collected from the Kalawahine Trail on Mt Tantalus (Table 1: GPS coordinates available through the US Fish and Wildlife service by request), under Department of Land and Natural Resources permit (FHM13-T&E-11). Microbial cultures were isolated from leaves or snail fecal samples obtained from locations on Oahu (Table 2). The microbial isolates are housed in the University of Hawai'i fungal culture collection and DNA sequence "barcode" regions were obtained using the ITS1F/ITS4B primers for fungi (Gardes & Bruns, 1993) and the 515f/806r 16s v4 primers for bacteria (Caporaso et al., 2012) and these are available from NCBI (Table 2 for accession numbers). Microbial isolates were grown on potato dextrose agar (PDA) for the feeding trial.

Determining the diet of *ex situ* snails with DNA sequencing

34 snail fecal samples were obtained from the HTSCL between late February and early March of 2013 (Table 1). The diet of the snails was determined by sequencing DNA extracted from these feces following the methods outlined in O'Rorke et al. (2014). Briefly, a next-generation sequencing (NGS) approach was used, where DNA was extracted from feces using the Powersoil® DNA isolation kit (MoBio) and then PCR amplified with ITS1 specific primers that contained Illumina primers and sequence index tags (Smith & Peay 2014). Sequences were cleaned using SequelPrep™ Normalization plates (Invitrogen, New York) and subsequently pooled, cleaned using a SPRI plate (Beckman Coulter, California) and Sera-Mag™ Magnetic SpeedBeads™ (Fisher Scientific, Pittsburgh) in an amplicon:bead ratio of 1.8:1, and quantified on a Qubit® fluorometer (Invitrogen) using the dsDNA HS assay. Bioanalyzer Expert 2100 High Sensitivity chip (Agilent Technologies, California) and qPCR determined cluster density before sequencing. Sequencing was undertaken at the University of Hawaii, Genetics Core Facility using 1/10<sup>th</sup> of an Illumina MiSeq sequencing reaction with the MiSeq Reagent v3 chemistry (Illumina®).

Sequences were merged using PEAR (Zhang et al. 2013), demultiplexed in QIIME (Caporaso et al. 2010) and clustered into operational taxonomic units (OTUs) at 97% similarity using UPARSE (Edgar 2013). The OTU community matrix was imported into R and rarefied to 3500 sequences per sample. Abundances of OTUs were used to generate ranked abundance curves and Shannon alpha-diversity indices (.r file in Suppl materials). Alpha diversity and Pielous evenness indices were compared between feces from wild (O'Rorke et al. 2014; Price et al. n.d.) and *ex situ* populations using the Mann-Whitney (Wilcox) test (.r file in Suppl materials).



### Determining food preferences of tree snails

Twenty-four hour feeding trials were conducted in an Percival Intellus environmental incubator on a 12 hour dark/light cycle (0.8 lx/1016.2 lx) shifting between 16°C and 20°C, based on ambient day/night temperatures recorded in the snail's natural environment. Snails were acclimated to the incubator for at least 14 days before trial and not fed for 12 hours prior to the feeding trial. Each individual snail was placed in a 450 mL glass jar. Twelve plugs of agar (diameter = 1 cm) that carried either one of eleven microbial isolates (Table 2) or a PDA-only control were evenly spaced around the perimeter of the ceiling of the jar in a random order (Figure 1). High-resolution photographs were taken of the snail feeding trial using a Canon 650D DSLR camera through a Canon 40 mm lens. One photograph was taken every 10 s. Shutter speeds were 1.3 s duration through the dark cycle (which caused some blurring when snails were moving) and 0.008 s during the light cycle.

The still images of the feeding trial were assembled into an animated movie in Adobe Premiere Pro. A snail was scored as being associated with food if its head was on a food item. Preference for a particular food item was visualized using the forage ratio,  $F = r/p$ , where  $r$  is the proportion of time associated with a particular food item and  $p$  is the proportion of that food item amongst all food choices (Savage 1931; Manly et al. 2002). A food item with a forage ratio  $< 1$  is considered to be avoided and  $> 1$  is preferred. The significance of food selection was tested using the 'compana' command of package (adehabitatHS) in  $r$  (Calenge 2006). This is a routine used to assess resource preference in animals, such as food preferences (Aebischer et al. 1993, Soininen et al 2013) in which log ratios of proportions of food visited relative to food availability are tested against other food choices to assess if they are distinct (Aebischer et al. 1993). This multivariate test is performed by Wilks'-Lambda, which provides a value that indicates the proportion of variance that is not explained by differences among groups. Subsequently a ranking matrix is built by the compana command, which formally clusters food choices by time spent in contact with them and then ranks these choices against available food options (Aebischer et al. 1993). Analyses are available as an .r file in Supplementary materials.

## Results

### Diversity of the *ex situ* diet

A total of 619,996 high quality DNA sequence reads were obtained from the 1/10th Illumina Miseq run of ITS1-barcoding genes amplified from feces from the HTSCL (NCBI SRA accession XXXXXXXX). The diversity of food items in the *ex situ* facility was  $0.700 \pm 0.042$  (S.E.M) and is significantly lower than that observed in snail feces sampled from the wild  $0.914 \pm 0.010$  (S.E.M)  $W=747$  and  $p=9.1 \times 10^{-9}$ . Differences were driven by a single OTU: "OTU\_1" which dominated the dataset and accounted for 38.6% of the reads (Figure 2A). In comparison OTU\_1 accounted for only 1.33% DNA sequence reads of wild snails (Figure 2B). DNA of OTU\_1 was 100% identical to the *Cladosporium* species that is used to supplement the diet of snails in culture.

### Feeding trials

Individual snails spent a disproportionate amount of time on a single food choice (Figure 3). Although there was no single food type that all snails preferred, there was a distinct set of preferred or avoided food choices with a low Wilks'-lambda value of 0.03 ( $p=0.002$ ) which demonstrates that there were large and significant differences in how much time a snail spent with each particular food choice. Compositional analysis, which was used to cluster and rank food choices based on how frequently snails visited them, found that there were three equally preferred food items: the PDA control, and the fungi *Botryosphaeria* and *Cladosporium* (Figure 3). Snails spent the greatest time on the PDA control on average (Figure 3). The bacteria from *Microbacterium* and *Micrococcus* occurred in the next cluster and had a forage ratio of  $\sim 1$ , which is indicative of no preference. All the other fungi and bacteria had a forage ratio  $<1$ , which is consistent with avoidance. Both *Bacillus* strains were clustered together in the most avoided grouping. The snails all spent less than 20 minutes with the *Bacillus* strains over the 24 hour trial, except for one snail which was associated with *Bacillus* strain 2 for 4.48 hours. While the PDA-only control was a preferred food type, the two bacterial strains of *Bacillus* sp. also acted as a control to test that the snails responses to similar food was consistent. Movie files in which *A. diaphana* are trialed on different foods can be viewed in supplementary materials. Snails were also placed on PDA medium and closely observed to confirm that they did feed on the medium (Movie file also in supplementary materials) and visual inspection of PDA controls for radula marks also confirmed that feeding had taken place.

## Discussion

### *Ex situ* diet

The Shannon diversity index of the diet of wild snails is significantly greater than that of cultured snails, which is due to the dominance of the *Cladosporium* "supplement" in the cultured diet. Therefore, the *Cladosporium* is less of a supplement and instead a major component of the diet of snails. We were concerned that after twenty-five years of cultivation, this isolate was no longer similar to wild strains due to contamination. However, we determined that this *Cladosporium* species is the sixth most common species of the snail diet in the wild (Figure 2).

### Feeding trials

Despite the superficial appearance that snails are indiscriminant feeders, we found that snails have significant food preferences. This result is similar to the discovery that aquatic snails are selective feeders despite the apparent evidence that they indiscriminately grazed periphyton (Brönmark 1989). Oahu tree snails were long believed to eat fungus. The basis for this determination, however, relied on microscopic analysis of fecal pellets (Pilsbry et al. 1912) in which fungi are more easily observed than smaller microbes. We found that classifying the snails as mycophagous is justified, because snails tended to avoid most bacteria tested. The bacteria, *Micrococcus* and *Microbacterium* were occasionally consumed and can be considered as "not repellent" if not attractive to snails (Figure 3). Both of these isolates are pigmented and belong to clades that do occur in the phyllosphere where pigments act as photo-protectants (Vorholt 2012), so it is plausible that snails do graze on these taxa in the wild. Of the fungi

offered to snails, they preferred the dark pigmented *Cladosporium* and *Botryosphaeria*, which are common colonists of leaves (Baker et al. 1979; Denman et al. 2003; van Niekerk et al. 2004), over either the *Cordyceps* or *Annulohyphoxylon*. These less preferred fungi are both typical members of a wild fungal assemblage but are not direct colonists of leaf surfaces, as *Cordyceps* are typically invertebrate pathogens and *Annulohyphoxylon* are pathogens of fungus. These data therefore suggest that tree snails do have a preference for particular microbes. There is no literature on how tree snails acquire preferences for foods, however studies of other pulmonate molluscs indicate that they can be conditioned to prefer food but also physiologically respond to particular components of food (Sahley et al. 1992; Desbuquois & Daguzan 2004). It is plausible that these particular snails preferred *Cladosporium* and *Botryosphaeria* because they had encountered them before.

That snails show some preference for particular food groups resolves an important long-standing ecological question about these lineages. In previous work it was found that the composition of the snail diet was similar to what was available to them (O'Rorke et al. 2014), but we were unable to resolve whether snails were truly indiscriminant feeders. Tree snails tend to be associated with particular host tree species (Meyer et al. 2014), which is also true of *Achatinella* snails (Price et al. n.d.). This host preference could be due to differences in the community composition of microbes that occur on those trees, even if those differences are subtle (O'Rorke et al. 2014).

When an endangered animal is in degraded habitat, or threatened by predation, it is common to translocate them to better or safer habitat. However, when translocation is used as a conservation measure it is frequently the case that animals attempt to return to an environment resembling that to which they are habituated (i.e. natal habitat preference induction, Stamps & Swaisgood 2007). This problematic phenomenon has been observed in *Achatinella* tree snails, which migrate when translocated (USFWS, 1993). Consequently, the recovery plan for *Achatinella* recommends that field workers should remain in the field with translocated snails for at least one week to monitor whether snails leave their new habitat, and return any that do (USFWS, 1993). That the present study indicates that snails have preferences for particular microbial foods suggests that translocating snails to environments to which they are habituated might reduce the chances of snails migrating away from translocation sites. Furthermore, if novel translocation sites can be manipulated so that the phyllosphere compositions resemble those of natal host trees, transplant fidelity may be improved. This is a topic requiring further research, because microbial manipulation could potentially reduce the labor effort associated with translocations.

#### *Consuming carbohydrate rich media*

A surprising result from the feeding trials was that snails preferred the control "PDA medium only" treatment over any treatment containing a microbial isolate on the PDA (Fig 2). PDA is the medium used to grow the *Cladosporium* food that is used for *ex situ* culture and is a very simple and high calorie medium that contains only potato extract and glucose (i.e., a western "junk food" diet). This

suggests that the current method of supplementing the *ex situ* diet with fungus on PDA should be re-evaluated, especially because the cultured fungus comprises such a high percentage of the snail diet (Figure 2). [Here might be a place to mention *Partula* culture, since they are provided with a dietary supplement that is high in carbohydrate. ]

*Achatinella mustelina* growth rates are more than two times faster when their diet of microbes grazed from wild sourced leaves is augmented by cultured fungus compared to when they feed on leaf microbes only (Kobayashi & Hadfield 1996). However, we don't know if increased growth rate is correlated with reproductive fitness of long-term survival of captive snails. The natural phyllosphere is a highly oligotrophic environment, and the snails have not evolved in an environment that provides calorie-rich simple carbohydrates for a sustained period as occurs in the *ex situ* enclosures. Very little research has been conducted on the effect of calorie intake on gastropods, and none on tree snails. However, it has been found that the egg laying activity of the snail *Biomphalaria glabrata* is reduced by 66% when fed on a carbohydrate rich diet compared to a control diet (Stanislowski & Becker 1979). It is also a common observation in model-animal systems that higher calorie intake has a detrimental effect on longevity, despite proximate gains in growth rate (Guarente & Kenyon 2000; Bishop & Guarente 2007).

Dietary supplementation is frequently used as a tool to manage the decline of wild animal populations, but recent criticism of this approach points to the need of frequent re-evaluation of whether supplementary feeding is having the intended ecosystem level results (Ewen *et al.*, 2014; Martínez-Abraín and Oro, 2013). The results of the present study indicate important next steps, such as developing a model tree snail system and to use this to determine if there is a similar reduction in fitness for endangered tree snails when fed a carbohydrate rich diet in captivity. It would also be beneficial to determine the energy requirements of these animals through respirometry to better match their energy needs to the energy content of the food with which they are provisioned. This would also be useful for evaluating the carrying capacity of habitats into which the snails are re-introduced.

## Conclusion

Hawaiian tree snails are under threat and translocating them to protected habitats and *ex situ* facilities is presently the best means to avoid extinction. However, the practice of provisioning captive bred snails with *Cladosporium* grown on PDA is clearly falling short of the objectives of making the *ex situ* habitat mimic that of the wild. *Cladosporium* is a disproportionately high component of their *ex situ* diet, and they preferentially feed on the PDA fungal growth media. Therefore there is a need to reevaluate how captive snails are fed, and to understand how deviating from their wild diet composition affects snail's long-term fitness. We suspect that increasing the diversity of snails' diets is a good initial conservation action. Understanding that snails have dietary preferences explains key behavioral and ecological traits of these animals, such as their patchy distributions in the wild and provides us with a valuable tool for

managing these animals in the future.

### Acknowledgements

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## Figures and Tables

**Table 1. Snail species sampled from *ex situ* facility.** Some of the species of endemic Hawaiian tree snails kept at the University of Hawaii Tree Snail Conservation Lab and the numbers of fecal samples collected from each for Illumina amplicon sequencing.

**Table 1**

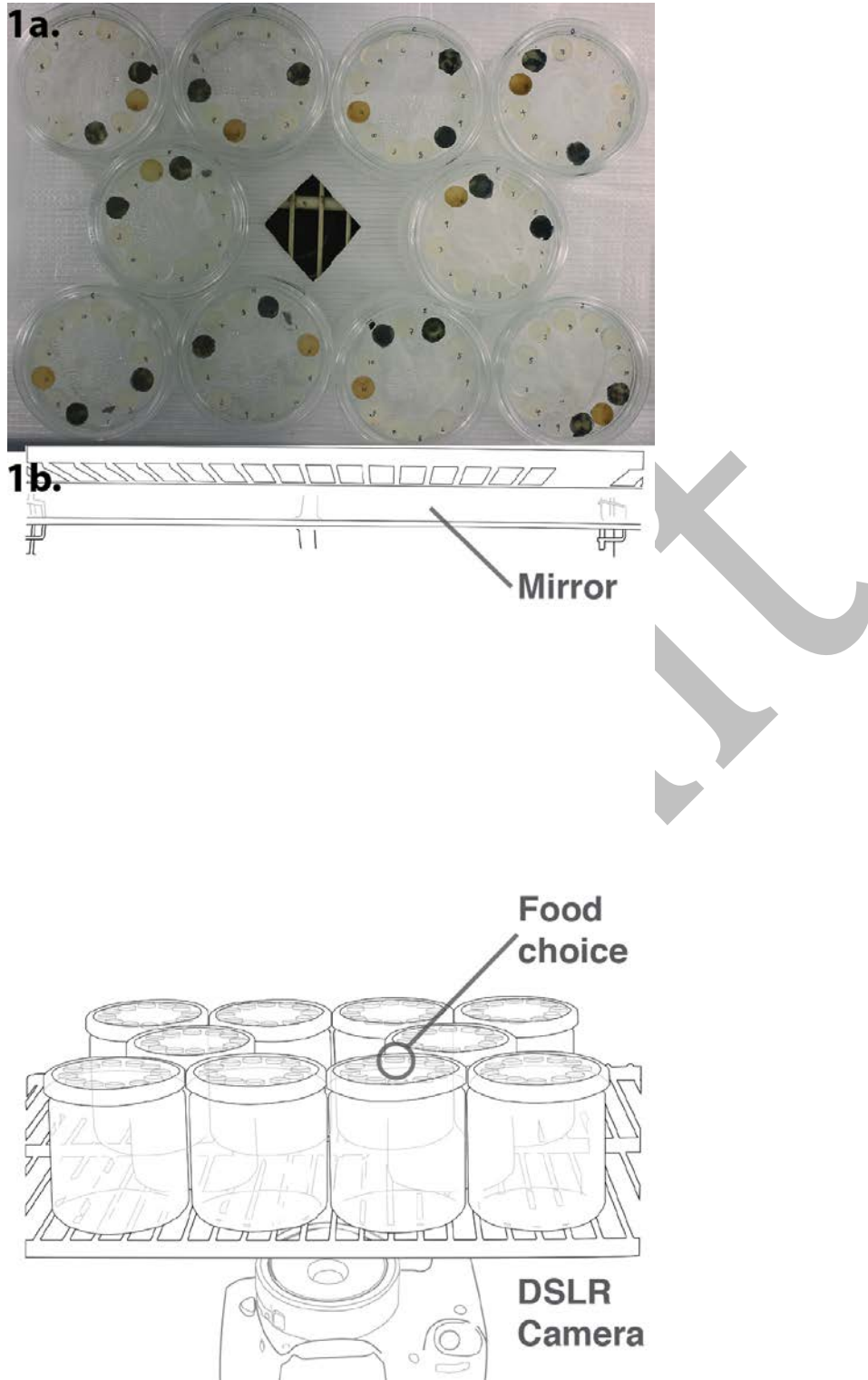
Snail species	Number of feces collected
<i>Achatinella apexfulva</i>	2
<i>A. decipiens</i>	1
<i>A. fulgens</i>	1
<i>A. fuscobasis</i>	5
<i>A. lila</i>	11
<i>A. livida</i>	2
<i>A. mustelina</i>	12
<i>A. sowerbyana</i>	1



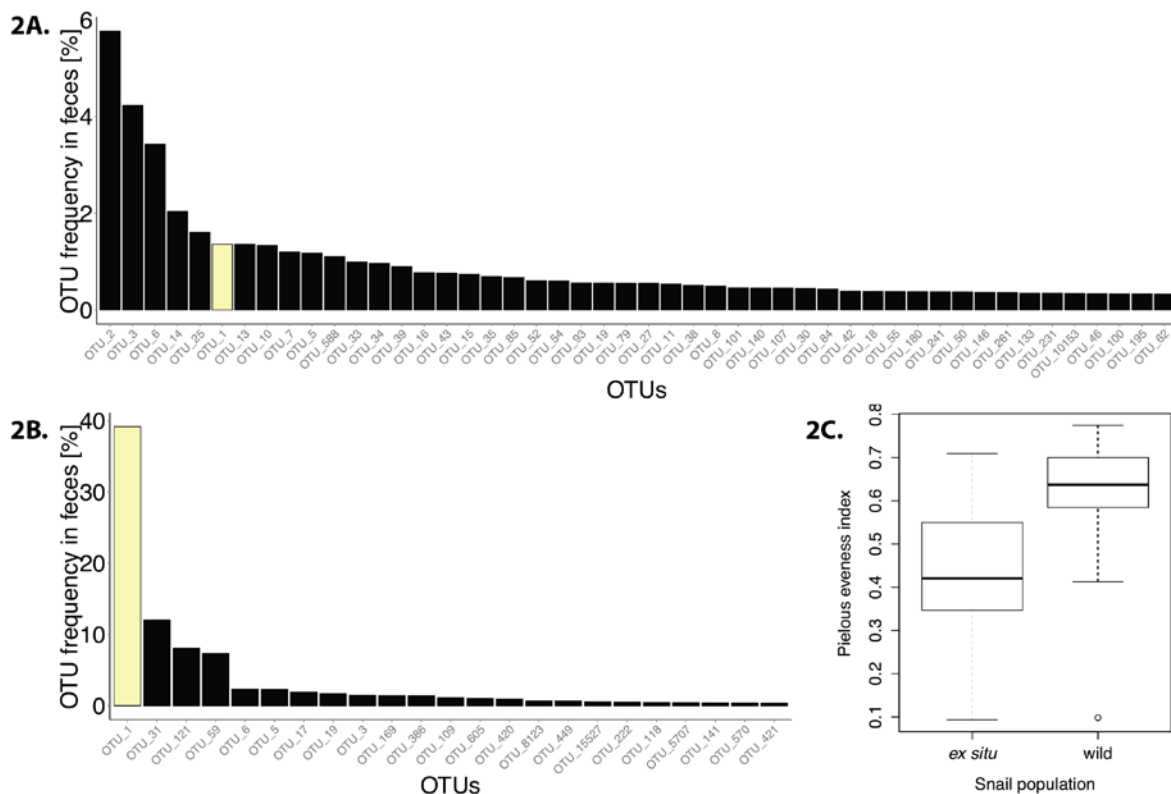
**Table 2. Microbial isolates used in feeding preference trial.** Isolates were obtained from either snail feces or leaf surfaces. The isolates from snail feces are assumed to either be undigested food or part of the gut microbiota. DNA sequences of the ITS1-ITS2 (Fungi) and 16S subregion (Bacteria) are available through NCBI.

**Table 2**

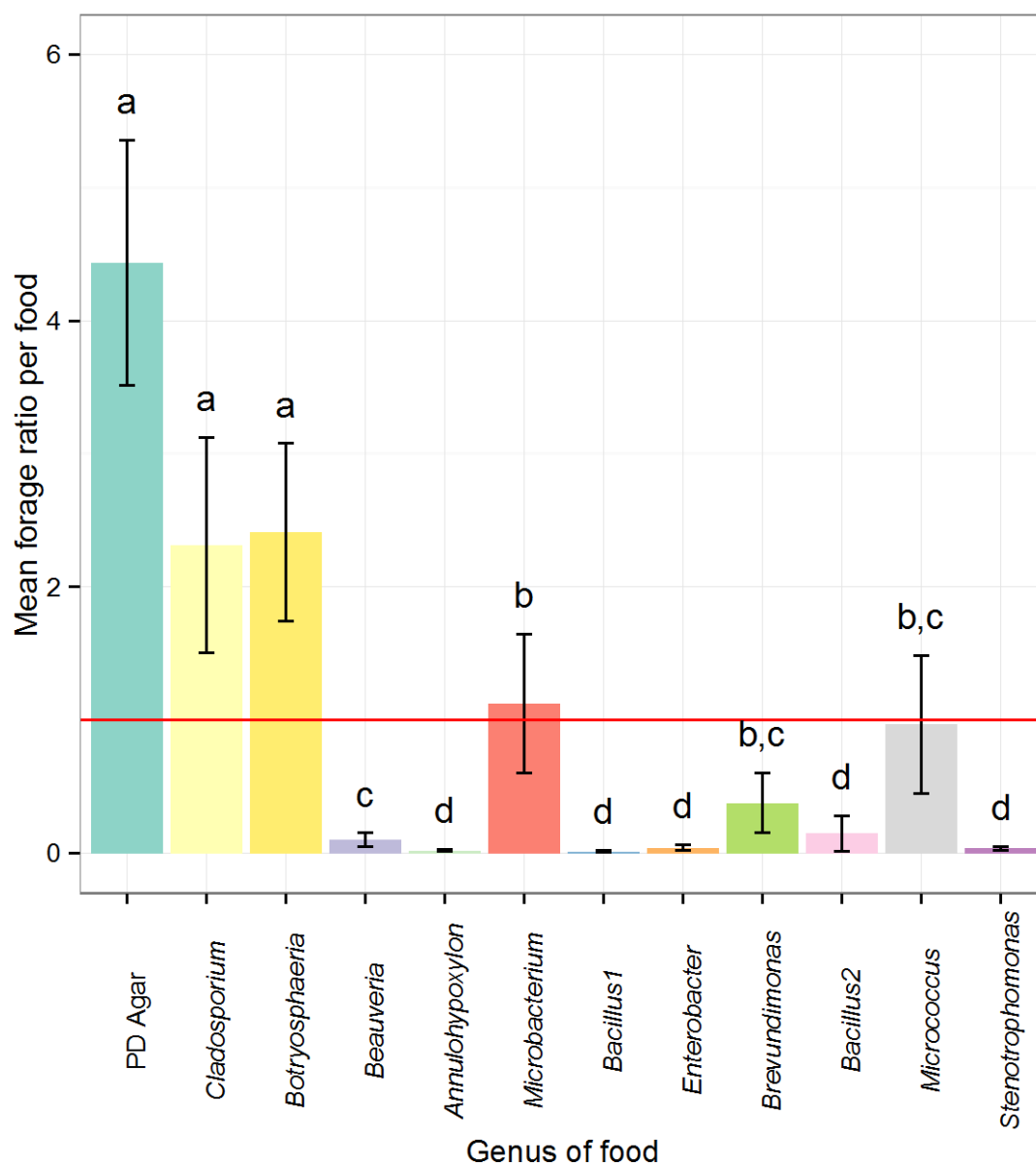
<b>Genus</b>	<b>ID</b>	<b>Source</b>	<b>Sampling location</b>	<b>NCBI Accession</b>
<i>Cladosporium</i>	RH1-01	Ohia Leaf	Mt Olympus	
<i>Beauveria</i>	PH_6	Snail Feces	Pu'u Hapapa	
<i>Microbacterium</i>	Kea_007	Snail Feces	Palikea	
<i>Bacillus</i> sp str 2	Kea_012	Snail Feces	Palikea	
<i>Enterobacter</i>	Kea_044	Snail Feces	Palikea	
<i>Brevundimonas</i>	Kea_041	Snail Feces	Palikea	
<i>Bacillus</i> sp str 2	Kea_043	Snail Feces	Palikea	
<i>Micrococcus</i>	Kea_013	Snail Feces	Palikea	
<i>Stenotrophomonas</i>	Kea_008	Snail Feces	Palikea	
<i>Annulohypoxylon</i>	RH1-04	Ohia Leaf	Mt Olympus	
<i>Botryosphaeria</i>	Kea_053	Snail Feces	Palikea	



**Figure 1. Experimental setup used to determine if snails do have feeding preferences.** Snails were fasted for 12 hours and then an individual snail was placed into one of each of ten jars. Twelve different food choices were placed around the perimeter of the underside of the lid of each jar. A digital single lens reflex (DSLR) camera was used to photograph the tops of the jars through a mirror, in order to record how much time each snail spent with each food option. Photographs were taken once every 10 s over 24 hr (12 hr dark 12 hr light) and then assembled into video clips for analyses. Movies are available in supplementary files (S1-S3).



**Figure 2. Ranked abundance of fungal OTUs from DNA sequences obtained from feces of a) wild and b) *ex situ* cultured snails and the c) evenness of food composition in diet (note the difference in scale). (2A) Wild populations of *Achatinella mustelina* have a diverse diet with no diet items dominating their gut content, (2B) the snails in the *ex situ* facility have a diet that is dominated by a single *Cladosporium* OTU (highlighted yellow), which took up 38.6% of the sequenced reads from the feces of cultured snails. This OTU also occurred in the wild (highlighted in yellow), but its overall abundance was 1.33%. (2C) The evenness of the diet composition of wild populations is less dispersed than for *ex situ* cultured snails.**



**Figure 3. Feeding preferences of snails.** A forage ratio above one (the red line) indicates a favored resource and less than one is an avoided item. The “food” offered to snails was an agar only control, then four fungi and the seven samples to the right of the graph are bacteria, Labels above bars are the results of compositional analysis of preference (Aebischer et al. 1993) and food ranked with an “a” are co-preferred, those with “b” are the next preferred group and those with a “c” and “d” are the next preferred groups respectively.

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### Accomplishments

DNA samples from Fifteen *Achatinella mustelina* populations and one *Partulina redfieldi* population (for use as an outgroup in phylogenetic analyses) were prepared using the ezRAD method and sequenced on the Illumina Miseq platform. Several bioinformatic processes have been accomplished so far. First, we have obtained about 80% of the mitochondrial genome for all 16 populations. After performing a de novo assembly and blasting the resulting contigs against the SwisProt database, we identified over 1000 protein-coding regions from across the genome. Finally, we used a program called Seanome to identify thousands of SNPs across the genomes of eight populations from ESUs A – C. GIS modeling of the projected range shifts for *Achatinella mustelina* has been refined. It still predicts a much-reduced range by the year 2080, with the species largely restricted to the area surrounding and including Mt. Ka'ala.

### Forecast

Continued work with SNP identification and Fst-outlier analysis will be used to identify SNPs correlated with environmental variables. These data will be combined with the species' current range data, as well as forecast data, to predict where populations will be likely to tolerate warmer, drier conditions, and which populations should be combined to maximize adaptive ability. GIS modeling will also be scaled down to the level of ESUs.

**Microhabitat heterogeneity and a non-native avian frugivore drive the population dynamics of an island endemic shrub, *Cyrtandra dentata***

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**Abstract**

Non-native frugivores can drastically reduce the population growth rate of localized endemic plants by dispersing fruits away from the population to unfavorable environmental conditions for seedling establishment. For localized endemic plants, fine-scale changes in microhabitat conditions can further limit population persistence. In this study, we used four years of demographic data to develop matrix projection models for a long-lived shrub, *Cyrtandra dentata*, which is endemic to the island of O‘ahu in Hawai‘i. This endemic shrub experiences frugivory by a non-native bird, red-billed leiothrix (*Leiothrix lutea*). Furthermore, seedling establishment of *C. dentata* was proportionally greater on talus rocky outcrops covered by moss, relative to soil. We examined the combined influences of frugivory by red-billed leiothrix and microhabitat heterogeneity on the population dynamics of *C. dentata*. Frugivory by red-billed leiothrix had a negative influence on population growth rate. Under the current level of frugivory at the field site, however, the *C. dentata* population was projected to persist in the long-term. The removal of optimum seedling microhabitat (i.e., rocky outcrops) reduced the population growth rate from growing to declining. Survival of mature plants had the greatest influence on long-term population dynamics, followed by the growth of seedlings and immature plants. The importance of mature plant survival was even greater when we simulated the combined effect of frugivory and the loss of optimal microhabitat, relative to population dynamics based on current field conditions. However, in the short-term (10 years), earlier life stages had the greatest relative influence on population growth rate. From a management perspective, these results indicate that it is critical to

maintain current levels of mature plants survival and seedlings establishment in order to ensure population persistence. Our findings emphasize the need to account for multiple environmental stressors when planning and prioritizing rare plant restoration.

## **Introduction**

The spatial distribution and abundance of plant populations are shaped by plant interactions with the environment. Human-induced changes in abiotic conditions and biotic factors (i.e., environmental stressors) can negatively influence demographic vital rates and population dynamics. Recent research suggests that plant endangerment is the result of the combined influence of multiple environmental stressors (Brook et al. 2008; Didham et al. 2007; Sala et al. 2000). To explicitly evaluate the individual or combined influence of targeted environmental stressors on population growth rate requires a demographic modeling approach (Morris & Doak 2002). Many demographic studies have quantified the individual influence of various environmental stressors on plant population dynamics. However, few studies have focused on the simultaneous effects of multiple environmental stressors (Dahlgren & Ehrlén 2009; Davies et al. 2004; Knight 2004; Souther & McGraw 2014; von Euler et al. 2014).

Tropical islands are biodiversity hotspots and, unfortunately, have some of the highest rates of extinction and species endangerment. For these reasons, tropical island ecosystems are often ranked as high conservation priority (Mittermeier et al. 1998; Myers et al. 2000). The high rates of extinction and species endangerment on islands are due, in part, to the sheer number of localized endemic species (Brigham & Schwartz 2003; Gilpin & Soule 1986; Menges 1990; Shaffer 1981). As a consequence of their limited



ranges, island endemic plants are typically adapted to narrow ecological niches (Lesica et al. 2006), making them more sensitive to changing environmental conditions, relative to common widespread species. As a consequence, even small-scale changes in the environment may have a disproportionately large effect on the population persistence of island plants. Thus, to effectively manage endangered species in an island context, it is critical to understand how changing environmental conditions influence population persistence (Mittermeier et al. 1998; Myers et al. 2000). Surprisingly, the demographic consequence of plant interactions with environmental stressors is rarely studied for localized island endemic species (Krushelnycky et al. 2013; Simmons et al. 2012).

A primary environmental driver of biodiversity loss on islands is the introduction of non-native plants and animals (Gillespie & Clague 2009; Wilcove et al. 1998). One of the most ubiquitous pests to island ecosystems is non-native frugivores (Harper 1977; Meyer & Butaud 2009; Pender et al. 2013; Shiels & Drake 2011). Removal of fruits from a population to microsites that are unfavorable for seed germination and establishment can lead to localized recruitment depression (Godínez-Alvarez et al. 2002; Loayza & Knight 2010). In contrast, if seeds are not destroyed following consumption and they are deposited on suitable habitat for establishment, non-native frugivores could actually have a positive influence on plant fitness by increasing gene flow between isolated plant populations (Bacles et al. 2006; Howe 1986; Slatkin 1985). Island species are also threatened by habitat degradation and human induced changes in abiotic conditions (Wilcove et al. 1998). Altered abiotic conditions, such as a reduction in the availability of optimal microhabitats, can have a particularly pronounced impact on seedling establishment (Dostálek & Münzbergová 2013; Eriksson & Ehrlén 1992; Fetcher et al.

1983). The suitability of microhabitat for seedling establishment can be highly variable among species. Important characteristics of optimal microhabitats for seedling establishment include light availability (Denslow 1980), substrate characteristics (Dostálek & Münzbergová 2013), low disturbance (Eriksson & Ehrlen 1992), and sufficient water availability (Fetcher et al. 1983).

In this study, we investigated the combined effects of abiotic and biotic environmental stressors on the dynamics of a localized endemic shrub, *Cyrtandra dentata* St. John & Storey (Gesneriaceae), confined to a narrow ecological threshold on the Island of O‘ahu in Hawai‘i. *Cyrtandra dentata* experiences frugivory by a non-native bird, the red-billed leiothrix. Given the nomadic nature of red-billed leiothrix during peak *C. dentata* fruiting season and the narrow ecological conditions and size of *C. dentata* populations, it is likely that red-billed leiothrix disperse fruits away from localized populations to unfavorable conditions for seedling establishment. In addition, a higher proportion of *C. dentata* plants are rooted on rocky outcrops covered by moss, relative to soil (L. Bialic-Murphy, *unpublished data*). We therefore considered rocky outcrops as a potential optimal microhabitat and asked the following research questions: (i) Do seed frugivory by red-billed leiothrix and removal of optimal microhabitat influence the short and long-term population dynamics of *C. dentata*? (ii) Under what combination of these stressors does *C. dentata* maintain positive population growth over the short and long-term? (iii) What life stages and associated vital rates have the greatest influence on population growth rate over the short and long-term? (iv) Do the intensity of these stressors influence the relative importance of life stages and associated vital rates on the short and long-term population growth rates?

## Materials and methods

### *Study species*

*Cyrtandra dentata* is a federally endangered shrub endemic to the island of O‘ahu in Hawai‘i. *Cyrtandra dentata* reaches 1.5–5 m at maturity and produces white subumbelliform cymes, 3–9 cm long with white ovate berries, 1–2.6 cm long (Wagner et al. 1999). The reproductive biology of *C. dentata* is poorly understood, but the white flowers it produces suggest it is moth pollinated. Furthermore, the fleshy berries are indicative of frugivorous bird dispersal (OANRP 2003b). Flowers and fruit are produced year round with peak fruiting in September and October (L. Bialic-Murphy, *unpublished data*).

*Cyrtandra dentata* historically spanned the northern Wai‘anae Mountains and the leeward side of the northern Ko‘olau Mountains on the island of O‘ahu, 300–610 m in elevation (Wagner et al. 1999). The typical habitat is shady gulch bottoms of mesic to wet forests. In 1996, *C. dentata* was listed as federally endangered and by 2010, it was restricted to seven geographically isolated locations (USFWS 2012).

### *Study site and management history*

We studied the demography of *C. dentata* in the Kahanahāiki Management Unit (36 ha), located in the northern Wai‘anae Mountain Range, on the island of O‘ahu (21° 32’ N, -158°12’ W). Kahanahāiki is a tropical mesic forest with a mix of native and non-native flora and fauna. The mean monthly rainfall is 53–227 mm (Giambelluca et al. 2013), and the mean daily temperature range is 16–24 °C (Shiels & Drake 2011). The

Kahanahāiki population is one of the two largest relictual *C. dentata* populations, in both numerical size and demographic structure. The population is located in the main Kahanahāiki drainage, spanning from the base of a seasonal waterfall to approximately 150 meters to the north. Within this area, the plants are concentrated in the gulch bottom and along the steep, mossy rock walls.

Since 1995, the Kahanahāiki *C. dentata* population has been actively managed by the O‘ahu Army Natural Resources Program (OANRP) as part of a larger mitigation effort to offset the potential impact of military training operations on 89 rare plants and animals. In 1996, OANRP constructed the Kahanahāiki fence to protect *C. dentata* and eleven other managed taxa from feral pigs (*Sus scrofa*). The removal of *S. scrofa* from Kahanahāiki was completed by 1998. That same year, OANRP initiated weed control of ecosystem-altering non-native vegetation (OANRP 2009). Feral ungulates directly impact all life stages of many native and introduced species through their physical disturbance to the forest. In general, native seedlings, saplings, and mature plants increase in frequency and density following fencing and feral pig removal (Busby et al. 2010; Cole et al. 2012; Kellner et al. 2011; Loh & Tunison 1999). Non-native plants are a threat through their competitive displacement of native plants (Minden et al. 2010; Ostertag et al. 2009; Vitousek 1996). Following the suppression of these top-down stressors (feral pig removal and weed control) in the Kahanahāiki fence, *C. dentata* started establishing at higher rates leading to greater numbers of seedlings and small juvenile plants (M. Kiehn, *unpublished data*).

*Demography data and projection matrix model*

In 2010, at the start of this study, the Kahanahāiki *C. dentata* population consisted of 45 mature plants, 158 immature, and 600 seedlings. For four consecutive years (2010–2014), we permanently tagged and monitored a subset of plants in the population annually. To ensure our effects on its habitat were minimal, we did not tag all the individual plants in the population. The life cycle of *C. dentata* was divided into four biologically discrete life stages: mature ( $> 80$  cm), large immature (20 cm–80 cm), small immature (2 cm–20 cm) plants, and seedling ( $< 2$  cm) (Figure 1). Since there were few plants in the mature and large immature life stages, all individuals in those life stages were permanently tagged. For the small immature and seedling life stages, a random sample of 60–75 plants was permanently tagged. Individual plants  $> 10$  cm in height were tagged with an aluminum tag while plants  $< 10$  cm in height were marked using numbered pin flags, placed five cm upslope from the plants. Seedlings growing on rocky outcrops covered by moss were marked using florescent-colored buttons, glued to the rocks 5 cm above each plant. For each tagged plant, we collected data on height to apical meristem (when possible), reproductive status, and vigor (classified as either healthy, moderate, poor, or dead).



Figure 1: Typical laceration markings on the remaining pericarp of mature *C. dentata* fruits. Incisor marks (white arrows) are indicative of fruit consumption by birds. The subset of tagged fruit likely consumed by red-billed leiothrix, given they were the only animal that were detected perching on *C. dentata* by the infrared image cameras.

We used these field data to estimate the survival, growth, and fecundity rates for each life stage and parameterize a matrix projection model (Caswell 2001):

$$\mathbf{n}(t + 1) = \mathbf{A}\mathbf{n}(t) \quad (1)$$

where the vector  $\mathbf{n}(t)$  represented the number of plants in four discrete life stages at time  $t$  and  $\mathbf{n}(t + 1)$  was the number of plants in each life stage the following year. The transition matrix  $\mathbf{A}$  was composed of eight non-zero matrix elements ( $a_{ij}$ ), which represented the transition probabilities of the seedling ( $s$ ), small immature ( $si$ ), large immature ( $li$ ), mature ( $m$ ) life stages from time  $t$  to  $t + 1$ :

$$\mathbf{A} = \begin{pmatrix} \sigma_s(1 - \gamma_s) & 0 & 0 & \phi_m \\ \sigma_s\gamma_s & \sigma_{si}(1 - \gamma_{si}) & 0 & 0 \\ 0 & \sigma_{si}\gamma_{si} & \sigma_{li}(1 - \gamma_{li}) & 0 \\ 0 & 0 & \sigma_{li}\gamma_{li} & \sigma_m \end{pmatrix}$$

Matrix **A** was parameterized to include the probability of survival ( $\sigma_i$ ), growth to the next stage class ( $\gamma_i$ ), and mature to seedling transition ( $\varphi_m$ ). The mature to seedling transition ( $\varphi_m$ ) was calculated by dividing the number of seedlings counted in a given year by the number of mature plants the previous year. The dominant eigenvalue of matrix **A** was the long-term population growth rate,  $\lambda$ . We omitted the survival of matures ( $\sigma_m = 47\%$ ) in 2011–2012 from our analyses because of mortality that was likely caused by unintentional herbicide drift. The impact of herbicide drift on mature plants was based on qualitative field observations. Mature plants wilted and shed their leaves two weeks after the control of ecosystem altering vegetation, which occurred directly around the plants. Since mortality from herbicide drift was not expected to occur in the future, we excluded it for analytical purposes. Instead, we calculated the mean survival of mature plants in 2010–2011, 2012–2013, and 2013–2014 and used it as the survival rate for the 2011–2012 matrix, using element selection. This matrix captures the population demographic transitions under management of feral pigs and invasive plant competition while including frugivory by red-billed leiothrix.

*Simulating the effects of microhabitat heterogeneity and frugivory*

To simulate the effects of microhabitat heterogeneity and seed consumption by red-billed leiothrix on the dynamics of the *C. dentata* population, we constructed three additional matrices **B**, **C**, and **D** by modifying matrix **A**, discussed above. Frugivory by red-billed leiothrix and the availability of optimal microhabitat impacted the mature to seedling transition  $\varphi_m$  of matrix **A** (see sections: Results, *Microhabitat heterogeneity and frugivory by non-native avifauna*). Thus, to construct matrix **B**, which captures the

removal of frugivory, we increased the  $\varphi_m$  element of matrix **A** by the percentage of fruits consumed by red-billed leiothrix at our field site. To construct matrix **C**, which represents suboptimal microhabitat, we decreased the  $\varphi_m$  element of matrix **B** by the difference in seedling establishment between the optimal and suboptimal microhabitat. Lastly, to construct matrix **D**, which simulates the influence of both stressors (i.e., frugivory and suboptimal microhabitat), we decreased  $\varphi_m$  of matrix **A** by the percent difference in seedling establishment between the optimal and suboptimal microhabitat.

#### *Frugivory by red-billed leiothrix*

To determine if red-billed leiothrix were the only frugivore consuming *C. dentata* fruits, we installed four infrared image cameras (Moultrie Game Spy D40, Moultrie Products, LLC, Alabama, USA) at the study site during the peak *C. dentata* 2011 fruiting season. Each infrared camera was attached to a stake, positioned 2 meters away from a mature plant, and focused on fruiting branches. The cameras were checked once a week for one month, from mid-August to mid-September 2011. The images were reviewed, and fruit visitation was recorded. During the fifteen monitoring dates, red-billed leiothrix was the only frugivore photographed. Thus, we assumed red-billed leiothrix was the only frugivore consuming *C. dentata* fruits. In Hawai'i, the home range of red-billed leiothrix is 3.07 ha  $\pm$  0.32 for males and 2.68 ha  $\pm$  0.27 for females (Male et al. 1998), being more nomadic during the non-breeding season (March - June). Given the size of the *C. dentata* population (> 0.075 ha) and the nomadic nature of red-billed leiothrix during peak *C. dentata* fruiting season, we assumed 100% of the fruits consumed by red-billed leiothrix were dispersed away from the population.



To measure the effect of frugivory by red-billed leiothrix on the *C. dentata* population dynamics (for matrices **B** and **C**), we randomly selected five mature plants. On each plant, four mature fruits were randomly tagged and monitored for a month, starting in mid-August of 2011. To identify the fruits in subsequent visits, we tied orange thread to the petiole of each fruit. We identified the animal species that consumed the fruit by examining the incisor marks on the remaining pericarp (Figure 1). The total number of fruits that was partially or fully consumed was counted each visit. Fruits that were not consumed following maturation and abscission from the plant were found on the forest floor with the orange string still attached. We then estimated the percent fruits that were consumed. The percent of fruits consumed by red-billed leiothrix were used to create matrix **B** and **C**.

#### *Microhabitat heterogeneity*

Preliminary observations suggested that *C. dentata* recruit preferentially on rocky outcrops (L. Bialic-Murphy, *unpublished data*). To determine if microhabitat heterogeneity influence vital rates and population dynamics of *C. dentata*, we first classified microhabitats as optimal (i.e., rocky outcrops) and suboptimal (i.e., soil). Then, we collected additional field data to determine the probability of survival, growth, and fertility in these two microhabitats. To quantify potential differences in survival and growth for each life stages by microhabitat, we recorded the rooting substrate for each tagged plants from 2010–2014. To evaluate the effect of microhabitat on seedling establishment, we first quantified the proportion of the study site that was covered by each microhabitat classification by installing ten 1m x 1m quadrats directly underneath

randomly selected mature plants. For each quadrat, we recorded the total number of seedlings established and visually estimated the percent cover of rocky outcrops covered by moss and soil. These data were then used to calculate the expected and observed seedling establishment rates by microhabitat. We assumed the percentage of total seedlings that established on each microhabitat classification would be equal to the percent cover by microhabitat, if there were no difference in microhabitat suitability. The difference in the expected and observed establishment rates of seedling by microhabitat were used to create matrices **C** and **D**.

*Stochastic long-term population dynamics*

Matrices **B**, **C**, and **D** simulated the changes in the mature to seedling transition  $\varphi_m$  element of matrix **A**. However, other demographic processes are subject to temporal variation due to changes in environmental conditions. Thus, to incorporate the effect of environmental stochasticity on population dynamics, we used the four years of demographic data to develop temporally varying stochastic matrix models for each of the scenario **A**, **B**, **C**, and **D** previously defined:

$$\mathbf{n}(t + 1) = \mathbf{X}(t)\mathbf{n}(t) \quad (2)$$

where  $\mathbf{X}(t)$  is a random population projection selected at given time  $t$  from a pool of four yearly matrix transitions (2010–2011, 2011–2012, 2012–2013, and 2013–2014) for the correspondent scenario (**A**, **B**, **C**, and **D**). The yearly matrices had an equal probability of being selected each iteration. We assumed the time-varying model followed an identically independent distribution (*i.i.d*). For each scenario, we calculated the stochastic

growth rate ( $\lambda_s$ ) with 95% confidence intervals by simulation using 10,000 iterations, following Tuljapurkar et al. (2003):

$$\log \lambda_s = \lim_{t \rightarrow \infty} \left( \frac{1}{t} \right) \log [P(t)/P(0)] \quad (3)$$

where  $P(t)$  is the population size, i.e., the sum of the elements of  $n(\square)$  at a given time  $t$ . To evaluate the individual and combined influence of microhabitat and seed consumption by red-billed leiothrix on population dynamics, we compared the  $\lambda_s$  of scenario **A**, **B**, **C**, and **D**. To identify the relative importance of different life stages on the stochastic population growth rate  $\lambda_s$  for each scenario, we calculated the elasticity  $E^{\mu S}$  of  $\lambda_s$  to perturbation of mean matrix elements  $\mu_{ij}$  following Tuljapurkar et al. (2003).

#### *Stochastic short-term population dynamics*

We calculated the stochastic short-term population growth rate for each of the management scenario **A**, **B**, **C**, and **D**, using the following formula:

$$r(t_1, t_{10}) = \frac{1}{t_{10}-t_1} \log \frac{N(t_{10})}{N(t_1)} \quad (4)$$

The transient population growth rate was iteratively calculated by simulation using 1,000 iterations. For a given year  $t$  ( $t < 10$ ), and for each management scenario, we randomly selected one of the four yearly transition matrices (2010–2011, 2011–2012, 2012–2013, and 2013–2014) with equal probability to account for the effect of environmental variability. We used the observed population size in 2014 as the initial stage structure,  $n(0)$ , and the projected timeframe of 10 years. The timeframe of  $t = 10$  years was used because it is the recommended timeframe to evaluate population dynamics of critically endangered plants by the IUCN red listing guideline (IUCN 2001) and a reasonable length of time of a restoration management plan.

Since the number of mature plants in a population is often used to define restoration goals, we also projected the number of matures at  $t = 10$  years for each of the management scenarios **A**, **B**, **C**, and **D**, using the solution of eqn (2). This projection accounts for the effect of environmental variability in our estimate of the projected population size at  $t = 10$  years. The number of mature plants was iteratively calculated by simulation using 1,000 iterations, multiplying the number of matures at given time  $t$ , starting with  $n(0)$ , by the matrix  $\mathbf{X}(t)$ , a random variable of matrices. Furthermore, to quantify the probability of the number of matures at  $n(10)$  dropping below two predefined thresholds (25 and 50 matures), we divided the number of iterations that were less than the defined number of matures by the total number of iterations. We selected 25 and 50 matures as the numerical thresholds because they are commonly used short-term restoration goals, which were based on previous studies that found those numerical values were sufficient to prevent short-term population extinction in some scenarios (Hartl & Clark 1998; Shaffer 1981). We considered <5% low probability of dropping below the defined thresholds.

To identify the relative importance of life stages on the short-term population growth rate, we conducted stochastic transient elasticity analyses with respect to small changes in matrix elements to unperturbed stage structure,  $e_{1,i,j}$  (Haridas & Gerber 2010; Haridas & Tuljapurkar 2007). The  $e_{1,i,j}$  distribution for each scenario (**A**, **B**, **C**, and **D**), was iteratively calculated by simulation, using 1,000 iterations. The four yearly transition matrices,  $\mathbf{X}(t)$ , were selected with equal probability each iteration.

## Results

*Frugivory by red-billed leiothrix and microhabitat heterogeneity*

Of the 20 monitored fruits, two were partially consumed (approximately 20% of one and 25% of the other, Figure 1). The observed incisor lacerations on the remaining pericarp of mature fruits were indicative of bird consumption (Figure 1). Given that the red-billed leiothrix was the only frugivore detected perching on *C. dentata*, using the infrared image cameras, we assumed it was the culprit of all fruit consumption. In addition, seedling establishment was 65% greater on rocky outcrops than on soil ( $\chi^2 = 18$ ,  $P < 0.0001$ ). However, the other life stages and associated vital rates did not differ significantly between rocky outcrops and soil. These results suggest that the fine-scale patchy distribution of *C. dentata* plants was driven by differences in seedling establishment and rocky outcrops is an optimal microhabitat for seedling establishment.

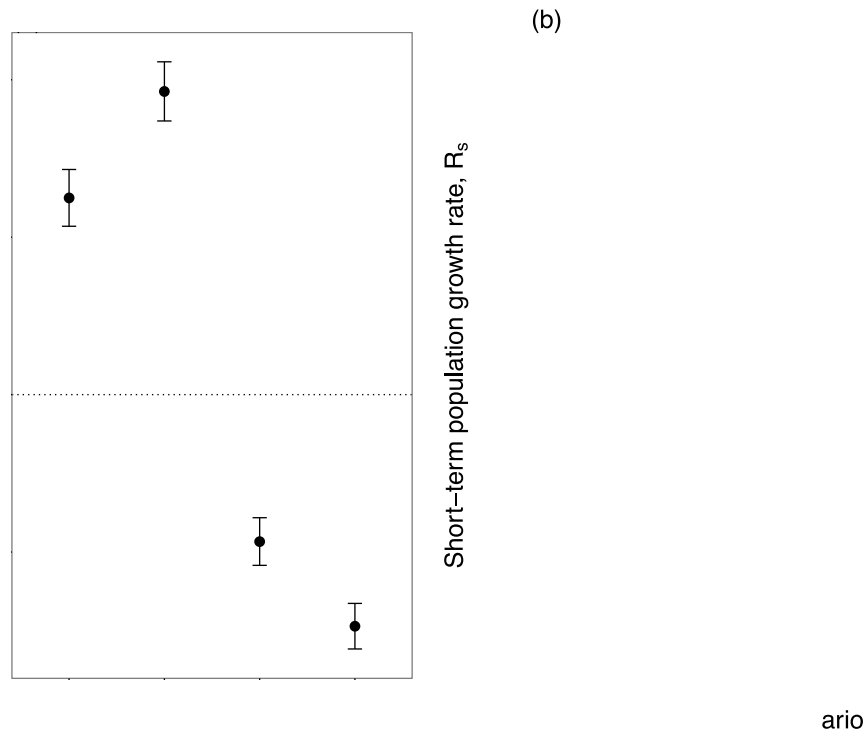


Figure 2: Stochastic short ( $R_s$ ) and long-term ( $\lambda_s$ ) population growth rates of *C. dentata* with 95% confidence intervals. Scenario **A** = Field conditions, **B** = No frugivory, **C** = Suboptimal microhabitat, **D** = Frugivory and suboptimal microhabitat.

### *Stochastic long-term population growth rates*

The stochastic growth rate of the *C. dentata* population, based on field conditions (matrix **A**), was positive ( $\lambda_s = 1.032$ , 95% CI [1.028–1.037]), indicating a moderately growing population in the long-term (Figure 2a). Removal of frugivory by red-billed leiothrix, scenario (**B**), increased the stochastic population growth rate by 1.7% ( $\lambda_s = 1.049$ , 95% CI [1.045–1.055]), relative to scenario **A** (Figure 2a). Under suboptimal microhabitat conditions, scenario (**C**), the population growth rate shifted from positive to negative ( $\lambda_s = 0.976$ , 95% CI [0.971–0.979]). The combined influence of both stressors (scenario **D**) decreased the stochastic population growth rate ( $\lambda_s = 0.963$ , 95% CI [0.960–0.967]) and led to a declining population trajectory (Figure 2a).

*Stochastic short-term population growth rates*

Over the short-term, the *C. dentata* population was projected to grow moderately ( $r_s = 1.085$ , 95% CI [1.081–1.089]; Figure 2b), to a total of 58 mature plants within the next 10 years (Figure 3). Similar to long-term projections, suppression of red billed-leiothrix increased the short-term population growth rate ( $r_s = 1.120$ , 95% CI [1.116–1.125]), with a mean of 64 mature individuals at  $t = 10$  years. Removal of optimal microhabitat reduced the short-term population growth rate ( $r_s = 0.984$ , 95% CI [0.980–0.987]), with a mean number of 40 mature individuals. The combined impact of frugivory from red-billed leiothrix and the removal of optimal microhabitat had the greatest negative impact on the population growth rate ( $r_s = 0.960$ , 95% CI [0.952–0.960]) with a population composed of the fewest number of mature plants (N=37) by the end of the 10-year period. For all four scenarios, there was high confidence that the population would be > 25 matures at  $t = 10$  and for scenario **A** and **B** there was high confidence the population would be > 50 matures at  $t = 10$ .

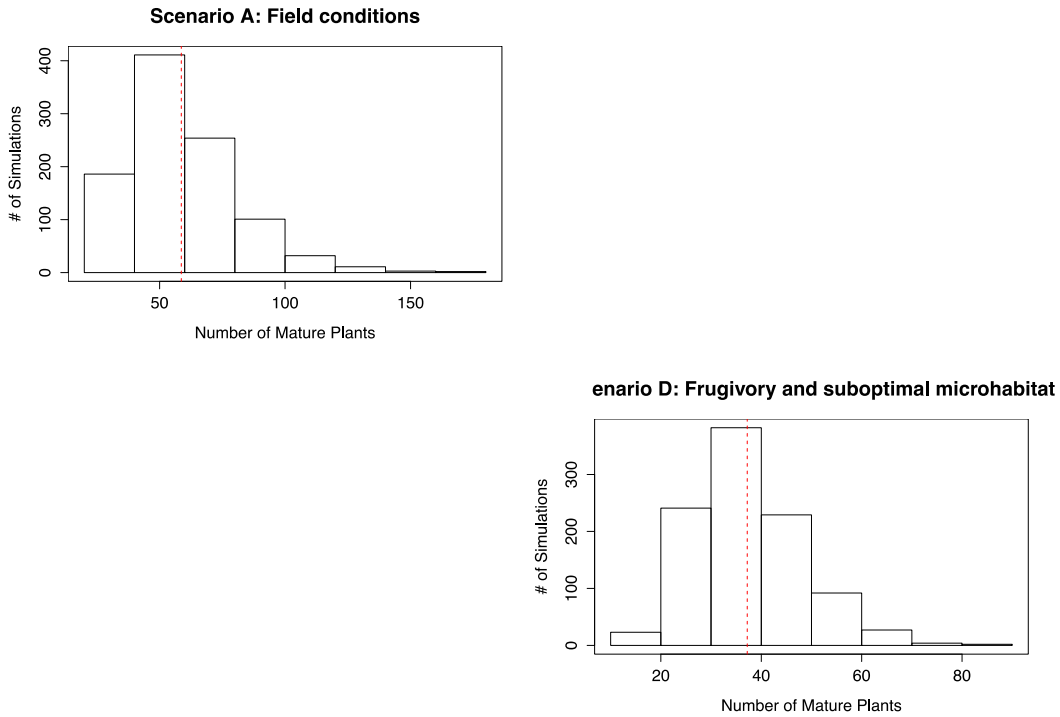


Figure 3: The projected number of mature *C. dentata* plants in 10 years for each scenario (A, B, C, and D). Red dash line indicates mean number of mature plants.

### *Stochastic short and long-term elasticity*

In the long-term, the survival of mature plants had the greatest proportional impact on the population growth rate, followed by the growth of seedlings, small immature, and large immature plants and fertility (Figure 4a). Under suboptimal microhabitat for seedling establishment and removal of seed consumption by the red-billed leiothrix increased the relative importance of the survival of mature plants on the long-term population growth rate. It also decreased the relative importance of the survival and growth of seedling, small immature, and large immature plants on the population growth rate (Figure 4a).



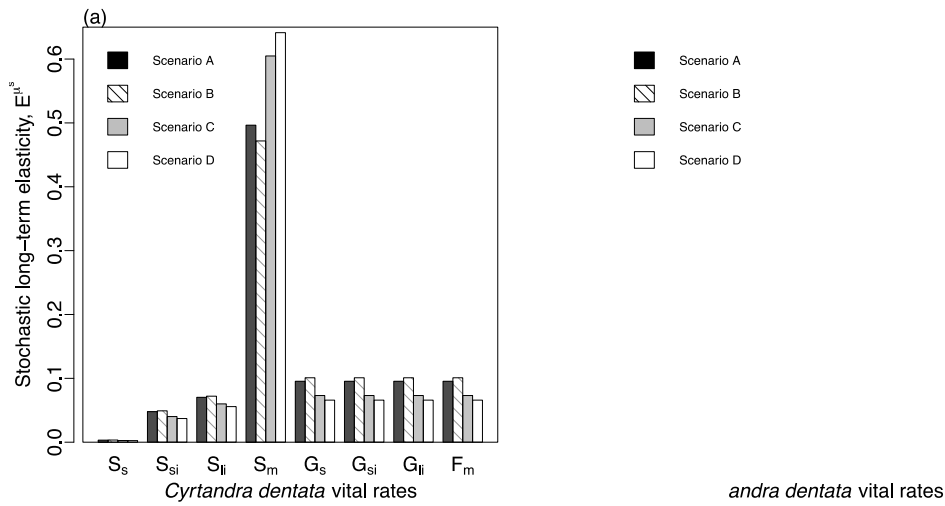


Figure 4: Stochastic elasticities of *C. dentata* (a) long- and (b) short-term growth rates to perturbation of mean vital rates. The vital rates are survival (S), growth (G), and fertility (F) and the life stages are seedling (*s*), small immature (*si*), large immature (*li*), and mature (*m*). Scenario **A** = Field conditions, **B** = No frugivory, **C** = Suboptimal microhabitat, **D** = Frugivory and suboptimal microhabitat.

In the short-term, the mature to seedling transition had the greatest relative importance for population growth rate, followed by the growth of seedlings to the small immature life stage (Figure 4b). The individual and combined impacts of seed consumption by red-billed leiothrix and removal of optimal microhabitat (scenario **A**, **C**, and **D**) reduced the relative importance of the mature to seedling transition and growth of seedlings to the small immature life stage (Figure 4b).

## **Discussion**

The influence of abiotic factors (e.g., light, soil type, elevation) on plant population dynamics has been well examined (Alvarez-Buylla et al. 1996; Brys et al. 2005; Colling & Matthies 2006; Dahlgren & Ehrlén 2009; Souther & McGraw 2014). However, the influence of frugivorous animals or the combined effects of frugivory and microhabitat heterogeneity on plant population dynamics are rarely measured, and studies on this topic have produced mixed results (Godínez-Alvarez & Jordano 2007; Loayza & Knight 2010). It is likely that, due to their relative isolation and limited size, islands are more likely to suffer stronger effects of multiple stressors. In this study, we found that rocky outcrops were an optimal microhabitat for *C. dentata* seedling establishment. Though the mechanism underpinning higher seedling establishment on rocky outcrops is unknown, previous research suggests that rocks covered by moss can maintain a moist microsite favorable for seedling establishment (Ren et al. 2010).

Under current field conditions (i.e., intensity of frugivory by red-billed leiothrix and microhabitat conditions at the field site), *C. dentata* was projected to persist in the long-term. Removing frugivory by red-billed leiothrix moderately increased the long-term

population growth rate, as compared to field conditions. Under suboptimal microhabitat conditions (i.e., removal of optimal microhabitat), long-term population growth rate was negative, regardless of whether or not frugivory by red-billed leiothrix was removed. These results suggest that for *C. dentata*, removal of microhabitat availability would have a greater influence on population dynamics than the current level of frugivory by red-billed leiothrix at the field site. Overall, the transient growth rate was slightly higher than the long-term growth rate. However, for each scenario, the projected direction of the short and long-term growth rates were not different. These results emphasize the importance of continually protecting optimal microhabitat conditions to maintain a positive population trajectory for endangered species. Furthermore, the influence of abiotic conditions on population persistence emphasizes the importance of selecting reintroduction sites with appropriate microhabitat for *C. dentata*, which will be necessary to delist this taxon following the United States Fish and Wildlife criteria (USFWS 1998).

For long-lived species, it is expected that later life stages will have a larger impact than earlier life stages on the long-term population growth rate (Haridas & Gerber 2010; Silvertown et al. 1993). The importance of later life stages on population dynamics of long-lived species is commonly explained by life history strategy. High survival of mature plants can insulate long-lived species from environmental variability and thus is the most important vital rate for maintaining population persistence in the long-term. However, recent research suggests that long-term elasticity does not always adequately describe the importance of life stages and associated vital rate in the short-term (Haridas & Gerber 2010; Haridas & Tuljapurkar 2007). In some scenarios, earlier life stages disproportionately contributed to the short-term population growth rate of long-lived

species, relative to later life stages (Gaoue 2015; Haridas & Gerber 2010; Haridas & Tuljapurkar 2007; McMahon & Metcalf 2008). Consistent with these studies, we also found a shift in the short and long-term elasticity patterns of the *C. dentata* population growth rate to perturbation of vital rates. *Cyrtandra dentata* long-term stochastic elasticity was dominated by the survival of mature plants. However, in the short-term, the establishment of *C. dentata* seedlings had the greatest influence on the population growth rate, followed by the growth of seedlings to the small immature life stage. These results have several management implications for *C. dentata*. First, with high mature plant survival (81% – 97%), there is likely little that can be done to improve that vital rate. However, the importance of mature plants on the long-term population growth rate emphasizes the gravity of maintaining high survival of matures over time. Secondly, management actions that increase seedling establishment would have the greatest positive impact on the population growth rate in the short-term.

Demographic studies tend to focus on population growth rate. However, restoration practitioners often use predefined populations size thresholds to evaluate rare plant recovery and risk of extinction (IUCN 2001; USFWS 1998). Two numerical benchmark goals that have been proposed as general rules of thumb to prevent imminent population extinction are a minimum of 25 matures (Shaffer 1981) and 50 matures (Franklin 1980; Hartl & Clark 1998; Shaffer 1981; Soulé & Wilcox 1980). For *C. dentata*, there was high confidence that the *C. dentata* population would be > 25 mature plants in the short-term (i.e., 10 years). Furthermore, for scenario **A** and **B** there was high confidence that the population would reach a minimum of > 50 in the short-term. Recently, Frankham et al. (2014) proposed a revision of the minimum number of

individuals to use as the short-term restoration goal, arguing that >100 reproductive individual is needed to maintain genetic diversity in the short-term. Conversely, other recent studies suggest that the number of matures needed to maintain a population is context specific and there is no general rule of thumb (Brook et al. 2006; Traill et al. 2007).

Studying the demography of rare and endangered species is challenging due to limited replication and a small sample size (Morris & Doak 2002). Despite these limitations, valuable insight can be gained from population dynamic studies of endangered species, such as quantifying the likely outcome of management actions and assessing the potential impact of environment parameters on population dynamics (Crone et al. 2011; Dostálek & Münzbergová 2013; Ellis et al. 2007; García 2003; Marrero-Gómez et al. 2007; Morris et al. 2002). It can also provide a proactive method of predicting the likely outcome of management actions, which would otherwise take several generations to detect (Menges 2000). For this study, we were limited to one study site because of the rarity of *C. dentata* populations that consisted of all life stages and rare plant permitting and logistical constraints. Thus, results from this study may not be extrapolated across varying habitat and ecological parameters. Furthermore, this study did not consider the potential influence of long-distance dispersal on plant fitness by increasing gene flow between populations. Future integrative studies on the combined impact of plant interactions with multiple environmental parameters would benefit from having replication across multiple study sites. Plant population response to environmental stressors should be studied for more species varying in life history in order to investigate

if generalized patterns emerge, which can be used as a “rule of thumb” to effectively manage rare plants and the habitat that they depend on.

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OAHU ARMY NATURAL RESOURCES PROGRAM  
MONITORING PROGRAM

**RESULTS OF A LABORATORY SEED SOW TRIAL FOR  
*CYANEA SUPERBA* SUBSP. *SUPERBA***

A preliminary trial to assess germination rates of seeds from senesced versus fresh  
*Cyanea superba* subsp. *superba* fruit

### **Introduction**

Limited dispersal and recruitment of *Cyanea superba* subsp. *superba* occurs at reintroduced populations, with the majority of fruits either depredated by rats (seeds are destroyed), or rotting on the plant and falling to the ground with limited subsequent seed germination and seedling survival, despite having typically high seed germination rates in fresh mature fruit (Pender et al. 2013, OANRP 2015a, 2015b, pers. obs.). Several factors may limit successful recruitment, including microsite specificity, predation of seedlings by slugs, soil moisture, light availability and fruit senescence. In order for the Oahu Army Natural Resources Program (OANRP) to achieve goals of long term self-sustaining *C. superba* subsp. *superba* populations, these issues must be taken into consideration. Should self-sustainment be ineffective, populations will require on-going replacement via outplanting or seed sowing. Greenhouse production and outplanting has been successful; however, efforts to determine if seed sowing is a feasible and more economical approach have been limited. This trial explores two questions to gain a preliminary understanding of recruitment limitations and factors affecting seed sow success. Do seeds from senesced *C. superba* subsp. *superba* fruit have reduced viability as compared with those from fresh mature fruit? If seed sowing is used to sustain populations, does total removal of fruit pulp promote higher germination rates? A laboratory trial was conducted by OANRP to examine 1) *C. superba* subsp. *superba* seed germination rates of senesced fruit in comparison with fresh material as a means of exploring the ability of seeds from senesced fruit to germinate upon falling on the ground vs. those from fresh fruit; and 2) germination rates of *C. superba* subsp. *superba* seeds with and without pulp extract to examine the effects of fruit pulp on germination during seed sow efforts.

### **Methods**

Senesced and fresh mature *C. superba* subsp. *superba* fruits were collected from Makaha, Pahole and Kahanahaiki Management Units in December 2014 and January 2015 (Figures 1 and 2). All fruits were collected from infructescences (not from the ground). Fruits from 10 individuals were used for each of four treatments (with a minimum of 1 fruit per plant per treatment): untreated seeds of senesced fruits, seeds of senesced fruits with pulp extract, untreated seeds of fresh fruits, and seeds of fresh fruits with pulp extract. The degree of senescence was not quantified, but was estimated to be less than 1 week following peak maturation. Number of seeds sown per sample ranged from 22 to 200 (mean = 88.4, SD = 37.4, 3534 total seeds sown). Seeds were sown on filter paper in petri dishes. Filter paper with untreated seeds was moistened with deionized water, while those with pulp extract were moistened with decanted liquid from a solution of water and smashed fruit. Petri dishes were stored in a Percival Controlled Environment Chamber (with diurnal light and temperature settings matching average monthly temperatures for the Nike missile installation at Pahole, at approximately 2100 feet elevation), and examined weekly for germination for a total of 10 weeks. Germination rates were compared using t-tests, performed in IBM SPSS Statistics Version 20.

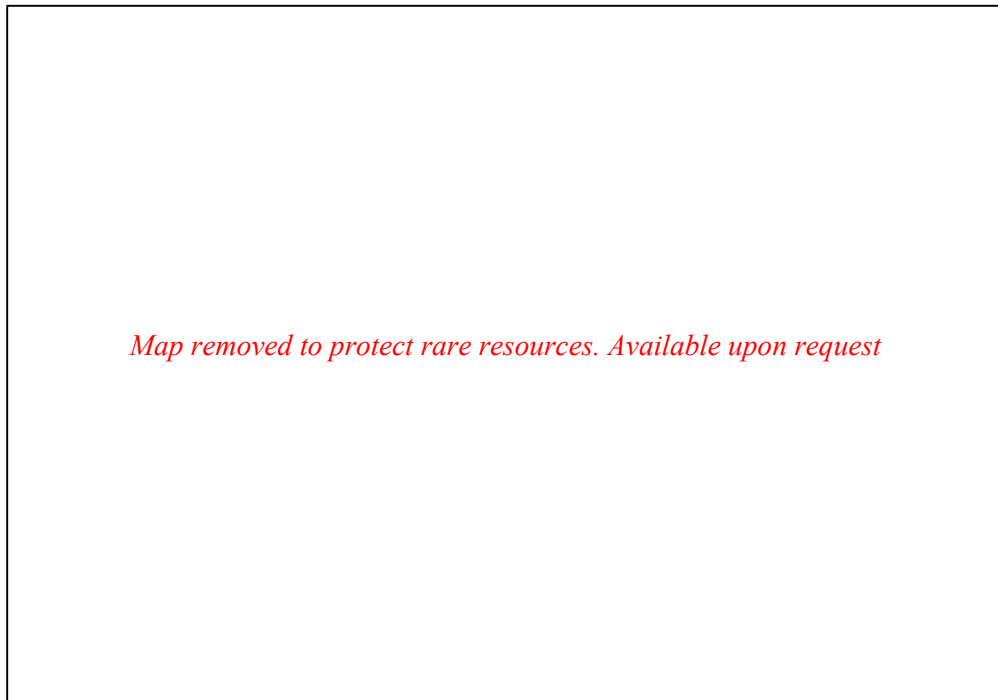


Figure 1. Locations of *Cyanea superba* subsp. *superba* fruit collections on Oahu.

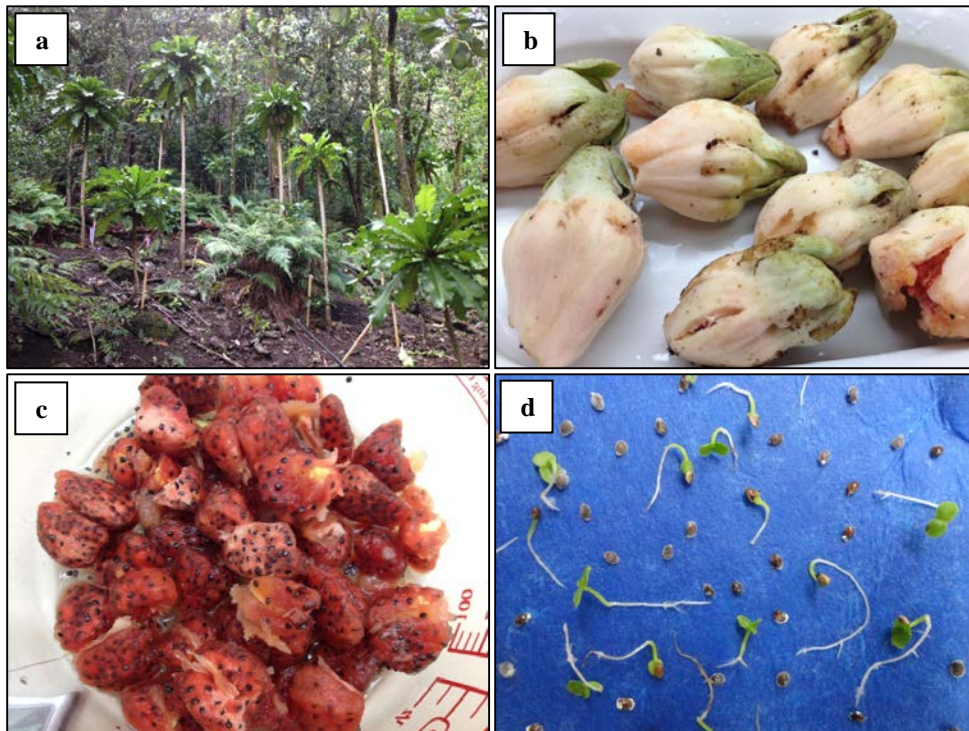


Figure 2. *Cyanea superba* subsp. *superba*. a) fruiting plants at the Makaha reintroduction site, b) fresh mature fruit, c) seeds embedded in fruit pulp, and d) seeds germinating on filter paper.

## Results and Discussion

Seeds were approximately 50% less viable from senesced vs. fresh *C. superba* subsp. *superba* fruit regardless of treatment (untreated seeds:  $t = 6.659$ ,  $p < 0.001$ ; seeds with pulp extract:  $t = 5.077$ ,  $p < 0.001$ ) (Figure 3). The reduced germination in seeds from senesced fruit limits recruitment potential in the absence of dispersers, as fresh mature fruits that are not consumed by dispersers will senesce and fall to the ground, and subsequently have reduced potential for germination. The rate and extent of reduction of seed viability of senesced fruit over time remains unexplored. Dispersers that cache or drop whole fruit likely do not facilitate recruitment. However, whole fresh mature fruits of *C. superba* subsp. *superba* are not easily removed from infructescences (pers. obs.), and are more likely to be consumed directly from the plant.

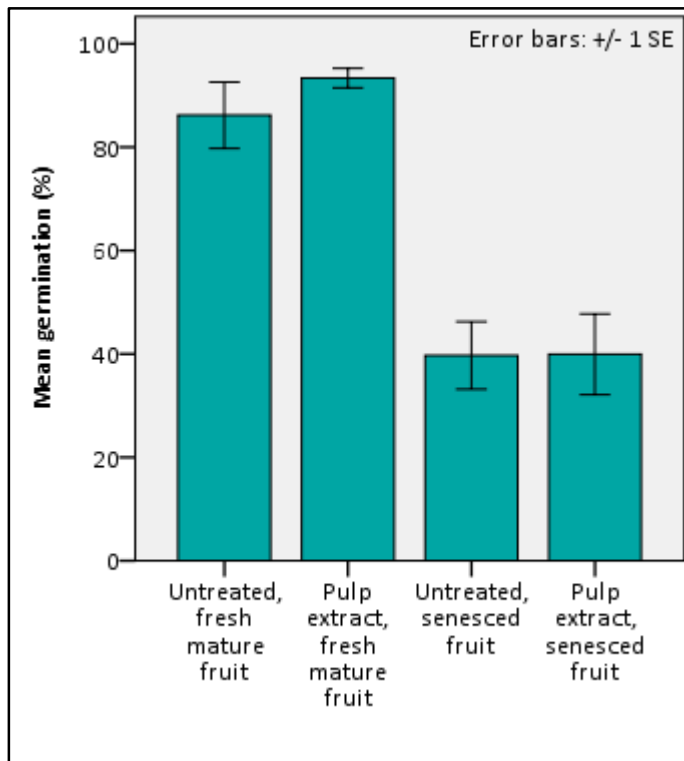


Figure 3. Seed viability from senesced and fresh mature fruits, with and without fruit pulp extract ( $n = 10$ ).

Fruit extract had no effect on germination of seeds for either senesced ( $t = 0.022$ ,  $p = 0.982$ ) or fresh mature fruit ( $t = 1.075$ ,  $p = 0.296$ ). Seeds used for sowing in the field will not necessarily require laboratory processing and cleaning, but rather may be processed in the field by gently smashing fruit pulp in water to extract seeds. The seeds will sink to the bottom of the container, and the floating smashed pulp may be poured off. The remaining seed slurry may then be sown, without concern for reduced viability resulting from pulp chemicals in the slurry. Because seed viability is reduced by fruit senescence, only fresh mature fruit should be used for seed sowing, and whole fruits should not be scattered as a means to enhance recruitment.

The results of this laboratory trial may help partially explain some of the population dynamics observed at reintroduction sites. The limited recruitment observed at Kahanahaiki (despite large numbers of mature plants, extensive rat control, and prolific production of viable seed), may be influenced by a lack of dispersers. Recruitment at this location is primarily located below mature plants. Fruit that is not

predated by rats is likely senescing, falling to the ground and having little to no recruitment. By comparison, at Palikea, recruitment occurs distant from the few mature plants present. This area has a more diverse avifauna, which may be effectively dispersing seeds.

### **Future Directions**

To examine the rate and extent of reduction in *C. superba* subsp. *superba* seed viability over time during fruit senescence, fresh mature fruit may be collected and stored at room temperature over a period of time to allow for total senescence, during which viability assays may be made at pre-determined intervals. E.g., seeds from fruit samples may be sown on the date of collection, then again every three days for three weeks. Similar trials may be considered for other OANRP managed species thought to be dispersal dependent.

To explore bird dispersal at *C. superba* subsp. *superba* reintroduction sites, fruit consumption by birds at these locations may be quantified by game cameras. Additionally, the number and height of seedlings as well as distance from the nearest plant may be quantified, excluding those in slug controlled areas and seedlings known to occur as a result of prior seed sow efforts. Seedling surveys are currently underway.

### **References**

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ASSESSMENT OF EFFECTS OF RODENT REMOVAL ON ARTHROPODS, AND  
DEVELOPMENT OF ARTHROPOD MONITORING PROTOCOLS, ON CONSERVATION  
LANDS UNDER US ARMY MANAGEMENT

Annual Statement of Work, September 2015

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Background

Invasive black rats are believed to exert severe predatory pressure on native arthropod species, but the effects of this pressure on arthropod populations has not been quantified in the field. Because rats are now nearly ubiquitous in natural areas of Hawaii, the most effective way to assess their impacts on arthropod species and communities is to monitor the response of arthropods to rat removal. The Oahu Army Natural Resource Program (OANRP) has implemented rat removal operations in several areas in the Waianae Mountains. In conjunction with these efforts, I have been conducting standardized, quantitative arthropod sampling before and after rat removal in two of these areas (Kahanahaiki and Palikea), as well as in adjacent control sites where rats will not be immediately removed, to measure arthropod responses and estimate the impacts of rats on native and introduced arthropod populations. This sampling will also serve as an arthropod inventory, providing important information on the biodiversity of these management areas. Thirdly, the sampling conducted in this project will be used to help develop broader arthropod monitoring protocols for the OANRP management units, as desired under the Makua and Oahu Implementation Plans.

FY15 progress

During fiscal year 2015, the samples from the final sampling event, conducted in July 2014, were sorted, and final data analysis and write-up for the project was started. In total, 2160 samples were collected from the two sites and sorted, and 305,848 specimens belonging to 582 species or morphospecies have been databased. July 2014 specimens still need to be databased.

## Results to date

Analysis of patterns after three years of rodent trapping at Kahanahaiki and two years of trapping at Palikea suggest that with some exceptions, rodent impacts on arthropod populations are likely to be context dependent and variable among sites. These patterns are summarized in Figure 1, and more detailed results are shown in Table 1.

Arthropod groups that showed some evidence of responding to rodent trapping at either site include spiders (Araneae), beetles (Coleoptera), springtails (Collembola), true bugs (Hemiptera), caterpillars (Lepidoptera), crickets and katydids (Orthoptera), and bark lice (Psocoptera). However, many of these groups did not respond consistently across the two sites, suggesting either that these responses are context-dependent and may often be inconsistent between sites or specific situations, or possibly that some of the measured responses may have been caused by factors other than the rodent trapping. Several groups did show quite consistent responses across sites, however, lending support to the interpretation that many or most of the arthropod population changes were caused either directly or indirectly by rodent suppression. Such consistent responses included decreases in abundance in ground-active caterpillars and arboreal bark lice, and increases in abundance in arboreal springtails, native crickets and katydids, and native predatory *Eupithecia* caterpillars. Although Figure 1 and Table 1 suggest that increases in orthopteran abundances did not occur in all situations, increases were in fact consistent for all sampling methods that captured substantial numbers of individuals of this group at each site (vegetation sweeps at Palikea and pitfalls at Kahanahaiki).

In general, changes in abundance tended to be more common and stronger at Kahanahaiki compared to Palikea. It is unknown whether this is related to the less comprehensive sampling methods used at Kahanahaiki, or to differences in food-web dynamics between the two sites. For example, a stronger positive response by birds to rodent trapping at Palikea could result in weaker arthropod abundance increases at that site, since birds have strong top-down effects on arthropod populations.

Analysis of changes in arthropod species richness provide evidence of some increases in diversity among spiders, beetles and arthropods overall (including native species) at Kahanahaiki following rodent trapping. At Palikea, evidence for changes in species richness was weaker, but included possible trends of increasing diversity among Hemiptera, and decreasing diversity among spiders (Table 2).

Analysis of changes in trophic structure following rodent trapping suggest that while some changes in arthropod biomass may occur, they tend to be relatively small and have relatively weak effects on the percent composition of different trophic groups.

Overall, the results to date suggest that rodent suppression using snap-trap grids in mesic forest habitats on Oahu tends to result in population-level changes for certain arthropod groups, some of which may vary among sites or situations, rather than dramatic community-wide changes in arthropod abundance, biomass or trophic structure.



The vegetation sampling on specific trees as Kahanahaiki and Pahole also allowed me to perform an assessment of the potential effects of invasive ants on arthropod communities in these forests. This analysis indicated that while 10 different ant species occurred on the sampled trees during the three-year study period, their incidence rates and abundances were usually quite low, and therefore these species probably have relatively insignificant impacts on arthropods. However, the results also suggested that if their densities increased substantially, their effects may be more similar to those typically documented for invasive ants in Hawaii and elsewhere. These results are reported more fully in the paper “Ecology of some lesser-studied introduced ant species in Hawaiian forests”, *Journal of Insect Conservation* 19(4): 659-667 (<http://manoa.hawaii.edu/hpicesu/DPW/PEC-2015/default.htm>).

### Future plans

While sampling for this project is now complete, I will continue to work on producing comprehensive write-ups of various aspects of the project for journal articles and/or technical reports.



	Palikea		Kahanahaiki		overall	
Spiders	↔	↓	↑	↑	↔	
Beetles	↔	↔	↑	↑	↔	
Springtails	↑	↔	↑	↔	↑	↔
Hemiptera	↑	↔	↔	↑	↔	
Caterpillars	↔	↓	↑	↓	↔	↓
<i>Eupithecia</i>	↑	↑	↑		↑	
Orthoptera	↑	↔	↔	↑	↑	
Psocoptera	↓	↔	↓	↔	↓	↔
	veg	ground	veg	ground	veg	ground

Figure 1. Summary of changes in abundance in rodent-trapping areas relative to adjacent untrapped areas at each site, for select arthropod groups. Taxonomic groups not shown exhibited less consistent changes in abundance. Green arrows indicate general trends of increases in abundance after trapping, red arrows indicate decreases in abundance after trapping, blue arrows indicate no significant trends or inconsistent trends in abundance. Thickness of arrows give a relative indication of the strength of each pattern in terms of level of statistical significance and/or consistency of trend over multiple time intervals (thicker arrows indicate stronger patterns). “Veg” refers to vegetation sampling (vegetation beating/sweeping), “ground” refers to ground sampling (pitfalls and leaf litter extraction). The first two columns indicate patterns at Palikea and Kahanahaiki, respectively, whereas the third column indicates overall patterns for each taxonomic group, considering trends at both sites.

Table 1. Median change in abundance at rodent trapping sites relative to adjacent untrapped sites, for different sampling types and time intervals. Colored cells (green = increase, red = decrease) indicate changes statistically significantly different from zero (Mann-Whitney U test,  $p < 0.05$ ).

Taxon	Palikeya				Kahanahaiki/Pahole					
	Vegetation sampling		Ground sampling		Vegetation sampling			Ground sampling		
	1 year	2 years	1 year	2 years	1 year	2 years	3 years	1 year	2 years	3 years
Chilopoda	1.00	-1.00	-1.00	-2.00				0.00	0.00	0.00
Diplopoda	5.00	-3.00	18.00	17.00	0.00	0.00	0.00	-2.50	-0.93	-0.50
Amphipoda	1.50	-0.50	-22.50	-54.50	0.00	0.00	0.00	-9.50	17.00	15.00
Isopoda	-5.00	-1.50	-53.50	-63.50	0.00	1.00	0.00	2.73	2.00	-2.00
Acari	-50.00	2.00	-5.50	133.00	-0.50	0.00	0.00	-0.50	0.00	0.00
Araneae	-16.50	16.50	-19.00	-9.00	1.00	2.25	1.25	4.00	5.00	2.00
native Araneae	-19.00	7.00	0.00	-1.00	0.50	0.00	0.00	0.00	0.50	0.00
adv Araneae	-1.00	-0.50	-12.00	-6.00	0.50	1.50	1.00	0.00	0.00	-1.00
Archaeognatha	-0.50	0.00								
Blattaria	-2.00	-1.50	0.00	0.00	0.00	0.00	0.00			
Coleoptera	-0.50	1.50	0.50	8.00	-0.50	2.00	2.50	1.00	8.75	35.00
native Coleoptera	0.50	-0.50	-0.50	3.00	0.00	0.50	1.00	0.00	0.00	0.40
adv Coleoptera	0.50	2.50	1.00	2.50	-0.50	1.00	0.50	-3.45	-1.00	16.30
Collembola	58.00	62.50	-108.50	-101.00	13.25	17.50	21.00	-3.50	8.00	-0.50
Dermaptera			-1.00	1.00				0.50	-0.50	1.50
Diptera	-1.00	3.50	10.00	-1.50	0.00	0.00	0.00	4.25	1.00	2.50
Hemiptera	14.50	17.00	-1.00	0.50	-3.00	3.00	4.50	0.57	0.50	2.03
native Hemiptera	12.50	10.00	0.50	0.50	-3.25	2.50	3.50	0.40	0.00	0.00
adv Hemiptera	1.50	2.50	0.50	0.00	-0.50	-0.50	-0.50	0.50	0.58	2.00
Hymenoptera	11.00	22.00	0.50	-1.00	0.50	1.50	1.00	0.50	0.00	1.33
Lepidoptera	1.00	0.50	-7.50	-26.50	1.00	1.00	1.00	-2.00	0.00	-2.00
immature Lepidoptera	0.00	1.00	-9.50	-26.50	0.50	0.50	0.50	-1.50	0.00	-2.00
Hyposmocoma	-4.00	-2.00	4.00	8.50	0.50	0.00	0.00	-0.20	0.00	-0.50
Eupithecia	0.00	1.00	0.50	0.50	0.50	0.50	0.00	0.00		
Neuroptera	0.00	-0.50			0.00	0.00	0.50			
Orthoptera	4.50	5.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	2.00
Gryllidae	4.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	2.00
native Tettigoniidae	0.50	1.00								
adv Tettigoniidae	0.00	0.00			0.00	0.00	0.00			

Psocoptera	-24.50	-18.00	9.00	-7.50	-6.00	-1.50	-3.50	0.00	0.00	-0.10
Thysanoptera	4.50	5.50	-9.00	-14.00	0.00	0.50	0.50	-0.25	0.00	0.00
Arthropoda total	36.50	93.50	-182.00	-194.50	8.50	36.75	32.00	2.25	43.75	82.00
native Arthropoda	5.00	32.00	1.50	10.00	-3.00	5.50	7.50	0.00	2.50	1.95
adv Arthropoda	6.00	4.00	-86.00	-120.00	1.00	8.00	3.75	-5.25	24.65	48.25
unk Arthropoda	45.00	72.50	-83.00	-19.50	8.00	16.50	14.50	12.50	27.65	21.50

Table 2. Median change in species richness at rodent trapping sites relative to adjacent untrapped sites, for different sampling types and time intervals. Colored cells indicate changes statistically significantly different from zero (Mann-Whitney U test,  $p < 0.05$ ).

Taxon	Palikea				Kahanahaiki/Pahole					
	Vegetation sampling		Ground sampling		Vegetation sampling			Ground sampling		
	1 year	2 years	1 year	2 years	1 year	2 years	3 years	1 year	2 years	3 years
Araneae	-2.50	-1.50	-0.50	-1.50	0.00	1.50	0.00	0.50	1.00	0.00
native Araneae	-2.00	-1.50	0.00	-0.50	0.00	0.50	0.00	0.00	0.50	0.00
adv Araneae	-0.50	0.50	0.00	-1.00	0.00	0.50	0.00	0.00	0.00	-1.00
Coleoptera	-0.50	1.00	1.00	3.00	0.00	1.50	1.00	-1.00	0.00	1.50
native Coleoptera	0.50	0.50	1.00	1.00	0.00	0.50	0.50	0.00	0.00	0.43
adv Coleoptera	-0.50	0.50	0.00	1.00	0.00	1.00	0.00	-0.50	-0.43	0.50
Hemiptera	3.00	3.00			0.00	0.00	0.00			
native Hemiptera	2.50	2.00			0.00	0.00	0.00			
adv Hemiptera	1.00	2.00			-0.25	-0.50	0.00			
Arthropoda total	-1.00	3.00	2.00	4.50	1.00	6.00	2.00	-1.00	2.50	3.50
native Arthropoda	0.00	-1.00	2.00	3.00	1.00	2.00	1.00	0.00	0.50	0.50
adv Arthropoda	0.50	3.00	-0.50	1.00	-0.50	2.00	1.00	-0.95	0.30	1.00
unk Arthropoda	-1.00	0.00	1.00	0.50	0.00	2.00	0.50	-0.52	1.47	1.50

## Summary of progress on Mycorrhiza project

PIs: Prof. Nicole Hynson and Postdoc Jeremy Hayward

### *Summary*

The goal of this project was to assess the community structure of the obligate mycorrhizal fungal symbionts associated with invasive and native host plant communities on Oahu, Hawaii. The results from this project represent the first systematic tests for differences among mycorrhizal communities associated with native versus invasive host plants in Hawaii. Owing to the importance of the mycorrhizal symbiosis for plant fitness, we anticipate that our results will provide immediate, testable suggestions for improving native plant restoration success, allowing us to bridge the gap between basic ecological research, restoration and land management.

### *Progress*

Fieldwork was completed summer 2014. Lab work was completed by the beginning of summer 2015, and data analysis occupied most of summer 2015. Details on our field methods, lab methods, and data analysis are included as Appendix 1 to this summary. With the completion of fieldwork, labwork and most data analysis, we have devoted our time to manuscript preparation, and dissemination of results. We are in the final stages of preparing a manuscript based on our results. This manuscript will be submitted to *Ecology Letters* in fall 2015. We have also presented a talk based on this work at the Botany 2015 conference in Edmonton, Canada.

### *Summary of Results*

Our results suggest that aboveground biological invasions cause systematic reductions in the diversity of arbuscular-mycorrhizal fungi. For example, a 1m<sup>2</sup> area of highly invaded forest is predicted to have on average 14 fewer arbuscular-mycorrhizal fungal species than a similar area consisting of native Hawaiian forest, representing the loss of approximately 1/3 of the typical community at that spatial scale. Details of our analyses and results are included as Appendix 2, below. This loss of diversity is observed in all three of the regions we sampled and is of similar intensity in each. Loss of diversity is troubling because plant community productivity is usually correlated with AM fungal diversity. As a result, native Hawaiian communities outplanted into previously invaded regions may underperform unless this loss of diversity can be remedied, for example through inoculation.

This loss of diversity is systematic and predictable. However, precisely *which* AM fungal species are lost under plant invasions cannot readily be predicted. The identities of species lost in invaded plots differs between individual plots despite very similar invasions. We believe that our data is most consistent with stochastic local extirpations of AM fungal species following plant invasions.

### *Outlook*

Our results suggest that restoration of plant communities may benefit from increasing AMF richness at outplanting sites. We suggest that one means of

accomplishing this may be to pre-inoculate greenhouse-grown seedlings destined for outplanting with AMF prior to introducing them into the field.

## **Appendix 1:** Methodological details.

### *Field methods*

We sampled AMF in soil in a total of 2592 soil samples in a hierarchically nested and spatially explicit sampling design. We established a total of 18 plots in 3 watersheds (Manuwai Gulch, Pahole and Kahanahaiki Gulches, and Palikea Ridge, respectively; the locations of these plots are shown in Appendix 3, below) with 3 plots per watershed dominated by native vegetation, and 3 dominated by exotic vegetation. We defined native- and exotic-dominated plots as having >90% canopy cover of native or exotic vegetation, respectively. Plots were 24m × 24m (576m<sup>2</sup>). Vegetation was heterogeneous between watersheds but largely homogenous within replicate plots, with most native-dominated plots consisting of Hawaiian mesic lowland forest with a highly diverse canopy, or else Hawaiian montane rainforest with native *Metrosideros polymorpha*-dominated canopy cover. All native dominant canopy species in this study have been reported to form arbuscular mycorrhizal associations. Invasive-dominated plots are classified as Hawaiian introduced wet-mesic forest with the exotic species *Psidium cattleianum*, *Schinus terebinthifolia* and *Toona ciliata* forming the dominant part of the canopy. All of these species form arbuscular mycorrhizal.

In each plot we established a regular grid with gridlines separated by 2m and sampled a single shallow soil core of approximately 430 mL inside each grid cell, yielding 144 soil cores per plot and 2592 soil cores in total. Within each plot we sampled a further 8 regularly spaced soil cores for soil chemical analysis. Within 8 hours of sampling, we began drying soil cores in air-drying ovens at approximately 55°C. We also froze soil cores taken for chemical analysis at -20°C within the same time period. Soil samples remained in dryers until fully dehydrated (3-5 days) and were then stored at room temperature pending processing. Samples were collected April-June 2014 with both invaded and native-dominated plots sampled throughout the entire range of dates. We recorded altitude, latitude and longitude for each plot using a handheld GPS (Garmin, Chicago, IL). Soil chemistry analysis was performed by the University of Hawaii's Center for Tropical Agriculture and Human Resources.

### *Molecular methods*

We thoroughly homogenized each dried soil core using a sterilized mallet, then subsampled 250mg (±10mg) of soil from each homogenate for DNA extraction. We extracted genomic DNA from each soil subsample independently. Following this preliminary extraction, we pooled equal volumes of extracts in each plot, yielding six pooled samples per plot. We re-extracted DNA from 100µL of pooled extract for each size class using PowerClean Pro DNA Clean-up Kits (Mo Bio Laboratories, Carlsbad, CA).

We amplified a fragment of the nuclear ribosomal large subunit (LSU), a diagnostic region for arbuscular-mycorrhizal fungi. We submitted these diagnostic regions for sequencing on an Illumina Miseq platform at the Hawaii Institute for Marine Biology. We received a total of 6,606,842 sequences. Following quality control, we clustered these sequences to a total of 182 operational taxonomic units. These operational taxonomic units represent near-species level identifications.

## Appendix 2: Detailed results and analyses

We identified our 182 AMF species as belonging to three orders and seven families. Considering presence/absence data, AM fungal communities in our sampled plots do not vary significantly with invaded/uninvaded status when stratified by sampling region (Kahanahaiki, Manuwai and Palikea,  $P=0.71$ ) in a permutation-based ANOVA (ADONIS test, 10000 permutations). The overwhelming majority of OTUs (158 of 182 total) were detected at least once in both native-dominated and invaded habitats. However, AM fungal communities in our plots do vary significantly by sampling region (ADONIS,  $R^2=0.28$ ,  $P<0.001$ ). Considering only contrasts within individual watersheds, invaded/uninvaded status does not predict the composition of plot community composition, considering either individual OTUs or AMF families ( $P$ -values all  $> 0.5$ ). Indicator species analysis suggests that none of the 182 OTUs detected in this study possess significant indicator value for either native-dominated or invaded plots (minimum  $P$ -value = 0.056).

To test differences in species richness (as opposed to species identities or community composition) with invaded / uninvaded status of our plots, we implemented Bayesian regression models relating the area sampled to richness in those areas. These models allowed us to leverage the statistical power of linear modeling and to extrapolate richnesses between sampled spatial scales. We implemented these models in the Bayesian modeling language JAGS. These models suggest lower richness in invaded plots than uninvaded plots ( $P = 0.007$ ).

## Appendix 3: Locations of our plots

Plot	Watershed	Invaded/Native-dominated	Replicate number	Latitude	Longitude	Altitude (M)
M1N	Manuwai	Native-dominated	1	21.523	-158.126	478
M2N	Manuwai	Native-dominated	2	21.522	-158.126	458
M3N	Manuwai	Native-dominated	3	21.52	-158.124	570
M1I	Manuwai	Invaded	1	21.523	-158.124	499
M2I	Manuwai	Invaded	2	21.523	-158.125	518
M3I	Manuwai	Invaded	3	21.521	-158.126	480
P1N	Pahole/Kahanahaiki	Native-dominated	1	21.543	-158.191	515
P2N	Pahole/Kahanahaiki	Native-dominated	2	21.537	-158.194	671
P3N	Pahole/Kahanahaiki	Native-dominated	3	21.536	-158.194	702
P1I	Pahole/Kahanahaiki	Invaded	1	21.54	-158.194	619
P2I	Pahole/Kahanahaiki	Invaded	2	21.538	-158.194	664
P3I	Pahole/Kahanahaiki	Invaded	3	21.541	-158.192	581
K1N	Palikea	Native-dominated	1	21.41	-158.097	834
K2N	Palikea	Native-dominated	2	21.416	-158.099	897
K3N	Palikea	Native-dominated	3	21.415	-158.097	816
K1I	Palikea	Invaded	1	21.409	-158.098	814
K2I	Palikea	Invaded	2	21.409	-158.099	845
K3I	Palikea	Invaded	3	21.416	-158.099	887



## ASSESSMENT OF EFFECTS OF SOLENOPSIS PAPUANA ON ARTHROPODS IN OAHU FORESTS

Annual Statement of Work, September 2015

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### Background

*Solenopsis papuana* is the most widespread and abundant invasive ant species in the upland forests of both mountain ranges on Oahu. While other more conspicuous ant species often occur in exposed, drier microsites such as ridgetops with short-statured vegetation, *S. papuana* is the only species that can commonly be found under the canopy in the interior of mesic to wet forests, and appears to be nearly ubiquitous above elevations of roughly 1000 ft. Although concern about the ecological effects of this species has been raised for many years, almost no research has been conducted on any aspect of its biology or ecology. I am directing a graduate student in a study of the ecological effects of *S. papuana* on the ground arthropod communities in forests under conservation management. A secondary goal is to attempt to measure effects of *S. papuana* on reproduction in native *Drosophila* flies in the field.

### FY15 progress and results

During fiscal year 2015, graduate student Sumiko Ogura-Yamada was hired to conduct the research on this project. Initial work included scouting of various locations in the Waianae and Koolau mountains for presence and abundance of *S. papuana*, in order to determine suitable sites to establish experimental plots. These locations included Palikeya, Ekahanui, Kaluaa, Puu Hapapa, Pahole and Kahanahaiki in the Waianae Mountains, and the Manoa Cliff restoration site in the Koolau Mountains. Distributional maps of *S. papuana* presence and absence at these localities are shown in the Appendix. These surveys revealed a surprisingly wide range in incidence and/or density of *S. papuana* among sites. *Solenopsis papuana* was sparsely distributed at Palikeya, but was nearly ubiquitous at sites like Ekahanui and Puu Hapapa.

Based on these surveys, it was determined to establish six pairs of plots at Ekahanui, Puu Hapapa, Pahole and Kahanahaiki. Each plot pair would serve as a replicate test of the effect of ant suppression on arthropod community composition, wherein ants would be suppressed with pesticide in one of the plots in the pair (treatment), and the other plot in the pair would remain unaltered (control). Arthropod sampling before and after treatment would be used to infer effects of ants on arthropod communities.

Methods for effective treatment and monitoring of *S. papuana* were developed at Lyon Arboretum and Pahole NAR. This included determination of an attractive food bait for the purpose of monitoring, determination of attractiveness and efficacy of pesticidal ant baits for the purpose of suppressing *S. papuana* in experimental plots, and determination of an effective bait station design to limit non-target impacts of the ant suppression treatment.

Four common ant bait attractants were compared: spam, peanut butter, corn syrup, and corn syrup and tuna blend. Spam and peanut butter were both found to be highly effective attractants for this species; peanut butter was chosen as the preferred bait for monitoring and distribution mapping because of its ease of use and lower cost compared to Spam. Five commercial pesticidal ant baits were also evaluated for attractiveness to *S. papuana*: Maxforce Complete (hydramethylnon active ingredient), Amdro (hydramethylnon), Extinguish Plus (hydramethylnon and methoprene), Siesta (metaflumizone), and Advion (indoxacarb). Amdro and Siesta were found to be the most attractive two baits. Amdro has the added advantage of the broadest label language of all of the baits tested, including provisions for use in forested natural areas.

Tests of bait station design indicated that a design used previously for Argentine ants, consisting of a pvc tube capped on both ends with small entry holes in each cap, was ineffective for attracting *S. papuana* to baits housed within. *Solenopsis papuana* forages much less actively than the Argentine ant, and the station design likely inhibited effective bait discovery and recruitment for this smaller, slower-foraging species. A station design that allowed more direct access from the soil and leaf litter proved to be much more effective. This consisted of a single pvc end cap sheltering the bait from above, and fitted with a fine mesh screen over the open bottom which allows access to *S. papuana* but appears to exclude nearly all other arthropods. These stations are staked to the ground with metal wire to keep them upright to exclude rain and maintain the contact between the screened bottom and the ground.

Initial tests of pesticidal bait efficacy indicated that of the two most attractive baits, Siesta was relatively ineffective in controlling *S. papuana*, most likely because of the bait's rapid activity: large numbers of dead ants were typically found in Siesta bait stations within a few hours, which may limit sharing of the bait throughout *S. papuana* colonies. In contrast, Amdro was found to be effective both when broadcast and when presented within bait stations. This result is now being tested more formally in a series of replicated plots at Pahole NAR, in which efficacy of Amdro is being compared with Siesta. Per HDOA consultation, these tests do not exceed the minimum area threshold that necessitates an Experimental Use Permit. So far, after one month, Amdro bait has resulted in substantially greater reduction in ant numbers compared to Siesta (Figure 1). The initial bait efficacy tests also provided important information on the spatial scale of control. The range of effectiveness of baits (Amdro) for suppressing *S. papuana* appears to be

only approximately 1-2 meters, whether Amdro is broadcast or presented in stations. This is again likely due to the short foraging range and generally low level of activity in this species.

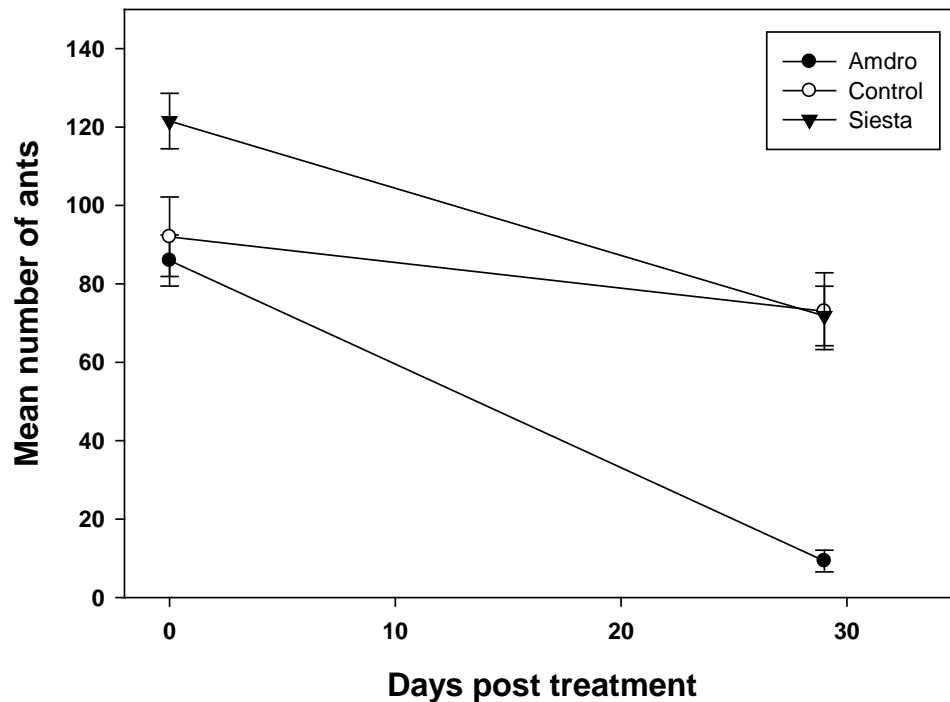


Figure 1. Mean number of ants at peanut butter bait cards in plots treated with Amdro ant bait, Siesta ant bait, and no ant bait (control), after approximately one month. Each treatment group replicated with three plots at Pahole NAR.

The above findings were used to select the methods used in the field plots designed to assess the ecological effects of *S. papuana* on arthropod communities. As mentioned, six pairs of plots were established at four locations in the Waianae mountains. Five of the plot pairs are 20 m by 20 m in dimension, while the sixth pair (one of the two pairs at Ekahanui) is 10 m by 10 m because of restrictive topography. In each plot pair, one was randomly selected as the treatment plot. In each treatment plot, a total of 81 bait stations were installed, with one station every 2.5 m in a grid pattern (25 stations were installed in the 10x10 m plot at Ekahanui). The control plot in each pair received no treatment. Amdro bait was first placed in bait stations from 4/18/15 to 5/7/15, after the initial pre-treatment arthropod sampling. On an approximately 4-6 week interval, ant numbers are monitored and Amdro bait is replaced in the plots. At each of the first three intervals post initial placement, bait station locations were also shifted 1.25 m such that every point within each treatment plot was eventually located no more than 1.25 m from a bait station. This was done to address the short range of efficacy mentioned above. This methodology appears to be working well for suppressing ants in the treatment plots: changes in ant abundances over the first 3 months after treatment are shown in Figure 2.

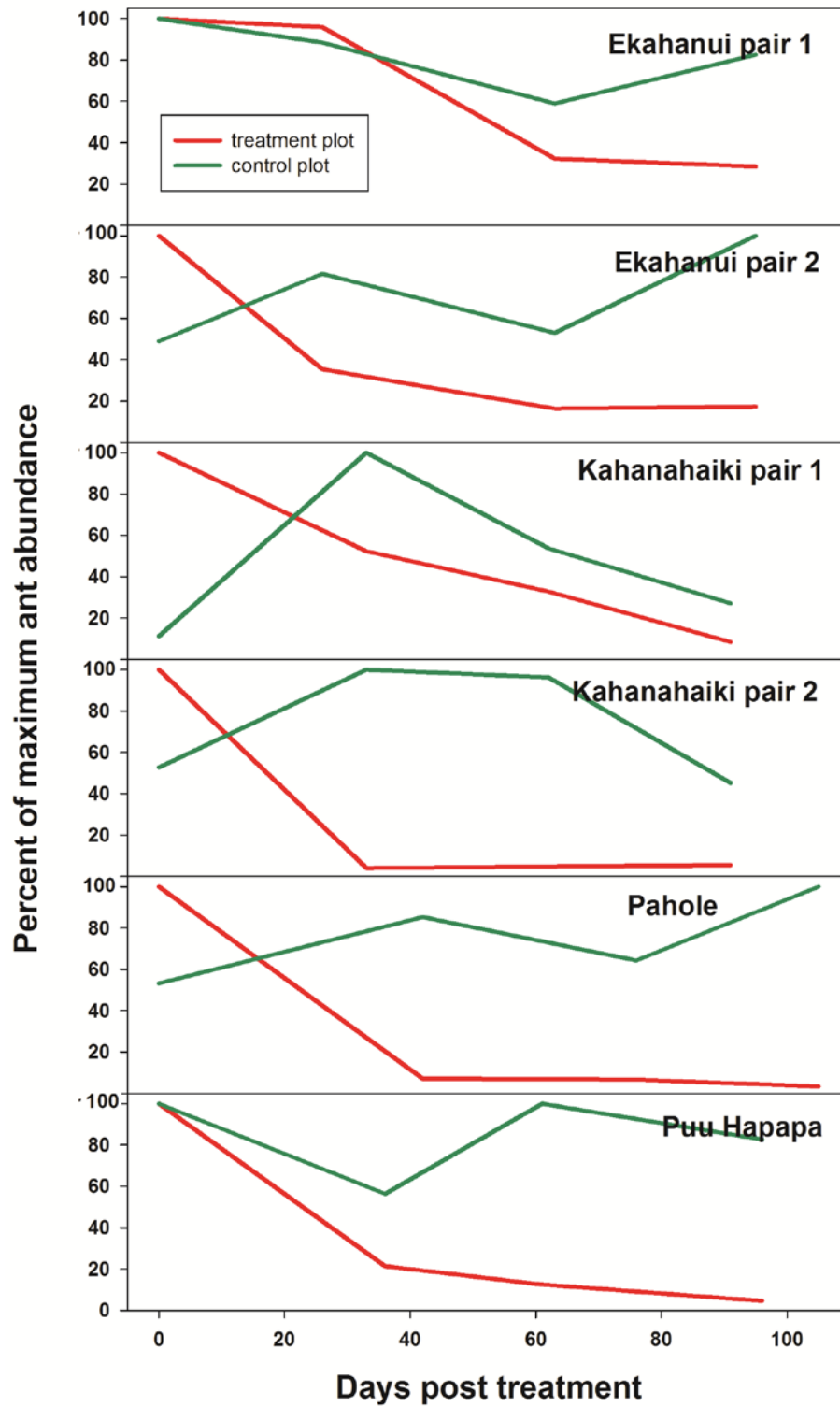


Figure 2. Changes in ant abundances over time in treatment and control plot pairs. Abundances expressed as percentage of the maximum recorded abundances in each plot.

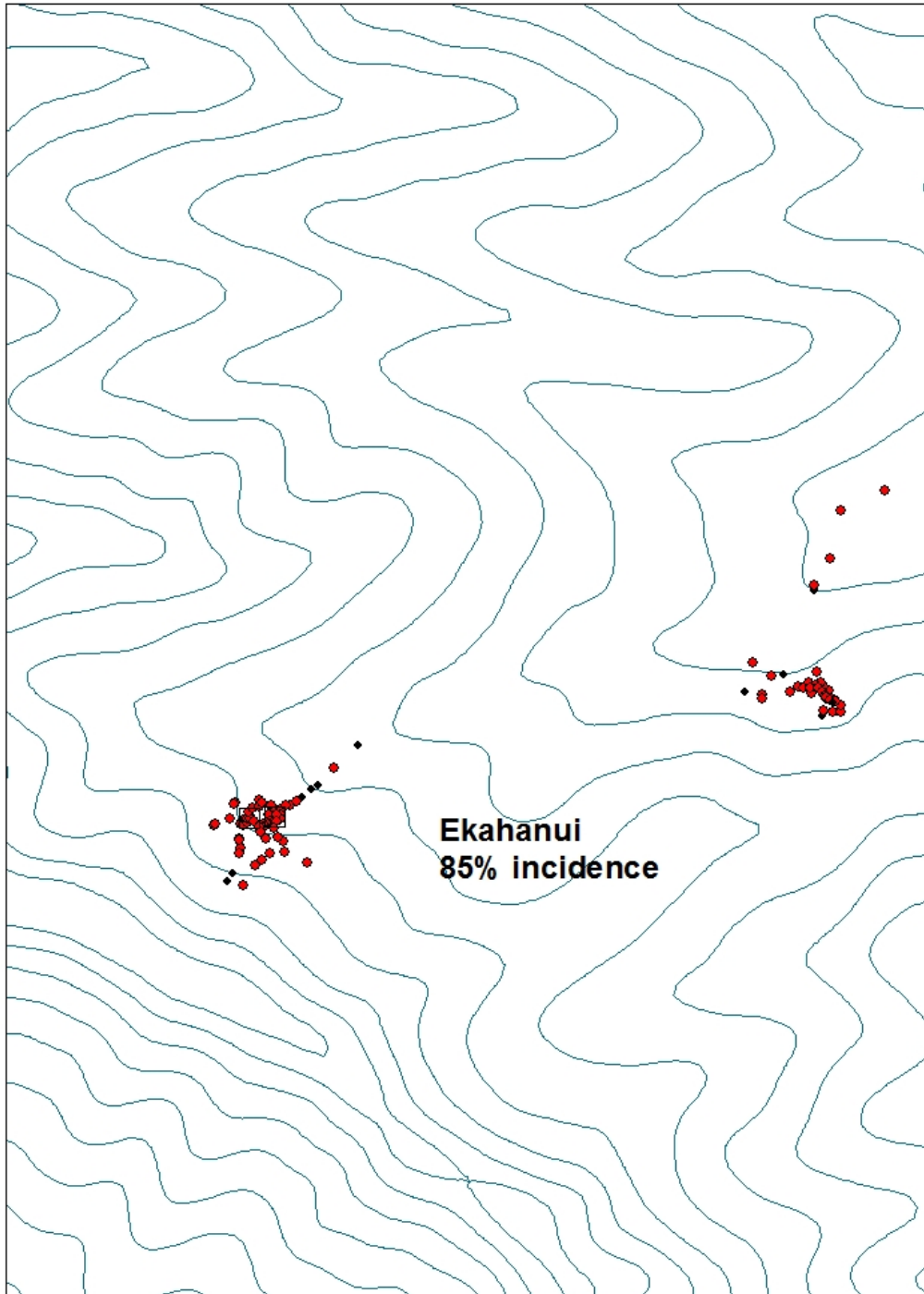
From 4/19/15-5/7/15, pre-treatment arthropod sampling was conducted in all 12 plots. This included five pitfall traps per plot (open for seven days each), five leaf litter samples per plot, and four vegetation sweeping samples per plot. Most of these 168 samples have been sorted to order, and lower-level identification has begun.

A captive lab colony of *Drosophila crucigera* has been established in Dr. Ken Kaneshiro's *Drosophila* rearing lab, using six wild-caught individuals provided by Dr. Karl Magnacca. Two individuals of *D. inedita* failed to lay eggs in the lab. *Drosophila crucigera* will be used as a surrogate for listed *Drosophila* species, to investigate potential impacts of *S. papuana* on *Drosophila* reproduction under realistic field conditions. Approximately 50 first-generation adults have been reared, and in the next phase we will attempt to rear a generation of flies in the lab from egg to adult using rotting *Pisonia* branch pieces as oviposition substrate and larval feeding substrate. If successful, this method will be used to place similar branch pieces inoculated with *Drosophila* eggs and/or larvae into field cages in the plots, to test if ant presence affects rates of adult emergence.

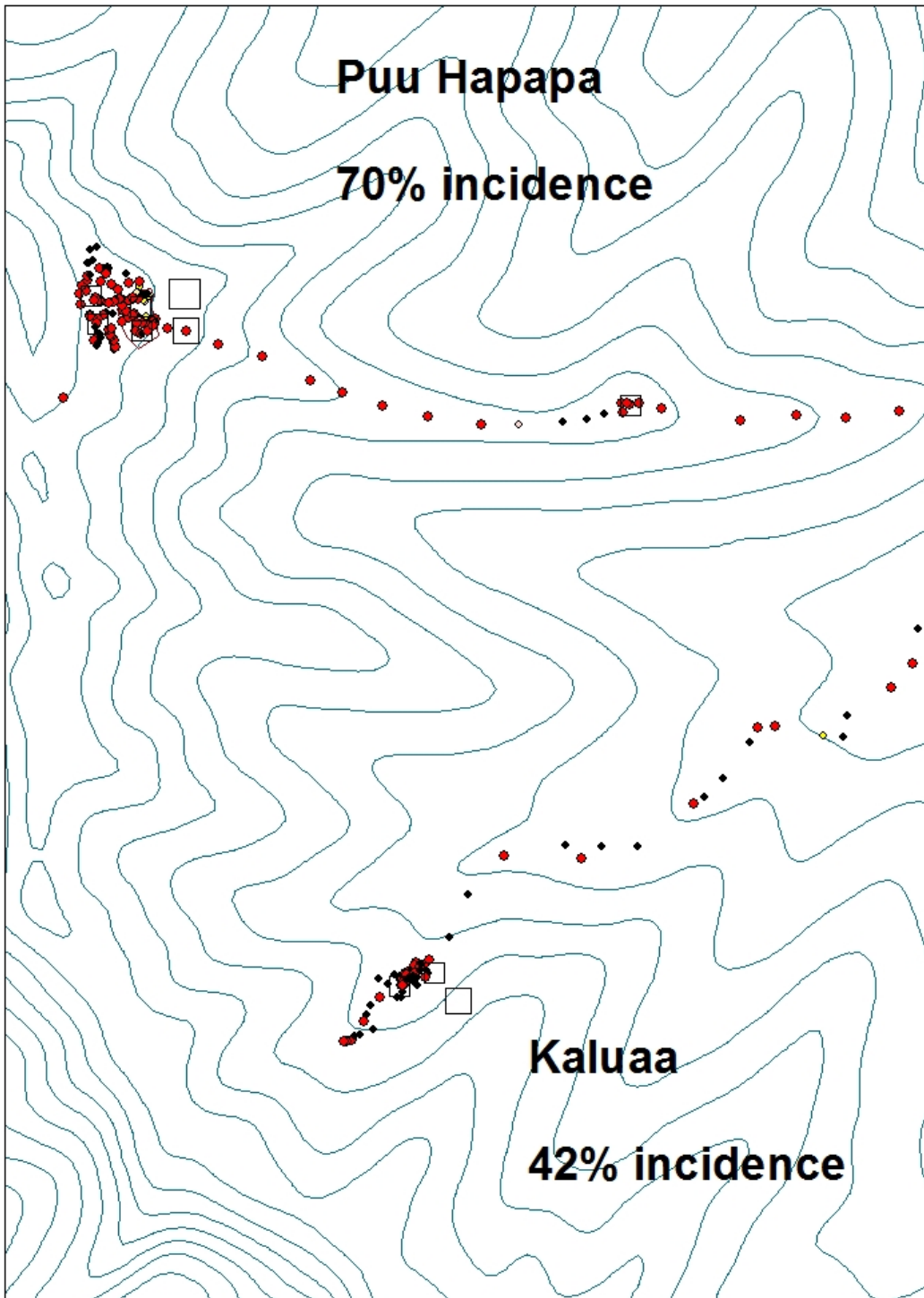
#### FY16 plans

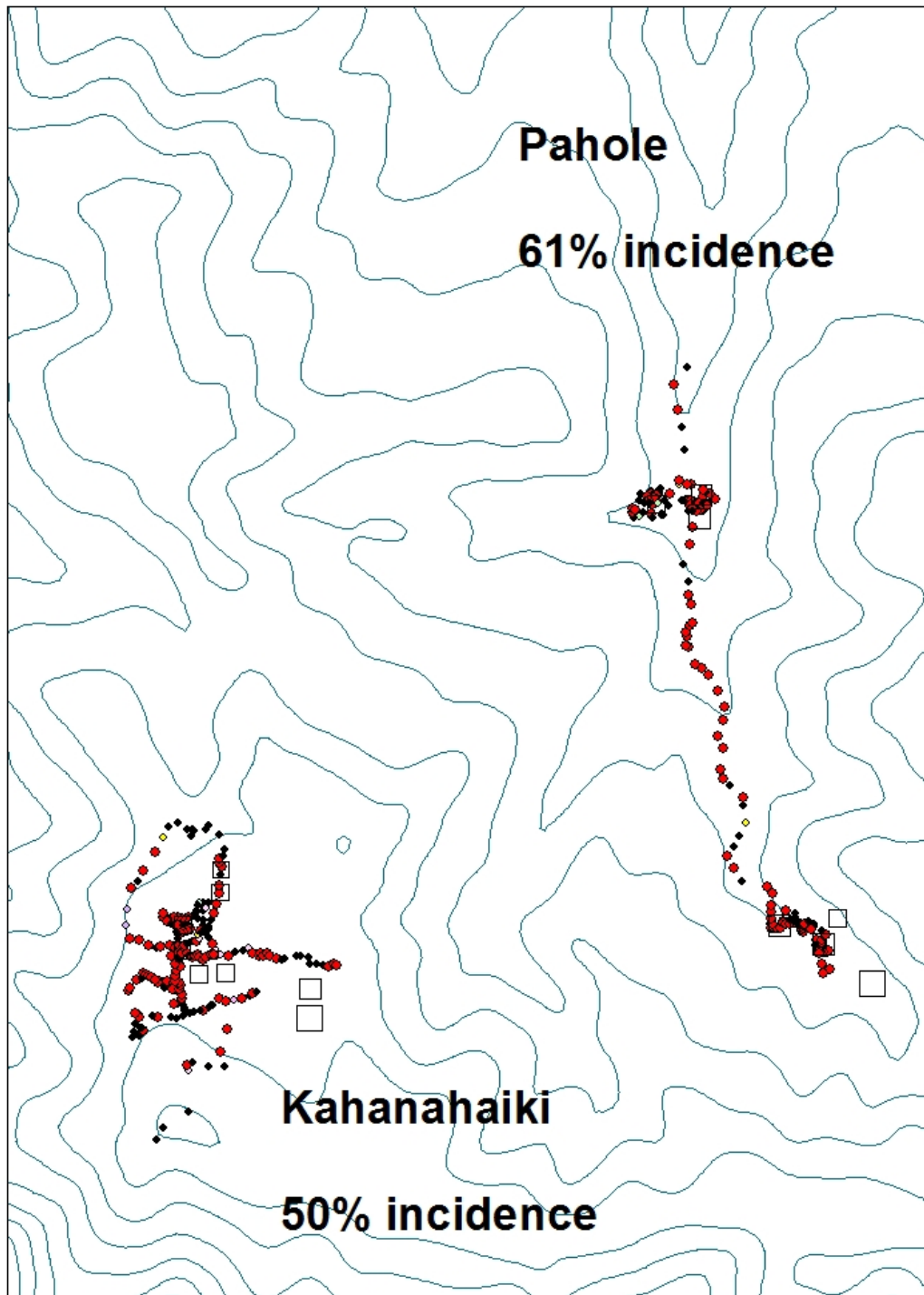
In the second year of this project, we will complete the field efficacy test comparing Amdro and Siesta ant baits at Pahole. We will continue suppressing ants and monitoring their numbers in the treatment field plots by visiting the plots about every 4-6 weeks to replace Amdro bait in the bait stations, for a period of one year after initial bait placement. Post-treatment arthropod monitoring will be conducted at one year post-treatment, and possibly at approximately 6-8 months post treatment to sample during the wet season. Work will continue to attempt to successfully rear *Drosophila crucigera* on *Pisonia* host branch material, and test their emergence rates under field conditions as described above.

Appendix. Distributional maps of *Solenopsis papuana* presence and absence at areas scouted for potential plot locations. Red dots indicate peanut butter bait cards that attracted *S. papuana*, and black dots indicate cards that did not attract *S. papuana*.

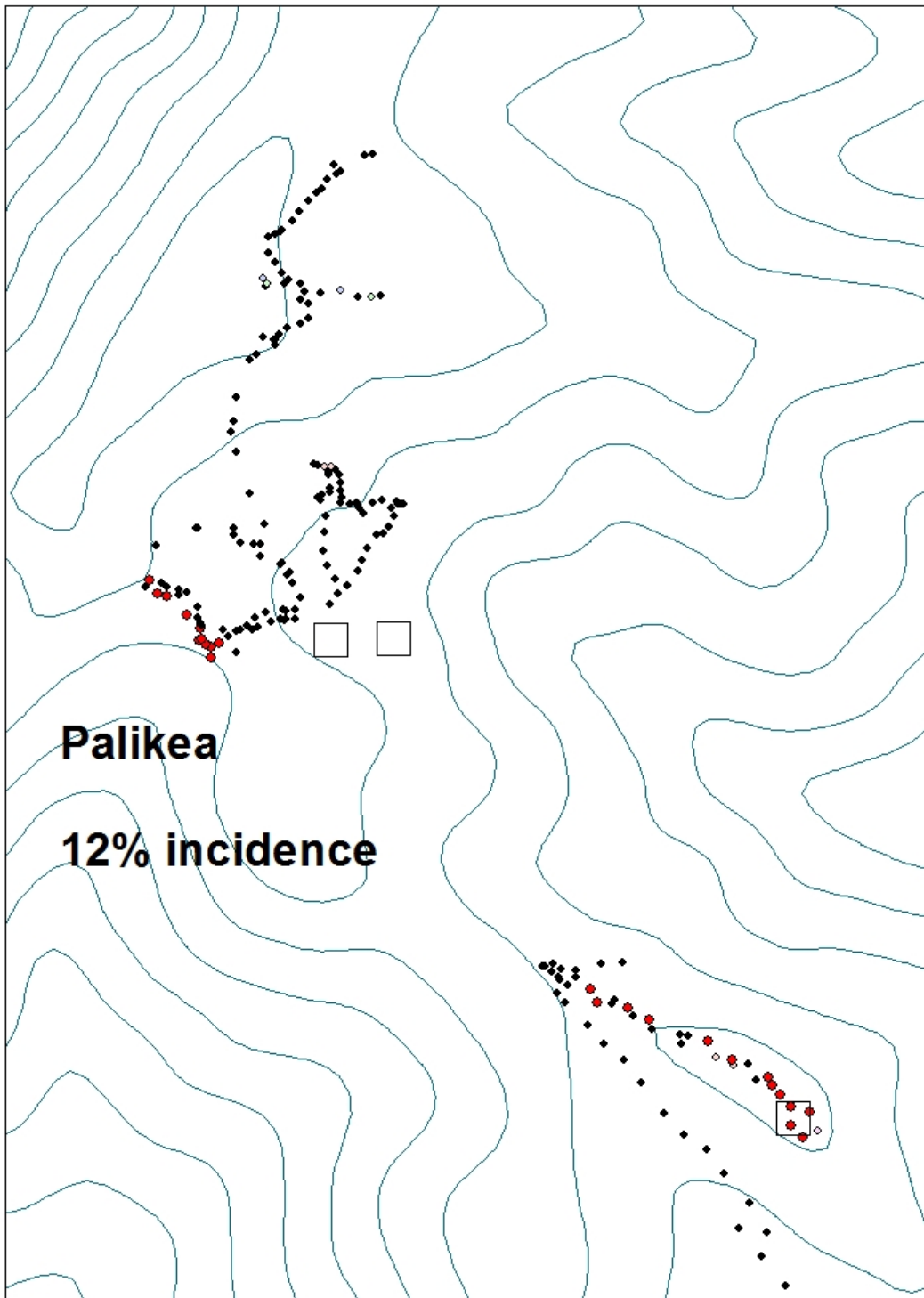


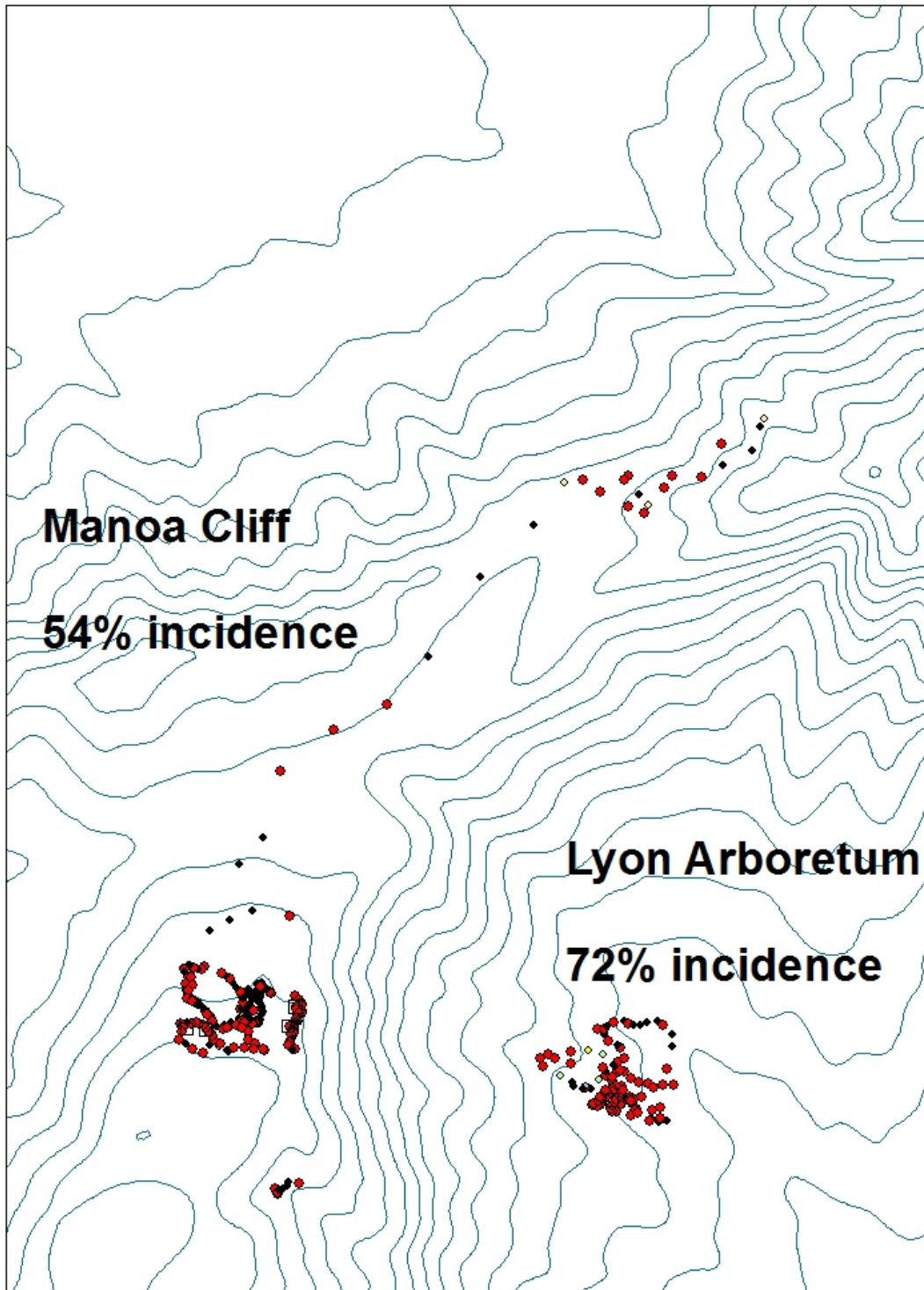
Areas surveyed at Ekahanui are 2D site and Palai Gulch.











**Appendix 1-1  
Environmental Outreach 2015**

**VOLUNTEER TRIP PHOTOS:**



**Above:** General public volunteers transplant native ukiuki (*Dianella sandwicensis*) into an area of the Kaala bog, recently cleared of invasive weeds. **Below left:** Students from Kapolei Alternative Center remove invasive downy wood fern (*Cyclosorus dentatus*) in native habitat at Pualii. **Below right:** Windward Community College lecturer digs out incipient weeds at Kaala on an OANRP volunteer trip with her Biology 124L students.





**Above:** President's Volunteer Service Awardees (from left) David Danzeiser and Elaine Mahoney, along with awardees Roy Kikuta and Kathy Altz (not pictured), enjoy the opportunity to observe mist netting of elepaio by the OANRP avian specialist.

**Left:** Kim Welch shows students from Hoala School how to dig out the incipient weed, *Crocoshia x crocosmiiflora*, from the bog at Kaala.

## INTERNSHIPS AND TEMPORARY STAFF:



**Above:** Natural Resources Management Specialist Eli Kimmerle orients the OANRP summer intern cohort to management at Kahanahaiki MU. **Below:** Hawaii Youth Conservation Corps team members learn about rare plants at West Makaleha from Natural Resource Management Specialist Scott Heintzman.



## OUTREACH EVENTS:



**Above:** Outreach specialist Kim Welch spreads the word about not releasing pet Jackson's chameleons into the wild at the Applause for Paws pet awareness event at Schofield Barracks.


**Right:** AmeriCorps intern Noweo Kai and volunteer Elizabeth Leaver help elementary school students "build" a native Hawaiian forest at Hawaii Agriculture and Environmental Awareness Day at the Pearl City Urban Garden Center.



**Left:** Kim Welch teaches students from Hale Kula Elementary how to prevent the spread of invasive weeds in a Field Gear-Decontamination activity at the OANRP baseyard.

**EDUCATIONAL MATERIALS:**

**'ŌPE'APE'A**  
HAWAIIAN HOARY BAT  
*Lasiurus cinereus semotus*



**DID YOU KNOW?**  
The Army spends more than \$10 million per year protecting the endangered plants and animals of Hawai'i. The Army employs over 100 technically-trained civilian and contracted field biologists to manage natural resources in Hawai'i.

**O'AHU ARMY NATURAL RESOURCES PROGRAM**

*Mālama i ka po'e 'ōiwi o nēia 'āina.*  
*Protecting the natives of this land.*

The native plants and animals of our isolated islands evolved with limited competition and few predators. Nearly 9,000 of our native species are found nowhere else in the world. Many of these species are listed as threatened or endangered. By working together, we can protect our remaining forests for future generations.

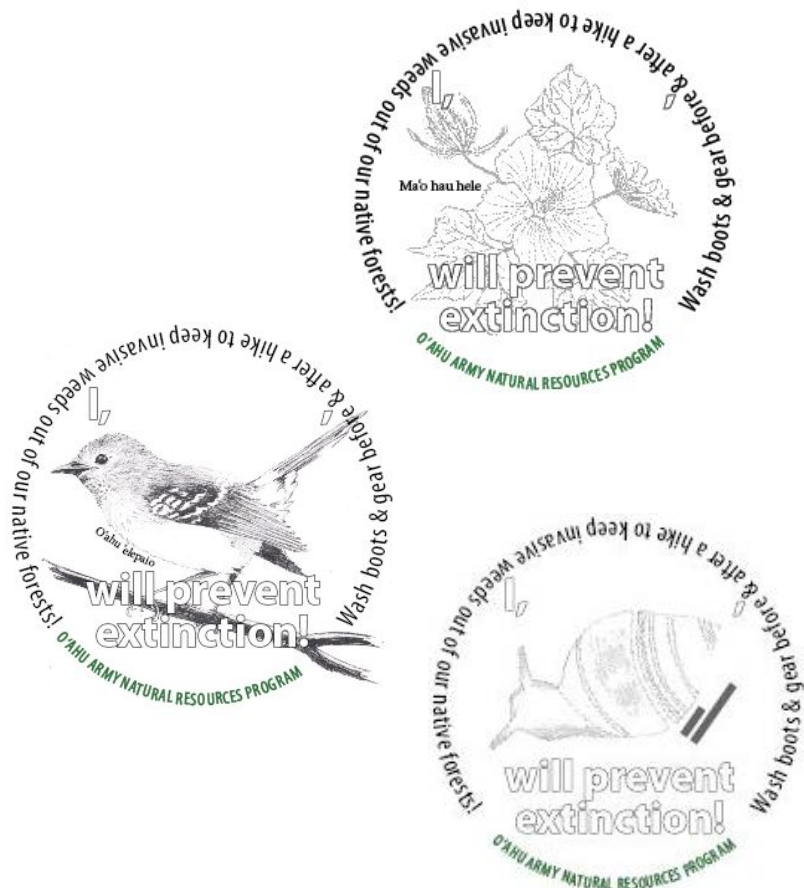


**MOVING FORWARD TOGETHER**

For more information please contact the  
**O'ahu Army Natural Resources Program**  
(808) 656-7741  
outreach@oanrp.com  
[www.garrison.hawaii.army.mil/sustainability/NaturalResources.aspx](http://www.garrison.hawaii.army.mil/sustainability/NaturalResources.aspx)

VERSION: 02/21/2015

Informational brochure on the native Hawaiian hoary bat, which can be found on Army Training Lands.



**Left:** Three color-in buttons developed for Earth Day festivals, Elementary School visits to the OANRP baseyard and other community events. **Upper right:** Jackson's chameleon pledge button created for *Applause for Paws* pet awareness event at Schofield Barracks. **Below:** Updated "Environmental Requirements" presentation for Officer-in-Charge briefs on Army training ranges.

# ENVIRONMENTAL REQUIREMENTS

**Kim Welch and Celeste Hanley**  
 Environmental Outreach Specialists  
 O'ahu Army Natural Resources Program



**656-7741**  
 outreach@oanrp.com

### Kahuku Training Area

**Nioi**  
*Eugenia koolauensis*  
 Endangered

80% of remaining nioi are found at KTA

Weed control in Kahuku Training Area

**PREVENT:**

**INVASIVE WEEDS**

- Use washracks
  - Kahuku Wash Rack
  - East Range Wash Rack
  - Schofield Central Wash Rack

**Using Drum Road?**  
 DO NOT spread weeds between training areas

- ✓ Use washracks
- ✓ Wash gear



## PUBLIC RELATIONS:

### Volunteers help protect Makua endangered plants

haw | October 4, 2014 | 0 Comments



Volunteers hike into Kahanahāiki, the northern section of Mākua Valley, along with staff from the O'ahu Army Natural Resources Program on National Public Lands Day, Sept. 27, to help control invasive weeds in the native forest. (Photos by Oahu Army Natural Resources Program staff)

*Kimberly Welch*  
*Environmental Outreach Specialist,*  
*O'ahu Army Natural Resources Program,*  
*Directorate of Public Works*  
*U.S. Army Garrison-Hawaii*

**MAKUA MILITARY RESERVATION** — In spite of the damp weather forecast, ten O'ahu residents gave up their Saturday to help control invasive weeds in Kahanahāiki, the northern Ahupua'a (traditional Hawaiian land division) of Mākua Valley.

The native forest of Kahanahāiki is home to several endangered species, including the hāhā, or *Cyanea superb* subsp. *superba*, a plant that nearly went extinct in 1995. Fortunately, before the last five *Cyanea* died-off, staff from the O'ahu Army Natural Resources Program (OANRP), Directorate of Public Works, U.S. Army Garrison-Hawaii, were able to collect fruit from these plants, and later grow new *Cyanea* from the seed in the OANRP nurseries.

Today, hundreds of *Cyanea* have been returned to the Kahanahāiki forest as staff and volunteers work to stabilize this fragile species by improving habitat and removing threats.

A Hawaii Army Weekly article from October 2014 describes the volunteer planting efforts for National Public Lands Day within the Kahanahaiki MU.

**Upper right:** Hawaii Army Weekly article highlights OANRP's interactive presentation at the Pearl City Urban Garden Center's Hawaii Agriculture and Environmental Awareness Day.

**Lower left:** Hawaii Army Weekly article advises the community on preventative measures for keeping incipient pests off installations, as well as a summary of the Army's efforts to eradicate such pests.

## Youth 'build' a forest, environmental awareness

haw | February 26, 2015 | 0 Comments



center in Pearl City on Feb. 13. The display, Hawaiian forest, was created by the Oahu Army Environmental Awareness Day. (Photo by Celeste

from central Oahu interacted with a native Awareness Day at the Urban Garden Center in Pearl



## Post works to oust pesky coconut rhinoceros beetle

haw | May 14, 2015 | 0 Comments



Pictured above is an adult coconut rhinoceros beetle, *Oryctes rhinoceros*, at Mamala Bay golf course, Joint Base Pearl Harbor-Hickam. At the time this photo was taken, a mesh covering had been put over the mulch pile that they're breeding in, in order to minimize the number of emerging adults that spread around.

Stephanie Joe

O'ahu Army Natural Resources Program

Directorate of Public Works

U.S. Army Garrison-Hawaii

SCHOFIELD BARRACKS — Within the last year, two new insect pests, the coconut rhinoceros beetle (*Oryctes rhinoceros*, or CRB) and the little fire ant (*Wasmannia auropunctata*, or LFA) have arrived and spread on O'ahu.

Both are major pests that can hurt our native ecosystems and agriculture, and affect our households.

Thanks to the cooperation between the Oahu Army Natural Resource Program and Patrick Ching, an agronomist with the Directorate of Public Works, Schofield Barracks remains free of these incipient pests.

With continued vigilance and help from the community, it can stay that way.

Cover and excerpts from the Ecosystem Management Program bulletins.



## DNA ANALYSIS REVEALS THE DIET OF AN ENDANGERED TREE SNAIL

BY RICHARD O'RORKE

# D R O S O P H

**F**ar back in the deep gulches of the Waianae range, some of the rarest animals in Hawai'i survive in pockets of native forest. The picture-winged pomace flies, *Drosophila*, live quietly in the shaded valleys, almost always unseen—only by tempting them out with fermented bananas and mushrooms can they be observed and counted. They are the product of 25 million years of evolution in the Hawaiian Islands, and hopefully the progenitors of millions more.

Conservation of insects has been late in coming to Hawai'i, and long overdue. With over 6,000 endemic species, including hundreds that are still undescribed, our native insect diversity dwarfs that of better known groups. Preserved remains from caves show insects have suffered the same kind of mass extinction and range contraction as forest birds. *Drosophila* is the largest Hawaiian insect radiation, with an estimated 800-1,000 species—equal to or greater than the total number of endemic flowering plants or land snails—and three other groups have evolved over 300 species each, all from single colonizers. The 120 species in the charismatic picture-wing group of *Drosophila* include some of the largest and most colorful *Drosophila* in the world, dwarfing the laboratory genetics workhorse *D. melanogaster*.

All of the Hawaiian picture-wing flies breed in dead or dying native trees, where the larvae burrow into the mushy bark as it rots to feed on bacteria and yeasts. Though often overlooked, saprophages (consumers of decaying material) like these play an important role in maintaining the balance of microbes and ultimately in the conversion of dead plant matter into organic soil. Each species is particular to only one or two species of host plants—a habit that has

**SOME OF THE SMALLEST LIVING MEMBERS OF OUR ARCHIPELAGO ARE AMONG THE MOST DIVERSE.**

contributed to both the astonishing and their own as many have a steady stream of broken off adequate As the contract impacts, of intro native in *Drosophila* in areas smaller species federal more a obsta traini Situ vulne lands can w thry flies a sit spec well in has





**Survey and Control of Devil Weed (*Chromolaena odorata*) in the Kahuku Training Area, O'ahu, Hawai'i  
Progress Report  
October 1, 2014—March 31, 2015**



Mature devil weed (*Chromolaena odorata*) in the Kahuku Training Area

## Summary of Project Objectives

The O‘ahu Invasive Species Committee (OISC) was founded by a concerned group of citizens and land managers volunteering their weekends to control fountain grass and miconia on O‘ahu. Since then, OISC has grown into a partnership of federal, state and municipal agencies with a full-time field crew that works across all land ownerships.

OISC now systematically controls the island’s most damaging forest invaders, employs 16 people and educates the public about forest health and invasive species. OISC’s partners include the Hawai‘i Department of Land and Natural Resources/Division of Forestry and Wildlife, Honolulu Board of Water Supply, Hawai‘i Department of Transportation, Hawai‘i Department of Agriculture, Honolulu Botanical Gardens, and other state and federal agencies. The O‘ahu Army Natural Resources Program (OANRP) is a founding partner of OISC and one of OISC’s most supportive partners throughout its ten-year history. OISC is a project of the Pacific Cooperative Studies Unit of the University of Hawai‘i at Mānoa.

During the reporting period, OISC dedicated an average of 235 field hours a month to the detection and control of *Chromolaena odorata* at Kahuku Training Area (KTA). 1,849 plants were treated over 767 acres during OISC’s surveys of subunits 3, 4, 7, 8 and 10.

The FY2015 survey and control plan is to:

- Sweep once through all hotspots to count plants prior to OANRP conducting aerial or power sprayer drench with Oust, and delimit hotspots with flagging, or something equivalent.
- Follow up with on the ground “spot” chemical or mechanical control of OANRP treated hotspot areas.
- Survey once through subunits 3, 4, 7, 8, and 10 twice a year and treat plant population of five plants or less when encountered.  
Communicate with OANRP via a google docs spreadsheet the locations where spray operations of large patches are needed. OISC also uses the spreadsheet to note if treatment was effective.

OISC continues to obtain permission from private landowners on the northern side of KTA to survey their properties. These efforts will complement the surveys on KTA. Non-OANRP funds are supporting this work.

OISC conducts monthly management camping trips to reduce the time spent commuting to the work site in order to increase logistics efficiency. OISC works with OANRP to acquire access using KTA’s range control protocols. OANRP staff observed that *C. odorata* tends to set seed between March and April so management actions are scheduled to minimize the chance that control work will inadvertently spread this species.

OISC also conducts survey and control efforts outside the property boundaries of the KTA. The OISC outreach specialist obtains permission from private landowners on the northwestern side of KTA to survey and control populations on their properties. These efforts complement work efforts on KTA to prevent the spread of *C. odorata* to other locations on the island. Non-OANRP funds are supporting this work.

*PROJECT ACCOMPLISHMENTS: OCTOBER 1, 2014-MARCH 31, 2015*

*Chromolaena odorata*, commonly known as devil weed is a state-listed noxious weed, toxic to other plants, livestock and humans, possesses the ability to root vegetatively, produces up to 800,000 wind-dispersed seeds a year and is a fire promoting species that forms dense, monotypic stands of vegetation. The OANRP discovered *C. odorata* at the Kahuku Training Area (KTA) on the north shore of O‘ahu in January 2011. The Biological Opinion for military activities on O‘ahu requires the Army to respond immediately to incipient weeds brought in via training operations. What is currently known about *C. odorata* supports the assumptions that the center of the population is the Kahuku Training Area and that *C. odorata* was introduced to KTA because of military activities:



Between 2006 and 2009, botanical surveys of all publicly accessible roads on O‘ahu were conducted by OISC’s O‘ahu Early Detection program. *C. odorata* was not found during these surveys. This means that it is unlikely *C. odorata* was introduced somewhere else and dispersed onto KTA. *C. odorata* is a major pest on the island of Guam, and units from Hawai‘i sometimes train in Guam. The seeds are wind dispersed and readily attach to clothing. One plant can produce approximately 800,000 seeds a year. Given these factors, it is highly likely the pathway of introduction was military activities.

OISC conducts survey and treatment for *C. odorata* at KTA in partnership with OANRP and the Hawai‘i Department of Agriculture. The OISC field crew conducted delimiting surveys to determine population distribution and density in the Kahuku region and some limited control work. The management trips averaged 241.5 fieldwork hours per month. During the reporting period, OISC staff dedicated 1,449 personnel hours, of which 1,360 were field personnel hours. OISC surveyed 767 acres and treated 316 mature and 1,533 immature plants for a total of 1,849 plants. It should be noted that these control numbers are not a reflection on the total amount of plants detected or that actually exist within the subunits OISC manages, just the total that were treated by OISC staff. Large “hotspots” suitable for ground or aerial spraying were flagged for later treatment by OANRP.

### *CHALLENGES*

The area to be treated poses logistical challenges and some safety concerns that OISC is working to resolve. Crewmembers find they must carry more than three liters of water to ensure adequate hydration and heat exhaustion is a concern. The amount of ground covered when it is extremely hot will be reduced due to the need to take frequent breaks to prevent heat-related illnesses.

Surveys through guinea grass have a low confidence level because it is difficult to see even a short distance to the next crewmember. Guinea grass also presents a safety hazard

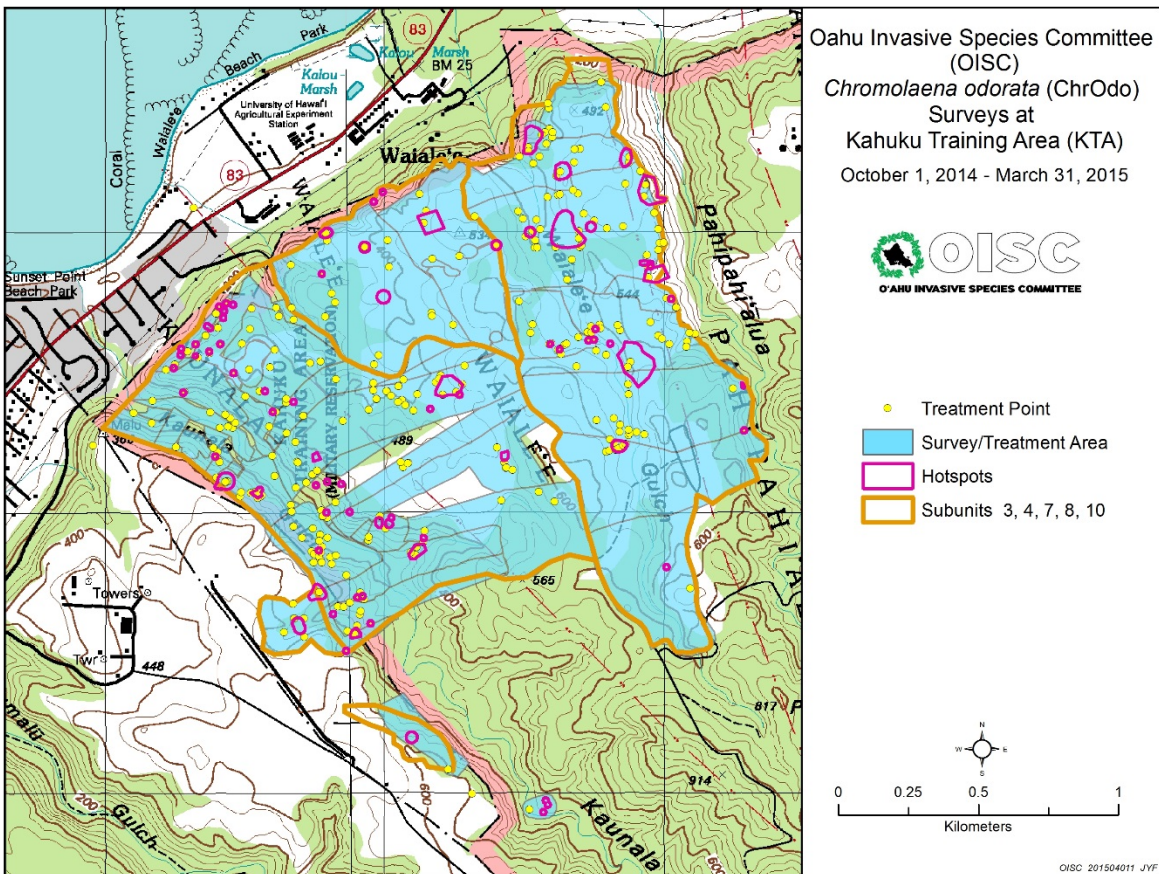
because it obscures the steep drop-offs and cliffs common in the area. As a result, OISC crews are treading more carefully and covering less acres per hour.

Additional acreage has been added to the area OISC needs to survey. Subunit 4 was extended to add 37 acres and subunit 10 was added. OISC had previously been able to sweep the entire area in 6 months and estimated that we could be finished in five months. However, the heat and terrain that have forced the crew to go more slowly and the additional acreage mean that we may not be able to complete all the surveys.

**Table 1: OISC *Chromolaena odorata* Work Effort Summary October 1, 2014-March 31, 2015**

Location	Acres Surveyed	Mature Plants Treated	Immature Plants Treated	Total Plants Treated	Effort (Hours)
KTA Subunits 3, 4, 7, 8, 10	767	316	1,533	1,849	1,449

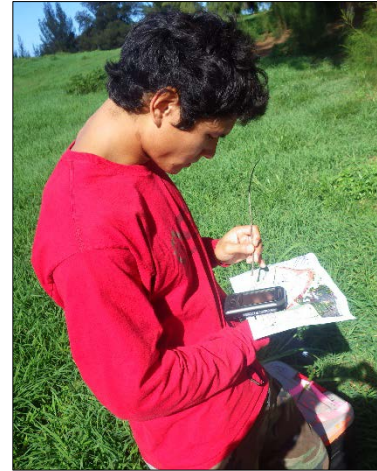
**Figure 1: OISC *Chromolaena odorata* Work Effort in Kahuku Training Area October 1, 2014 – March 31, 2015**



### *DATA MANAGEMENT*

OISC tracks its survey and control efforts in Microsoft Access and ArcGIS databases. It uses this data to plan field operations and report on progress. The OISC field crew completes field forms daily and is trained in the use of ArcPad and ArcGIS programs and the OISC Access database. The OISC Operations Planner and Data Analyst compiles and analyzes data collected in the field to assess work effort and if target work goals are being met.

OANRP and OISC jointly update a google doc spreadsheet to communicate hotspot treatment efficacy. OISC communicates to OANRP via the spreadsheet if a location is still a hotspot or if plants are present and OANRP lets OISC know when treatments have been completed.



### *PUBLIC EDUCATION & OUTREACH*

OISC's outreach specialist provided an informational update to the Ko'olauloa Neighborhood Board and an identification and reporting workshop to Board of Water Supply maintenance crew at their Kalihi baseyard.

### *OTHER*

In January 2013, botanists confirmed a satellite population of *C. odorata* in Kahana Valley. Since then, OISC obtained funding from the Watershed Partnership Program Grants to conduct surveys and control in this region. OISC's Outreach Specialist obtained Annual Special Use Permits for the survey and control of *C. odorata* populations at Kahana Heiau and Kea'iwa Heiau State Parks. Summaries of these efforts at the State Parks are provided by the outreach specialist to the respective Park Coordinators on a quarterly basis. As of March 31, the initial 200 meters around hotspots were surveyed and 2,008 plants controlled. Unfortunately, more plants were found within this initial buffer and the crew will continue to survey outward until they have delimited the population.

In addition to the Kahana population, a significant infestation of *C. odorata* was discovered by off-duty OANRP employees in 'Aiea. OISC is still working to delimit and treat the population. Plants are spread across Navy, State Park, State Forest Reserve, and Honolulu Board of Water Supply land. Staff from Marine Corps Base Hawai'i and OANRP have joined OISC staff during surveys and treatment. Staff from MCBH also assisted with gaining access to the Navy managed portion of the land.

**Table 2: OISC *Chromolaena odorata* Work Effort Summary in Kahana Valley October 1, 2014 – March 31, 2015**

Location	Acres Surveyed	Mature Plants Treated	Immature Plants Treated	Total Plants Treated	Effort (Hours)
Kahana Valley	25.36	11	290	301	209
'Aiea	109.33	125	95	220	300



In January, the OISC field crew found one *C. odorata* plant while doing surveys for *Senecio madagascariensis* in the Keamanea watershed at a spot that OISC visits frequently. OISC has dedicated gear for *C. odorata* surveys and washes the trucks in between species but there is a possibility that OISC dispersed it to this area. However there are other possible vectors. This area is near KTA, but close enough that wind dispersal is a possibility. Drum Road also runs through this area. OISC will continue to watch for *C. odorata* in this area and to closely follow decontamination protocols.

#### *COMPLIANCE*

OISC is a project of the Pacific Cooperative Studies Unit through the Research Corporation of the University of Hawaii, an equal opportunity employer. OISC utilizes RCUH and PCSU standard operating procedures and employee guidelines. OISC employees are trained in wilderness first aid, off-trail hiking safety and pesticide safety.

OAHU ARMY NATURAL RESOURCES PROGRAM  
MONITORING PROGRAM

**VEGETATION MONITORING AT KAHANAHAIKI  
MANAGEMENT UNIT, 2015**

**INTRODUCTION**

Vegetation monitoring was conducted at Kahanahaiki Management Unit (MU) (Subunit I) in 2015 in association with MIP/OIP requirements for long term monitoring of vegetation composition and change over time (OANRP 2008) (Figure 1). The primary objective of MU monitoring is to assess if the percent cover of non-native plant species is less than 50% across the MU, or is decreasing towards that threshold requirement. The secondary objective is to assess native cover is greater than 50% across the MU, or is increasing towards that threshold recommendation. Kahanahaiki MU vegetation monitoring occurs on a three-year interval, and took place twice previously (OANRP 2009, OANRP 2012). Previous monitoring indicated that goals were met only for the non-native understory (in 2009 and 2012) and canopy (in 2009) cover. Baseline data prior to fence completion in 1997 was not obtained.

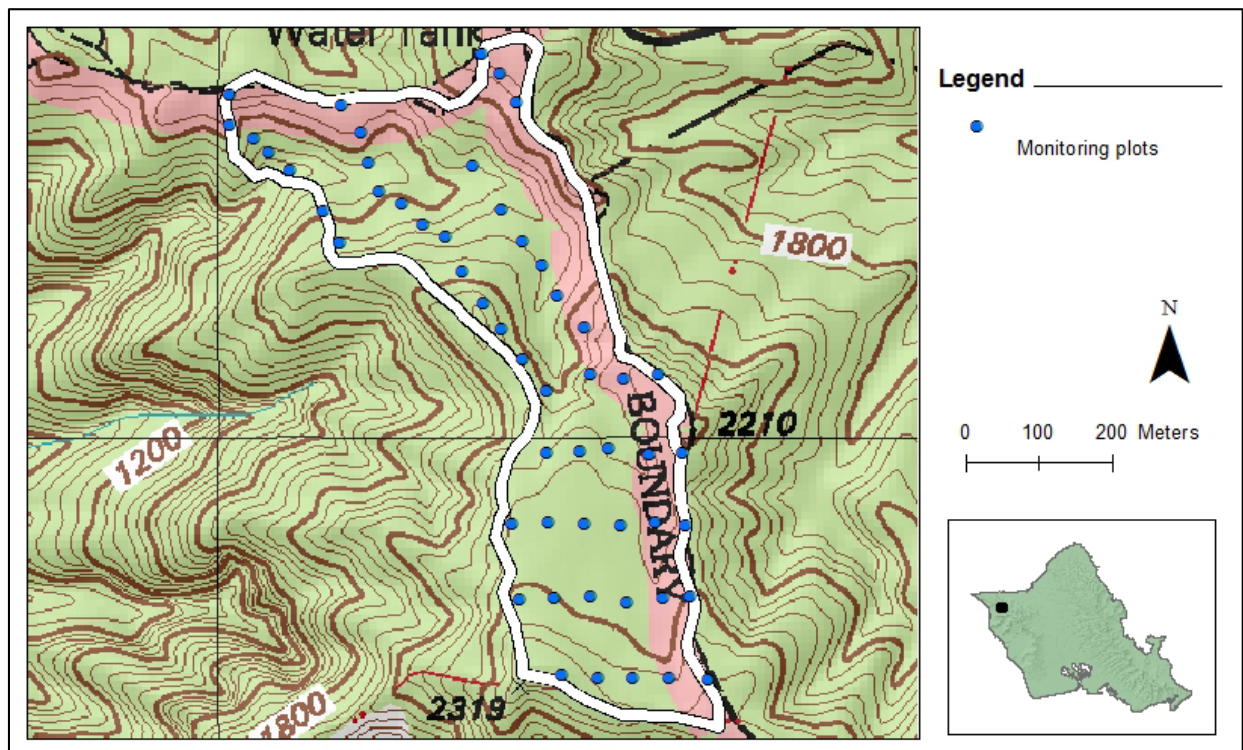


Figure 1. Kahanahaiki Subunit I vegetation monitoring plot locations.

**METHODS**

In June 2015, 53 plots were monitored along nine transects in Kahanahaiki Management Unit, Subunit I. Transects were spaced 100 meters (m) apart, and plots measuring 5 x 10 m were located every 50 m along transects. Understory [occurring from 0 – 2 m above ground level (AGL), including low branches from canopy species] and canopy (occurring > 2 m AGL, including epiphytes) vegetation was

recorded by percent cover for all non-native and native species present, summary percent cover by vegetation type (shrub, fern, grass/sedge) in the understory, overall summary percent cover of non-native and native vegetation in the understory and canopy, as well as bare ground (non-vegetated below 25 centimeters AGL). Bare ground was not clearly defined in 2009, and was not recorded in 2012.

Recruitment (defined as seedlings or saplings < 2 m AGL) data for tree species was recorded in 2015, but not documented previously. With the exception of tree recruitment and bare ground, monitoring results were compared with data from both 2009 and 2012. Based on MIP recommendations,  $\alpha = 0.05$  was used for significance determinations, and only cover changes  $\geq 10\%$  were recognized. Additional methodology information is detailed in Monitoring Protocol 1.2.1 (OANRP 2008). All analyses were performed in IBM SPSS Statistics Version 20. These included either Friedman's test with pot-hoc Bonferroni adjusted pairwise comparisons or Wilcoxon signed rank test for cover data, Mann-Whitney test of cover in plots with > 50% vs. < 50% non-native canopy, repeated measures ANOVA with post-hoc Bonferroni adjusted pairwise comparisons for species richness data, McNemar's test for frequency data, regression analyses for time spent weeding in association with cover change, and t tests for cover change in plots within vs. outside weed control areas.

## RESULTS

### Understory and canopy cover categories

Management objectives of having < 50% non-native understory and canopy and > 50% native understory and canopy cover were only met with respect to the non-native understory in 2015 (Table 1). Native understory and canopy percent cover were low (25% and 15% median values, respectively). Non-native understory and canopy cover were moderate (35% and 55% median values, respectively). There were several significant<sup>1</sup> changes in percent cover of vegetation from previous monitoring results. Non-native shrubs, total non-native understory, and bare ground increased significantly by 10% from 2009 and/or 2012 to 2015 (Figure 2). Caution should be applied in interpreting the results of the change in bare ground, as the method for this measurement was not as clearly defined as that of the vegetation measurements during monitoring in 2009, and as such is less comparable. Non-native canopy and total canopy increased significantly by 10% or more between 2009 and 2012, but remained unchanged between 2012 and 2015. Native shrubs, non-native ferns and grasses, and native canopy had significant changes in their relative distributions, while median values either remained unchanged or did not meet the 10% threshold for recognized change, among the years monitored. The highest percent cover of native understory and canopy in 2015 primarily occurred in the southern (Maile Flats) portion of the MU (Figure 3). Non-native canopy cover was high throughout much of the northern half of the MU as well as the eastern edge of Maile Flats. Locations of moderate to high percent cover of non-native understory were patchily distributed across the MU. Beneficial changes in native and non-native understory and canopy cover occurred primarily in Maile Flats, while locations of worsening conditions were patchily distributed across the MU (Figure 4).

**<sup>1</sup>Notes for readers less familiar with statistics:** Statistical significance is determined by p-values. P-values indicate to what extent the results support a hypothesis (the lower the number, the stronger the support for the hypothesis). In this study, the hypotheses would be that there are changes occurring in percent cover, frequency, and species richness. In this study, p-values less than 0.05 were significant. P-values only slightly greater than 0.05 were denoted as marginally significant, meaning that while not technically significant, it is worthy of note, e.g., perhaps a change is occurring, but at a gradual rate that may only become apparent in future monitoring, should that pattern continue. In some instances, there may be significant p-values despite no change in median values, if change occurred in the distribution of data, e.g., percent cover may range from 15 to 35 with a median of 25 one year, then the next year have a range of 15 to 95 but still have only a median of 25.

Table 1. Percent cover of native and non-native vegetation categories in the canopy and understory at Kahanahaiki from 2009 to 2015. Median values are represented (n = 53). Statistically significant values that meet 10% standard for recognized change in cover are in boldface. Arrows indicate increase (↑) or decrease (↓) in cover. Categories specifically addressed in management objectives are shaded.

	2009	2012	2015	p	X <sup>2</sup>	years that differed significantly	p (post-hoc <sup>**</sup> )	Management objective currently met?
<b>Understory</b>								
Native shrubs	8.00	15.00	8.00	< 0.001*↑	20.672	2009 vs. 2012 2009 vs. 2015	0.007↑ 0.007↑	
Native ferns	8.00	2.00	8.00	0.105*	4.500	NA		
Native grasses	0.00	0.00	0.00	0.544*	1.217	NA		
Total native understory	15.00	25.00	25.00	0.157*	3.705			No
Non-native shrubs	15.00	25.00	25.00	< <b>0.001</b> *↑	28.573	2009 vs. 2015 2012 vs. 2015	< <b>0.001</b> ↑ 0.005↑	
Non-native ferns	0.00	0.00	0.00	0.010*↑	9.155	NA		
Non-native grasses	0.00	0.00	2.00	< 0.00*↑↓	25.650	2012 vs. 2015	0.002↑	
Total non-native understory	25.00	25.00	35.00	< <b>0.001</b> *↑	31.207	2009 vs. 2015 2012 vs. 2015	< <b>0.001</b> ↑ < <b>0.001</b> ↑	Yes, but getting worse
Bare ground	45.00	N/A	55.00	<b>0.020</b> ***↑				
<b>Canopy</b>								
Native canopy	15.00	15.00	15.00	0.042*↑	6.347	NA		No
Non-native canopy	45.00	55.00	55.00	<b>0.002</b> *↑	12.296	2009 vs. 2015	<b>0.017</b> ↑	No
Total canopy	65.00	95.00	95.00	< <b>0.001</b> *↑	34.228	2009 vs. 2012 2009 vs. 2015	< <b>0.001</b> ↑ < <b>0.001</b> ↑	

\* from Friedman's test, asymptotic significance

\*\*from post-hoc pairwise comparisons with Bonferroni adjustment

\*\*\* from Wilcoxon signed-rank test

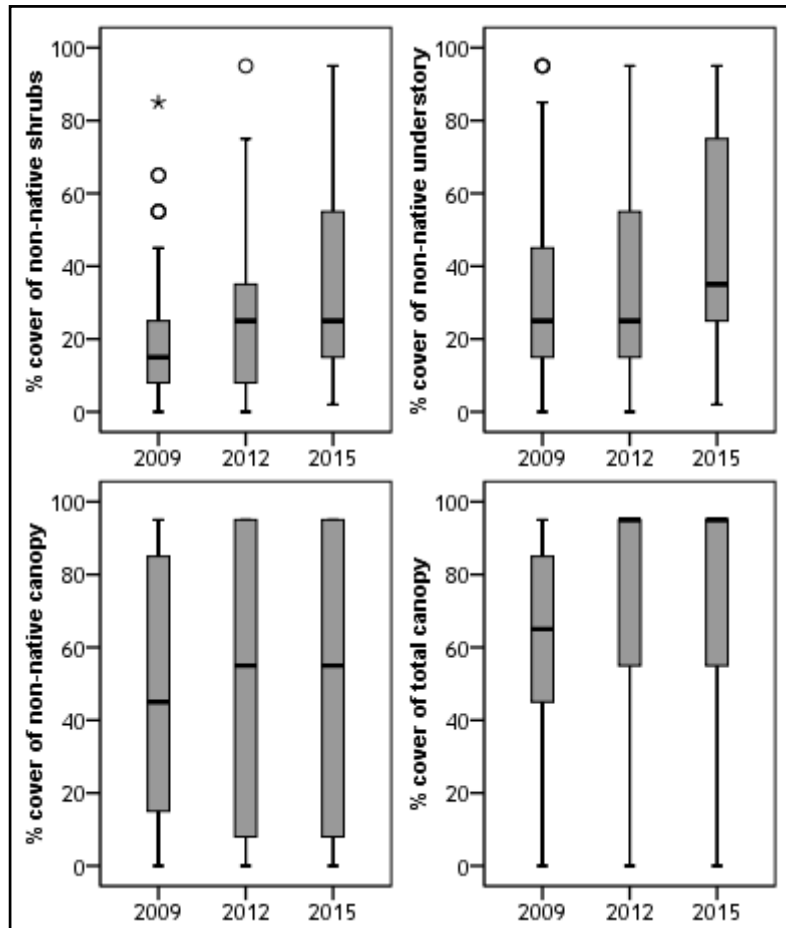


Figure 2. Boxplots<sup>2</sup> for vegetation categories with significant, and  $\geq 10\%$ , change in percent cover between years 2009 and 2015.

<sup>2</sup>**Additional notes for readers less familiar with statistics:** Boxplots show the range of data values for a given variable, analogous to a squashed bell curve turned on its side. The shaded boxes depict 50% of the data values, and the horizontal line inside the shaded box represents the median value. In this report, very high or low values relative to the shaded box are indicated by circles (1.5 to 3 times the length of the shaded box) and asterisks ( $> 3$  times the length of the shaded box), while the lines extending above and below the shaded box depict the range in values for all remaining data. Boldface circles and asterisks indicate multiple data points for the same value.

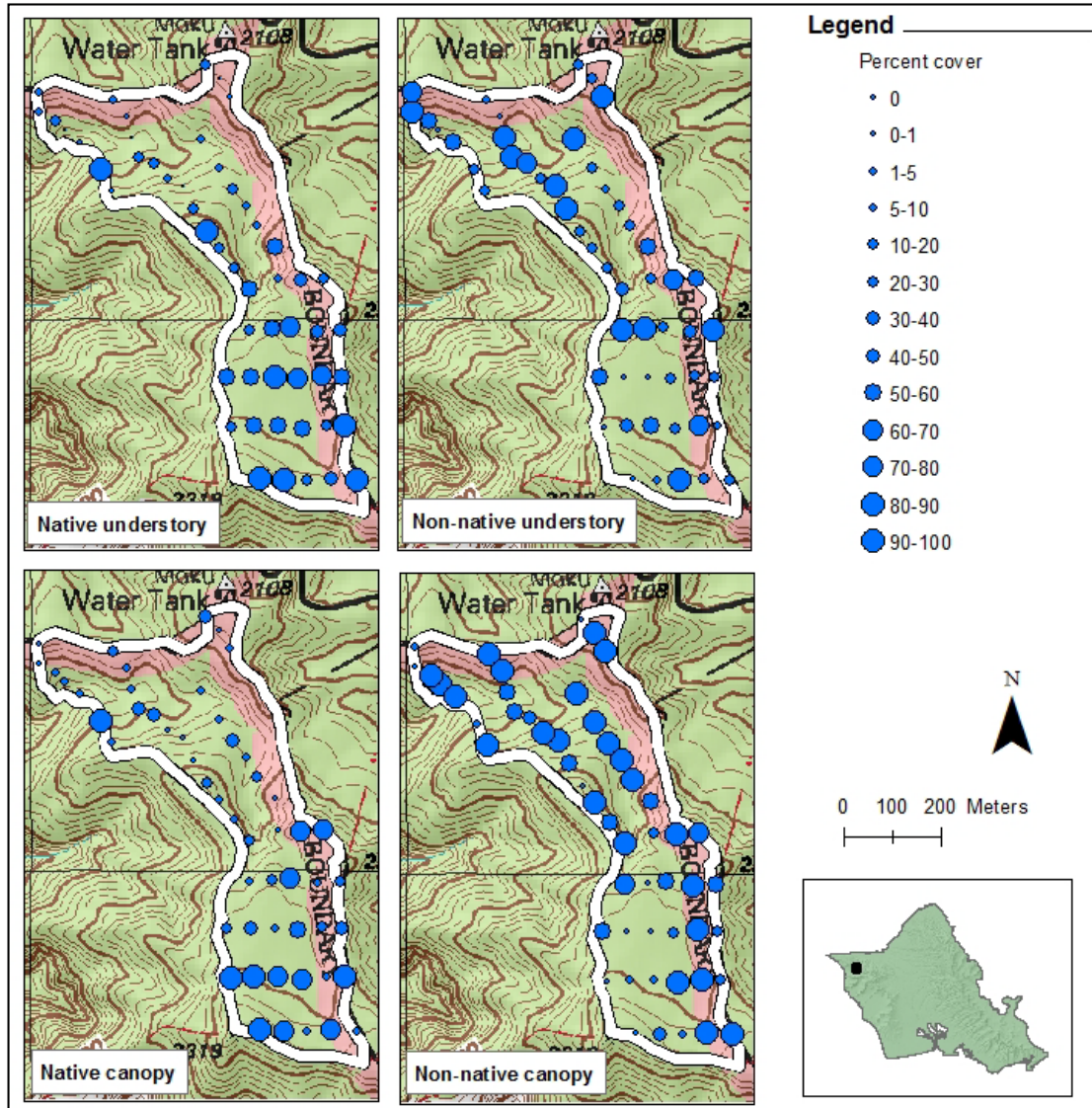


Figure 3. Locations of low to high percent cover of native and non-native understory and canopy vegetation among monitored plots at Kahanahaiki Subunit I in 2015. Larger circles denote higher percent cover, while smaller circles represent lower percent cover.

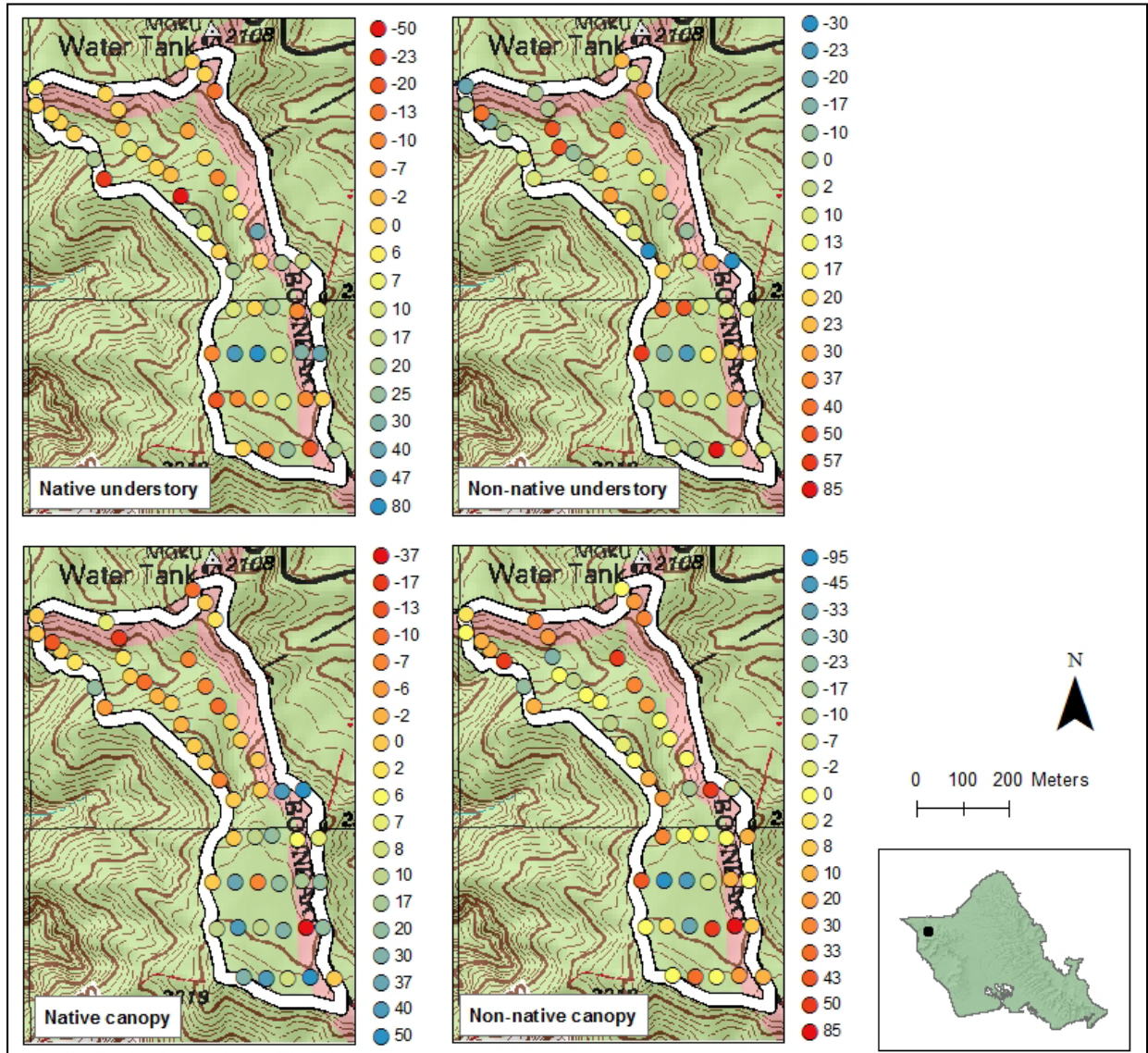


Figure 4. Locations of change in native and non-native percent cover for the understory and canopy (from 2009 to 2015) vegetation in monitored plots in Kahanahaiki Subunit I. Color gradients are inverted for native and non-native vegetation, such that blue indicates beneficial change, red depicts worsening conditions. Cover change of 0 indicates there was no change in percent cover.

Following the 2012 monitoring of Kahanahaiki, it was observed that plots with > 50% non-native canopy cover had differing patterns of change as compared with plots with < 50% non-native canopy cover (segregated using 2009 data). Similar analyses were performed incorporating the current data that further support differences in vegetation change in association with non-native canopy cover. Native understory and canopy cover was higher in the plots with < 50% non-native cover than in those with > 50% non-native cover (Mann-Whitney: native understory 2015  $p = 0.003$ ,  $W = 922.5$ ; native canopy 2015  $p = 0.011$ ,  $W = 898.5$ ) (Figure 5). Increases occurred in native canopy in plots with < 50% non-native canopy (from 2009 to 2015), and in non-native canopy in plots with > 50% non-native canopy (from 2009 to 2012) (Table 2). However, non-native understory cover increased among plots in 2015 regardless of non-native canopy cover.

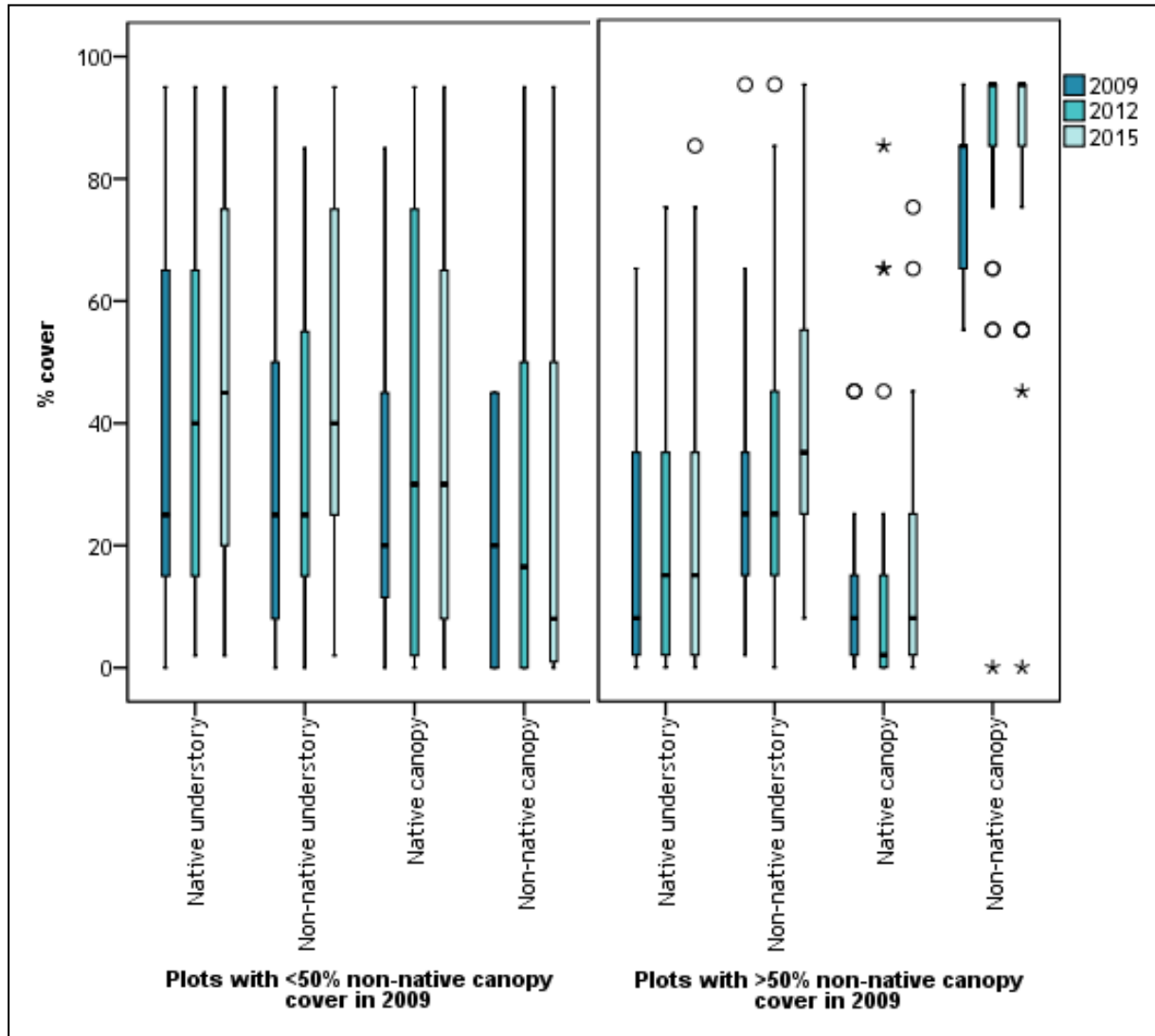


Figure 5. Boxplot of percent cover of native and non-native understory and canopy in 2009, 2012, and 2015, among plots with < 50% and > 50% non-native canopy in 2009.

Table 2. Percent cover change among plots with < 50% and > 50% non-native canopy cover as of 2009. Statistically significant values are in boldface.

	Plots with < 50% non-native canopy cover as of 2009 (n = 28)					Plots with > 50% non-native canopy cover as of 2009 (n = 25)				
	direction of change	p*	X <sup>2</sup>	years that differed	p (post-hoc**)	direction of change	p*	X <sup>2</sup>	years that differed	p (post-hoc**)
Native understory		0.194	3.28	NA			0.661	0.827	NA	
Non-native understory	increase	<b>&lt;0.001</b>	20.438	2009 vs. 2015 2012 vs. 2015	<b>0.002</b> <b>&lt;0.001</b>	increase	<b>0.003</b>	11.783	2009 vs. 2015	<b>0.009</b>
Native canopy	increase	<b>0.012</b>	8.86	2009 vs. 2015	<b>0.048</b>		0.890	0.233	NA	
Non-native canopy		0.065	5.48	NA		increase	<b>0.001</b>	13.452	2009 vs. 2012	<b>0.017</b>

\*from Friedman's test

\*\*post-hoc comparison with Bonferroni adjustment



## Species richness

During monitoring in 2015, 105 species were recorded in the understory (53% native species), and 44 species were identified in the canopy (72% native species). Altogether, there were 58 native and 50 non-native taxa identified in the understory and/or canopy. Most species present in the canopy were also represented in the understory, with the exception of two native (*Gynochthodes trimera* and *Santalum freycinetianum* var. *freycinetianum*) and one non-native (*Eucalyptus urophylla*) species. Native understory and canopy species richness was generally higher in the Maile Flats region, and lower in the northern portion of the MU (Figure 6). Locations of high and low species richness for the non-native understory and canopy were primarily patchily distributed across the MU, with few evident patterns. Species richness was higher for native as compared with non-native understory and canopy (Table 3). There was a small significant increase in species richness among plots in 2015 in the non-native understory. No detectable change occurred in species richness among plots in the native understory or canopy, or in the non-native canopy. In concert with the significant increase in non-native understory richness among plots, the overall non-native understory diversity for the MU increased. Fourteen taxa (50% native) occurred in plots in 2015 that were not observed previously, while sixteen taxa (63% native) recorded previously during monitoring were not present in 2015 (Table 4). The presence or absence of species may be due in part to human error, including misidentification (e.g., difficulties in distinguishing *Cyperus* and *Emelia* taxa); observer bias regarding plot boundaries or amount of time spent searching; or accidental non-recording. The presence of short-lived, less common species is expected to vary over time. All of the species that were not present in 2015 were uncommon in previous years (primarily occurring in only one or two plots), with frequencies no greater than 0.08.

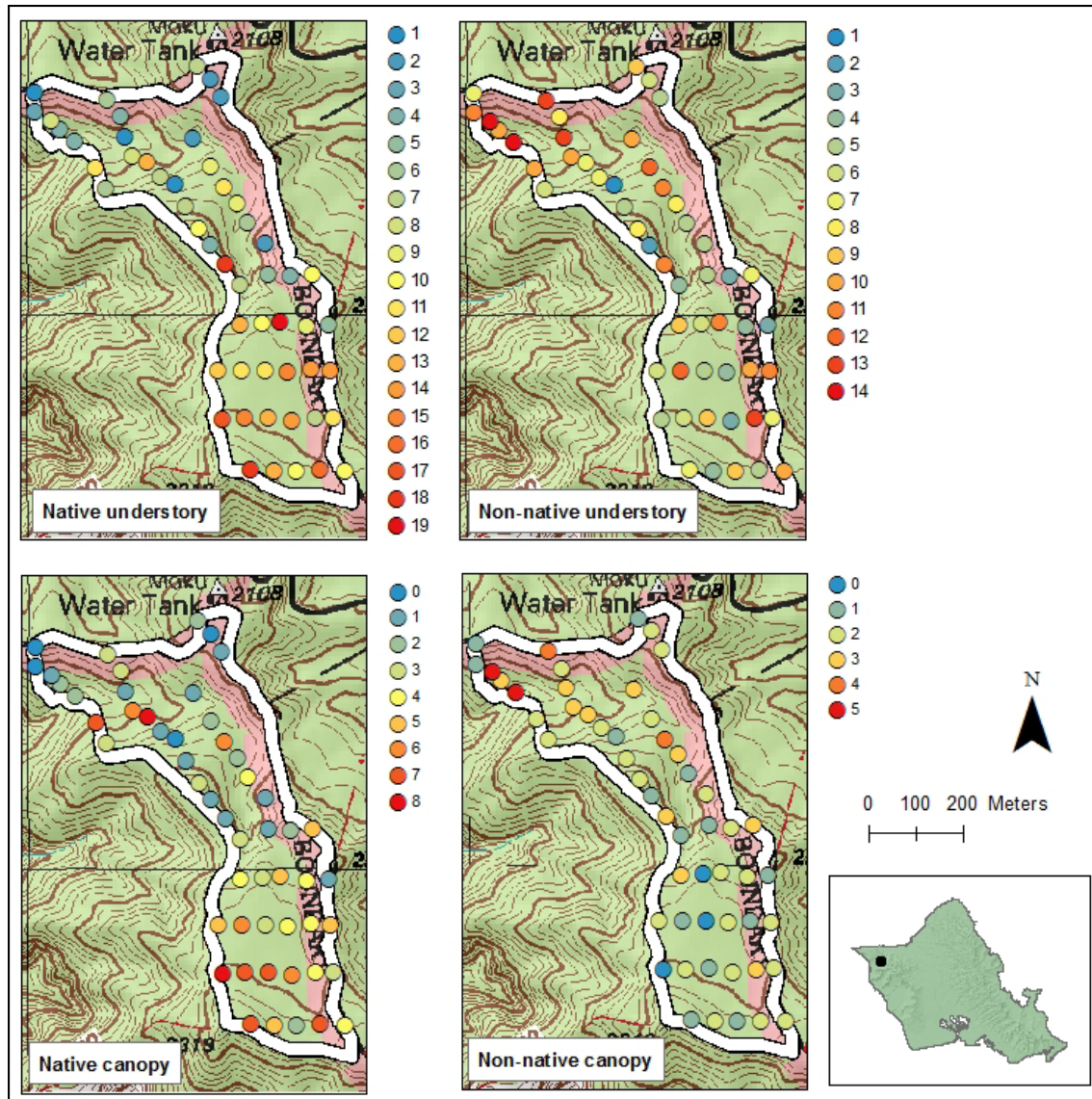


Figure 6. Locations of low to high species richness among plots in the native and non-native understory and canopy in Kahanahaiki Subunit I, 2015. Color gradients of blue to red indicate low to high values, respectively, of the number of species occurring in plots (i.e., blue indicates low diversity, while red indicates relatively higher diversity).

Table 3. Kahanahaiki MU understory and canopy species richness. Mean values of species richness per plot during vegetation monitoring is shown by year, with the total number of species recorded among all plots in parenthesis (n = 53). Statistically significant values are in boldface. Arrows indicate increase (↑) or decrease (↓) in richness.

	2009	2012	2015	p*	F	years that differed	p (post-hoc**)
Native understory	8.53 (58)	8.62 (56)	8.85 (56)	0.597	0.518	NA	
Non-native understory	6.17 (43)	6.53 (42)	7.68 (49)	<b>0.001</b> ↑	6.929	2009 vs. 2015 2012 vs. 2015	<b>0.004</b> ↑ <b>0.010</b> ↑
Native canopy	3.47 (30)	3.23 (28)	3.34 (32)	0.472***	0.072	NA	
Non-native canopy	2.08 (10)	1.83 (9)	2 (12)	0.068***	2.869	NA	

\*derived from repeated measures ANOVA

\*\*derived from post-hoc comparison with Bonferroni correction

\*\*\*Greenhouse-Geisser correction applied

Table 4. Newly recorded, and no longer present, species during 2015 Kahanahaiki MU monitoring. Native taxa are in boldface.

	2009	2012	2015		2009	2012	2015
New species recorded in plots in 2015				Species not recorded in 2015 but observed in plots previously			
<i>Ageratina adenophora</i>			0.02	<b><i>Asplenium caudatum</i></b>	0.08	0.04	
<b><i>Asplenium macraei</i></b>			0.02	<i>Casuarina glauca</i>		0.02	
<b><i>Canavalia galeata</i></b>			0.02	<b><i>Charpentiera tomentosa</i></b>	0.06	0.04	
<i>Castilleja arvensis</i>			0.04	<b><i>Cibotium glaucum</i></b>	0.02	0.04	
<b><i>Coprosma longifolia</i></b>			0.02	<b><i>Cyperus hillebrandii</i> var. <i>hillebrandii</i></b>	0.04		
<i>Erechtites valerianifolia</i>			0.06	<b><i>Doryopteris decipiens</i></b>	0.02		
<i>Eucalyptus urophylla</i>			0.02	<i>Emilia fosbergii</i>	0.04		
<b><i>Metrosideros tremuloides</i></b>			0.08	<i>Gamochaeta purpurea</i>	0.02		
<b><i>Panicum nephelophilum</i></b>			0.02	<i>Leucaena leucocephala</i>	0.06	0.02	
<i>Pityrogramma austroamericana</i>			0.02	<b><i>Myrsine lessertiana</i></b>	0.02	0.04	
<i>Urochloa maxima</i>			0.02	<b><i>Pisonia umbellifera</i></b>	0.02	0.02	
<i>Vernonia cinerea</i>			0.04	<b><i>Pittosporum glabrum</i></b>	0.04	0.04	
<b><i>Viola chamissoniana</i></b>			0.02	<b><i>Rumex albenscens</i></b>	0.02	0.02	
<b><i>Waltheria indica</i></b>			0.02	<i>Setaria parviflora</i>	0.02		
				<b><i>Streblus pendulinus</i></b>	0.02	0.02	
				<i>Triumfetta semitriloba</i>	0.02		

### Species frequency

Non-native species that most frequently occurred in plots (present in more than half the plots) in the understory included *Psidium cattleianum*, *Schinus terebinthifolius*, and *Clidemia hirta*, while those most commonly occurring in the canopy were *P. cattleianum* and *S. terebinthifolius* (Table 5). The most frequent native species included *Psydrax odorata*, *Alyxia stellata*, and *Nephrolepis exaltata* subsp. *hawaiiensis* in the understory, and *P. odorata* in the canopy. Of the 13 rare taxa occurring at Kahanahaiki Subunit I, two (*Cenchrus agrimonioides* var. *agrimonioides* and *Delissea waianaensis*) were identified during monitoring in 2015. Analysis of frequency change (McNemar's test) was limited to taxa with  $\geq 10\%$  change between years monitored. In 2015, increases in frequency occurred for one native understory species (*Bidens torta*) and one non-native understory species (*Conyza bonariensis*), while decreases in frequency occurred for one native canopy species (*Cocculus orbiculatus*) (Table 6). Among these, *C. bonariensis* had the greatest change, with a frequency increase from 0.11 in 2009 to 0.38% in 2015. Native taxa frequencies increased for *Dianella sandwicensis* in the understory and decreased for *Kadua affinis* in the canopy between 2009 and 2012, but did not change significantly between 2012 and 2015. Of note, while there was a marginally significant reduction in the frequency of *Grevillea robusta* in the canopy from 0.19 in 2009 to 0.08 in 2012 ( $p = 0.07$ ) following targeted weeding of larger *G. robusta* trees across the MU, the frequency rebounded to 0.13 by 2015. This may be due in part to saplings in the understory that grew to become canopy components, and expanded growth of smaller trees in the canopy (not targeted for weed control) between 2012 and 2015. Following the 2015 monitoring, targeted weeding of larger *G. robusta* trees resumed, which may be reflected by subsequent monitoring in 2018.

Table 5. Species frequency among plots (proportion of plots in which a given taxa occurs) during 2015 Kahanahaiki MU monitoring (n= 53), in order of most to least frequent. Native species are in boldface. \*Rare taxa.

Taxa	Freq	Taxa	Freq	Taxa	Freq	Taxa	Freq
<b>Understory</b>							
<i>Psidium cattleianum</i>	0.96	<i>Cyclosorus parasiticus</i>	0.19	<i>Oxalis corniculata</i>	0.08	<i>Asplenium macraei</i>	0.02
<i>Psychdrax odorata</i>	0.83	<i>Lepisorus thunbergianus</i>	0.19	<i>Planchonella sandwicensis</i>	0.08	<i>Bobea elatior</i>	0.02
<i>Schinus terebinthifolius</i>	0.79	<i>Passiflora suberosa</i>	0.19	<i>Pteridium aquilinum</i>	0.08	<i>Canavalia galeata</i>	0.02
<i>Clidemia hirta</i>	0.77	<i>Antidesma platyphyllum</i>	0.17	<i>Syzygium cumini</i>	0.08	<i>Cenchrus agrimonioides</i> var. <i>agrimonioides</i> *	0.02
<i>Alyxia stellata</i>	0.62	<i>Carex wahuensis</i>	0.17	<i>Youngia japonica</i>	0.08	<i>Coprosma longifolia</i>	0.02
<i>Nephrolepis exaltata</i>	0.51	<i>Grevillea robusta</i>	0.17	<i>Ageratum conyzoides</i>	0.06	<i>Delissea waianaensis</i> *	0.02
<i>Coprosma foliosa</i>	0.47	<i>Psilotum nudum</i>	0.17	<i>Aleurites moluccana</i>	0.06	<i>Deparia petersenii</i>	0.02
<i>Acacia koa</i>	0.42	<i>Sphenomeris chinensis</i>	0.17	<i>Chamaecrista nictitans</i>	0.06	<i>Desmodium incanum</i>	0.02
<i>Blechnum appendiculatum</i>	0.42	<i>Ageratina riparia</i>	0.15	<i>Erechtites valerianifolia</i>	0.06	<i>Elaphoglossum aemulum</i>	0.02
<i>Cocculus orbiculatus</i>	0.42	<i>Leptecophylla tameiameiae</i>	0.15	<i>Mesosphaerum pectinatum</i>	0.06	<i>Gahnia beecheyi</i>	0.02
<i>Doodia kunthiana</i>	0.40	<i>Asplenium kaulfussii</i>	0.13	<i>Oxalis corymbosa</i>	0.06	<i>Hibiscus arnottianus</i> subsp. <i>arnottianus</i>	0.02
<i>Melinis minutiflora</i>	0.40	<i>Crassocephalum crepidoides</i>	0.13	<i>Pipturis albidus</i>	0.06	<i>Macrotyloma axillare</i> var. <i>glabrum</i>	0.02
<i>Conyza bonariensis</i>	0.38	<i>Melinis repens</i>	0.13	<i>Psidium guajava</i>	0.06	<i>Melicope oahuensis</i>	0.02
<i>Lantana camara</i>	0.38	<i>Dodonaea viscosa</i>	0.11	<i>Psychotria hathewayi</i>	0.06	<i>Metrosideros tremuloides</i>	0.02
<i>Bidens torta</i>	0.36	<i>Emilia sonchifolia</i>	0.11	<i>Adiantum hispidulum</i>	0.04	<i>Montanoa hibiscifolia</i>	0.02
<i>Carex meyenii</i>	0.36	<i>Psychotria mariniana</i>	0.11	<i>Buddleja asiatica</i>	0.04	<i>Myrsine lanaiensis</i>	0.02
<i>Metrosideros polymorpha</i>	0.34	<i>Andropogon virginicus</i>	0.09	<i>Castilleja arvensis</i>	0.04	<i>Panicum nephelophilum</i>	0.02
<i>Microlepia strigosa</i>	0.34	<i>Cordyline fruticosa</i>	0.09	<i>Dicranopteris linearis</i>	0.04	<i>Peperomia tetraphylla</i>	0.02
<i>Paspalum conjugatum</i>	0.34	<i>Cyperus hypochlorus</i> var. <i>hypochlorus</i>	0.09	<i>Diospyros hillebrandii</i>	0.04	<i>Pityrogramma austroamericana</i>	0.02
<i>Dianella sandwicensis</i>	0.30	<i>Euphorbia multififormis</i>	0.09	<i>Korthalsella cylindrica</i>	0.04	<i>Pluchea carolinensis</i>	0.02
<i>Kadua affinis</i>	0.30	<i>Phlebodium aureum</i>	0.09	<i>Passiflora edulis</i>	0.04	<i>Rivina humilis</i>	0.02
<i>Stachytarpheta australis</i>	0.25	<i>Pisonia brunoniana</i>	0.09	<i>Pisonia sandwicensis</i>	0.04	<i>Sapindus oahuensis</i>	0.02
<i>Oplismenus hirtellus</i>	0.23	<i>Scaevola gaudichaudiana</i>	0.09	<i>Spathodea campanulata</i>	0.04	<i>Urochloa maxima</i>	0.02
<i>Diospyros sandwicensis</i>	0.21	<i>Cyclosorus dentatus</i>	0.08	<i>Vernonia cinerea</i>	0.04	<i>Viola chamissoniana</i>	0.02
<i>Rubus rosifolius</i>	0.21	<i>Nephrolepis brownii</i>	0.08	<i>Acacia mearnsii</i>	0.02	<i>Waltheria indica</i>	0.02
<i>Wikstroemia oahuensis</i>	0.21	<i>Nestegis sandwicensis</i>	0.08	<i>Ageratina adenophora</i>	0.02	<i>Xylosma hawaiiense</i>	0.02
<i>Cibotium chamissoi</i>	0.19						
<b>Canopy</b>							
<i>Psidium cattleianum</i>	0.81	<i>Antidesma platyphyllum</i>	0.09	<i>Dodonaea viscosa</i>	0.04	<i>Dicranopteris linearis</i>	0.02
<i>Psychdrax odorata</i>	0.70	<i>Kadua affinis</i>	0.09	<i>Hibiscus arnottianus</i> subsp. <i>arnottianus</i>	0.04	<i>Eucalyptus urophylla</i>	0.02
<i>Schinus terebinthifolius</i>	0.70	<i>Planchonella sandwicensis</i>	0.09	<i>Leptecophylla tameiameiae</i>	0.04	<i>Gynochthodes trimera</i>	0.02
<i>Alyxia stellata</i>	0.43	<i>Cordyline fruticosa</i>	0.08	<i>Pisonia sandwicensis</i>	0.04	<i>Korthalsella cylindrica</i>	0.02
<i>Acacia koa</i>	0.38	<i>Metrosideros tremuloides</i>	0.08	<i>Psidium guajava</i>	0.04	<i>Lantana camara</i>	0.02
<i>Metrosideros polymorpha</i>	0.28	<i>Cibotium chamissoi</i>	0.06	<i>Santalum freycinetianum</i> var. <i>freycinetianum</i>	0.04	<i>Montanoa hibiscifolia</i>	0.02
<i>Coprosma foliosa</i>	0.25	<i>Nestegis sandwicensis</i>	0.06	<i>Syzygium cumini</i>	0.04	<i>Passiflora edulis</i>	0.02
<i>Diospyros sandwicensis</i>	0.15	<i>Pisonia brunoniana</i>	0.06	<i>Acacia mearnsii</i>	0.02	<i>Pipturis albidus</i>	0.02
<i>Grevillea robusta</i>	0.13	<i>Sapindus oahuensis</i>	0.06	<i>Bobea elatior</i>	0.02	<i>Psychotria hathewayi</i>	0.02
<i>Aleurites moluccana</i>	0.11	<i>Bidens torta</i>	0.04	<i>Canavalia galeata</i>	0.02	<i>Scaevola gaudichaudiana</i>	0.02
<i>Psychotria mariniana</i>	0.11	<i>Diospyros hillebrandii</i>	0.04	<i>Cocculus orbiculatus</i>	0.02	<i>Xylosma hawaiiense</i>	0.02

Table 6. Species with significant frequency change at Kahanahaiki between 2009 and 2015. Only taxa with at least 10% change in frequency were analyzed.

Frequency values represent the proportion of plots in which species are present (n = 53). Native species are in boldface. P-values obtained from McNemar's test with exact significance. Arrows indicate increase (↑) or decrease (↓) in frequency.

	2009	2012	2015	years that differed	p
Understory					
<i>Bidens torta</i>	0.21	0.30	0.36	2009 vs. 2015	0.039↑
<i>Dianella sandwicensis</i>	0.17	0.32	0.30	2009 vs. 2012 2009 vs. 2015	0.008↑ 0.039↑
<i>Conyza bonariensis</i>	0.11	0.21	0.38	2012 vs. 2015 2009 vs. 2015	0.022↑ < 0.001↑
Canopy					
<i>Cocculus orbiculatus</i>	0.15	0.06	0.02	2009 vs. 2015	0.016↓
<i>Kadua affinis</i>	0.23	0.11	0.09	2009 vs. 2012 2009 vs. 2015	0.031↓ 0.016↓

### Species cover

Species with frequencies > 0.20 in 2015 were analyzed for percent cover change. Small significant increases in cover occurred in 2015 for three native understory species (*A. stellata*, *B. torta*, and *D. sandwicensis*), four non-native understory species (*C. hirta*, *Melinis minutiflora*, *P. cattleianum*, and *S. terebinthifolius*), three native canopy species (*Acacia koa*, *A. stellata*, and *P. odorata*), and two non-native canopy species (*P. cattleianum* and *S. terebinthifolius*) (Table 7 and Figure 7). No species declined in cover in 2015. The median change in cover was < 10.0% for all species, with the greatest change occurring for *P. cattleianum* in the understory. The changes in cover for non-native understory were likely driven by cumulative changes among multiple taxa, and were likely heavily influenced by *P. cattleianum*, given its combination of high frequency and cover change relative to other species.

Table 7. Native and non-native species with significant percent cover change in the canopy and understory for the years 2009, 2012, and 2015. Only species with frequencies > 0.20 (in ≥ 6 plots) in 2015 were analyzed. Native taxa in boldface. Arrows indicate cover increase (↑) or decrease (↓).

Taxa	p*	X <sup>2</sup>	years that differ significantly	p (post-hoc**)	Median cover change
Understory					
<i>Alyxia stellata</i>	< 0.001↑	24.539	2009 vs. 2015	0.004	0.0
<i>Bidens torta</i>	0.003↑	11.353	NA		
<i>Clidemia hirta</i>	< 0.001↑	27.517	2009 vs. 2015	0.002	0.0
<i>Dianella sandwicensis</i>	0.014↑	8.583	NA		
<i>Melinis minutiflora</i>	0.001↑	13.273	NA		
<i>Psidium cattleianum</i>	0.001↑	14.182	2009 vs. 2015	0.004	2.0
<i>Schinus terebinthifolius</i>	0.013↑	8.738	NA		
Canopy					
<i>Acacia koa</i>	0.001↑	13.178	NA		
<i>Alyxia stellata</i>	0.015↑	8.444	NA		
<i>Psydrax odorata</i>	0.045↑	6.209	NA		
<i>Psidium cattleianum</i>	0.009↑	9.318	NA		
<i>Schinus terebinthifolius</i>	0.049↑	6.019	NA		

\*derived from Friedman's test

\*\*post-hoc comparison with Bonferroni adjustment

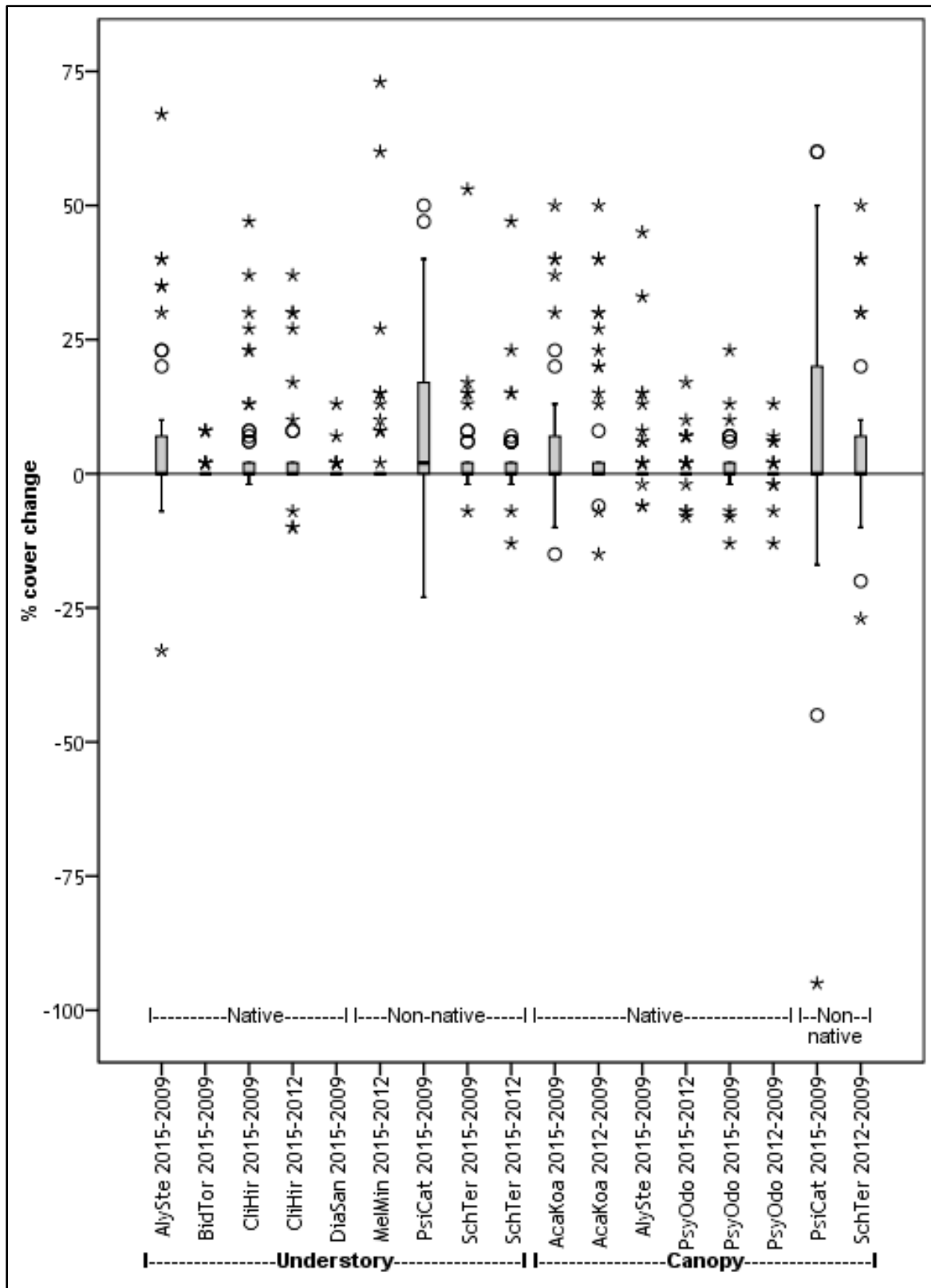


Figure 7. Boxplots of percent cover change between 2009 and 2015 at Kahanahaiki MU, for species with significant changes in cover. Values > 0 represent increased cover in plots, while those < 0 represent decreased cover.

## Canopy replacement

Most canopy tree species were found recruiting (seedlings or saplings < 2 m AGL) in the understory (Table 8). These include 25 out of 34 tree species recorded in the canopy, as well as 4 tree species that were not recorded in the canopy. *Psydrax odorata* and *A. koa* and were the most commonly recruiting native tree species (in nearly half the plots), while non-native recruiting tree species were primarily *P. cattleianum* (in the majority of the plots) and *S. terebinthifolius* (in more than half the plots). Native species with no recruitment in the understory were also infrequent in the canopy. Of note, the age of saplings may vary greatly, from less than one year to decades, in accordance with differing species and individual growth rates, complicating interpretations of presence/absence and change over time with respect to concerns over long term canopy replacement.

Table 8. Canopy tree species recruitment in the understory during 2015 Kahanahaiki MU monitoring, in order of most to least frequent. Frequency represents the occurrence of tree species with a maximum height < 2 meters (seedlings to small trees) among plots (n = 148). Native taxa in are boldface.

Species	Frequency	Species	Frequency
<i>Psidium cattleianum</i>	0.91	<i>Syzygium cumini</i>	0.06
<i>Schinus terebinthifolius</i>	0.64	<b><i>Diospyros hillebrandii</i></b>	0.04
<b><i>Psydrax odorata</i></b>	0.42	<b><i>Psychotria hathewayi</i></b>	0.04
<b><i>Acacia koa</i></b>	0.40	<i>Spathodea campanulata</i>	0.04
<b><i>Diospyros sandwicensis</i></b>	0.15	<i>Acacia mearnsii</i>	0.02
<i>Grevillea robusta</i>	0.15	<i>Cordyline fruticosa</i>	0.02
<b><i>Kadua affinis</i></b>	0.15	<b><i>Hibiscus arnottianus</i> subsp. <i>arnottianus</i></b>	0.02
<b><i>Metrosideros polymorpha</i></b>	0.15	<b><i>Leptecophylla tameiameia</i></b>	0.02
<b><i>Wikstroemia oahuensis</i> var. <i>oahuensis</i></b>	0.15	<b><i>Melicope oahuensis</i></b>	0.02
<i>Dodonaea viscosa</i>	0.11	<i>Myrsine lanaiensis</i>	0.02
<i>Pisonia brunoniana</i>	0.08	<i>Nestegis sandwicensis</i>	0.02
<i>Psychotria mariniana</i>	0.08	<b><i>Pipturis albidus</i></b>	0.02
<i>Scaevola gaudichaudiana</i>	0.08	<b><i>Planchonella sandwicensis</i></b>	0.02
<i>Aleurites moluccana</i>	0.06	<i>Psidium guajava</i>	0.02
<b><i>Antidesma platyphyllum</i></b>	0.06		

## Weed control

Weed control efforts at Kahanahaiki Subunit I between the 2012 and 2015 monitoring intervals included 1947.77 person hours, which was 25% less time than was spent weeding between the 2009 and 2012 monitoring intervals (2554.90 person hours). Similarly, fewer plots happened to fall within weeded areas between 2012 and 2015. Weed control efforts crossed through 21% of the plots between 2012 and 2015, as compared with 64% between 2009 and 2012 (Figure 8). The proportion of plots weeded was somewhat less than the percent total area weeded within the MU (38% of the MU was weeded between 2012 and 2015, and 68% was weeded between 2009 and 2012). I.e., weeding efforts in the monitored plots should be representative of those occurring across the entire MU. It should be noted that the weeding efforts between 2009 and 2012 included sizable areas where only large *G. robusta* trees were targeted. The total amount of effort varied among the 16 weed control areas (WCA) that encompass Subunit I, ranging from 0 to 582.83 hours per WCA from 2009-2012 and 0 to 721.35 hours per WCA from 2012-2015. There was a weak positive correlation between person hours spent weeding and change in native understory cover between 2012 and 2015 by WCA ( $p = 0.021$ ,  $r^2 = 0.10$ ). Change in native and non-native cover in the understory and canopy did not correlate with the amount of time spent weeding per WCA for any other time range comparisons. Change in native and non-native cover did not differ among plots weeded vs. not weeded between the years 2009-2012, or 2012-2015, even when single species targeted weeding was parsed out in analyses. Reductions in non-native canopy did not correlate with increases in native or non-native understory vegetation among the monitored plots.

Three incipient non-native species (*Acacia mearnsii*, *Macrotyloma axillare* var. *glabrum*, and *Nephrolepis brownii*) and four widespread weed taxa targeted specifically at Subunit I by OANRP (*G.*

*robusta*, *Montanoa hibiscifolia*, *Passiflora suberosa*, and *Spathodea campanulata*) (OANRP 2009) were identified during monitoring in 2015, with at least one target taxa present in 43% of the plots in the understory or canopy (Figure 9). These species were already known to occur in the MU, and were primarily located in only 1 to 4 plots, with the exception of *G. robusta* (in 25% of plots) and *P. suberosa* (in 19% of plots).

Caution should be applied in interpreting the results of vegetation monitoring in association with weed control due to error associated with GIS data for both vegetation plots and weeded areas. Accuracy for vegetation plot locations was often poor, at times requiring hand plotting. For the older data, weeded areas were often hand plotted, with estimations of size and location that may be inexact to varying degrees.

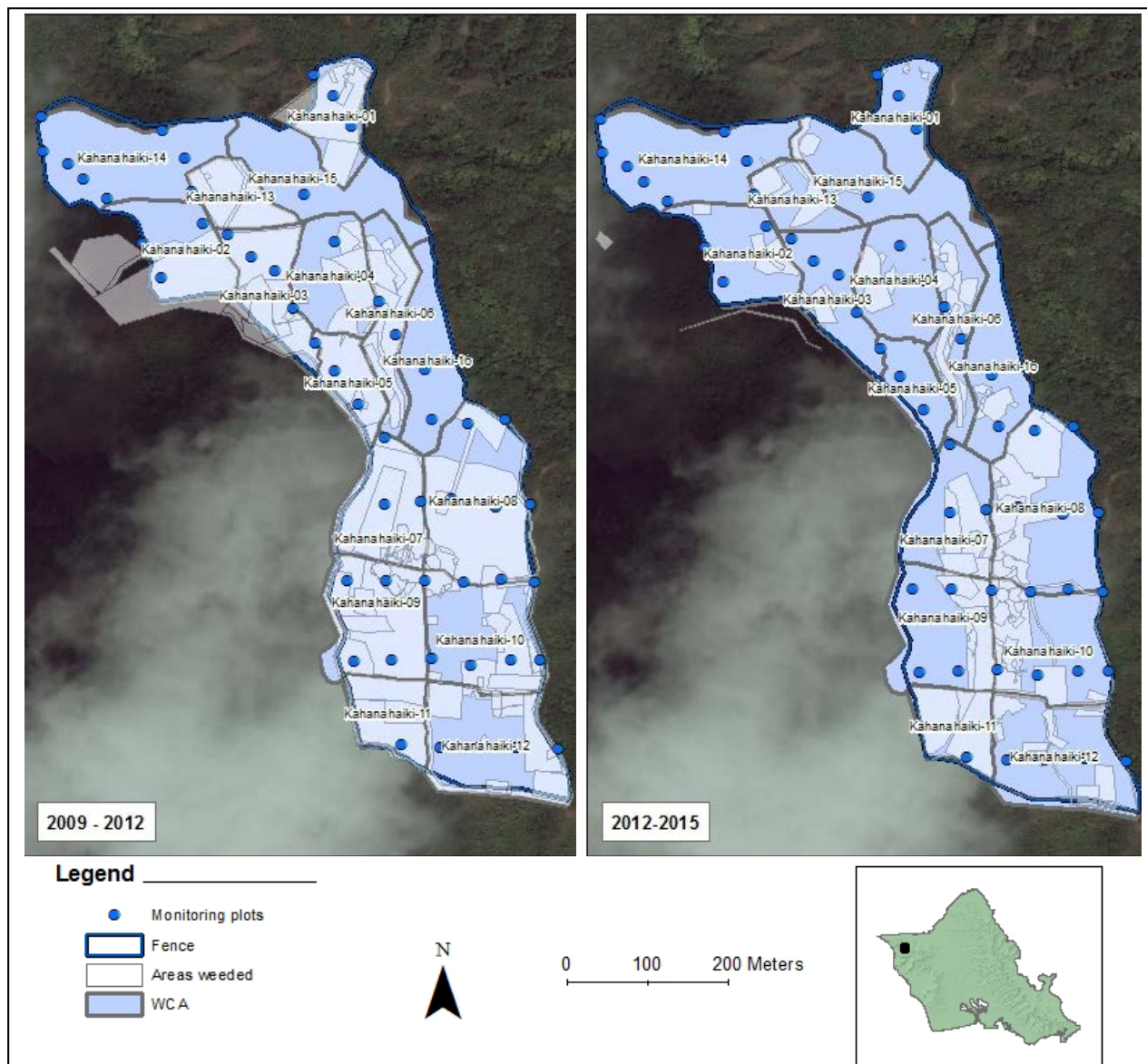


Figure 8. Locations of vegetation monitoring plots at Kahana haiki Subunit I in relation to weed control areas (WCA) and areas weeded between the 2009-2012 and 2012-2015 monitoring intervals.



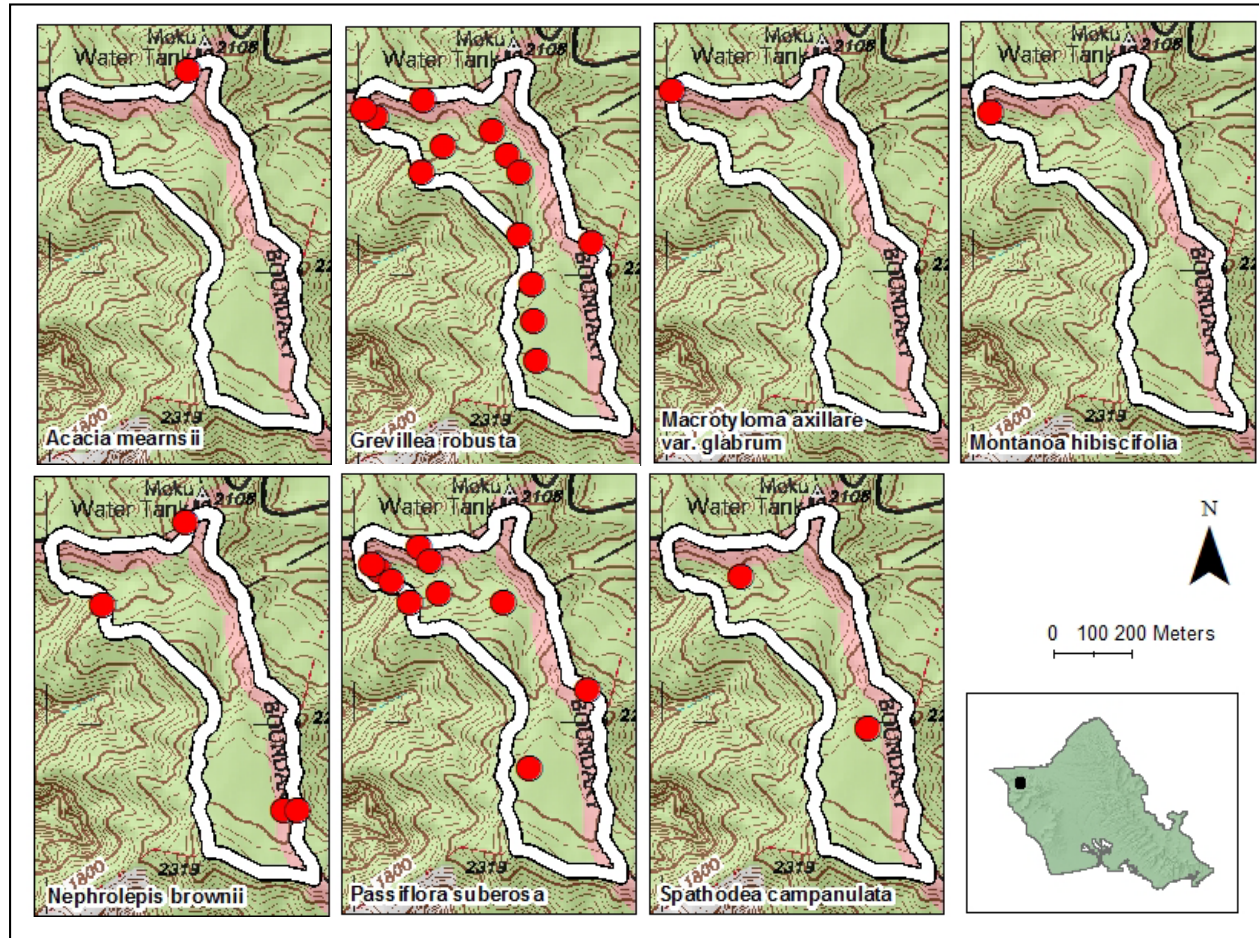


Figure 9. Locations of target taxa among plots in Kahanahaiki Subunit I in 2015.

## SUMMARY AND DISCUSSION

Management objectives were not met for percent cover of native understory, native canopy, and non-native canopy vegetation for Kahanahaiki Subunit I. Objectives were only met for non-native understory percent cover, however, conditions worsened. There were a number of noteworthy significant differences in the 2015 data as compared with prior years, including:

- greater non-native understory shrub cover, total non-native understory cover (regardless of non-native canopy cover or weed control efforts), non-native canopy, total canopy, and bare ground
- greater non-native understory species richness
- change in frequency for native species:
  - *Bidens torta* (increase in understory)
  - *Cocculus orbiculatus* (decrease in canopy)
- an increase in frequency for non-native species:
  - *Conyza bonariensis* (understory)
- an increase in percent cover for native species:
  - *Acacia koa* (canopy)
  - *Alyxia stellata* (understory and canopy)
  - *Bidens torta* (understory)
  - *Dianella sandwicensis* (understory)

- *Psydrax odorata* (canopy)
- an increase in percent cover for non-native species:
  - *Clidemia hirta* (understory)
  - *Melinis minutiflora* (understory)
  - *Psidium cattleianum* (understory and canopy)
  - *Schinus terebinthifolius* (understory and canopy)

The vegetation changes observed at Kahanahaiki follow a similar pattern to that of prior studies comparing fenced and unfenced areas, wherein both native and non-native species respond positively to ungulate removal during the initial years following fencing (Weller et al. 2011, Cole and Litton 2014).

## RECOMMENDATIONS

Based on the results of vegetation monitoring, a number of recommendations were made with the goal of making progress towards meeting management objectives:

- Conduct grass control.
- Continue control of incipient weeds. Targeted control of *Montanoa hibiscifolia* and *Triumfetta semitriloba* seems to be effective at suppression. Additional control is needed for *Nephrolepis brownii* and *Passiflora suberosa*. On-going *Grevillea robusta* canopy control is necessary.
- The Maile Flats area has higher native cover and has shown more beneficial change as compared with the gulch, and needs to be maintained with large weed sweeps every few years on the west side, and more attention to weed control on the east side where there are areas with greater canopy weed cover that are getting somewhat worse.
- The gulch is becoming weedier. Though OANRP managed rare taxa primarily occur in the gulch, less weed control has been done here, in part because it has much of the worst habitat in the MU, and the strategy has been to prioritize large scale efforts on the areas with greater native cover. MU-scale changes in native and non-native cover will require substantially large projects. Two restoration sites are currently underway in the gulch. Should larger projects be initiated, careful considerations must be made for follow-up maintenance to prevent resurgence of weed cover and increases in non-native richness. Large scale projects should not be initiated if resources are not available for on-going maintenance.
- Expand restoration planting capacity as a means of enabling larger restoration sites in gulch areas where limited native species recruitment is expected to occur.
- There should be critical consideration and discussion of why change in native and non-native cover did not differ among weeded vs. not weeded plots.
- Further research is needed to gain a better understanding of ecosystem dynamics and to help guide restoration efforts, addressing questions such as the following: What are limiting factors to native canopy replacement? How does the soil seed bank differ across the MU? Are there enough seedlings, saplings, and gaps? Where are outplants are doing well or failing, and how this is this affected by soil types in different parts of the MU? How do limiting factors differ between canopy species in the gulch vs. Maile Flats? Are *Pisonia* limited by slugs? Are they gap dependent? What is the difference in response to gaps formed by weeding in different communities? How long does it take for differing native taxa to become canopy? In what timeframe should we expect canopy changes to occur?

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OAHU ARMY NATURAL RESOURCES PROGRAM  
MONITORING PROGRAM

## VEGETATION MONITORING AT MAKAHA SUBUNITS I AND II, 2014

### INTRODUCTION

Vegetation monitoring was conducted at Makaha Management Unit (MU) in Subunits I and II in 2014 in association with MIP/OIP requirements for long term monitoring of vegetation composition and change over time (OANRP 2008) (Figure 1). The primary objective of MU monitoring is to assess if the percent cover of non-native plant species is less than 50% across the MU, or is decreasing towards that threshold requirement. The secondary objective is to assess if native cover is greater than 50% across the MU, or is increasing towards that threshold recommendation. Makaha MU vegetation monitoring occurs on a five-year interval, and took place once previously in Subunit I, one year following ungulate removal (OANRP 2010). Previous monitoring indicated that goals were met only for the non-native understory cover in Subunit I. This is the first vegetation monitoring of Subunit II following fence completion and ungulate removal approximately one year earlier.

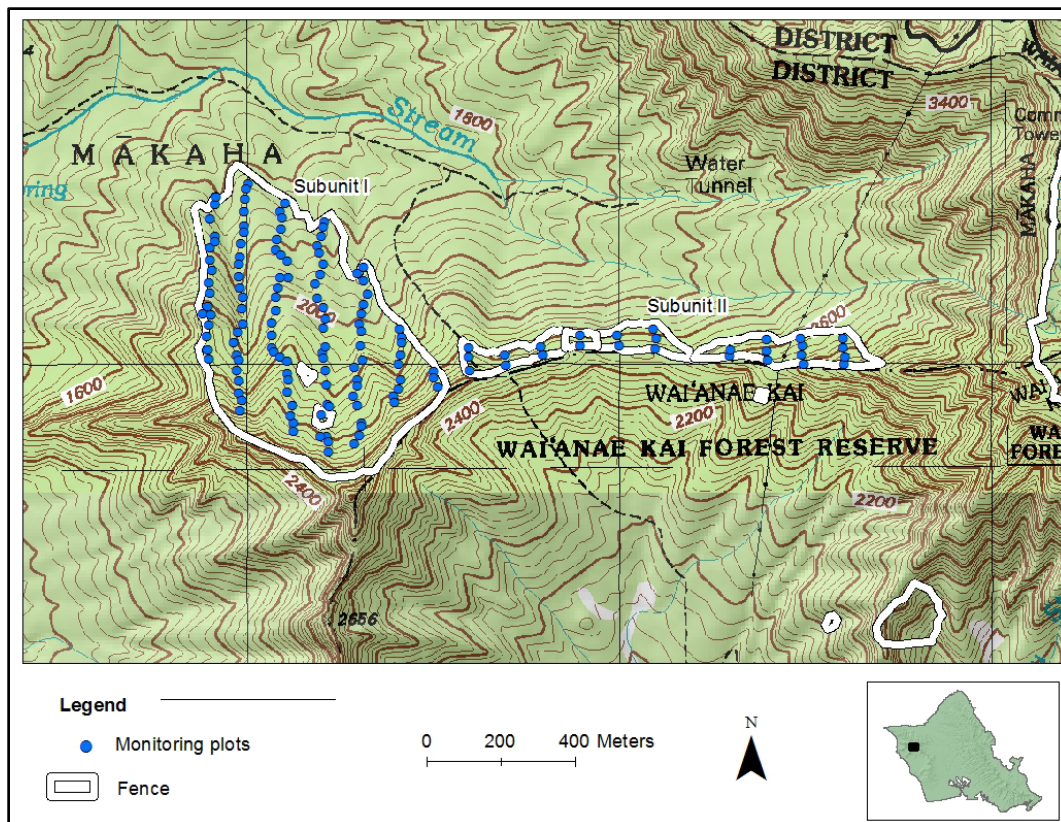


Figure 1. Makaha MU vegetation monitoring plot locations, 2014

### METHODS

In August and September 2014, 121 plots were monitored along seven transects in Subunit I, and 27 plots were monitored along ten transects in Subunit II. Transects were spaced 200 meters (m) apart,

and plots measuring 5 x 10 m were located every 30 m along transects. The Subunit I plots were also monitored in 2009 (OANRP 2010). Subunit II plots were newly established in 2014. Understory [occurring from 0 – 2 m above ground level (AGL), including low branches from canopy species] and canopy (occurring > 2 m AGL, including epiphytes) vegetation was recorded by percent cover for all non-native and native species present. Summary percent cover by vegetation type (shrub, fern, grass/sedge) in the understory, overall summary percent cover of non-native and native vegetation in the understory and canopy, and bare ground, were also documented. Understory recruitment (defined as seedlings or saplings < 2 m AGL) data for tree species was recorded in 2014, but not documented previously. Monitoring results for Subunit I were compared with data from 2009. Subunit I and II data were combined in the summary results for 2014, as these areas are nearly contiguous, separated by less than 100 m. Based on MIP recommendations,  $\alpha = 0.05$  was used for significance determinations, and only cover changes  $\geq 10\%$  were recognized. Additional methodology information is detailed in Monitoring Protocol 1.2.1 (OANRP 2008). All analyses were performed in IBM SPSS Statistics Version 20. These included Wilcoxon signed-rank tests for cover data, paired t tests for species richness data, McNemar's test for frequency data, regression analyses for time spent weeding in association with cover change, and t tests for cover change in plots within vs. outside weed control areas.

## RESULTS

### Understory and canopy cover categories

Management objectives of having < 50% non-native understory and canopy and > 50% native understory and canopy cover were only met with respect to the non-native understory in 2014 (Table 1). Native understory and canopy percent cover were low (7.5% and 25% median values, respectively). Non-native understory cover was moderate, and non-native canopy cover was high (45% and 95% median values, respectively). There were several significant<sup>1</sup> changes in percent cover of vegetation from previous monitoring results (Figure 2). These included small increases in understory cover for native ferns as well as non-native shrubs, fern, grasses, and total understory. Both native and non-native canopy (as well as total native and non-native canopy) also increased significantly. In some instances (native ferns, non-native grasses, native canopy), significant change occurred in relative distributions, while median values remained unchanged. Only non-native shrubs, total non-native understory, non-native canopy, and total canopy met the 10% standard for recognized change in cover. There was also a marginally significant decrease in bare ground. However, caution should be applied in interpreting the results of the change in bare ground, as the method for this measurement was not as clearly defined as that of the vegetation measurements, and as such was less repeatable. Locations of low to high percent cover of native understory and canopy in 2014 were patchily distributed across the MU, while locations of moderate to high percent cover of non-native understory and canopy were more consistently distributed across the MU (Figure 3). Locations where cover changes occurred were patchily distributed (Figure 4).

**<sup>1</sup>Notes for readers less familiar with statistics:** Statistical significance is determined by p-values. P-values indicate to what extent the results support a hypothesis (the lower the number, the stronger the support for the hypothesis). In this study, the hypotheses would be that there are changes occurring in percent cover, frequency, and species richness. In this study, p-values less than 0.05 were significant. P-values only slightly greater than 0.05 were denoted as marginally significant, meaning that while not technically significant, it is worthy of note, e.g., perhaps a change is occurring, but at a gradual rate that may only become apparent in future monitoring, should that pattern continue. In some instances, there may be significant p-values despite no change in median values, if change occurred in the distribution of data, e.g., percent cover may range from 15 to 35 with a median of 25 one year, then the next year have a range of 15 to 95 but still have only a median of 25.

Table 1. Percent cover of native and non-native vegetation categories in the canopy and understory at Makaha from 2009 to 2014. Median values are represented (Subunit I: n=121, Subunit I and II: n = 148). Statistically significant values are in boldface (Wilcoxon signed-rank test). Categories specifically addressed in management objectives are shaded. Arrows indicate increase (↑) or decrease (↓) in cover. \*Meets 10% standard for recognized change in cover.

	2009 (Subunit I)	2014 (Subunit I)	p (Subunit I)	W	2014 (Subunit I & II)	Management objective currently met (Subunit I & II)?
<b>Understory</b>						
Native shrubs	7.5	2.5	0.223	1258.5	2.5	
Native ferns	0.5	0.5	< <b>0.001</b> ↑	248.0	0.1	
Native grasses	0.0	0.0	0.125	89.0	0.0	
Total native understory	7.5	7.5	0.76	1052.5	7.5	No
Non-native shrubs	25.0	35.0	< <b>0.001</b> ↑*	845.5	35.0	
Non-native ferns	0.5	2.5	<b>0.002</b> ↑	650.5	2.5	
Non-native grasses	0.0	0.0	<b>0.042</b> ↑	79.5	0.0	
Total non-native understory	35.0	45.0	< <b>0.001</b> ↑*	882.0	45.0	Yes, but getting worse
Bare ground	85.0	75.0	0.055	2520.0	75.0	
<b>Canopy</b>						
Native canopy	25.0	25.0	<b>0.013</b> ↑	1539.0	35.0	No
Non-native canopy	75.0	95.0	< <b>0.001</b> ↑*	605.0	85.0	
Total canopy	85.0	95.0	< <b>0.001</b> ↑*	205.0	95.0	No

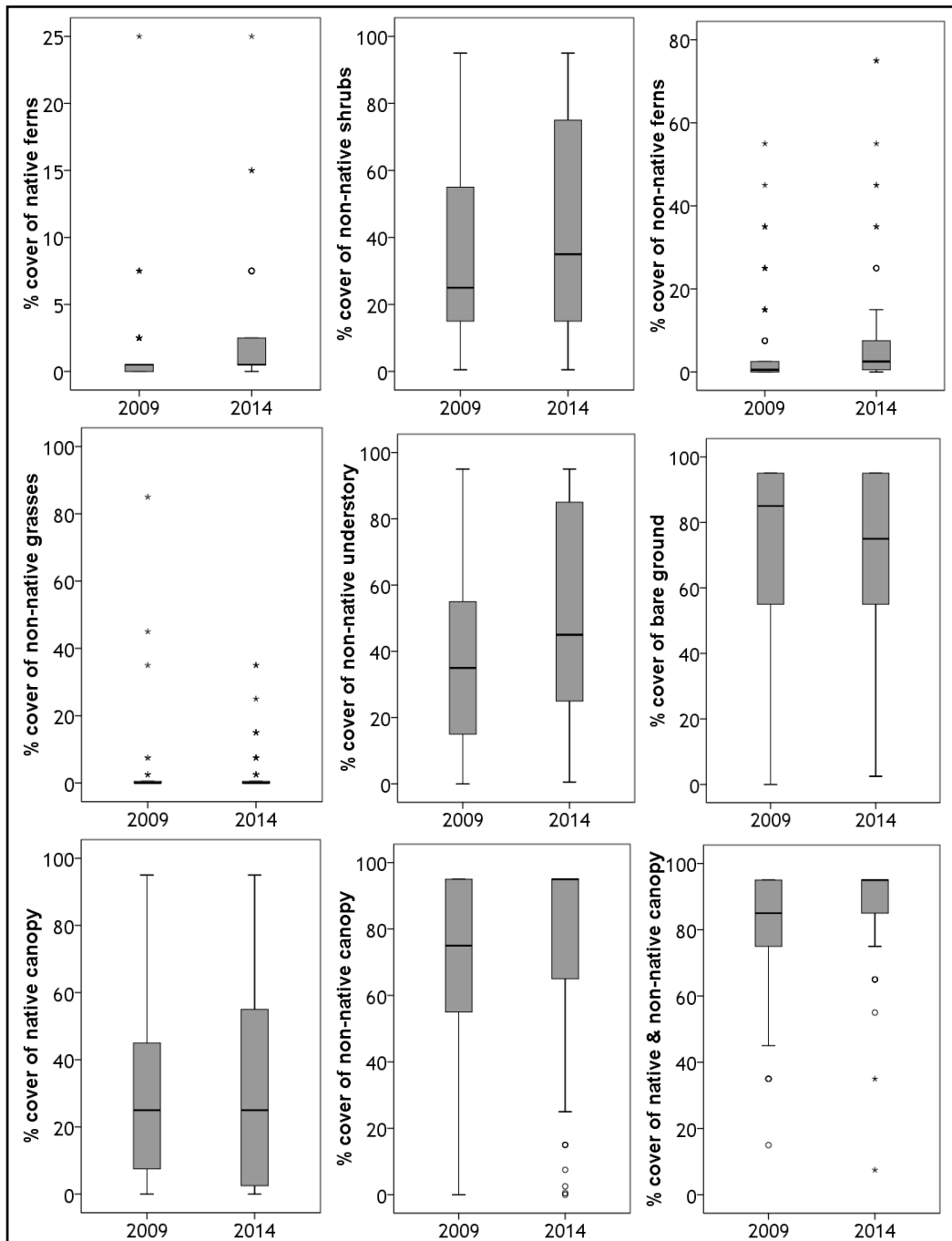


Figure 2. Boxplots<sup>2</sup> for vegetation categories with significant (or marginally significant) change in percent cover between years 2009 and 2014 in Makaha Subunit I.

<sup>2</sup>**Additional notes for readers less familiar with statistics:** Boxplots show the range of data values for a given variable, analogous to a squashed bell curve turned on its side. The shaded boxes depict 50% of the data values, and the horizontal line inside the shaded box represents the median value. In this report, very high or low values relative to the shaded box are indicated by circles (1.5 to 3 times the length of the shaded box) and asterisks (> 3 times the length of the shaded box), while the lines extending above and below the shaded box depict the range in values for all remaining data. Boldface circles and asterisks indicate multiple data points for the same value.

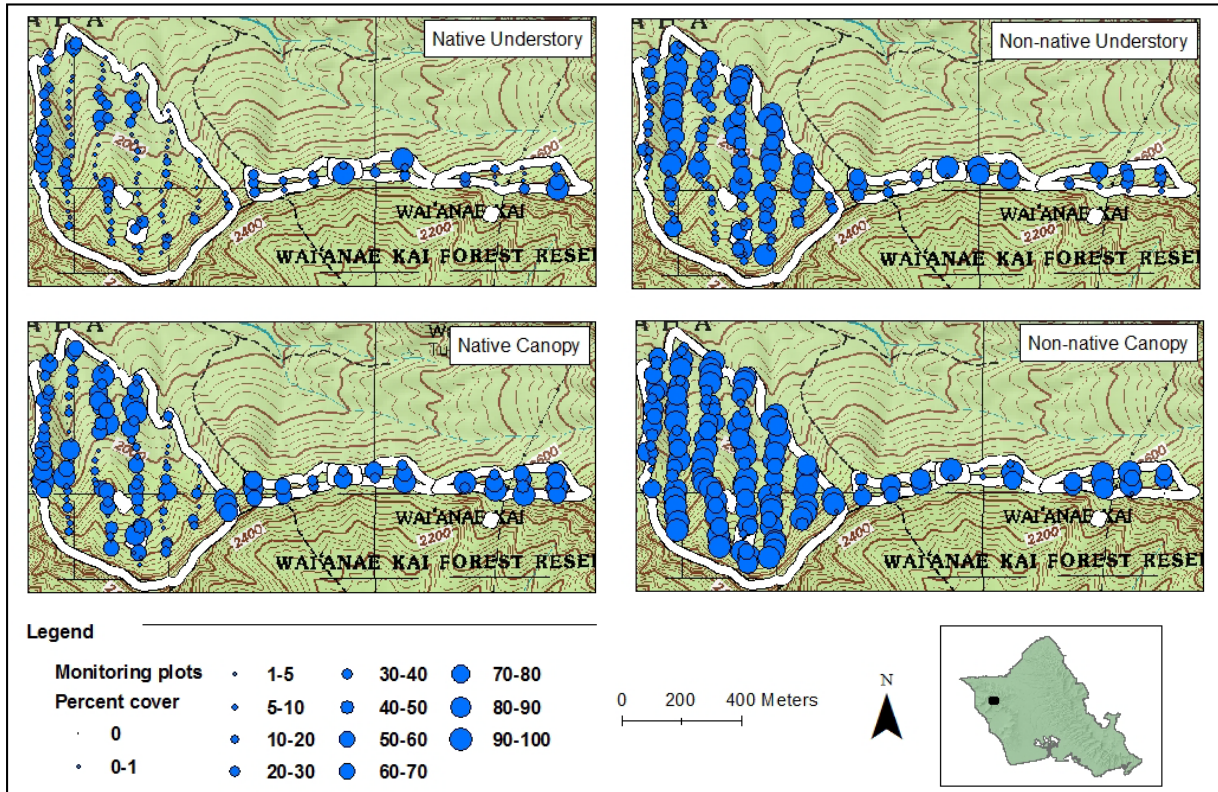


Figure 3. Locations of low to high percent cover of native and non-native understory and canopy vegetation among monitored plots at Makaha in 2014. Larger circles denote higher percent cover, while smaller circles represent lower percent cover.



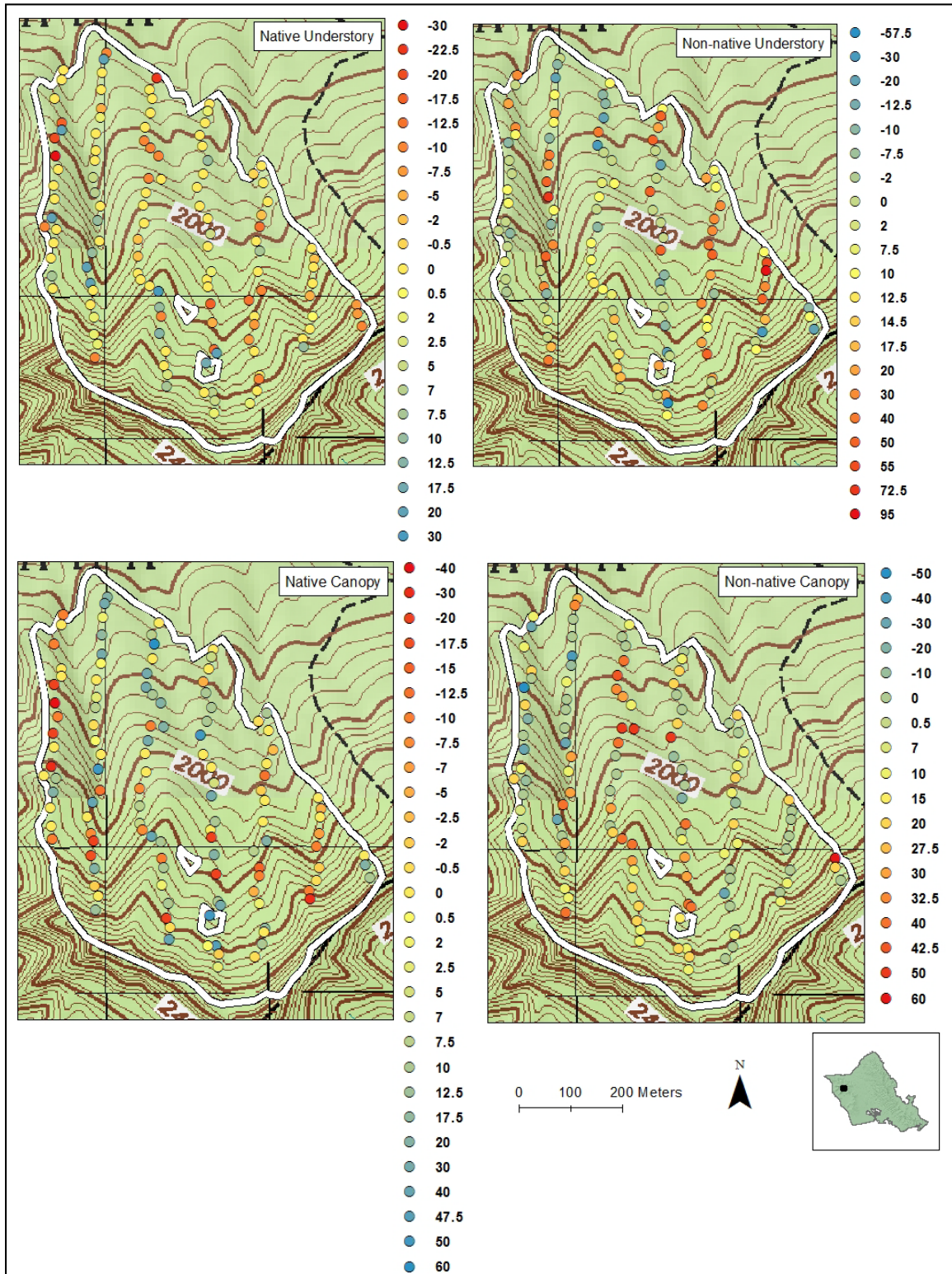


Figure 4. Locations of change in native and non-native percent cover for the understory and canopy (from 2009 to 2014) vegetation in monitored plots in Mahaka Subunit I between 2009 and 2014. Color gradients are inverted for native and non-native vegetation, such that blue indicates beneficial change, red depicts worsening conditions. Cover change of 0 indicates there was no change in percent cover.

## Species richness

During monitoring in 2014, 171 species were recorded in the understory (62% native taxa), and 79 were identified in the canopy (78% native) of Subunits I and II. Most species present in the canopy were also represented in the understory, with the exception of three native (*Dubautia plantaginea*, *Korthalsella cylindrica*, and *Polyscias kawaiensis*) and two non-native species (*Passiflora ligularis* and *Polystachya concreta*). Locations of high and low species richness for the native and non-native understory and canopy were primarily patchily distributed across the MU, with few evident patterns (Figure 5). Native understory diversity was highest in the westernmost portion of Subunit II. Non-native understory diversity was highest along the upper fence line in Subunit II and in the westernmost gulch of Subunit I. Non-native canopy diversity was low throughout Subunit II, and highest in the westernmost gulch of Subunit I. In Subunit I, species richness among plots differed significantly between the years monitored in the native understory, and non-native understory and canopy, with small increases in median values from 2009 to 2014 (Table 2). No detectable change occurred in species richness among plots in the native canopy. Despite the significant increase in native understory richness among plots, the overall native understory (as well as canopy) diversity for the MU has declined slightly. A decrease in MU-scale diversity paired with an increase in plot-scale diversity could occur if the frequencies of less common species are declining, while frequencies of more common species are increasing. In concert with the significant increase in non-native understory and canopy richness among plots, the overall non-native understory and canopy diversity for the MU has increased slightly. Similar numbers of new species were found in 2014 (23 species) as compared with those recorded in 2009 but not observed in 2014 (25 species) in Subunit I (Table 3). However, there was a greater proportion of non-native species among those newly recorded (43%) as compared with those not observed (20%) in 2014. The presence or absence of species may be due in part to human error, including misidentification (e.g., difficulties in distinguishing *Korthalsella* and *Bobea* taxa); observer bias regarding plot boundaries, amount of time spent searching, or looking for specific taxa (e.g., searching for small native epiphytes in the canopy, such as *Lepisorus thunbergianus*); or accidental non-recording. The presence of short-lived, less common species is expected to vary over time. All of the species that were not present in 2014 were uncommon in previous years, with frequencies less than 0.03.

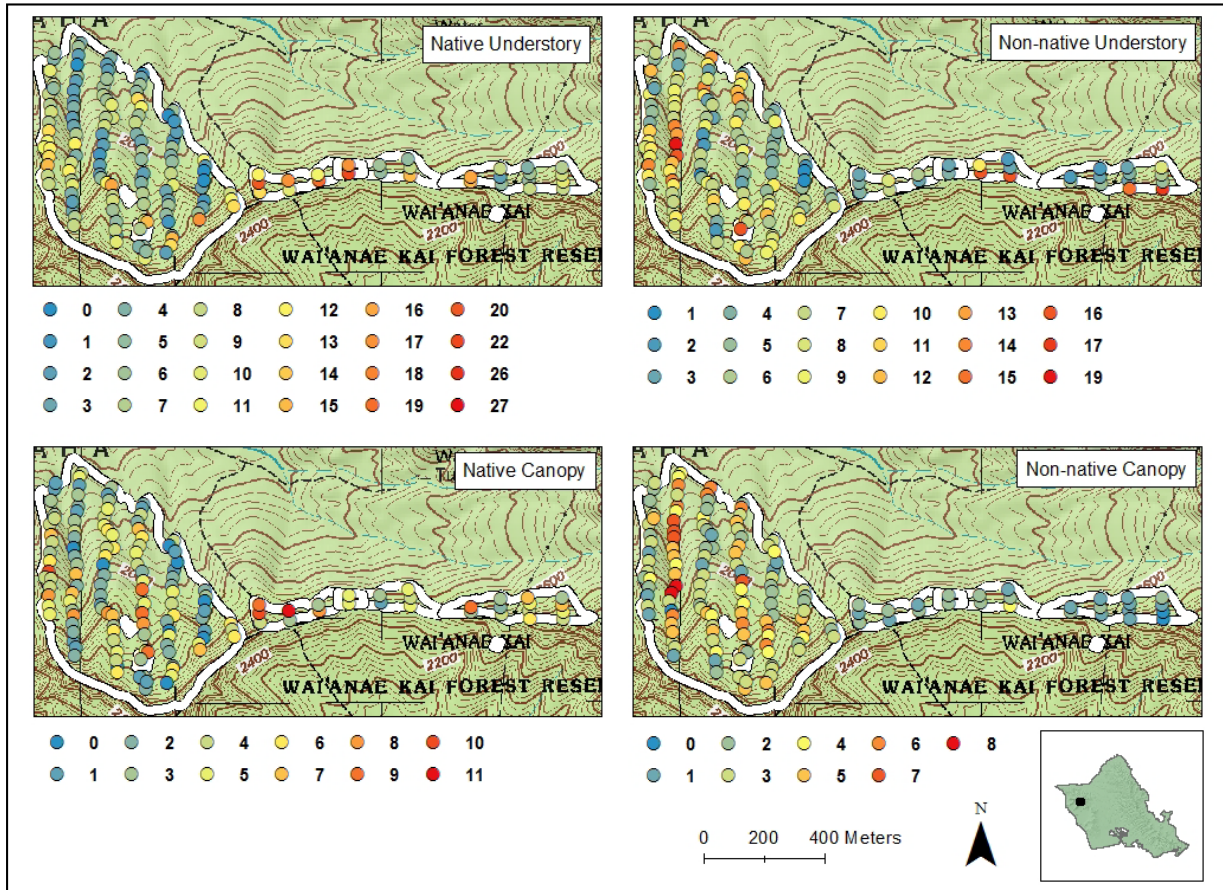


Figure 5. Locations of low to high species richness among plots in the native and non-native understory and canopy in Makaha, 2014. Color gradients of blue to red indicate low to high values, respectively, of the number of species occurring in plots (i.e., blue indicates low diversity, while red indicates relatively higher diversity).

Table 2. Makaha MU understory and canopy species richness. Mean values of species richness per plot during vegetation monitoring is shown by year, with the total number of species recorded among all plots in parenthesis (Subunit I: n = 121; Subunit I & II: n = 148). P-values obtained from paired t test for Subunit I years 2009 vs. 2014. Statistically significant values are in boldface. Arrows indicate increase (↑) or decrease (↓) in richness.

	2009 (Subunit I)	2014 (Subunit I)	p	t	2014 (Subunit I & II)
Native understory	5.60 (79)	6.23 (74)	< <b>0.001</b> ↑	4.134	7.01 (106)
Non-native understory	6.34 (48)	7.55 (52)	< <b>0.001</b> ↑	6.389	7.30 (65)
Native canopy	3.60 (54)	3.60 (47)	0.952	-0.06	3.87 (62)
Non-native canopy	3.15 (14)	3.48 (15)	<b>0.004</b> ↑	2.915	3.11 (17)

Table 3. Newly recorded, and no longer present, species from 2014 Makaha Subunit I MU monitoring.

New species recorded in plots in 2014	Species not recorded in 2014 but recorded in same plots previously
<b>Non-native</b>	
<i>Asclepias physocarpa</i>	<i>Ageratina adenophora</i>
<i>Castilleja arvensis</i>	<i>Melia azedarach</i>
<i>Cheilanthes viridis</i>	<i>Passiflora ligularis</i>
<i>Emilia sonchifolia</i>	<i>Physalis peruviana</i>
<i>Fraxinus uhdei</i>	<i>Trema orientalis</i>
<i>Hyptis pectinata</i>	
<i>Phaius tankervilleae</i>	
<i>Phlebodium aureum</i>	
<i>Polystachya concreta</i>	
<i>Spathodea campanulata</i>	
<b>Native</b>	
<i>Antidesma pulvinatum</i>	<i>Adenophorus tenellus</i>
<i>Bidens torta</i>	<i>Alectryon macrococcus</i> var. <i>macrococcus</i>
<i>Cyrtandrae waiolani</i>	<i>Asplenium macraei</i>
<i>Ilex anomala</i>	<i>Asplenium polyodon</i>
<i>Korthalsella complanata</i>	<i>Bobea timonioides</i>
<i>Labordia tinifolia</i>	<i>Coprosma longifolia</i>
<i>Microlepia speluncae</i>	<i>Diplazium sandwichianum</i>
<i>Nephrolepis cordifolia</i>	<i>Dryopteris glabra</i>
<i>Panicum nephelophilum</i>	<i>Korthalsella cylindrica</i>
<i>Peperomia blanda</i>	<i>Korthalsella degeneri</i>
<i>Pittosporum confertiflorum</i>	<i>Labordia kaalae</i>
<i>Psilotum nudum</i>	<i>Machaerina mariscoides</i>
<i>Pteralyxia macrocarpa</i>	<i>Melicope clusiifolia</i>
	<i>Melicope makahae</i>
	<i>Melicope oahuensis</i>
	<i>Polyscias oahuensis</i>
	<i>Sicyos lanceoloideus</i>
	<i>Streblus pendulinus</i>
	<i>Urera glabra</i>
	<i>Wikstroemia oahuensis</i> var. <i>oahuensis</i>

### Species frequency

Non-native species that most frequently occurred in plots (present in more than half the plots) in the understory included *Psidium cattleianum*, *Blechnum appendiculatum*, *Schinus terebinthifolius*, *Toona ciliata*, and *Coffea arabica*, while those most commonly occurring in the canopy were *P. cattleianum* and *S. terebinthifolius* (Table 4). The most frequent native species (in at least a third of the plots) included *Alyxia stellata*, *L. thunbergianus*, and *Acacia koa* in the understory, and *Metrosideros polymorpha* and *A. stellata* in the canopy. *Alyxia stellata* is often the final native species remaining in *P. cattleianum* dominated forests (K. Kawelo, pers comm.). Of the 23 rare taxa occurring at Makaha Subunits I and II (OANRP 2010), 9 were identified during monitoring in 2014. Analysis of frequency change (McNemar's test) was limited to taxa with at least ten percent change between 2009 and 2014 in Subunit 1. These included five species in the non-native understory, one non-native canopy species, and three native understory species (Table 5). Among these, all increased in frequency, with the greatest change occurring for *L. thunbergianus* and *S. terebinthifolius* (26% and 17%, respectively).

Table 4. Species frequency among plots (proportion of plots in which a given species occurs) during 2014 Makaha MU monitoring (Subunits I and II, n= 148), in order of most to least frequent. Native species are in bold print. \*Rare taxa. \*\*Target weed taxa

Taxon	Freq.	Taxon	Freq.	Taxon	Freq.	Taxon	Freq.
Understory							
<i>Psidium cattleianum</i> **	0.905	<i>Passiflora suberosa</i>	0.095	<i>Crassocephalum crepidoides</i>	0.027	<i>Asplenium caudatum</i>	0.007
<i>Blechnum appendiculatum</i>	0.601	<i>Pisonia brunoniana</i>	0.095	<i>Elaphoglossum aemulum</i>	0.027	<i>Asplenium macraei</i>	0.007
<i>Alyxia stellata</i>	0.595	<i>Buddleja asiatica</i>	0.088	<i>Psilotum nudum</i>	0.027	<i>Axonopus fissifolius</i>	0.007
<i>Schinus terebinthifolius</i>	0.574	<i>Cibotium chamissoi</i>	0.088	<i>Sapindus oahuensis</i>	0.027	<i>Begonia foliosa</i>	0.007
<i>Toona ciliata</i> **	0.568	<i>Euphorbia multiformis</i>	0.088	<i>Selaginella arbuscula</i>	0.027	<i>Boehmeria grandis</i>	0.007
<i>Coffea arabica</i> **	0.514	<i>Asplenium dielfalcatum</i> *	0.081	<i>Sphenomeris chinensis</i>	0.027	<i>Cheilanthes viridis</i>	0.007
<i>Cyclosorus parasiticus</i>	0.459	<i>Cyperus hypochlorus</i>	0.074	<i>Tectaria gaudichaudii</i>	0.027	<i>Clermontia persicifolia</i>	0.007
<i>Clidemia hirta</i>	0.405	<i>Syzygium cumini</i>	0.074	<i>Ageratina adenophora</i>	0.020	<i>Cuphea carthagenesis</i>	0.007
<i>Lepisorus thungbergianus</i>	0.351	<i>Wikstroemia oahuensis</i>	0.068	<i>Bobea elatior</i>	0.020	<i>Cyanea membranacea</i> *	0.007
<i>Acacia koa</i>	0.345	<i>Carex meyenii</i>	0.061	<i>Elaphoglossum crassifolium</i>	0.020	<i>Cyrtandra garnotiana</i>	0.007
<i>Metrosideros polymorpha</i>	0.291	<i>Kalanchoe pinnata</i>	0.061	<i>Emilia sonchifolia</i>	0.020	<i>Cyrtandrae waiolani</i>	0.007
<i>Microlepia strigosa</i>	0.284	<i>Pisonia sandwicensis</i>	0.061	<i>Freycinetia arborea</i>	0.020	<i>Deparia prolifera</i>	0.007
<i>Psydrax odorata</i>	0.277	<i>Psychotria hathewayi</i>	0.061	<i>Ilex anomala</i>	0.020	<i>Doryopteris decipiens</i>	0.007
<i>Psidium guajava</i>	0.264	<i>Viola chamissoniana</i> subsp. <i>trachelifolia</i>	0.061	<i>Melinis repens</i>	0.020	<i>Eragrostis grandis</i>	0.007
<i>Dodonaea viscosa</i>	0.257	<i>Phleboalum aureum</i>	0.054	<i>Phlebodium aureum</i>	0.020	<i>Erechtites valerianifolia</i>	0.007
<i>Coprosma foliosa</i>	0.250	<i>Dianella sandwicensis</i>	0.054	<i>Plectranthus parviflorus</i>	0.020	<i>Flueggea neowawraea</i> *	0.007
<i>Grevillea robusta</i>	0.243	<i>Gahnia becheyi</i>	0.054	<i>Spathodea campanulata</i> **	0.020	<i>Fraxinus uhdei</i>	0.007
<i>Adiantum hispidulum</i>	0.236	<i>Hibiscus arnotianus</i>	0.054	<i>Ageratum conyzoides</i>	0.014	<i>Hesperomannia oahuensis</i> *	0.007
<i>Diospyros sandwicensis</i>	0.236	<i>Melicope pedunculata</i>	0.054	<i>Asplenium contiguum</i>	0.014	<i>Hyptis pectinata</i>	0.007
<i>Doodia kunthiana</i>	0.236	<i>Oxalis corniculata</i>	0.054	<i>Castilleja arvensis</i>	0.014	<i>Kadua cordata</i>	0.007
<i>Ageratina riparia</i>	0.203	<i>Panicum nephelophilum</i>	0.054	<i>Charpentiera obovata</i>	0.014	<i>Labordia kaalae</i> *	0.007
<i>Rubus argutus</i> **	0.189	<i>Rivina humilis</i>	0.054	<i>Coprosma longifolia</i>	0.014	<i>Labordia tinifolia</i>	0.007
<i>Carex wahuensis</i>	0.182	<i>Asplenium nidus</i>	0.047	<i>Cyperus meyenianus</i>	0.014	<i>Leptospermum scoparium</i>	0.007
<i>Cordyline fruticosa</i>	0.176	<i>Claoxylon sandwicensis</i>	0.047	<i>Cyrtomium caryotideum</i>	0.014	<i>Lysimachia hillebrandii</i>	0.007
<i>Rubus rosifolius</i>	0.169	<i>Dryopteris glabra</i>	0.047	<i>Dicliptera chinensis</i> **	0.014	<i>Lythrum maritimum</i>	0.007
<i>Dryopteris sandwicensis</i>	0.162	<i>Elaeocarpus bifidus</i>	0.047	<i>Digitaria insularis</i>	0.014	<i>Machaerina mariscoides</i>	0.007
<i>Kadua affinis</i>	0.142	<i>Passiflora edulis</i>	0.047	<i>Doryopteris decora</i>	0.014	<i>Myrsine lanaiensis</i>	0.007
<i>Oplismenus hirtellus</i>	0.142	<i>Cyclosorus dentatus</i>	0.041	<i>Elaphoglossum paleaceum</i>	0.014	<i>Panicum nephelophilum</i>	0.007
<i>Psychotria mariniana</i>	0.142	<i>Deparia petersenii</i>	0.041	<i>Emilia fosbergii</i>	0.014	<i>Peperomia latifolia</i>	0.007
<i>Antidesma platyphyllum</i>	0.135	<i>Pisonia umbellifera</i>	0.041	<i>Erigeron karvinskianus</i>	0.014	<i>Peperomia membranacea</i>	0.007
<i>Nestegis sandwicensis</i>	0.135	<i>Sadleria cyatheoides</i>	0.041	<i>Gynochthodes trimera</i>	0.014	<i>Perrottetia sandwicensis</i>	0.007
<i>Youngia japonica</i>	0.128	<i>Scaevola gaudichaudiana</i>	0.041	<i>Korthalsella complanata</i>	0.014	<i>Phaius tankervilleae</i>	0.007
<i>Diospyros hillebrandii</i>	0.122	<i>Dicranopteris linearis</i>	0.034	<i>Machaerina angustifolia</i>	0.014	<i>Pittosporum confertiflorum</i>	0.007
<i>Planchonella sandwicensis</i>	0.122	<i>Kadua acuminata</i>	0.034	<i>Microlepia speluncae</i>	0.014	<i>Pityrogramma austroamericana</i>	0.007
<i>Bidens torta</i>	0.115	<i>Metrosideros tremuloides</i>	0.034	<i>Myoporum sandwicense</i>	0.014	<i>Pteralyxia macrocarpa</i> *	0.007
<i>Cocculus orbiculatus</i>	0.115	<i>Myrsine lessertiana</i>	0.034	<i>Peperomia blanda</i>	0.014	<i>Rauvolfia sandwicensis</i>	0.007
<i>Nephrolepis exaltata</i>	0.115	<i>Nephrolepis brownii</i>	0.034	<i>Psilotum complanatum</i>	0.014	<i>Santalum freycinetianu</i>	0.007
<i>Aleurites moluccana</i>	0.108	<i>Nephrolepis cordifolia</i>	0.034	<i>Pteridium aquilinum</i>	0.014	<i>Schiedea nuttallii</i> *	0.007
<i>Conyza bonariensis</i>	0.108	<i>Peperomia tetraphylla</i>	0.034	<i>Ricinus communis</i>	0.014	<i>Setaria parviflora</i>	0.007
<i>Pipturis albidus</i>	0.108	<i>Xylosma hawaiiense</i>	0.034	<i>Sacciolepis indica</i>	0.014	<i>Smilax melastomifolia</i>	0.007
<i>Lantana camara</i>	0.101	<i>Andropogon virginicus</i>	0.027	<i>Triunfetta semitriloba</i> **	0.014	<i>Spathoglottis plicata</i>	0.007
<i>Melinis minutiflora</i>	0.101	<i>Andropogon virginicus</i>	0.027	<i>Antidesma pulvinatum</i>	0.007	<i>Strongylodon ruber</i> *	0.007
<i>Paspalum conjugatum</i>	0.095	<i>Charpentiera tomentosa</i>	0.027	<i>Asclepias physocarpa</i>	0.007	<i>Trema orientalis</i> **	0.007

Table 4, continued.

Taxon	Freq.	Taxon	Freq.	Taxon	Freq.	Taxon	Freq.
Canopy							
<i>Psidium cattleianum</i> **	0.838	<i>Antidesma platyphyllum</i>	0.095	<i>Metrosideros tremuloides</i>	0.027	<i>Xylosma hawaiiense</i>	0.014
<i>Schinus terebinthifolius</i>	0.514	<i>Hibiscus arnottianus</i>	0.095	<i>Myrsine lessertiana</i>	0.027	<i>Antidesma pulvinatum</i>	0.007
<b><i>Metrosideros polymorpha</i></b>	0.439	<i>Cordyline fruticosa</i>	0.068	<i>Pisonia umbellifera</i>	0.027	<i>Boehmeria grandis</i>	0.007
<i>Alyxia stellata</i>	0.392	<i>Elaeocarpus bifidus</i>	0.068	<i>Sapindus oahuensis</i>	0.027	<i>Clermontia persicifolia</i>	0.007
<i>Toona ciliata</i> **	0.372	<i>Korthalsella complanata</i>	0.068	<i>Strongylodon ruber</i> *	0.027	<i>Cyanea membranacea</i> *	0.007
<i>Psydrax odorata</i>	0.304	<i>Pipturis albidus</i>	0.061	<i>Canavalia galeata</i>	0.020	<i>Dubautia plantaginea</i>	0.007
<i>Coffea arabica</i> **	0.291	<i>Passiflora edulis</i>	0.054	<i>Coprosma longifolia</i>	0.020	<i>Elaphoglossum aemulum</i>	0.007
<i>Psidium guajava</i>	0.270	<i>Asplenium nidus</i>	0.047	<i>Phlebodium aureum</i>	0.020	<i>Kadua acuminata</i>	0.007
<i>Acacia koa</i>	0.264	<i>Lepisorus thungbergianus</i>	0.047	<i>Wikstroemia oahuensis</i>	0.020	<i>Korthalsella cylindrica</i>	0.007
<i>Diospyros sandwicensis</i>	0.236	<i>Pisonia sandwicensis</i>	0.047	<i>Charpentiera tomentosa</i>	0.014	<i>Labordia kaalae</i> *	0.007
<i>Syzygium cumini</i>	0.223	<i>Bobea elatior</i>	0.041	<i>Cocculus orbiculatus</i>	0.014	<i>Labordia tinifolia</i>	0.007
<i>Aleurites moluccana</i>	0.216	<i>Buddleja asiatica</i>	0.041	<i>Elaphoglossum crassifolium</i>	0.014	<i>Passiflora ligularis</i>	0.007
<i>Planchonella sandwicensis</i>	0.216	<i>Psychotria hathewayi</i>	0.041	<i>Flueggea neowawraea</i> *	0.014	<i>Perrottetia sandwicensis</i>	0.007
<i>Grevillea robusta</i>	0.162	<i>Claoxylon sandwicensis</i>	0.034	<i>Freycinetia arborea</i>	0.014	<i>Pittosporum confertiflorum</i>	0.007
<i>Dodonaea viscosa</i>	0.149	<i>Ilex anomala</i>	0.034	<i>Lantana camara</i>	0.014	<i>Rauvolfia sandwicensis</i>	0.007
<i>Nestegis sandwicensis</i>	0.142	<i>Melicope peduncularis</i>	0.034	<i>Myoporum sandwicense</i>	0.014	<i>Scaevola gaudichaudiana</i>	0.007
<i>Psychotria mariniana</i>	0.135	<i>Pisonia brunoniana</i>	0.034	<i>Polyscias kavaensis</i> *	0.014	<i>Smilax melastomifolia</i>	0.007
<i>Coprosma foliosa</i>	0.128	<i>Bidens torta</i>	0.027	<i>Polystachya concreta</i>	0.014	<i>Spathodea campanulata</i> **	0.007
<i>Diospyros hillebrandii</i>	0.108	<i>Cibotium chamissoi</i>	0.027	<i>Psilotum nudum</i>	0.014	<i>Trema orientalis</i> **	0.007
<i>Kadua affinis</i>	0.101	<i>Gynochthodes trimera</i>	0.027	<i>Santalum freycinetianum</i>	0.014		

Table 5. Species frequency change at Makaha I MU between 2009 and 2014. Only taxa with at least 10% change in frequency were analyzed. Frequency values represent the proportion of plots in which species are present (n = 121). Native species are in boldface. P-values obtained from McNemar's test. Arrows indicate increase (↑) or decrease (↓) in frequency.

Species	Frequency 2009	Frequency 2014	% change	p
Understory				
<b><i>Acacia koa</i></b>	0.157	0.264	11	0.007 <sup>a</sup> ↑
<i>Coffea arabica</i>	0.488	0.603	12	0.018 <sup>b</sup> ↑
<b><i>Dryopteris sandwicensis</i></b>	0.083	0.190	11	< 0.001 <sup>a</sup> ↑
<b><i>Lepisorus thunbergianus</i></b>	0.149	0.413	26	< 0.001 <sup>b</sup> ↑
<i>Psidium cattleianum</i>	0.760	0.884	12	0.001 <sup>a</sup> ↑
<i>Schinus terebinthifolius</i>	0.479	0.653	17	< 0.001 <sup>b</sup> ↑
<i>Toona ciliata</i>	0.579	0.686	11	0.015 <sup>a</sup> ↑
<i>Youngia japonica</i>	0.033	0.140	11	0.001 <sup>a</sup> ↑
Canopy				
<i>Coffea arabica</i>	0.248	0.355	11	0.001 <sup>a</sup> ↑

<sup>a</sup>Exact significance. <sup>b</sup>Asymptotic significance.

### Species cover

Species with frequencies > 0.20 (present in at least 25 plots) in 2009 and/or 2014 were subjected to analysis of cover change (Wilcoxon signed-rank test). Significant increases in percent cover occurred for three species in the native understory (*Diospyros sandwicensis*, *L. thunbergianus*, and *Microlepia strigosa*), nine non-native understory species (*Adiantum hispidulum*, *Blechnum appendiculatum*, *Clidemia hirta*, *C. arabica*, *Cordyline fruticosa*, *Grevillea robusta*, *P. cattleianum*, *S. terebinthifolius*, and *T. ciliata*), and four species in the non-native canopy (*C. arabica*, *P. cattleianum*, *S. terebinthifolius* and *T. ciliata*) (Table 6). A single non-native canopy species declined in cover (*Aleurites moluccana*). The median change in percent cover was 0.0% for all species except *P. cattleianum* (0.5% in the understory; 10.0% in the canopy), largely as a result of most species having frequencies < 0.50 (i.e., most taxa were absent from more than half of the plots, thus most plots had no change in cover). Among the species with significant change in cover, two had only very small changes, including native fern *L. thunbergianus*, with a maximum cover change of 0.5% in the understory, and non-native *G. robusta*, with a maximum change of 2.0% in the understory (Figure 6). The changes in percent cover for understory and canopy categories for native understory ferns, non-native understory shrubs and ferns, and non-native canopy were likely driven by changes in species cover, along with cumulative changes among multiple taxa. Changes in non-native understory shrub and canopy were likely heavily influenced by *P. cattleianum*, given its combination of high frequency and cover change relative to other species. The changes in non-native grasses and native canopy cover does not appear to be attributable to specific species, but rather may be a result of cumulative changes in the percent cover of multiple species.

Table 6. Percent cover change of native and non-native species in the canopy and understory at Makaha Subunit I from 2009 to 2014. Only species with frequencies greater than 0.20 (present in at least 25 plots) in 2009 and/or 2014 were analyzed. Statistically significant values are in boldface (Wilcoxon signed-rank test,  $n = 121$ ). Arrows indicate increase (↑) or decrease (↓) in cover.

Species	Median cover change	p	W
<b>Native understory</b>			
<i>Acacia koa</i>	0.0	0.062 <sup>a</sup> ↑	210.0
<i>Alyxia stellata</i>	0.0	0.609	745.0
<i>Carex wahuensis</i>	0.0	0.334	51.0
<i>Coprosma foliosa</i>	0.0	0.244	205.0
<i>Diospyros sandwicensis</i>	0.0	<b>0.008</b> ↑	224.5
<i>Dodonaea viscosa</i>	0.0	0.233	162.5
<i>Doodia kunthiana</i>	0.0	0.121	39.5
<i>Lepisorus thunbergianus</i>	0.0	< <b>0.001</b> ↑	629.0
<i>Microlepia strigosa</i>	0.0	<b>0.018</b> ↑	367.0
<i>Psydrax odorata</i>	0.0	0.544	171.0
<b>Non-native understory</b>			
<i>Adiantum hispidulum</i>	0.0	<b>0.001</b> ↑	193.5
<i>Ageratina riparia</i>	0.0	0.128	118.5
<i>Blechnum appendiculatum</i>	0.0	<b>0.011</b> ↑	898.0
<i>Clidemia hirta</i>	0.0	< <b>0.001</b> ↑	246.0
<i>Coffea arabica</i>	0.0	< <b>0.001</b> ↑	1439.5
<i>Cordyline fruticosa</i>	0.0	<b>0.021</b> ↑	125.0
<i>Cyclosorus parasiticus</i>	0.0	0.083	513.5
<i>Grevillea robusta</i>	0.0	<b>0.004</b> ↑	148.5
<i>Psidium cattleianum</i>	0.5	< <b>0.001</b> ↑	442.5
<i>Psidium guajava</i>	0.0	0.154	422.5
<i>Schinus terebinthifolius</i>	0.0	<b>0.002</b> ↑	891.5
<i>Toona ciliata</i>	0.0	<b>0.030</b> ↑	828.0
<b>Native canopy</b>			
<i>Alyxia stellata</i>	0.0	0.072	469.5
<i>Diospyros sandwicensis</i>	0.0	0.415	272.0
<i>Metrosideros polymorpha</i>	0.0	0.146	494.0
<i>Planchonella sandwicensis</i>	0.0	0.173	298.5
<i>Psydrax odorata</i>	0.0	0.807	348.5
<b>Non-native canopy</b>			
<i>Aleurites moluccana</i>	0.0	<b>0.040</b> ↓	190.0
<i>Coffea arabica</i>	0.0	< <b>0.001</b> ↑	470.0
<i>Psidium cattleianum</i>	10.0	< <b>0.001</b> ↑	3213.5
<i>Psidium guajava</i>	0.0	0.723	375.0
<i>Schinus terebinthifolius</i>	0.0	<b>0.019</b> ↑	1312.0
<i>Syzygium cumini</i>	0.0	0.176	356.0
<i>Toona ciliata</i>	0.0	<b>0.001</b> ↑	1091.0



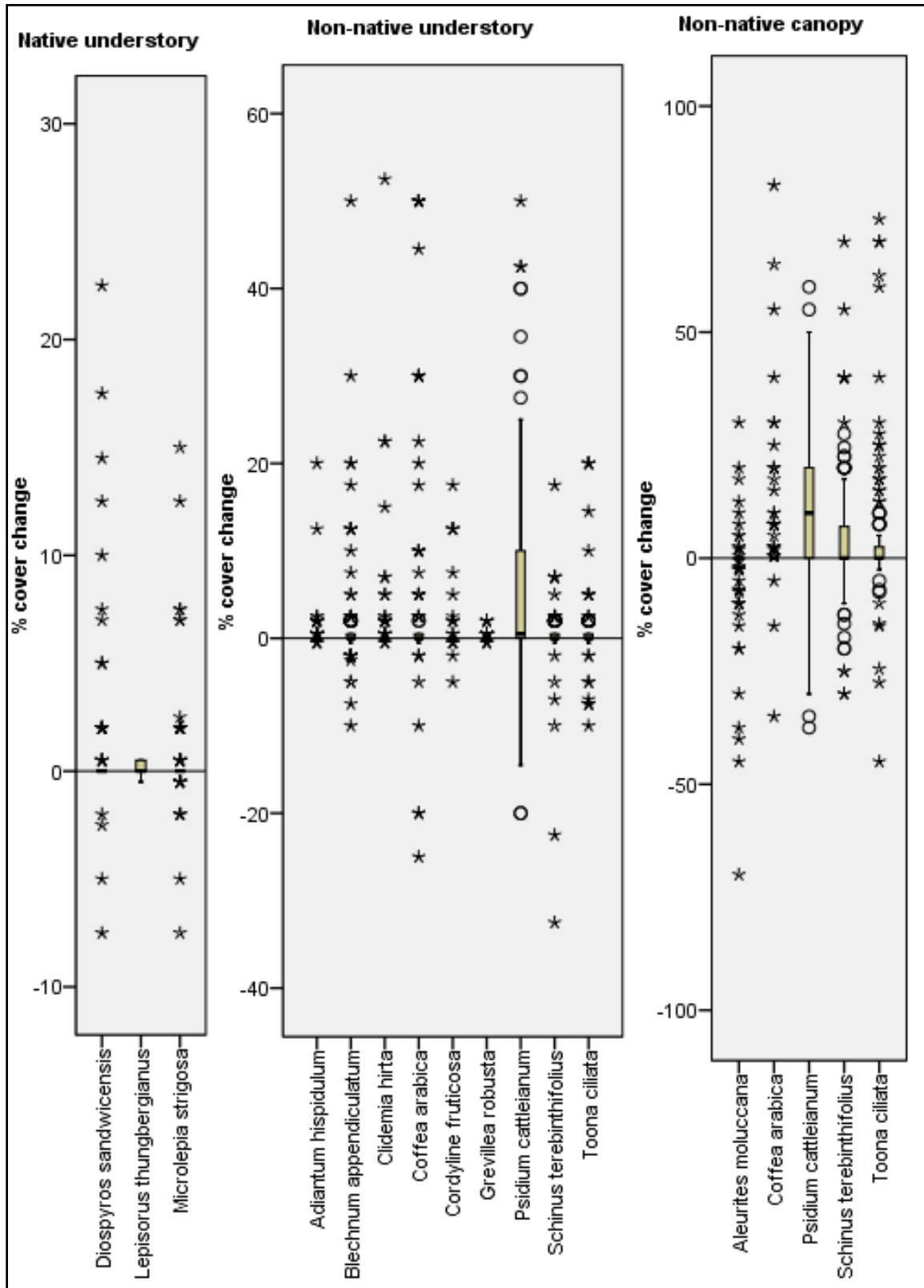


Figure 6. Boxplots of percent cover change between 2009 and 2014 at Makaha Subunit I, for species with significant changes in cover. Values > 0 represent increased cover in plots, while those < 0 represent decreased cover.

## Canopy replacement

Most canopy tree species were found recruiting in the understory (Table 7). *Acacia koa*, *Dodonaea viscosa*, and *Psydrax odorata* were the most commonly recruiting native tree species, while non-native recruiting tree species were primarily *P. cattleianum*, *T. ciliata*, *C. arabica*, and *S. terebinthifolius*. Native species with no recruitment in the understory were also infrequent in the canopy. It should be noted that the age of saplings may vary greatly, from less than one year to decades, in accordance with differing species and individual growth rates, complicating interpretations of presence/absence and change over time with respect to concerns over long term canopy replacement.

Table 7. Summary of canopy tree species recruitment in the understory during 2014 Makaha Subunit I and II MU monitoring, in order of most to least frequent. Frequency represents the occurrence of tree species with a maximum height < 2 meters (seedlings to small trees) among plots (n = 148). Native species are in boldface.

Species	Freq.	Species	Freq.	Species	Freq.
<i>Psidium cattleianum</i>	0.797	<i>Pisonia sandwicensis</i>	0.047	<i>Cyrtandrae waiolani</i>	0.007
<i>Toona ciliata</i>	0.507	<i>Buddleja asiatica</i>	0.041	<i>Flueggea neowawraea</i>	0.007
<i>Coffea arabica</i>	0.480	<b><i>Melicope peduncularis</i></b>	0.041	<i>Fraxinus uhdei</i>	0.007
<i>Schinus terebinthifolius</i>	0.399	<i>Claoxylon sandwicensis</i>	0.034	<b><i>Hesperomannia oahuensis</i></b>	0.007
<b><i>Acacia koa</i></b>	0.311	<b><i>Metrosideros tremuloides</i></b>	0.027	<b><i>Ilex anomala</i></b>	0.007
<i>Dodonaea viscosa</i>	0.230	<i>Nestegis sandwicensis</i>	0.027	<i>Myrsine lanaiensis</i>	0.007
<i>Psydrax odorata</i>	0.203	<i>Psychotria hathewayi</i>	0.027	<b><i>Perrottetia sandwicensis</i></b>	0.007
<i>Grevillea robusta</i>	0.196	<b><i>Scaevola gaudichaudiana</i></b>	0.027	<i>Trema orientalis</i>	0.007
<b><i>Diospyros sandwicensis</i></b>	0.142	<i>Syzygium cumini</i>	0.027	<b><i>Antidesma pulvinatum</i></b>	0.000
<i>Psidium guajava</i>	0.122	<b><i>Xylosma hawaiiense</i></b>	0.027	<b><i>Bobea elatior</i></b>	0.000
<b><i>Metrosideros polymorpha</i></b>	0.108	<b><i>Charpentiera tomentosa</i></b>	0.020	<b><i>Cyanea membranacea</i></b>	0.000
<b><i>Pipturis albidus</i></b>	0.101	<i>Pisonia umbellifera</i>	0.020	<b><i>Dubautia plantaginea</i></b>	0.000
<i>Aleurites moluccana</i>	0.095	<i>Spathodea campanulata</i>	0.020	<b><i>Freycinetia arborea</i></b>	0.000
<b><i>Coprosma foliosa</i></b>	0.088	<b><i>Coprosma longifolia</i></b>	0.014	<b><i>Gynochthodes trimeria</i></b>	0.000
<i>Pisonia brunoniana</i>	0.088	<i>Elaeocarpus bifidus</i>	0.014	<b><i>Labordia kaalae</i></b>	0.000
<i>Cordylone fruticosa</i>	0.081	<b><i>Hibiscus arnottianus</i></b>	0.014	<b><i>Labordia tinifolia</i></b>	0.000
<b><i>Diospyros hillebrandii</i></b>	0.068	<i>Ricinus communis</i>	0.014	<b><i>Myoporum sandwicense</i></b>	0.000
<b><i>Planchonella sandwicensis</i></b>	0.068	<b><i>Sapindus oahuensis</i></b>	0.014	<b><i>Myrsine lessertiana</i></b>	0.000
<i>Psychotria mariniana</i>	0.061	<i>Boehmeria grandis</i>	0.007	<b><i>Pittosporum confertiflorum</i></b>	0.000
<b><i>Wikstroemia oahuensis</i></b>	0.061	<b><i>Charpentiera obovata</i></b>	0.007	<b><i>Polyscias kavaensis</i></b>	0.000
<i>Kadua affinis</i>	0.047	<i>Clermontia persicifolia</i>	0.007	<b><i>Pteralyxia macrocarpa</i></b>	0.000
<b><i>Antidesma platyphyllum</i></b>	0.047	<b><i>Cyrtandra garnotiana</i></b>	0.007	<b><i>Rauvolfia sandwicensis</i></b>	0.000

## Weed control

Weed control efforts at Makaha Subunit I between the 2009 and 2014 monitoring intervals included approximately 1,368.05 person hours. The total amount of effort varied among the eight weed control areas (WCA) that encompass Subunit I, ranging from 7 to 469.9 hours per WCA. The change in native and non-native cover in the understory and canopy did not correlate with the amount of time spent weeding per WCA.

Weed control efforts crossed through 23% of the plots in Subunit I between the 2009 and 2014 monitoring intervals (Figure 7). The proportion of plots that happened to be weeded was somewhat less than the percent total area weeded within Makaha Subunit I (30% of the MU was weeded between the 2009 and 2014 monitoring intervals). I.e., the weeding efforts that occurred in the monitored plots should be nearly representative of weeding efforts that occurred across the entire MU. Change in native and non-native cover did not differ among plots weeded vs. not weeded. There was no correlation between the number of times weeded and cover change for native and non-native understory and canopy. Reductions in non-native canopy did not correlate with increases in native or non-native understory vegetation among the monitored plots. There was a weak positive correlation between changes in non-native and native canopy vegetation (Pearson's  $r^2 = 0.042$ ,  $p = 0.024$ ).

Half of the sixteen target weed species for Makaha Subunits I and II (OANRP 2010) were identified during monitoring, and at least one target taxa was present in all but a single plot. These included four widespread target taxa (*C. arabica*, *P. cattleianum*, *Rubus argutus*, and *T. ciliata*), and four less common target species (*Dicliptera chinensis*, *Spathodea campanulata*, *Trema orientalis*, and *Triumfetta semitriloba*) (Figure 8). Of these, only *C. arabica*, *P. cattleianum*, and *T. ciliata* were present in higher frequencies, and had increased frequency and percent cover. No incipient non-native taxa were identified in any plots.

Caution should be applied in interpreting the results of vegetation monitoring in association with weed control due to error associated with GIS data for both vegetation plots and weeded areas. Accuracy for vegetation plot locations was often poor, at times requiring hand plotting. Weeded areas were often hand plotted, with estimations of size and location that may be inexact to varying degrees.

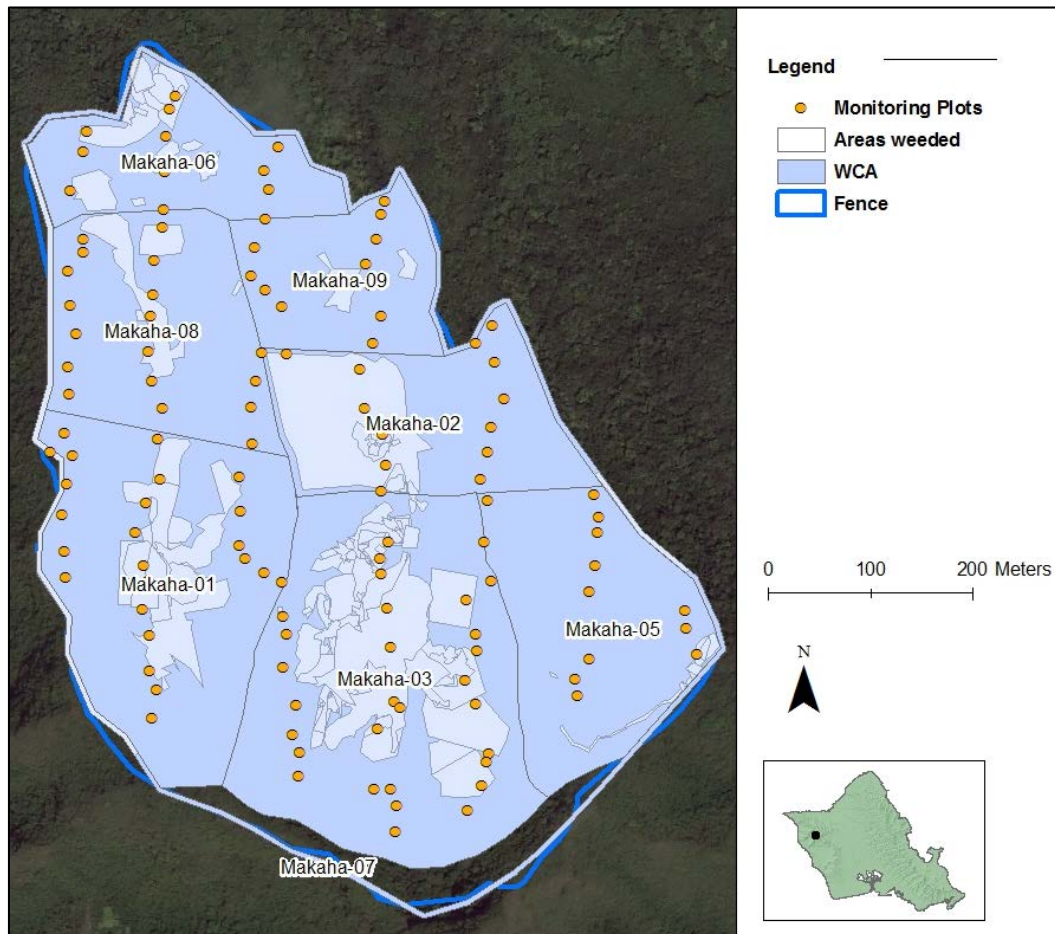


Figure 7. Locations of vegetation monitoring plots at Makaha Subunit I in relation to weed control areas (WCA) and areas weeded between the 2009 and 2014 monitoring intervals.

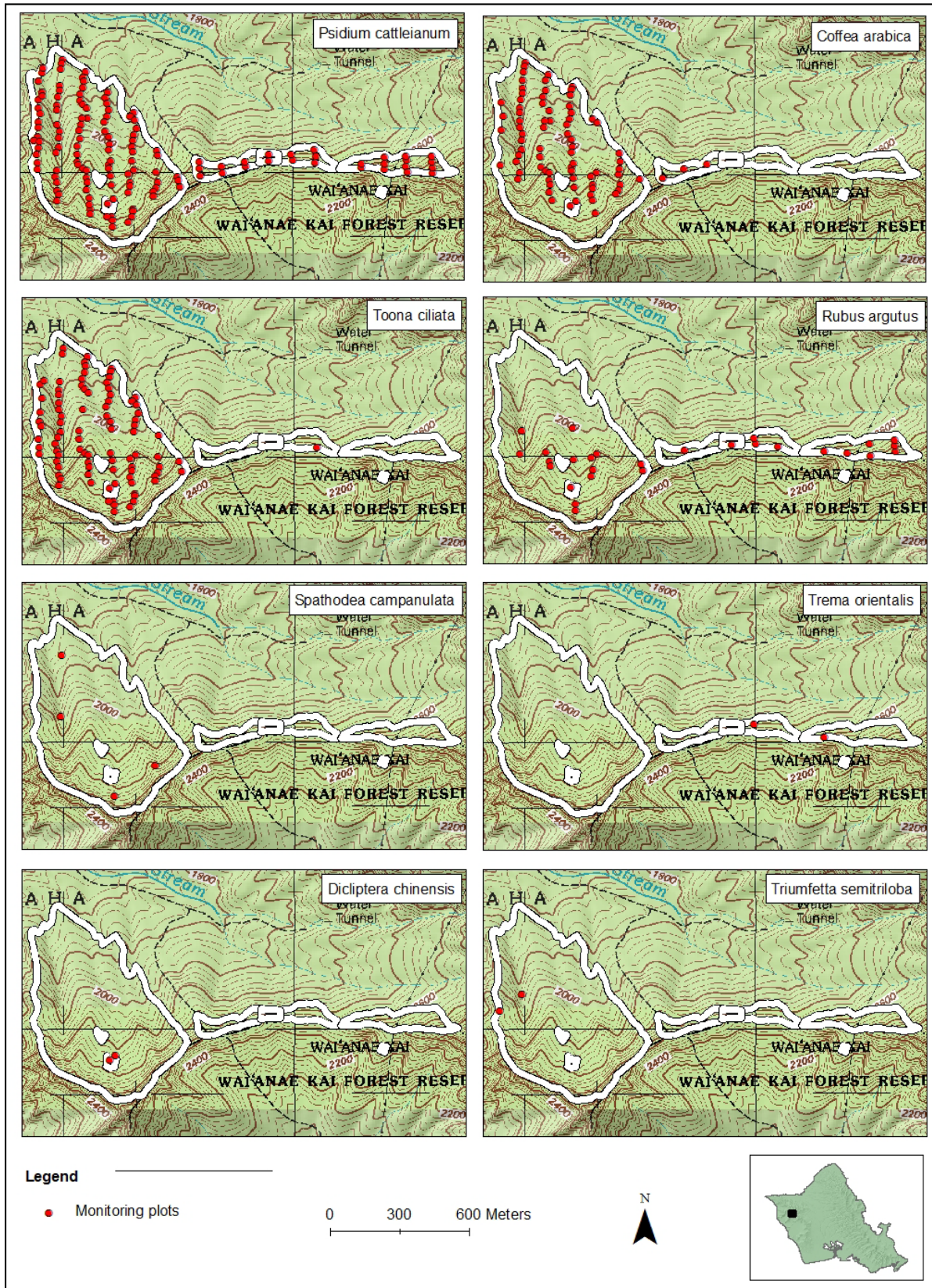


Figure 8. Locations of target taxa in the understory and/or canopy among plots in Makaha Subunit I and II in 2014.

## SUMMARY AND DISCUSSION

Management objectives were not met for percent cover of native understory, native canopy, and non-native canopy vegetation for Makaha Subunit I and II. Objectives were only met for non-native understory percent cover. There were a number of noteworthy significant differences in the 2014 data as compared with five years ago in Subunit I, including:

- greater non-native understory shrub cover, total non-native understory cover, non-native canopy cover, and total canopy cover
- greater native and non-native understory as well as non-native canopy species richness
- an increase in frequency for native understory species:
  - *Acacia koa*
  - *Dryopteris sandwicensis*
  - *Lepisorus thunbergianus*
- an increase in frequency for non-native species:
  - *Coffea arabica* (understory and canopy)
  - *Psidium cattleianum* (understory)
  - *Schinus terebinthifolius* (understory)
  - *Toona ciliata* (understory)
  - *Youngia japonica* (understory)
- an increase in percent cover for native understory species:
  - *Diospyros sandwicensis*
  - *Lepisorus thunbergianus*
  - *Microlepia strigosa*
- an increase in percent cover for non-native species:
  - *Adiantum hispidulum* (understory)
  - *Blechnum appendiculatum* (understory)
  - *Clidemia hirta* (understory)
  - *Coffea arabica* (understory and canopy)
  - *Cordyline fruticosa* (understory)
  - *Grevillea robusta* (understory)
  - *Psidium cattleianum* (understory and canopy)
  - *Schinus terebinthifolius* (understory and canopy)
  - *Toona ciliata* (understory and canopy)
- a decrease in percent cover for non-native canopy species:
  - *Aleurites moluccana*

The vegetation changes observed at Makaha follow a similar pattern to that of prior studies comparing fenced and unfenced areas, wherein both native and non-native species respond positively to ungulate removal during the initial years following fencing (Weller et al. 2011, Cole and Litton 2014). The beneficial changes that occurred for the native vegetation were generally small, while the worsening changes for the non-native vegetation were larger, particularly in the canopy, irrespective of weeding efforts. Given the high level of non-native canopy cover in the MU, management goals of < 50% cover may be unrealistic across the MU. Refinement of management goals to apply specifically to prioritized areas (those with greater potential for restoration) within the MU may result in goals that are more likely to be successfully accomplished.

## RECOMMENDATIONS

Based on the results of vegetation monitoring, a number of recommendations were made with the goal of making progress towards meeting management objectives:

- more aggressive ecosystem level weed control
- more grass control
- develop aggressive restoration projects for carefully selected sites, targeting stands of *Psidium cattleianum*, *Coffea arabica*, *Toona ciliata*, and/or *Schinus terebinthifolius*, to include restoration plantings
- continue to target *Grevillea robusta* and *Toona ciliata*
- efforts should be made to limit/reduce the expansion of *Coffea arabica*, *Toona ciliata*, and *Rubus argutus* in Subunit II
- weed control trials for *Adiantum hispidulum* and *Rubus argutus* to explore most effective method for control (consider locations other than Makaha due to pesticide use restrictions)
- target uncommon weeds when seen (particularly *Fraxinus uhdei*, *Trema orientalis*, and *Spathodea campanulata*)
- there should be critical consideration and discussion of why change in native and non-native cover did not differ among weeded vs. not weeded plots

## REFERENCES

- Cole, R. J. and C. M. Litton. 2014. Vegetation response to removal of non-native feral pigs from Hawaiian tropical montane wet forest. *Biological Invasions* 16:125–140.
- Oahu Army Natural Resource Program. 2008. Appendix 2.0 MIP/OIP Belt Plot Sampling Monitoring Protocol *in* 2008 Status Report for the Makua Implementation Plan.
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- Weller, S. G., R. J. Cabin, D. H. Lorence, S. Perlman, K. Wood, T. Flynn, and A. K. Sakai. 2011. Alien Plant Invasions, Introduced Ungulates, and Alternative States in a Mesic Forest in Hawaii. *Restoration Ecology* 19: 671–680.

# Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: **Abutilon sandwichense**

Target # of Matures: 50

# MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kaawa to Puulu	Manage for stability	36	88	6	27	78	0	32	59	0	32	59	0	0	0	0	2015-08-13	The sites were visited, but not thoroughly counted in the last year
Kahanahaiki	Manage reintroduction for stability	0	0	0	13	16	0	72	6	0	0	0	0	72	6	0	2015-07-28	Many of the outplants were observed to have matured in the last year and more outplants were added to the site
Kaluakauila	Manage reintroduction for storage	0	4	0	0	7	0	0	7	0	0	0	0	0	7	0	2012-11-05	No monitoring in the last year
Keaau	Genetic Storage	1	0	10	1	0	10	1	0	10	1	0	10	0	0	0	2002-04-06	No monitoring in the last year
<b>In Total:</b>		37	92	16	41	101	10	105	72	10	33	59	10	72	13	0		

# Oahu Implementation Plan - Population Unit Status

Action Area: Out

TaxonName: **Abutilon sandwichense**

Target # of Matures: 50

# MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
East Makaleha	Genetic Storage	2	2	40	0	0	0	0	0	0	0	0	0	0	0	0	2013-09-10	No monitoring in the last year
Ekahanui and Huliwai	Manage for stability	14	30	0	18	128	0	46	118	5	5	15	5	41	103	0	2015-07-14	Many of the outplants were observed to have matured in the last year and more outplants were added to the site
Halona	Genetic Storage	0	0	0	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	65	55	0	92	133	0	92	133	0	0	0	0	2015-07-08	A thorough census of the known area found more plants
Makaha Mauka	Genetic Storage	5	58	4	10	51	0	13	1	0	13	1	0	0	0	0	2015-07-09	A thorough census of the known area found fewer plants
Nanakuli	Genetic Storage	0	0	0	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	9	11	0	9	11	0	9	11	0	0	0	0	2012-07-19	No monitoring in the last year
South Mikilua	Genetic Storage	0	0	0	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	1	0	0	0	0	0	0	0	0	0	0	0	2015-07-09	The last wild plant died in the last year
West Makaleha	Genetic Storage	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2012-09-17	No monitoring in the last year
<b>Out Total:</b>		98	158	50	103	245	0	160	263	5	119	160	5	41	103	0		
<b>Total for Taxon:</b>		135	250	66	144	346	10	265	335	15	152	219	15	113	116	0		



# Makua Implementation Plan - Population Unit Status

## Action Area: In

**TaxonName: Alectryon macrococcus var. macrococcus**

Target # of Matures: 50

# MFS PU Met Goal: 0 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kahanahaiki to Keawapilau	Manage for stability	2	6	0	3	2	0	1	1	0	1	0	0	0	1	0	2015-09-01	Three of the known trees were observed dead in the last year
Makua	Manage for stability	15	0	0	16	0	0	11	0	0	11	0	0	0	0	0	2015-08-13	Five of the known trees were observed dead in the last year
South Mohiakea	Genetic Storage	16	1	0	2	0	0	2	0	0	2	0	0	0	0	0	2015-06-23	Monitoring showed no change
West Makaleha	Genetic Storage	40	4	0	13	0	0	13	0	0	13	0	0	0	0	0	2015-05-11	Monitoring showed no change
<b>In Total:</b>		73	11	0	34	2	0	27	1	0	27	0	0	0	1	0		

## Action Area: Out

**TaxonName: Alectryon macrococcus var. macrococcus**

Target # of Matures: 50

# MFS PU Met Goal: 0 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Central Kaluua to Central Waielei	Manage for stability	50	3	0	4	5	0	3	5	0	3	0	0	0	5	0	2015-03-03	One of the known trees was observed dead in the last year
Makaha	Manage for stability	75	0	2	37	0	0	36	0	0	36	0	0	0	0	0	2015-04-23	One of the known trees was observed dead in the last year
Waianae Kai	Genetic Storage	16	0	0	2	0	0	1	0	0	1	0	0	0	0	0	2015-06-15	One of the known trees was observed dead in the last year
<b>Out Total:</b>		141	3	2	43	5	0	40	5	0	40	0	0	0	5	0		
<b>Total for Taxon:</b>		214	14	2	77	7	0	67	6	0	67	0	0	0	6	0		

# Makua Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: *Cenchrus agrimonioides* var. *agrimonioides*

Target # of Matures: 50

# MFS PU Met Goal: 3 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kahanahaiki and Pahole	Manage for stability	210	66	0	327	138	128	319	61	79	80	42	70	239	19	9	2015-09-02	Thorough monitoring in the last year showed a decline
Kuaokala	Genetic Storage				1	3	0	1	3	0	1	3	0	0	0	0	2014-04-30	No monitoring in the last year
<b>In Total:</b>		210	66	0	328	141	128	320	64	79	81	45	70	239	19	9		

## Action Area: Out

### TaxonName: *Cenchrus agrimonioides* var. *agrimonioides*

Target # of Matures: 50

# MFS PU Met Goal: 3 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Central Ekahanui	Manage for stability	20	0	0	168	89	0	168	89	0	47	72	0	121	17	0	2014-09-02	Monitoring showed no change
Makaha and Waianae Kai	Manage for stability	9	3	0	10	7	5	171	128	5	5	7	5	166	121	0	2015-04-13	More plants were added to the outplanting site
South Huliwai	Genetic Storage	27	0	0	15	13	0	15	13	0	15	13	0	0	0	0	2014-09-03	Monitoring showed no change
<b>Out Total:</b>		56	3	0	193	109	5	354	230	5	67	92	5	287	138	0		
<b>Total for Taxon:</b>		266	69	0	521	250	133	674	294	84	148	137	75	526	157	9		

# Oahu Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: *Cyanea acuminata*

Target # of Matures: 50

# MFS PU Met Goal: 3 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Helemano-Punaluu Summit Ridge to North Kaukonahua	Manage for stability	59	13	7	189	186	1	130	142	0	130	142	0	0	0	0	2015-06-02	Thorough monitoring last year showed a decline. Many of the plants were observed with rodent damage last year and have since died.
Kahana and South Kaukonahua	Genetic Storage	2	0	0	2	0	0	2	0	0	2	0	0	0	0	0	1993-01-01	No monitoring in the last year
Kawaiiki	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		No monitoring in the last year
Makaleha to Mohiakea	Manage for stability	85	33	0	158	70	0	151	65	0	151	65	0	0	0	0	2015-02-23	Small changes were noted during monitoring last year
<b>In Total:</b>		147	46	7	349	256	1	283	207	0	283	207	0	0	0	0		

## Action Area: Out

### TaxonName: *Cyanea acuminata*

Target # of Matures: 50

# MFS PU Met Goal: 3 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kahana and Makaua	Genetic Storage	5	0	0	11	3	0	11	3	0	11	3	0	0	0	0	2008-11-06	No monitoring in the last year
Kaipapau and Koloa	Genetic Storage	0	0	0	70	30	0	70	30	0	70	30	0	0	0	0	2013-12-16	No monitoring in the last year
Kaluani and Maakua	Manage for stability	0	0	0	113	108	50	123	126	50	123	126	50	0	0	0	2015-01-14	New plants were discovered during DOFAW surveys
Konahuanui	Genetic Storage	30	0	0	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	0	0	0		No monitoring in the last year
Puukeahiakahoe	Genetic Storage	3	0	0	3	0	0	3	0	0	3	0	0	0	0	0	1997-02-04	No monitoring in the last year
Puuokona	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		No monitoring in the last year
<b>Out Total:</b>		39	0	0	197	141	50	207	159	50	207	159	50	0	0	0		
<b>Total for Taxon:</b>		186	46	7	546	397	51	490	366	50	490	366	50	0	0	0		

# Makua Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: *Cyanea grimesiana* subsp. *obatae*

Target # of Matures: 100

# MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Pahole to West Makaleha	Manage for stability	22	24	0	64	52	0	75	36	0	6	11	0	69	25	0	2015-06-09	More of the outplants were observed to have matured in the last year
<b>In Total:</b>		22	24	0	64	52	0	75	36	0	6	11	0	69	25	0		

## Action Area: Out

### TaxonName: *Cyanea grimesiana* subsp. *obatae*

Target # of Matures: 100

# MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kaluaa	Manage for stability	0	0	0	115	49	0	128	22	1	2	0	1	126	22	0	2015-06-02	Many of the outplants were observed to have matured in the last year
Makaha	Genetic Storage				4	18	0	4	18	0	0	0	0	4	18	0	2015-05-12	Monitoring showed no change
North branch of South Ekahanui	Manage reintroduction for stability	5	0	0	72	93	0	83	66	0	0	0	0	83	66	0	2015-06-15	Many of the outplants were observed to have matured in the last year
Paliikea (South Palawai)	Manage for stability	3	60	0	113	34	12	108	36	1	7	7	0	101	29	1	2015-04-22	Thorough monitoring in the last year showed a decline
<b>Out Total:</b>		8	60	0	304	194	12	323	142	2	9	7	1	314	135	1		
<b>Total for Taxon:</b>		30	84	0	368	246	12	398	178	2	15	18	1	383	160	1		

# Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: *Cyanea koolauensis*

Target # of Matures: 50

# MFS PU Met Goal: 1 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kaipapau, Koloa and Kawainui	Manage for stability	51	25	6	113	12	0	106	13	0	106	13	0	0	0	0	2015-03-19	Several wild plants were observed to have died in the last year
Kamananui-Kawainui Ridge	Genetic Storage	6	2	0	6	2	0	6	2	0	6	2	0	0	0	0	2001-03-12	No monitoring in the last year
Kaukonahua	Genetic Storage	11	1	0	14	3	0	8	3	0	8	3	0	0	0	0	2015-07-01	No monitoring in the last year
Kawaiiki	Genetic Storage	3	4	0	4	4	0	4	4	0	4	4	0	0	0	0	2000-01-01	No monitoring in the last year
Lower Opaepala	Genetic Storage	3	1	0	1	0	0	1	0	0	1	0	0	0	0	0	2011-07-12	No monitoring in the last year
Opaepala to Helemano	Manage for stability	10	3	0	22	2	0	23	4	0	23	4	0	0	0	0	2015-05-19	Small changes were noted during monitoring in the last year
Poamoho	Manage for stability	12	0	0	18	18	0	21	18	0	21	18	0	0	0	0	2015-03-18	New plants were discovered during surveys
<b>In Total:</b>		96	36	6	178	41	0	169	44	0	169	44	0	0	0	0		

# Oahu Implementation Plan - Population Unit Status

Action Area: Out

TaxonName: *Cyanea koolauensis*

Target # of Matures: 50

# MFS PU Met Goal: 1 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Halawa	Genetic Storage	3	0	0	4	0	0	4	0	0	4	0	0	0	0	0	1990-09-16	No monitoring in the last year
Halawa-Kalauao Ridge	Genetic Storage	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0		No monitoring in the last year
Lulumahu	Genetic Storage	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0		No monitoring in the last year
Waialae Nui	Genetic Storage	2	0	0	2	0	0	2	0	0	2	0	0	0	0	0	1990-09-06	No monitoring in the last year
Waiawa to Waimano	Genetic Storage	1	0	0	11	2	0	11	2	0	11	2	0	0	0	0	2012-09-18	No monitoring in the last year
Wailupe	Genetic Storage	15	0	0	1	0	0	1	0	0	1	0	0	0	0	0	2006-08-10	No monitoring in the last year
Waimalu	Genetic Storage	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0		No monitoring in the last year
<b>Out Total:</b>		39	0	0	18	2	0	18	2	0	18	2	0	0	0	0		
<b>Total for Taxon:</b>		135	36	6	196	43	0	187	46	0	187	46	0	0	0	0		

# Makua Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: *Cyanea longiflora*

Target # of Matures: 75

# MFS PU Met Goal: 1 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kapuna to West Makaleha	Manage for stability	66	0	0	26	115	1	28	244	2	13	18	2	15	226	0	2015-08-25	More plants were added to the outplanting site
Pahole	Manage for stability	114	0	0	55	76	67	58	104	21	58	104	21	0	0	0	2015-05-28	A thorough census of the known area found more plants
<b>In Total:</b>		180	0	0	81	191	68	86	348	23	71	122	23	15	226	0		

## Action Area: Out

### TaxonName: *Cyanea longiflora*

Target # of Matures: 75

# MFS PU Met Goal: 1 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Makaha and Waianae Kai	Manage for stability	4	0	0	15	37	0	110	207	0	8	4	0	102	203	0	2015-06-10	More plants were added to the outplanting site
<b>Out Total:</b>		4	0	0	15	37	0	110	207	0	8	4	0	102	203	0		
<b>Total for Taxon:</b>		184	0	0	96	228	68	196	555	23	79	126	23	117	429	0		

# Makua Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: *Cyanea superba* subsp. *superba*

Target # of Matures: 50

# MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kahanahaiki	Manage reintroduction for stability	3	149	0	50	254	139	58	199	113	0	0	0	58	199	113	2015-04-22	Thorough monitoring in the last year showed a decline
Pahole to Kapuna	Manage reintroduction for stability	31	139	0	102	98	36	95	71	4	0	0	0	95	71	4	2015-06-08	Thorough monitoring in the last year showed a decline
<b>In Total:</b>		34	288	0	152	352	175	153	270	117	0	0	0	153	270	117		

## Action Area: Out

### TaxonName: *Cyanea superba* subsp. *superba*

Target # of Matures: 50

# MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Makaha	Manage reintroduction for stability				27	170	0	27	172	246	0	0	0	27	172	246	2015-04-14	Small changes were noted during monitoring in the last year and many new seedlings were observed
Manuwai	Manage reintroduction for stability	0	0	0	0	173	0	0	142	0	0	0	0	0	142	0	2015-05-26	Thorough monitoring in the last year showed a decline
<b>Out Total:</b>		0	0	0	27	343	0	27	314	246	0	0	0	27	314	246		
<b>Total for Taxon:</b>		34	288	0	179	695	175	180	584	363	0	0	0	180	584	363		



# Makua Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: *Cyrtandra dentata*

Target # of Matures: 50

# MFS PU Met Goal: 1 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kahanahaiki	Manage for stability	52	45	0	34	89	98	37	76	94	37	76	94	0	0	0	2015-06-10	No monitoring in the last year
Kawaiiki (Koolaus)	Manage for stability	50	0	0	5	79	0	5	79	0	5	79	0	0	0	0	2012-07-23	No monitoring in the last year
Opaepala (Koolaus)	Manage for stability	21	5	0	23	102	0	23	107	0	23	107	0	0	0	0	2014-09-25	Small changes were noted during monitoring in the last year
Pahole to West Makaleha	Manage for stability	300	0	0	603	670	281	603	670	281	603	670	281	0	0	0	2013-10-10	No monitoring in the last year
<b>In Total:</b>		423	50	0	665	940	379	668	932	375	668	932	375	0	0	0		

## Action Area: Out

### TaxonName: *Cyrtandra dentata*

Target # of Matures: 50

# MFS PU Met Goal: 1 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Central Makaleha	Genetic Storage				3	0	0	3	0	0	3	0	0	0	0	0	2006-10-23	No monitoring in the last year
<b>Out Total:</b>					3	0	0	3	0	0	3	0	0	0	0	0		
<b>Total for Taxon:</b>		423	50	0	668	940	379	671	932	375	671	932	375	0	0	0		

# Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: *Delissea waianaensis*

Target # of Matures: 100

# MFS PU Met Goal: 3 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kahanahaiki to Keawapilau	Manage for stability	33	1	0	253	27	0	240	19	0	3	6	0	237	13	0	2015-05-05	Small changes were noted during monitoring in the last year
Kaluakauila	Manage reintroduction for storage				15	3	0	15	3	0	0	0	0	15	3	0	2014-04-30	No monitoring in the last year
Kapuna	Manage reintroduction for storage				113	46	0	113	46	0	0	0	0	113	46	0	2014-04-29	No monitoring in the last year
Paliikea Gulch	Genetic Storage	2	0	0	1	0	0	1	0	0	1	0	0	0	0	0	2014-05-28	No monitoring in the last year
South Mohiakea	Genetic Storage	2	0	0	8	9	11	12	23	6	12	23	6	0	0	0	2015-06-22	A few more plants were observed in the known sites
<b>In Total:</b>		37	1	0	390	85	11	381	91	6	16	29	6	365	62	0		

# Makua Implementation Plan - Population Unit Status

Action Area: Out

TaxonName: *Delissea waianaensis*

Target # of Matures: 100

# MFS PU Met Goal: 3 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Ekahanui	Manage for stability	14	44	0	168	27	0	196	23	0	2	1	0	194	22	0	2015-05-28	A thorough census of the known area found more plants
Kaluaa	Manage for stability	44	0	0	590	130	68	650	89	6	5	2	0	645	87	6	2015-05-28	Many of the outplants were observed to have matured in the last year and new plants are recruiting at the outplanting sites
Kealia	Genetic Storage	0	7	0	1	2	0	4	13	2	4	13	2	0	0	0	2015-05-28	Small changes were noted during monitoring in the last year
Manuwai	Manage reintroduction for stability				112	85	0	88	44	0	0	0	0	88	44	0	2015-05-26	No monitoring in the last year
Palawai	Genetic Storage	1	0	0	9	13	300	17	47	0	17	47	0	0	0	0	2015-07-23	Small changes were noted during monitoring in the last year
<b>Out Total:</b>		59	51	0	880	257	368	955	216	8	28	63	2	927	153	6		
<b>Total for Taxon:</b>		96	52	0	1270	342	379	1336	307	14	44	92	8	1292	215	6		

# Makua Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: *Dubautia herbstobatae*

Target # of Matures: 50

# MFS PU Met Goal: 2 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Keaau	Genetic Storage	70	0	0	70	0	0	70	0	0	70	0	0	0	0	0	2000-01-01	No monitoring since 2000
Makaha/Ohikilolo	Genetic Storage				350	0	0	350	0	0	350	0	0	0	0	0	2000-10-18	No monitoring since 2000
Ohikilolo Makai	Manage for stability	700	0	0	89	2	0	89	2	0	89	2	0	0	0	0	2013-09-04	No monitoring in the last year
Ohikilolo Mauka	Manage for stability	1300	0	0	415	9	0	415	9	0	415	9	0	0	0	0	2011-06-07	No monitoring in the last year
<b>In Total:</b>		2070	0	0	924	11	0	924	11	0	924	11	0	0	0	0		

## Action Area: Out

### TaxonName: *Dubautia herbstobatae*

Target # of Matures: 50

# MFS PU Met Goal: 2 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kamaileunu	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2001-01-01	No monitoring since 2001
Makaha	Manage for stability	0	0	0	28	1	0	28	1	0	28	1	0	0	0	0	2013-09-17	No monitoring in the last year
Waianae Kai	Genetic Storage	5	0	0	10	4	0	10	4	0	10	4	0	0	0	0	2005-06-22	No monitoring since 2005
<b>Out Total:</b>		6	0	0	38	5	0	38	5	0	38	5	0	0	0	0		
<b>Total for Taxon:</b>		2076	0	0	962	16	0	962	16	0	962	16	0	0	0	0		

# Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: *Eugenia koolauensis*

Target # of Matures: 50

# MFS PU Met Goal: 0 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Aimuu	Genetic Storage	0	0	0	11	9	5	8	10	0	8	10	0	0	0	0	2015-04-09	Small changes were noted during monitoring in the last year
Kaiwikoele and Kamananui	Genetic Storage	16	16	15	13	70	19	21	26	1	21	26	1	0	0	0	2015-03-25	Thorough monitoring in the last year showed a decline
Kaleleiki	Genetic Storage	25	30	250	12	62	80	14	54	80	14	54	80	0	0	0	2015-05-06	Thorough monitoring in the last year showed a decline
Kaunala	Manage for stability	48	93	6	23	39	31	20	39	27	20	39	27	0	0	0	2015-06-09	The sites were visited for collections, but not thoroughly counted in the last year
Malaekahana	Genetic Storage				5	21	0	5	21	0	5	21	0	0	0	0	2014-04-09	No monitoring in the last year
Ohiaai and East Oio	Genetic Storage	5	8	10	4	1	0	1	1	0	1	1	0	0	0	0	2015-03-18	Thorough monitoring in the last year showed a decline
Oio	Manage for stability	18	56	0	7	5	0	5	2	0	5	2	0	0	0	0	2015-05-07	The sites were visited for collections, but not thoroughly counted in the last year
Pahipahialua	Manage for stability	57	234	1	22	6	141	22	6	141	22	6	141	0	0	0	2014-07-23	The sites were visited for collections, but not thoroughly counted in the last year
<b>In Total:</b>		169	437	282	97	213	276	96	159	249	96	159	249	0	0	0		

# Oahu Implementation Plan - Population Unit Status

Action Area: Out

TaxonName: *Eugenia koolauensis*

Target # of Matures: 50

# MFS PU Met Goal: 0 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Hanaimoa	Genetic Storage	1	0	0	2	2	0	1	0	0	1	0	0	0	0	0	2015-06-25	Several wild plants were observed to have died in the last year
Paliikea and Kaimuhole	Genetic Storage	3	0	0	1	0	0	1	0	0	1	0	0	0	0	0	2014-05-28	No monitoring in the last year
Papali	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		No monitoring in the last year
<b>Out Total:</b>		5	0	0	3	2	0	2	0	0	2	0	0	0	0	0		
<b>Total for Taxon:</b>		174	437	282	100	215	276	98	159	249	98	159	249	0	0	0		

# Makua Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: Euphorbia celastroides var. kaenana

Target # of Matures: 25

# MFS PU Met Goal: 3 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
East Kahanahaiki	Genetic Storage	2	0	0	2	0	0	2	0	0	2	0	0	0	0	0	2010-11-18	No monitoring in the last year
Kaluakauila	Genetic Storage	17	1	0	11	3	0	11	3	0	11	3	0	0	0	0	2010-06-24	No monitoring in the last year
Makua	Manage for stability	36	4	0	125	2	0	85	0	0	85	0	0	0	0	0	2014-12-09	Thorough monitoring in the last year showed a decline
North Kahanahaiki	Genetic Storage	218	0	0	115	36	0	115	36	0	115	36	0	0	0	0	2013-03-21	No monitoring in the last year
Puaakanoa	Manage for stability	147	10	0	149	32	1	150	16	2	150	16	2	0	0	0	2014-10-16	Small changes were noted during monitoring in the last year
<b>In Total:</b>		420	15	0	402	73	1	363	55	2	363	55	2	0	0	0		

## Action Area: Out

### TaxonName: Euphorbia celastroides var. kaenana

Target # of Matures: 25

# MFS PU Met Goal: 3 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
East of Alau	Manage for stability	21	5	0	21	2	0	21	2	0	21	2	0	0	0	0	2014-08-25	No monitoring in the last year
Kaena	Manage for stability	300	0	0	579	896	0	579	896	0	579	896	0	0	0	0	2011-05-17	No monitoring in the last year
Keawaula	Genetic Storage	69	6	0	43	1	2	43	1	2	43	1	2	0	0	0	2014-08-25	No monitoring in the last year
Waianae Kai	Genetic Storage	48	0	0	34	0	0	34	0	0	34	0	0	0	0	0	2011-06-13	No monitoring in the last year
<b>Out Total:</b>		438	11	0	677	899	2	677	899	2	677	899	2	0	0	0		
<b>Total for Taxon:</b>		858	26	0	1079	972	3	1040	954	4	1040	954	4	0	0	0		

# Makua Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: Euphorbia herbstii

Target # of Matures: 25

# MFS PU Met Goal: 1 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kapuna to Pahole	Manage for stability	170	0	0	43	49	9	56	52	0	14	9	0	42	43	0	2015-06-30	More plants were added to the outplanting site
Manuwai	Manage reintroduction for stability				0	0	0	0	0	0	0	0	0	0	0	0		The reintroduction will begin once propagules are available
<b>In Total:</b>		170	0	0	43	49	9	56	52	0	14	9	0	42	43	0		

## Action Area: Out

### TaxonName: Euphorbia herbstii

Target # of Matures: 25

# MFS PU Met Goal: 1 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kaluaa	Manage reintroduction for stability				0	0	0	0	0	0	0	0	0	0	0	0		The reintroduction will begin once propagules are available
Makaha	Manage reintroduction for storage				4	31	0	4	31	0	0	0	0	4	31	0	2014-11-10	Monitoring showed no change
<b>Out Total:</b>					4	31	0	4	31	0	0	0	0	4	31	0		
<b>Total for Taxon:</b>		170	0	0	47	80	9	60	83	0	14	9	0	46	74	0		



# Makua Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: Flueggea neowawraea

Target # of Matures: 50

# MFS PU Met Goal: 0 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kahanahaiki to Kapuna	Manage for stability	6	26	0	6	121	0	6	123	0	6	0	0	0	123	0	2015-06-10	More plants were added to the outplanting site
Ohikilolo	Manage for stability	3	0	0	1	0	0	1	0	0	1	0	0	0	0	0	2014-02-26	No monitoring in the last year
West Makaleha	Genetic Storage	3	0	0	6	0	0	6	0	0	6	0	0	0	0	0	2014-01-29	No monitoring in the last year
<b>In Total:</b>		12	26	0	13	121	0	13	123	0	13	0	0	0	123	0		

## Action Area: Out

### TaxonName: Flueggea neowawraea

Target # of Matures: 50

# MFS PU Met Goal: 0 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Central and East Makaleha	Genetic Storage	6	0	0	5	0	0	5	0	0	5	0	0	0	0	0	2014-03-31	No monitoring in the last year
Halona	Genetic Storage	2	0	0	1	0	0	1	0	0	1	0	0	0	0	0	2010-12-07	No monitoring in the last year
Kauhiuhi	Genetic Storage	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	2006-11-22	No monitoring in the last year
Makaha	Manage for stability	4	0	0	10	51	0	10	55	0	10	0	0	0	55	0	2015-05-18	More plants were added to the outplanting site
Manuwai	Manage reintroduction for stability	0	0	0	0	29	0	0	35	0	0	0	0	0	35	0	2015-03-18	More plants were added to the outplanting site
Mikilua	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2009-02-19	No monitoring in the last year
Mt. Kaala NAR	Genetic Storage	4	0	0	3	0	0	3	0	0	3	0	0	0	0	0	2014-09-18	Monitoring showed no change
Nanakuli, south branch	Genetic Storage	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	2010-10-19	No monitoring in the last year
Waianae Kai	Genetic Storage	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	2014-05-12	No monitoring in the last year
<b>Out Total:</b>		20	0	0	22	80	0	22	90	0	22	0	0	0	90	0		
<b>Total for Taxon:</b>		32	26	0	35	201	0	35	213	0	35	0	0	0	213	0		

# Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: **Gardenia mannii**

Target # of Matures: 50

# MFS PU Met Goal: 1 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Haleauau	Manage for stability	2	0	0	2	0	0	69	0	0	3	0	0	66	0	0	2015-08-26	Many plants were added to the new outplanting site and a new wild tree was found
Helemano and Poamoho	Manage for stability	18	0	0	8	0	0	17	0	0	17	0	0	0	0	0	2015-06-30	New plants were discovered during surveys
Kaiwikoele, Kamananui, and Kawainui	Genetic Storage	20	0	0	14	0	0	13	0	0	13	0	0	0	0	0	2015-06-17	One of the known trees was observed dead in the last year
Lower Peahinaia	Manage for stability	45	1	0	9	1	0	9	1	0	9	1	0	0	0	0	2015-06-01	Monitoring showed no change
South Kaukonahua	Genetic Storage	2	0	0	1	0	0	1	0	0	1	0	0	0	0	0	2015-07-29	One of the known trees was observed dead in the last year
Upper Opaepala/Helemano	Genetic Storage	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	2015-03-12	Monitoring showed no change
<b>In Total:</b>		88	1	0	35	1	0	110	1	0	44	1	0	66	0	0		

# Oahu Implementation Plan - Population Unit Status

Action Area: Out

TaxonName: **Gardenia mannii**

Target # of Matures: 50

# MFS PU Met Goal: 1 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Ihiihi-Kawainui ridge	Genetic Storage	2	0	0	2	0	0	2	0	0	2	0	0	0	0	0	1993-01-01	No current monitoring data
Kahana and Makaua	Genetic Storage	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0		No current monitoring data
Kaipapau to Punaluu	Genetic Storage	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0		No current monitoring data
Kalauao	Genetic Storage	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0		No current monitoring data
Kaluaa and Maunauna	Genetic Storage	1	0	0	2	0	0	2	0	0	2	0	0	0	0	0	2014-06-17	No monitoring in the last year
Kamananui-Malaekahana Summit Ridge	Genetic Storage	13	0	0	4	0	0	3	0	0	3	0	0	0	0	0	2015-03-31	One of the known trees was observed dead in the last year
Kapakahi	Genetic Storage	4	0	0	4	0	0	2	0	0	2	0	0	0	0	0	2014-03-14	No monitoring in the last year
Manana-Waimano Ridge	Genetic Storage	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0		No current monitoring data
Pukele	Genetic Storage	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	1986-07-29	No current monitoring data
Waialae Nui	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		No current monitoring data
<b>Out Total:</b>		36	0	0	13	0	0	10	0	0	10	0	0	0	0	0		
<b>Total for Taxon:</b>		124	1	0	48	1	0	120	1	0	54	1	0	66	0	0		

# Makua Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: Gouania vitifolia

Target # of Matures: 50

# MFS PU Met Goal: 1 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Keaau	Manage for stability				55	0	0	55	0	0	55	0	0	0	0	0	2013-06-05	No monitoring in the last year
<b>In Total:</b>					55	0	0	55	0	0	55	0	0	0	0	0		

## Action Area: Out

### TaxonName: Gouania vitifolia

Target # of Matures: 50

# MFS PU Met Goal: 1 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Makaha (Future Introduction)	Manage reintroduction for stability				0	0	0	0	0	0	0	0	0	0	0	0		Introduction not begun
Manuwai (Future Introduction)	Manage reintroduction for stability				0	0	0	0	0	0	0	0	0	0	0	0		Introduction not begun
Waianae Kai	Genetic Storage				3	0	0	3	0	0	3	0	0	0	0	0	2014-02-26	No monitoring in the last year
<b>Out Total:</b>					3	0	0	3	0	0	3	0	0	0	0	0		
<b>Total for Taxon:</b>					58	0	0	58	0	0	58	0	0	0	0	0		

# Makua Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: *Hesperomannia oahuensis*

Target # of Matures: 75

# MFS PU Met Goal: 0 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Haleauau	Manage for stability				1	0	0	1	0	0	1	0	0	0	0	0	2015-08-26	Monitoring showed no change
Pahole NAR	Manage reintroduction for stability	8	0	0	2	48	0	4	38	0	0	0	0	4	38	0	2015-01-26	Thorough monitoring in the last year showed a decline as some of the outplants were girdled by rats
<b>In Total:</b>		8	0	0	3	48	0	5	38	0	1	0	0	4	38	0		

## Action Area: Out

### TaxonName: *Hesperomannia oahuensis*

Target # of Matures: 75

# MFS PU Met Goal: 0 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Makaha	Manage for stability	13	0	0	3	24	0	3	43	0	3	2	0	0	41	0	2015-06-17	More plants were added to the outplanting site
Napepeiauolelo	Genetic Storage				0	0	0	0	0	0	0	0	0	0	0	0	2013-06-12	The last wild plants died in 2013
North Palawai	Genetic Storage	5	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2012-08-15	The last wild plants died in 2013
Pualii	Manage reintroduction for stability				1	64	0	6	67	0	0	0	0	6	67	0	2015-02-04	More plants were added to the outplanting site
Waianae Kai	Genetic Storage	9	0	1	0	1	0	0	1	0	0	1	0	0	0	0	2014-08-12	Monitoring showed no change
<b>Out Total:</b>		27	0	3	4	89	0	9	111	0	3	3	0	6	108	0		
<b>Total for Taxon:</b>		35	0	3	7	137	0	14	149	0	4	3	0	10	146	0		

# Oahu Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: *Hesperomannia swezeyi*

Target # of Matures: 25

# MFS PU Met Goal: 2 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kamananui to Kaluanui	Manage for stability	54	45	14	134	112	45	134	112	45	134	112	45	0	0	0	2015-07-29	Monitoring showed no change
Kaukonahua	Manage for stability	76	51	122	65	63	52	55	54	2	55	54	2	0	0	0	2015-07-29	Thorough monitoring in the last year showed a decline
Lower Opaepala	Manage for stability	9	15	0	18	9	0	18	21	0	18	21	0	0	0	0	2015-07-21	A thorough census of the known area found more plants
Ohiaai ridge	Genetic Storage	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0		No current monitoring data
Poamoho	Genetic Storage	38	16	3	22	7	3	21	12	5	21	12	5	0	0	0	2015-06-01	Small changes were noted during monitoring in the last year
<b>In Total:</b>		182	128	139	239	191	100	228	199	52	228	199	52	0	0	0		

## Action Area: Out

### TaxonName: *Hesperomannia swezeyi*

Target # of Matures: 25

# MFS PU Met Goal: 2 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Halawa	Genetic Storage	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0		No current monitoring data
Kapakahi	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		No current monitoring data
Niu-Waimanalo Summit Ridge	Genetic Storage	4	0	0	0	0	0	1	4	1	1	4	1	0	0	0	2015-05-29	New plants were reported by OPEPP
Waimano	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		No current monitoring data
<b>Out Total:</b>		8	0	0	0	0	0	1	4	1	1	4	1	0	0	0		
<b>Total for Taxon:</b>		190	128	139	239	191	100	229	203	53	229	203	53	0	0	0		

# Makua Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: Hibiscus brackenridgei subsp. mokuleianus

Target # of Matures: 50

# MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Keaau	Manage for stability				1	26	0	0	16	0	0	16	0	0	0	0	2015-02-25	Fewer plants were observed this last year
Makua	Manage for stability	4	3	0	89	10	0	80	8	0	13	8	0	67	0	0	2015-03-30	Thorough monitoring in the last year showed a small decline
<b>In Total:</b>		4	3	0	90	36	0	80	24	0	13	24	0	67	0	0		

## Action Area: Out

### TaxonName: Hibiscus brackenridgei subsp. mokuleianus

Target # of Matures: 50

# MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Haili to Kawaii	Manage for stability	3	1	0	6	2	0	5	3	2	5	3	2	0	0	0	2015-02-03	Small changes were noted during monitoring in the last year
Manuwai	Manage reintroduction for stability				173	25	0	160	10	0	0	0	0	160	10	0	2015-04-29	Thorough monitoring in the last year showed a decline as some of the outplants died
Waialua	Genetic Storage	4	9	0	49	85	9	49	85	9	49	85	9	0	0	0	2013-04-02	No monitoring in the last year
<b>Out Total:</b>		7	10	0	228	112	9	214	98	11	54	88	11	160	10	0		
<b>Total for Taxon:</b>		11	13	0	318	148	9	294	122	11	67	112	11	227	10	0		

# Makua Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: Kadua degeneri subsp. degeneri

Target # of Matures: 50

# MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kahanahaiki to Pahole	Manage for stability	161	0	0	147	131	23	147	131	23	147	131	23	0	0	0	2012-10-25	The sites were visited, but not thoroughly counted in the last year
Outplanting site to be determined	Manage reintroduction for stability				0	0	0	0	0	0	0	0	0	0	0	0		Outplanting site to be determined
<b>In Total:</b>		161	0	0	147	131	23	147	131	23	147	131	23	0	0	0		

## Action Area: Out

### TaxonName: Kadua degeneri subsp. degeneri

Target # of Matures: 50

# MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Alaiheie and Manuwai	Manage for stability	60	0	0	70	88	2	78	70	2	25	2	2	53	68	0	2015-03-17	Small changes were noted during monitoring in the last year as some of the outplants died
Central Makaleha and West Branch of East Makaleha	Manage for stability	47	0	0	23	13	8	23	13	8	23	13	8	0	0	0	2015-06-03	Monitoring showed no change
East branch of East Makaleha	Genetic Storage	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2010-09-22	No monitoring in the last year
<b>Out Total:</b>		117	0	0	93	101	10	101	83	10	48	15	10	53	68	0		
<b>Total for Taxon:</b>		278	0	0	240	232	33	248	214	33	195	146	33	53	68	0		



# Makua Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: Kadua parvula

Target # of Matures: 50

# MFS PU Met Goal: 2 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Ohikilolo	Manage for stability	66	0	0	100	157	5	100	157	5	100	157	5	0	0	0	2011-06-07	No monitoring in the last year
<b>In Total:</b>		66	0	0	100	157	5	100	157	5	100	157	5	0	0	0		

## Action Area: Out

### TaxonName: Kadua parvula

Target # of Matures: 50

# MFS PU Met Goal: 2 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Halona	Manage for stability	64	0	0	93	28	19	93	28	19	93	28	19	0	0	0	2013-12-03	The sites were visited, but not thoroughly counted in the last year
To be determined (Ekahanui?)	Manage reintroduction for stability				0	0	0	0	0	0	0	0	0	0	0	0		The outplanting has not yet begun
<b>Out Total:</b>		64	0	0	93	28	19	93	28	19	93	28	19	0	0	0		
<b>Total for Taxon:</b>		130	0	0	193	185	24	193	185	24	193	185	24	0	0	0		

# Oahu Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: *Labordia cyrtandrae*

Target # of Matures: 50

# MFS PU Met Goal: 1 of 2

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
East Makaleha to North Mohiakea	Manage for stability	84	16	2	271	69	0	295	40	0	74	0	0	221	40	0	2015-08-05	Many of the outplants were observed to have matured in the last year
<b>In Total:</b>		84	16	2	271	69	0	295	40	0	74	0	0	221	40	0		

## Action Area: Out

### TaxonName: *Labordia cyrtandrae*

Target # of Matures: 50

# MFS PU Met Goal: 1 of 2

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Koloa	Manage reintroduction for stability				23	100	0	33	48	0	0	0	0	33	48	0	2015-03-18	Many of the outplants were observed to have matured in the last year and many more outplants were observed to have died
<b>Out Total:</b>					23	100	0	33	48	0	0	0	0	33	48	0		
<b>Total for Taxon:</b>		84	16	2	294	169	0	328	88	0	74	0	0	254	88	0		

# Makua Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: *Melanthera tenuifolia*

Target # of Matures: 50

# MFS PU Met Goal: 3 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kahanahaiki	Genetic Storage	300	0	0	13	6	0	13	6	0	13	6	0	0	0	0	2011-05-04	No monitoring in the last year
Kaluakauila	Genetic Storage	113	0	0	4	80	0	4	80	0	4	80	0	0	0	0	2011-03-07	No monitoring in the last year
Keawaula	Genetic Storage	20	20	0	60	33	0	60	33	0	60	33	0	0	0	0	2010-05-19	No monitoring in the last year
Ohikilolo	Manage for stability	2008	1	0	1109	8	0	1109	8	0	1109	8	0	0	0	0	2011-06-07	No monitoring in the last year
<b>In Total:</b>		2441	21	0	1186	127	0	1186	127	0	1186	127	0	0	0	0		

## Action Area: Out

### TaxonName: *Melanthera tenuifolia*

Target # of Matures: 50

# MFS PU Met Goal: 3 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kamaileunu and Waianae Kai	Manage for stability	880	0	0	815	246	274	815	246	274	815	246	274	0	0	0	2010-04-28	No monitoring in the last year
Mt. Kaala NAR	Manage for stability	250	0	0	70	0	0	121	4	0	121	4	0	0	0	0	2015-06-17	Population counts are currently being updated
<b>Out Total:</b>		1130	0	0	885	246	274	936	250	274	936	250	274	0	0	0		
<b>Total for Taxon:</b>		3571	21	0	2071	373	274	2122	377	274	2122	377	274	0	0	0		

# Makua Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: *Neraudia angulata*

Target # of Matures: 100

# MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kaluakauila	Manage reintroduction for stability				65	69	0	65	69	0	0	0	0	65	69	0	2013-05-21	The sites were visited, but not thoroughly counted in the last year
Kapuna	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2014-07-24	No monitoring in the last year
Makua	Manage for stability	29	0	22	120	6	0	120	6	0	25	4	0	95	2	0	2014-09-02	No monitoring in the last year
Punapohaku	Genetic Storage				4	0	0	4	0	0	4	0	0	0	0	0	2014-04-30	No monitoring in the last year
<b>In Total:</b>		30	0	22	189	75	0	189	75	0	29	4	0	160	71	0		

## Action Area: Out

### TaxonName: *Neraudia angulata*

Target # of Matures: 100

# MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Halona	Genetic Storage	15	0	0	30	4	0	32	5	0	32	5	0	0	0	0	2015-04-14	Small changes were noted during monitoring in the last year
Leeward Puu Kaua	Genetic Storage	3	0	0	9	0	0	9	0	0	9	0	0	0	0	0	2006-11-21	No monitoring in the last year
Makaha	Manage for stability (backup site)	56	14	0	5	2	0	52	13	0	3	8	0	49	5	0	2015-06-16	Plants were added to the new outplanting site
Manuwai	Manage for stability	12	0	0	88	0	0	115	84	0	0	2	0	115	82	0	2015-04-30	More plants were added to the outplanting site
Waianae Kai Makai	Genetic Storage	4	0	0	13	0	0	13	0	0	13	0	0	0	0	0	2013-11-25	The sites were visited, but not thoroughly counted in the last year
Waianae Kai Mauka	Manage for stability	21	25	0	16	3	0	13	3	0	7	2	0	6	1	0	2015-05-26	Thorough monitoring in the last year showed a decline in both outplanted and wild plants
<b>Out Total:</b>		111	39	0	161	9	0	234	105	0	64	17	0	170	88	0		

# Makua Implementation Plan - Population Unit Status

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Total for Taxon:	141	39	22	350	84	0	423	180	0	93	21	0	330	159	0
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# Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: *Nototrichium humile*

Target # of Matures: 25

# MFS PU Met Goal: 4 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kahanahaiki	Genetic Storage	140	0	0	91	4	1	50	2	1	50	2	1	0	0	0	2015-08-26	Thorough monitoring in the last year showed a decline
Kaluakauila	Manage for stability	200	0	0	132	27	0	160	48	0	160	48	0	0	0	0	2014-08-06	No monitoring in the last year
Keaau	Genetic Storage	21	31	0	21	31	0	21	31	0	21	31	0	0	0	0	2004-08-30	No monitoring in the last year
Keawaula	Genetic Storage	200	30	0	35	6	0	35	6	0	35	6	0	0	0	0	2010-05-19	No monitoring in the last year
Makua (East rim)	Genetic Storage	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	1997-01-01	No monitoring in the last year
Makua (south side)	Manage for stability	120	18	0	50	3	0	50	3	0	43	3	0	7	0	0	2013-07-11	No monitoring in the last year
Punapohaku	Genetic Storage	152	14	0	178	77	0	178	77	0	178	77	0	0	0	0	2013-10-08	No monitoring in the last year
<b>In Total:</b>		834	93	0	508	148	1	495	167	1	488	167	1	7	0	0		

# Makua Implementation Plan - Population Unit Status

Action Area: Out

TaxonName: *Nototrichium humile*

Target # of Matures: 25

# MFS PU Met Goal: 4 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kaimuhole and Palikea Gulch	Genetic Storage	48	6	0	29	1	0	29	1	0	29	1	0	0	0	0	2013-09-26	No monitoring in the last year
Keawapilau	Genetic Storage	9	1	0	1	0	0	1	0	0	1	0	0	0	0	0	2013-04-17	No monitoring in the last year
Kolekole	Genetic Storage	13	0	0	12	0	0	12	0	0	12	0	0	0	0	0	2005-01-01	No monitoring in the last year
Makaha	Genetic Storage	159	0	0	22	5	0	22	5	0	22	5	0	0	0	0	2010-03-02	No monitoring in the last year
Manuwai	Manage reintroduction for stability				119	0	0	115	0	0	0	0	0	115	0	0	2015-03-25	Small changes were noted during monitoring in the last year as a few of the outplants died
Nanakuli	Genetic Storage	5	0	0	5	0	0	5	0	0	5	0	0	0	0	0	2005-01-01	No monitoring in the last year
Puu Kaua (Leeward side)	Genetic Storage	12	0	0	2	0	0	2	0	0	2	0	0	0	0	0	2006-11-21	No monitoring in the last year
Waianaean Kai	Manage for stability	200	0	0	216	54	0	216	54	0	216	54	0	0	0	0	2014-08-18	No monitoring in the last year
<b>Out Total:</b>		446	7	0	406	60	0	402	60	0	287	60	0	115	0	0		
<b>Total for Taxon:</b>		1280	100	0	914	208	1	897	227	1	775	227	1	122	0	0		

# Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: *Phyllostegia hirsuta*

Target # of Matures: 100

# MFS PU Met Goal: 1 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Haleauau to Mohiakea	Manage for stability	6	12	0	91	41	0	71	76	0	11	2	0	60	74	0	2015-05-05	More plants were added to the outplanting site
Helemano and Opaepala	Genetic Storage	14	5	6	1	4	0	1	4	0	1	4	0	0	0	0	2013-11-20	No monitoring in the last year
Helemano to Poamoho	Genetic Storage	1	0	0	1	0	0	2	0	0	2	0	0	0	0	0	2014-12-03	A new plant was discovered during surveys
Kaipapau and Kawainui	Genetic Storage	7	0	0	4	0	0	4	0	0	4	0	0	0	0	0	2013-12-17	No monitoring in the last year
Kaukonahua	Genetic Storage	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2010-07-28	No monitoring in the last year
Kawaiiki	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2008-10-09	No monitoring in the last year
Koloa	Manage for stability	0	0	0	25	104	4	97	123	1	6	3	1	91	120	0	2015-05-13	More plants were added to the outplanting site
<b>In Total:</b>		32	19	6	122	149	4	175	203	1	24	9	1	151	194	0		



# Oahu Implementation Plan - Population Unit Status

Action Area: Out

TaxonName: *Phyllostegia hirsuta*

Target # of Matures: 100

# MFS PU Met Goal: 1 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Hapapa to Kaluaa	Genetic Storage	11	9	7	2	10	0	2	10	0	2	10	0	0	0	0	2014-06-03	No monitoring in the last year
Kaluanui and Punaluu	Genetic Storage	5	0	0	5	3	0	5	3	0	5	3	0	0	0	0	2011-05-17	No monitoring in the last year
Makaha-Waianae Kai Ridge	Genetic Storage	2	0	0	1	0	0	1	0	0	1	0	0	0	0	0	2013-08-27	No monitoring in the last year
Palawai	Genetic Storage	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2009-03-03	No monitoring in the last year
Puu Palikea	Manage reintroduction for stability				101	103	0	114	127	0	0	0	0	114	127	0	2015-03-09	More plants were added to the outplanting site
Waiamano	Genetic Storage				1	0	0	1	0	0	1	0	0	0	0	0	2006-01-01	No monitoring in the last year
<b>Out Total:</b>		18	10	7	110	116	0	123	140	0	9	13	0	114	127	0		
<b>Total for Taxon:</b>		50	29	13	232	265	4	298	343	1	33	22	1	265	321	0		

# Makua Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: *Phyllostegia kaalaensis*

Target # of Matures: 50

# MFS PU Met Goal: 0 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Keawapilau to Kapuna	Manage reintroduction for stability	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2010-08-02	No plants remaining
Pahole	Manage reintroduction for stability	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2010-08-10	No plants remaining
Palikea Gulch	Genetic Storage	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2004-09-01	No plants remaining
<b>In Total:</b>		20	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

## Action Area: Out

### TaxonName: *Phyllostegia kaalaensis*

Target # of Matures: 50

# MFS PU Met Goal: 0 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Makaha	Manage reintroduction for stability	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2015-01-01	No plants remaining
Manuwai	Manage reintroduction for stability	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	2015-03-18	No plants remaining
Waianae Kai	Genetic Storage	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2004-01-01	No plants remaining
<b>Out Total:</b>		6	2	0	0	6	0	0	0	0	0	0	0	0	0	0		
<b>Total for Taxon:</b>		26	2	0	0	6	0	0	0	0	0	0	0	0	0	0		

# Oahu Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: *Phyllostegia mollis*

Target # of Matures: 100

# MFS PU Met Goal: 0 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Mohiakea	Genetic Storage	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	2015-06-23	The wild plants died in the last year
<b>In Total:</b>		0	4	0	0	0	0	0	0	0	0	0	0	0	0	0		

## Action Area: Out

### TaxonName: *Phyllostegia mollis*

Target # of Matures: 100

# MFS PU Met Goal: 0 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Ekahanui	Manage for stability	35	0	0	76	0	0	11	1	0	0	0	0	11	1	0	2015-03-11	Many of the outplants were observed to have died in the last year
Kaluaa	Manage for stability	38	11	0	132	59	0	88	42	0	0	0	0	88	42	0	2015-05-14	Many of the outplants were observed to have died in the last year
Pualii	Manage reintroduction for stability	0	0	0	33	0	0	11	0	0	0	0	0	11	0	0	2015-05-06	Many of the outplants were observed to have died in the last year
Waieli	Genetic Storage	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	2012-12-04	No current monitoring data
<b>Out Total:</b>		73	11	0	242	59	0	111	43	0	1	0	0	110	43	0		
<b>Total for Taxon:</b>		73	15	0	242	59	0	111	43	0	1	0	0	110	43	0		

# Makua Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: *Plantago princeps* var. *princeps*

Target # of Matures: 50

# MFS PU Met Goal: 0 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
North Mohiakea	Manage for stability	20	10	0	39	12	0	39	12	0	39	12	0	0	0	0	2013-05-21	No monitoring in the last year
Ohikilolo	Manage for stability	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2014-03-20	No monitoring in the last year
Pahole	Genetic Storage	12	0	0	2	1	0	2	2	0	2	2	0	0	0	0	2015-04-30	No monitoring in the last year
<b>In Total:</b>		46	10	0	41	13	0	41	14	0	41	14	0	0	0	0		

## Action Area: Out

### TaxonName: *Plantago princeps* var. *princeps*

Target # of Matures: 50

# MFS PU Met Goal: 0 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Ekahanui	Manage for stability	16	17	0	46	158	0	48	191	0	46	122	0	2	69	0	2015-05-11	A few more plants were observed in the known sites
Halona	Manage for stability	50	0	0	10	1	0	10	1	0	10	1	0	0	0	0	2012-05-03	No monitoring in the last year
North Palawai	Genetic Storage	32	0	0	1	2	0	5	1	0	5	1	0	0	0	0	2014-11-24	A few more plants were observed in the known sites
Waieli	Manage reintroduction for storage				12	30	0	12	30	0	0	0	0	12	30	0	2014-04-14	No monitoring in the last year
<b>Out Total:</b>		98	17	0	69	191	0	75	223	0	61	124	0	14	99	0		
<b>Total for Taxon:</b>		144	27	0	110	204	0	116	237	0	102	138	0	14	99	0		

# Makua Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: Pritchardia kaalae

Target # of Matures: 25

# MFS PU Met Goal: 2 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Ohikilolo	Manage for stability	65	408	0	85	1590	0	85	1590	0	72	1178	0	13	412	0	2014-04-23	No monitoring in the last year
Ohikilolo East and West Makaleha	Manage reintroduction for stability	0	75	0	4	330	0	4	330	0	0	0	0	4	330	0	2014-06-23	No monitoring in the last year
<b>In Total:</b>		65	483	0	89	1920	0	89	1920	0	72	1178	0	17	742	0		

## Action Area: Out

### TaxonName: Pritchardia kaalae

Target # of Matures: 25

# MFS PU Met Goal: 2 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Makaha	Genetic Storage	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	2014-09-17	No monitoring in the last year
Makaleha to Manuwai	Manage for stability	138	3	0	123	13	0	122	13	0	122	13	0	0	0	0	2015-06-08	Small changes were noted during monitoring in the last year
Waianae Kai	Genetic Storage	7	2	0	4	5	0	4	5	0	4	5	0	0	0	0	2002-06-12	No monitoring in the last year
<b>Out Total:</b>		146	5	0	128	18	0	127	18	0	127	18	0	0	0	0		
<b>Total for Taxon:</b>		211	488	0	217	1938	0	216	1938	0	199	1196	0	17	742	0		

# Makua Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: Sanicula mariverosa

Target # of Matures: 100

# MFS PU Met Goal: 0 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Keaau	Manage for stability	16	125	0	0	43	0	0	43	0	0	43	0	0	0	0	2014-04-22	No monitoring in the last year
Ohikilolo	Manage for stability	34	128	0	0	30	200	0	216	200	0	30	200	0	186	0	2015-02-12	Plants were added to the new outplanting site
<b>In Total:</b>		50	253	0	0	73	200	0	259	200	0	73	200	0	186	0		

## Action Area: Out

### TaxonName: Sanicula mariverosa

Target # of Matures: 100

# MFS PU Met Goal: 0 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kamaileunu	Manage for stability	26	0	0	1	360	14	5	408	135	5	408	135	0	0	0	2015-03-18	A thorough census of the known area found more plants
Puu Kawiwi	Genetic Storage	2	0	0	0	8	0	0	8	0	0	8	0	0	0	0	2014-04-28	No monitoring in the last year
<b>Out Total:</b>		28	0	0	1	368	14	5	416	135	5	416	135	0	0	0		
<b>Total for Taxon:</b>		78	253	0	1	441	214	5	675	335	5	489	335	0	186	0		

# Makua Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: *Schiedea kaalae*

Target # of Matures: 50

# MFS PU Met Goal: 3 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Pahole	Manage for stability	3	0	0	106	26	200	83	145	47	2	0	0	81	145	47	2015-04-06	Many of the outplants died, but new immature plants are becoming established and seedlings are still present
<b>In Total:</b>		3	0	0	106	26	200	83	145	47	2	0	0	81	145	47		

## Action Area: Out

### TaxonName: *Schiedea kaalae*

Target # of Matures: 50

# MFS PU Met Goal: 3 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kahana	Genetic Storage	0	0	0	8	0	2	8	0	2	5	0	1	3	0	1	2012-08-09	No monitoring in the last year
Kaluaa and Waieli	Manage for stability	2	53	0	198	8	0	166	5	0	0	0	0	166	5	0	2015-01-22	Thorough monitoring in the last year showed a decline as many of the outplants died
Maakua (Koolaus)	Manage for stability	4	0	0	10	0	0	10	0	0	10	0	0	0	0	0	2008-07-02	The sites were visited, but not thoroughly counted in the last year
Makaua (Koolaus)	Genetic Storage	2	0	0	85	0	0	85	0	0	1	0	0	84	0	0	2012-02-29	No monitoring in the last year
North Palawai	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2011-04-18	No monitoring in the last year
South Ekahanui	Manage for stability	10	75	0	160	268	12	160	268	12	9	2	0	151	266	12	2015-04-15	The sites were visited, but not thoroughly counted in the last year
<b>Out Total:</b>		19	128	0	461	276	14	429	273	14	25	2	1	404	271	13		
<b>Total for Taxon:</b>		22	128	0	567	302	214	512	418	61	27	2	1	485	416	60		

# Makua Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: *Schiedea nuttallii*

Target # of Matures: 50

# MFS PU Met Goal: 3 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kahanahaiki to Pahole	Manage for stability	48	17	0	113	113	58	108	112	58	6	0	0	102	112	58	2015-04-06	Small changes were noted during monitoring in the last year
Kapuna-Keawapilau Ridge	Manage for stability	3	1	0	98	15	0	74	0	0	0	0	0	74	0	0	2015-04-21	Thorough monitoring in the last year showed a decline as more of the outplants died. Several were predated by rodents in the last year
<b>In Total:</b>		51	18	0	211	128	58	182	112	58	6	0	0	176	112	58		

## Action Area: Out

### TaxonName: *Schiedea nuttallii*

Target # of Matures: 50

# MFS PU Met Goal: 3 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Makaha	Manage reintroduction for stability	0	0	0	57	0	0	68	43	0	0	0	0	68	43	0	2015-05-12	More plants were added to the outplanting site though many were injured by rodents
<b>Out Total:</b>		0	0	0	57	0	0	68	43	0	0	0	0	68	43	0		
<b>Total for Taxon:</b>		51	18	0	268	128	58	250	155	58	6	0	0	244	155	58		



# Makua Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: Schiedea obovata

Target # of Matures: 100

# MFS PU Met Goal: 2 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kahanahaiki to Pahole	Manage for stability	65	25	0	232	1729	2729	283	1028	210	0	0	0	283	1028	210	2015-09-02	Small changes were noted during monitoring in the last year and fewer seedlings were observed
Keawapilau to West Makaleha	Manage for stability	24	12	0	72	1347	2160	58	526	67	12	524	67	46	2	0	2015-06-22	Thorough monitoring in the last year showed a decline from the previous year
<b>In Total:</b>		89	37	0	304	3076	4889	341	1554	277	12	524	67	329	1030	210		

## Action Area: Out

### TaxonName: Schiedea obovata

Target # of Matures: 100

# MFS PU Met Goal: 2 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Makaha	Manage reintroduction for stability	0	0	0	104	122	0	146	52	13	0	0	0	146	52	13	2015-05-12	Many of the outplants were observed to have matured in the last year and seedlings were observed at this outplanting site
<b>Out Total:</b>		0	0	0	104	122	0	146	52	13	0	0	0	146	52	13		
<b>Total for Taxon:</b>		89	37	0	408	3198	4889	487	1606	290	12	524	67	475	1082	223		

# Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: *Schiedea trinervis*

Target # of Matures: 50

# MFS PU Met Goal: 1 of 1

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kalena to East Makaleha	Manage for stability	180	196	318	352	270	333	296	351	377	296	351	377	0	0	0	2015-08-04	Population counts were revised after updating old observations and finding a few new sites
<b>In Total:</b>		180	196	318	352	270	333	296	351	377	296	351	377	0	0	0		
<b>Total for Taxon:</b>		180	196	318	352	270	333	296	351	377	296	351	377	0	0	0		

# Oahu Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: Stenogyne kanehoana

Target # of Matures: 100

# MFS PU Met Goal: 0 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Haleauau	Manage reintroduction for stability	1	0	0	0	0	0	0	129	0	0	0	0	0	129	0	2015-08-26	Plants were added to the new outplanting site
<b>In Total:</b>		1	0	0	0	0	0	0	129	0	0	0	0	0	129	0		

## Action Area: Out

### TaxonName: Stenogyne kanehoana

Target # of Matures: 100

# MFS PU Met Goal: 0 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kaluaa	Manage reintroduction for stability	0	79	0	28	194	0	26	178	0	0	0	0	26	178	0	2015-03-23	Thorough monitoring in the last year showed a decline
Makaha	Manage reintroduction for stability				0	156	0	0	130	0	0	0	0	0	130	0	2015-06-03	Thorough monitoring in the last year showed a decline as some of the outplants were observed to have died
<b>Out Total:</b>		0	79	0	28	350	0	26	308	0	0	0	0	26	308	0		
<b>Total for Taxon:</b>		1	79	0	28	350	0	26	437	0	0	0	0	26	437	0		

# Makua Implementation Plan - Population Unit Status

## Action Area: In

### TaxonName: Tetramolopium filiforme

Target # of Matures: 50

# MFS PU Met Goal: 1 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kahanahaiki	Genetic Storage	50	0	0	40	0	0	40	0	0	40	0	0	0	0	0	2006-10-04	The sites were visited, but not thoroughly counted in the last year
Kalena	Manage for stability				24	93	0	24	93	0	24	93	0	0	0	0	2013-05-21	No monitoring in the last year
Keaau	Genetic Storage	25	0	0	30	41	17	30	41	17	30	41	17	0	0	0	2005-11-07	No monitoring in the last year
Makaha/Ohikilolo Ridge	Genetic Storage				300	0	0	300	0	0	300	0	0	0	0	0	1998-01-01	No monitoring in the last year
Ohikilolo	Manage for stability	2500	0	0	2394	1464	20	2394	1464	20	2394	1464	20	0	0	0	2014-07-23	The sites were visited, but not thoroughly counted in the last year
Puhawai	Manage for stability	6	6	0	10	75	3	21	9	2	0	0	0	21	9	2	2015-06-24	Small changes were noted during monitoring in the last year and several of the new plants matured. Most outplants are now dead at this site, but seedlings are still observed
<b>In Total:</b>		2581	6	0	2798	1673	40	2809	1607	39	2788	1598	37	21	9	2		

## Action Area: Out

### TaxonName: Tetramolopium filiforme

Target # of Matures: 50

# MFS PU Met Goal: 1 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Waianae Kai	Manage for stability	20	2	0	30	8	1	20	0	0	20	0	0	0	0	0	2015-06-24	Thorough monitoring in the last year showed a decline
<b>Out Total:</b>		20	2	0	30	8	1	20	0	0	20	0	0	0	0	0		
<b>Total for Taxon:</b>		2601	8	0	2828	1681	41	2829	1607	39	2808	1598	37	21	9	2		

# Makua Implementation Plan - Population Unit Status

## Action Area: In

**TaxonName: Viola chamissoniana subsp. chamissoniana**

Target # of Matures: 50

# MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Keaau	Genetic Storage	40	10	0	40	10	0	40	10	0	40	10	0	0	0	0	2002-06-04	No monitoring in the last year
Makaha/Ohikilolo Ridge	Genetic Storage	250	0	0	7	0	0	7	0	0	7	0	0	0	0	0	2000-04-24	No monitoring in the last year
Ohikilolo	Manage for stability				386	25	1	386	25	1	386	25	1	0	0	0	2013-09-04	No monitoring in the last year
Puu Kumakalii	Manage for stability	19	1	0	44	0	0	44	0	0	44	0	0	0	0	0	2004-10-21	The sites were visited, but not thoroughly counted in the last year
<b>In Total:</b>		309	11	0	477	35	1	477	35	1	477	35	1	0	0	0		

## Action Area: Out

**TaxonName: Viola chamissoniana subsp. chamissoniana**

Target # of Matures: 50

# MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Halona	Manage for stability	3	0	0	41	3	0	22	5	0	22	5	0	0	0	0	2013-12-03	No monitoring in the last year
Kamaileunu	Genetic Storage	38	0	0	35	0	0	35	0	0	35	0	0	0	0	0	2000-05-23	No monitoring in the last year
Makaha	Manage for stability	50	0	0	68	11	0	68	11	0	68	11	0	0	0	0	2014-05-14	No monitoring in the last year
Makaleha	Genetic Storage				34	1	0	18	9	0	18	9	0	0	0	0	2015-06-03	Thorough monitoring in the last year showed a decline
Puu Hapapa	Genetic Storage	10	3	0	7	2	0	7	2	0	7	2	0	0	0	0	2013-12-05	No monitoring in the last year
<b>Out Total:</b>		101	3	0	185	17	0	150	27	0	150	27	0	0	0	0		
<b>Total for Taxon:</b>		410	14	0	662	52	1	627	62	1	627	62	1	0	0	0		

## Threat Control Summary

### Action Area: In

#### TaxonName: *Abutilon sandwicense*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kaawa to Puulu	Manage for stability	32	Partial 59%	Partial 0%	No	No	Partial 100%
Kahanahaiki	Manage reintroduction for stability	72	Yes	Partial 100%	No	No	No
Kaluakauila	Manage reintroduction for storage	0	Yes	No	No	No	No
Keaau	Genetic Storage	1	No	No	No	No	No

### Action Area: Out

#### TaxonName: *Abutilon sandwicense*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
East Makaleha	Genetic Storage	0	No	No	No	No	No
Ekahanui and Huliwai	Manage for stability	46	Yes	Partial 93%	No	No	No
Makaha Makai	Manage for stability	92	Partial 75%	No	No	No	No
Makaha Mauka	Genetic Storage	13	No	No	No	No	No
North Mikilua	Genetic Storage	9	Yes	No	No	No	No
Waianae Kai	Genetic Storage	0	Partial	No	No	No	Partial
West Makaleha	Genetic Storage	0	No	No	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: *Alectryon macrococcus* var. *macrococcus*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki to Keawapilau	Manage for stability	1	Yes	Partial 0%	Partial 0%	No	No
Makua	Manage for stability	11	Partial 100%	No	No	No	No
South Mohiakea	Genetic Storage	2	Yes	No	No	No	No
West Makaleha	Genetic Storage	13	No	No	No	No	No

### Action Area: Out

#### TaxonName: *Alectryon macrococcus* var. *macrococcus*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Central Kaluaa to Central Waielei	Manage for stability	3	Partial 0%	Partial 0%	No	No	No
Makaha	Manage for stability	36	Yes	Partial 97%	No	No	No
Waianae Kai	Genetic Storage	1	No	No	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: *Cenchrus agrimonioides* var. *agrimonioides*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki and Pahole	Manage for stability	319	Yes	Partial 2%	Partial 37%	No	No
Kuaokala	Genetic Storage	1	No	No	No	No	No

### Action Area: Out

#### TaxonName: *Cenchrus agrimonioides* var. *agrimonioides*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Central Ekahanui	Manage for stability	168	Yes	No	Yes	No	No
Makaha and Waianae Kai	Manage for stability	171	Partial 97%	Partial 96%	No	No	No
South Huliwai	Genetic Storage	15	No	No	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants



## Threat Control Summary

### Action Area: In

#### TaxonName: *Cyanea acuminata*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Helemano-Punaluu Summit Ridge to North Kaukonahua	Manage for stability	130	No	No	No	No	No
Kahana and South Kaukonahua	Genetic Storage	2	No	No	No	No	No
Makaleha to Mohiakea	Manage for stability	151	Partial 97%	Partial 2%	No	No	No

### Action Area: Out

#### TaxonName: *Cyanea acuminata*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahana and Makaua	Genetic Storage	11	No	No	No	No	No
Kaipapau and Koloa	Genetic Storage	70	Partial 0%	No	No	No	No
Kaluanui and Maakua	Manage for stability	123	No	No	No	No	No
Puukeahiakahoe	Genetic Storage	3	No	No	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: *Cyanea grimesiana* subsp. *obatae*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Pahole to West Makaleha	Manage for stability	75	Yes	Partial 65%	Partial 35%	Partial 35%	No

### Action Area: Out

#### TaxonName: *Cyanea grimesiana* subsp. *obatae*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kaluaa	Manage for stability	128	Yes	Partial 100%	No	No	No
Makaha	Genetic Storage	4	Yes	No	Yes	Yes	No
North branch of South Ekahanui	Manage reintroduction for stability	83	Yes	Partial 100%	Yes	Yes	No
Paliikea (South Palawai)	Manage for stability	108	Yes	Yes	Yes	Yes	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: *Cyanea koolauensis*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kaipapau, Koloa and Kawaiui	Manage for stability	106	Partial 84%	Partial 2%	No	No	No
Kamananui-Kawainui Ridge	Genetic Storage	6	No	No	No	No	No
Kaukonahua	Genetic Storage	8	No	No	No	No	No
Kawaiiki	Genetic Storage	4	No	No	No	No	No
Lower Opaepala	Genetic Storage	1	No	No	No	No	No
Opaepala to Helemano	Manage for stability	23	Partial 48%	Partial 9%	No	No	No
Poamoho	Manage for stability	21	No	No	No	No	No

### Action Area: Out

#### TaxonName: *Cyanea koolauensis*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Halawa	Genetic Storage	4	No	No	No	No	No
Waialae Nui	Genetic Storage	2	No	No	No	No	No
Waiawa to Waimano	Genetic Storage	11	Partial 45%	No	No	No	No
Wailupe	Genetic Storage	1	No	No	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: *Cyanea longiflora*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kapuna to West Makaleha	Manage for stability	28	Yes	Partial 57%	No	Partial 18%	No
Pahole	Manage for stability	58	Yes	No	No	No	No

### Action Area: Out

#### TaxonName: *Cyanea longiflora*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Makaha and Waianae Kai	Manage for stability	110	Yes	Partial 100%	Partial 100%	Yes	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: *Cyanea superba* subsp. *superba*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki	Manage reintroduction for stability	58	Yes	Partial 78%	Yes	Partial 45%	No
Pahole to Kapuna	Manage reintroduction for stability	95	Yes	Partial 71%	Partial 60%	No	No

### Action Area: Out

#### TaxonName: *Cyanea superba* subsp. *superba*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Makaha	Manage reintroduction for stability	27	Yes	No	Yes	No	No
Manuwai	Manage reintroduction for stability	0	Yes	Yes	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

# Threat Control Summary

## Action Area: In


### TaxonName: *Cyrtandra dentata*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki	Manage for stability	37	Yes	Yes	Yes	No	No
Kawaiiki (Koolaus)	Manage for stability	5	No	No	No	No	No
Opaeula (Koolaus)	Manage for stability	23	Partial 100%	No	No	No	No
Pahole to West Makaleha	Manage for stability	603	Partial 96%	No	No	No	No

## Action Area: Out

### TaxonName: *Cyrtandra dentata*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Central Makaleha	Genetic Storage	3	No	No	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: *Delissea waianaensis*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki to Keawapilau	Manage for stability	240	Yes	Partial 98%	Partial 12%	No	No
Kaluakauila	Manage reintroduction for storage	15	Yes	No	No	No	No
Kapuna	Manage reintroduction for storage	113	Yes	No	No	No	No
Palikea Gulch	Genetic Storage	1	No	No	No	No	Partial 100%
South Mohiakea	Genetic Storage	12	Yes	Yes	No	No	No

### Action Area: Out

#### TaxonName: *Delissea waianaensis*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Ekahanui	Manage for stability	196	Yes	Partial 99%	Yes	Partial 99%	No
Kaluaa	Manage for stability	650	Yes	Partial 99%	No	Partial 55%	No
Kealia	Genetic Storage	4	No	No	No	No	No
Manuwai	Manage reintroduction for stability	88	Yes	Yes	Yes	No	No
Palawai	Genetic Storage	17	Partial 94%	No	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: *Dubautia herbstobatae*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Keaau	Genetic Storage	70	No	No	No	No	No
Makaha/Ohikilolo	Genetic Storage	350	No	No	No	No	No
Ohikilolo Makai	Manage for stability	89	Yes	No	No	No	No
Ohikilolo Mauka	Manage for stability	415	Yes	No	No	No	No

### Action Area: Out

#### TaxonName: *Dubautia herbstobatae*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kamaileunu	Genetic Storage	0	No	No	No	No	No
Makaha	Manage for stability	28	No	No	No	No	No
Waianae Kai	Genetic Storage	10	No	No	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants



## Threat Control Summary

### Action Area: In

#### TaxonName: *Eugenia koolauensis*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Aimuu	Genetic Storage	8	No	No	No	No	No
Kaiwikoele and Kamananui	Genetic Storage	21	Partial 0%	No	No	No	No
Kaleleiki	Genetic Storage	14	Partial 50%	No	No	No	No
Kaunala	Manage for stability	20	Partial 95%	Partial 95%	No	No	No
Malaekahana	Genetic Storage	5	No	No	No	No	No
Ohiaai and East Oio	Genetic Storage	1	No	No	No	No	No
Oio	Manage for stability	5	Yes	No	No	No	No
Pahipahialua	Manage for stability	22	Yes	No	No	No	No

### Action Area: Out

#### TaxonName: *Eugenia koolauensis*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Hanaimoa	Genetic Storage	1	No	No	No	No	No
Palikea and Kaimuhole	Genetic Storage	1	No	No	No	No	Partial 100%

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: Euphorbia celastroides var. kaenana

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
East Kahanahaiki	Genetic Storage	2	No	No	No	No	No
Kaluakauila	Genetic Storage	11	No	No	No	No	No
Makua	Manage for stability	85	Yes	Yes	No	No	Partial 100%
North Kahanahaiki	Genetic Storage	115	No	No	No	No	No
Puaakanoa	Manage for stability	150	No	No	No	No	No

### Action Area: Out

#### TaxonName: Euphorbia celastroides var. kaenana

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
East of Alau	Manage for stability	21	No	No	No	No	No
Kaena	Manage for stability	579	No	No	No	No	No
Keawaula	Genetic Storage	43	No	No	No	No	No
Waianae Kai	Genetic Storage	34	No	No	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: Euphorbia herbstii

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kapuna to Pahole	Manage for stability	56	Yes	Partial 96%	No	No	No
Manuwai	Manage reintroduction for stability	0	Yes	No	No	No	No

### Action Area: Out

#### TaxonName: Euphorbia herbstii

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kaluaa	Manage reintroduction for stability	0	Yes	No	No	No	No
Makaha	Manage reintroduction for storage	4	Yes	No	Yes	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: Flueggea neowawraea

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki to Kapuna	Manage for stability	6	Yes	Partial 0%	Partial 17%	No	No
Ohikilolo	Manage for stability	1	Yes	No	No	No	No
West Makaleha	Genetic Storage	6	No	No	No	No	No

### Action Area: Out

#### TaxonName: Flueggea neowawraea

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Central and East Makaleha	Genetic Storage	5	No	No	No	No	No
Halona	Genetic Storage	1	No	No	No	No	No
Kauhiuhi	Genetic Storage	1	No	No	No	No	No
Makaha	Manage for stability	10	Partial 40%	Partial 0%	No	No	No
Manuwai	Manage reintroduction for stability	0	Yes	Yes	No	No	No
Mikilua	Genetic Storage	0	Yes	No	No	No	No
Mt. Kaala NAR	Genetic Storage	3	No	No	No	No	No
Nanakuli, south branch	Genetic Storage	1	No	No	No	No	No
Waianae Kai	Genetic Storage	1	No	No	No	No	No

█ = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: Gardenia mannii

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Haleauau	Manage for stability	69	Partial 100%	Partial 87%	No	No	No
Helemano and Poamoho	Manage for stability	17	No	No	No	No	No
Kaiwikoele, Kamananui, and Kawaiui	Genetic Storage	13	No	No	No	No	No
Lower Peahinaia	Manage for stability	9	Partial 67%	Partial 56%	No	No	No
South Kaukonahua	Genetic Storage	1	No	No	No	No	No
Upper Opaepala/Helemano	Genetic Storage	1	Yes	No	No	No	No

### Action Area: Out

#### TaxonName: Gardenia mannii

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Ihiihi-Kawainui ridge	Genetic Storage	2	No	No	No	No	No
Kaluaa and Maunauna	Genetic Storage	2	No	No	No	No	No
Kamananui-Malaekahana Summit Ridge	Genetic Storage	3	No	No	No	No	No
Kapakahi	Genetic Storage	2	No	No	No	No	No
Pukele	Genetic Storage	1	No	No	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: *Gouania vitifolia*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Keaau	Manage for stability	55	No	No	No	No	No

### Action Area: Out

#### TaxonName: *Gouania vitifolia*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
<b>Makaha (Future Introduction)</b>	Manage reintroduction for stability	0	Yes	No	No	No	No
<b>Manuwai (Future Introduction)</b>	Manage reintroduction for stability	0	Yes	No	No	No	No
<b>Waianae Kai</b>	Genetic Storage	3	Yes	No	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: *Hesperomannia oahuensis*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Haleauau	Manage for stability	1	Yes	No	Yes	No	No
Pahole NAR	Manage reintroduction for stability	4	Yes	Yes	Yes	No	No

### Action Area: Out

#### TaxonName: *Hesperomannia oahuensis*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Makaha	Manage for stability	3	Yes	Partial 0%	Yes	Partial 0%	No
Napepeiauolelo	Genetic Storage	0	Yes	No	No	No	No
North Palawai	Genetic Storage	0	Yes	No	No	No	No
Pualii	Manage reintroduction for stability	6	Yes	Yes	Yes	No	No
Waianae Kai	Genetic Storage	0	Yes	No	Yes	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: *Hesperomannia swezeyi*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kamananui to Kaluanui	Manage for stability	134	Partial 4%	No	No	No	No
Kaukonahua	Manage for stability	55	No	No	No	No	No
Lower Opaepala	Manage for stability	18	No	No	No	No	No
Poamoho	Genetic Storage	21	No	No	No	No	No

### Action Area: Out

#### TaxonName: *Hesperomannia swezeyi*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Niu-Waimanalo Summit	Genetic Storage	1	No	No	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants



## Threat Control Summary

### Action Area: In


#### TaxonName: Hibiscus brackenridgei subsp. mokuleianus

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Keaau	Manage for stability	0	Yes	No	No	No	No
Makua	Manage for stability	80	Yes	Yes	No	No	Partial 100%

### Action Area: Out

#### TaxonName: Hibiscus brackenridgei subsp. mokuleianus

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Haili to Kawaii	Manage for stability	5	No	No	No	No	No
Manuwai	Manage reintroduction for stability	160	Yes	Yes	No	No	No
Waialua	Genetic Storage	49	Partial 37%	No	No	No	Partial 100%

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: Kadua degeneri subsp. degeneri

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki to Pahole	Manage for stability	147	Yes	No	No	No	No

### Action Area: Out

#### TaxonName: Kadua degeneri subsp. degeneri

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Alaiheihe and Manuwai	Manage for stability	78	Partial 95%	Partial 51%	No	No	No
Central Makaleha and West Branch of East Makaleha	Manage for stability	23	No	No	No	No	No
East branch of East Makaleha	Genetic Storage	0	No	No	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: Kadua parvula

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Ohikilolo	Manage for stability	100	Yes	No	No	No	No

### Action Area: Out

#### TaxonName: Kadua parvula

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Halona	Manage for stability	93	No	No	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

# Threat Control Summary

## Action Area: In

### TaxonName: Labordia cyrtandrae

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
East Makaleha to North Mohiakea	Manage for stability	295	Partial 88%	Partial 65%	No	No	No

## Action Area: Out

### TaxonName: Labordia cyrtandrae

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Koloa	Manage reintroduction for stability	33	Yes	No	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In


#### TaxonName: *Melanthera tenuifolia*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki	Genetic Storage	13	Partial 100%	No	No	No	No
Kaluakauila	Genetic Storage	4	Yes	No	No	No	No
Keawaula	Genetic Storage	137	No	No	No	No	No
Ohikilolo	Manage for stability	1109	Yes	No	No	No	Partial 52%

### Action Area: Out

#### TaxonName: *Melanthera tenuifolia*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kamaileunu and Waianae Kai	Manage for stability	815	No	No	No	No	No
Mt. Kaala NAR	Manage for stability	121	Yes	No	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: *Neraudia angulata*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kaluakauila	Manage reintroduction for stability	65	Yes	No	No	No	No
Kapuna	Genetic Storage	0	No	No	No	No	No
Makua	Manage for stability	120	Yes	No	No	No	No
Punapohaku	Genetic Storage	4	No	No	No	No	No

### Action Area: Out

#### TaxonName: *Neraudia angulata*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Halona	Genetic Storage	32	No	No	No	No	No
Leeward Puu Kaua	Genetic Storage	9	No	No	No	No	No
Makaha	Manage for stability (backup site)	52	Partial 94%	Partial 96%	No	No	No
Manuwai	Manage for stability	115	Yes	Yes	No	No	No
Waianae Kai Makai	Genetic Storage	13	Yes	No	No	No	Partial 100%
Waianae Kai Mauka	Manage for stability	13	Yes	Partial 100%	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: *Nototrichium humile*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki	Genetic Storage	50	Partial 100%	No	Partial 30%	No	No
Kaluakauila	Manage for stability	160	Yes	No	No	No	No
Keaau	Genetic Storage	21	No	No	No	No	No
Keawaula	Genetic Storage	35	No	No	No	No	No
Makua (East rim)	Genetic Storage	1	No	No	No	No	No
Makua (south side)	Manage for stability	50	Partial 100%	No	No	No	No
Punapohaku	Genetic Storage	178	No	No	No	No	No

### Action Area: Out

#### TaxonName: *Nototrichium humile*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kaimuhole and Palikea Gulch	Genetic Storage	29	No	No	No	No	Partial 100%
Keawapilau	Genetic Storage	1	No	No	No	No	No
Kolekole	Genetic Storage	12	Partial 33%	No	No	No	No
Makaha	Genetic Storage	22	No	No	No	No	No
Manuwai	Manage reintroduction for stability	115	Yes	Yes	No	No	No
Nanakuli	Genetic Storage	5	No	No	No	No	No
Puu Kaua (Leeward side)	Genetic Storage	2	No	No	No	No	No
Waianae Kai	Manage for stability	216	Partial 88%	Partial 88%	No	No	Partial 88%

█ = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: *Phyllostegia hirsuta*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Haleauau to Mohiakea	Manage for stability	71	Partial 100%	Partial 85%	No	No	No
Helemano and Opaeula	Genetic Storage	1	Partial 0%	No	No	No	No
Helemano to Poamoho	Genetic Storage	2	No	No	No	No	No
Kaipapau and Kawainui	Genetic Storage	4	No	No	No	No	No
Kaukonahua	Genetic Storage	0	No	No	No	No	No
Kawaiiki	Genetic Storage	0	No	No	No	No	No
Koloa	Manage for stability	97	Partial 98%	Partial 98%	No	No	No

### Action Area: Out

#### TaxonName: *Phyllostegia hirsuta*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Hapapa to Kaluaa	Genetic Storage	2	Partial 0%	No	No	No	No
Kaluanui and Punaluu	Genetic Storage	5	No	No	No	No	No
Makaha-Waianae Kai Ridge	Genetic Storage	1	No	No	No	No	No
Palawai	Genetic Storage	0	No	No	No	No	No
Puu Paliikea	Manage reintroduction for stability	114	Yes	Yes	No	No	No
Waiamano	Genetic Storage	1	No	No	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants



## Threat Control Summary

### Action Area: In

#### TaxonName: *Phyllostegia kaalaensis*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Keawapilau to Kapuna	Manage reintroduction for stability	0	Yes	No	No	No	No
Pahole	Manage reintroduction for stability	0	Yes	No	No	No	No
Palikea Gulch	Genetic Storage	0	No	No	No	No	No

### Action Area: Out

#### TaxonName: *Phyllostegia kaalaensis*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Makaha	Manage reintroduction for stability	0	Yes	No	No	No	No
Manuwai	Manage reintroduction for stability	0	Yes	Yes	No	No	No
Waianae Kai	Genetic Storage	0	No	No	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: *Phyllostegia mollis*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Mohiakea	Genetic Storage	0	Yes	No	No	No	No

### Action Area: Out

#### TaxonName: *Phyllostegia mollis*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Ekahanui	Manage for stability	11	Yes	Partial 82%	Partial 100%	Partial 82%	No
Kaluaa	Manage for stability	88	Yes	Partial 100%	No	No	No
Pualii	Manage reintroduction for stability	11	Yes	No	No	No	No
Waieli	Genetic Storage	1	Partial 100%	No	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: *Plantago princeps* var. *princeps*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
North Mohiakea	Manage for stability	39	Yes	No	No	No	No
Ohikilolo	Manage for stability	0	Yes	No	No	No	No
Pahole	Genetic Storage	2	Yes	No	No	No	No

### Action Area: Out

#### TaxonName: *Plantago princeps* var. *princeps*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Ekahanui	Manage for stability	48	Yes	Partial 4%	Yes	No	No
Halona	Manage for stability	10	No	No	No	No	No
North Palawai	Genetic Storage	5	No	No	No	No	No
Waieli	Manage reintroduction for storage	12	Yes	Yes	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: Pritchardia kaalae

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Ohikilolo	Manage for stability	85	Yes	Partial 12%	Partial 88%	No	No
Ohikilolo East and West Makaleha	Manage reintroduction for stability	4	Yes	No	No	No	No

### Action Area: Out

#### TaxonName: Pritchardia kaalae

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Makaha	Genetic Storage	1	No	No	No	No	No
Makaleha to Manuwai	Manage for stability	122	Partial 2%	No	No	No	No
Waianae Kai	Genetic Storage	4	No	No	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In


#### TaxonName: *Sanicula marivera*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Keaau	Manage for stability	0	Yes	Yes	No	No	No
Ohikilolo	Manage for stability	0	Yes	No	No	No	No

### Action Area: Out

#### TaxonName: *Sanicula marivera*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kamaileunu	Manage for stability	5	Yes	No	No	No	No
Puu Kawiwi	Genetic Storage	0	Yes	No	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In


#### TaxonName: *Schiedea kaalae*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Pahole	Manage for stability	83	Yes	No	No	Partial 80%	No

### Action Area: Out

#### TaxonName: *Schiedea kaalae*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahana	Genetic Storage	8	Yes	No	No	No	No
Kaluaa and Waieli	Manage for stability	166	Yes	Partial 4%	No	Partial 4%	No
Maakua (Koolaus)	Manage for stability	10	No	No	No	No	No
Makaua (Koolaus)	Genetic Storage	85	Yes	No	No	No	No
North Palawai	Genetic Storage	0	Yes	No	No	No	No
South Ekahanui	Manage for stability	160	Yes	Partial 99%	Yes	Partial 99%	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

# Threat Control Summary

## Action Area: In


### TaxonName: Schiedea nuttallii

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki to Pahole	Manage for stability	108	Yes	Partial 0%	Partial 94%	Partial 90%	No
Kapuna-Keawapilau Ridge	Manage for stability	74	Yes	Partial 100%	Yes	No	No

## Action Area: Out

### TaxonName: Schiedea nuttallii

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Makaha	Manage reintroduction for stability	68	Yes	Partial 100%	Yes	Yes	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: *Schiedea obovata*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki to Pahole	Manage for stability	283	Yes	Partial 88%	Partial 88%	Partial 88%	No
Keawapilau to West Makaleha	Manage for stability	58	Partial 95%	Partial 60%	No	Partial 62%	No

### Action Area: Out

#### TaxonName: *Schiedea obovata*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Makaha	Manage reintroduction for stability	146	Yes	No	No	Yes	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants




# Threat Control Summary

Action Area: In

TaxonName: *Schiedea trinervis*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kalena to East Makaleha	Manage for stability	288	Partial 89%	Partial 43%	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: Stenogyne kanehoana

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Haleauau	Manage reintroduction for stability	0	Partial	Partial	No	No	No

### Action Area: Out

#### TaxonName: Stenogyne kanehoana

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kaluaa	Manage reintroduction for stability	26	Yes	No	No	No	No
Makaha	Manage reintroduction for stability	0	Yes	Partial	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

# Threat Control Summary

## Action Area: In


### TaxonName: Tetramolopium filiforme

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki	Genetic Storage	40	No	No	No	No	No
Kalena	Manage for stability	24	Yes	No	No	No	No
Keaau	Genetic Storage	30	No	No	No	No	No
Makaha/Ohikilolo Ridge	Genetic Storage	300	No	No	No	No	No
Ohikilolo	Manage for stability	2394	Yes	No	No	No	No
Puhawai	Manage for stability	21	No	No	No	No	No

## Action Area: Out

### TaxonName: Tetramolopium filiforme

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Waianae Kai	Manage for stability	20	No	No	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Threat Control Summary

### Action Area: In

#### TaxonName: *Viola chamissoniana* subsp. *chamissoniana*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Keaau	Genetic Storage	40	No	No	No	No	No
Makaha/Ohikilolo Ridge	Genetic Storage	7	No	No	No	No	No
Ohikilolo	Manage for stability	386	Yes	No	No	No	No
Puu Kumakalii	Manage for stability	44	No	No	No	No	No

### Action Area: Out

#### TaxonName: *Viola chamissoniana* subsp. *chamissoniana*

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Halona	Manage for stability	22	No	No	No	No	No
Kamaileunu	Genetic Storage	35	No	No	No	No	No
Makaha	Manage for stability	68	Yes	No	No	No	No
Makaleha	Genetic Storage	18	No	No	No	No	No
Puu Hapapa	Genetic Storage	7	No	No	No	No	No

 = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

Partial%=Percent of mature plants in Population Unit that have threat controlled

Partial 100%= All PopRefSites within Population Unit have threat partially controlled

Partial 0%= Threat partially controlled, but no mature plants

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement
<b>Action Area: In</b>														
<b>Abutilon sandwicense</b>														
Kaawa to Puulu	Manage for stability	32	59	0	13	9	0	0	7	0	0	0	0	0%
Kahanahaiki	Manage reintroduction for stability	0	0	1	0	0	0	1	0	0	0	1	1	100%
Keaau	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0%
<b>Action Area: Out</b>														
<b>Abutilon sandwicense</b>														
East Makaleha	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	0%
Ekahanui and Huliwai	Manage for stability	5	15	8	10	9	0	0	9	5	0	0	5	38%
Makaha Makai	Manage for stability	92	133	2	72	67	0	1	63	54	0	0	54	100%
Makaha Mauka	Genetic Storage	13	1	8	19	17	0	0	16	9	0	0	9	43%
North Mikilua	Genetic Storage	9	11	0	0	0	0	0	0	0	0	0	0	0%
Waianae Kai	Genetic Storage	0	0	1	2	1	0	0	1	0	0	0	0	0%
West Makaleha	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	0%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		152	219	20	116	103	0	2	96	68	0	1	69	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met		
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement	
<b>Action Area: In</b>															
<b>Alectryon macrococcus var. macrococcus</b>															
Haleauau	No Management	0	0	0	0	0	0	1	0	0	0	0	0	0	0%
Kahanahaiki to Keawapilau	Manage for stability	1	0	0	0	0	0	0	0	0	0	0	0	0	0%
Makua	Manage for stability	11	0	1	0	0	0	2	0	0	0	2	2	17%	
Palikeya Gulch	No Management	2	0	0	0	0	0	0	0	0	0	0	0	0%	
South Mohiakea	Genetic Storage	2	0	0	0	0	0	1	0	0	0	0	0	0%	
South Mohiakea South Slope	No Management	1	0	0	0	0	0	0	0	0	0	0	0	0%	
West Makaleha	Genetic Storage	13	0	0	0	0	0	3	0	0	0	0	0	0%	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement
<b>Action Area: Out</b>														
<b>Alectryon macrococcus var. macrococcus</b>														
Alaiheihe	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Central and East Makaleha	No Management	12	0	0	0	0	0	0	0	0	0	0	0	0%
Central Kaluaa to Central Waieli	Manage for stability	3	0	0	0	0	0	0	0	0	0	0	0	0%
Ekahanui	No Management	4	0	0	0	0	0	0	0	0	0	0	0	0%
Huliwai	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Kaawa	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Kaomoku Nui	No Management	2	0	0	0	0	0	0	0	0	0	0	0	0%
Makaha	Manage for stability	36	0	0	0	0	18	0	0	0	1	1	3%	
Manuwai	No Management	1	0	0	0	0	0	0	0	0	0	0	0%	
North Waieli	No Management	0	0	0	0	0	0	0	0	0	0	0	0%	
South Kaluaa	No Management	2	0	0	0	0	2	0	0	0	1	1	50%	
Waianae Kai	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0%	
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		91	0	1	0	0	0	27	0	0	0	4	4	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	% Completed Genetic Storage Requirement	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal		
<b>Action Area: In</b>															
<b>Cenchrus agrimonioides var. agrimonioides</b>															
Kahanahaiki and Pahole	Manage for stability	80	42	40	74	56	0	2	34	10	0	1	11	22%	
Kuaokala	Genetic Storage	1	3	0	0	0	0	1	0	0	0	1	1	100%	
<b>Action Area: Out</b>															
<b>Cenchrus agrimonioides var. agrimonioides</b>															
Central Ekahanui	Manage for stability	47	72	18	36	19	0	40	12	1	0	38	38	76%	
Makaha and Waianae Kai	Manage for stability	5	7	6	3	2	0	9	0	0	0	9	9	82%	
South Huliwai	Genetic Storage	15	13	13	18	10	0	20	6	3	0	17	19	68%	
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>		
		148	137	77	131	87	0	72	52	14	0	66	78		



## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement
<b>Action Area: In</b>														
<b>Cyanea acuminata</b>														
Helemano-Punaluu Summit Ridge to North Kaukonahua	Manage for stability	130	142	0	4	4	0	0	4	4	0	0	4	8%
Kahana and South Kaukonahua	Genetic Storage	2	0	0	0	0	0	0	0	0	0	0	0	0%
Makaleha to Mohiakea	Manage for stability	151	65	0	1	1	0	1	1	1	0	0	1	2%
<b>Action Area: Out</b>														
<b>Cyanea acuminata</b>														
Kahana and Makaua	Genetic Storage	11	3	0	1	1	0	0	1	0	0	0	0	0%
Kaipapau and Koloa	Genetic Storage	70	30	0	0	0	0	0	0	0	0	0	0	0%
Kaluanui and Maakua	Manage for stability	123	126	0	0	0	0	0	0	0	0	0	0	0%
Puukeahiakahoe	Genetic Storage	3	0	0	0	0	0	0	0	0	0	0	0	0%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		490	366	0	6	6	0	1	6	5	0	0	5	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement
<b>Action Area: In</b>														
<b>Cyanea grimesiana subsp. obatae</b>														
Haleauau	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Pahole to West Makaleha	Manage for stability	6	11	9	15	15	0	7	15	15	0	5	15	100%
Palikea Gulch	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
<b>Action Area: Out</b>														
<b>Cyanea grimesiana subsp. obatae</b>														
Kaluaa	Manage for stability	2	0	1	3	3	0	0	3	3	0	0	3	100%
North branch of South Ekahanui	Manage reintroduction for stability	0	0	2	2	2	2	0	2	2	2	0	2	100%
Palikea (South Palawai)	Manage for stability	7	7	9	15	15	5	0	15	15	5	0	15	94%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		15	18	21	35	35	7	7	35	35	7	5	35	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement
<b>Action Area: In</b>														
<b>Cyanea koolauensis</b>														
Kaipapau, Koloa and Kawainui	Manage for stability	106	13	0	0	0	0	0	0	0	0	0	0	0%
Kamananui-Kawainui Ridge	Genetic Storage	6	2	0	0	0	0	0	0	0	0	0	0	0%
Kaukonahua	Genetic Storage	8	3	0	0	0	0	0	0	0	0	0	0	0%
Kawaiiiki	Genetic Storage	4	4	0	0	0	0	0	0	0	0	0	0	0%
Lower Opaepala	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0%
Opaepala to Helemano	Manage for stability	23	4	0	0	0	0	0	0	0	0	0	0	0%
Poamoho	Manage for stability	21	18	0	0	0	0	0	0	0	0	0	0	0%
<b>Action Area: Out</b>														
<b>Cyanea koolauensis</b>														
Halawa	Genetic Storage	4	0	0	0	0	0	0	0	0	0	0	0	0%
Waialae Nui	Genetic Storage	2	0	0	0	0	0	0	0	0	0	0	0	0%
Waiawa to Waimano	Genetic Storage	11	2	0	0	0	0	0	0	0	0	0	0	0%
Wailupe	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		187	46	0	0	0	0	0	0	0	0	0	0	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	% Completed Genetic Storage Requirement
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	
<b>Action Area: In</b>														
<b>Cyanea longiflora</b>														
Kapuna to West Makaleha	Manage for stability	13	18	11	20	20	9	2	20	20	9	1	20	83%
Pahole	Manage for stability	58	104	16	55	55	1	4	53	52	1	2	53	100%
<b>Action Area: Out</b>														
<b>Cyanea longiflora</b>														
Makaha and Waianae Kai	Manage for stability	8	4	3	4	4	2	0	4	4	2	0	4	36%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		79	126	30	79	79	12	6	77	76	12	3	77	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	% Completed Genetic Storage Requirement
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	
<b>Action Area: In</b>														
<b>Cyanea superba subsp. superba</b>														
Kahanahaiki	Manage reintroduction for stability	0	0	3	3	3	2	1	3	3	2	0	3	100%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		0	0	3	3	3	2	1	3	3	2	0	3	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	% Completed Genetic Storage Requirement
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	
<b>Action Area: In</b>														
<b>Cyrtandra dentata</b>														
Kahanahaiki	Manage for stability	37	76	18	25	25	0	0	24	24	0	0	24	48%
Kawaiiki (Koolaus)	Manage for stability	5	79	0	0	0	0	0	0	0	0	0	0	0%
Opaepala (Koolaus)	Manage for stability	23	107	0	1	1	0	0	1	1	0	0	1	4%
Pahole to West Makaleha	Manage for stability	603	670	0	53	53	0	0	53	53	0	0	53	100%
<b>Action Area: Out</b>														
<b>Cyrtandra dentata</b>														
Central Makaleha	Genetic Storage	3	0	0	0	0	0	0	0	0	0	0	0	0%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		671	932	18	79	79	0	0	78	78	0	0	78	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	% Completed Genetic Storage Requirement
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	
<b>Action Area: In</b>														
<b>Delissea waianaensis</b>														
Kahanahaiki to Keawapilau	Manage for stability	3	6	9	13	13	1	0	13	13	1	0	13	100%
Palikeya Gulch	Genetic Storage	1	0	6	7	7	4	0	7	7	3	0	7	100%
South Mohiakea	Genetic Storage	12	23	4	12	12	0	0	11	11	0	0	11	69%
<b>Action Area: Out</b>														
<b>Delissea waianaensis</b>														
Ekahanui	Manage for stability	2	1	4	6	6	0	0	6	6	0	0	6	100%
Huliwai	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Kaawa	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Kaluaa	Manage for stability	5	2	3	7	7	0	0	7	7	0	0	7	88%
Kealia	Genetic Storage	4	13	3	5	5	0	0	5	5	0	0	5	71%
Palawai	Genetic Storage	17	47	7	22	22	0	0	22	22	0	0	22	92%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		44	92	36	72	72	5	0	71	71	4	0	71	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement
<b>Action Area: In</b>														
<b>Dubautia herbstobatae</b>														
Keaau	Genetic Storage	70	0	0	0	0	0	0	0	0	0	0	0	0%
Makaha/Ohikilolo	Genetic Storage	350	0	0	1	0	0	0	0	0	0	0	0	0%
Ohikilolo Makai	Manage for stability	89	2	0	0	0	0	0	0	0	0	0	0	0%
Ohikilolo Mauka	Manage for stability	415	9	0	1	0	0	0	1	0	0	0	0	0%
<b>Action Area: Out</b>														
<b>Dubautia herbstobatae</b>														
Kamaileunu	Genetic Storage	0	0	1	1	0	0	1	1	0	0	1	1	100%
Makaha	Manage for stability	28	1	13	19	0	0	21	14	0	0	20	20	49%
Waianae Kai	Genetic Storage	10	4	0	5	0	0	3	4	0	0	3	3	30%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		962	16	14	27	0	0	25	20	0	0	24	24	



## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement
<b>Action Area: In</b>														
<b>Eugenia koolauensis</b>														
Aimuu	Genetic Storage	8	10	2	0	0	0	12	0	0	0	7	7	70%
Kaiwikoele and Kamananui	Genetic Storage	21	26	1	0	0	0	23	0	0	0	8	8	36%
Kaleleiki	Genetic Storage	14	54	14	0	0	0	22	0	0	0	0	0	0%
Kaunala	Manage for stability	20	39	6	0	0	0	29	0	0	0	9	9	35%
Malaekahana	Genetic Storage	5	21	0	0	0	0	5	0	0	0	2	2	40%
Ohiaai and East Oio	Genetic Storage	1	1	1	0	0	0	3	0	0	0	1	1	50%
Oio	Manage for stability	5	2	10	0	0	0	14	0	0	0	4	4	27%
Pahipahialua	Manage for stability	22	6	9	0	0	0	22	0	0	0	14	14	45%
<b>Action Area: Out</b>														
<b>Eugenia koolauensis</b>														
Hanaimoa	Genetic Storage	1	0	2	0	0	0	3	0	0	0	1	1	33%
Palikea and Kaimuhole	Genetic Storage	1	0	1	0	0	0	2	0	0	0	2	2	100%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		98	159	46	0	0	0	135	0	0	0	48	48	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met		
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement	
<b>Action Area: In</b>															
<b>Euphorbia celastroides var. kaenana</b>															
East Kahanahaiki	Genetic Storage	2	0	0	1	0	0	0	0	0	0	0	0	0	0%
Kaluakauila	Genetic Storage	11	3	0	2	2	0	0	0	0	0	0	0	0	0%
Makua	Manage for stability	85	0	28	77	74	0	0	61	53	0	0	53	100%	
North Kahanahaiki	Genetic Storage	115	36	4	14	14	0	0	11	8	0	0	8	16%	
Puaakanoa	Manage for stability	150	16	3	48	42	0	0	29	28	0	0	28	56%	
<b>Action Area: Out</b>															
<b>Euphorbia celastroides var. kaenana</b>															
East of Alau	Manage for stability	21	2	5	26	26	0	0	24	20	0	0	20	77%	
Kaena	Manage for stability	579	896	1	68	67	0	0	66	58	0	0	58	100%	
Keawaula	Genetic Storage	43	1	6	31	27	0	0	18	10	0	0	10	20%	
Waianae Kai	Genetic Storage	34	0	0	0	0	0	0	0	0	0	0	0	0%	
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>		
		1040	954	47	267	252	0	0	209	177	0	0	177		

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement
<b>Action Area: In</b>														
<b>Euphorbia herbstii</b>														
Kapuna to Pahole	Manage for stability	14	9	44	31	29	0	2	16	14	0	0	14	28%
<b>Action Area: Out</b>														
<b>Euphorbia herbstii</b>														
South Branch of South Ekahanui	No Management	0	0	2	0	0	0	0	0	0	0	0	0	0%
		Total Current Mature	Total Current Imm.	Total Dead and Repres.	Total # Plants w/ >=10 Seeds in SeedLab	Total # Plants w/ >=10 Est Vaible Seeds in SeedLab	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants w/ >=50 Seeds in SeedLab	Total # Plants w/ >=50 Est Viable Seeds in SeedLab	Total # Plants w/ >=3 in Microprop	Total # Plants w/ >=3 Army Nursery	Total # Plants that Met Goal	
		14	9	46	31	29	0	2	16	14	0	0	14	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement
<b>Action Area: In</b>														
<b>Flueggea neowawraea</b>														
Kahanahaiki to Kapuna	Manage for stability	6	0	1	1	1	0	5	1	1	0	1	2	29%
Mohiakea	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Ohikilolo	Manage for stability	1	0	0	0	0	0	1	0	0	0	1	1	100%
West Makaleha	Genetic Storage	6	0	0	0	0	0	6	0	0	0	1	1	17%
<b>Action Area: Out</b>														
<b>Flueggea neowawraea</b>														
Central and East Makaleha	Genetic Storage	5	0	1	1	1	0	5	1	1	0	3	3	50%
Halona	Genetic Storage	1	0	0	0	0	0	1	0	0	0	1	1	100%
Kaluaa	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Kauhiuhi	Genetic Storage	1	0	0	0	0	0	1	0	0	0	1	1	100%
Makaha	Manage for stability	10	0	1	0	0	0	10	0	0	0	5	5	45%
Mikilua	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	0%
Mt. Kaala NAR	Genetic Storage	3	0	1	1	1	0	3	1	1	0	1	2	50%
Nanakuli, south branch	Genetic Storage	1	0	0	0	0	0	1	0	0	0	1	1	100%
Waianae Kai	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		35	0	4	3	3	0	33	3	3	0	15	17	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement
<b>Action Area: In</b>														
<b>Gardenia mannii</b>														
Haleauau	Manage for stability	3	0	5	0	0	0	4	0	0	0	4	4	50%
Helemano and Poamoho	Manage for stability	17	0	0	0	0	0	6	0	0	0	2	2	12%
Kaiwikoele, Kamananui, and Kawainui	Genetic Storage	13	0	0	0	0	0	0	0	0	0	0	0	0%
Lower Peahinaia	Manage for stability	9	1	0	0	0	0	4	0	0	0	1	1	11%
South Kaukonahua	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0%
Upper Opaepala/Helemano	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0%
<b>Action Area: Out</b>														
<b>Gardenia mannii</b>														
Ihiihi-Kawainui ridge	Genetic Storage	2	0	0	0	0	0	0	0	0	0	0	0	0%
Kaluaa and Maunauna	Genetic Storage	2	0	0	0	0	0	2	0	0	0	1	1	50%
Kamananui-Malaekahana Summit Ridge	Genetic Storage	3	0	0	0	0	0	2	0	0	0	0	0	0%
Kapakahi	Genetic Storage	2	0	0	0	0	0	0	0	0	0	0	0	0%
Pukele	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		54	1	5	0	0	0	18	0	0	0	8	8	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	% Completed Genetic Storage Requirement
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	
<b>Action Area: In</b>														
<b>Gouania vitifolia</b>														
Keaau	Manage for stability	55	0	4	56	49	0	5	44	31	0	2	31	62%
<b>Action Area: Out</b>														
<b>Gouania vitifolia</b>														
Waianae Kai	Genetic Storage	3	0	0	0	0	0	2	0	0	0	0	0	0%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		58	0	4	56	49	0	7	44	31	0	2	31	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	% Completed Genetic Storage Requirement	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal		
<b>Action Area: In</b>															
<b>Hesperomannia oahuensis</b>															
Haleauau	Manage for stability	1	0	0	0	0	0	1	0	0	0	0	0	0	0%
<b>Action Area: Out</b>															
<b>Hesperomannia oahuensis</b>															
Kaaiukukai	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Makaha	Manage for stability	3	2	0	0	0	0	0	0	0	0	0	0	0	0%
Napepeiauolelo	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
North Palawai	Genetic Storage	0	0	4	0	0	0	4	0	0	0	0	0	0	0%
Waianae Kai	Genetic Storage	0	1	2	0	0	0	0	0	0	0	0	0	0	0%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>		
		4	3	6	0	0	0	5	0	0	0	0	0		

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	% Completed Genetic Storage Requirement	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal		
<b>Action Area: In</b>															
<b>Hesperomannia swezeyi</b>															
Kamananui to Kaluanui	Manage for stability	134	112	0	0	0	0	0	0	0	0	0	0	0	0%
Kaukonahua	Manage for stability	55	54	0	0	0	0	0	0	0	0	0	0	0	0%
Lower Opaeha	Manage for stability	18	21	0	0	0	0	0	0	0	0	0	0	0	0%
Palikea Gulch	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Poamoho	Genetic Storage	21	12	0	0	0	0	1	0	0	0	0	0	0	0%
<b>Action Area: Out</b>															
<b>Hesperomannia swezeyi</b>															
Niu-Waimanalo Summit Ridge	Genetic Storage	1	4	0	0	0	0	0	0	0	0	0	0	0	0%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>		
		229	203	0	0	0	0	1	0	0	0	0	0		



## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement
<b>Action Area: In</b>														
<b>Hibiscus brackenridgei subsp. mokuleianus</b>														
Keaau	Manage for stability	0	16	6	1	1	0	6	1	1	0	6	6	100%
Makua	Manage for stability	13	8	28	33	27	0	34	27	25	0	30	34	83%
<b>Action Area: Out</b>														
<b>Hibiscus brackenridgei subsp. mokuleianus</b>														
Haili to Kawaii	Manage for stability	5	3	8	0	0	0	15	0	0	0	13	13	100%
Waialua	Genetic Storage	49	85	28	7	5	0	67	3	0	0	41	41	82%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		67	112	70	41	33	0	122	31	26	0	90	94	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	% Completed Genetic Storage Requirement
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	
<b>Action Area: In</b>														
<b>Kadua degeneri subsp. degeneri</b>														
Kahanahaiki to Pahole	Manage for stability	147	131	21	72	72	0	0	63	59	0	0	59	100%
<b>Action Area: Out</b>														
<b>Kadua degeneri subsp. degeneri</b>														
Alaiheihe and Manuwai	Manage for stability	25	2	16	30	30	1	0	29	27	1	0	28	68%
Central Makaleha and West Branch of East Makaleha	Manage for stability	23	13	21	39	37	0	0	36	30	0	0	30	68%
East branch of East Makaleha	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	0%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		195	146	58	141	139	1	0	128	116	1	0	117	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	% Completed Genetic Storage Requirement
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	
<b>Action Area: In</b>														
<b>Kadua parvula</b>														
Ohikilolo	Manage for stability	100	157	15	108	104	0	0	102	97	0	0	97	100%
<b>Action Area: Out</b>														
<b>Kadua parvula</b>														
East Makaleha	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Halona	Manage for stability	93	28	19	70	67	0	0	62	55	0	0	55	100%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		193	185	34	178	171	0	0	164	152	0	0	152	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement
<b>Action Area: In</b>														
<b>Labordia cyrtandrae</b>														
East Makaleha to North Mohiakea	Manage for stability	74	0	0	8	7	4	6	7	7	2	2	9	18%
<b>Action Area: Out</b>														
<b>Labordia cyrtandrae</b>														
Manana	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		74	0	0	8	7	4	6	7	7	2	2	9	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement
<b>Action Area: In</b>														
<b>Melanthera tenuifolia</b>														
Kahanahaiki	Genetic Storage	13	6	23	11	0	0	13	5	0	0	6	6	17%
Kaluakauila	Genetic Storage	4	80	0	9	0	0	16	1	0	0	11	11	100%
Keawaula	Genetic Storage	60	33	0	0	0	0	0	0	0	0	0	0	0%
Ohikilolo	Manage for stability	1109	8	19	16	0	0	8	13	0	0	6	6	12%
<b>Action Area: Out</b>														
<b>Melanthera tenuifolia</b>														
Kamaileunu and Waianae Kai	Manage for stability	815	246	0	0	0	0	0	0	0	0	0	0	0%
Mt. Kaala NAR	Manage for stability	121	4	0	0	0	0	0	0	0	0	0	0	0%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		2122	377	42	36	0	0	37	19	0	0	23	23	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement
<b>Action Area: In</b>														
<b>Neraudia angulata</b>														
Kapuna	Genetic Storage	0	0	2	2	2	0	2	2	0	0	1	1	50%
Lower Kahanahaiki	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Makua	Manage for stability	25	4	31	2	2	0	23	1	0	0	21	21	42%
Punapohaku	Genetic Storage	4	0	0	0	0	0	4	0	0	0	3	3	75%
<b>Action Area: Out</b>														
<b>Neraudia angulata</b>														
Halona	Genetic Storage	32	5	8	0	0	0	9	0	0	0	6	6	15%
Leeward Puu Kaua	Genetic Storage	9	0	0	0	0	0	1	0	0	0	1	1	11%
Makaha	Manage for stability (backup site)	3	8	12	2	1	0	15	1	0	0	14	14	93%
Manuwai	Manage for stability	0	2	2	0	0	0	2	0	0	0	2	2	100%
Waianae Kai Makai	Genetic Storage	13	0	0	0	0	0	3	0	0	0	2	2	15%
Waianae Kai Mauka	Manage for stability	7	2	9	0	0	0	11	0	0	0	10	10	63%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		93	21	64	6	5	0	70	4	0	0	60	60	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met		
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement	
<b>Action Area: In</b>															
<b>Nototrichium humile</b>															
Kahanahaiki	Genetic Storage	50	2	0	0	0	0	1	0	0	0	0	0	0	0%
Kaluakauila	Manage for stability	160	48	1	2	1	0	0	1	1	0	0	1	2%	
Keaau	Genetic Storage	21	31	0	0	0	0	0	0	0	0	0	0	0%	
Keawaula	Genetic Storage	35	6	1	0	0	0	8	0	0	0	8	8	22%	
Makua (East rim)	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0%	
Makua (south side)	Manage for stability	43	3	0	0	0	0	0	0	0	0	0	0	0%	
Punapohaku	Genetic Storage	178	77	1	0	0	0	36	0	0	0	35	35	70%	
<b>Action Area: Out</b>															
<b>Nototrichium humile</b>															
Kaimuhole and Palikea Gulch	Genetic Storage	29	1	12	0	0	0	43	0	0	0	41	41	100%	
Kealia	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%	
Keawapilau	Genetic Storage	1	0	4	0	0	0	5	0	0	0	5	5	100%	
Kolekole	Genetic Storage	12	0	0	0	0	0	10	0	0	0	10	10	83%	
Makaha	Genetic Storage	22	5	0	0	0	0	0	0	0	0	0	0	0%	
Nanakuli	Genetic Storage	5	0	0	0	0	0	0	0	0	0	0	0	0%	
Pahole Gulch	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%	
Puu Kaa (Leeward side)	Genetic Storage	2	0	0	0	0	0	0	0	0	0	0	0	0%	
Waianae Kai	Manage for stability	216	54	0	0	0	0	2	0	0	0	2	2	4%	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	% Completed Genetic Storage Requirement	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal		
		Total Current Mature	Total Current Imm.	Total Dead and Repres.	Total # Plants w/ >=10 Seeds in SeedLab	Total # Plants w/ >=10 Est Vaible Seeds in SeedLab	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants w/ >=50 Seeds in SeedLab	Total # Plants w/ >=50 Est Viable Seeds in SeedLab	Total # Plants w/ >=3 in Microprop	Total # Plants w/ >=3 Army Nursery	Total # Plants that Met Goal		
		775	227	19	2	1	0	105	1	1	0	101	102		



## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met		
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement	
<b>Action Area: In</b>															
<b>Phyllostegia hirsuta</b>															
Haleauau to Mohiakea	Manage for stability	11	2	2	4	4	2	10	0	0	2	10	10	77%	
Helemano and Opaepala	Genetic Storage	1	4	1	2	1	1	4	1	0	1	3	3	100%	
Helemano to Poamoho	Genetic Storage	2	0	0	0	0	0	0	0	0	0	0	0	0%	
Kaipapau and Kawainui	Genetic Storage	4	0	0	1	1	0	4	0	0	0	4	4	100%	
Kaukonahua	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	0%	
Kawaiiki	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	0%	
Koloa	Manage for stability	6	3	2	1	1	1	6	1	0	1	6	6	75%	
<b>Action Area: Out</b>															
<b>Phyllostegia hirsuta</b>															
Ekahanui	No Management	0	1	0	0	0	0	0	0	0	0	0	0	0%	
Hapapa to Kaluaa	Genetic Storage	2	10	6	5	5	8	10	4	4	7	10	10	100%	
Huliwai	No Management	0	0	1	1	1	1	2	1	0	1	2	2	100%	
Kaluanui and Punaluu	Genetic Storage	5	3	0	0	0	0	0	0	0	0	0	0	0%	
Makaha-Waianae Kai Ridge	Genetic Storage	1	0	0	0	0	0	1	0	0	0	1	1	100%	
Palawai	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	0%	
Waiamano	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0%	
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>		
		33	23	12	14	13	13	37	7	4	12	36	36		

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	% Completed Genetic Storage Requirement
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	
<b>Action Area: In</b>														
<b>Phyllostegia kaalaensis</b>														
Keawapilau to Kapuna	Manage reintroduction for stability	0	0	1	1	1	1	1	0	0	1	0	1	100%
Pahole	Manage reintroduction for stability	0	0	2	0	0	2	2	0	0	2	1	2	100%
Palikeya Gulch	Genetic Storage	0	0	3	0	0	3	3	0	0	3	1	3	100%
<b>Action Area: Out</b>														
<b>Phyllostegia kaalaensis</b>														
Waiana Kai	Genetic Storage	0	0	2	1	0	2	2	0	0	2	0	2	100%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		0	0	8	2	1	8	8	0	0	8	2	8	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	% Completed Genetic Storage Requirement
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	
<b>Action Area: In</b>														
<b>Phyllostegia mollis</b>														
Mohiakea	Genetic Storage	0	0	8	6	6	6	7	3	2	4	6	6	75%
<b>Action Area: Out</b>														
<b>Phyllostegia mollis</b>														
Ekahanui	Manage for stability	0	0	2	2	2	1	2	1	0	1	2	2	100%
Huliwai	No Management	0	0	1	1	1	1	1	1	1	1	1	1	100%
Kaluaa	Manage for stability	0	0	1	1	1	1	1	1	1	0	1	1	100%
Pualii	Manage reintroduction for stability	0	0	1	1	1	1	1	0	0	1	1	1	100%
Waieli	Genetic Storage	1	0	5	5	5	4	3	4	4	4	1	6	100%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		1	0	18	16	16	14	15	10	8	11	12	17	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement
<b>Action Area: In</b>														
<b>Plantago princeps var. princeps</b>														
North Mohiakea	Manage for stability	39	12	9	20	20	0	1	19	19	0	0	19	40%
Ohikilolo	Manage for stability	0	0	17	19	18	0	0	12	12	0	0	12	71%
Pahole	Genetic Storage	2	2	3	4	4	0	0	3	3	0	0	3	60%
<b>Action Area: Out</b>														
<b>Plantago princeps var. princeps</b>														
Ekahanui	Manage for stability	46	122	34	68	66	0	12	59	42	0	1	42	84%
Halona	Manage for stability	10	1	7	22	22	0	0	22	18	0	0	18	100%
Konahuanui	No Management	100	10	0	5	4	0	0	0	0	0	0	0	0%
North Palawai	Genetic Storage	5	1	1	2	2	0	0	2	2	0	0	2	33%
Nuuanu	No Management	4	8	0	0	0	0	0	0	0	0	0	0	0%
Waiawa (Koolaus)	No Management	16	17	0	6	2	0	0	1	0	0	0	0	0%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		222	173	71	146	138	0	13	118	96	0	1	96	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	% Completed Genetic Storage Requirement
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	
<b>Action Area: In</b>														
<b>Pritchardia kaalae</b>														
Ohikilolo	Manage for stability	72	1178	0	1	0	1	0	1	0	0	0	0	0%
<b>Action Area: Out</b>														
<b>Pritchardia kaalae</b>														
Makaha	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0%
Makaleha to Manuwai	Manage for stability	122	13	0	0	0	1	0	0	0	1	0	1	2%
Waianae Kai	Genetic Storage	4	5	0	0	0	0	0	0	0	0	0	0	0%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		199	1196	0	1	0	2	0	1	0	1	0	1	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement
<b>Action Area: In</b>														
<b>Sanicula marivera</b>														
Keaau	Manage for stability	0	43	43	68	64	0	0	50	30	0	0	30	70%
Ohikilolo	Manage for stability	0	30	58	59	43	0	6	25	17	0	1	18	36%
<b>Action Area: Out</b>														
<b>Sanicula marivera</b>														
Kamaileunu	Manage for stability	5	408	39	76	76	0	0	62	55	0	0	55	100%
Puu Kawiwi	Genetic Storage	0	8	2	3	3	0	0	3	1	0	0	1	50%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		5	489	142	206	186	0	6	140	103	0	1	104	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement
<b>Action Area: In</b>														
<b>Schiedea kaalae</b>														
Mohiakea	No Management	0	0	1	0	0	1	1	0	0	1	1	1	100%
Pahole	Manage for stability	2	0	0	2	2	2	2	2	2	1	0	2	100%
<b>Action Area: Out</b>														
<b>Schiedea kaalae</b>														
Huliwai	No Management	0	0	1	1	1	1	1	1	1	1	1	1	100%
Kahana	Genetic Storage	5	0	4	2	2	7	8	0	0	7	1	7	78%
Kaipapau	No Management	0	0	2	1	1	2	2	1	1	2	1	2	100%
Kaluaa and Waieli	Manage for stability	0	0	1	1	1	1	1	1	1	1	0	1	100%
Maakua (Koolaus)	Manage for stability	10	0	0	1	1	4	4	0	0	4	1	4	40%
Makaua (Koolaus)	Genetic Storage	1	0	0	0	0	1	1	0	0	1	0	1	100%
North Palawai	Genetic Storage	0	0	1	1	1	1	0	1	1	1	0	1	100%
South Ekahanui	Manage for stability	9	2	8	14	12	10	14	10	8	10	8	14	82%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		27	2	18	23	21	30	34	16	14	29	13	34	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	% Completed Genetic Storage Requirement	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal		
<b>Action Area: In</b>															
<b>Schiedea nuttallii</b>															
Kahanahaiki to Pahole	Manage for stability	6	0	38	34	30	2	44	24	8	2	42	42	95%	
Kapuna-Keawapilau Ridge	Manage for stability	0	0	2	2	2	0	2	2	1	0	2	2	100%	
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>		
		6	0	40	36	32	2	46	26	9	2	44	44		



## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	% Completed Genetic Storage Requirement	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal		
<b>Action Area: In</b>															
<b>Schiedea obovata</b>															
Kahanahaiki to Pahole	Manage for stability	0	0	5	5	5	1	0	5	5	1	0	5	100%	
Keawapilau to West Makaleha	Manage for stability	12	524	72	79	79	1	0	78	77	0	0	77	100%	
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>		
		12	524	77	84	84	2	0	83	82	1	0	82		

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	% Completed Genetic Storage Requirement
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	
<b>Action Area: In</b>														
<b>Schiedea trinervis</b>														
Kalena to East Makaleha	Manage for stability	296	351	15	62	61	2	0	61	59	1	0	59	100%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		296	351	15	62	61	2	0	61	59	1	0	59	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement
<b>Action Area: In</b>														
<b>Stenogyne kanehoana</b>														
Haleauau	Manage reintroduction for stability	0	0	1	0	0	1	1	0	0	1	1	1	100%
<b>Action Area: Out</b>														
<b>Stenogyne kanehoana</b>														
Kaluaa	Manage reintroduction for stability	0	0	1	0	0	1	1	0	0	1	1	1	100%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		0	0	2	0	0	2	2	0	0	2	2	2	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement
<b>Action Area: In</b>														
<b>Tetramolopium filiforme</b>														
Kahanahaiki	Genetic Storage	40	0	35	99	62	0	0	60	6	0	0	6	12%
Kalena	Manage for stability	24	93	6	6	5	0	2	6	2	0	2	3	10%
Keaau	Genetic Storage	30	41	0	17	15	0	0	2	1	0	0	1	3%
Makaha/Ohikilolo Ridge	Genetic Storage	300	0	0	0	0	0	0	0	0	0	0	0	0%
Ohikilolo	Manage for stability	2394	1464	38	146	62	0	1	53	7	0	1	7	14%
Puhawai	Manage for stability	0	0	5	4	4	0	0	4	4	0	0	4	80%
<b>Action Area: Out</b>														
<b>Tetramolopium filiforme</b>														
Waianae Kai	Manage for stability	20	0	0	1	1	0	0	0	0	0	0	0	0%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Vaible Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		2808	1598	84	273	149	0	3	125	20	0	3	21	

## Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement
<b>Action Area: In</b>														
<b>Viola chamissoniana subsp. chamissoniana</b>														
Keaau	Genetic Storage	40	10	0	0	0	0	0	0	0	0	0	0	0%
Makaha/Ohikilolo Ridge	Genetic Storage	7	0	0	0	0	0	0	0	0	0	0	0	0%
Ohikilolo	Manage for stability	386	25	0	1	0	0	0	0	0	0	0	0	0%
Puu Kumakalii	Manage for stability	44	0	0	12	0	0	11	3	0	0	11	11	25%
<b>Action Area: Out</b>														
<b>Viola chamissoniana subsp. chamissoniana</b>														
Halona	Manage for stability	22	5	2	4	0	0	4	1	0	0	3	3	13%
Kamaileunu	Genetic Storage	35	0	0	0	0	0	0	0	0	0	0	0	0%
Makaha	Manage for stability	68	11	0	0	0	0	0	0	0	0	0	0	0%
Makaleha	Genetic Storage	18	9	2	8	0	0	11	1	0	0	8	8	40%
Puu Hapapa	Genetic Storage	7	2	4	7	0	0	5	4	0	0	3	3	27%
		<b>Total Current Mature</b>	<b>Total Current Imm.</b>	<b>Total Dead and Repres.</b>	<b>Total # Plants w/ &gt;=10 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=10 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=1 Microprop</b>	<b>Total # Plants w/ &gt;=1 Army Nursery</b>	<b>Total # Plants w/ &gt;=50 Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=50 Est Viable Seeds in SeedLab</b>	<b>Total # Plants w/ &gt;=3 in Microprop</b>	<b>Total # Plants w/ &gt;=3 Army Nursery</b>	<b>Total # Plants that Met Goal</b>	
		627	62	8	32	0	0	31	9	0	0	25	25	

## Tree Snail Monitoring Overview

### BACKGROUND

The Army is responsible for stabilizing *Achatinella mustelina*. This involves management of numerous field sites with 8 geographically expansive locations across the Waianae Mountains. The goal set forth in the Makua Implementation Plan (MIP) 2003 and the Addendum to the MIP 2005 is to achieve a total of 300 *A. mustelina* at each of the 8 locations. The number of field sites is based on 6 (two of which are subdivided), genetically identified, Evolutionarily Significant Units (ESUs) and the number 300 snails was based on Dr. Michael Hadfield's tracking of wild populations within the Pahole Natural Area Reserve (Hadfield and Mountain 1980, Hadfield 1986, Hadfield *et al.* 1993). Monitoring is key in reporting progress toward the MIP goals and an integral part of the Oahu Army Natural Resource Program's (OANRP) tree snail stabilization program. This document is meant to summarize the OANRP prioritization scheme for management and monitoring of wild snail populations and to present and summarize the various monitoring protocols and strategies employed.

Many factors were considered in selecting population reference sites within the 8 geographic regions for management to be designated as 'manage for stability'. Habitat quality was one factor considered and sites with suitable and abundant host trees were favored. In addition, the relative native condition of the habitat was a factor, favoring native-dominated habitat. These are the same factors considered in decisions about where to construct habitat scale ungulate-proof fences (Management Units or MUs). Generally, MU fences were designed to incorporate multiple MIP species, *A. mustelina* being one of those considered in the placement of these fences. In addition, sites with gently sloping or flat terrain were incorporated in anticipation of predator proof-fence construction. Also considered were population numbers at the time of initial surveys. Sites with larger numbers of *A. mustelina* were favored over sites with lower numbers. Maximized management of greater numbers of snails may be achieved by focusing efforts on concentrated populations of snails using rat control grids and predator proof fences. Lastly, predator presence was considered. For example, one factor in selecting Ohikilolo as a site for management of ESU-B was the lack of *Euglandina rosea*. Unfortunately, both *E. rosea* and rats are abundant at all other *A. mustelina* sites. All of the above considerations relate to the relative ability of OANRP, given finite resources, to successfully achieve stability goals, control predators and protect *A. mustelina* in quality habitat.

Tree snail management involves threats that are very numerous and challenging to address. Many remaining populations are small, existing in degraded habitat, have up to three predators to manage per site and threat management techniques are limited. In the final MIP, protecting habitat was a top priority. Therefore, construction of ungulate-proof fences was the top priority. OANRP also initiated rat control using small-scale grids with snap traps and poison baits around tree snail 'hot-spots'. As additional snail locations were discovered across management units, OANRP adopted MU-scale rat control grids using best management practices from colleagues in New Zealand. Lastly, predator control fences were constructed at sites with suitable terrain and high concentrations of tree snails. Construction and planning for additional predator control fences is still underway.

## MONITORING CHALLENGES

The challenging nature of tree snail monitoring cannot be understated as they are cryptic, often occur in low numbers and are mobile. OANRP's monitoring approaches have adapted through the years based on a trial and error and available methods. Each field situation and habitat warrants a different method in order to avoid negative impacts on habitat and to ensure that the method selected is the most suitable for the situation. Tree snails can be very easy to overlook. Snails are often tucked in-between dense foliage and can climb to the upper canopy where they may be out of reach and view of observers. Snails can be on host trees where slope requires the observer to be on rappel (see photo below). Tree snail monitoring is often a game of diminishing returns given an overall trend of decline in wild populations. The fewer snails present at a site, the more difficult it is to obtain reliable data on population trends and status. Tree snails are mobile, they move between trees, sometimes are found in understory vegetation and at times are observed on the ground. For an animal which appears rather sedentary, it cannot be assumed that snails remain in the same tree for most of their life. In addition, there are ~120 field populations of *A. mustelina*. OANRP cannot realistically dedicate the time and resources necessary to monitor each of these 120 sites intensively, nor is it practical in many cases, particularly at disparate populations with very low numbers where reliable monitoring data is difficult to achieve. Monitoring focus is therefore placed on those sites within habitat fences and tree snail enclosures which are designated 'manage for stability'. Amongst these 'manage for stability' sites, monitoring schedules are based on many factors which are outlined on page 5 in the monitoring prioritization section. The following is a timeline of important dates related to OANRP's tree snail monitoring program.



Vince Costello rappelling to survey habitat in Makaleha.

## MONITORING TIMELINE

1995-2006 Conducted all tree snail monitoring and management under Dr. Michael Hadfield's guidance and permit (TE-826600). Mainly conducted surveys to establish distribution patterns and attempted to conduct population censuses. Used paint pen method and timed count monitoring within the Kahanahaiki enclosure after completion in 1998. Three OANRP staff were included on his permit as Authorized Individuals.

2006: OANRP authorized for some *Achatinella* activities under Army's permit (TE-043638).

2008 Kevin Hall began graduate studies using pre-printed paper dots with unique alphanumeric codes applied using cyanoacrylic glue to shell of the snail.

2010: Dr. Hadfield's USFWS permit amended to include use of the glue-dot method to mark adult snails. Juvenile snails must be marked with paint pen.

2011: USFWS hires Kevin Hall to write general *Achatinella* monitoring protocols. Protocols emphasize the use of glue dot and paint pen methods with intensive capture mark recapture plot establishment. Protocol defines primary, secondary and tertiary populations and prescribes different monitoring methods for each. OANRP registers concern to FWS with the primary population monitoring protocols based on observed harmful effects to tree snail habitats and host trees because of the intensity and frequency of monitoring conducted.

2011: Authorization to conduct *Achatinella* collection for captive propagation, reintroduction, translocation and release activities under Army's amended USFWS permit. Kevin Hall's unedited *Achatinella* monitoring protocol included as an attachment to the permit despite Army's concerns.

2012: Conduct Pu'u Hapapa snail reintroduction into predator enclosure. Concern raised over paint pen dots eroding shell tips. Literature search raised concern over using glues on *Achatinella*. Use of glues or paints on *Achatinella* ceases.

2014: Snail extinction prevention program conducts field trials with Hotspotter®, photo cataloguing method of tracking individual snails at Palikea enclosure.

2014: OANRP prepares most extensive *Achatinella mustelina* management plan for annual report since 2010. Includes table outlining monitoring plan for each ESU.

## MONITORING TECHNIQUES

OANRP has employed various snail monitoring techniques over the years, each of which is described and discussed below.

### Non-systematic counts:

This form of monitoring is used in association with documenting newly found population reference sites or expansions of previously known sites, as well as anecdotal information about known sites upon planned return visits or happenstance observations during the course of other resource management actions. Counts of snails may encompass either portions or the entirety of the known extent of the site, occur opportunistically during the day or night (when snails are more easily seen), and include unspecified amounts of time spent searching by varying numbers of observers with differing degrees of expertise. Given the cryptic nature of snails, this method does not reveal the total population size, but rather represents a subset of the population, even when the entire extent of the site is surveyed extensively by numerous skilled staff. This method does not provide data that can be compared over time. Much of the snail monitoring by OANRP in previous years has been done in this manner, as alternative forms of monitoring incorporating repeatable methods that provide data comparable over time remained in the experimental stage. As timed-count monitoring (described below) has been found to be an efficient and effective means of tracking population change, OANRP no longer uses non-systematic counts aside from the purposes of making anecdotal observations that are not meant to measure changes in population size.

### Timed-Count Monitoring:



This method is used to monitor population growth. All visible snails are counted within a prescribed area (generally a subset of the areal extent of the population) by a specific number of skilled observers for a predetermined amount of time and time of day (day vs. night). Search aids that may be used (e.g., binoculars, flashlights, etc.) are also specified, and unspecified means of searching (ladders, tree climbing, etc.) may not be used. From this, repeatable measures may be made that are comparable over time. Due to the cryptic nature of snails, and because generally only a portion of the actual extent of the site is monitored, this method does not provide total population size information, but rather provides an index of change over time. However, if detection rates for a given site are known (e.g., by conducting timed-count monitoring following translocation of snails into a new location), population size may be roughly approximated (or a minimum population size if only a portion of the site is monitored). The interval for timed-count monitoring is based on the desired timeline for feedback of information. For example, quarterly monitoring was conducted within the Pu'u Hapapa snail enclosure in order to determine the success of lab snail reintroductions. In addition, translocation of wild snails into an enclosure is also a possible reason for conducting timed-count monitoring on a shorter interval. Given the large number of sites and limited resources for monitoring, most sites are scheduled for monitoring either every 2 or 3 years. OANRP has adopted timed-count monitoring for tracking population change in all sites, and has designated specific protocols and monitoring intervals for each (Chapter 3 in Status Report for the Makua and Oahu Implementation Plans 2014).

#### Capture-Mark-Recapture:

This method is used to estimate population size. Traditionally, this method involves capturing and marking all snails observed within a designated location, and at a later time(s) recapturing all snails observed within the same designated area (using the same number of individuals and time spent searching) to determine the number of marked and unmarked snails. To mark snails, OANRP used a paint pen to apply a colored dot to the tip of the snail's shell. Alternatively, if used in combination with obtaining survival, population viability analysis, and/or immigration data, a unique code may be assigned to individual snails. In association with Kevin Hall's graduate research, this was done by OANRP by adhering two paper punch-outs to the shell, one with a letter and the other a number printed on them, using a small drop of cyanoacrylic glue (see photos below). The total number of snails in the population may then be estimated by various formulae, the simplest (Lincoln-Petersen Method) being:

$$\text{Total \# in population} = \frac{(\# \text{ marked on the first visit}) (\text{total \# captured on the second visit})}{(\# \text{ of marked snails recaptured on second visit})}$$



Paint dot applied to tip of tree snail.



Kevin Hall making paper punch-outs.



Letter-number combination tags.

Implicit in this method are the assumptions that all individuals have an equal chance of being captured on the second visit (i.e., individuals are randomly mixing), and that there is no immigration or emigration. These assumptions are problematic with regards to tree snails, as they are unlikely to be randomly mixing (snails at times may not move for extended periods of time, or may not move very far), while at other times may immigrate or emigrate if not confined to an enclosure. This method may also be problematic when small numbers are captured (as would be the case with many of our sites), as small differences in the number of recaptured snails can make a large difference in the population estimate. As an example, using the formula above, an estimated population size may double if by chance one additional snail happens to be recaptured:

$$\text{Est. pop. size of 10} = \frac{(5 \text{ marked on first visit}) (4 \text{ captured on second visit})}{(2 \text{ marked snails recaptured on second visit})}$$

vs.

$$\text{Est. pop. size of 20} = \frac{(5 \text{ marked on first visit}) (4 \text{ captured on second visit})}{(1 \text{ marked snail recaptured on second visit})}$$

The capture-mark-recapture method was used at Opaepala (for *A. sowerbyana*) and Kahanahaiki (for *A. mustelina*) by OANRP in association with Kevin Hall's graduate research. OANRP decided to discontinue use of this method for several reasons. There were concerns over the use of paint pens and glues, as OANRP observed that snails which had been marked with pens had eroding shell tips, and studies were found indicating glues may be harmful to snails. Because the assumptions inherent in this method are poorly met when applied to tree snails, the accuracy of the resulting population estimate is uncertain. Additionally, the degree of trampling that occurred at Opaepala associated with this form of monitoring was unacceptable. And ultimately, it was determined that the type of information obtained from this method, namely population estimates, is unnecessary with respect to MIP goals of maintaining 300 total snails per ESU. At least (or nearly) 300 snails have been counted via non-systematic counts and/or timed-counts for each ESU, and as discussed above, these counts represent subsets of the total population. From detection rates estimated following translocations of snails (30% at Hapapa, and 37% at Kahanahaiki), it is likely that the counts reflect roughly a third of the actual population, and as such, the goal of 300 snails is far exceeded in each ESU. It was determined that tracking population change via timed-counts produces more meaningful data, and importantly, may be conducted in a manner that does not harm snails.

In recent years, an alternative means has been developed using what is essentially the capture-mark-recapture method, but identifies snails via photography in lieu of marking, using Hotspotter© photo identification software. OANRP is exploring the use of this method, and determining its utility with respect to OANRP's management and goals.

#### Ground-Shell Plots:

Monitoring ground shell plots provides an index of mortality change and is the most direct way to detect rat predation at a site. This method involves establishing a permanently-marked ground-level plot under host trees containing *Achatinella*. The plot is carefully searched for empty shells on the ground. These shells are removed from the plot to an area outside the plot. If a spike in mortality is

observed, efforts may be made to determine and mitigate the cause, such as searching for and removing *Euglandina*, or, if available, may relocate snails into a snail enclosure. If rat predation is identified, managers can respond by increasing rat control until newly predated shells are not found in the plot or, if available, can relocate snails into a snail enclosure. Ground shell plot monitoring in snail enclosures may additionally provide evidence for any adverse responses to translocations. The interval for ground shell plot monitoring is based on the desired timeline for feedback of information. Similarly to timed-count monitoring intervals, more frequent monitoring occurs at the snail enclosures following translocations. Given the large number of sites and limited resources for monitoring, most manage for stability sites are scheduled for monitoring annually.

## MONITORING SCHEDULE

All snail actions, including monitoring actions are scheduled using the Army's program database. The screenshot below is from the database. It shows the information for the timed-count monitoring action for the Achmus.MAK-A population reference site in Makaha. As shown, this action is a priority one. It is also given an "A" rank in the NRM column, the top priority as screened by OANRP's senior program managers. In the action comments section, the detailed baseline survey information is shown. Field crews must retrieve the specific information from the baseline monitoring rare snail observation form to follow. This data can be printed from the OANRP database. Under the action schedule tab (second screenshot below), OANRP managers designate the frequency that this monitoring event will happen each year. The database then folds this action into a comprehensive schedule by area for implementation in the applicable quarter by the field team responsible for this area. Team coordinators ensure that top priority actions are implemented. Lastly, field leaders record the hours spent conducting a given action by clicking on the staff time button at the bottom of this tab. This allows program managers to conduct quality checks and ensure that their priority one actions were implemented. In addition, field crews complete a rare snail observation form to track timed-count results in the database for comparison. These data are reviewed and considered in adapting strategies for management at each respective site.

ScheduleDB\_TeamActions\_Form

### Team Actions and Schedule

Go To Action:  

TeamAction | Action Schedules

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**Action** Unsure of which CEA #?  
Click below

ActionID: 3166 FieldTeam: Foundation Priority: 1 NRM Rank: A

CategoryCode+:   SubCategory: Monitor-Timed Count

Category:   Priority+:   ActionComments: Baseline is Oct 2010, night survey, 3 personnel 2 hours each 6 hour total. See original form for sketch map of survey boundaries. Determine if snails should be moved to MAK-D nr F

**Taxonomic**

TaxonCode: AchMus TaxonCodePopRefSiteID+: AchMus.MAK-A PopRefSiteComments:  

Select "None" if no Taxon (RP Action ONLY)

**Management**

ManagementUnit: Makaha I MU\_Comments:   WCACode+:   ICACode+:   SurveySiteCode+:  

**Ungulates/Predators**

TrailName+:   FenceCode+:   TransectID+:   HuntLocCode+:   SnareGroupCode+:  

PredSiteCode+:   SLCASiteID+:  

Location: Magic Olopua DiscontinueDate:   EditDate: 2015-08-19

DiscontinueReason:  

Close | Enter New Team Action | <Previous Action | Next Action> | Staff Time

### Team Actions and Schedule

Go To Action:  

TeamAction | Action Schedules

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Frequency (old version use below): 1 Use Quarter=0 to for Yearly Frequency

ActionID: 3166 FieldTeam: Foundation Cat: I SubCategory: Monitor-Timed C TaxonCode: AchMus MgmtUnit: Makaha I View Year:  

**Quarter Estimated (to do)**

Year	Quarter	Frequency	ActionQComments
2017	3	1	
2015	3	1	
2014	3	1	
2008	0	1	
*			

**Work Week Action Planned and Completed**

PlanWeekDate	UnPlanned	PlanAction	PauDate	PlanPauComments
2014-08-20	<input type="checkbox"/>	night survey	2014-08-20	
2014-08-18	<input type="checkbox"/>	night survey	2014-08-21	
2014-04-23	<input type="checkbox"/>	MAK-A	2014-04-23	
2013-08-12	<input type="checkbox"/>	survey	2013-08-13	
2013-04-22	<input type="checkbox"/>	snail collections	2013-04-22	
2010-10-13	<input type="checkbox"/>	snail counts	2010-10-13	
2009-06-17	<input type="checkbox"/>	None	2009-06-17	
*				

Yr-Q | 1 of 4 | Search | No Filter

PlanDate | 1 of 7 | Search | No Filter

(Date when Work is Planned- Use Monday for all work that Week) (Pau Date= Staff time worked. AKA Implement Date)

Close | Enter New Team Action | <Previous Action | Next Action> | Staff Time

## MONITORING PRIORITIZATION

The Army must monitor *A. mustelina* in order to provide evidence that there are at least 300 total snails at each managed field site and to monitor population trends. If downward trends are detected, OANRP can investigate the potential cause of the decline. Demonstrating positive population growth indicates that current management is effective. Early identification of predation is another important reason for monitoring. In addition, a balance must be achieved between visiting field sites often enough to check on current population numbers and trends versus over-visitation leading to negative impacts on the habitat and *Achatinella* survivorship. The methods chosen must be carefully selected for each site after considering site characteristics, opportunities and limitations.

The best way to demonstrate the OANRP prioritization and planning approach for *Achatinella* monitoring is via an example. ESU-F, Pu'u Palikea area, will be used to show the nuances involved in determining OANRP *Achatinella* monitoring frequency and the methods applied. Please see the map below which illustrates the spread of *A. mustelina* population reference sites in the Palikea habitat fence. There are 20 sites with snails that fall within this ESU. To illustrate OANRP's monitoring approach for this ESU, the sites close to and within the habitat fence will be used, see the map below. The number of snails known at the site in 2014 is shown in parentheses following the population reference site code.

*Map removed to protect rare resources. Available upon request*

The number of snails observed during surveys varies dramatically between population reference sites. The goal at Palikea is to monitor each population reference site no less than every two years. The monitoring schedule is staggered so that about half of the sites will be monitored each year. This spreads out the workload of snail monitoring across years. In addition, the sites monitored in a given year are geographically spaced across the fenced habitat to ensure that each year OANRP is monitoring a representative sample. The table below is an updated version of the table presented in the *A. mustelina* management chapter in the 2014 annual report.

Ground shell plot monitoring and timed-count monitoring are the two methods currently applied within this ESU. Capture-mark-recapture methods are not currently employed by OANRP as this level of detailed information is not necessary for tracking population numbers relative to the *A. mustelina* stabilization goal. OANRP monitors ground shell plots annually in order to detect predation and respond with increased predator control. In general, ground shell plots are placed at sites with higher densities of tree snails and with larger numbers of individuals to ensure sufficient data will be captured. That being said, within the last year, snails at the two sites where ground shell plots were located, have been translocated into the Palikea snail enclosure. Thus, these plots have been discontinued and new ground shell plots will be installed at the two sites indicated below. The gray-shaded rows are discontinued monitoring actions since last year's report. These have been discontinued mainly due to the removal/translocation of snails at this population reference site into the Palikea snail enclosure.

ESU-F Monitoring Plan for MFS PRS (excerpt from 2014 annual report)

PRS	Monitoring Type	Monitoring Interval	Survey Years	Comments
KAA-A Mauna Kapu	TCM	every 3 years	N/A	Conduct night TCM with 2 personnel 2 hours each, for 4 person-hours total until translocation is complete. Translocation will require up to three visits.  TRANSLOCATED SNAILS (DISCONTINUE)
PAK-A Puu Palikea Ohia Spot	TCM	every 2 years	N/A	Conduct night TCM for 2 person-hours.  TRANSLOCATED SNAILS (DISCONTINUE)
	GSP	annually	N/A	GSP PAK-A-3  TRANSLOCATED SNAILS (DISCONTINUE)
PAK-C Steps	TCM	every 2 years	N/A	Conduct night TCM for 4 person-hours until translocation is complete. Translocation will require up to three visits.  TRANSLOCATED SNAILS (DISCONTINUE)
PAK-D Joel's	TCM	every 2 years	2016, 2018	Conduct night TCM for 8 person-hours, (refer to VC for survey area boundaries from 2008-09-23). Based on results determine if snails should be translocated into enclosure. If translocation recommended, visit 3 times to collect all.
PAK-G Hame	TCM	every 2 years	N/A	Conduct baseline day surveys until translocation is complete. Translocation will require up to three visits.  TRANSLOCATED SNAILS (DISCONTINUE)

PAK-H Hadfield's	TCM	every 2 years	2015, 2017	Conduct baseline day survey, recording hours to use as standard.
PAK-K Pilo	TCM	every 2 years	2015, 2017	Conduct day TCM for 4 person-hours.
	GSP	annually	2015, 2016	Install new GSP. GSP-PAK-K-1
PAK-L Olapa	TCM	every 2 years	2015, 2017	Conduct baseline survey, recording hours to use as standard. Determine night or day TCM based on terrain.
PAK-M Middle	TCM	every 2 years	2016, 2018	Conduct baseline night survey, recording hours to use as standard.
PAK-P Palikea Enclosure	TCM	annually	N/A	Conduct night TCM for 4 person-hour survey. Discontinued, changed to quarterly
PAK-P Palikea Enclosure	TCM	quarterly	2016, 2017	Once translocation is complete conduct night TCM, standard to be determined.
	GSP	quarterly	2016, 2017	Install two new GSPs. GSP-PAK-P-1 and GSP-PAK-P-2
PAK-Q Outside the Enclosure	TCM	every 2 years	2016, 2018	Conduct night TCM for 4 person-hours until translocation is complete. Translocation will require up to three visits.  TRANSLOCATED SNAILS (DISCONTINUE)

Some of the population reference sites are in especially sensitive habitat which are negatively impacted by frequent monitoring events. In particular PAK-M, which has the largest number of remaining individuals, is uluhe fern dominated. If habitat was not a limitation in this situation, OANRP would select PAK-M to install a new ground shell plot because of the high density and total number of tree snails present at this site. Ground shell plots require regularly combing the ground that would lead to considerable ground disturbance. Therefore, this population reference site was not chosen for installation of a ground shell plot.

The table shows two lines for timed-count monitoring at PAK-P, the Palikea snail enclosure. Initially, OANRP were conducting TCM within the enclosure on an annual basis. The annual frequency was selected because, at the completion of the enclosure construction, the site was not the primary focus of tree snail stabilization efforts. Since this time, Jackson's chameleon presence at Palikea was not confirmed and management via the rat control grid alone was showing stable to increasing numbers at population reference sites. Since declining trends have been observed and Jackson's within the Palikea MU, OANRP has begun translocating snails into the enclosure. Thus, OANRP has switched to quarterly TCM in order to track the population changes over time more closely within the enclosure. This

approach follows the monitoring timeline and methods employed at the Pu'u Hapapa and Kahanahaiki enclosures.

## CONCLUSIONS

Many factors have affected the Army's snail monitoring approach through the years. This document is an attempt to illustrate the biology behind tree snail monitoring priorities, methods and schedule to the U.S. Fish and Wildlife Service. This information dovetails with the extensive *A. mustelina* plan presented in the 2014 annual report.

## Literature Cited

Hadfield, M.G. and B.S. Mountain. 1981. A field study of a vanishing species, *Achatinella mustelina* (Gastropoda, Pulmonata), in the Waianae Mountains of Oahu. *Pacific Science*, 34: 345-358.

Hadfield, M.G. 1986. Extinction in Hawaiian Achatinelline snails. *Malacologia* 27: 67-81.

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## Hawaiian Hoary Bat

### ***Acoustic and Thermal IR Monitoring Project for Tree Removal at Nehelani on Schofield Barracks 17-29 June 2015***

*Data prepared by C. Pinzari, for OANRP, July 2015*

#### **Survey Goals**

Establish whether or not Hawaiian Hoary bats (*Lasiurus cinereus semotus*) are roosting with pups on four trees that are required to be removed for a construction project. The trees to be removed are (1) Mango (*Mangifera indica*), (1) Coconut palm (*Cocos nucifera*) and (2) Chinese Banyans (*Ficus microcarpa*). If bats present, discuss with regulatory agency possible mitigation measures to continue project or postpone removal of trees until pupping season is completed.

#### **Survey Map**

*Map removed to protect rare resources. Available upon request*

Figure 1. Map of the Nehelani construction project site which received bat acoustic survey. Green dots indicate location of the two acoustic detectors at the site.

## **Survey Methods**

Acoustic surveys for bats were conducted from 17-29 June 2015 at the proposed tree cutting site for a total of 12 nights. Two SM2Bat+ ultrasonic “bat detector” (Wildlife Acoustics) were placed about 80 meters apart, on either end of the row of trees proposed to be removed (Figure 1).

Bat detectors were set to record bat echolocation calls or “pulses” from dusk until dawn, and a bat “event” was triggered, recorded as a sound file, and logged for each pass a flying bat made by the microphone of a detector during the night. The number of bat events and number of echolocation pulses within an event can be used to confirm bat presence and describe bat activity levels. Bat events can also contain information on foraging activity, by the presence of characteristic echolocation pulses that form a “feeding buzz”. Files collected during the recordings were scanned and filtered for bat presence using the program Kaleidoscope (version 1.1.22, Wildlife Acoustics) and visually inspected by sound and sight to confirm and count bat echolocation pulses. Foraging activity was also noted in call events containing feeding buzzes. Bat detectability (p), signifying presence or absence of the species for each survey was calculated using the program Presence (version 6.2, J.E. Hines, USGS). These acoustic surveys can detect whether bats are actively using the area within the range of the detectors with any frequency. The effective range of these detectors is upwards of about 50 m (C. Pinzari pers. comm.) A high detection rate could indicate the presence of a roost tree within the detection range. Whereby further surveys with a thermal imager would be required.

Visual surveys for bats were conducted on 29 June 2015, the day of the scheduled tree removal. A Fluke Ti400 thermal imager was employed to scan the tree for any roosting bats as well to confirm no presence. Scanning commenced from about 05:40 and completed around 07:00 from the ground scanning from different angles and locations around the two trees. An aerial bucket was also on site as an extra resource to scan higher in the tree.

## **Results and Discussion**

Survey results show no measure of bat detectability at this location during the acoustic survey period. No bats were recorded passing through or utilizing the site during this time. The visual thermal IR survey detected no bats at all. Multiple species of birds were observed with the thermal IR, with visual confirmation, in and around the area. It was determined that there would be ‘No Effect’ to bats if the trees were removed.

## **Recommendations**

Continue to utilize acoustical surveys to determine bat presence in these small well defined areas with low numbers of trees. Bat detectors can be placed within 40 meters of each other so that there is overlap in effective detection distance. If a bat is using the area around the detector frequently it is expected that there would be more activity, more passes, longer files, more than 1 per night, or more than 1 night. If bat activity is higher in a specific area then the thermal IR should be used to verify bat roosting.

## Hawaiian Hoary Bat

### ***Thermal IR Monitoring Project for Tree Removal at Vought Street on Wheeler Army Airfield 25 June 2015***

*Data prepared by C. Pinzari, for OANRP, June 2015*

#### **Survey Goals**

Establish whether or not Hawaiian Hoary bats (*Lasiurus cinereus semotus*) are roosting with pups on two Coconut palm trees (*Cocos nucifera*) that are required to be trimmed for safety reasons. The trees were not trimmed prior to the pupping season so they still contained falling coconuts directly over residences. If bats present, discuss with regulatory agency possible mitigation measures to continue project or postpone removal of trees until pupping season is completed.

#### **Survey Map**

*Map removed to protect rare resources. Available upon request*

Figure 1. Map of the Vought Avenue project site which received bat acoustic surveys. Green dots indicate location of the trees to be trimmed at the site.

## **Survey Methods**

Visual surveys for bats were conducted on 25 June 2015, the day of the scheduled tree trimming. A Fluke Ti400 thermal imager was employed to scan the tree for any roosting bats as well to confirm no presence. Scanning commenced at about 05:50 (#824 Vought Avenue.) and completed around 07:00 (#762 Vought Avenue) from the ground scanning from different angles and locations around the two trees.

## **Results and Discussion**

The visual thermal IR survey detected no bats at all. Multiple species of birds were observed with the thermal IR, with visual confirmation, in and around the area. It was determined that there would be 'No Effect' to bats if the trees were removed.

## **Recommendations**

Work with DPW to better monitor the contractors work so that trees that need trimming are not missed prior to the pupping season.

## Hawaiian Hoary Bat

### ***Acoustic Monitoring Project for Tree Removal at Maili Street on Schofield Barracks 01-14 July 2015***

*Data prepared by C. Pinzari, for OANRP, July 2015*

#### **Survey Goals**

Establish whether or not Hawaiian Hoary bats (*Lasiurus cinereus semotus*) are roosting with pups on two trees that are required to be removed for a construction project. The trees to be removed are (1) Kukui nut (*Aleurites moluccanus*) and (1) *Eucalyptus spp.* If bats are present, discuss with regulatory agency possible mitigation measures to continue project or postpone removal of trees until pupping season is completed.

#### **Survey Map**

*Map removed to protect rare resources. Available upon request*

Figure 1. Map of the Maili Street project site which received bat acoustic survey. Green dots indicate location of the two trees to be removed at the site.

## **Survey Methods**

Acoustic surveys for bats were conducted from 01-14 July 2015 at the proposed tree cutting site for a total of 13 nights. One SM2Bat+ ultrasonic “bat detector” (Wildlife Acoustics) was placed between the two trees proposed to be removed (Figure 1). The trees are only about 5 meters apart.

Bat detectors were set to record bat echolocation calls or “pulses” from dusk until dawn, wherein each bat “event” is triggered, recorded as a sound file, and logged for each pass a flying bat makes by the microphone of a detector during the night. The number of bat events and number of echolocation pulses within an event can be used to confirm bat presence and describe bat activity levels. Bat events can also contain information on foraging activity, by the presence of characteristic echolocation pulses that form a “feeding buzz”. Files collected during the recordings were scanned and filtered for bat presence using the program Kaleidoscope (version 1.1.22, Wildlife Acoustics) and visually inspected by sound and sight to confirm and count bat echolocation pulses. Foraging activity was also noted in call events containing feeding buzzes. Bat detectability (p), signifying presence or absence of the species for each survey was calculated using the program Presence (version 6.2, J.E. Hines, USGS). These acoustic surveys can detect whether bats are actively using the area within the range of the detectors with any frequency. The effective range of these detectors is upwards of about 50 m (C. Pinzari pers. comm.) A high detection rate could indicate the presence of a roost tree within the detection range. Whereby further surveys with a thermal imager would be required.

## **Results and Discussion**

Survey results show an extremely low measure of bat detectability at this location during the acoustic survey period. A single bat pass was recorded on 2 July at 20:22:26. It was a very short file, with three pulses of echolocation. This type of flight is considered a fly by, whereby the animal is just flying through to visit another site (C. Pinzari pers. comm.). It was determined that there would be ‘No Effect’ to bats if the trees were removed.

## **Recommendations**

Continue to utilize acoustical surveys to determine bat presence in these small well defined areas with low numbers of trees. Bat detectors can be placed within 40 meters of each other so that there is overlap in effective detection distance. If a bat is using the area around the detector frequently it is expected that there would be more activity, more passes, longer files, more than 1 per night, or more than 1 night. If bat activity is higher in a specific area then the thermal IR should be used to verify bat roosting.

## Hawaiian Hoary Bat

### ***Thermal IR Monitoring Project for Tree Removal at Schofield Barracks Building 684 on 28 July 2015***

#### **Survey Goals**

Establish whether or not Hawaiian Hoary bats (*Lasiurus cinereus semotus*) are roosting with pups on a Chinese arbovitae (*Platyclusus orientalis*) that is infested with termites so requires removal for safety reasons. If bats present, discuss with regulatory agency possible mitigation measures to continue project or postpone removal of trees until pupping season is completed.

#### **Survey Map**

*Map removed to protect rare resources. Available upon request*

Figure 1. Map of the SB Bldg 684 project site which Fluke thermal imager surveys. Green dot indicates location of the tree to be removed at the site.



Figure 2. Chinese arbovitae (*Platyclusus orientalis*) on site

### **Survey Methods**

Visual surveys for bats were conducted on 28 July 2015, the day of the scheduled tree trimming. A Fluke Ti400 thermal imager was employed to scan the tree for any roosting bats as well to confirm no presence. Scanning commenced from 05:30-05:43 from the ground from different angles and locations.

### **Results and Discussion**

The visual thermal IR survey detected no bats at all. Multiple species of birds were observed with the thermal IR, with visual confirmation, in and around the area. It was determined that there would be 'No Effect' to bats if the trees were removed.

### **Recommendations**

Work with DPW to better monitor the contractors work so that trees that need trimming are not missed prior to the pupping season.



***Thermal IR Monitoring Project for Tree Removal at Schofield Barracks Credit Union and Warrior Transition Battalion on 28 July 2015***

**Survey Goals**

Establish whether or not Hawaiian Hoary bats (*Lasiurus cinereus semotus*) are roosting with pups on two Mexican fan palms (*Washingtonia robusta*), two Coconut palms (*Cocos nucifera*), 16 Royal palms (*Roystonea regia*), eight Loulu palms (*Pritchardia* spp.) and five queen palms (*Syagrus romanzoffiana*) that require trimming for safety reasons. If bats present, discuss with regulatory agency possible mitigation measures to continue project or postpone removal of trees until pupping season is completed.

**Survey Map**

*Map removed to protect rare resources. Available upon request*

Figure 1. Map of the SB Credit Union and Warrior Transition Battalion project site which Fluke thermal imager surveys. Red dot indicates location of the site.

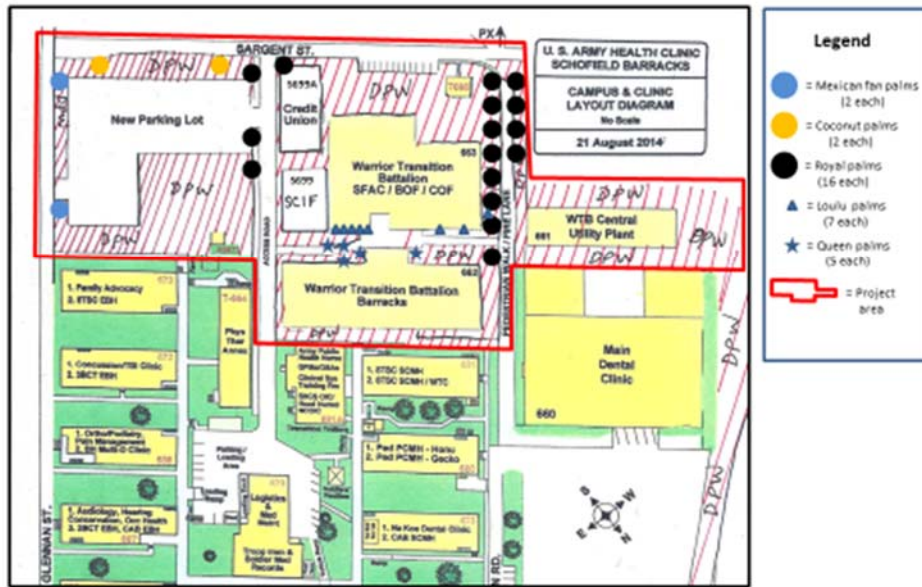


Figure 2. Map of palm locations

### Survey Methods

Visual surveys for bats were conducted on 28 July 2015, the day of the scheduled tree trimming. A Fluke Ti400 thermal imager was employed to scan the tree for any roosting bats as well to confirm no presence. Scanning commenced from 05:45-06:30 from the ground from different angles and locations.

### Results and Discussion

The visual thermal IR survey detected no bats at all. Multiple species of birds were observed with the thermal IR, with visual confirmation, in and around the area. It was determined that there would be No Effect to bats if the trees were removed.

### Recommendations

Work with DPW to better monitor the contractors work so that trees that need trimming are not missed prior to the pupping season.



Figure 3. Photo samples of the palms on site



REPLY TO  
ATTENTION OF

**DEPARTMENT OF THE ARMY**  
**US ARMY INSTALLATION MANAGEMENT COMMAND, PACIFIC REGION**  
**HEADQUARTERS, UNITED STATES ARMY GARRISON, HAWAII**  
**745 WRIGHT AVENUE, BUILDING 107, WHEELER ARMY AIRFIELD**  
**SCHOFIELD BARRACKS, HAWAII 96857-5000**

IMHW-ZA

MEMORANDUM FOR All Military Personnel, Contractors and Department of Defense Civilian Employees within United States Army Garrison, Hawaii (USAG-HI) Installations

SUBJECT: Policy Memorandum 72, Tree Cutting Moratorium

1. References.

a. Army Regulation (AR) 200-1, Environmental Protection and Enhancement, 13 December 2007.

b. Federal Endangered Species Act (1973).

2. Applicability. This policy applies to all Soldiers, civilians, family members, contractors, and other personnel who work on, reside on, or visit any U.S. Army installation, facility, or work site on the Island of Oahu.

3. Policy.

a. In February, 2014, the Natural Resource Program (NRP) discovered the presence of the Federally listed endangered species, Hawaiian Hoary Bat, *Lasiurus cinereus semotus*, at Schofield Barracks West Range. In addition, the NRP discovered the presence of the bat in Schofield Barracks East Range in Spring 2013. Bats have also been found by the US Geological Survey in numerous locations on Oahu spanning from Waikiki to Ford Island to the Waianae Mountains to the North Shore of Oahu. For this reason, bats are now considered to be ubiquitous on Oahu.

b. The Army is required to consult with the US Fish and Wildlife Service (USFWS) anytime an action may affect a listed threatened or endangered species or their critical habitat. In the meantime, the Army must practice avoidance.

c. The NRP is in the process of preparing a formal consultation package for the USFWS. Until a Biological Opinion is received from the USFWS, the following measures must be followed to maintain compliance with the Federal Endangered Species Act (1973):

(1) During the bat pupping season, 1 June to 15 September, there shall be no cutting or trimming of any tree over 15 feet tall.

(2) If a tree falls on its own that is over 15 feet tall, the Army may remove the tree.

IMHW-ZA

SUBJECT: Policy Memorandum 72, Tree Cutting Moratorium

(3) In case of an emergency situation, for example, a tree larger than 15 feet tall is threatening a power line, the staff must contact the Natural Resource Program for guidance, prior to cutting the tree.

(4) This policy applies to all Army installations on the island of Oahu, including housing. The policy pertains to cantonment as well as the actual training areas.

(5) This policy is in place until further notice.

4. Proponent. The proponent for administration of the Tree Cutting Moratorium is DPW, Environmental Division, at 655-9189.

RICHARD A. FROMM  
COL, AD  
Commanding

**Army Regulation 200-1**

Environmental Quality

**Environmental  
Protection and  
Enhancement**

Headquarters  
Department of the Army  
Washington, DC  
13 December 2007

**UNCLASSIFIED**

# ***SUMMARY of CHANGE***

AR 200-1

Environmental Protection and Enhancement

This administrative revision, dated 13 December 2007--

- o Updates the policy regarding Army Program Guidance Memorandum (para 15-1).
- o Corrects typographical errors throughout the publication.

Headquarters  
Department of the Army  
Washington, DC  
13 December 2007

\*Army Regulation 200–1

Effective 27 December 2007


## Environmental Quality

### Environmental Protection and Enhancement

By Order of the Secretary of the Army:

GEORGE W. CASEY, JR.  
*General, United States Army*  
*Chief of Staff*

Official:

  
JOYCE E. MORROW  
*Administrative Assistant to the*  
*Secretary of the Army*

**History.** This publication is an administrative revision. The portions affected by this administrative revision are listed in the summary of change.

**Summary.** This regulation covers environmental protection and enhancement and provides the framework for the Army Environmental Management System.

**Applicability.** This regulation addresses environmental responsibilities of all Army organizations and agencies. Specifically, this regulation applies to—

- (a) Active Army, Army National Guard/Army National Guard of the United States, and United States Army Reserve.
- (b) Tenants, contractors, and lessees performing functions on real property under jurisdiction of the Department of the Army (for example, Army and Air Force Exchange Service (AAFES), Defense Commissary Agency (DECA)).
- (c) Activities and operations under the purview of the Army even when performed off of installations.
- (d) Formerly used defense sites (FUDS) and other excess properties managed by the Army. As used throughout this regulation, the term Army National Guard includes the Army National Guard of the United States.

Installations and facilities in foreign countries will comply with requirements of this regulation that specifically prescribe overseas requirements.

Contracts to operate Government-owned facilities will reference this regulation and will designate by specific citation the applicable provisions.

This regulation does not apply to civil works (CW) functions under the jurisdiction of the U.S. Army Corps of Engineers (USACE).

The terms "Army environmental programs" and "Army Environmental Program" must be read in context. All Army organizations, regardless of their organizational level or chain of command, have environmental responsibilities as part of their functions; these environmental responsibilities must be incorporated into the planning, programming, budgeting, and execution of their respective missions. The Assistant Chief of Staff for Installation Management, working through the Director of Environmental Programs (see Responsibilities, para 1–13x), has specific and more narrowly defined responsibilities that are planned, programmed, budgeted, and executed via assigned accounts. These accounts resource specifically prescribed and focused environmental efforts. Each organization must program and fund its environmental activities from the appropriate account of the proponent's operating budget, not necessarily an environmental account. Being mindful of the context in which requirements are articulated will help define the scope of the "program" being addressed and will preclude inappropriate resourcing decisions or expectations.

**Proponent and exception authority.** The proponent of this regulation is the Assistant Chief of Staff for Installation Management. The proponent has the authority to approve exceptions or waivers

to this regulation that are consistent with law and regulations. The proponent may delegate this approval authority, in writing, to a division chief within the proponent agency or its direct reporting unit or field operating agency, in the grade of colonel or the civilian equivalent. Activities may request a waiver to this regulation by providing justification that includes a full analysis of the expected benefits and must include formal review by the activity's senior legal officer. All waiver requests will be endorsed by the commander or senior leader of the requesting activity and forwarded through their higher headquarters to the policy proponent. Refer to AR 25–30 for specific guidance.

**Army management control process.** This regulation contains management control provisions and identifies key management controls that must be evaluated.

**Supplementation.** Supplementation of this regulation and establishment of command or local forms are prohibited without prior approval from Assistant Chief of Staff for Installation Management, 600 Army Pentagon, Washington, DC 20310–0600.

**Suggested improvements.** Users are invited to send comments and suggested improvements on DA Form 2028 (Recommended Changes to Publications and Blank Forms) through the chain of command to HQDA, DAIM–ED, 600 Army Pentagon, Washington, DC 20310–0600.

**Distribution.** This publication is available in electronic media only and is intended for command levels C, D, and E for the Active Army, the Army National Guard/Army National Guard of the United States and the United States Army Reserve.

\*This regulation supersedes AR 200–1, dated 28 August 2007.



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## Chapter 1 Introduction

### Section I General

#### 1–1. Purpose

*a.* This regulation implements Federal, State, and local environmental laws and DOD policies for preserving, protecting, conserving, and restoring the quality of the environment. This regulation should be used in conjunction with 32 Code of Federal Regulations (CFR) Part 651 (32 CFR 651), which provides Army policy on National Environmental Policy Act (NEPA, 42 USC 4321–4347) requirements, and supplemental program guidance, which the proponent of this regulation may issue as needed to assure that programs remain current. Environmental stewardship includes, but is not limited to—

- (1) Environmental components of installation sustainability.
- (2) Environmental support to the Army training and testing mission.
- (3) Environmental support during deployments and contingency operations on and off the installation, and operations at Army facilities that are not officially designated as installations.
- (4) Compliance-related Cleanup (CC) Program.
- (5) Army Defense Environmental Restoration Program (DERP).
- (6) Formerly used defense sites (FUDS).
- (7) Defense and State Memoranda of Agreement/Cooperative Agreement (DSMOA/CA) Program.
- (8) Pollution prevention.
- (9) Compliance with environmental legal mandates.
- (10) Natural resources.
- (11) Cultural resources.
- (12) Environmental protection aspects of pest management.
- (13) Environmental training for military and civilian personnel.
- (14) Base realignment and closure (BRAC) environmental program.
- (15) NEPA requirements.
- (16) Operational noise.
- (17) Environmental quality technology (EQT).
- (18) Environmental Legislative/Regulatory Analysis and Monitoring Program (EL/RAMP).
- (19) Environmental reporting and information management.
- (20) Environmental considerations in real estate and materiel acquisition programs.

*b.* This regulation defines the framework for the Army Environmental Management System (EMS). All appropriate facilities were to have implemented a mission focused EMS by the end of calendar year (CY) 05, and must attain International Organization for Standardization standard 14001 (ISO 14001) conformance by the end of FY09. The Army EMS Commanders Guide, Army EMS Implementer's Guide, and Army EMS Aspects and Impact Methodology for Army Training Ranges provide detailed implementation guidance.

*c.* The chapters of this regulation reflect inclusion of the five interconnected EMS areas of policy, planning, implementation and operation, checking and corrective action, and management review.

(1) *Policy.* The Army Environmental Policy Statement reflects the Army's commitment to environmental protection and enhancement, pollution prevention, and continual improvement (chap 2).

(2) *Planning and implementation.* The Army will identify how its operations impact the environment. It will set objectives and targets for reducing impacts. It will identify and track applicable legal and other requirements, and will support operational effectiveness and improve program management (chap 3).

(3) *Program management and operation.* The Army will assign roles and responsibilities for environmental management (section II of this chap), provide required environmental training, establish procedures for communication within and outside the organization, document environmental procedures, and provide for emergency preparedness and response (chap 15).

(4) *Checking and corrective action.* The Army will monitor and measure its progress in achieving stated goals, objectives, and targets, and will identify and implement corrective actions (chap 16).

(5) *Management review.* The Army will periodically review program performance and management system implementation and ensure continual improvement (chap 17).

#### 1–2. References

Required and related publications and prescribed and referenced forms are listed in appendix A.

### 1-3. Explanation of Abbreviations and Terms

Abbreviations and special terms used in this regulation are explained in the glossary.

## Section II Responsibilities

### 1-4. The Secretary of the Army

The Secretary of the Army (SA) serves as trustee for the natural and cultural resources managed by the Army. The SA is responsible for protecting and sustaining the quality of the air, land, and water resources entrusted to the Army. The SA signs the Army Environmental Policy Statement and certifies that the Army Environmental Program Objective Memorandum (POM) for the Army Environmental Restoration Program (ERP) meets all legal requirements and agreements.

### 1-5. The Assistant Secretary of the Army (Installations and Environment)

The Assistant Secretary of the Army (Installations and Environment) (ASA(I&E)) has primary responsibility for the Army's military environmental programs (that is, other than civil works (CW) functions of the U.S. Army Corps of Engineers (USACE)). Those responsibilities are carried out through the Deputy Assistant Secretary of the Army (Environment, Safety, and Occupational Health) (DASA(ESOH)) who will—

*a.* Provide overall policy, advocacy, program direction, and oversight across installations, logistics, acquisition, and operations. This includes, but is not necessarily limited to, military operations and activities (including training, deployments, and contingency operations) on and off the installation and operations at Army facilities that are not officially designated as installations or sites.

*b.* Establish long-term strategy and annual AEP goals, objectives, and metrics.

*c.* Serve as the Army's top management representative for the Army EMS.

*d.* Provide policy and oversight for EMS responsibilities per ISO 14001 and this regulation.

*e.* Serve as the Army's senior policy level official for historic preservation in accordance with Executive Order (EO) 13287, Preserve America, and as the Federal Preservation Officer for oversight and coordination of Army activities under the National Historic Preservation Act (NHPA), including approving and signing Army National Register of Historic Places (NRHP) nominations for Federally-owned and -controlled historic properties.

*f.* Serve as the primary point of contact with the Office of the Secretary of Defense (OSD), Congress, other Federal and State agencies, and other components for environmental matters.

*g.* On behalf of the SA, carry out DOD executive agent (EA) responsibilities for the following OSD programs: Environmental Information Technology Management (EITM), FUDS, DSMOA, Low-Level Radioactive Waste (LLRW), Defense Occupational Health Program (DOHP), National Defense Center for Environmental Excellence (NDCEE), DOD regional environmental coordinators (RECs), DOD Forestry Reserve Account, and environmental-related annexes to Master Data Exchange Agreements.

*h.* Provide policy, advocacy, program direction, and oversight for Formerly Used Defense Sites (FUDS), Base Realignment and Closure (BRAC), and the Army's Defense Environmental Restoration Program.

*i.* Approve selection of Army representative(s) for inter-service and interagency environmental committees.

*j.* Provide oversight and coordination of strategic outreach and communication.

*k.* Provide policy, advocacy, program direction, and oversight of the Army EQT Program.

*l.* Serve as a permanent co-chair of the Environmental Technology Technical Committee (ETTC); consolidate and prioritize Army environmental technology needs and ensure the cost-effective allocation of available resources, consistent with the Army Program Guidance Memorandum (APGM).

*m.* Provide policy, advocacy, program direction, and oversight of environmental support to the Army acquisition process.

(1) In conjunction with the Assistant Secretary of the Army (Acquisition, Logistics, and Technology) (ASA (ALT)), annually review Army environmental quality research, development, test, and evaluation (RDT&E) efforts.

(2) Provide representation on the Overarching Integration Product Teams (OIPT) supporting Army Systems Acquisition Review Councils (ASARC) to ensure Army material in all acquisition categories meet requisite environmental criteria prior to milestone reviews.

(3) Provide recommendations to the Milestone Decision Authority regarding program environmental quality requirements.

*n.* Review all Army weapons system acquisition programs for potential or real impacts to environmental quality and/or Army installations.

*o.* Review Army weapons system acquisition program environmental quality costs by participating on the Army Cost Review Boards (CRB) and providing representation on weapons system cost working group Integrated Product Teams (IPTs).

- p.* Develop and approve funding policies for environmental programs in coordination with the Assistant Secretary of the Army (Financial Management & Comptroller) (ASA (FM&C)), and with the ASA (ALT) for RDT&E efforts.
- q.* Approve Army environmental input to Program Objective Memorandum (POM) direction, priorities, and guidance.
- r.* Approve AEP POM and budget submissions, resource allocations, unfinanced requirements (UFRs), and budget adjustments recommended by the ACSIM in coordination with the DCS, G-8 and the ASA (FM&C).
- s.* Ensure that the Army's trust responsibility and government-to-government relationship with Federally-recognized Indian Tribes are fulfilled.
- t.* Approve NHPA compliance agreements, as required.
- u.* Approve and integrate the Army Environmental Policy Institute (AEPI) and U.S. Army Environmental Command (USAEC) annual work plans.
- v.* Provide supervision and program direction for the AEPI, to include POM, budget, and UFR approvals.
- w.* Consult with the ACSIM on selection of the Director of Environmental Programs (DEP).
- x.* Serve as the intermediate rater for the DEP and Commander, USAEC, and provide input into their performance objectives.
- y.* Act as co-chair with the ACSIM for the HQDA Environmental Quality Control Committee (EQCC).
- z.* Provide direction and delegate specific actions to the Army DOD RECs.
- aa.* Manage the operation of the regional environmental offices (REOs).
- ab.* Serve a permanent co-chair of the DOD Operational and Environmental Executive Steering Committee on Munitions (OEESCM).
- ac.* Report annually to the SA/CSA on AEP execution.
- ad.* Serve as point of contact for external audits of the AEP.
- ae.* Provide Congressional testimony and reports to Congress.
- af.* Provide programmatic environmental scoping and planning to include National Environmental Policy Act (NEPA) and Strategic Environmental Assessment (SEA).
- ag.* Oversee AEP support to natural and built environments, to include ranges.
- ah.* Ensure the AEP addresses overseas installations and activities.
- ai.* Integrate energy, pollution prevention, and EMS.
- aj.* Integrate ESOH programs and activities with force protection and national security.
- ak.* Execute the EL/RAMP.

#### **1-6. The Assistant Secretary of the Army (Financial Management and Comptroller)**

The Assistant Secretary of the Army (Financial Management and Comptroller) (ASA (FM&C)) will—

- a.* Issue planning, programming, budgeting, and execution (PPBE) system policy, Funding Authorization Document (FAD) footnotes for the Conservation Reimbursable Forestry and Agricultural/Grazing Outlease Programs, guidance for environmental programs, and Fish and Wildlife Conservation Fund (21X5095) apportionments, in coordination with the ASA (I&E).
- b.* Develop an independent cost estimate (ICE) that includes an environmental quality life cycle cost estimate (EQLCCE) for each weapons system. Reconciles differences in the EQLCCE, and the program office estimate (POE) in developing the Army cost position (ACP).
- c.* Collect and report environmental liabilities for the Army's Financial Statement.

#### **1-7. The Assistant Secretary of the Army (Acquisition, Logistics, and Technology)**

The Assistant Secretary of the Army (Acquisition, Logistics, and Technology) (ASA (ALT)) will—

- a.* Provide policy, guidance, oversight, and technical assistance to acquisition program managers and program executive offices as required to ensure integration of environmental quality considerations in all aspects of acquisition programs.
- b.* Plan, program, budget, and execute the Army's Environmental Quality Technology Program (for EQT Budget Activity 1, 2, and 3 Program initiatives) in coordination with the ASA (I&E) to maximize the ability of the Army to achieve its environmental strategy.
- c.* Develop policy to ensure procurement of materiel designed to minimize environmental impacts throughout its life cycle, while ensuring operational effectiveness.
- d.* Develop policy in coordination with the ASA (I&E) on acquisition of hazardous material.
- e.* Develop and oversee initiatives to reduce the volume and toxicity of hazardous materials and ozone depleting substances (ODS) used in Army materiel.
- f.* Review annually Army environmental quality technology program RDT&E efforts in conjunction with the ASA (I&E).
- g.* Designate the Director, Research and Laboratory Management, OASA(ALT), a permanent co-chair of the Environmental Technology Technical Committee (ETTC), who in conjunction with the ACSIM, consolidates and



prioritizes Army environmental technology needs and ensures the cost-effective allocation of available resources, consistent with the APMG.

*h.* Integrate environmental considerations/awareness into acquisition programs and training in accordance with DODD 5000.1.

*i.* Ensure that environmental quality life cycle costs are clearly identified in the Program Office Estimate.

*j.* Serve as the proponent for the Army Green Procurement Program (GPP) to facilitate compliance with Affirmative Procurement requirements (for recovered materials and biobased items) and encourage the acquisition and use of environmentally preferable products and services.

*k.* Ensure all requests for proposal (RFP), contracts, and contract modifications include a requirement that bidders providing goods and services to installations certify (in the Representations and Certifications component of their proposal) that operations of their team (including subcontractors) will be consistent with the installation's and the Army's EMS.

*l.* Incorporate environmental and EMS requirements into appropriate acquisition regulations, policies, and procedures, and appoint a single point of contact for coordinating this action with the ACSIM/DEP.

*m.* Provide direct support to the Army Acquisition Community, Program Executive Officers, and Program/Product/Project Managers regarding environmental and affirmative procurement initiatives, issues and concerns by—

(1) Providing recommendations to the Army Acquisition Executive (AAE) or other decision authority about environmental issues associated with materiel and ASA (ALT) mission functions.

(2) Designating a single point of contact for coordinating environmental issues related to materiel development, logistics, and technology for Headquarters, Department of the Army (HQDA) component organizations in coordination with the Office of the ASA (I&E).

(3) Ensuring execution of environmental policy by acquisition managers.

#### **1-8. The Chief of Public Affairs**

The Chief of Public Affairs (CPA) will—

*a.* Provide policy, guidance, and oversight for public affairs support to the Army's environmental programs.

*b.* Provide advice and recommendations on handling the public affairs aspects of Section 552, Title 5, United States Code (5 USC 552) requests related to the environmental program.

#### **1-9. The Deputy Chief of Staff, G-3/5/7**

The Deputy Chief of Staff, G-3/5/7 (DCS, G-3/5/7) is responsible for developing and coordinating policy, programs, and initiatives to achieve directed levels of training readiness for the Army and serves as the overall integrator of Army Transformation. The DCS, G-3/5/7 will—

*a.* Serve as the focal point for spectrum activities encompassing force development, combat development, training development, resource management, and prioritization.

*b.* Establish priorities and requirements for Army ranges and training lands.

*c.* Exercise overall supervision, direction, and management oversight for the Sustainable Range Program (SRP). Specific responsibility for the SRP resides with the Chief, Training Support Systems Division (DAMO-TRS), who will—

(1) Serve as the HQDA functional proponent for the SRP and its core programs.

(2) Formulate policies and issue administrative programmatic guidance and instructions for implementing and sustaining the core programs within Army Commands (ACOMs), Army Service Component Commands (ASCCs), and Direct Reporting Units (DRUs), the Army National Guard (ARNG), and Headquarters, Installation Management Command (HQ IMCOM).

(3) Formulate policies for planning, programming, operating, and managing ranges and training lands that specify how the Army will—

*(a)* Resource range operations and modernization through the Range and Training Land Program, and land management and maintenance through the Integrated Training Area Management (ITAM) Program.

*(b)* Integrate range requirements into the overall Army infrastructure investment strategy in conjunction with the Office of the Assistant Chief of Staff for Installation Management (OACSIM).

*(c)* Centrally fund unexploded ordnance (UXO) clearance for range modernization projects.

*(d)* Centrally fund the preparation of NEPA documentation for range modernization projects and major training land acquisitions.

*(e)* Coordinate and synchronize range and training land policy to preclude conflicts between range operations and military training, natural and cultural resources management, environmental management, facilities management, and master planning activities.

(4) Serve as the co-chair of the Army Range Sustainment Integration Council (ARSIC).

### **1-10. The Deputy Chief of Staff, G-4**

The Deputy Chief of Staff, G-4 (DCS, G-4) will—

- a.* Identify, program, and secure funds to address the environmental aspects of the functions for which the DCS, G-4 is responsible.
- b.* Incorporate environmental considerations and requirements into all aspects of the DCS, G-4 mission, to include materiel management, integrated logistics support, supply, transportation, maintenance management, and logistics training.
- c.* Serve as the staff proponent for policy development pertaining to hazardous materials minimization and management, to include inventory management per AR 710-2.
- d.* Ensure that timely hazardous material (HM) handling, packaging, and transportation training is provided to Army personnel within the continental United States (CONUS) and overseas as required.
- e.* Serve as the proponent for implementation of the Military Munitions Rule.
- f.* Execute quarantine responsibilities for transport and logistics.

### **1-11. The Deputy Chief of Staff, G-8**

The Deputy Chief of Staff, G-8 (DCS, G-8) will—

- a.* Provide Army cross-PEG (Program Evaluation Group) funding process guidance to assure cost effective compliance with environmental legal mandates while optimizing benefits to the Army missions and operations.
- b.* Assure priority is given to resource allocation that cost effectively resolves environmental aspects that impact missions and operations needed to equip, sustain and train our combat forces.
- c.* Review plans and requirements of Senior Mission Commanders, Army Command/Army Service Component Command/Direct Reporting (ACOM/ASCC/DRU) commanders, acquisition program managers and garrison commanders that address compliance with legal environmental mandates and resolve environmental aspects impacting missions and operations.
- d.* Review plans and requirements for the Army Environmental Program in coordination with the Assistant Chief of Staff for Installation Management (ACSIM).
- e.* Conduct annual review of resources allocated to sustaining Army environmental compliance to overhead investments in the most cost effective manner.

### **1-12. Commander, U.S. Army Corps of Engineers**

The Commander, U.S. Army Corps of Engineers (USACE) will—

- a.* Administer the Clean Water Act (CWA) Section 404 permit program pertaining to the discharge of dredged/fill material into waters/wetlands of the United States.
- b.* Provide additional environmental support to the Army and other DOD elements as requested.
- c.* Provide environmental support to other Federal, State, and local agencies when tasked.
- d.* Provide Army DERP execution support on a reimbursable basis to installations through Districts and the Centers of Expertise for hazardous, toxic, and radioactive waste (HTRW) and for munitions and explosives of concern (MEC).
- e.* Administer the DSMOA/CA Program for the Assistant Deputy Undersecretary of Defense (Environment, Safety, and Occupational Health) (ADUSD (ESOH)).
- f.* Serve as executing agency for the FUDS program, consistent with the FUDS Charter. Establish FUDS requirements and policy guidance for program management, planning, reporting, execution, data access, quality control, and performance measurement.
- g.* Provide technical support by implementing sustainable design and development (SDD) practices, including incorporating SDD/sustainable project rating tool (SPiRiT) and environmental criteria into the Army's project design and construction process. (NOTE: Beginning in FY08, SPiRiT will be replaced by Leadership in Energy and Environmental Design (LEED); all new construction must meet the LEED Silver standard.)
- h.* Incorporate environmental requirements into appropriate USACE activities, and appoint a single point of contact for coordinating this action with the ACSIM/DEP.
- i.* Approve and integrate the USACE Engineer Research and Development Center (ERDC) EQT program and provide overall policy direction for the ERDC.

### **1-13. The Assistant Chief of Staff for Installation Management**

The Assistant Chief of Staff for Installation Management (ACSIM) will—

- a.* Serve as the HQDA proponent for the AEP.
- b.* Establish priorities, guidance, and procedures for installation operations, real property management, and environmental stewardship for all activities and functions within Army garrisons.
- c.* Promote environmental stewardship and sustainability in support of the ASA (I&E).
- d.* Incorporate environmental requirements into appropriate regulations, guidance documents, and procedures to support environmental stewardship.

- e.* Co-chair the HQDA annual Review and Analysis with the ASA (I&E).
- f.* Issue appropriate programming and funding guidance to ACOMs, ASCCs, DRUs, NGB-ARNG, HQ IMCOM, and special installations to support development of the environmental programs component of the Program Objective Memorandum (POM).
- g.* Develop and direct the planning, programming, and budget execution of the environmental components of the Installations Program Evaluation Group (II PEG) programs needed to sustain readiness and comply with appropriate Federal, State, and local laws, Executive Orders, DOD Directives overseas Final Governing Standards, international treaties and Status of Forces Agreements (SOFAs) in accordance with General Order #3 and APGM. This specifically includes base operations support (BOS) service activities addressed by the following Management Decision Packages (MDEPs):
  - (1) VENC (Environmental Compliance).
  - (2) VENN (Environmental Conservation).
  - (3) VEMR (Environmental Support to Ranges and Munitions).
  - (4) VEPP (Pollution Prevention).
  - (5) VEQT (Environmental Technology).
  - (6) ENVR (Environmental Restoration).
- h.* Direct execution of the environmental components of the Installations Program Evaluation Group (II PEG) programs.
- i.* Serve as proponent of the Army Compatible Use Buffer (ACUB) program.
- j.* Perform the EA duties for the DOD Forestry Reserve Account in coordination with the DASA (ESOH).
- k.* Provide representation for environmental and installation concerns on the Army Requirements Oversight Council (AROC).
- l.* Provide guidance on incorporating BRAC oversight and responsibilities on environmental and Military Munitions Response Program (MMRP) through the ACSIM BRAC Division (DAIM-BD).
- m.* As the Army's combat developer (CBTDEV) for installations, generate, validate, and prioritize environmental quality RDT&E requirements.
- n.* Serve as a member of the Environmental Technology Technical Council (ETTC).
- o.* Serve as proponent for Army SDD facility policies that are incorporated into the process of planning, designing, constructing, operating, maintaining, renovating, and disposing installation facilities.
- p.* Serve as the technical advisor to ASA (I&E) for all environmental matters impacting installation sustainment and materiel operation and support.
- q.* Promote and integrate installation sustainability across all functional areas (for example, logistics, environment, training, engineering).
- r.* Maintain an organization within the OACSIM that will—
  - (1) Provide to the ASA (I&E), and others as directed, an Environmental Quality Impact Analysis (EQIA) for major weapons systems acquisition program decision reviews.
  - (2) Provide technical support to the ASA(FM&C) for environmental quality life cycle cost estimates as part of the Army Cost Review process as required.
  - (3) Upon request, assist program managers in integrating environmental quality considerations into all aspects of the acquisition program.
- s.* Issue implementing guidance to eliminate ODS use on Army installations.
- t.* Issue implementing guidance with respect to endangered species critical habitat designation.
- u.* Provide annual authorities for the forestry, agricultural/grazing, and hunting and fishing fee reimbursable programs.
- v.* Serve as initial denial authority and acts on FOIA requests for records pertaining to environmental activities, other than litigation.
- w.* Manage the Environmental Restoration, Army (ER, A) account.
- x.* Manage environmental program responsibilities for base operations support (BOS) through the Office of the Director of Environmental Programs (ODEP). The ODEP will—
  - (1) Serve as the HQDA functional proponent for the Army Environmental Program (AEP).
  - (2) Provide HQDA oversight of the AEP that reflects overall Army compliance, stewardship, sustainability, and readiness priorities.
  - (3) Formulate and issue Army guidance and instructions for implementing and sustaining the AEP.
  - (4) Coordinate AEP requirements with all appropriate organizations to preclude conflicts, and to synchronize activities, among operations and training, real property management, and master planning.
  - (5) Identify, plan, program, budget, support, and defend military resource requirements for the AEP.
  - (6) Exercise primary Army staff (ARSTAF) responsibility to oversee, manage, and coordinate Army military

environmental programs as described in paragraphs 1–1a(1)–1a(20), including resource utilization and progress toward goals and objectives for II PEG funded programs.

- (7) Serve as the proponent for the Army Environmental Awards Program.
- (8) Establish the Configuration Control Management Board (CCMB) to advise the DEP on Army Environmental Reporting matters.
- (9) Develop guidance for implementation, utilization, and coordination of geospatial information and services within the environmental program.
- (10) Exercise primary ARSTAF responsibility to collect, coordinate, and integrate user requirements for the Army EQT Program through the Army Environmental Requirements and Technology Assessment (AERTA) process.
- (11) Participate in the EQT Teams to ensure the Army's EQT user needs are effectively addressed.
- (12) Provide guidance and recommendations on all issues directed to the ACSIM concerning policies and PPBE for the CC Program, Army DERP (including Installation Restoration Program (IRP) and MMRP), BRAC cleanup, and FUDS.
- (13) Provide general oversight, resource requirements verification, and guidance for the execution of the FUDS Program to ensure program execution consistent with the FUDS Charter.
- (14) Provide oversight of the Environmental Performance Assessment System (EPAS).
- (15) Serve as the Executive Secretary to the DOD Operational and Environmental Executive Steering Committee for Munitions (OEESCM) and the HQDA EQCC.
- (16) Serve as the chairman of the DOD Hazardous Waste Management Subcommittee.
- (17) Serve as co-chair of the ARSIC.
- (18) Execute EMS responsibilities per ISO 14001 and this regulation.
- (19) Monitor the execution of the AEP to conform to EMS.
- (20) Establish implementing guidance for Army environmental reporting systems.
- (21) Provide upward reporting on progress in meeting AEP goals and objectives to HQDA leadership, OSD, and Congress.
- (22) Develop appropriate Army-wide standards and metrics for the AEP.
- (23) Designate two ACSIM representatives as voting members on the Armed Forces Pest Management Board (AFPMB). Designate Army senior consultant (ASC) and DOD certification officials for Army civilian personnel per DOD policies and procedures.
- (24) Maintain an efficient and well-trained workforce.
- (25) Coordinate AEP strategic outreach.
- (26) Centrally manage the Conservation Reimbursable Forestry, Agricultural/Grazing Outlease, and Fish and Wildlife Conservation Programs; set installation specific Automatic Reimbursable Authority for forestry and agricultural/grazing at installations.

#### **1–14. Commander, Installation Management Command**

The Commander, Installation Management Command (IMCOM) will—

- a.* Execute sustainable base operations support for all installations under its purview in compliance with applicable laws and regulations (to include Final Governing Standards (FGS), and international agreements overseas) to support the Army training and testing mission.
- b.* Integrate program guidance, goals, and issue across installation functional areas (for example, logistics, environment, training, engineering, and planning).
- c.* Oversee management of installation environmental programs.
- d.* Provide program management reviews for the ACSIM and DASA (ESOH).
- e.* Monitor and track environmental performance of Regional Offices and the US Army Reserve.
- f.* Assist installations in the execution of the Army CC program.
- g.* Develop an annual program management plan (PMP), consistent with the Army Cleanup Strategy and Strategic Plan, for the CC Program.
- h.* Coordinate IMCOM issues that affect mission among senior mission commanders (SMCs), ACOMs, ASCCs, DRUs, and garrisons.
- i.* Coordinate the execution of the EPAS Program for the active Army through USAEC.
- j.* Participate in environmental awards activities as appropriate.
- k.* Review, analyze, perform quality assurance/quality control (QA/QC), and approve environmental requirements and data reported by installations.
- l.* Maintain an efficient and well-trained workforce.
- m.* Coordinate with the DCS, G–3/5/7, ACOMs, ASCCs, DRUs, and Directorate of Plans, Training, Mobilization, and Security (DPTMS) to ensure ITAM Program requirements are implemented in accordance with DAMO–TRS resource allocations and guidance.

- n.* Report progress in meeting AEP goals and objectives to HQDA leadership.
- o.* Provide guidance and assistance to garrisons and monitor the execution of IMCOM's portion of the AEP in accordance with EMS.
- p.* Assist IMCOM installations in negotiations with regulatory agencies to preclude adverse mission impacts or the inadvertent establishment of Army policy that may conflict with regulatory requirements.
- q.* Provide AEP technical implementation support through the Commander, USAEC, who will—
  - (1) Provide environmental technical products and services in support of Army training, operations, acquisition, and sound stewardship.
  - (2) Manage assigned elements of the Army Cleanup Program in accordance with ACSIM direction and guidance. Develop and execute an annual program management plan (PMP), consistent with the Army Cleanup Strategy and Strategic Plan, for the Army DERP.
  - (3) Provide technical support for pest management.
  - (4) Program for and coordinate execution of EPAS for the active Army.
  - (5) Provide program management for the Army DERP at active installations.
  - (6) Execute policy and guidance for Army environmental reporting systems.
  - (7) Provide technical support to the Chief, Training Support Systems Division, Office of the DCS, G-3/5/7 in support of the SRP core programs.
  - (8) Provide technical support and day-to-day operational oversight for Conservation Reimbursable Forestry, Agricultural/Grazing Outlease and Fee Collection Programs.
  - (9) Provide technical support to DASA (ESOH) in support of the ASARC and CRB.
  - (10) Provide technical support to the Army's EQT Program as it relates to installation issues.
  - (11) Provide outreach support to the AEP.
  - (12) Provide public affairs support to the AEP.
  - (13) Maintain an efficient and well-trained workforce.
  - (14) Provide Hazardous Material Management Program (HMMP) operational oversight to the DCS, G-4 for environmental hazardous material management.
  - (15) Perform data collection and analyses of HMMP environmental information to measure program success.

#### **1-15. The Chief, Army Reserve**

The Chief, Army Reserve (CAR) will—

- a.* Ensure environmentally sustainable operations.
- b.* Serve as the primary ARSTAF adviser for all Army Reserve mission-related environmental issues.
- c.* Ensure that Army environmental policy is implemented within the Army Reserve.
- d.* Ensure that environmental stewardship is incorporated into all aspects of the Army Reserve mission.
- e.* Coordinate with IMCOM on matters of mutual interest or concern.

#### **1-16. National Guard Bureau - Director, Army National Guard**

The National Guard Bureau – Director, Army National Guard (NGB-DARNG) will—

- a.* Execute environmentally sustainable base operations support in compliance with applicable laws and regulations to support the Army training and testing mission.
- b.* Ensure the NGB-DARNG acquires, manages and distributes resources; develops and administers policies and programs.
- c.* Serve as the "Channel of Communication" between the Army and the National Guard of the States, Territories and the District of Columbia.
- d.* Serve as the primary ARSTAF advisor for all ARNG environmental issues, and sign or appoint a designated representative to sign all ARNG Federal compliance agreements, consent orders, and environmental assessments, findings of no significant impact, and other pertinent Federal environmental documentation.
- e.* Coordinate with HQDA, State ARNGs, and other organizations to fulfill the NGB-ARNG's ARSTAF role as an Army component, the NGB-ARNGs role as the installation management organization for the State ARNGs, and the NGB-ARNG's role in performing ACOM, ASCC, or DRU functions.
- f.* Specific day-to-day responsibility for the environmental management program resides with the NGB-ARNG Chief of Environmental Programs (CEP). To carry out this responsibility, the NGB-ARNG CEP will—
  - (1) Ensure environmentally sustainable operations and planning.
  - (2) Ensure that Army environmental policy is implemented within the ARNG.
  - (3) Ensure that environmental stewardship is incorporated into all aspects of the ARNG mission.
  - (4) Integrate program guidance, goals, and issues across installation functional areas (for example, logistics, environment, training, engineering) and planning areas.

- (5) Submit environmental base support requirements to the OACSIM. Budget and execute environmental resources consistent with program needs.
- (6) Develop an annual program management plan (PMP), consistent with the Army Cleanup Strategy and Strategic Plan, for the Army CC Program; and provide program management reviews for the ACSIM and DASA (ESOH).
- (7) Provide supplemental implementing guidance and instructions consistent with HQDA guidance for environmental reporting to the states.
- (8) Report progress in meeting AEP goals and objectives to HQDA leadership.
- (9) Provide State ARNGs guidance and assistance, and monitor the execution of the NGB-ARNG's portion of the AEP in accordance with EMS.
- (10) Schedule and conduct all aspects of EPAS audits.
- (11) Review, analyze, perform QA/QC, and approve environmental reporting data submitted by NGB-ARNG installations.
- (12) Assist NGB-ARNG installations in negotiations with regulatory agencies to prevent adverse mission impacts due to Federal natural and cultural resources requirements.
- (13) Support environmental awards activities.
- (14) Maintain an efficient and well-trained workforce.
- (15) At Federally-owned or leased NGB-ARNG installations, facilities, activities and properties—
  - (a) Provide oversight and facilitate coordination in the remediation process.
  - (b) Assist in the management and execution of ER, A-funded NGB-ARNG remediation sites.
- (16) At Non-Federally-owned, Federally-supported NGB-ARNG installations, facilities, activities, and properties, provide guidance, planning, oversight, execution, monitoring, and reporting for NGB-ARNG cleanup sites.

### **1-17. The Judge Advocate General**

The Judge Advocate General (TJAG) will provide legal advice to the Army on all environmental law matters, except those arising out of civil works (CW) and FUDS activities. The Chief, Environmental Law Division (ELD), will exercise those authorities on behalf of TJAG, and will specifically—

- a. Serve as legal advisor to the ACSIM and DEP with regard to all environmental matters.
- b. Advise the Army Secretariat in coordination with the General Counsel.
- c. Provide technical channel supervision, coordination, and advice to all Army lawyers involved in Army environmental matters.
- d. Monitor and provide advice regarding environmental legislation and regulatory developments that affect the Army.
- e. Review and render legal opinions on all draft environmental orders, consent agreements, and settlements with Federal, State, or local regulatory officials (except those arising from FUDS) before signature.
- f. Provide assistance to ACOMs, ASCCs, DRUs, IMCOM, NGB-ARNG, and installations in drafting or negotiating interagency agreements or orders on consent with Federal, State, and local regulators.
- g. Be responsible for representing the Army in Federal and State litigation and for communicating the Army's position in litigation and settlement with the Department of Justice subject to the general oversight of the General Counsel.
- h. Serve as agency counsel for the Army in appropriate administrative cases, hearings, and enforcement actions (ENFs).
- i. Serve as initial denial authority and act on FOIA requests for records pertaining to environmental activities when the records relate to litigation in which the United States has an interest.

### **1-18. The Surgeon General**

The Surgeon General (TSG) will—

- a. Approve human health risk assessments and review environmental hazards and ecological risk assessments.
- b. Provide policy on the human health aspects of Army installation activities and operations, to include those aspects associated with environmental contamination.
- c. Integrate environmental awareness and technical information into the training programs sponsored by the Army Medical Department (AMEDD).
- d. Serve as the Lead Agent for the DOD and as the Army representative in negotiating services with the Agency for Toxic Substances and Disease Registry (ATSDR).
- e. Develop toxicological profiles concerning chemicals and hazardous substances commonly found on military installations. Develop and propose human health and safety environmental standards for chemical agents and explosive compounds, and other unregulated compounds when such standards do not exist.
- f. Identify pollution-related health and ecological effects topics requiring research and development; and initiate needed research in areas where AMEDD has responsibility and provides toxicological and exposure data when required to support human health risk assessments.

- g.* Advise on human health aspects of environmental issues, including the “known and imminent substantial endangerment” (KISE) determination for environmental response actions overseas.
- h.* Provide technical assistance relating to health and, as requested, on environmental aspects of programs and initiatives.
- i.* Coordinate on the human and ecological health risk assessment portions of active installations, BRAC, and FUDS decision documents (DDs).
- j.* Promulgate policy for the disposition of dental, veterinary, medical, and pharmaceutical waste.
- k.* Provide two representatives as voting members on the AFPMB and designate personnel to serve as DOD pest management certification officials for Army uniformed personnel per DOD policies and procedures.
- l.* Coordinate with OACSIM for surveillance, prevention, and control of medically important pests and disease vectors and occupational health exposures from pest management operations.
- m.* Provide health and environmental risk communication support to all Army assets, to include training, consultation, conflict management, and facilitation.
- n.* Develop policy on occupational and public health issues related to Army environmental actions.
- o.* Through the U.S. Army Medical Command (MEDCOM) and the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) will—
  - (1) Plan, organize, budget, and execute medical support to the Army environmental program.
  - (2) Serve as the decision authority for determinations of public health threat arising from Army environmental activities.
  - (3) Provide a broad range of expertise and services in environmental health, occupational health, and preventive medicine to evaluate the health aspects of the Army’s environmental program.
  - (4) Provide environmental health support in all environmental media to Army and other DOD elements, as requested.
  - (5) Assist in the maintenance of the Military Item Disposal Instructions (MIDI) for the DOD.
  - (6) Provide preventive medicine leadership and services to anticipate, identify, assess and counter environmental and occupational health threats.
  - (7) Provide environmental health and occupational health expertise, products and services in support of training, operations, acquisition, research and development to assess the health risks associated with Army environmental programs and activities.
  - (8) Support USAEC with coordination and execution of the EPAS Program.

**1–19. Army Command, Army Service Component Command, and Direct Reporting Unit commanders**

The ACOM, ASCC, and DRU commanders, including those outside the continental United States (OCONUS), as used in this regulation, include the Director, NGB–ARNG when performing an ACOM, ASCC, or DRU role relative to State ARNGs, the State Adjutants General when performing an ACOM, ASCC, or DRU role relative to State ARNGs, and major subordinate commands (MSC). The ACOM, ASCC, and DRU commanders will—

- a.* Consistent with HQDA policy, provide oversight, policy, guidance, and resources to subordinate commands and activities to execute mission-related aspects of the Army’s environmental program, to include: training and deployments; industrial operations; research, technology, and testing activities; operations other than war; and other operations and activities not falling under the direct control of supporting Garrison/Installation commanders.
- b.* Ensure that subordinate units comply with the policies and standards of the installations on which they are tenants.
- c.* Ensure that all subordinate units comply with all applicable laws, regulations, internal directives and goals, EOs, and overseas FGS.
- d.* Fully integrate environmental considerations into ACOM, ASCC, and DRU mission requirements.
- e.* Participate in and fully support all installation internal and external assessments and audits, and implement corrective actions.
- f.* Support environmental awards activities.
- g.* Ensure that assigned environmental staff is efficient and well-trained.
- h.* ACOM, ASCC, and DRU commanders that exercise command and control of installations will execute the same responsibilities listed under paragraph 1–13, Commander, IMCOM, with the following exceptions:
  - (1) Environmental requirements must be submitted through the ACOM, ASCC, DRU, and NGB–ARNG chain of command unless otherwise specified in the ISSA.
  - (2) ACOM, ASCC, and DRU commanders must monitor and track environmental performance at subordinate installations.
- i.* Additionally, the Commander, U.S. Army North (USARNORTH) will—
  - (1) Provide, upon request, personnel/resources support to the National Response Team (NRT) or Regional Response Team (RRT) responding to an environmental emergency. The requester will reimburse the cost of the support.

(2) Serve as the lead for all phases of mobilization, deployment/redeployment operations, and environmental support activities related to national emergencies.

#### **1–20. The Commanding General, U.S. Army Forces Command**

The Commanding General (CG), and U.S. Army Forces Command (FORSCOM) will—

- a. Incorporate environmental planning requirements in mobilization guidance as appropriate.
- b. Coordinate with IMCOM and DCS, G–3/5/7 on environmental support for mission activities, to include training exercises, range operations, and mission MILCON projects.
- c. Provide explosive ordnance disposal (EOD) units for emergency response activities.

#### **1–21. The Commanding General, U.S. Army Materiel Command**

The Commanding General, U.S. Army Materiel Command (CG, AMC) will—

- a. Provide technical assistance to acquisition program managers and program executive offices as required to ensure integration of environmental quality considerations in all aspects of acquisition programs and weapons system's life cycle, such as acquisition, maintenance, disposal, and demilitarization.
- b. Conduct environmental research, development, testing, and evaluation and technical investigations in support of its missions and activities.
- c. Support ASA (ALT) efforts to develop an integrated Army Environmental Quality Science and Technology program, and manage the portion of that program that supports acquisition, logistics, and industrial base user needs.
- d. Coordinate acquisition, logistics, and industrial base user needs with the USACE and the ACSIM in areas impacting installation EQT.
- e. Execute low-level radioactive waste (LLRW) management, including disposal.
- f. Ensure that contracts include provisions for operations at government-owned, contractor-operated (GOCO) facilities to meet and remain compliant with environmental legal mandates and protect the Army from liability and/or fines assessed due to contractor operations.
- g. Review and revise military specifications, standards, and drawings, when appropriate, to eliminate and/or reduce the use of extremely hazardous substances and toxic chemicals. Coordinate this effort with other program offices as required.
- h. Conduct ACOM responsibilities for installations under its purview (see para 1–19).

#### **1–22. The Commanding General, U.S. Army Training and Doctrine Command**

The Commanding General, U.S. Army Training and Doctrine Command (CG, TRADOC) will—

- a. Ensure the development and implementation of environmental training and doctrine programs and products that support military training and readiness operations are consistent with regulatory requirements and Army environmental policies.
- b. Ensure that the U.S. Army Engineer School solicits and prepares environmental training packages as required for Soldiers and makes them available on-line through Army Knowledge Online (AKO) and/or other appropriate websites.
- c. Ensure requirements documents incorporate environmental resources sustainment and lessons learned into all appropriate Army and Joint doctrinal publications and references.
- d. Ensure all training procedures, training manuals, training doctrine, and requirements documents include sound environmental practices and procedures.
- e. Coordinate with the OACSIM regarding establishment of staffing or training standards for all modified tables of organization and equipment (MTOE) and tables of distribution and allowances (TDA) unit designated environmental officers. Ensure environmental officer responsibilities are consistent with regulatory requirements and Army environmental policies.
- f. Ensure organizations/units are designed with equipment and personnel to meet established environmental requirements.

#### **1–23. Senior mission commanders**

Senior mission commanders (SMC) will—

- a. Comply with installation policies, applicable Federal, State, and local environmental laws, regulations, EOs, and overseas FGS and signed agreements.
- b. Participate in the installation's planning, sustainability efforts, and EMS.
- c. Designate a representative to the Environmental Quality Control Committee (EQCC).
- d. Ensure personnel receive appropriate environmental training.
- e. Coordinate testing and fielding of technology with the garrison commander (GC).
- f. Participate in and fully support all installation internal and external assessments and audits, and implement corrective actions.



- g.* Fund environmental requirements not covered in the standard installation services or the ISSA (this does not apply to military units).
- h.* Appoint trained environmental officer(s) to ensure operational compliance and coordination with installation environmental staff.
- i.* Immediately report spills or releases of petroleum, hazardous substances, or hazardous waste (HW) to the GC.
- j.* Participate in the development of integrated natural and cultural resources management plans to ensure they are compatible with and support the mission.
- k.* In conjunction with the GC, ensure environmental requirements that impact ranges and training land are incorporated into the installation range complex master plan.
- l.* Where appropriate, coordinate with JALS-EL early on all environmental agreements, including but not limited to, fine and penalty settlement agreements, prior to signing them.

#### **1-24. Garrison commanders**

Garrison commanders (GC) as used in this regulation include commanders of USAR Regional Readiness Support Commands (RRSCs), State Adjutants General relative to the concept of the State as an installation, OCONUS U.S. Army Garrisons, and GCs as appropriate as determined by the IMCOM, Headquarters NGB-ARNG, and State Adjutants General. The GC will—

- a.* Ensure that Base Support activities support military training and readiness operations, enhance mission accomplishment, and are conducted in a manner conducive to environmental stewardship (see para 1-1a).
- b.* Comply with applicable Federal, State, and local environmental laws, regulations, internal directives and goals, EOs, and overseas FGS.
- c.* Investigate regulatory enforcement actions, complaints, and spills/releases, and correct systemic problems. Document investigation, negotiation, and resolution of enforcement actions and submit through the respective chain of command to ODEP, and through technical legal channels to JALS-EL.
- d.* Ensure environmental requirements that impact ranges and training land are identified and incorporated into the installation range complex master plan. Ensure the affected SMC is made aware of these impacts.
- e.* Ensure installation activities incorporate applicable environmental requirements into all procurement actions.
- f.* Apply for, sign, arrange funding, and maintain all applicable Federal, State and local environmental permits. Incorporate potential mission surge conditions when applying for environmental permits.
- g.* Maintain appropriate environmental records as required by law.
- h.* Record enforcement actions within 48 hours via the Army Environmental Reporting Online (AERO).
- i.* Coordinate with JALS-EL early on all environmental agreements, including but not limited to, fine and penalty settlement agreements, prior to signing them. GCs may not delegate approval or signature authority.
- j.* Ensure that compliance agreements and consent orders that are attributable to a tenant's mission and/or operations are coordinated through applicable legal and command channels to determine the appropriate funding activity.
- k.* Assess the long-term resource impacts of all environmental agreements. Coordinate resource implications for agreements through command channels to IMCOM, NGB-ARNG, ACOMs, ASCCs, or DRUs as appropriate prior to approval.
- l.* Ensure that non-DOD HM (that is, HM owned and/or used by non-DOD entities) is not stored, treated, or disposed of on the installation unless approved by the ASA (I&E), his or her designee, or higher authority.
- m.* Ensure that the installation strategic planning office (or equivalent) incorporates sustainability principles into strategic and other installation management plans; coordinate installation strategic plans with the SMC prior to finalization.
- n.* Implement an installation-wide Hazardous Materials Management Program (HMMP).
- o.* Promote recycling/reuse programs and Green Procurement policies.
- p.* Organize and chair the installation EQCC.
- q.* Organize and chair the installation Technical Review Committee/Restoration Advisory Board (TRC/RAB), as required.
- r.* Implement and maintain a mission-focused EMS in accordance with the ISO 14001 standard. Third party registration to the standard is not required, and environmental funds will not be used for this purpose. However, GCs may pursue third party registration when it provides clear and documented mission benefits.
- s.* Champion the installation EMS and designate an EMS representative in the appropriate organizational planning cell; ensure all planning incorporates the requirements of the EMS.
- t.* Participate fully in EPAS, conduct annual internal environmental compliance assessments, and coordinate assessments with all tenants.
- u.* Prepare and execute the installation corrective action plan (ICAP); coordinate and monitor completion of installation-wide corrective actions.
- v.* Ensure all environmental program plans are completed and implemented per guidance in chapter 3.

- w. Designate personnel who are responsible and accountable for executing major program requirements as prescribed in chapters 4 through 14.
- x. Deposit all proceeds from Conservation Reimbursable Programs as outlined in Section 2665, Title 10, United States Code (10 USC 2665); Section 2667, Title 10, United States Code (10 USC 2667); and Sections 670a and 670b, Title 16, United States Code (16 USC 670a and 670b, Sikes Act).
- y. Serve as the Federal Agency Official with responsibility for installation compliance with the Native American Graves Protection and Repatriation Act (NAGPRA).
- z. Establish government-to-government relations with Federally recognized Indian Tribes and Native Alaskans.
  - aa. Maintain a public affairs program that encourages public involvement.
  - ab. Ensure that the installation master plan incorporates environmental considerations.
  - ac. Identify environmental requirements, forward through command channels, and maintain auditable records.
  - ad. Execute the environmental budget to meet critical requirements.
  - ae. Maintain an efficient and well-trained environmental staff.
  - af. Ensure that Army law enforcement personnel are trained in conservation law enforcement where appropriate.
  - ag. Ensure that sufficient numbers of professionally trained natural resource management personnel and natural resources law enforcement personnel are available and assigned the responsibility to perform tasks necessary to comply with Section 670e, Title 16, United States Code (16 USC 670e).
  - ah. Approve record of decision (ROD)/decision documents (DDs) for environmental response actions within delegated approval authority.
  - ai. Approve integrated natural resource management plans (INRMPs).
  - aj. Hold tenant units accountable for complying with the policies and standards of the installation.
  - ak. Approve annual reports of availability (ROA) for timber sales after review by higher headquarters and USAEC.
  - al. Designate an installation wildland fire program manager and approve the integrated wildland fire management plan.

#### **1–25. Medical Department Activity/Medical Center/Health Service Support Area commanders**

The Medical Department Activity/Medical Center/Health Service Support Area (MEDDAC/MEDCEN/HSSA) commanders will—

- a. Comply with applicable Federal, State, and local environmental laws, regulations, EOs, and overseas FGS.
- b. Manage and dispose of non-*Resource Conservation and Recovery Act* (RCRA) Subtitle C medical, dental, veterinary, pharmaceutical and regulated medical wastes in accordance with AR 40–5 and applicable regulations.
- c. Verify disposal requirements via the MIDI system updated and maintained by USACHPPM.
- d. Ensure that regulated medical waste manifests are only signed by those individuals who have been appropriately trained and are authorized in writing by the activity commander or supervisor.
- e. Appoint a trained environmental officer to ensure operational compliance and coordination with installation environmental staff, to include the coordination of medical waste management plans.
- f. Advise on health aspects of the installation environmental program, and provide technical consultation and support services.
- g. Identify environmental requirements, forward through command channels, and maintain auditable records.

#### **1–26. Tenants**

A tenant is an authorized activity located on an installation that is not part of the garrison organization. This includes, but is not limited to, military units, the Army and Air Force Exchange Service (AAFES), and the Defense Commissary Agency (DeCA). Tenants will—

- a. Comply with installation policies, applicable Federal, State, and local environmental laws, regulations, EOs, and overseas FGS.
- b. Establish an ISSA with the GC that addresses environmental oversight, to include funding responsibilities and facility access (this does not apply to military units).
- c. Participate in the installation’s planning, sustainability, and EMS (note, however, that installations should evaluate their liabilities concerning non-governmental tenants to determine whether any of them can be exempted from the installation EMS).
- d. Designate a representative to the EQCC.
- e. Ensure personnel receive required environmental training.
- f. Participate in all installation internal and external assessments and audits, to include programming for corrective actions.
- g. Fund environmental requirements not covered in the standard installation services or the ISSA (this does not apply to military units).
- h. Identify and submit environmental requirements to the supporting ACOM, ASCC, DRU/higher headquarters (this does not apply to military units).

- i. Identify and coordinate non mission-specific environmental requirements with the GC.
- j. Pay environmental fines and penalties resulting from their mission activities.
- k. Immediately report spills or releases of hazardous substances to the on-scene coordinator (OSC). Pay or reimburse costs associated with cleanup and spill response if not covered in the standard installations services or the ISSA.
- l. Report all instances of non-compliance and notification of enforcement actions to the GC immediately.
- m. Ensure that non-DOD hazardous material is not stored, treated, or disposed of on the installation unless approved by the OASA (I&E), his or her designee, or higher authority.

#### **1–27. Commanders of Government-Owned, Contractor-Operated facilities**

The Commanders of Government-Owned, Contractor-Operated (GOCO) facilities will—

- a. In coordination with the contracting officer, ensure that contracts include provisions for operations at GOCO facilities to meet and remain compliant with environmental legal mandates to protect the Army from liability and/or fines assessed due to contractor operations.
- b. Comply with installation policies, applicable Federal, State, and local environmental laws, regulations, and EOs.
- c. Ensure that contractors assume responsibility for management and disposal of contractor-generated solid and HW.
- d. Ensure that non-DOD hazardous material is not stored, treated, or disposed of on the installation unless approved by the OASA (I&E), his or her designee, or higher authority.
- e. Deposit all proceeds from Conservation Reimbursable Programs as outlined in 10 USC 2665, 10 USC 2667, and 16 USC 670b.
- f. Execute EMS responsibilities in accordance with contract provisions.
- g. Assess the long-term resource impacts of all environmental agreements in coordination with the acquisition community. Coordinate resource implications for agreements through command channels as appropriate prior to approval.
- h. Ensure that all contractor personnel receive appropriate levels of training on environmental awareness, hazardous material/waste management, and the installation EMS.

#### **1–28. Unit commanders**

The unit commanders will—

- a. Instill an environmental ethic in soldiers and civilians under their command.
- b. Ensure personnel receive required environmental training.
- c. Comply with installation policies, applicable Federal, State, and local environmental laws, regulations, EOs, and overseas FGS.
- d. Report noncompliance and spills through appropriate channels to the GC.
- e. Incorporate environmental responsibilities and environmental risk management into unit SOPs and operation orders (OPORDs) as appropriate; integrate environmental considerations into the planning and execution processes in accordance with FM 3–100.4.
- f. Appoint and train environmental officers at appropriate organizational levels to ensure compliance actions take place (see FM 3–34.500 for environmental officer responsibilities).
- g. Support the installation-wide EMS.

## **Chapter 2 Environmental Policy**

### **2–1. Commitment to Environmental Stewardship**

a. The Army is committed to environmental stewardship in all actions as an integral part of its mission and to ensure sustainability.

b. This regulation supports the *Army Strategy for the Environment*, 1 October 2004, which presents the Army's environmental vision as sustainable operations, installations, systems, and communities enabling the Army mission. Under the strategy, the Army's environmental mission is to sustain the environment to enable the Army mission and secure the future. In doing so, all Army organizations and activities will—

- (1) Foster an ethic within the Army that takes us beyond environmental compliance to sustainability.
- (2) Strengthen Army operational capability by reducing our environmental footprint through more sustainable practices.
- (3) Meet current and future training, testing and other mission requirements by sustaining land, air, and water resources.
- (4) Minimize impacts and total ownership costs of Army systems, materiel, facilities, and operations by integrating the principles and practices of sustainability.

(5) Enhance the well being of our soldiers, civilians, families, neighbors, and communities through leadership in sustainability.

(6) Use innovative technology and the principles of sustainability to meet user needs and anticipate future Army challenges.

## **2–2. Army Environmental Policy Statement**

*a.* All Army organizations and activities will comply with applicable Federal, State, and local environmental laws, regulations, executive orders (EOs), or overseas Final Governing Standards (FGS) (see para 15–8 for additional specific overseas requirements); develop and implement pollution prevention and control strategies; and establish environmental priorities in consideration of the benefits to the sustainment of missions and operations.

*b.* All Army organizations and activities will strive to achieve continual improvement in overall environmental performance and supporting management systems.

*c.* All Army organizations will ensure that this policy is implemented, maintained, and communicated to all military and civilian employees and supporting contractors. In addition, this policy will be made readily available to the public upon request.

*d.* All contracts and contract modifications will specify that contractors are liable for any enforcement actions, fines, and/or penalties resulting from their failure to comply with applicable environmental requirements.

## **2–3. Legal Requirements**

All references to legal requirements in this regulation are intended to refer to laws, regulations, and executive orders that, in the opinion of legal counsel, are applicable to the Army. While most environmental laws apply to the Army, some include exemptions (or provisions for requesting exemptions) for military activities under certain conditions. It is essential that Army counsel, including but not limited to the Office of the Judge Advocate General, Army Environmental Law Division, JALS–EL), be consulted on the applicability of all laws, regulations, initiatives, and executive orders. Similarly, all permits, agreements, notices of violations, enforcement actions, especially reports of potential liability under paragraph 16–4, require early and close coordination with Army legal counsel that is responsible for direct support to the command or activity. As necessary, legal counsel at the installation level will coordinate issues and positions within the appropriate Army legal chain. Precedent-setting opinions, all enforcement actions, and agreements must be coordinated with JALS–EL. The requirement to consult with legal counsel supporting a command or activity is considered an essential part of effectively using this regulation. Additionally, this regulation prescribes program requirements in terms of "will" and "must", which mean that the actions are mandatory. All Army organizations will incorporate environmental considerations and requirements into all aspects of the organization's mission.

# **Chapter 3 Planning and Implementation**

## **3–1. Installation strategic planning**

*a.* Environmental considerations must be incorporated into installation plans, including installation strategic plans. Installation strategic planning incorporates the concepts and philosophy of sustainability, the ultimate objective in strategic planning, and must be applied to and supported by all functional areas within the command.

*b.* Installation strategic planning is the long-term planning process that establishes the baseline and direction for all other plans and planning processes, including real property master plans (RPMPs), human resource plans, information technology (IT) and knowledge management plans, environmental management plans, functional business plans, etc. Guidance for these plans is provided by Headquarters, Installation Management Command (HQ, IMCOM), National Guard Bureau - Army National Guard (NGB–ARNG), and for special installations, owning Army Commands (ACOMs), Army Service Component Commands (ASCCs) and Direct Reporting Units (DRUs). This includes synthesizing and aligning pertinent information from The Army Plan, Army strategic planning guidance, Army programming and budgeting guidance, policies, and other sources of strategic guidance with the organizational mission, vision, values, principles, strategy maps, balanced scorecards, and so forth. The garrison commander (GC) applies this guidance to his or her own operations through the installation strategic planning process.

## **3–2. Activities, products, and services**

*a.* The Army mans, equips, trains, sustains, mobilizes, deploys, and demobilizes the force as needed to support the combatant commanders.

*b.* Achieving the foregoing requires the Army to undertake a number of activities and to provide various products and services that include, but are not limited to (listed by mission/functional area):

(1) Weapons System Acquisition - including the major systems acquisition phases of concept and technology development, system development and demonstration, production and deployment, operations and support, and demilitarization and disposal.

(2) Logistics Support - including the acquisition, storage, distribution, and recovery of all classes of supply; maintenance of materials and equipment; transportation of personnel and materiel; and provision of support services such as food, commissaries, laundries, and property disposal.

(3) Training - including providing and conducting individual, functional, and organizational (both tactical and non-tactical) training.

(4) Infrastructure Development and Maintenance - including the total system of facilities; buildings; structures; horizontal transportation facilities (roads, railroads, bridges, dams, and airfields); utility, transport, and communication systems; ranges and other training areas; ports; airfields, and associated lands and equipment; and facilities (that is, real property) operation and maintenance, to include utilities, minor construction, and general engineering support.

(5) Industrial Operations - including the manufacture of commodities, equipment, and weapons systems.

(6) Base Operations Support - including all of the activities required to accomplish the missions and functions of assigned and tenant units and activities at the installation level.

(7) Health and Medical Support - including providing general health care and medical and dental support to personnel, as well as the operation and maintenance of Army hospitals, medical centers (MEDCENS), dental and veterinary clinics, medical treatment facilities, and supporting laboratories.

(8) Transportation Equipment - including tactical and non-tactical vehicles, fixed and rotary wing aircraft, rail systems, watercraft, and supporting maintenance operations.

(9) Mobilization and Deployment - including the assembly and organization of material and personnel resources in response to war or other emergencies including low intensity conflict and military operations other than war, and the physical movement of those resources to the theater of operations.

(10) Research, Development, Test, and Evaluation (RDT&E) - including the demonstration/validation and technology transfer of materiel, equipment, and weapons systems at Army proving grounds, laboratories, and related facilities.

### **3-3. Important environmental aspects**

*a.* Environmental aspects are elements of products, activities, or services that interact with the environment. Important environmental aspects are those that result in mission or environmental impacts, and may include, but are not limited to:

(1) Air emissions (fugitive or from stacks), including but not limited to, Clean Air Act criteria pollutants (carbon dioxide, nitrous oxides, sulfur oxides, ozone, particulates, and lead), combustion gases, volatile organic compounds (VOCs), and hazardous air pollutants (HAPs).

(2) Generation of noise, vibration, odor, dust, heat, mold, light, radiation, and other nuisance activities.

(3) Discharges and disposals (point and non-point), spills, or other releases to soil or ground and/or surface waters, including sewage, sediment, or solid, hazardous, and other wastes.

(4) Natural resource alteration (that is, consumption or conservation), including water, timber, minerals, soil, and so forth. This includes the acquisition of goods and services that affect the consumption of natural resources.

(5) Ecological resource alteration, including wetland and endangered species protection or destruction.

(6) Cultural resource alteration, including historic properties; archeological sites; sacred sites; and properties of traditional cultural or religious importance to American Indians, Alaska Natives, and Native Hawaiians.

(7) Energy consumption or conservation, including electricity, fossil, alternative fuels, and renewable energy, such as solar energy.

*b.* All appropriate facilities (see glossary) will establish and maintain procedures to identify the environmental aspects of their operations, activities, products, or services that they can control and over which they can be expected to have an influence, to determine which have or can have impacts on the mission and/or the environment. This will include maintaining scientifically defensible information and inventories of facilities, resources, and environmental aspects, including geospatial information where the spatial location and extent of these affects their impact to mission and/or the environment. Installations must evaluate their liabilities concerning non-governmental tenants to determine whether any of them can be exempt from the installation EMS.

*c.* The aspects related to those important impacts will be considered in setting environmental objectives at all appropriate organizational levels. Additionally, appropriate facilities will consider processes for external communications on their important environmental aspects and document their decision regarding external communications.

*d.* Acquisition program managers should ensure that weapons systems are designed so that they can be tested, operated, maintained, repaired, and disposed of in accordance with applicable environmental, safety, and occupational health statutes, regulations, policies, and environmental treaties and agreements. (see PD: DODD 5000.1)

### **3-4. Environmental objectives and targets**

*a.* An environmental objective is an overall environmental goal, arising from the environmental policy, which an organization sets for itself to achieve, and which is quantified where practicable (for example, reduce hazardous waste (HW) disposal by a certain amount). An environmental target is a detailed performance requirement, quantified where practicable, applicable to the organization or parts thereof, that arises from the environmental objectives and that needs

to be set and met to achieve those objectives (for example, reduce HW disposal by a certain amount by a certain point in time). Environmental objectives and targets will be developed in consideration of impacts on Army operations.

*b.* Installations/activities will establish and maintain environmental objectives and targets for all operations and activities having the potential for important mission and/or environmental impact. Objectives and targets will be established at each relevant function and level within the organization, will be documented, and will meet DOD Measures of Merit (MOMs), Army-level program goals, objectives, and targets; long-term strategic goals; legal and other requirements; important environmental aspects; technological options; financial and operational requirements; and the views of interested parties, as appropriate.

*c.* Headquarters, Department of the Army (HQDA) will disseminate detailed Army-level program goals, objectives, and targets through periodic publication and update of appropriate plans, directives, and guidance documents.

### **3-5. Operational controls**

*a.* Installations/activities will identify those operations and activities that are associated with important environmental aspects (see para 3-3a) and manage them consistent with established policies, objectives, and targets.

*b.* Installations/activities will establish and maintain documented standing operating procedures (SOPs) to avoid unacceptable environmental impacts from these operations and activities.

*c.* Contracting officers should ensure that contract provisions are consistent with SOPs.

### **3-6. Emergency preparedness and response**

*a.* Installations/activities will establish and maintain procedures to identify the potential for and to respond to accidents and emergency situations, and for preventing and mitigating the environmental impacts that may be associated with them. These procedures will be tested periodically.

*b.* Installations/facilities will review and revise, where necessary, emergency preparedness and response procedures. In particular, critical reviews and revisions should be conducted after any occurrence of accidents or emergency situations.

### **3-7. Management programs**

*a.* Appropriate facilities will establish and maintain management programs (see chaps 4 -14) for achieving objectives and targets, and will track and measure progress toward achieving them.

*b.* As a minimum, management programs will designate responsibility for achieving objectives and targets at each relevant function and organizational level, and specify the means and timeframe by which they are to be achieved.

*c.* Appropriate facilities will track their targets and objectives to measure continual improvement.

## **Chapter 4 Environmental Asset Management**

Environmental assets entrusted to the Army's care include, but are not limited to, air, water, land, and natural and cultural resources. Specific DOD and Army policies, legal and other requirements, major program goals, and program requirements associated with environmental resources are presented in this section. The Office of the Assistant Chief of Staff for Installation Management (OACSIM) and the Office of the Director of Environmental Programs (ODEP) are responsible for environmental program policy implementation and Headquarters, Department of the Army (HQDA) level program oversight. The Installation Management Command (IMCOM) and National Guard Bureau - Army National Guard (NGB-ARNG) are responsible for executing environmental program requirements prescribed herein in accordance with this regulation and applicable federal, state, and local requirements. Technical support for addressing the various requirements prescribed in this section is the responsibility of the appropriate program offices within the U.S. Army Environmental Command (USAEC), U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM), Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA (ALT)) Environmental Support Office (ESO), and the Military Programs Directorate of the U.S. Army Corps of Engineers (USACE).

### **4-1. Air resources**

*a. Policy.*

(1) Comply with applicable Federal, State and local air quality regulations, permit requirements, and overseas Final Governing Standards (FGS).

(2) Identify and implement cost-effective pollution prevention measures that will reduce toxic or criteria air emissions.

(3) Eliminate dependency on ozone depleting substances (ODS).

*b. Legal and other requirements.* Section 7401, Title 42, United States Code (42 USC 7401, et seq., Clean Air Act (CAA), as amended); Section 6901, Title 42, United States Code (42 USC 6901, et seq., the Resource Conservation

and Recovery Act of 1976 (RCRA), as amended); the Energy Policy Act of 2005; applicable State and local requirements; or country-specific FGS requirements.

*c. Major program goal.* Achieve and maintain air quality standards to protect human health and the environment, while minimizing mission impacts.

*d. Program requirements.*

(1) Assess the need for and obtain necessary CAA Title V Operating Permits and all other applicable permits. (LD: 40 CFR 71.1)

(2) Update existing or obtain new permits as needed when planning to modify, construct, install, or remove from service an emissions source that is, or should be, regulated under a Title V or other permit. (LD: 40 CFR 71.6)

(3) Perform air emissions inventories as required by statute, regulation, permit, or country-specific FGS. (LD: 40 CFR 51; 40 CFR 70.6; 40 CFR 71.6; FGS)

(4) Determine the need to comply with New Source Performance Standards, New Source Review for Non-attainment, or for Prevention of Significant Deterioration (PSD). In addition, determine the need to perform a Conformity Determination. (LD: 40 CFR 51.307)

(5) Cooperate with Federal, State, and local authorities to achieve the goals of implementation plans. (LD: 40 CFR 51)

(6) Perform technology, permitting, and preconstruction assessments as required before beginning construction or reconstruction of air emissions sources. (LD: 40 CFR 51.160 and related State regulations)

(7) Establish a Risk Management Program and develop and maintain a risk management plan (RMP) when required under Section 112(r) of the CAA. (LD: 40 CFR 68.150–195)

(8) Implement and maintain plans to eliminate dependency on commercial acquisition of Class I ODS. (LD: 40 CFR 82)

(9) Reduce all ODS use to zero as cost-effective substitutes that meet applicable standards become available. (LD: 40 CFR 82)

(10) Recovered Class I ODS cannot be bartered, sold, or traded. Return recovered ODS that are excess to installation needs to the DOD ODS Reserve. (LD: 40 CFR 82)

(11) Coordinate natural resources activities having potential air quality impacts (for example, prescribed burning) with appropriate State and local officials.

(12) Comply with applicable Standards of Performance for New Stationary Sources and corresponding monitoring requirements. (LD: 40 CFR 60)

(13) Comply with all air toxics regulations, to include, but not limited to, applicable National Emission Standards for Hazardous Air Pollutants (NESHAP) maximum achievable control technology (MACT) requirements for regulated sources of hazardous air pollutants (HAPs). (LD: 40 CFR 63)

(14) Overseas installations will comply with permits obtained on their behalf in accordance with the FGS.

## **4–2. Water resources**

*a. General policy.*

(1) Comply with applicable Federal, State, and local laws and regulations regarding water resources management and permitting. Overseas, the Army will comply with country-specific FGS requirements.

(2) Obtain and comply with all required Federal, State, and local Clean Water Act (CWA), Coastal Zone Management Act (CZMA), and Safe Drinking Water Act (SDWA) permits (includes wastewater and storm water permits, operational permits for drinking water systems, groundwater discharge permits, wetland 404/401 permits, septic system permits, underground injection control, and so forth).

(3) Overseas installations will comply with permits obtained on their behalf in accordance with the FGS.

(4) Identify and implement pollution prevention initiatives.

(5) Participate with regional authorities in the development and implementation of water resource initiatives and plans.

(6) Mitigation wetlands are wetlands that replace the functions performed by drained, filled, or degraded wetlands on installation project sites. They should, whenever possible, be sited within the same watershed as the affected installation wetlands and outside installation boundaries so installations can retain maximum land-use flexibility.

*b. Recreational waters.* Management of recreational waters at military installations will be in accordance with AR 40–5, TB MED 575, and TM 5–662.

*c. Water resource protection and management.*

(1) All Army organizations and activities will comply with legally applicable Federal, State, and local regulations, executive orders (EOs), and FGS to conserve, protect and restore surface water resources (including wetlands, estuaries, streams, lakes and so forth), and groundwater (wells and aquifers).

(2) Executive Order 11988 and EO 11990 address the actions Federal agencies take to identify and protect flood plains and wetlands, respectively.

(3) The CZMA requires that activities within the coastal zone of any state must be consistent with the state's coastal zone management plan.

*d. Watershed management.*

(1) *Policy.* Installations use a watershed management approach when evaluating projects and programs to satisfy environmental regulations, facility projects, and master planning that may impact the quality of water resources. Using a watershed approach means that installations should develop a framework or plan for coordinating, integrating and managing their mission activities that impact the quality of water resources located on (and those that migrate off) their installation. This approach also requires a strong commitment to involving stakeholders, both internal and external, in the management of these water resources. To implement applicable total maximum daily load (TMDL) regulations, all Army facilities will:

(a) Initiate and maintain contact with Federal and State water regulators concerning the process of setting TMDLs and allocations for water bodies located on or passing through Army installations.

(b) Integrate all aspects of CWA requirements, programs and available information (for example, the National Pollutant Discharge Elimination System (NPDES) program, 404 wetlands program, wellhead protection, storm water plans/projects, storm water construction permits, spill prevention, control, and countermeasures (SPCC) plans/projects, State CWA 319 requirements (State plans & strategies for reducing non-point source runoff)) with TMDL development and future planning. Ensure all of these programs are consistent with, and work together to attain compliance under, TMDL allocations once they are set by states.

(c) Ensure that activities required to meet other environmental legal requirements, like RCRA, that impact water quality in an impaired water or are impacted by an impaired water (for example, Chapter 35, Title 16, United States Code (16 USC Chapter 35)) are informed of CWA requirements. These non-CWA activities should be integrated into the management plan.

(d) Ensure other programs that are or may have their activities affected by identification of impaired waters and new TMDL allocations are informed of the impacts and requirements (for example, facilities construction, master planning, National Environmental Policy Act (NEPA) requirements).

(e) Ensure that watershed assessments and management plans are integrated with the installation master plan, integrated natural resources management plan (INRMP), and other plans as appropriate.

(f) Establish and integrate environmental education and participation programs required by CWA/SDWA/the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)/ESA and so forth for all Army personnel and their families based on watershed concepts and requirements to restore impaired waters and maintain designated uses of local water bodies.

(g) Ensure that mission and non-mission activities and construction designs utilize best management practices (BMPs) to minimize TMDL impacts.

(2) *Legal and other requirements.* The principal applicable laws governing water resource protection and management are the CWA, SDWA, and related Federal, State, and local implementing regulations; and for overseas installations, the country-specific FGS requirements.

(3) *Major program goal.* Implement the "Unified Federal Policy for a Watershed Approach to Federal Land and Resource Management". (PD: Unified Federal Policy for a Watershed Approach to Federal Land and Resource Management, 65 FR 62565–62572, 18 October 2000).

(4) *Program requirements.*

(a) Assess installation watershed impacts as appropriate, considering upstream and downstream water quality data or other background levels, proximity to potentially designated impaired waters, and any effects on mission activities. (PD: Unified Federal Policy for a Watershed Approach to Federal Land and Resource Management, 65 FR 62565–62572, 18 October 2000)

(b) Carry out Army activities consistent with EPA/State approved plans/strategies to restore impaired or threatened water bodies to their designated use. (LD: 40 CFR 130.12)

(c) Control soil erosion in accordance with applicable and appropriate Federal, State, or local requirements. (LD: 40 CFR 122.26)

(d) Comply with all applicable and appropriate State Source Water Assessment and Protection Program requirements as they relate to ground water (for example, wellhead protection plans) (LD: SDWAA 1996, PL 104–182, Sections 1428 and 1453); (LD: 40 CFR 144–148); and (LD: 40 CFR 149).

*e. Wastewater and stormwater.*

(1) *Policy.*

(a) Comply with facilities policy concerning use of wastewater collection/treatment systems that are owned and operated by public or private entities when economically feasible and when security is not compromised.

(b) Comply with all requirements, substantive and procedural, for control and abatement of water pollution, as outlined in the CWA that require Army compliance.

(c) Control or eliminate sources of pollutants and contaminants to protect water bodies and groundwater.



- (d) Employ abatement measures for non-point source runoff from construction, facility operations, and land management activities.
- (e) Encourage reuse or recycling of wastewater, sewage sludge, wash rack sediment, greases or oils, and other wastes whenever economically feasible and environmentally beneficial.
- (2) *Legal and other requirements.* Applicable laws are Chapter 26, Title 33, United States Code (33 USC Chapter 26, as amended; Section 108 of Section 6961, Title 42, United States Code (42 USC 6961); Section 1401, et seq., Title 33, United States Code (33 USC 1401); Section 2701, Title 33, United States Code (33 USC 2701); and State and local laws; and for overseas installations, the country-specific FGS requirements.
- (3) *Major program goals.* The Army's wastewater and stormwater management goals are to reduce the pollutant loadings in point source and non-point source discharges and to ensure efficient water reuse.
- (4) *Program requirements.*
- (a) Obtain and comply with NPDES and/or State discharge permits, to include all required plans. (LD: 40 CFR 122)
- (b) Ensure that discharges from industrial activities to Federally-owned Treatment Works (FOTWs) and Publicly-owned Treatment Works (POTWs) comply with the substantive pretreatment requirements applicable to POTWs under the CWA. (LD: 40 CFR 403)
- (c) Develop pretreatment programs as required to ensure FOTWs meet NPDES permit requirements and to improve opportunities for reuse of wastewater effluent and sewage sludge. (LD: 40 CFR 403)
- (d) Develop and implement a stormwater management plan for a regulated Municipal Separate Stormwater Sewer System (MS4) as required in accordance with the installation's general permit. (LD: 40 CFR 122.26)
- (e) Develop and implement a Stormwater Pollution Prevention Plan(s) (SWPPP) as required, in accordance with the installation's industrial, construction, or Municipal Separate Storm Sewer (MS4) storm water permit(s). (LD: 40 CFR 122.26)
- (f) Develop and implement a spill prevention, control, and countermeasures plan (SPCCP), as required. (LD: CWA Section 311(j), 40 CFR 112.3)
- (g) Perform shipboard or shore-side oil/water separation before the discharge of ballast water from watercraft. Effluent limitations from watercraft are prescribed by the U.S. Coast Guard (USCG) (LD: 33 CFR 151-158) EPA; (LD: 40 CFR 110); individual states; and TB 55-1900-206-14.
- (h) Coordinate proposed military activities involving the discharge of fill material into waters of the United States, including wetlands, with, and if necessary, secure a permit from the local U.S. Army Corps of Engineers (USACE) district and appropriate State agency. (LD: 33 CFR 323; 40 CFR 230)
- (i) Ensure that operators of wastewater (including industrial) treatment plants and wastewater collection systems have necessary training and certification. (LD: 42 USC 300g-8)
- (j) Use analytical laboratories that are certified per applicable Federal, State, local or host nation (HN) requirements, as appropriate. (LD: 40 CFR 136; 40 CFR 141.28)
- (k) Follow State approved plans and local permit requirements for non-point source water pollution control where applicable. (LD: 40 CFR 123)
- f. Drinking water.*
- (1) *Policy.*
- (a) Provide drinking water to fixed facilities in accordance with the requirements of the SDWA and applicable State and local regulations. Overseas, all Army organizations and activities will comply with country-specific FGS.
- (b) Comply with Army facilities policy to transfer ownership and operation of water supply treatment systems to public and private entities when economically feasible and when security is not compromised.
- (2) *Legal and other requirements.* Applicable laws are the SDWA, as amended; PL 109-58 (Energy Policy Act of 2005); and State and local laws; and for overseas installations, the country-specific FGS requirements.
- (3) *Major program goals.* The Army's drinking water resource management goals are to consistently provide safe, aesthetically pleasing drinking water at adequate pressures and quantities to protect the health and quality of life of people living and working on our installations, and to better manage the cost of drinking water programs.
- (4) *Program requirements.*
- (a) Obtain and comply with all necessary water appropriation and use permits, National Pollutant Discharge Elimination System (NPDES) permits for wastewater discharges from drinking water treatment plants, or other permits that are required for operation of drinking water treatment systems at both fixed and field facilities. (LD: 40 CFR 122; 40 CFR 141-143)
- (b) Comply with the provisions of the SDWA as implemented by State and local regulations which include, but are not limited to the following: (LD: 42 USC 300g-8; 40 CFR 136; 40 CFR 141.28)
1. Primary and Secondary drinking water standards.
  2. Training and operator certification requirements.
  3. Lead contamination control act requirements.
  4. Public notification and consumer confidence reporting requirements.
  5. Water system vulnerability assessment and emergency response plan requirements.

6. Certified laboratory requirements.

(c) Provide copies of annual Consumer Confidence Reports (CCRs) to the Installation Management Command (IMCOM) and State Adjutants General (where appropriate) by the end of each fiscal year.

(d) Perform a lifecycle cost analysis whenever the upgrade or construction of a new water supply facility is considered. Guidelines for military installations to perform the cost analysis are contained in AR 420-49, section 4-1.

(e) Monitor and upgrade Army water supply, treatment, distribution, and storage systems as needed to comply with environmental requirements. Routine operation, maintenance, and repair of Army water systems will be in accordance with AR 40-5; AR 420-49; AR 700-136; TB MED 576; TB MED 577; UFC 3-230-02; TM 5-810-5; TM 5-813-1 through TM 5-813-9; and USACHPPM TG 179.

(f) After consultation with supporting legal counsel, comply with applicable additional State and local drinking water regulations not covered under the SDWA.

#### 4-3. Land resources

Land resources are the ranges, cantonment areas, and associated natural resources (to include soils and the biota they support).

*a. Policy.*

(1) Comply with applicable Federal, State, and local regulations regarding land resources management and permitting where applicable. Overseas, all Army organizations and activities will comply with applicable country-specific FGS.

(2) Provide for the conservation and rehabilitation of natural resources on Army lands.

(3) Integrate training and testing range operations and support activities within the installation environmental management system (EMS).

(4) Ensure that all management plans address range operations and activities as appropriate.

(5) Quantify environmental encroachment vulnerabilities and assess the feasibility of using external buffer zones to enhance testing and training capabilities. Where warranted, work with private landowners and eligible entities through the Army Compatible Use Buffer (ACUB) process.

(6) The management and conservation of natural and cultural resources under Army control, including planning, implementation, and enforcement functions, are inherently governmental functions that will not be contracted. Components that have contractor-operated installations or facilities will ensure that contract instruments clearly address contractor and government functions as they relate to natural and cultural resources.

*b. Legal and other requirements.* Principal statutes, regulations, and guidance applicable to the Army Natural Resources Management Program include:

(1) 16 USC 670a and 670b.

(2) 16 USC 35.

(3) 50 CFR 401-453, implementing regulations of the U.S. Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration (NOAA) - Fisheries.

(4) Sections 1801-1882, et seq., Title 16, United States Code (16 USC 1801-1882).

(5) 10 USC 2665.

(6) 10 USC 2667(d).

(7) Section 2671, Title 10, United States Code (10 USC 2671).

(8) Section 2684a, Title 10, United States Code (10 USC 2684a).

(9) Section 2694a, Title 10, United States Code (10 USC 2694a).

(10) Sections 1361-1407, Title 16, United States Code (16 USC 1361-1407).

(11) Sections 4701-4751, et seq., Title 16, United States Code (16 USC 4701-4751).

(12) Sections 661-667d, United States Code (16 USC 661-667d).

(13) Section 701, Title 16, United States Code (16 USC 701).

(14) Sections 703-712, Title 16, United States Code (16 USC 703-712).

(15) Sections 3371-3378, Title 16, United States Code (16 USC 3371-3378).

(16) Part 13, Title 50, Code of Federal Regulations (50 CFR 13).

(17) Part 21, Title 50, Code of Federal Regulations (50 CFR 21).

(18) Part 190, Title 32, Code of Federal Regulations (32 CFR 190).

(19) Parts 10-16, Title 50, Code of Federal Regulations (50 CFR 10-16).

(20) EO 13186.

(21) EO 13112.

(22) EO 13423.

(23) EO 11990.

(24) PL 108-136, sections 312, 319.

(25) DODD 4715.1E.

(26) DODI 4715.3.

(27) DODI 4715.5.

(28) Memorandum, Deputy Under Secretary of Defense for Installations and Environment (DUSD (I&E)), 10 October 2002, subject: Implementation of Sikes Act Improvement Act: Updated Guidance.

(29) Applicable FGS and any legally binding international agreements.

*c. Major program goals.* The Army's land resources management goals are to:

(1) Integrate natural resources stewardship and compliance responsibilities with operational requirements to help achieve sustainable ranges, training areas, and other land assets.

(2) Develop, initiate, and maintain programs for the conservation, utilization, and rehabilitation of natural resources on Army lands.

*d. Program requirements.*

(1) *Integrated natural resources management.*

(a) Develop and implement an integrated natural resources management plan (INRMP) in accordance with 16 USC 670a in cooperation with the USFWS and the State fish and wildlife agency unless significant natural resources are absent. OCONUS installations will develop and implement an INRMP in consonance with FGS requirements. Significant natural resources are present if one or more of the following criteria apply: (LD: 16 USC 670a).

1. Federally listed, proposed, or candidate species are onsite, or critical habitat has been designated or proposed on the installation, and on-installation conservation measures are necessary to conserve the federally listed species.

2. Conservation reimbursable forestry or agricultural outleasing activities consist of 100 acres or more.

3. Hunting and/or fishing takes place for which special State permits are issued by the installation in accordance with 16 USC 670a(b)(3).

4. The installation conducts intensive, on-the-ground military missions that require conservation measures to minimize impacts (for example, soil erosion control, prescribed fire) and sustain natural resources. Installations designated by the DCS, G-3/5/7 for management under the ITAM program meet this criterion.

5. Unique biological resources, wetlands, species at risk, or ecological issues require a level of planned management that can only be addressed by an INRMP.

6. In some cases, it may be difficult to determine whether an installation has significant natural resources. In these cases the ACSIM is delegated the authority to determine whether significant natural resources are present, and, therefore, whether an INRMP is required.

*(b) Implement the INRMP by:*

1. Actively requesting, receiving, and using funds for priority projects and activities.

2. Ensuring that sufficient numbers of professionally trained natural resources management personnel are available to perform the tasks required by the INRMP.

3. Coordinating annually with all cooperating offices.

4. Documenting specific INRMP action accomplishments undertaken each year.

*(c) Prepare INRMPs that include components addressing specific natural resources (for example, endangered species, forests, flora, fauna, soil, wetlands) and their interdependency.*

*(d) Review the INRMP with regard to operation and effect by the parties thereto on a regular basis, but not less often than every 5 years. Update the INRMP as appropriate in concert with installation needs to obtain mutual agreement in coordination with the USFWS, State fish and game agency(ies), and other internal and external stakeholders. A 5-year update is not required if circumstances have not changed. (LD: 16 USC 670a).*

*(e) Use the INRMP, range complex master plan, and ITAM 5-year plan as the garrison commander's (GC) tools for planning and integrating land resources compliance and management activities with the military mission.*

*(f) Provide access to training and testing ranges through sustainment of installation land resources and in compliance with natural resources laws, regulations, EOs, and Army policies.*

*(g) To the extent appropriate and applicable, provide for no net loss in the capability of the installation lands to support the military mission. Identify and address threats to mission land use and give high priority to management objectives that protect mission capabilities of installation lands. (LD: 16 USC 670a).*

*(h) Designate and ensure that the installation has ready access to a qualified military, Department of the Army (DA) civilian, or State Army National Guard (ARNG) staff member (or ARNG contractor) to serve as installation natural resources coordinator.*

*(i) Assure NEPA requirements are satisfied when preparing the INRMP. (LD: 50 CFR 402.06; 42 USC 4331).*

*(j) Conduct appropriate internal and external coordination prior to GC approval of INRMPs and revisions (for example, with Director of Plans, Training, Mobilization, and Security (DPTMS); Staff Judge Advocate; Morale, Welfare, and Recreation; Provost Marshall, and so forth). INRMPs will meet the following conditions (note that 2-5 do not apply to overseas installations):*

1. Concurrence from the installation's next higher headquarters, and coordination with affected Army Commands (ACOMs), Army Service Component Commands (ASCCs), Direct Reporting Units (DRUs), NGB-ARNG, and tenants.

2. Agreement from the Regional Directors of the USFWS concerning aspects within the scope of their authority. (LD: 16 USC 670a(a)(2)).
  3. Coordination with NOAA–Fisheries in those instances where INRMPs include TES or critical habitat within the scope of their authority.
  4. Concurrence from land management agencies exercising jurisdiction over installation property.
  5. Agreement from the Director of the State fish and wildlife agency concerning aspects within the scope of their authority. (LD: 16 USC 670a(a)(2)).
  6. Opportunity for public comment provided (minimum of 30 days). (LD: Section 2905, PL 105–85).
- (k) Coordinate the draft INRMP with the Office of the Director of Environmental Programs (ODEP) when requested.
- (l) Integrate the INRMP with the installation master plan, range plans, training plans, integrated cultural resources management plans (ICRMPs), integrated pest management plans (IPMPs), cleanup installation action plans (IAPs), and other appropriate plans to ensure consistency.
- (m) For installations that have training or testing missions, ensure the DPTMS (or Range Control staff or equivalent) provides a description of optimum mission landscape requirements (current and future (next 5 years)) to include recommendations for improving the capability, availability and accessibility of land.
- (n) Establish specific goals and measurable objectives for all components of the INRMP. (LD: 16 USC 670a(b)) Establish metrics and measure progress towards achieving the objectives.
- (o) Prioritize projects and required resources necessary to achieve the objectives of the INRMP and its components.
- (p) Make unclassified portions of INRMPs available to the public through electronic format (for example, world wide web, compact disk, and so forth.). All INRMPs will undergo DPTMS security review prior to being made available. This requirement does not apply to overseas installations.
- (q) Accurately report INRMP data using the metrics in the Army Environmental Data Base - Environmental Quality (AEDB–EQ) Report and the Reimbursable Programs Tracking System (RPTS).
- (r) Conduct Planning Level Surveys (PLSs) and data analysis as the foundation for effective planning and decision-making. PLSs, with the exception of flora, will be maintained electronically as geospatial data, and will be submitted to the GIS Repository as they are updated. Existing Army scopes of work will be used when available. PLSs should be kept current according to an installation’s specific needs, but at a minimum, will be reviewed and updated if necessary prior to the INRMP’s revision. PLSs include as a minimum:
1. *Topography*. A map with elevation, elevation contours, and associated data consistent with U.S. Geological Survey (USGS) standards and topographic map products.
  2. *Wetlands*. A description and map of the distribution and extent of wetlands consistent with the statement of work as defined in the Army/USFWS Memorandum of Agreement (MOA).
  3. *Surface waters*. A survey that describes and maps the distribution and extent of surface waters, and is consistent with USGS standards.
  4. *Soils*. A survey that classifies, categorizes, describes, and maps soils by map unit, and meets current National Cooperative Soil Survey standards and procedures.
  5. *Flora*. An installation-wide vascular plant survey that produces a list of plant species with verified nomenclature, classification and annotation compatible with the Natural Resources Conservation Service’s (NRCS) Plant List of Accepted Nomenclature, Taxonomy, and Symbols (PLANTS).
  6. *Vegetation communities*. A survey, including field data, which describes and maps the distribution and extent of dominant and co-dominant plant communities (alliances).
  7. *Threatened and endangered (T&E) species*. A survey that maps and shows the occurrence, habitat distribution, and habitat management areas of Federally endangered, threatened, proposed, candidate, and species at risk occurring on the installation.
  8. *Fauna*. A survey, including field data, that describes and maps the distribution and extent of animals.
- (s) Ensure that turbidity and sediment levels do not irreparably degrade aquatic biota and habitat from an ecosystem perspective, or significantly impact shallow ground water aquifers.
- (t) Evaluate the feasibility and potential impacts of operating motorized off-road vehicles (ORVs) and non-motorized vehicles (for example, mountain bikes) on the military mission and natural and cultural resource management. If determined feasible, develop procedures for operating motorized ORVs and non-motorized vehicles that will protect resource values; preserve public health, safety, and welfare; and minimize use conflicts. (LD: EO 11644).
- (u) Obtain ACSIM approval prior to setting aside areas for an exclusive use that might constrain future land use decisions. Obtain supporting ACOM, ASCC, DRU, or NGB–ARNG concurrence before submitting request to ACSIM.
- (2) *Leases, easements, and other special land uses*.
- (a) Address leases, easements, and other special land uses within the INRMP.
  - (b) Ensure all conditions of leases and easements are consistent with the military mission and natural resources conservation and protection.
  - (c) Follow the policies set forth in AR 405–80 regarding rights-of-way or easements.

(3) *Soil resources.*

(a) Use the INRMP for the planned management of soil resources across the entire installation. The Soil Erosion and Sediment Control Component (SESCC) to the INRMP will address the following soils policy.

(b) Keep soil erosion from water within tolerance limits as defined in soil surveys prepared by the U.S. Department of Agriculture (USDA), NRCS or as required by FGS or host nation authorities.

(c) Keep soil sediment, as a pollutant, in wetlands and waterways within compliance limits.

(d) Minimize the impact of land uses on soil erosion and sedimentation when and where possible, to include:

1. Locating physically intensive land disturbing activities on the least erodible soils.

2. Using climatic/seasonal changes in soil erosion as a factor in scheduling intensive mission operations and real property management activities.

3. Identifying and rehabilitating land disturbed by operations and real property management activities.

(4) *Flora and fauna.*

(a) Promote biodiversity and ecosystem sustainability on Army lands and waters consistent with the mission and INRMP objectives.

(b) Manage flora and fauna consistent with accepted scientific principles and in accordance with applicable laws and regulations, and, where lands and waters are suitable, for conservation of indigenous flora and fauna.

(c) Manage habitat to conserve and enhance existing flora and fauna consistent with the Army goal to conserve, protect, and sustain biological diversity while supporting the accomplishment of the military mission.

(d) Introduce or reintroduce any species only upon approval of the USFWS, the State, higher headquarters, and HQDA and include in the installation INRMP. In those instances where the training mission may be impacted, coordinate with the supporting ACOM, ASCC, DRU, or NGB-ARNG and secure joint approval from the OACSIM and the Office of the DCS, G-3/5/7, DAMO-TRS. (LD: EO 11987)

(e) Consult with NOAA-Fisheries on actions authorized, funded, or undertaken that may adversely impact fisheries or marine mammals. (LD: 16 USC 1801).

(5) *Threatened and endangered (T&E) species.*

(a) Prepare and implement an Endangered Species Management Component (ESMC) to the INRMP consistent with current policy and guidance.

(b) Carry out mission requirements in compliance with 16 USC 35.

(c) Integrate endangered species management and installation planning functions to ensure compliance with 16 USC 35. (LD: 50 CFR 402)

(d) In accordance with ACSIM guidance, take appropriate actions to preclude critical habitat designation.

(e) Assess all activities (to include Military Construction (MILCON)) at the earliest opportunity to determine whether they may affect listed species or critical habitat.

(f) Coordinate T&E actions or issues with ACOM, ASCC, and DRU commanders and other tenants that may be affected by them.

(g) Conduct biological assessments for activities that may have an effect on listed species or critical habitat where they are present or may be present in the action area. (LD: 50 CFR 402).

(h) Informally consult with the USFWS or NOAA-Fisheries, document the results in writing, and if necessary, conduct a biological assessment or biological evaluation (see glossary) to assess whether an action may affect a listed species or critical habitat. If the action is likely to adversely affect the listed species or its habitat, formal consultation is required. (LD: 50 CFR 402).

(i) Coordinate with affected installation organizations and the higher headquarters prior to initiating formal consultation. HQDA may identify proposed formal consultations that require higher level review. Installations will provide the proposal and supporting documentation as requested. ODEP, in coordination with JALS-EL, will review proposals and provide comments.

(j) Formally consult with the USFWS or NOAA-Fisheries when it is determined an action "may affect" a listed species or critical habitat. If the action is not likely to adversely affect the listed species or its habitat, and the USFWS or NOAA-Fisheries concur in writing, formal consultation is not required. (LD: 50 CFR 402).

(k) Confer with the USFWS or NOAA-Fisheries on any action that is likely to jeopardize the continued existence of any proposed species or result in the destruction or adverse modification of proposed critical habitat. (LD: 50 CFR 402.10).

(l) Review all ongoing and proposed actions immediately upon listing of a threatened or endangered species or designation of critical habitat to determine if formal consultation is necessary (even if a conference has previously occurred). (LD: 50 CFR 402).

(m) Complete a Biological Evaluation before initiating formal conference on actions affecting a proposed species or proposed critical habitat. (LD: 50 CFR 402.10).

(n) Develop and implement strategies to promote, in cooperation with other landowners, the use of conservation banking and/or ACUB initiatives to minimize impacts of an action on T&E species and/or critical habitat.

- (o) Within 24 hours report 16 USC Chapter 35 (ESA) violations, by telephone or electronic means, through the chain of command to HQDA (ODEP and JALS-EL). Submit a followup written report within 7 days.
- (p) Coordinate with higher headquarters and HQDA (ODEP and JALS-EL) in taking final action to correct any endangered species management problems contributing to the 16 USC 35 (ESA) violation(s).
- (q) Ensure that T&E awareness is included in unit training for personnel who may come in contact with listed species and/or their habitats or critical habitat. Coordinate training with the installation engineer, environmental directorate, and ITAM sustainable range component.
- (r) Obtain HQDA approval before supporting USFWS's or NOAA-Fisheries' introduction and/or reintroduction of Federal and State listed, proposed, and candidate species on Army lands.
- (s) Protect the water rights necessary for the survival and recovery of listed, proposed, or candidate aquatic or riparian species. Coordinate all water rights issues with appropriate legal counsel.
- (t) Participate in the listing/delisting process, recovery plan development, and critical habitat designation where the species in question may impact installation military missions.
- (u) Cooperate with State and local authorities in the management of ACSIM-designated Army species at risk and habitats with the goal of avoiding listings that could adversely affect military readiness.
- (v) Participate in regional/habitat-wide efforts to conserve candidate and ACSIM-designated Army species at risk and habitats when it has the potential to benefit the Army.
- (w) Include State-listed species in the installation INRMP.
- (6) *Species at risk.*
  - (a) In accordance with ACSIM guidance, manage species at risk and habitats to prevent listing that could affect military readiness.
  - (b) Program and plan for environmental conservation critical funding for designated Army species at risk and coordinate Real Property Services funding opportunities for other species at risk.
  - (c) Incorporate species at risk management in the INRMP.
  - (d) Implement management plans for species at risk to include, but not limited to, survey, monitoring, habitat enhancement, and protection.
- (7) *Forest management.* Practice responsible stewardship of forested lands to support the mission.
- (8) *Conservation reimbursable agricultural/grazing outleasing and forestry programs.*
  - (a) Conduct programs that are compatible with mission operations and that support conservation compliance, sustainability, and natural resources stewardship.
  - (b) Routinely examine Army land to determine what areas, if any, are available for outleasing and/or forest management. (PD: AR 405-80 and AR 405-90)
  - (c) Coordinate with DPTMS to establish needed doctrinal terrain and ground cover requirements.
  - (d) Maintain Conservation Reimbursable Programs where these provide a direct benefit to the mission and environmental goals.
  - (e) Deposit all revenues from agriculture and grazing outleases, forest product sales, or sale of equipment procured with Conservation Reimbursable funds into the Army Forestry Account or the Army Agricultural/Grazing Account per DFAS-IN Manual 37-100-\*\*.
  - (f) Sell no forest products nor outlease land for agricultural or grazing purposes unless the effects of the sale or lease are compatible with the INRMP. (LD: 16 USC 670a)
  - (g) Ensure that equipment procured with Conservation Automatic Reimbursable Authority is not transferred to tables of distributions and allowances (TDAs) outside of the programs or Federal Government ownership. Salvage value for equipment procured with Conservation Automatic Reimbursable Authority (Forestry or Agricultural/Grazing Outlease) will be deposited into the Army timber or agricultural/grazing outlease proceeds accounts.
  - (h) Ensure that outleases do not grant offsets that exceed the total amount of outlease value. At a minimum, revenues must cover the costs of administering the installation lease. (LD: 10 USC 2667).
  - (i) Continue Conservation Reimbursable Programs on excess or base realignment and closure (BRAC) lands until title is no longer held by the Army. Clear-cuts on excess or BRAC lands are prohibited unless approved by ODEP.
  - (j) Use revenues generated from the reimbursable programs to maintain, improve, or rehabilitate previously degraded ecosystems on the installation.
    - 1. Use revenues from agricultural/grazing outleases only for reimbursement of administrative costs of outleasing and other expenses incurred in support of multiple-land use management of natural resources.
    - 2. Use revenues from forest product sales only for management of forests and natural resources that support forest stewardship on land affected by conservation reimbursable forestry programs.
    - 3. Do not use automatic reimbursable authority to augment general operating expenses of the installation as overhead.
  - (k) Prepare determinations of availability (agricultural/grazing) and reports of availability (ROA) (forestry) as required by AR 405-80 and 405-90.
  - (l) Enter annual requirements into the Reimbursable Program Tracking System (RPTS).

- (m) Assure that agricultural and forest products are not given away, abandoned, carelessly destroyed, used to offset contract costs or traded for services, supplies, or products or otherwise improperly removed.
- (n) Assess lands to assure they are safe for nonmilitary purposes before outleasing. Document the environmental condition in a finding of suitability to lease (FOSL), Environmental Condition of Property (ECP) Report. (LD: 42 USC 4321).
- (o) When disposing of forest products from Army land by any means other than a commercial sale, the fair market dollar value will be used. This amount will be deposited in the Army Forestry Account by the proponent. Forest products may be used to directly assist the military mission without payment.
- (p) Account for all forest products and complete all commercial harvests before starting any construction that may impact forest resources.
- (q) Ensure all Army solicitations and contracts for timber sales affected by Sections 620–620j, Title 16, United States Code (16 USC 620–620j) contain a provision restricting the export of unprocessed timber procured on Army land.
- (9) *Hunting, Fishing, and Trapping.*
- (a) Support the Provost Marshal in enforcement of State and Federal laws pertaining to hunting, fishing, and trapping.
- (b) Coordinate with morale, welfare, and recreation (MWR) for the management and collection of fees for hunting, fishing and trapping. Do not expend environmental appropriated funds for non-appropriated fund (NAF) administration of hunting, fishing, and trapping activities.
- (c) Deposit collected fees from the sale of Special State Licenses into the Army Fish and Wildlife Conservation Fund (21X5095). GCs are authorized to provide no-cost Special State Licenses for junior enlisted soldiers (pay grade E4 and below) and to institute a sliding fee schedule for enlisted soldiers based on ability to pay.
- (d) Provide for controlled recreational access where feasible at Army installations containing land and water areas suitable for recreational use. (LD: 16 USC 670a).
- (e) Provide access to uniformed personnel, family members, and the public to hunting, fishing, and trapping, consistent with security requirements and safety concerns. Membership in an organization, including rod and gun clubs, has no bearing on receiving access. Exceptions to the above include specific access rights protected by treaties with or retained by American Indian and Alaska Native Tribes (see also para 6–4).
- (f) Provide access to disabled veterans, military dependents with disabilities, and other persons with disabilities when public access is available and when topographic, vegetative, and water resources allow access for such persons without substantial modification to the natural environment. Coordinate actions and solutions with appropriate organizations within the Army, OSD, and the Access Board as appropriate.
- (g) Hunting, fishing, and trapping plans will be included in the INRMP for installations that have such programs.
- (10) *Noxious weeds and invasive species management.* The Director of Public Works is the proponent for noxious weeds and invasive species management.
- (a) Prepare and implement an invasive species management component (ISMC) of the INRMP consistent with specific Federal or State initiatives. (LD: EO 13112).
- (b) Where applicable, synchronize invasive species management practices with objectives of the installation ITAM program.
- (c) Conduct mission activities in a manner that precludes the introduction or spread of invasive species. (LD: EO 13112).
- (d) Do not use invasive species in installation landscaping or land rehabilitation and management projects. (LD: EO 13112).
- (e) Use the most effective and environmentally sound approach for controlling invasive species, to include the use (or reduction in use) of pesticides. (PD: DODI 4150.7).
- (f) Assure that installation INRMP and pest management plan are in concert regarding noxious weeds management. (PD: DODI 4150.7).
- (11) *Migratory birds.*
- (a) Consistent with HQDA endorsement, implement conservation measures identified in the memorandum of understanding (MOU) between DOD and the USFWS pursuant to EO 13186.
- (b) Obtain appropriate authorization (that is, take permit) from the USFWS before intentionally and directly taking any migratory bird species. Record any birds purposefully and intentionally taken under the authorization and provide an annual report to the USFWS. (LD: 16 USC 703–712).
- (c) Establish procedures to avoid the unintentional take of migratory birds, including nests and eggs. (LD: 16 USC 703–712).
- (12) *Wildland fire management.*
- (a) Reduce wildfire potential using appropriate management practices such as prescribed burning, firebreak maintenance/construction, etc.
- (b) Installations with unimproved grounds that present a wildfire hazard and/or installations that utilize prescribed

burns as a land management tool will develop and implement an integrated wildland fire management plan (IWFMP) that is compliant and integral with the INRMP, the installations' existing fire and emergency services program plan(s), and the ICRMP.

(c) Assure that all civilian, contractor, and emergency services personnel involved in wildland fire management possess the level of training and physical fitness needed for their expected level of involvement.

(d) Ensure that only qualified personnel conduct prescribed burns.

## **Chapter 5 Pest Management**

### **5-1. Policy**

a. Protect real property and the health of soldiers, civilians, and family members from pests through use of integrated pest management (IPM) strategies.

b. Reduce the use of chemical pesticides.

c. Reduce environmental risks from pesticides through proper storage, handling, application, and disposal of pesticides.

### **5-2. Legal and other requirements**

Listed below are statutes, laws, regulations applicable to the Army Pest Management Program.

a. Section 136, Title 7, United States Code (7 USC 136).

b. DODI 4150.7.

c. DOD 4150.7-M.

d. DOD 4150.7-P.

e. DODI 4715.5.

f. AR 40-5

g. AR 420-10.

h. AR 385-10.

i. AR 210-50.

j. For overseas installations, the country-specific FGS requirements.

### **5-3. Major program goals**

a. Monitor and control pests that pose a threat to the health and safety of the installation population.

b. Maintain current pest management plans at all installations.

c. Minimize the use of pesticides through appropriate surveillance methods and programs.

d. Ensure that all pesticide applicators are appropriately trained and certified.

e. Develop and enforce measures to properly store and safeguard pesticides and pesticide application equipment for installation pesticide security.

f. Ensure all pesticide waste is properly disposed.

### **5-4. Program requirements**

a. Prepare an integrated pest management plan (IPMP) that defines pest management requirements, responsibilities, and resources needed to correct pest problems at each installation. Coordinate the IPMP with all affected parties. (PD: DODI 4150.7)

b. Conduct IPM programs in accordance with plans approved by garrison commander (GC), National Guard Bureau - Army National Guard (NGB-ARNG), Installation Management Command (IMCOM)-Korea, or IMCOM-Europe, as appropriate.

c. Establish procedures to store, secure, handle, apply, dispose, and manage pesticides that are consistent with Army safety and security requirements (PD: DODI 4150.7)

d. Conduct periodic program reviews at the installation using pest management professionals to ensure regulatory compliance and correct any deficiencies (PD: DODI 4150.7)

e. Ensure Army military and civilian personnel who apply or supervise application of pesticides on Army facilities or installations or during military contingencies, will be trained and certified in accordance with DOD certification standards. Non-DOD personnel (including State employees and contractors) who apply or supervise application of pesticides on Army facilities or installations will be trained and certified by the State where the Army facility or installation is located. Quality assurance evaluators that develop or review pest management contract specifications, or assess performance of those contracts will be trained in accordance with DOD policy and guidance. (PD: DODI 4150.7)



f. Maintain and archive records and reports on all pesticide applications and operations made to all facilities and grounds to include those performed under contract by tenant and supported activities, by lessees per formal agreements, those installations and facilities in the base realignment and closure (BRAC) cleanup program, and for closing overseas installations. (PD: DODI 4150.7)

g. Ensure installation self-help programs are cost-effective and promote IPM approaches for control of minor nuisance pests through use of authorized pest management materiel, equipment, awareness training, and record keeping requirements. (PD: DODI 4150.7)

h. Ensure requirements for aerial pesticide applications over Army lands to control pests of medical, economic, or other emergencies or urgencies of military significance are addressed in an aerial spray statement of need (ASSON) and submitted to the U.S. Army Environmental Command (USAEC), NGB-ARNG, IMCOM-Korea, or IMCOM-Europe as appropriate. (PD: DODI 4150.7)

i. Ensure pest management commercial solicitations incorporate Army requirements for the application and safe handling of pesticides and are forwarded to USAEC, NGB-ARNG, IMCOM-Korea or IMCOM-Europe as appropriate for technical review prior to solicitation. (PD: DODI 4150.7; DOD 4150.7-M; DOD 4150.7-P)

j. Appoint an installation pest management coordinator (IPMC). (PD: DODI 4150.7)

## **Chapter 6 Cultural Resources**

### **6-1. Policy**

Ensure that installations make informed decisions regarding the cultural resources under their control in compliance with public laws, in support of the military mission, and consistent with sound principles of cultural resources management.

### **6-2. Legal and other requirements**

Statutes, laws, regulations, and other guidance applicable to the Army Cultural Resources Management Program include:

- a. Section 470, Title 16, United States Code (16 USC 470).
- b. Section 1996, Title 42, United States Code (42 USC 1996) and Executive Order (EO) 13007.
- c. Section 3001, Title 25, United States Code (25 USC 3001).
- d. Section 470aa-470mm, Title 16, United States Code (16 USC 470); Sections 431-433, Title 16, United States Code (16 USC 431-433); and Section 469, Title 16, United States Code (16 USC 469).
- e. Part 79, Title 36, Code of Federal Regulations (36 CFR 79).
- f. Part 800, Title 36, Code of Federal Regulations (36 CFR 800).
- g. Part 229, Title 32, Code of Federal Regulations (32 CFR 229).
- h. Part 10, Title 43, Code of Federal Regulations (43 CFR 10).
- i. DOD American Indian and Alaska Native Policy Memorandum, 20 October 1998.
- j. Presidential Memorandum for Heads of Executive Departments and Agencies, Government-to-Government Relations with Native American Tribal Governments, 29 April 1994.
- k. EO 13175.
- l. EO 13287.
- m. For overseas installations, the country-specific FGS requirements.

### **6-3. Major program goal**

Develop and implement procedures to protect against encumbrances to mission by ensuring that Army installations effectively manage cultural resources.

### **6-4. Program requirements**

- a. *General program management.*
  - (1) Develop integrated cultural resources management plans (ICRMPs) for use as a planning tool.
  - (2) Develop NHPA programmatic agreements (PAs) and memorandums of agreement (MOAs), Army alternate procedures (AAP) historic property component (HPC) plans, NAGPRA Comprehensive Agreements (CAs) and Plans of Action (POA), Cooperative Agreements, and other compliance documents as needed.
  - (3) Appoint a government (that is, Federal or State Army National Guard (ARNG)) employee as the installation cultural resources manager (CRM).
  - (4) Establish a government-to-government relationship with Federally recognized Indian Tribes, as needed. Initial formal government-to-government consultation with Federally recognized Indian Tribes will occur only between the

garrison commander (GC) or the Adjutant General (TAG) of an ARNG and the heads of tribal governments. Follow-on activities may be accomplished by staff.

(5) Establish a process that effects early coordination between the CRM and all staff elements, tenants, proponents of projects and actions, and other affected stakeholders to allow for proper identification, planning, and programming for cultural resource requirements.

*b. National Historic Preservation Act compliance.*

(1) Ensure that the GC functions as the agency official with responsibility for installation compliance with the National Historic Preservation Act (NHPA).

(2) Establish a historic preservation program, to include the identification, evaluation, and treatment of historic properties in consultation with the Advisory Council on Historic Preservation (ACHP), State Historic Preservation Officer (SHPO), local governments, Federally recognized Indian Tribes, Native Hawaiian organizations, and the public as appropriate. Document historic properties that will be substantially altered or destroyed as a result of Army actions. (LD: Section 110, NHPA; 36 CFR 800)

(3) Identify, evaluate, take into account, and treat the effects of all undertakings on historic properties. If an Army undertaking may affect properties of traditional religious or cultural significance to a Federally-recognized Indian Tribe, initiate consultation on a government-to-government basis. (LD: Section 106, NHPA; 36 CFR 800)

(4) Prepare and implement, as required, an NHPA Section 106 MOA, PA, or HPC, to address NHPA compliance for undertakings. Coordinate all NHPA compliance documents (for example, MOAs, PAs, HPCs) through the chain of command to obtain HQDA technical and legal review prior to execution. (LD: 36 CFR 800)

(5) Ensure that efforts to identify, evaluate, and treat historic properties consider the Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation, and are conducted under the supervision of personnel who meet applicable professional qualifications for undertaking such work. (LD: 36 CFR 61; Section 112, NHPA)

(6) Maintain an up-to-date listing of all historic properties, and where applicable, maintain historic status in conjunction with real property inventory and reporting guidelines. (LD: EO 13287)

(7) Withhold from public disclosure information about the location, character, or ownership of a historic property when the GC determines that disclosure may cause risk of harm to the historic property or may impede the use of a traditional religious site by practitioners. (LD: Section 304, NHPA)

(8) Consider alternatives for historic properties, including adaptive reuse, that are not needed for current or projected installation mission requirements. (LD: Section 111, NHPA)

(9) Nominate to the National Register of Historic Places (NRHP) only those properties that the Army plans to transfer out of Federal management through privatization efforts. Nominate other properties only when justified by exceptional circumstances. Avoid adversely affecting properties that are 50-years old or older that have not been evaluated for eligibility against NHPA criteria. Treat (assume) that all historic sites are eligible (that is, off-limits) until the SHPO concurs with the federal finding of non-eligible.

(10) Where disagreement occurs with the SHPO regarding the eligibility of a historic property for the NRHP, where applicable obtain a "Determination of Eligibility" from the Keeper of the National Register, National Park Service (NPS). (LD 36 CFR 800, 36 CFR 63)

(11) Undertake such planning and actions as may be necessary to minimize harm to any National Historic Landmark that may be directly and adversely affected as a result of Army actions. (LD: 36 CFR 800)

*c. AIRFA, Executive Order 13007 and Executive Order 13175 compliance.*

(1) Consult with Federally recognized Indian Tribes to provide access to sacred sites on Army installations. Consistent with appropriate health, safety mission constraints provide access to allow the practice of traditional religions, rights and ceremonies. The GC will maintain the appropriate confidentiality of sacred site locations. The GC may impose reasonable restrictions and conditions on access to sacred sites on Army installations for the protection of health and safety, or for reasons of national security. (LD: EO 13007)

(2) Avoid adversely affecting the physical integrity of sacred sites. Ensure reasonable notice is provided to Federally-recognized Indian Tribes when proposed actions may adversely affect or restrict access to the ceremonial use of, or the physical integrity of, sacred sites. (LD: EO 13007)

(3) Consult with tribal governments before taking actions that affect Federally recognized Indian Tribes. Assess the impact of Army plans, projects, programs, and activities on tribal trust resources and assure that tribal government rights and concerns are considered during the development of such plans, projects, programs and activities. (LD: EO 13175)

*d. Native American Graves Protection and Repatriation Act compliance.*

(1) Designate the GC as the Federal agency official with responsibility for installation compliance with Native American Graves Protection and Repatriation Act (NAGPRA). (LD: 43 CFR 10)

(2) Prepare CAs and POAs in coordination with Federally recognized Indian Tribes and Native Hawaiian organizations. Coordinate all NAGPRA CAs through the chain of command to obtain HQDA technical and legal review prior to execution. (LD: 43 CFR 10)

(3) Absent a CA, take reasonable steps to determine whether a planned activity (including MILCON) may result in the intentional excavation or inadvertent discovery of cultural items from Federally-owned or controlled Army lands. When cultural items may be encountered, the GC will implement consultation procedures and planning requirements of Section 3 and Section 5 of NAGPRA prior to issuing approval to proceed with the activity. (LD: 43 CFR 10.3 and 43 CFR 10.5)

(4) Establish initial communication with Federally recognized Indian Tribes via written correspondence between the GC and heads of tribal governments. Formally document all resulting agreements. (LD: 43 CFR 10)

(5) Inventory, summarize, and repatriate cultural items that are in existing collections under Army possession or control. Where there is a dispute as to the affiliation of cultural items, safeguard the cultural items until the dispute is resolved. (LD: 43 CFR 5, 6, 7, and 10)

*e. ARPA and AHPA Compliance.*

(1) Ensure the GC serves as the Federal land manager with responsibility for installation compliance with ARPA. (LD: 32 CFR 229)

(2) Ensure the GC serves as the Federal agency official with management authority over archeological collections and associated records. (LD: 36 CFR 79)

(3) Establish and include installation policy for management of, and for limitation of collection and removal of, paleontological resources in ICRMPs. Address known paleontological resources in any NEPA documentation prepared for actions that may impact or cause irreparable loss or destruction of such resources.

(4) Prohibit searching for or collection of historic properties (including archaeological resources) on Army installations except when authorized by the GC and pursuant to a permit issued under ARPA.

(5) Minimize the amount of archeological material remains permanently curated by reserving such treatment for diagnostic artifacts and other significant and environmentally sensitive material that will add important information to site interpretation.

(6) Curation of archeological materials from Army lands will occur only in 36 CFR 79-compliant repositories. Maximize use of off-installation facilities that are better able to provide for adequate long-term curatorial services.

(7) Do not disclose to the public information concerning the nature and location of any archaeological resource for which the excavation or removal requires a permit or other permission under ARPA or under any other provision of Federal law. (LD: Section 9a, ARPA 1979)

## **Chapter 7 Pollution Prevention**

### **7-1. Policy**

*a.* Pollution prevention is the Army's preferred approach, where timely and cost-effective, to achieve and maintain compliance with environmental laws and regulations.

*b.* Prevent pollution from all sources to the extent practicable by:

(1) Reducing pollutants at the source.

(2) Modifying manufacturing, packaging, and shipping processes, maintenance or other industrial practices.

(3) Modifying product designs.

(4) Developing and modifying acquisition systems.

(5) Recycling/reuse (to include implementing water and energy conservation measures), especially in closed-loop processes.

(6) Preventing disposal and transfer of pollution between media.

(7) Meeting affirmative procurement requirements and promoting the acquisition and use of environmentally preferable products and services.

(8) Promoting use of nontoxic substances.

*c.* Use pollution prevention to complement, and where practicable, replace traditional pollution control approaches.

*d.* Incorporate pollution prevention planning throughout the mission, operation, or product life cycle.

### **7-2. Legal and other requirements**

*a.* 42 USC 6901, (*RCRA*).

*b.* PL 109-58.

*c.* Sections 6901-6992k, Title 42, United States Code (42 USC 6901-6992k)).

*d.* Sections 13101-13102, Title 42, United States Code (42 USC 13101-13102).

*e.* EO 13423.

*f.* DODI 4715.4.

g. AR 70–1.

### **7–3. Major program goals**

- a. Reduce use of products or processes that degrade the environment.
- b. Invest in pollution prevention in all mission and support areas, as applicable.
- c. Minimize the use of toxic and hazardous materials and processes in all life cycle phases of acquisition programs, logistics support, modification of existing weapons systems, and installation management.
- d. Implement pollution prevention initiatives to reduce life cycle costs of military missions and improve demilitarization and disposal of systems.
- e. Disseminate pollution prevention opportunities and lessons learned across the Army.
- f. Incorporate a Hazardous Materials Management Program (HMMP) into logistics business practices to reduce hazardous material inventory and hazardous waste (HW) disposal.

### **7–4. Program requirements**

- a. Periodically review operations and conduct pollution prevention opportunity assessments. Maintain an updated installation pollution prevention plan. Implement cost-effective pollution prevention opportunities identified by the assessments.
- b. Develop and implement a Green Procurement Program with emphasis on the mandatory purchasing preference programs (Affirmative Procurement for all designated Environmental Protection Agency (EPA) and DOD guidelines). (LD: EO 13423; 40 CFR 247)
- c. Address environmental concerns throughout the acquisition life cycle. (PD: AR 70–1)
- d. Emergency Planning and Community Right-to-Know Act (EPCRA).
  - (1) Army activities within the United States will comply with EPCRA. Army activities will prepare and maintain an inventory of hazardous substances present at the activity. (LD: EO 13423)
  - (2) Activities will submit EPCRA reports to Local Emergency Planning Committees (LEPC), State Emergency Response Commissions (SERC), local fire departments with jurisdiction over the activity, and EPA if they exceed reporting threshold quantities. Tier I and Tier II reports are due by 1 March in each calendar year. An activity may be a LEPC when appointed by a SERC. (LD: EO 13423)
  - (3) Activities will submit draft electronic Toxic Release Inventory (TRI) Form R reports to the U.S. Army Environmental Command (USAEC) via chain of command by 1 May of each calendar year. After review and comment from USAEC, activities will provide final report to the EPA by 1 July, with copy to USAEC. (LD: EO 13423)

## **Chapter 8 Munitions Use on Ranges**

### **8–1. Policy**

This chapter applies to operational ranges, which are defined as ranges that are under the jurisdiction, custody, or control of the Secretary of Defense and that are used for range activities; or, although not currently being used for range activities, that are still considered by the Secretary to be a range and have not been put to a new use that is incompatible with range activities. In managing operational ranges, all Army organizations and activities will—

- a. Consider demilitarization, constituent migration, and range cleanup and clearance in the weapons systems total lifecycle cost.
- b. Manage the Army munitions inventory to achieve and maintain compliance with the Military Munitions Rule (or applicable Final Governing Standards (FGS) overseas).
- c. Whenever practicable, recycle obsolete, excess, or unserviceable munitions and munitions residue.
- d. Incorporate environmental considerations into sustainable range designs to support mission requirements.
- e. Coordinate with the Headquarters, Department of the Army, Deputy Chief of Staff, G–3/5/7 before closing an operational range.

### **8–2. Legal and other requirements**

- a. Section 9601, Title 42, United States Code (42 USC 9601); Section 300f, Title 42, United States Code (42 USC 300f); Section 26, Title 33, United States Code (33 USC 26); Section 7401, Title 42, United States Code (42 USC 7401); FGS requirements; and other regulations that apply to soil, water, and air.
- b. Sections 200 to 206, Part 266, Title 40, Code of Federal Regulations (40 CFR 266.200 to 40 CFR 266.206) or applicable State versions.
- c. DODD 4715.11 and DODD 4715.12.
- d. DODI 4140.62.

### 8-3. Major program goals

Identify and address environmental issues that impact the use of Army ranges.

### 8-4. Program requirements

#### *a. Munitions management.*

(1) Train munitions managers and handlers on the Munitions Rule and related State requirements (or applicable FGS requirements overseas). (PD: Munitions Action Plan)

(2) Audit for compliance with the Munitions Rule and related State requirements (or applicable FGS requirements overseas). (PD: Munitions Action Plan)

#### *b. Environmental support to range operations.*

(1) Prepare an annual Toxic Release Inventory (TRI) Form R for operational ranges as required and submit with the installation's TRI report to the U.S. Army Environmental Command (USAEC) via chain of command by 1 May of each calendar year (this does not apply overseas). After review and comment from USAEC, facilities will provide final report to the Environmental Protection Agency (EPA) by 1 July, with copy to USAEC (see para 7-4d).

(2) Respond to a release or substantial threat of release of munitions constituents (MC), munitions and explosives of concern (MEC), or unexploded ordnance (UXO) from an operational range to off-range areas, when such release poses or may pose an imminent and substantial threat to human health or the environment.

(3) Where practicable, maintain records of the historical uses of operational ranges; and retain environmental cleanup investigations, hydro-geologic, geologic, and soil surveys, and other environmental documents that support sustainable range planning.

(4) Maintain and sustain ranges in an environmentally compliant manner, and undertake emergency response action when appropriate.

#### *c. Response to munitions and explosives of concern.*

(1) Investigate and address, as appropriate, the explosives safety, human health, or environmental risks presented by MEC. (This can be as simple as a notification to the community with an education program about the hazards posed by military munitions and how to avoid them, or as complicated as a long-term response action involving sophisticated technology, specialized expertise, and significant resources.)

(2) Maintain permanent records of the coordinates of all areas known or suspected to contain MEC.

(3) Maintain permanent records of all MEC clearance operations, explosive ordnance disposal (EOD) incidents, and open burn/open detonation operations conducted on the range.

*d. Chemical warfare agent wastes.* Storage and disposal of chemical warfare agent waste and related agent-contaminated material may be subject to the requirements of RCRA or applicable State regulations (this does not apply overseas). Generators of chemical warfare agent waste and agent-contaminated material are responsible for ensuring proper storage and for paying disposal costs (this does not apply to Defense Environmental Restoration Program (DERP)-eligible sites).

## Chapter 9 Materials Management

### 9-1. Hazardous materials

#### *a. Policy.*

(1) Follow approved standardized hazardous material management business practices as specified by the Deputy Chief of Staff, G-4 (DCS, G-4) and the Office of the Assistant Chief of Staff for Installation Management (OACSIM) to implement the Hazardous Material Management Program (HMMP).

(2) Review and approve hazardous material (HM) usage and track usage to using processes and work centers.

(3) Reduce the acquisition and use of hazardous materials and the generation of solid or hazardous wastes (HW) through centralized inventory control, best management practices (BMPs), pollution prevention actions, improved procurement practices, material re-use, recycling, and enhanced shelf-life management. HMs should be procured through the standard Army supply system. Use of government IMPAC credit cards to purchase HM is generally prohibited, and may only be allowed on a case-by-case basis by Garrison Commanders or their designated representative.

(4) Manage and dispose of pesticides, residues, and their containers in an environmentally safe manner.

(5) Do not allow the transport, storage, or disposal of non-DOD hazardous materials on Army installations unless approved by the Office of the Assistant Secretary of the Army for Installations and Environment (OASA (I&E)), his or her designee, or higher authority.

*b. Legal and other requirements.* Section 11011, Title 42, United States Code (42 USC 11011); Section 302-313, Title 33, United States Code (33 USC 26); and Executive Order (EO) 13423.

*c. Major program goals.* The goals of the HMMP are to reduce risk to public health and the environment by

employing management controls and pollution prevention initiatives to comply with regulations and executive orders and to support sustainability.

*d. Program requirements.*

(1) Follow Army logistics policy for identifying, storing, and transporting hazardous materials as specified by the DCS, G-4. Related policy guidance can be found in safety, medical, acquisition and logistics regulations. Installation supplements involving any hazardous material management should be coordinated with the installation environmental coordinator, safety coordinator, and installation medical officer.

(2) Record, review, and analyze HM and HW operational data as a source of information to measure HMMP effectiveness.

## **9-2. Toxic substances**

*a. General.* As used in this regulation, toxic substances include asbestos, polychlorinated biphenyls (PCBs), and lead-based paints (LBP). Generators will pay disposal costs for toxic substances (except that the installation will pay disposal costs for toxic substances that are also classified as a RCRA-C hazardous waste).

*b. Asbestos management.*

(1) *Policy.* The Army proponent for asbestos hazard management is the Assistant Chief of Staff for Installation Management (ACSIM), Directorate of Facilities and Housing. Army facility policy and guidance on asbestos management is provided in AR 420-70, chapter 3. The Army's medical policy related to asbestos is found in AR 40-5.

(2) *Legal and other requirements.* Applicable legal and other requirements for asbestos management include Section 2651, Title 15, United States Code (15 USC 2651); Section 1801, Title 49, United States Code (49 USC 1801); Section 2601, Title 15, United States Code (15 USC 2601); 42 USC 7401, as amended; Section 1001, Part 1910, Title 29, Code of Federal Regulations (29 CFR 1910.1001); Section 1101, Part 1926, Title 29, Code of Federal Regulations (29 CFR 1926.1101); for overseas installations, the country-specific FGS requirements.

(3) *Major program goals.* Prevent human exposure to asbestos hazards on Army-owned property and maintain compliance with all pertinent regulations. This also applies to accommodations made available to the Army for its exclusive use overseas.

*(4) Program requirements.*

*(a)* Comply with Sections 140-156, Part 61, Title 40, Code of Federal Regulations (40 CFR 61.140-156) requirements regarding fees and notification. (LD: 40 CFR Part 61.140-156; 40 CFR 70)

*(b)* Ensure that all workers in facilities where asbestos exposure may occur are trained under Environmental Protection Agency (EPA) and Occupational Safety and Health Administration (OSHA) regulations and asbestos safe work practices requirements. (LD: 40 CFR 763)

*(c)* Ensure that all workers that perform OSHA asbestos work are trained, equipped, and supervised according to EPA abatement and respiratory protection requirements. (LD: 29 CFR 1926.1101; 40 CFR 763)

*(d)* Use only laboratories accredited under the National Voluntary Laboratory Accreditation Program or host nation (HN) accredited laboratories for overseas installations for the quantitative measurement of bulk and air asbestos samples. (LD: 40 CFR 763.87)

*(e)* Remove/abate asbestos-containing material only when it:

1. Can no longer be managed in place.
2. Will be disturbed during maintenance, repair, or construction projects.
3. Is friable or will become friable during demolition of a facility.
4. Is economically justified to be removed during building deconstruction.
5. Has been identified to be a hazard and the Army is transferring ownership of the facility to a non-federal entity.

*c. Polychlorinated biphenyl management.*

(1) *Policy.* Army policy is for generators of polychlorinated biphenyl (PCBs) to manage them in place unless operational, economic, or regulatory considerations justify removal. Economic analyses include potential environmental damage.

(2) *Legal and other requirements.* Requirements for PCB management are found in 15 USC 2601, and applicable State and local requirements; and for overseas installations, the country-specific FGS requirements.

(3) *Major program goals.* Prevent human exposure to PCB hazards on Army-owned property and maintain compliance with pertinent regulations.

*(4) Program requirements.*

*(a)* Ensure that the inventory, management, reporting, storage, disposal, and cleanup of PCBs comply with Federal, State, and local regulations. (LD: 40 CFR 761)

*(b)* Require generators, commercial storers, transporters, and disposers of PCBs to have an EPA identification number. (LD: 40 CFR 761.20, 761.60(b), 761.202 through 761.205)

*(c)* Train personnel who handle or may potentially be exposed to PCBs to perform PCB-related responsibilities in a safe and environmentally sound manner. (LD: 29 CFR 1910.1200; 29 CFR 1910.120(q))

*(d)* Prohibit the new use or introduction of PCBs at Army facilities.

*d. Lead-based paint management.*

(1) *Policy.* The Army proponent for lead-based paint (LBP) management is the ACSIM, Directorate of Facilities and Housing. Army facility policy and guidance on LBP management is provided in AR 420–70, chapter 3.

(2) *Legal and other requirements.* Requirements for LBP management are found in 15 USC 2601; Section 1025, Part 1910, Title 29, Code of Federal Regulations (29 CFR 1910.1025); Section 62, Part 1926, Title 29, Code of Federal Regulations (29 CFR 1926.62); Part 745, Title 40, Code of Federal Regulations (40 CFR 745); AR 420–70, chapter 3; and applicable State and local requirements; for overseas installations, the country-specific FGS requirements.

(3) *Major program goals.* Prevent human exposure to LBP hazards on Army-owned property and maintain compliance with pertinent regulations.

*(4) Program requirements.*

(a) Ensure that all workers that perform lead abatement work in child occupied facilities and target housing are trained, equipped, and supervised according to EPA lead-based paint abatement requirements and OSHA requirements for lead in construction. (LD: 40 CFR 745 and 29 CFR 1926.62, respectively). Construction work impacting lead-based paint that is not considered abatement of lead-based paint in target housing or child occupied facilities need only comply with OSHA requirements. (LD: 29 CFR 1926.62)

(b) Per facility and housing BMPs, manage LBP and lead-contaminated soil in place unless operational, economic, and/or regulatory requirements dictate its removal.

(c) Disclose known LBP hazards in Army housing. (LD: 40 CFR 745)

(d) Ensure that disposal of LBP complies with Federal, State, and local regulations.

## Chapter 10 Waste Management

### 10–1. Hazardous waste

*a. Policy.*

(1) Hazardous waste disposal costs are those costs associated with the collection, treatment, storage, transportation and disposal of hazardous wastes. This includes all Defense Reutilization and Marketing Service (or other contract agent) costs directly related to the packaging and offsite shipment of the wastes. It does not include the disposal of special wastes defined as non-hazardous unless otherwise defined as hazardous by State and local regulations, or country-specific Final Governing Standards (FGS); asbestos; chemical and biological agent waste; radioactive waste; and regulated medical wastes (RMW).

(a) Garrisons must directly charge or seek reimbursement from non-Army tenants and activities funded through an operating fund (Defense Business Operating Fund and Army Working Capital Fund), a procurement fund (Procurement of Ammunition, Army), a research and development fund (Research, Development, Test, and Evaluation and Army Test and Evaluation Command activities), and other DOD funded activities (primarily Defense Logistics Agency, Medical Command, and Defense Commissary Agency). Though appropriated funds can be used for a non-appropriated fund activity (Category C), it is subject to the availability of funds of HQ, IMCOM. Special installations will pay for hazardous waste disposal. Excess or expired hazardous materials must be handled in accordance with AR 710–2 and garrison procedures.

(b) Hazardous wastes generated under service, facility, maintenance or construction contracts (construction demolition debris, paints, soil disposal, disposal of sand from ranges, sludge from wash racks, oil/water separators, water treatment plants, and so forth.) should not be a separate cost and funded as part of the original contract.

(c) The Garrison environmental office will be considered the generator, for funding purposes, of orphan wastes found on post, and wastes from a household hazardous waste collection program.

(2) Comply with all applicable Federal, State, and local HW regulations, and FGS.

(3) Effectively manage HW and reduce its generation.

(4) Minimize the need for Army-owned or operated permitted HW treatment, storage, and disposal facilities.

(5) Minimize HW generation through pollution prevention actions, for example, source reduction, material substitution, and recycling/reuse. Where cost effective and timely, implement pollution prevention solutions to reduce or eliminate compliance requirements.

(6) Prohibit the storage of HW in underground storage tanks (USTs), except where allowed by FGS.

*b. Legal and other requirements.* 42 USC 6901, Subtitle C; Parts 260–279, Title 40, Code of Federal Regulations (40 CFR 260–279); DOD 4500.9–R, chapter 204; Parts 171–178, Title 49, Code of Federal Regulations (49 CFR 171–178); for overseas installations, the country-specific FGS requirements.

*c. Major program goals.* Continually reduce the volume of HW generated by Army installations, and maintain compliance with pertinent HW regulations.

*d. Program requirements.*

(1) Systematically evaluate waste streams to ensure all potential hazardous or special wastes are properly identified and characterized. (LD: 40 CFR 262.11; 40 CFR 264.13)

(2) Ensure that all persons handling or managing HW are provided with appropriate training.

(3) Develop and implement a hazardous waste management plan (HWMP) or other comparable document appropriate to the size and complexity of the operation. The HWMP (or other comparable document) should include, at a minimum, written procedures for all aspects of HW management, to include the identification, storage, and transporting of HW; training of personnel; tracking manifests; and maintaining required records.

(4) Maintain appropriate records in accordance with RCRA and applicable State or FGS requirements.

(5) Complete State/EPA or applicable FGS annual or biennial reporting requirements.

(6) Ensure that HW manifests are only signed by those individuals who have been appropriately trained, and are authorized in writing by the garrison commander (GC). (LD: 49 CFR 172.700–704 (Subpart H); DOD 4500.9–R, chapter 204)

(7) Ensure that the GC signs the RCRA HW permit applications for the installation, sub-installations, and supported facilities as the facility “owner.” This responsibility cannot be delegated.

(a) Officials in charge of tenant activities will sign the permit application as the “operator.”

(b) For the Defense Logistics Agency, the DRMS Commander will sign as the “operator.”

(c) For Army Reserve facilities, the Reserve Readiness Command (RRC) Commander will sign as the facility “owner.”

(d) For Army National Guard (ARNG) facilities, the Adjutant General (TAG) of the respective State or territory will sign as the facility “owner.”

(e) For closed, transferred, or transferring facilities, the GC of the receiving installation will sign as “owner”, and the agency maintaining control and influence over the closed or transferring facility’s HW management program will sign the permit as “operator.”

(f) For installations not under the purview of the IMCOM, the senior mission commander (SMC) will sign as the facility “owner.”

(8) If non-DOD tenants require HW treatment, storage, and disposal facility permits, ensure that the contract, lease, or agreement with the non-DOD tenant holds the Army harmless and contains specific language regarding the operation of the facility, access, damages, and environmental liability in strict accordance with permit conditions. The GC will sign permit applications as the “owner,” and the tenant will sign as the “operator” of the facility.

(9) Use the Defense Reutilization Marketing Office (DRMO) for HW disposal with the following exceptions:

(a) When DRMO has indicated or demonstrated the inability to provide the service, and only when a waiver has been approved in writing by the next higher echelon on a case-by-case basis. Waivers will be renewed in writing every 5 years.

(b) Hazardous waste generated incidental to the execution of service or construction contracts should be disposed of by the contractor performing the basic contract, at the contractor’s expense, using the installation’s generator identification number on the manifest. Such actions must be coordinated with the installation environmental coordinator and documented in writing. The GC remains the “owner” of the waste.

(c) Ensure that all contracts for HW disposal are reviewed by the installation environmental coordinator and the Director of Contracting, and approved by the GC. Such contracts must comply with contract standards in DOD 4160.21–M, chapter 10.

## 10–2. Solid waste

*a. Policy.* The Army proponent for solid waste management is the Assistant Chief of Staff for Installation Management (ACSIM), Directorate of Facilities and Housing. Army facility policy and guidance on solid waste management is provided in AR 420–49, chapter 3.

(1) Comply with legally applicable Federal, State, and local requirements, both substantive and procedural, for managing solid waste, including generation, collection, storage, and disposal. This includes the terms and conditions of State and Federal solid waste permits. Overseas, all Army organizations and activities will comply with country-specific FGS and any permits obtained on behalf of the installation by the host nation.

(2) Emphasize integrated solid waste management, pollution prevention, and individual participation to achieve compliance.

(3) Minimize solid waste generation and disposal, and maximize recovery, recycling, and reuse through pollution prevention actions.

(4) Integrate the management of wastes into construction and demolition (C&D) activities such that a significant amount of the materials generated can be reused in their original form with little or no processing, through systematic disassembly or deconstruction, more careful handling, segregating, and making them available to specialized markets.

(5) Ensure that waste accumulation, storage, or transfer facilities are designed and constructed to prevent releases to the environment.

*b. Legal and other requirements.*



(1) 42 USC 6901, Subtitle D (as amended); PL 98-616; Paragraph a, Sections 6941-6949, Title 42, United States Code (42 USC 6941-6949a, Subtitle D; as amended; Parts 239-258 and Part 261, Title 40, Code of Federal Regulations (40 CFR 239-258 and 261); applicable FGS; and EO 13423.

(2) AR 420-49, chapter 3 defines the Army's policy for managing solid waste. This section of AR 200-1 supplements AR 420-49 by identifying environmental aspects of solid waste management.

(3) AR 415-15, appendix F, Item F-37, Army Disposal/Demolition Program, describes the Army requirement to dispose of one square foot of facilities to offset each square foot of new construction added to the real property inventory.

(4) DA Pam 40-11, chapter 4, Section 4-11 defines the Army's policy for managing regulated medical wastes.

*c. Major program goals.* The environmental goals of the Army's solid waste management program are to protect public health and the environment by increasing solid waste diversion, minimizing the generation of solid wastes, and increasing the program's economic benefit by investing in pollution prevention initiatives and better managing costs associated with disposal and diversion.

*d. Program requirements.* Army installations with Army-owned landfills will operate under 42 USC 6941-6949a and meet the criteria of a municipal solid waste landfill (MSWLF) as defined by Federal regulation or State-approved program. Installations may also operate landfills specifically for construction and demolition debris, and/or non-hazardous industrial process wastes, as determined by their mission. These landfills will be operated in accordance with applicable Federal, State, and local regulations. (LD: 40 CFR 257, 258)

## **Chapter 11**

### **Storage Tank Systems/Oil and Hazardous Substances Spills**

#### **11-1. Policy**

Manage tank systems used to store oil and hazardous substances in an environmentally safe manner, prevent spills of these substances, and rapidly respond to spills.

#### **11-2. Legal and other requirements**

*a.* 42 USC 9601; 42 USC 11011; 33 USC 26, as amended to include Part 112, Title 40, Code of Federal Regulations (40 CFR 112); Part 300, Title 40, Code of Federal Regulations (40 CFR 300); 42 USC 6901, as amended to include Part 280, Title 40, Code of Federal Regulations (40 CFR 280) and Part 281, Title 40, Code of Federal Regulations (40 CFR 281); 33 USC 2701; 15 USC 2601, as amended; Public Law (PL 109-58), Sections 1521-1532; and AR 50-6. Related Federal laws and regulations are referenced in appendix A.

*b.* Overseas, all Army organizations and activities will comply with applicable Final Governing Standards (FGS).

#### **11-3. Major program goal**

Storage tanks used to transport, store, and handle oil and hazardous substances will be managed to protect the environment and public health.

#### **11-4. Program requirements**

##### *a. Storage Tank Systems.*

(1) Provide leak detection for regulated underground storage tanks (UST) by retrofit or inventory control procedures. (LD: 40 CFR 280.43)

(2) Provide leak detection, overfill protection, and cathodic protection for aboveground storage tanks (ASTs) as required. (LD: 40 CFR 112.8)

(3) Use double wall construction with interstitial monitoring on all new regulated USTs.

(4) Ensure that all UST systems are cathodically protected or constructed of non-metallic material to meet corrosion protection requirements. (LD: 40 CFR 280.20)

##### *b. Oil and hazardous substance spills.*

(1) Develop and implement a spill prevention, control, and countermeasures plan (SPCCP), as required. (LD: CWA Section 311(j), 40 CFR 112, and OPA)

(2) Ensure that the SPCCP addresses secondary containment (or lack thereof) at oil and hazardous material storage facilities. (LD: 40 CFR 112.7)

(3) Develop and implement a facility spill contingency plan (SCP) for each oil and hazardous material storage facility that does not have adequate spill prevention structures in place. (LD: 40 CFR 112.7)

(4) Ensure secondary containment is provided for oil and hazardous material storage facilities, including piping. If it is determined that secondary containment is impracticable, the installation must address this in the SPCCP and facility SCP (an SCP is only required if adequate spill prevention structures are not in place). (LD: 40 CFR 112.7)

(5) Ensure the SPCCP is reviewed at least once every 5 years. Amend the plan within 6 months of a change that

materially affects its potential for discharge. If technical changes have been made, the plan must be signed by an individual with authority to commit the necessary resources to respond to a release, and certified by a professional engineer familiar with installation operations. (LD: 40 CFR 112.5)

(6) Use the Environmental Quality Control Committee (EQCC) to coordinate the SPCCP with affected installation elements.

(7) Maintain an accurate inventory of SPCCP applicable containers, including the location and/or spatial extent of such containers. (LD: 40 CFR 112.7)

(8) Prepare spill response plans and notification procedures, to include a facility response plan, as needed, for spills caused by Army actions, including coordination with local emergency planning authorities. (LD: 40 CFR 300.211; 40 CFR 112.20; 33 CFR 154; 49 CFR 130; 49 CFR 171–172)

(9) Conduct training to ensure proper response to spills or releases. This includes annual spill response exercises for the spill response organization. (LD: 29 CFR 1910.120 (e), (p), (q); 40 CFR 112.21)

(10) Ensure the garrison commander (GC) designates, in writing, a qualified on-scene coordinator (OSC) responsible for executing spill response. The local commander will designate in writing the OSC at USAR maintenance facilities. The State Adjutants General will designate in writing the OSC at Army National Guard (ARNG) maintenance facilities. (LD: 40 CFR 300.120)

(11) Ensure that facility operators and OSC understand and comply with Federal and State reportable quantity requirements.

(12) When a spill occurs, immediately report the spill or release to the OSC and implement the SCP and/or SPCCP. The OSC will determine if it exceeds reportable quantities and will notify regulatory authorities as required. Any spill that requires notification of regulatory authorities will be reported to the next higher headquarters. (LD: 40 CFR 112.4; 40 CFR 300.125; 33 CFR 153, Subpart B; 40 CFR 302)

(13) Assist Federal or State agencies in response to spills outside the Army property where practicable in accordance with AR 75–15.

(14) For outside the continental United States (OCONUS) installations, provide response assistance for spills off Army property in accordance with their applicable FGS and garrison SPCCP.

(15) For further guidance in managing ASTs and equipment subject to 40 CFR 112, refer to the 2 April 2004, DOD Joint Services Spill Prevention, Control, and Countermeasure (SPCC) Guidance.

## **Chapter 12 Environmental Cleanup**

### **12–1. Policy**

*a.* Comply with applicable Federal, State, local, and Department of Defense (DOD) requirements for the cleanup of contamination on Army installations and formerly used defense sites (FUDS). Figure 12–1 depicts the differences and commonalities among the various cleanup program areas. For overseas installations, only the Compliance-related Cleanup (CC) Program applies.

*b.* Accomplish early and continued public involvement in the cleanup programs.

*c.* Keep State regulatory agencies and the U.S. Environmental Protection Agency (EPA) informed of cleanup program activities, as appropriate.

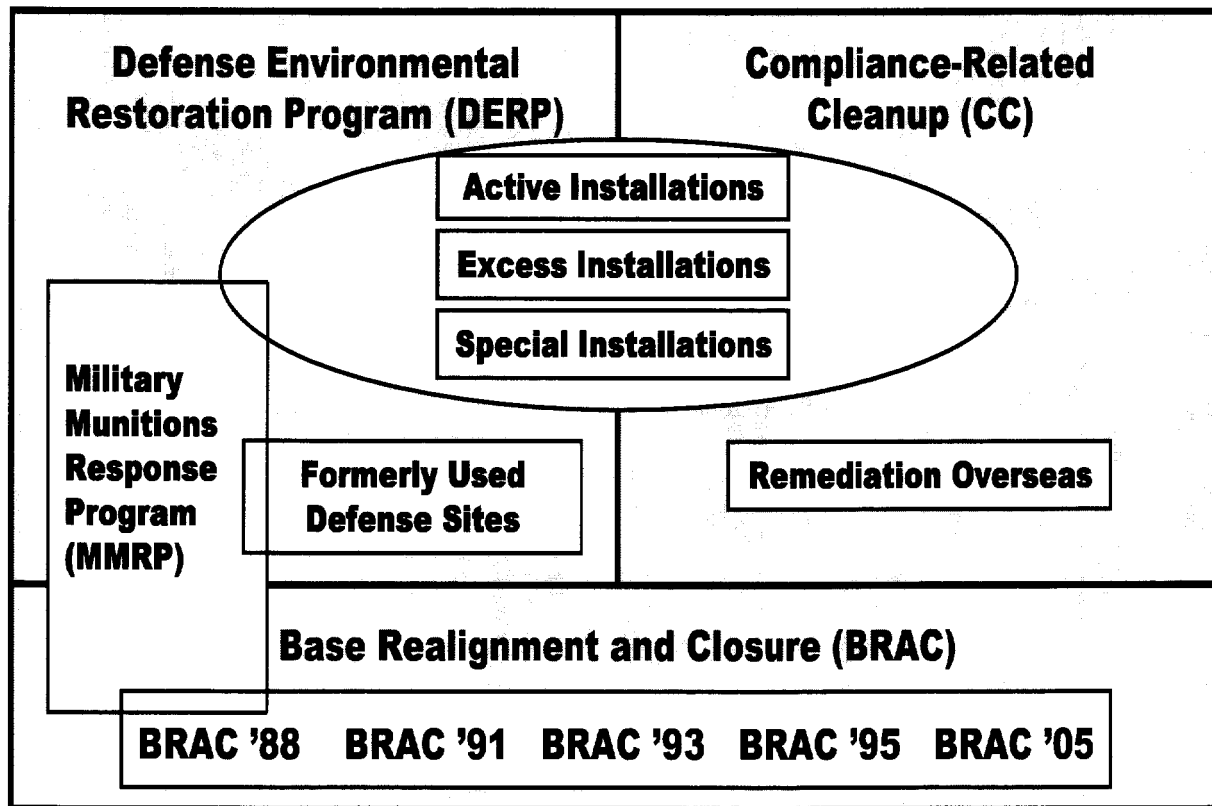


Figure 12-1. Army Environmental Cleanup Program Areas

## 12-2. Legal and other requirements

The following list of statutory requirements apply to environmental cleanup:

*a.* 42 USC 9601; 40 CFR 300; Section 120, Part 1910, Title 29, Code of Federal Regulations (29 CFR 1910.120); Executive Order (EO) 12580; and 42 USC 6901, Sections 3004u, 3004v, and 3008h; Section 2701, Title 10 United States Code (10 USC 2701); DOD 7000.14-R; DODI 4715.7, for all but overseas installations; DODI 4715.8; Engineer Regulation (ER) 200-3-1, formerly Used Defense Site (FUDS) Program Policy; Charter for the Formerly Used Defense Sites Program, 31 October 2003; and Office of the Assistant Secretary of the Army for Installations and Environment (OASA (I&E)) Deputy Assistant Secretary of the Army (Environment, Safety, and Occupational Health) (DASA (ESOH)) memorandum, 18 June 2004, subject: The Army Environmental Compliance-related Cleanup Program Eligibility. The Army environmental cleanup programs include the Army DERP at active, closing, and realigning installations; DERP at FUDS properties; and compliance-related cleanup (CC) at active and excess installations, including those overseas. Regulations that pertain to the Army's environmental cleanup programs are referenced in appendix A.

(1) Defense Environmental Restoration Program (DERP) cleanups (Installation Restoration Program (IRP), Military Munitions Response Program (MMRP), base realignment and closure (BRAC), FUDS) address hazardous substances, pollutants and contaminants, and military munitions sites, consistent with the provisions of 42 USC 9601, et seq. (CERCLA); 40 CFR 300 (National Oil and Hazardous Substances Pollution Contingency Plan); EO 12580; and 42 USC 6901, Sections 3004u, 3004v, and 3008h for activities that resulted in contamination prior to 17 October 1986 at non-permitted sites.

(2) Compliance related cleanup (CC) addresses cleanup requirements that are legally mandated but not eligible for funding under the Army DERP. The program focuses on the remediation of contamination at Army overseas facilities (it does not include actions to remedy contamination that are covered by environmental annexes to operations orders and similar operational directives), and on the cleanup of contamination resulting from operations that have occurred since 17 October 1986. This includes sites at Active Army, Army Reserve, Army National Guard (ARNG) Federally-owned facilities, as well as cleanup at non-Federally-owned, Federally-supported (State-owned, State-operated) ARNG

facilities. CC does not include initial response actions to address spills, but does include follow-on response action, if required.

b. The DERP is supplemented by the *DOD Management Guidance for the Defense Environmental Restoration Program (DERP)*, September 2001. The DERP Management Guidance defines eligibility and addresses sites in the following three program categories:

(1) The IRP includes response actions to address releases of hazardous substances, pollutants and contaminants (as defined in CERCLA); petroleum, oil, lubricants (POL); DOD-unique materials; hazardous wastes (HW); and low-level radioactive materials or low-level radioactive wastes (LLRW). The IRP also includes military munitions (including munitions and explosives of concern (MEC), see glossary) or munitions constituents (MC) at a relatively small number of sites where the following three conditions all exist:

(a) The release occurred prior to 30 September 2000.

(b) The release is at a site that is not an operational range, an active munitions demilitarization facility, an active waste military munitions (WMM) treatment or disposal unit, or FUDS.

(c) The site was identified or included in the Army Environmental Data Base-Restoration (AEDB-R) or Formerly Used Defense Sites Management Information System (FUDSMIS) prior to 30 September 2000, and was not classified as “response complete.”

(2) The MMRP addresses munitions responses at active or BRAC installations where the release occurred prior to 30 September 2002, and the release is at a site that is not a FUDS, an operational range, an active munitions demilitarization facility, or an active WMM treatment or disposal unit that operated after 30 September 2002, and the site was not identified or included in the AEDB-R prior to 30 September 2000.

(3) Building demolition/debris removal (BD/DR) addresses the demolition and removal of unsafe buildings and structures at facilities or sites that are or were owned by, leased to, or otherwise possessed by the United States and under the jurisdiction of the DOD.

### 12-3. Major program goals

Perform appropriate, cost-effective cleanup so that property is safe for Army use (or transfer as appropriate), sustains operations and training, and protects human health and the environment.

### 12-4. Program requirements

a. *Cleanup program areas.* All cleanup program areas must:

(1) Identify cleanup requirements at the site level using the more stringent of current or projected future land use as documented in the installation master plan, develop a reasonable schedule and cost to complete cleanup, record liabilities in a database of record, and pursue cleanup until regulatory agreement with site closure.

(2) Provide site-level data in response to Assistant Chief of Staff for Installation Management (ACSIM) data calls for updates to the databases of record.

(3) Develop and maintain an administrative record for National Priorities List (NPL) sites or similar documentation for non-NPL sites on the installation or U.S. Army Corps of Engineers (USACE) District responsible for FUDS.

(4) Prepare annual cost-to-complete estimates for each site in the program that reflect the environmental strategy and sequence as presented in the installation action plan (IAP), BRAC IAP, or FUDS management action plan (MAP). Maintain an audit trail for changes that occur in a fiscal year (FY) that reflects actions taken, change in estimates, and new or deleted requirements. Estimates must be based on reliable, complete and fully documented data and will be in constant year dollars. (LD: PL 101-576)

(5) Determine contamination migration. Garrison commanders (GCs) must approve off-site data collection and any off-post monitoring to ensure that contamination has not migrated off-site. (LD: EO 12580 at CERCLA sites; PD at other sites)

(6) Notify the DASA (ESOH) through the chain-of-command prior to initiating any off-site response actions. The Army has the authority to conduct response actions outside the installation boundary, however, the lack of Army control over this off-installation property, potential legal and technical complexity, sensitivity, and the necessity for increased public involvement requires additional oversight on these responses. This notification requirement does not apply to FUDS.

(7) Maintain a permanent document repository to ensure cleanup information is available to protect future Army liability at any date in the future.

(8) Document environmental response decisions in a CERCLA record of decision (ROD) or an equivalent decision document (DD) or action memorandum prior to conducting removal or remedial actions.

(9) Coordinate remedial documents with Natural Resource Trustees.

(10) Work cooperatively with regulatory agencies to ensure that the Army’s cleanup goals are accomplished cost-effectively, and in accordance with applicable laws and regulations.

(11) Fully support public involvement in cleanup programs where there is potential impact on the health, environment, and economic well being of the local community.

- (12) Maintain an inventory and maps of land use controls (LUCs) resulting from response decisions, and at active installations, integrate them into the installation master plan.
- (13) Establish procedures for evaluating implemented remedies that:
- (a) Optimize the overall performance and effectiveness of the remedy.
  - (b) Control the operation and maintenance cost of remedies in the remedial operations phase.
  - (c) Assess whether remedial action objectives specified in the ROD/DD for the site are being achieved and whether treatment systems are still needed.
  - (d) Determine whether different remedial action objectives or different technologies are more appropriate.
- b. Army Defense Environmental Restoration Program.* The DERP addresses sites at real property under U.S. jurisdiction, custody, and control of the Army to include: (LD: 10 USC 2701(c))
- (1) Active and excess U.S. Army and U.S. Army Reserve installations and facilities.
  - (2) Federally owned or leased ARNG installations, activities, and properties.
  - (3) Contractor activities, lessees, and other tenants on Army installations or facilities.
  - (4) The Army DERP addresses contamination at sites on active installations in the three categories described previously: IRP, MMRP, and BD/DR. The Army funds the DERP at active installations with Environmental Restoration, Army (ER, A) funds authorized and appropriated specifically to execute the DERP at active installations. ER, A is “fenced” and must be used for the restoration projects in the approved IAP for sites included in AEDB–R. (LD: 10 USC 2703)
  - (5) For IRP category sites:
    - (a) Conduct screening for past use of hazardous substances, pollutants and contaminants and the potential for contamination (or reassessment, if appropriate) at active Army and Federally-owned NGB–ARNG installations and sub-installations. (LD: 10 USC 2701)
    - (b) Conduct studies and response actions in accordance with the annual IAP approved by the GC (or equivalent).
    - (c) Establish an information repository and administrative record to provide public access to information about the cleanup activities at the installation. (LD: 42 USC 9613 and 9620)
    - (d) Establish an effective community involvement program, to include a community relations plan (CRP) at NPL sites (LD: 40 CFR 300.155) or public involvement and response plan for Army installations with an active cleanup program.
    - (e) Negotiate a Federal Facilities Agreement/Interagency Agreement at NPL sites complying with the DOD approved model agreement. (LD: CERCLA Section 120(e)(2) and 120(e)(4))
    - (f) Establish a Technical Review Committee (TRC) or Restoration Advisory Board (RAB) when applicable to allow the local community an opportunity to participate in the remedy selection process. Form a RAB at all BRAC installations where closure involves the transfer of property to the community, unless otherwise determined by the ACSIM. At installations on the NPL, a RAB will meet the requirements of paragraph c, Section 2705, Title 10, United States Code (10 USC 2705(c)) for a TRC. (LD: 10 USC 2705(d))
    - (g) Initiate action to have the site expeditiously deleted from the NPL by EPA once all site completion criteria are met, or request partial delisting of specific operable units, as appropriate. (LD: 40 CFR 300.425)
  - (6) For MMRP category sites: conduct response actions to address military munitions or the chemical residues of munitions at active installations.
  - (7) For BD/DR: BD/DR program category responses for buildings unused since 17 October 1986 may be undertaken when the requirement to demolish the building(s) is an integral part of activities under an IRP or MMRP category response. Any other ER, A funded BD/DR program category response for buildings unused since 17 October 1986 may only be undertaken when specifically authorized by the Assistant Deputy Undersecretary of Defense (Environment, Safety, and Occupational Health) (ADUSD (ESOH)).
- c. Base realignment and closure.*
- (1) The Base Realignment and Closure (BRAC) cleanup program addresses sites at installations designated for closure or realignment by Base Closure legislation and is funded from the Base Closure Account (BCA) using DOD’s DERP authority. At closing installations, cleanup requirements consist of previously identified IRP and MMRP category requirements plus those closure related compliance actions required for property transfer. The BRAC cleanup program may address BD/DR category requirements for unsafe buildings or structures unused since 17 October 1986, where the activities are an integral part of actions under the IRP or MMRP category responses.
  - (2) Army activities will—
    - (a) Update BRAC IAPs annually.
    - (b) Ensure that BRAC cleanup activities comply with the ADUSD(E) policy guidance for Fast Track Cleanups and the Base Redevelopment and Realignment Manual.
    - (c) Strive to transfer BRAC property to productive reuse.
- d. Compliance-related cleanup.*
- (1) The CC includes actions to address contamination at Army facilities overseas; contamination resulting from

operations that have occurred since October 1986 (that is, non-DERP) at Army Active, Excess, and Special installations, and ARNG Federally owned facilities; and contamination at non-Federally-owned, Federally-supported ARNG facilities.

(2) The CC projects are projects needed to further investigate, and if necessary, conduct response actions to address contaminants that present an imminent and substantial threat to human health and/or the environment.

(3) Undertake CC projects when needed to address the following requirements:

(a) Releases under CERCLA or RCRA corrective action that are not eligible for funding under the DOD Management Guidance for the DERP (for example, releases that occurred on or after 17 October 1986).

(b) Cleanup mandated under authority of Federal and/or State environmental laws that are not being addressed under other cleanup programs (for example, DERP, BRAC, and so forth).

(c) Releases from HW treatment, storage, or disposal facilities (TSDF) or solid waste landfills that are undergoing RCRA closure.

(d) Releases from a RCRA underground storage tank (UST) if it was in service as of 17 October 1986.

(e) Army contamination beyond the installation boundary where necessary to protect human health and the environment (and not eligible for DERP funding).

(f) Contamination at overseas installations in accordance with DODI 4715.8.

(g) Contamination at non-Federally-owned, Federally-supported ARNG sites, regardless of date.

(h) Munitions responses at ranges closed after 30 September 2002.

(i) Response actions outside the boundaries of operational ranges required as a result of the Range Assessment Program established in accordance with DODD 4715.11.

(j) Non-DERP environmental liabilities at excess installations.

(k) Army Commands (ACOMs), Army Service Component Commands (ASCCs), and Direct Reporting Units (DRUs) with special installations will program and budget mission or working capital fund resources to address non-DERP, CC eligible releases. Special installations are eligible for Army DERP consistent with DERP eligibility requirements.

*e. Other.*

(1) *Formerly used defense sites (FUDS).*

(a) Under the DERP, the FUDS Program addresses properties that were under the jurisdiction of the Secretary of Defense and owned by, leased by, or otherwise possessed by the United States, or otherwise under the operational control of the Secretary of Defense or the military components that were transferred from DOD control prior to 17 October 1986. The FUDS program addresses sites in the following program categories: IRP; MMRP; and BD/DR. Also eligible are former DOD sites that were transferred after 17 October 1986, but that have a completed Findings and Determination of Eligibility (FDE) and a final inventory project report (INPR), signed prior to 30 September 2000 stating that the property was FUDS eligible, and that were listed in Restoration Management Information System (RMIS) as a FUDS property prior to 30 September 2000.

(b) The ADUSD (ESOH) establishes overall FUDS program policy and budget guidance. Regardless of which military service formerly controlled the property, the Army is the executive agent (EA) to administer the FUDS program. General policy on management and execution of the FUDS program is provided in the DOD Management Guidance for the DERP and the FUDS Program Charter. The ASA (I&E) and ACSIM are, respectively, the Army Secretariat and Army Staff (ARSTAF) proponents for the FUDS program. The USACE is responsible for management and execution of the FUDS Program.

(c) Specific FUDS execution guidance and procedures are provided in USACE's Engineer Regulation (ER) 200-3-1.

(2) *Defense and State Memoranda of Agreement/Cooperative Agreement (CA).*

(a) DOD, through the Defense and State Memoranda of Agreement/Cooperative Agreement (DSMOA/CA) program, involves State/Territorial governments in the environmental restoration of DOD installations including FUDS properties. The Office of the Secretary of Defense (OSD) has given the Army the authority to negotiate DSMOAs and recommend approval of DSMOAs to the ADUSD (ESOH). USACE executes the DSMOA/CA Program for all military services.

(b) Authority for this program is contained in 10 USC 2701(d) which allows the Secretary of Defense to enter into agreements on a reimbursable basis with states/territories to support DERP cleanup efforts at DOD installations. The DSMOA/CA program does not apply to compliance-related cleanup (CC). Specific criteria, funding information, and services eligible for State reimbursement for this program are contained in Part 28835, Title 57, Federal Register (57 FR 28835), dated 29 June 1992.

(c) Funding for the Army's contribution to the DSMOA/CA Program will be provided by the Army from the ER, A; Environmental Restoration, FUDS (ER, F); and BCA accounts.

(3) *Memorandum of Understanding between DOD and the Agency for Toxic Substances and Disease Registry.*

(a) DOD has entered into a MOU with ATSDR that delineates the responsibilities and procedures under which

Agency for Toxic Substances and Disease Registry (ATSDR) and DOD will conduct activities mandated in CERCLA. The MOU is the single document governing the relationship between DOD and ATSDR.

(b) Funding for the ATSDR to conduct Army-related studies under the MOU with DOD is provided by the Army from the ER, A; ER, F; and BCA accounts. Each military component funds its own ATSDR services.

(c) Refer to the U.S. Army Environmental Restoration Programs Guidance Manual and the Guidelines for the Coordination of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Activities Between Agency for Toxic Substances and Disease Registry and Department of Defense for additional information about the roles of ATSDR and DOD components in DOD cleanup activities.

(4) *Exemptions.* The above guidance for environmental cleanup does not apply to:

(a) Contractor-owned and contractor-operated facilities that are not on real property controlled by the Army.

(b) Properties that are not on real property that is or was owned, controlled, or otherwise under the jurisdiction of DOD (that is, a third-party site).

(c) Responses to releases that occur solely as a result of an act of war.

(d) Emergency response to and cleanup of a release from any routine operation, management, or maintenance at an operating Army facility or site that does not become a cleanup project.

(e) Routine range maintenance and sustainment activities at operational ranges.

## **Chapter 13 Environmental Quality Technology**

The Environmental Quality Technology (EQT) effort is planned, programmed, and budgeted for at Headquarters, Department of the Army (HQDA) level. It focuses investments on the Army's most pressing needs and provides visibility of the Army's environmental research, development, test, and evaluation (RDT&E) efforts. EQT requirements are identified and validated through the Army Environmental Requirements and Technology Assessments (AERTA). The AERTA requires a review of new and existing requirements to determine if changes in doctrine, organization, training, materiel, leadership and education, or personnel and facilities (DOTMLPF) will resolve the requirement(s). Only those requirements requiring a materiel solution will be included in the AERTA. Requirements with other than materiel solutions will be forwarded to the appropriate proponent/organization for action. The EQT Program Operating Principles, October 2001, provide detailed guidance.

### **13-1. Environmental Technology Technical Council**

a. The Army established an Environmental Technology Technical Council (ETTC) to provide management oversight and endorsement of the EQT programs formulation process. The Deputy Assistant Secretary of the Army (Environment, Safety, and Occupational Health) (DASA (ESOH)) and the Director, Research and Laboratory Management, Office of the Assistant Secretary of the Army for Acquisition, Logistics, and Technology (OASA (ALT)) co-chair the ETTC.

b. The ETTC consists of members representing the operational, logistics, scientific and engineering, planning, resource management, infrastructure, and medical interests of the Army. The ETTC consolidates and prioritizes Army environmental technology needs, and articulates the requirements to the appropriate proponent.

c. The ETTC establishes technology teams as needed to carry out its assigned functions.

d. The ETTC meets as needed to endorse new programs and to review technology priorities and program execution.

### **13-2. Policy**

Provide environmental quality RDT&E and technology transfer to resolve the Army's EQT requirements. EQT efforts are integrated and coordinated with other Defense RDT&E initiatives, such as the National Defense Center for Environmental Excellence (NDCEE), Strategic Environmental Research and Development Program (SERDP), the Environmental Security Technology Certification Program (ESTCP), and Federal and State government and international forums, to leverage their technology output, reduce total life-cycle costs, and resolve these EQT requirements in a timely manner.

a. Focus efforts on high priority user defined requirements.

b. Implement technology development when technology is not commercially available.

c. Provide an adequate science and engineering base to sustain future technology needs.

d. Focus efforts of the Army EQT program to support and enhance technology transfer of validated capabilities and processes.

### **13-3. Legal and other requirements**

10 USC 160, Sections 2706 and 2709.

### **13-4. Major program goals**

The Army goal for EQT is to enable mission readiness through the development and exploitation of technology that provides sustainable installations, training lands, and weapons systems.

### **13-5. Major requirements**

- a.* Identify and document user requirements and invest in high priority environmental requirements providing validated solutions to the end-user for qualification, production, or fielding.
- b.* Leverage other DOD and Congressionally-directed initiatives to help resolve Army environmental requirements.
- c.* Use the EQT requirements to prioritize the Army funded efforts at the NDCEE.

## **Chapter 14 Operational Noise**

### **14-1. Policy**

- a.* Evaluate and document the impact of noise produced by ongoing and proposed Army actions/activities and minimize annoyance to humans to the extent practicable.
- b.* Develop installation noise management plans as appropriate.
- c.* Reduce noise to acceptable levels in on-post noise sensitive locations (for example, medical treatment, education, family housing) through appropriate land use planning and/or architectural and engineering controls.
- d.* Monitor, record, archive and address operational noise complaints.
- e.* Develop and procure weapons systems and other military combat equipment (for example, electrical generators, etc.) that produce less noise, when consistent with operational requirements. Measure the noise emitted by all combat equipment and weapons systems to be used in training before deployed to units.
- f.* Procure commercially manufactured products, or those adapted for general military use that produce less noise, and comply with regulatory noise emissions standards.
- g.* Acquire property only as a last resort to resolve off-post noise issues.
- h.* Manage operational noise issues and community relations to maintain sustainable testing and training capabilities and prevent encroachment.

### **14-2. Legal and other requirements**

Property and tort law; Noise Control Act of 1972, Quiet Communities Act of 1978; AR 95-1; AR 210-20; AR 350-19; and applicable State and local laws.

### **14-3. Major program goals**

- a.* Control operational noise to protect the health and welfare of people, on- and off- post, impacted by all Army-produced noise, including on- and off-post noise sources.
- b.* Reduce community annoyance from operational noise to the extent feasible, consistent with Army training and materiel testing mission requirements.
- c.* Actively engage local communities in land use planning in areas subject to high levels of operational noise and a high potential for noise complaints.

### **14-4. Program requirements**

*a.* Noise descriptors (metrics) appropriate for determination of compatible land use, and assessment procedures will be based on the best available scientific information.

(1) The day-night level (DNL) is the primary descriptor for military noise, except small arms, see table 14-1. The DNL is the time weighted energy average sound level with a 10-decibel (dB) penalty added to the nighttime levels (2200 to 0700 hours). The DNL noise metric may be further defined, as appropriate, by the installation with a specific, designated time period (for example, annual average DNL, average busy month DNL). The typical assessment period over which the noise energy is averaged is 250 days for Active Army installations and 104 days for Army Reserve and National Guard installations. The use of average busy month DNL is appropriate when the OPTEMPO is significantly different during certain peak periods of the year. For future land use planning and encroachment assessment purposes, a reasonable annual growth factor in activity (for example, 10 or 15 percent) may be assumed.

(2) Supplemental metrics, such as single event noise data (for example, Peak, PK 15(met) or CSEL), may be employed where appropriate to provide additional information on the effects of noise from test and training ranges. A-weighted maximum noise levels will be used to assess aviation low level military training routes (MTRs) and/or flight tracks.

(3) The use of average noise levels over a protracted time period generally does not adequately assess the probability of community noise complaints. Assess the risk of noise complaints from large caliber impulsive noise



resulting from testing and training activities, ex. armor, artillery, mortars and demolition activities, in terms of a single event metric, either peak sound pressure level (PK 15(met)) or C-weighted sound exposure level (CSEL). The metric PK 15(met) accounts for statistical variation in received single event peak noise level that is due to weather. It is the calculated peak noise level, without frequency weighting, expected to be exceeded by 15 percent of all events that might occur. If there are multiple weapon types fired from one location, or multiple firing locations, the single event level used should be the loudest level that occurs at each receiver location.

(4) Assess noise from small arms ranges using a single event metric, either PK 15(met) or A-weighted sound exposure level (ASEL).

(5) Use the land use planning zone (LUPZ) contour to better predict noise impacts when levels of operations at airfields or large caliber weapons ranges are above average.

(6) Use available DOD noise assessment software as the primary means of operational noise assessment.

(7) Prepare noise maps showing noise zones and limits as defined in tables 14-1 and 14-2.

(8) Manage noise-sensitive land uses, such as housing, schools, and medical facilities as being acceptable within the LUPZ and noise zone I, normally not recommended in noise zone II, and not recommended in noise zone III. These noise zones are defined in table 14-1.

(9) Single event noise limits in table 14-2 correspond to areas of low to high risk of noise complaints from large caliber weapons and weapons systems. These should be used to supplement the noise zones defined in table 14-1 for land use decisions. Noise sensitive land uses are discouraged in areas where PK 15(met) is between 115 and 130 dB; medium risk of complaints. Noise sensitive land uses are strongly discouraged in areas equal to or greater than PK 15(met) = 130 dB; high risk of noise complaints. For infrequent noise events, installations should determine if land use compatibility within these areas is necessary for mission protection. In the case of infrequent noise events, such as the detonation of explosives, the installation should communicate with the public.

(10) Transportation and industrial noise will be assessed on a case by case basis using appropriate noise metrics, including U.S. Department of Transportation guidelines.

b. Address issues concerning building vibration and rattle due to weapons blast through the appropriate subject matter experts and legal counsel.

c. Address noise impacts on domestic animals and wildlife, as required, through the study of each species' response or a surrogate response to noise. The noise levels set forth herein apply to humans only and do not apply to domestic animals or wildlife.

**Table 14-1  
Noise Limits for Noise Zones**

Noise zone	Noise limits (dB)		
	Aviation ADNL	Impulsive CDNL	Small arms — PK 15(met)
LUPZ	60 - 65	57 - 62	N/A
I	< 65	< 62	<87
II	65 - 75	62 - 70	87 - 104
III	>75	>70	>104

Legend for Table 14-1:

dB=decibel

LUPZ=land use planning zone

ADNL=A-weighted day-night levels

CDNL=C-weighted day-night levels

PK 15(met)=Single event peak level exceeded by 15 percent of events

<=less than

>=greater than

N/A=Not Applicable

**Table 14–2**  
**Risk of Noise Complaints by Level of Noise**

Risk of Noise complaints	Large caliber weapons noise limits (dB) PK 15(met)
Low	< 115
Medium	115 - 130
High	130 - 140
Risk of physiological damage to unprotected human ears and structural damage claims	> 140

Legend for Table 14-2:

dB = decibel

PK 15(met) = Single event peak level exceeded by 15 percent of events

Notes:

<sup>1</sup> Although local conditions regarding the need for housing may require noise-sensitive land uses in Noise Zone II, on or off post, this type of land use is strongly discouraged. The absence of viable alternative development options should be determined and an evaluation should be conducted locally prior to local approvals indicating that a demonstrated community need for the noise-sensitive land use would not be met if development were prohibited in Noise Zone II.

<sup>2</sup> Where the community determines that these uses must be allowed, measures to achieve an outdoor to indoor noise level reduction (NLR) of at least 25 dB to 30 dB in Noise Zone II, from small arms and aviation noise, should be incorporated into building codes and be in individual approvals. The NLR for communities subject to large caliber weapons and weapons system noise is lacking scientific studies to accomplish the recommended NLR. For this reason it is strongly discouraged that noise-sensitive land uses be allowed in Noise Zone II from large caliber weapons.

<sup>3</sup> Normal permanent construction can be expected to provide a NLR of 20 dB, for aircraft and small arms, thus the reduction requirements are often stated as 5, 10 or 15 dB over standard construction and normally assume mechanical ventilation, upgraded Sound Transmission Class (STC) ratings in windows and doors and closed windows year round. Additional consideration should be given to modifying NLR levels based on peak noise levels or vibrations.

<sup>4</sup> NLR criteria will not eliminate outdoor noise problems. However, building location and site planning, and design and use of berms and barriers, can help mitigate outdoor noise exposure NLR particularly from ground level aircraft sources. Barriers are generally not effective in noise reduction for large arms such as artillery and armor, large explosions, or from high-level aircraft sources.

## Chapter 15

### Program Management and Operation

#### 15–1. Structure and resourcing

##### *a. Army Environmental Funding Policy.*

(1) Army organizations are responsible for addressing environmental requirements for activities under their purview to ensure timely compliance with legal mandates, and for sustaining environmental stewardship.

(2) Environmental requirements must be funded from the appropriate account of the proponent who has the responsibility for the action, not necessarily the Installations Program Evaluation Group (II PEG) environmental program accounts.

*b. Programming and budgeting.* Commensurate with their responsibilities, Army organizations (to include tenants) will plan, program, budget, and execute resources to:

- (1) Mitigate actual or imminent health and environmental hazards.
- (2) Comply with Federal, State and local statutes, regulations, agreements, and other judgments, applicable executive orders (EOs), Final Governing Standards (FGS), and legally-binding international agreements at overseas installations.
- (3) Sustain the quality and continued availability of lands for essential operations, training, and testing by protecting natural and cultural resources.
- (4) Maintain an adequately trained and staffed organization for environmental monitoring and program management.
- (5) Employ cost-effective pollution prevention and reuse/recycle-based solutions in all mission areas as the preferred approach for meeting compliance requirements, reducing operating costs, and maintaining environmental stewardship.
- (6) Focus environmental quality technology (EQT) research and innovative applications to achieve program goals and reduce program costs.
- (7) Address environmental quality costs associated with weapons system life cycle within the context and requirements of the life cycle cost estimate, and adequately assess these costs in the acquisition milestone review process.

*c. Investment strategy.* Army organizations will make prudent investments in environmental initiatives that support mission accomplishment, enhance readiness, reduce future funding needs, prevent or mitigate pollution, improve compliance, and reduce the overall cost of compliance with applicable environmental requirements.

*d. Payment of fines and penalties for environmental violations.* Fines, penalties, and supplemental environmental project (SEP) costs will be paid by the organization against which the fine or penalty has been assessed, using applicable Army appropriations unless otherwise required by law. Payment of fines and penalties will be charged to the

funding account of the operation causing the violation. Contracting Officers will ensure that contracts require contractors to pay fines or penalties resulting from their operations.

*e. Compliance agreements and consent orders.* Compliance agreements and consent orders attributable to a tenant's mission and/or operations will be financed with mission funds and must be coordinated through the mission chain of command.

#### **15-2. Environmental Quality Control Committee**

*a.* Installations will establish Environmental Quality Control Committees (EQCCs) chaired by the Garrison Commander (GC). In overseas areas, the EQCC may be organized at the appropriate military community level. The EQCC will include major and sub-installations and tenant activities. EQCCs will meet at least quarterly and document decisions.

*b.* The EQCC should consist of members representing the operational, logistics, engineering, planning, resource management, legal, medical, environmental, morale, welfare, and recreation (MWR), commissary, exchange service, and safety interests of the command, including military installation tenant activities.

*c.* The EQCC will help to plan, execute, and monitor actions and programs with environmental implications. The committee will identify issues, make recommendations, and advise the GC.

#### **15-3. Environmental training, awareness, and competence**

*a.* All personnel who perform tasks that can cause significant environmental impacts will be competent on the basis of appropriate education, training, and/or experience.

*b.* Personnel in non-environmental managerial functions will receive appropriate technical and/or awareness training.

*c.* All organizations will identify training needs (including legally mandated training), document training taken, and evaluate effectiveness.

*d.* Supervisors are responsible to ensure their employees are properly trained.

*e.* Organizations should use the most effective and efficient education and training sources available, such as academia, private vendors, Federal or State agencies, workshops and conferences, and distributive training. Army organizations will develop training courses only when such training courses do not exist. Proposals to develop training courses will be coordinated with higher headquarters and Training and Doctrine Command (TRADOC).

*f.* The U.S. Army Engineer School (USAES) is responsible for developing and integrating environmental considerations into personnel training.

*g.* All organizations will ensure applicable personnel at all levels conform to a single installation-wide environmental management system (EMS).

#### **15-4. Communications**

*a. Internal.* Organizations at all levels will establish and maintain procedures for internal communication among all their levels and functions and report environmental incidents.

*b. External.*

(1) Organizations at all levels will establish and maintain procedures for receiving, documenting, and responding to communication from external interested parties in coordination with the Public Affairs staff.

(2) Organizations will only provide information on publicly accessible, non-restricted Army environmental Web sites that have been properly cleared for release by the appropriate Public Affairs Office (PAO).

(3) Information available to the public through the Internet will be consistent with guidance issued by the Army Chief Information Officer/G-6 (CIO/G-6).

(4) All environmental agreements must be reviewed and approved by the next higher echelon. Proposed agreements and their review will include consideration of long-term Army resource commitments. In addition, environmental agreements with regulatory agencies will be forwarded through command channels to the JALS-EL for review prior to signature, and those resulting from tenant activities will be coordinated with the tenant, the Army Commands (ACOMs), Army Service Component Commands (ASCCs), Direct Reporting Units (DRUs), National Guard Bureau-Army National Guard (NGB-ARNG), and the Installation Management Command (IMCOM), if applicable.

(5) Army elements will include public involvement as a component of the decision making process to build mutual understanding with interested parties through two-way communication. Dialogue will strive to reduce miscommunication and foster a mutually beneficial exchange of information.

#### **15-5. Real property acquisition, leases, outgrants, and disposal transactions**

*a.* The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requires the Army to perform certain actions to assess the environmental condition of property prior to entering into designated real property transactions. These transactions include fee acquisition of real property on behalf of the United States, deeds divesting title from the United States, transfers of jurisdiction between federal agencies, and leases of Army-controlled real property to non-Army entities.

*b.* This section is not applicable to reassignments within Army or DOD elements; to acquisition of less than fee; or

to other outgrants (license, easement, or permit). However, the Environmental Condition of Property (ECP) requirements of this section apply, as a matter of policy, to DA licenses to the National Guard Bureau (NGB), licenses for State National Guard Components, and to state land acquisition where the land will be provided for federally funded construction. Army proponents will conduct these transactions in accordance with the procedures found in AR 405–10; AR 405–80; AR 405–90; Section 2688, Title 10, United States Code (10 USC 2688); 32 CFR 651; and Part 800, Title 36, Code of Federal Regulations (36 CFR 800). Base Realignment and Closure (BRAC) actions will comply with DODI 4165.66M, or its successor. The Army proponent may elect to perform an environmental site assessment for the inapplicable transactions. (LD: 42 USC 9620(h))

*c.* Except as noted in *b.* above, Army will assess, determine, and document the environmental condition of transferable property in an ECP Report. The ECP Report will summarize historical, cultural, and environmental conditions and include references to publicly available and related reports, studies, and permits. The report will provide an accurate summary of the environmental condition of the property. If the property will be deeded or leased, the site may require additional site characterization to meet applicable regulatory requirements or to help value the property. (Note: The GC/Army proponent is responsible for initiating the ECP Report.)

(1) An ECP Report will normally result in a conclusion regarding the advisability of the transaction and forms the basis for Findings of Suitability, if applicable to the transaction. Environmental contamination and potential environmental liabilities associated with properties being considered for acquisition, lease, and disposal will be determined prior to completing the transaction. The ECP Report and, if applicable, the Findings of Suitability, are an integral part of the Report of Availability or the Disposal Report which form the basis for the Army official with delegated authority to approve the real property transaction and for USACE to prepare the required legal documents, land use controls and covenants. (Note: Findings of Suitability are required for BRAC disposals, both transfers and leases, but are not required for active installation leases.) (LD: 42 USC 9620(h))

(2) Content of the ECP Report depends upon the nature of the transaction and the proposed transferee/lessee. Transfers or leases between the Army and non-federal entities will require at a minimum, a Phase I ECP Report. Where conditions indicate uncertainty regarding the condition of property, a Phase II ECP Report is also required.

(3) The ECP Report will comply with applicable American Society for Testing and Materials (“ASTM”) Standards, such as ASTM E1527, E1903, and D6008 and will be consistent with the DOD Base Redevelopment and Realignment Manual (BRRM) for BRAC actions.

(4) An ECP Report is optional for reassignments within the Army and between Army and another DOD component depending on whether the HQDA approval authority deems it necessary. Those reassignments without an ECP Report should have a statement describing the environmental condition with the package forwarded to HQDA for approval. (PD)

(5) For non-BRAC actions, the ECP report will be attached to the environmental section of the Report of Availability or Disposal Report (AR 405–80 and AR 405–90) that is submitted to the Army decision-making official.

(6) Fee acquisitions and fee acquisition by State Guard components for land that will be provided for federally funded construction require an ECP Report to comply with EPA’s “All Appropriate Inquiry” rules under CERCLA prior to obtaining title to the real property so as to preserve defenses to CERCLA liability as an innocent land owner, bona fide prospective purchaser, or contiguous property owner and to reduce risk to Army and ensure that Army pays appropriate consideration for the property. The Army component will perform due diligence in determining the environmental condition of the property using applicable Environmental Protection Agency guidelines and applicable American Society for Testing and Materials (“ASTM”) Standards on real property acquisition (ASTM E 1527). (LD: 42 USC 9620)

(7) The activity initiating the property transfer or lease will include the ECP Report with the Disposal Report or Report of Availability for the transaction.

*d.* Active installation leases and non-lease outgrants (easements, license, permit):

(1) The environmental section of the Report of Availability (ROA) (AR 405–80) will be used to document the environmental condition of the property being leased by active installations. There is no requirement to prepare a FOGL. The non-BRAC ECP included with the ROA will include, as an appendix, the appropriate environmental protection provisions necessary for continued human health and environmental protection.

(2) The GC (or equivalent) or the NGB having accountability for the real property at the installation may determine that the environmental section of the ROA alone may be sufficient to document environmental requirements for permits, licenses, easements, and similar real estate actions where environmental concerns are very minor. Under these circumstances an ECP report would not be required.

(3) An ECP report will be done as an exception to this section when licenses are issued to state National Guard components; when hazardous materials will be stored for one year or more or disposed on Army property except when authorized by 10 USC 2692 (as amended); and where the authorized use of Army lands and facilities poses a hazard to human health or the environment. Leasing space to others for trailer sites or automatic teller machines (ATMs) does not require an ECP Report except where extraordinary circumstances exist.

*e.* The GC (or equivalent) is responsible for determining the appropriate ECP category (ASTM D5746) for a property being transferred based on the results of the ECP Report and actions taken to address contamination. (PD)

*f.* For real property transactions initiated by non-Army parties: (PD)

(1) The party initiating the transaction is responsible for funding and completing the ECP Report.

(2) The GC/Army proponent should approve the ECP Report.

(3) The Army may prepare the ECP Report, even though others initiated the transaction, if it has demonstrable benefit to the Army.

*g.* For non-BRAC transfers when GSA is the disposal agent, Army prepares the ECP Report. However, disposal by GSA is not considered a transfer of jurisdiction to GSA. The level of detail for the ECP Report will be coordinated with GSA. (PD)

*h.* Findings of Suitability are listed below:

(1) The Finding of Suitability to Transfer (FOST) / Finding of Suitability for Early Transfer (FOSET)/or BRAC Finding of Suitability to Lease (FOSL) will certify that the property is compatible with the proposed use and that the use restrictions or remedies in place (if any) are protective of human health and the environment. (PD)

(2) Deeds divesting title or leases executed under BRAC or other special legislative authority will proceed only after a FOST/FOSET/FOSL.

(3) A FOSET is required when transferring title to property pursuant to the provisions of CERCLA 120(h)(3)(c) (early transfer authority), when remedial action has not been completed prior to transfer. (LD: CERCLA 120(h)(3)(c)) (PD)

(4) A FOST is not required for deeds divesting title when disposed by the General Services Administration (GSA).

(5) Responsibility for environmental remediation for transfers or interchanges between the Army and other federal entities will be addressed in the Memorandum of Agreement between the Army and the transferee. The Army requires an ECP Report which will be initiated per paragraph *f.* above and provided to the transferee.

(6) The BRAC FOST/FOSET/FOSLs will be coordinated with regulators and made available to the public for their review. (PD)

*i.* Review and approval authorities are listed below:

(1) The IMCOM, Army commands or service component commands and direct reporting units with special installations, or Army National Guard (NGB-ARNG) will review and approve ECP Reports in coordination with the affected organizations. (PD)

(2) Approval authorities for ECP Report, FOST, FOSET, and BRAC FOSL documents for property disposals are in table 15-1 below. (PD)

(3) The Deputy Assistant Secretary of the Army (Environment, Safety, and Occupational Health) (DASA (ESOH)) will—

(a) Recommend approval for fee acquisition of property with an ECP Category designation of 5 or above or with known or suspected munitions and explosives of concern (MEC);

(b) Recommend approval for proceeding with the transfer to non-DOD federal agencies for properties with known or suspected MEC;

(c) Approve the FOSTs/BRAC FOSLs and approve the ECP report for non-BRAC leases for properties with known or suspected munitions and explosives of concern (MEC); and

(d) Approve all FOSETs

(4) The approving official will ensure that the document(s) receive appropriate legal and environmental professional review prior to approving the document(s).

*j.* Real property transactions require preparation of appropriate National Environmental Policy Act (NEPA) documentation per 32 CFR Part 651. (LD: 32 CFR 651)

*k.* Lease Termination. Upon termination of any lease, the Army proponent and lessee may jointly conduct a final lease close out using the ECP Report funded by the lessee to ascertain any changes in the environmental condition of the subject property. If the lessee refuses to participate, the GC/Army proponent will conduct the final assessment at the lessee's expense and provide a copy to the grantee. If an environmentally significant change has occurred, it will be documented as an amendment to the ECP Report, or a previous environmental site assessment report, if one was done, and the lessee will be required to make suitable compensation. The lessee will be made aware of these requirements and procedures in the original lease document. (PD)

*l.* Lease Renewals. ECP requirements must be met before renewing existing leases. If the lease did not have an environmental site assessment performed originally, an ECP must be done prior to renewal. For renewal of existing leases that have previously had an ECP, or other versions of site assessment documents, the GC/Army proponent must ascertain if environmental conditions have changed. If an environmentally significant change has occurred, it will be documented as a supplement or amendment to the original assessment report. An environmentally significant change involves the storage of a hazardous substance for a year or more, a known release of such substance, or its disposal on the property. The revised report will be processed in accordance with paragraph 15-5c above. A copy of the ECP report and/or any supplements or amendments will be provided to the grantee. (PD)

m. See also Leases, Easements, and Other Special Land Uses, paragraph 4-3d(2) and Conservation Reimbursable Agricultural/Grazing Outleasing and Forestry Programs, paragraph 4-3d(8).

n. Table 15-2 summarizes the documents required for the various types of real property acquisition, leases, and disposal transactions.

**Table 15-1**  
**Property disposal approval authorities<sup>1, 3</sup>**

DOCUMENT	PROGRAM		
	ACTIVE	LEGACY BRAC	BRAC 05
ECP Category Designation <sup>2</sup>	Garrison Commander	Garrison Commander	Garrison Commander
ECP Report	IMCOM <sup>4</sup>	BRAC D	IMCOM <sup>4</sup>
FOST <sup>5</sup>	ECP 1-4: IMCOM <sup>4</sup>	ECP 1-4: BRAC D <sup>4</sup>	ECP 1-4: IMCOM <sup>4</sup>
	ECP 5-7: N/A	ECP 5-7: N/A	ECP 5-7: N/A
FOSET <sup>5</sup>	ECP 5-7: DASA (ESOH)	ECP 5-7: DASA (ESOH)	ECP 5-7: DASA (ESOH)
FOSL	Not Required	ECP 1-7: BRAC D <sup>4</sup>	ECP 1-7: IMCOM <sup>4</sup>

Notes:

<sup>1</sup> The approving official will ensure that the document(s) receive appropriate legal and environmental professional review prior to approving the document(s).

<sup>2</sup> DOD ECP Designation (ASTM D5746).

<sup>3</sup> Transactions with known or suspected MEC require DASA (ESOH) approval.

<sup>4</sup> Army commands or service component commands and direct supporting units with special installations and NGB exercise this authority for their installations. Approval authority may delegate ECP 1-2 to installations.

<sup>5</sup> Documents are not required for GSA transfers; refer to AR 405-90.

**Table 15-2**  
**Documents required**

DOCUMENT	ECP Report <sup>5</sup>	FINDING OF SUITABILITY
<b>ACQUISITION</b>		
Fee title for USA	Yes	No
Less than Fee (easement, permit, license)	No	No
Inlease <sup>1</sup>	No	No
<b>DISPOSAL DOCUMENTS</b>		
Deed divesting title from USA	Yes	FOST/FOSET
Report as Excess to GSA <sup>2</sup>	Yes	No
Transfer to another Fed Agency	Yes	No
Reassignment within DA or DOD <sup>3</sup>	Optional	No
Release or termination of less than fee estate <sup>4</sup>	No	No
<b>OUTGRANTS</b>		
Lease Documents	Yes	No, use ROA to document
Other outgrants (license, easement, permit)	No, use ROA to document	No, use ROA to document
License to NGB	Yes	No

Notes:

<sup>1</sup> Type of less than fee; however, an ECP may be done for large, long-term leases.

<sup>2</sup> Reporting as Excess to GSA is not a transfer or reassignment to GSA.

<sup>3</sup> Within DoD elements, doing an ECP Report is optional for those reassignments requiring HQDA approval (see para 15-5(c)(4) above). The Army proponent will consult the HQDA activity requiring approval prior to initiating a Report of Availability without an ECP Report.

<sup>4</sup> Release, Affidavit, or other non-deed document – if a deed is required, then follow deed policy.

<sup>5</sup> The ECP Report will be forwarded with the ROA or Disposal Report.

## 15–6. Military construction and Morale, Welfare, and Recreation Construction on Army installations

Military Construction (MILCON) includes major and minor construction projects funded by Military Construction, Army (MCA); Military Construction, Army Reserve (MCAR); Military Construction, National Guard (MCNG); Army Family Housing (AFH); Defense MILCON; and Tenant Service MILCON. For specific guidance for MILCON planning and environmental/safety remediation see AR 415–15, and AR 210–20. Morale, Welfare, and Recreation (MWR) construction includes Army appropriated fund (APF) and non-appropriated fund (NAF) construction depending on the type of facility (see AR 215–1).

*a. Pre-construction site selection.* Preparation of environmental documentation and site survey is considered advance planning and will be funded from other than MILCON or NAF. The project proponent at the installation is responsible for funding and executing the environmental survey, unexploded ordnance survey, and associated documentation of a proposed MILCON/MWR construction site before site selection. Installations will coordinate site selection activities with the supporting IMCOM Regional Office.

(1) When selecting a proposed site, the installation should consider locations that avoid unnecessary environmental remediation and/or mitigation costs. However, installations should consider using all existing infrastructure wisely, to include locations that may require some degree of remediation and/or mitigation. A final determination should be based on sound economic and relative risk analysis.

(2) If a proposed project must be sited in a known environmentally sensitive area where an Army cleanup program has already cleaned to current or reasonably anticipated future land use, the cost of design and construction of mitigation measures required as a direct result of MILCON or NAF projects may be paid from MILCON funds if included in the cost estimate and description of work on the DD Form 1391, FY\_ Military Construction Project Data. AR 415–15 and DA Pam 415–15 provide detailed guidance for completing DD Form 1391 for MILCON and NAF.

(3) Non-Army tenants on Army installations are responsible for funding environmental surveys and associated documentation of proposed MILCON or NAF construction sites where they are the user.

*b. Site categorization.* The IMCOM/ACOM/ASCC/DRU/NGB–ARNG is responsible for certifying the site categorization. Sites are classified into the three following categories.

(1) Category I - There is no reason to expect contamination will be encountered during the construction.

(2) Category II - There is no known contamination, there remains some potential that contamination may be encountered during construction.

(3) Category III - The site is known to be contaminated or there is strong suspicion contamination will be encountered during construction.

*c. Site clearance standards.* Site categorizations will be completed in accordance with:

(1) ASTM D6008–96: Standard Practice for Conducting Environmental Baseline Surveys.

(2) ASTM E1527–00: Environmental Site Assessments: Phase I Site Assessment Process.

(3) ASTM E1903–97: Environmental Site Assessments: Phase II Site Assessment Process.

*d. Discovered contamination.* The installation or MILCON proponent is responsible for the remediation/cleanup of environmental contaminants discovered during the execution of a MILCON or NAF construction project.

(1) If removal of discovered contamination adequately addresses the environmental condition of the property for construction and a decision of no further action is secured by the installation, the project should proceed.

(2) If initial response activities are not adequate and additional remediation/cleanup is required, the project proponent is responsible for identifying the environmental requirements and securing funds.

(3) Construction contractor costs (such as direct delays costs and unabsorbed or extended overhead) incidental to discovery, remediation and cleanup, however, will be MILCON funded or APF or NAF funded as appropriate for MWR projects to the extent it is determined that the Army is responsible and liable for such costs.

## 15–7. National security emergencies and exemptions/waivers

*a.* In conducting their mission, GCs should anticipate and allow for mission surge conditions that could result during times of national security emergencies, including but not limited to contingency operations, suppression of insurrection, humanitarian and civic assistance, peace-keeping activities, and disaster relief. In cases where mission surge conditions could potentially exceed permit limitations or other environmental requirements, the GC should request an exemption in accordance with this section.

*b.* In evaluating possible courses of action, the GC will consult with legal counsel and determine the appropriateness of seeking an environmental exemption or waiver.

*c.* In national security emergencies, the requirements of this regulation remain in effect unless waived by the ACSIM.

*d.* If a GC anticipates that surge conditions could result in a violation of Federal or State environmental law or regulation, as soon as practicable, the GC should consult with the appropriate Federal, State, or local authorities on a mutually agreeable course of action. If a satisfactory resolution cannot be agreed upon, the GC will submit a request for a national security exemption to HQDA, DAIM–ED through the chain of command. The request must include:

(1) Identification of the action prompting need for exemption;

- (2) The statute(s) from which an exemption is sought;
- (3) The applicable statutory exemption provision(s);
- (4) Adequate supporting information and justification for the exemption; and
- (5) Alternatives considered and the reasons they were not adopted.

*e.* ACSIM will coordinate with other Army staff (ARSTAF) elements and will forward the request with a recommendation to the Assistant Secretary of the Army (Installations and Environment) (ASA (I&E)), who may transmit the request to the Office of the Secretary of Defense (OSD) for disposition.

*f.* In the event an exemption is denied or cannot be granted in a timely manner, the ACSIM will provide specific guidance on the resolution of the conflicts identified in the request.

#### **15–8. Army Environmental Program in Foreign Countries**

*a. Policy.* This section clarifies environmental policy and requirements applicable to permanent installations or facilities located in foreign countries. This section does not apply to training, off-installation deployments, contingency operations, or those locations for which no DOD Environmental Executive Agent (EEA) has been designated.

(1) Army policy in foreign countries is to comply with applicable standards, criteria and regulations that preserve, protect, and enhance environmental quality and human health. These standards, criteria, and regulations include the country-specific FGS, DODI 4715.5, DODI 4715.8, EO 12088, and EO 12114.

(2) The FGS define the environmental standards for Army permanent installations in foreign countries. The FGS take precedence over requirements of this regulation unless otherwise specifically noted in this section. Army facilities in a foreign nation with no FGS will comply with DOD 4715.05–G and applicable international agreements.

(3) Only the designated DOD EEA can revise an FGS. In cases where it is necessary to comply with more protective criteria than the FGS prescribes, the GC must consult with the EEA.

(4) Waivers to an FGS may be granted only by the DOD-designated EEA or the Unified Command (combatant commanders) in accordance with the country-specific FGS and DOD designated EEA waiver policy.

(5) Hazardous waste (HW) that cannot be disposed of in accordance with the FGS will be returned to the United States or another location where the disposal criteria can be met. In addition to compliance standards for disposal, all Army organizations and activities will comply with the provisions of any applicable Status of Forces Agreement (SOFA) or other legally-binding international agreements respecting the shipping and storage of HW.

(6) An external Environmental Performance Assessment System (EPAS) assessment will be conducted at overseas installations in accordance with DODI 4715.5 and the country-specific FGS (generally this will be every 3 years).

(7) Environmental remediation at overseas installations is addressed in paragraph 12–4, and will be conducted in accordance with DODI 4715.8.

*b. Program requirements.* Program requirements for overseas activities are addressed throughout this regulation. Additionally:

(1) Army ACOMs, ASCCs, DRUs, IMCOM, and installations will comply with the provisions of DODI 4715.5, DODI 4715.8, and appropriate country-specific implementing guidance per the DOD designated EEA.

(2) GCs will consider the adverse impacts of installation activities on a property listed on the World Heritage List, European Union natural conservation site of importance, or a host nation's (HN) equivalent of the U.S. National Register of Historic Places (NRHP). Reasonable effort will be made to avoid or mitigate any adverse effects.

(3) GCs will consider the adverse impacts of installation activities on internationally protected animal and plant species and their habitat, to include flora and fauna in a HN's equivalent of the Endangered Species Act (16 USC 35 (ESA)). Reasonable effort will be made to avoid or minimize adverse effects on such resources.

(4) Army components (that is, Active, Reserve, ARNG) participating in joint operations will comply with the environmental annex as specified by combatant command plans (for example, an annex L to the operation plan (OPLAN)).

(5) Army commanders will report overseas violations through command channels to DAIM–ED, with a courtesy copy to JALS–EL.

#### **15–9. Environmental Management System documentation and document control**

*a.* Installations will establish and maintain information in paper or electronic form to describe the core elements of the management system and their interaction, and provide direction to related documentation.

*b.* Installations will establish and maintain procedures for controlling all documents required by the ISO 14001 standard to ensure that: they can be located; they are periodically reviewed, revised as necessary, and approved for adequacy by authorized personnel; the current versions of relevant documents are available at all locations where operations essential to the effective functioning of the EMS are performed; obsolete documents are promptly removed from all points of issue and points of use, or otherwise assured against unintended use; and any obsolete documents retained for legal and/or knowledge preservation purposes are suitably identified.

*c.* Documentation will be legible, dated (with dates of revision), and readily identifiable, maintained in an orderly



manner and retained for a specific period. Procedures and responsibilities will be established and maintained concerning the creation and modification of the various types of documents.

## Chapter 16

### Checking and Corrective Action

#### 16-1. Environmental performance assessments and Environmental Management System audits

##### *a. General.*

(1) Garrison commanders (GCs) should maintain an inventory of compliance sites and activities with potential to impact the environment.

(2) Audits conducted under the Environmental Performance Assessment System (EPAS) will include all operations and activities within the installation boundary (including operational ranges, and other training areas), or a representative sample of similar activity types, and will evaluate overall environmental program performance and conformance with ISO 14001.

(3) Assessments will include tenant activities, outgrants, leases, and other activities under the purview of the Army.

(4) Generally, assessments will not include privatized facilities. However, special circumstances related to facility and/or associated land lease or ownership status could warrant their inclusion. Accordingly, installations will report the status of their privatized facilities to the U.S. Army Environmental Command (USAEC) EPAS Program Manager as soon as possible after being notified of a scheduled EPAS audit so that a determination regarding inclusion/exclusion can be made.

##### *b. External assessments.*

(1) CONUS external performance assessments are scheduled based on risk analysis and in consultation with HQDA and appropriate commands. Outside the continental United States (OCONUS) external assessments are conducted every three years in accordance with DODI 4715.5.

(2) External assessments will be conducted using a team of independent assessors not associated with the installation and having the necessary organizational and subject matter expertise. This expertise will include the requisite environmental media and regulatory expertise as well as expertise in the functional mission areas that are the subject of the assessment.

(3) External assessments will be conducted using Headquarters, Department of the Army (HQDA) approved protocols. OCONUS, these protocols will be based on the country-specific final governing standards (FGS).

(4) Individuals performing external assessments will provide required assessment data into the Army approved application/database (AEDB-EPAS) to assist in producing the draft and final Environmental Performance Assessment Report (EPAR) and the draft installation corrective action plan (ICAP).

(5) Army installations will prepare the draft ICAP, identify corrective actions, and secure resources for correction through the chain of command.

(6) Assessment results and ICAP will be made available to the Environmental Quality Control Committee (EQCC).

(7) Draft ICAP will be forwarded to affected units, Army Commands (ACOM), Army Service Component Commands (ASCC), Direct Reporting Units (DRU), and/or tenants for review.

##### *c. Internal assessments.*

(1) Internal assessments will be conducted annually, at a minimum, by installation personnel as part of their regular management, checking, and corrective action functions, unless an external assessment is conducted that calendar year.

(2) Army installations will provide required internal assessment data into the Army approved application/database (AEDB-EPAS) to assist in producing the draft ICAP.

(3) Internal assessments will include a review of previous assessments and draft ICAP, review corrective actions not completed, assess compliance with any new regulatory requirements, and address areas specified by higher command.

(4) Installations will notify their respective command when their internal assessment has been completed.

(5) Assessment results and ICAP will be made available to the Environmental Quality Control Committee (EQCC).

##### *d. Installation Corrective Action Plan (ICAP).*

(1) Each installation will prepare or revise a draft ICAP in accordance with Army requirements.

(2) The ICAP will track externally and internally reported compliance and program performance deficiencies.

(3) The ICAP will remain in draft.

*e. Releasability.* All draft assessment reports and supporting papers are internal working documents. The draft documents must be marked "for official use only" (FOUO) and distribution will be handled accordingly. All requests for release of reports will be referred to the appropriate installation Freedom of Information Act (FOIA) Officer.

*f. Environmental Performance Assessment System (EPAS) in-progress review (IPR).* The Director of Environmental

Programs (DEP) may convene an IPR as necessary to review the performance of the program and to identify and resolve issues.

## 16-2. Monitoring and measurement

*a.* Installation Management Command (IMCOM), National Guard Bureau-Army National Guard (NGB-ARNG), Army Commands (ACOMs), Army Service Component Commands (ASCCs), Direct Reporting Units (DRUs), installations, and tenants will establish and maintain documented procedures to monitor and measure, on a regular basis, the key characteristics of those operations and activities that can have an impact on the environment. This will include the recording of information to track performance, relevant operational controls, and conformance with the organization's environmental objectives and targets.

*b.* Monitoring equipment will be calibrated and maintained and records of this process will be retained according to installation standard operating procedures.

## 16-3. Army environmental information and reporting

*a. Army Environmental Information Policy.* Army environmental information is an asset that will be managed as part of the Army I&E information technology (IT) portfolio management. Environmental information investments will meet the Chief Information Officer (CIO)/Deputy Chief of Staff, G-6 (DCS, G-6) Army Knowledge Management (AKM) goals, adhere to the I&E IT domain governance process, and be incorporated into the Office of the Assistant Chief of Staff for Installation Management (OACSIM) Business Enterprise Architecture (BEA) strategy and plan.

*b. Program goal.* Army environmental information will facilitate planning, execution, monitoring, and reporting of programs at all activity levels in support of the Army mission. Environmental information and information tools will be built in standardized formats and incorporated into the Army enterprise architecture.

*c. Coordination requirements.* Army environmental reporting systems will be coordinated with the OACSIM Business Transformation Board of Directors (BT BOD).

(1) The DEP represents functional environmental information requirements at the BT BOD.

(2) USAEC represents technical environmental information requirements at the BT BOD.

(3) Environmental reporting systems will be executed in accordance with the OACSIM BEA Strategy and plan.

*d. Primary Systems.* The following are the Army's primary systems for data collection and reporting:

(1) *Army Environmental Data Base - Environmental Quality (AEDB-EQ).* The AEDB-EQ serves as a primary source of information for reporting the Army's environmental status to Senior Army Leadership, DOD, and Congress. AEDB-EQ tracks Army compliance with environmental laws (to include permits and enforcement actions) and regulations to determine Army progress towards meeting the DOD Measures of Merit (MOMs), and allows the Army to populate other required reports.

(2) *Environmental Restoration Information System (ERIS).* ERIS and ERIS Range document the Army environmental restoration and range program field data to support a central repository for Army installation chemical, geological, and remedial action data.

(3) *Army Environmental Data Base-Restoration (AEDB-R).* This is the database of record for collecting and reporting data for sites being cleaned up under the purview of Environmental Restoration, Army (ER, A) or Base Closure Account (BCA).

(4) *Army Environmental Data Base-Compliance-Related Cleanup (AEDB-CC).* This is the database of record that identifies and documents requirements for the cleanup of contamination at Army sites that are not eligible for the Defense Environmental Restoration Program (DERP).

(5) *Reimbursable Programs Tracking System (RPTS).* RPTS stores data used to report the financial elements of the agricultural grazing, reimbursable forestry, hunting, fishing and trapping fees, the DOD Forestry Reserve Account, and the Army Wildland Fire programs.

(6) *Army Environmental Data Base - Environmental Performance Assessment System (AEDB-EPAS).* The AEDB-EPAS serves as a primary source of information for reporting, collecting, tracking, and analyzing the Army's environmental compliance and conformance data from external and internal audits.

(7) *Installation Status Report, Natural Infrastructure.* The ISR-NI collects and reports on the readiness of Army installations. The information is collected annually based upon 18 media within the Army Environmental Program (AEP).

(8) *Toxic release inventory (TRI).* Installations meeting established threshold criteria are to submit an annual TRI report as required by the *Emergency Planning and Community Right-to-Know Act (EPCRA)* and Executive Order (EO) 13423.

(9) *Solid Waste Annual Reporting-Web (SWARWeb) System.* SWARWeb is a web-based system to support integrated solid waste management at the installation level. It allows the tracking of solid waste and construction and deconstruction debris waste generation and costs as well as waste diversion through recycling and reuse.

(10) *Hazardous Substance Management System (HSMS).* HSMS is an installation centric client-server software

system to support the integrated management of hazardous materials. It is capable of tracking the authorized ordering, issue and return of hazardous material as well as the disposal of hazardous waste (HW).

#### **16-4. Reporting violations**

*a.* Installation Commanders will enter enforcement actions (ENF) using official electronic Army Environmental Quality Reporting System ((for example, Army Environmental Data Base - Environmental Quality (AEDB-EQ)) reporting mechanisms with verification/confirmation through proper Command channels (for example, ACCS, DRUs, MSCs, regional offices, ACOMS) to the AEC. Initial reports for ENFs must be reported in accordance with current Army environmental quality reporting policy requirements as published and updated by the HQDA. Initial reports will be entered via the Army Environmental Quality Reporting System within 48 hours (2 business days) for any ENF involving:

- (1) Criminal enforcement;
- (2) A fine, penalty, fee, or tax;
- (3) Installation-wide (show stopper or major mission restriction), Army-wide, or DOD-wide impact, media attention, or community (on/off post) impact; or,
- (4) Third party fault (that is, a non-Army entity is responsible in whole or part for the alleged violation(s)).

*b.* All other ENFs will be reported/entered into the AEDB-EQ within 7 business days through proper Command channels.

*c.* The aforementioned 48 hours (2 business days) reporting includes notification to HQDA (DAIM-ED (ODEP) & JALS-ELD (Army Legal Office) through proper Command channels. Additionally, coordinate with JALS-ELD (Army Legal Office) in writing, through technical legal channels, regarding litigation, administrative proceedings, and settlement negotiations.

#### **16-5. Nonconformance and corrective and preventive action**

*a.* All Army facilities identified by HQDA for environmental management system (EMS) implementation will accomplish the following in accordance with the ISO 14001 standard:

(1) Establish and maintain procedures for defining responsibility and authority for handling and investigating nonconformance with the facility's EMS requirements and procedures.

(2) Implement and record any changes in the documented procedures resulting from corrective and preventive action.

*b.* Any corrective or preventive action taken to eliminate the causes of actual or potential nonconformance will be appropriate to the magnitude of problems and commensurate with the environmental impact encountered, if any.

#### **16-6. Environmental records**

*a. General.*

(1) IMCOM, NGB-ARNG, ACOMs, ASCCs, DRUs, installations, and tenants will establish and maintain procedures for identification, maintenance, and disposition of environmental records, to include training records and the results of audits and reviews.

(2) Environmental records will be legible, identifiable and traceable to the activity, product, or service involved, and will contain the name and office symbol of the point of contact for that record.

(3) Environmental records will be stored and maintained (in hard copy or electronic format) in such a way that they are readily retrievable and protected against damage, deterioration, or loss.

*b. Recordkeeping guidelines.* Environmental records will be maintained, as appropriate, to demonstrate conformance to ISO 14001, and requirements set forth in AR 25-400-2.

*c. Environmental cleanup documents.* All installations and facilities will provide copies of environmental cleanup documents to the electronic permanent repository at USAEC. Environmental cleanup documents that should be submitted are detailed in the Army Environmental Cleanup Program Permanent Document Repository Guidance, which was issued 29 Sep 2004. Copies of the guidance are available from the USAEC Cleanup Division.

## **Chapter 17 Management Review**

### **17-1. Environmental Management System management reviews**

*a.* Installations will establish written procedures for conducting recurring management reviews of their environmental management system (EMS).

*b.* At least annually, Garrison commanders (in conjunction with the Environmental Quality Control Committee (EQCC) or equivalent) of all appropriate facilities will conduct a management review of their respective environmental management system (EMS) to ensure its continuing suitability, adequacy, and effectiveness.

*c.* The management review process will ensure that the necessary information is collected to allow management to carry out this evaluation.

*d.* The management review, which will be documented, will address the possible need for changes to policy, objectives, and other elements of the EMS in light of EMS audit results, changing circumstances, and the commitment to continual improvement.

**17-2. Headquarters, Department of the Army environmental program reviews**

HQDA will conduct periodic program reviews to ensure adequate oversight, program effectiveness, and proper resource allocation and execution.

## **Appendix A References**

DOD Directives are available at [www.dtic.mil/whs/directives](http://www.dtic.mil/whs/directives). United States Codes (USC) are available at [www.gpoaccess.gov/uscode/](http://www.gpoaccess.gov/uscode/). Executive Orders are available at [www.archives.gov/federal\\_register/executive\\_orders/disposition-tables.html](http://www.archives.gov/federal_register/executive_orders/disposition-tables.html). Code of Federal Regulations (CFR) are available at [www.gpoaccess.gov/cfr/index.html](http://www.gpoaccess.gov/cfr/index.html).

### **Section I Required Publications**

#### **AR 11-2**

Management Control. (Cited in para 1-4.)

#### **AR 25-400-2**

Army Records Information Management System (ARIMS). (Cited in para 16-6.)

#### **AR 40-5**

Preventive Medicine. (Cited in paras 1-25, 4-2, 5-2, 9-2.)

#### **AR 50-6**

Chemical Surety. (Cited in para 11-2.)

#### **AR 70-1**

Army Acquisition Policy. (Cited in paras 7-2 , 7-4.)

#### **AR 75-15**

Policy for Explosive Ordnance Disposal (O). (Cited in para 11-4.)

#### **AR 95-1**

Flight Regulations. (Cited in para 14-2.)

#### **AR 210-20**

Real Property Master Planning for Army Installations. (Cited in paras 14-2, 15-6.)

#### **AR 210-50**

Housing Management. (Cited in para 5-2.)

#### **AR 350-19**

The Army Sustainable Range Program. (Cited in para 14-2.)

#### **AR 385-10**

The Army Safety Program. (Cited in para 5-2.)

#### **AR 405-10**

Acquisition of Real Property and Interests Therein. (Cited in para 15-5.)

#### **AR 405-80**

Management of Title and Granting Use of Real Property. (Cited in paras 4-3, 15-5.)

#### **AR 405-90**

Disposal of Real Estate. (Cited in paras 4-3, 15-5.)

#### **AR 415-15**

Army Military Construction and Nonappropriated Fund Construction Program Development and Execution. (Cited in paras 10-2, 15-6.)

#### **AR 420-10**

Management of Installation Directorates of Public Works. (Cited in para 5-2.)

#### **AR 420-49**

Utility Services. (Cited in paras 4-2, 10-2.)

**AR 420-70**

Buildings and Structures. (Cited in para 9-2.)

**AR 700-136**

Tactical Land-Based Water Resources Management. (Cited in para 4-2.)

**AR 710-2**

Supply Policy Below the National Level. (Cited in paras 1-10, 10-1.)

**U.S. Army EMS Aspects and Impact Methodology for Army Training Ranges**

Implementation Guidance. (Cited in para 1-1.) (Available at [www.sustainability.army.mil](http://www.sustainability.army.mil).)

**U.S. Army EMS Commanders Guide**

Implementation Guidance. (Cited in para 1-1.) (Available at [www.sustainability.army.mil](http://www.sustainability.army.mil).)

**U.S. Army EMS Implementer's Guide**

Implementation Guidance. (Cited in para 1-1.) (Available at [www.sustainability.army.mil](http://www.sustainability.army.mil).)

**Army Strategy for the Environment**

Brochure, 1 Nov 04. (Cited in para 2-1.) (Available at [www.asaie.army.mil](http://www.asaie.army.mil).)

**ASTM D6008-96 (2005)**

Standard Practice for Conducting Environmental Baseline Surveys. (Cited in para 15-6.) (Available for ordering at [www.webstore.ansi.org](http://www.webstore.ansi.org).)

**ASTM E1527-00**

Standard Practice Environmental Site Assessments: Phase I Environment Site Assessment Process. (Cited in para 15-6.) (Available for ordering at [www.webstore.ansi.org](http://www.webstore.ansi.org).)

**ASTM E1903-97 (2002)**

Standard Guide for Environmental Site Assessments: Phase II Environment Site Assessment Process. (Cited in para 15-6.) (Available for ordering at [www.webstore.ansi.org](http://www.webstore.ansi.org).)

**DA PAM 40-11**

Preventive Medicine. (Cited in para 10-2.)

**DA PAM 415-15**

Army Military Construction Program Development and Execution. (Cited in para 15-6.)

**DFAS-IN Manual 37-100-\*\***

Financial Management - The Army Management Structure FY04. (Cited in para 4-3.) (Available at [www.asafm.army.mil](http://www.asafm.army.mil).)

**DOD American Indian and Alaska Native Policy Memorandum**

Policy Document, 20 Oct 1998. (Cited in para 6-2.) (Available at [www.denix.osd.mil](http://www.denix.osd.mil).)

**DOD Management Guidance for the Defense Environmental Restoration Program (DERP)**

Guidance Document, September 2001. (Cited in para 12-2.) (Available at [www.denix.osd.mil](http://www.denix.osd.mil).)

**DOD 4150.7-M**

DOD Pest Management Training and Certification. (Cited in paras 5-2, 5-4.)

**DOD 4150.7-P**

DOD Plan for the Certification of Pesticide Applicators. (Cited in paras 5-2, 5-4.)

**DOD 4160.21-M**

Defense Material Disposition Manual. (Cited in para 10-1.)

**DOD 4500.9-R**

Defense Transportation Regulation. (Cited in para 10-1.)

**DOD 4715.5-G**

Overseas Environmental Baseline Guidance Document. (Cited in para 15-8.)

**DOD 7000.14-R**

DOD Financial Management Regulation (FMRS). (Cited in para 12-2.)

**DODD 4715.1**

Environmental Security. (Cited in para 4-3.)

**DODD 4715.11**

Environmental and Explosives Safety Management on Operational Ranges Within the United States. (Cited in paras 8-2, 12-4.)

**DODD 4715.12**

Environmental and Explosives Safety Management on Operational Ranges Outside the United States. (Cited in para 8-2.)

**DODD 5000.1**

The Defense Acquisition System. (Cited in paras 1-7, 3-3.)

**DODI 4150.7**

DOD Pest Management Program. (Cited in paras 4-3, 5-2, 5-4.)

**DODI 4715.3**

Environmental Conservation Program. (Cited in para 4-3.)

**DODI 4715.4**

Pollution Prevention, Jun 1996. (Cited in para 7-2.)

**DODI 4715.5**

Management of Environmental Compliance at Overseas Installations. (Cited in paras 4-3, 5-2, 15-8, 16-1.)

**DODI 4715.7**

Environmental Restoration Program. (Cited in para 12-2.)

**DODI 4715.8**

Environmental Remediation for DOD Activities Overseas. (Cited in paras 12-2, 12-4, 15-8.)

**EO 11988**

Floodplain Management, 42 FR 26951 (Cited in para 4-2.)

**EO 11990**

Protection of Wetlands. (Cited in paras 4-2, 4-3.)

**EO 12580**

Superfund Implementation, 52 FR 2923. (Cited in paras 12-2, 12-4.)

**EO 13007**

Indian Sacred Sites, 61 FR 26771. (Cited in para 6-4.)

**EO 13112**

Invasive Species (Cited in para 4-3.)

**EO 13175**

Consultation and Coordination with Indian Tribal Governments, 65 FR 67249. (Cited in paras 6-2, 6-4.)

**EO 13186**

Responsibilities of Federal Agencies to Protect Migratory Birds, 66 FR 3853. (Cited in para 4-3.)

**EO 13287**

Preserve America. (Cited in paras 1–5, 6–2, 6–4.)

**EO 13423**

Strengthening Federal Environmental, Energy, and Transportation Management. (Cited in paras 4–3, 7–2, 7–4, 9–1, 10–2, 16–3, B–2.)

**ER 200–3–1**

Formerly Used Defense Sites Program Policy. (Cited in paras 12–2, 12–4.)

**Field Manual (FM) 3–100.4**

Environmental Considerations in Military Operations. (Cited in para 1–28.)

**ISO 14001 (also known as ANSI/ISO 14001–2004)**

Environmental Management System Requirements - Specifications with Guidance for Use (Cited in paras 1–1, 1–13, 1–24, 15–9, 16–1, 16–5, 16–6.) (Available for ordering at [www.webstore.ansi.org](http://www.webstore.ansi.org).)

**Memorandum, DUSD (I&E), 10 October 2002**

Implementation of Sikes Act Improvement Act: Updated Guidance. (Cited in para 4–3.) (Available at [www.aec.army.mil/usaec/natural](http://www.aec.army.mil/usaec/natural).)

**PL 108–136**

National Defense Authorization Act FY04. (Cited in para 4–3.)

**PL 109–58**

Energy Policy Act of 2005 (Cited in paras 4–2, 11–2.)

**TB MED 575**

Swimming Pools and Bathing Facilities. (Cited in para 4–2.)

**TB MED 576**

Occupational and Environmental Health: Sanitary Control and Surveillance of Water Supplies at Fixed Installations. (Cited in para 4–2.)

**TB MED 577**

Occupational and Environmental Health: Sanitary Control and Surveillance of Field Water Supplies. (Cited in para 4–2.)

**TB 55–1900–206–14**

Control and Abatement of Pollution by Army Watercraft. (Cited in para 4–2.)

**TM 5–662**

Swimming Pool Operation and Maintenance. (Cited in para 4–2.)

**TM 5–813–1**

Water Supply: Sources and General Considerations. (Cited in para 4–2.) (Available at [www.usace.army.mil](http://www.usace.army.mil).)

**TM 5–813–3**

Water Supply: Water Treatment. (Cited in para 4–2.) (Available at [www.usace.army.mil](http://www.usace.army.mil).)

**TM 5–813–4**

Water Supply: Water Storage. (Cited in para 4–2.) (Available at [www.usace.army.mil](http://www.usace.army.mil).)

**TM 5–813–5**

Water Supply: Water Distribution. (Cited in para 4–2.) (Available at [www.usace.army.mil](http://www.usace.army.mil).)

**TM 5–813–7**

Water Supply: Special Projects, Volume 7. (Cited in para 4–2.) (Available at [www.usace.army.mil](http://www.usace.army.mil).)



**TM 5-813-8**

Water Supply: Water Desalination. (Cited in para 4-2.) (Available at [www.usace.army.mil](http://www.usace.army.mil).)

**TM 5-813-9**

Water Supply: Pumping Stations. (Cited in para 4-2.) (Available at [www.usace.army.mil](http://www.usace.army.mil).)

**UFC 3-230-02**

Unified Facilities Criteria - Operation and Maintenance: Water Supply Systems. (Cited in para 4-2.) (Available at [wbdg.org.ccb/](http://wbdg.org.ccb/).)

**USACHPPM TG-179**

Guide for Providing Safe Drinking Water at Army Installations. (Cited in para 4-2.) (Available at [chppm-www.apgea.army.mil](http://chppm-www.apgea.army.mil).)

**5 USC 552**

Freedom of Information Act, as amended (FOIA) (Cited in paras 1-8, 16-1.)

**7 USC 136, et seq.**

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended. (Cited in para 5-2.)

**10 USC 2665**

Sale of Certain Interest in Lands; Logs. (Cited in paras 1-24, 1-27, 4-3.)

**10 USC 2667**

Leases: Non-excess Property of Military Departments. (Cited in paras 1-24, 1-27, 4-3.)

**10 USC 2671**

Military Reservations and Facilities, Hunting, Fishing, and Trapping. (Cited in para 4-3.)

**10 USC 2684a**

Agreements to Limit Encroachment and other Constraints on Military Training, Testing, and Operations. (Cited in para 4-3.)

**10 USC 2688**

Utility Systems: Conveyance Authority. (Cited in para 15-5.)

**10 USC 2694a**

Conveyance of Surplus Real Property for natural resource conservation. (Cited in para 4-3.)

**10 USC 2701, et seq.**

Defense Environmental Restoration Program (DERP). (Cited in paras 12-2, 12-4.)

**15 USC 2601, et seq.**

Toxic Substances Control Act (TSCA), as amended. (Cited in paras 9-2, 11-2.)

**15 USC 2651, et seq.**

Asbestos Hazard Emergency Response Act (AHERA). (Cited in para 9-2.)

**16 USC 31**

Marine Mammal Protection Act. (Cited in para 4-3.)

**16 USC 35**

Endangered Species Act of 1973 (ESA). (Cited in paras 4-2, 4-3, 15-8.)

**16 USC 431**

Antiquities Act of 1906. (Cited in para 6-2.)

**16 USC 432**

Permits to examine ruins, excavations, and gathering of objects; regulations. (Cited in para 6-2.)

**16 USC 433**

American antiquities. (Cited in para 6–2.)

**16 USC 469**

Archeological and Historic Preservation Act of 1974 (AHPA), as amended. (Cited in paras 6–2, 6–4.)

**16 USC 470**

National Historic Preservation Act of 1966 (NHPA), as amended. (Cited in paras 1–5, 6–2, 6–4.)

**16 USC 620–620j**

Forest Resources Conservation and Shortage Relief Act of 1990. (Cited in para 4–3.) (Available at [www.fws.gov.laws/](http://www.fws.gov.laws/).)

**16 USC 661–667e**

Fish and Wildlife Coordination Act. (Cited in para 4–3.) (Available at [www.fws.gov.laws/](http://www.fws.gov.laws/).)

**16 USC 670a–670b**

Sikes Act. (Cited in paras 1–24, 4–3.) (Available at [www.fws.gov.laws/](http://www.fws.gov.laws/).)

**16 USC 670a**

Program for Conservation and Rehabilitation of Natural Resources on Military Installations. (Cited in para 4–3.)

**16 USC 670b**

Migratory Game Birds; Permits; Fees; Stamp Act and State Law Requirements (Sikes Act). (Cited in paras 1–24, 1–27.)

**16 USC 670e**

Applicability to Other Laws; National Forest Lands. (Cited in para 1–24.)

**16 USC 701**

Games and wild birds; preservation. (Cited in para 4–3.)

**16 USC 703–712**

Migratory Bird Treaty Act (MBTA). (Cited in para 4–3.)

**16 USC 1801–1882**

Magnuson Fishery Conservation and Management Act. (Cited in para 4–3.)

**16 USC 3371–3378**

Lacey Act (Cited in para 4–3.)

**16 USC 4701–4751**

Aquatic Nuisance Prevention and Control. (Cited in para 4–3.)

**25 USC 32**

Native American Graves Protection and Repatriation Act of 1990 (NAGPRA). (Cited in paras 1–24, 6–2, 6–4.)

**29 CFR 1910.120**

Occupational Safety and Health Standards, Hazardous Waste Operations and Emergency Response. (Cited in para 12–2.)

**29 CFR 1910.1001**

Occupational Safety and Health Standards, Asbestos. (Cited in para 9–2.)

**29 CFR 1910.1025**

Occupational Safety and Health Standards, Lead. (Cited in para 9–2.)

**29 CFR 1910.1200**

Occupational Safety and Health Standards, Hazard Communication. (Cited in para 9–2.)

**29 CFR 1926.1101**

Safety and Health Regulations for Constructions. (Cited in para 9–2.)

**29 CFR 1926.62**

Safety and Health Regulations for Construction, Lead. (Cited in para 9–2.)

**32 CFR 190**

Office of the Secretary of Defense (OSD), Natural Resources Management Program. (Cited in para 4–3.)

**32 CFR 651**

Environmental Analysis of Army Actions. (Cited in paras 1–1, 15–5.)

**33 USC 26**

Clean Water Act (CWA). (Cited in paras 4–2, 8–2, 9–1, 11–2, 11–4.)

**33 USC 1401**

Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA), as amended (Ocean Dumping). (Cited in para 4–2.)

**33 USC 2702 to 2761**

Oil Pollution Act of 1990 (OPA). (Cited in para 3–14.)

**42 USC 300f**

Safe Drinking Water Act (SDWA), as amended. (Cited in paras 4–2, 8–2, 12–2.)

**42 USC 1996**

American Indian Religious Freedom Act of 1978 (AIRFA). (Cited in paras 6–2, 6–4.)

**42 USC 4321–4347**

National Environmental Policy Act of 1969, as amended (NEPA). (Cited in paras 1–1, 4–2, 4–3, B–4.)

**42 USC 6901**

Resource Conservation and Recovery Act (RCRA), as amended. (Cited in paras 1–25, 4–1, 4–2, 7–2, 8–2, 8–4, 10–1, 10–2, 11–2, 12–2.)

**42 USC 4901**

Noise Control Act of 1972. (Cited in para 14–2.)

**42 USC 6901–6992k**

Hazardous and Solid Waste Amendments of 1984 (HSWA). (Cited in para 7–2.)

**42 USC 6941–6949a**

Subtitle D, the Resource Conservation and Recovery Act (RCRA). (Cited in para 10–2.)

**42 USC 6961**

Federal Facility Compliance Act of 1992. (Cited in paras 4–2, 10–1.)

**42 USC 7401**

Clean Air Act, as amended (CAA). (Cited in paras 4–1, 8–2, 9–2, 11–2.)

**42 USC 9601**

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA). (Cited in paras 4–2, 8–1, 11–2, 12–2, 12–4, 15–5.)

**42 USC 11011**

Emergency Planning and Community Right-to-Know Act (EPCRA). (Cited in paras 7–5, 9–1, 11–2.)

**42 USC 13101–13102**

Pollution Prevention Act of 1990 (PPA). (Cited in paras 7–2, 11–2.)

**36 CFR 79**

Curation of Federally-Owned and -Administered Archeological Collections. (Cited in paras 6–2, 6–4.)

**36 CFR 800**

Protection of Historic Properties. (Cited in paras 6–2, 6–4, 15–5.)

**40 CFR 61**

National Emission Standards for Hazardous Air Pollutants (NESHAP). (Cited in paras 4–1, 9–2.)

**40 CFR 112**

Oil Pollution Prevention. (Cited in paras 11–2, 11–4.)

**40 CFR 260–279**

Hazardous Waste. (Cited in para 10–1.)

**40 CFR 261**

Identification and Listing of Hazardous Waste. (Cited in para 10–2.)

**40 CFR 266.200–206**

EPA’s Military Munitions Rule. (Cited in para 8–2.)

**40 CFR 280**

Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks. (Cited in para 11–2.)

**40 CFR 281**

Approval of State Underground Storage Tank Programs. (Cited in para 11–2.)

**40 CFR 300**

National Oil and Hazardous Substances Pollution Contingency Plan. (Cited in paras 11–2, 11–4, 12–2.)

**40 CFR 302**

Designation, Reportable Quantities, and Notification. (Cited in para 11–4.)

**40 CFR 403**

General Pretreatment Regulations for Existing and New Sources of Pollution. (Cited in para 4–2.)

**40 CFR 745**

Lead-based Paint Poisoning Prevention in Certain Residential Structures. (Cited in para 9–2.)

**43 CFR 5**

Making Pictures, Television Productions or Sound Tracks on Certain Areas Under the Jurisdiction of the Department of the Interior (Cited in para 6–4.)

**43 CFR 6**

Patent Regulations - Table of Contents (Cited in para 6–4.)

**43 CFR 7**

Protection of Archeological Resources (Cited in para 6–4.)

**43 CFR 10**

Native American Graves Protection and Repatriation Regulations. (Cited in paras 6–2, 6–4.)

**43 CFR 10.3**

Native American Graves Protection and Repatriation Regulations - International Archeological Excavations. (Cited in para 6–4.)

**43 CFR 10.5**

Native American Graves Protection and Repatriation Regulations - Consultation. (Cited in para 6–4.)

**49 USC 1801**

Federal Hazardous Materials Transportation Law. (Cited in para 9–2.)

**50 CFR 10–16**

Taking, Possession, Transportation, Sale, Purchase, and Barter, Exportation and Importation of Wildlife and Plants. (Cited in para 4–3.)

**50 CFR 13**

US Fish and Wildlife Service (USFWS) General Permit Procedures (Cited in para 4–3.)

**50 CFR 21**

and Migratory Bird Permits. (Cited in para 4–3.)

**50 CFR 402**

Endangered Species Act of 1973, as amended. (Cited in para 4–3.)

**57 FR 28835**

DOD - Office of the Secretary of Defense Environmental Restoration Program. (Cited in para 12–4.)

**Section II**

**Related Publications**

A related publication is a source of additional information. The user does not have to read it to understand this regulation. DOD Directives are available at [www.dtic.mil/whs/directives](http://www.dtic.mil/whs/directives). United States Codes (USC) are available at [www.gpoaccess.gov/uscode/](http://www.gpoaccess.gov/uscode/). Executive Orders are available at [www.archives.gov/federal\\_register/executive\\_orders/disposition\\_tables.html](http://www.archives.gov/federal_register/executive_orders/disposition_tables.html). Code of Federal Regulations (CFR) are available at [www.gpoaccess.gov/cfr/index.html](http://www.gpoaccess.gov/cfr/index.html). Public laws are available at <http://thomas.loc.gov/bss/>. EPA publications are available at <http://www.epa.gov/epahome/publications.htm>. Military standards are available at <http://assist.daps.dla.mil/quicksearch/>.

**AR 1–1**

Planning, Programming, Budgeting, and Execution System

**AR 5–4**

Department of the Army Productivity Improvement Program.

**AR 5–20**

Competitive Sourcing Program

**AR 10–87**

Major Army Commands in the Continental United States

**AR 11–9**

Army Radiation Safety Program

**AR 11–27**

Army Energy Program

**AR 25–55**

The Department of the Army Freedom of Information Act Program

**AR 37–49**

Budgeting, Funding, and Reimbursement for Base Operations Support of Army Activities

**AR 40–7**

Use of Investigational Drugs and Devices in Humans and the Use of Schedule I Controlled Drug Substances

**AR 40–13**

Medical Support-Nuclear/Chemical Accidents and Incidents

**AR 50–5**

Nuclear Surety

**AR 50-7**

Army Reactor Program

**AR 56-9**

Watercraft

**AR 70-65**

Management of Controlled Substances, Ethyl Alcohol and Hazardous Biological Substances in Army Research, Development, Test, and Evaluation Facilities

**AR 75-1**

Malfunctions Involving Ammunition and Explosives

**AR 75-14**

Interservice Responsibilities for Explosive Ordnance Disposal

**AR 350-1**

Army Training and Leader Development

**AR 360-1**

The Army Public Affairs Program

**AR 385-16**

System Safety Engineering and Management

**AR 385-40**

Accident Reporting and Records

**AR 385-64**

US Army Explosives Safety Program

**AR 420-90**

Fire and Emergency Services.

**AR 700-141**

Hazardous Materials Information Resource System (RCS DDFM&P (A,Q,&AR)1486)

**AR 725-50**

Requisitioning, Receipt, and Issue System

**AR 750-1**

Army Material Maintenance Policy

**DA PAM 40-8**

Occupational Health Guidelines for the Evaluation and Control of Occupational Exposure to Nerve Agents GA, GB, GD, AND VX

**DA PAM 40-501**

Hearing Conservation Program

**DA PAM 200-1**

Environmental Protection and Enhancement

**DASA (ESOH) Directive, 13 Jul 01**

HQDA Memorandum, Army Environmental Management System - Action Memorandum.

**DODD 3200.15**

Sustainment of Ranges and Operating Areas (OPAREAs)

**DODI 4000.19**

Interservice and Intragovernmental Support

**DODI 4715.10**

Environmental Education, Training and Career Development

**DODI 6055.6**

DOD Fire and Emergency Services (F&ES) Program

**EM 385-1-1**

Safety and Health Requirements (Available at [www.usace.army.mil/publications/](http://www.usace.army.mil/publications/))

**EO 11514**

Protection and Enhancement of Environmental Quality

**EO 11644**

Use of Off-Road Vehicles in the Public Lands

**EO 12114**

Environmental Effects Abroad of Major Federal Actions

**EO 12759**

Federal Energy Management

**EO 12844**

Federal Use of Alternatively Fueled Vehicles

**EP 1130-2-540**

Environmental Stewardship Operations and Maintenance Guidance and Procedures (Available at [www.usace.army.mil/publications/](http://www.usace.army.mil/publications/))

**EPA-340/1-90-018**

Asbestos/NESHAP Regulated Asbestos Containing Materials Guidance

**EPA-560/5-85-024**

Guidance for Controlling Asbestos-Containing Materials in Buildings

**EPA-600/4-85-049**

Measuring Airborne Asbestos Following an Abatement Action

**EPA-600/9-79-045**

National Pollutant Discharge Elimination System (NPDES) Best Management Practices Guidance Document

**EPA-560-OPTS-86-001**

A Guide to Respiratory Protection for the Asbestos Abatement Industry

**ER 200-3-1**

FUDS Program Policy

**FM 5-19**

Composite Risk Management

**JP Publication 4-04**

Joint Doctrine for Civil Engineering Support

**MIL-STD-3007**

Standard Practice for Unified Facilities Criteria and Unified Facilities Guide Specifications (Available at <http://assist.daps.dla.mil/quicksearch.>)

**MIL–STD–129P**

Military Marking for Shipment and Storage

**MIL–STD–1474D**

Department of Defense Design Criteria Standard, Noise Limits

**NFPA 295**

Standard for Wildlife Control. (Available for ordering at [www.webstore.ansi.org](http://www.webstore.ansi.org).)

**NFPA 299**

Standard for Protection of Life and Property from Wildfire (Available for ordering at [www.webstore.ansi.org](http://www.webstore.ansi.org).)

**NFPA 1051**

Standard for Wildland Fire Fighter Professional Qualifications (Available for ordering at [www.webstore.ansi.org](http://www.webstore.ansi.org).)

**OMB Circular A–95**

Evaluation, Review, and Coordination of Federal and Federally Assisted Programs and Projects. (Available for ordering at the Office of Management and Budget's information line.)

**PL 99–145, section 1412**

National Defense Authorization Act of 1986 - Destruction of Existing Stockpile of Lethal Chemical Weapons

**PL 101–576**

Chief Financial Officers Act of 1990.

**PL 101–637**

Asbestos School Hazard Abatement Reauthorization Act

**PL 102–484**

National Defense Authorization Act for FY93

**PL 102–550**

Residential Lead Based Paint Hazard Reduction Act 1992

**PL 105–85**

National Defense Authorization Act for FY98

**PL 106–065**

National Defense Authorization Act for FY00

**PL 107–188**

Public Health Security and Bioterrorism Preparedness and Response Act of 2002; Title IV–Drinking Water Security and Safety

**PMS 310–1/NFES 1414**

National Wildfire Coordinating Group Wildland Fire and Prescribed Fire Qualification System Guide, Jan 2000

**SB 8–75 – medcase**

Army Medical Department Supply Information

**TB MED 513**

Guidelines for the Evaluation and Control of Asbestos Exposure

**TC 25–1**

Training Land

**TM 3–250**

Storage, Shipment, Handling and Disposal of Chemical Agents and Hazardous Chemicals



**TM 3-261**

Handling and Disposal of Unwanted Radioactive Material

**TM 5-629**

Weed Control and Plant Growth Regulation

**TM 5-630**

Natural Resources - Land Management

**TM 5-632**

Military Entomology Operational Handbook

**TM 5-633**

Natural Resources - Fish and Wildlife Management

**TM 5-635**

Natural Resources - Outdoor Recreation and Cultural Values

**TM 5-814-5**

Sanitary Landfills

**TM 38-250**

Preparing Hazardous Materials for Military Air Shipment

**TM 38-410**

Storage and Handling of Hazardous Materials

**USACHPPM TG No. 135**

Data Base for Assessing the Annoyance of the Noise of Small Arms (Available at [chppm-www.apgea.army.mil](http://chppm-www.apgea.army.mil).)

**USACHPPM TG No. 177**

Commander's Guide to Regulated Medical Waste Management at Army Medical Treatment Facilities (Available at [chppm-www.apgea.army.mil](http://chppm-www.apgea.army.mil).)

**USACHPPM TG No. 197**

Guide for Developing an Integrated Solid Waste Management Plans at Army Installations (Available at [chppm-www.apgea.army.mil](http://chppm-www.apgea.army.mil).)

**USACHPPM TG No. 198**

Childhood Lead Poisoning Prevention/Lead-Based Paint Management Program on DOD Installations (Available at [chppm-www.apgea.army.mil](http://chppm-www.apgea.army.mil).)

**10 CFR 20**

Nuclear Regulatory Commission - Standards for Protection Against Radiation

**14 CFR 150**

Federal Aviation Administration, Department of Transportation - Airport Noise Compatibility Planning

**24 CFR 51**

Office of the Secretary, Department of Housing and Urban Development - Environmental Criteria and Standards

**29 CFR 1910.120e, p, q**

Occupational Safety and Health Administration (OSHA), Department of Labor (DOL) - Occupational Safety Health Standards - Hazardous Waste Operations and Emergency Response.

**29 CFR 1926**

Occupational Safety and Health Administration (OSHA), Department of Labor (DOL) - Safety and Health Regulations for Construction

**32 CFR 229**

Office of the Secretary of Defense - Protection of Archeological Resources: Uniform Regulations

**32 CFR 651.18**

Department of the Army - Environmental Analysis of Army Actions - Introduction.

**33 CFR 153**

Coast Guard (CG), Department of Homeland Security (DHS) - Control of Pollution by Oil and Hazardous Substances, Discharge Removal

**33 CFR 154**

CG, DHS - Facilities Transferring Oil or Hazardous Material in Bulk

**33 CFR 159**

CG, DHS - Marine Sanitation Devices

**33 CFR 209**

Corps of Engineers, Department of the Army, DOD - Administrative Procedure

**33 CFR 320**

Corps of Engineers, Department of the Army, DOD - General Regulatory Policies

**36 CFR 60**

National Park Service (NPS), Department of the Interior (DOI) - National Register of Historic Places

**36 CFR 61**

NPS, DOI - Procedures for State, Tribal, and Local Government Historic Preservation Programs

**36 CFR 63**

NPS, DOI - Determinations of Eligibility for Inclusion in the National Register of Historic Places

**40 CFR 51**

EPA - Requirements for the Preparation, Adoption, and Submittal of Implementation Plans

**40 CFR 51.1**

EPA - Requirements for the Preparation, Adoption, and Submittal of Implementation Plans - Who is Responsible for Actions Described in this Subpart?

**40 CFR 51.307**

EPA - Requirements for the Preparation, Adoption, and Submittal of Implementation Plans - New Source Review

**40 CFR 63**

EPA - National Emission Standards for Hazardous Air Pollutants for Source Categories.

**40 CFR 68**

EPA - Chemical Accident Prevention Provision

**40 CFR 70**

EPA - State Operating Permit Programs.

**40 CFR 70.6**

EPA - State Operating Permit Programs - Permit Content.

**40 CFR 71**

EPA - Federal Operating Permit Programs.

**40 CFR 71.1**

EPA - Federal Operating Permit Programs - Program Overview.

**40 CFR 71.6**

EPA - Federal Operating Permit Programs - Permit Content.

**40 CFR 82**

EPA - Protection of Stratospheric Ozone

**40 CFR 112.3**

EPA - Oil Pollution Prevention - Requirement to Prepare and Implement a Spill Prevention, Control, and Countermeasure Plan

**40 CFR 112.4**

EPA - Oil Pollution Prevention - Amendment of Spill Prevention, Control, and Countermeasure Plan by Regional Administrator.

**40 CFR 112.5**

EPA - Oil Pollution Prevention - Amendment of Spill Prevention, Control, and Countermeasure Plan by Owners or Operators.

**40 CFR 112.7**

EPA - Oil Pollution Prevention - General Requirements for Spill Prevention, Control, and Countermeasure Plans

**40 CFR 112.8**

EPA - Oil Pollution Prevention - Spill Prevention, Control, and Countermeasure Plan Requirements for Onshore Facilities (excluding production facilities).

**40 CFR 112.20**

EPA - Oil Pollution Prevention - Facility Response Plans.

**40 CFR 112.21**

EPA - Oil Pollution Prevention - Facility Response Training and Drills/Exercises.

**40 CFR 122**

EPA - EPA Administered Permit Programs: The National Pollutant Discharge Elimination System (NPDES).

**40 CFR 122.26**

EPA - EPA Administered Permit Programs - The National Pollutant Discharge Elimination System (NPDES) - Storm Water Discharges

**40 CFR 123**

EPA - State Program Requirements

**40 CFR 125**

EPA - Criteria and Standards for the National Pollutant Discharge Elimination System (NPDES)

**40 CFR 130.12**

EPA - Water Quality Planning and Management - Coordination with Other Programs

**40 CFR 136**

EPA - Guidelines Establishing Test Procedures for the Analysis of Pollutants

**40 CFR 140**

EPA - Marine Sanitation Device Standard.

**40 CFR 141**

EPA - National Primary Drinking Water Regulations

**40 CFR 141.28**

EPA - National Primary Drinking Water Regulations - Certified Laboratories

**40 CFR 142**

EPA - National Primary Drinking Water Regulations Implementation

**40 CFR 143**

EPA - National Secondary Drinking Water Regulations

**40 CFR 144**

EPA - Underground Injection Control Program.

**40 CFR 146**

EPA - Underground Injection Control Program: Criteria and Standards

**40 CFR 147**

EPA - State Underground Injection Control Programs

**40 CFR 148**

EPA - Hazardous Waste Injection Restrictions

**40 CFR 149**

EPA - Sole Source Aquifers.

**40 CFR 202**

EPA - Motor Carriers Engaged in Interstate Commerce

**40 CFR 204**

EPA - EPA Noise Emission Standards for Construction Equipment

**40 CFR 205**

EPA - Transportation Equipment Noise Emission Controls

**40 CFR 225**

EPA - Dredged Material Permits

**40 CFR 230**

EPA - Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material.

**40 CFR 239**

EPA - Requirements for State Permit Program Determination of Adequacy

**40 CFR 240**

EPA - Guidelines for the Thermal Processing of Solid Wastes

**40 CFR 243**

EPA - Guidelines for the Storage and Collection of Residential, Commercial, and Institutional Solid Waste

**40 CFR 246**

EPA - Source Separation for Materials Recovery Guidelines

**40 CFR 247**

EPA - Comprehensive Procurement Guideline for Products Containing Recovered Materials.

**40 CFR 257**

EPA - Criteria for Classification of Solid Waste Disposal Facilities and Practices.

**40 CFR 258**

EPA - Criteria for Municipal Solid Waste Landfills.

**40 CFR 262**

EPA - Standards Applicable to Generators of Hazardous Waste

**40 CFR 262.11**

EPA - Standards Applicable to Generators of Hazardous Waste - Hazardous Waste Determination.

**40 CFR 264.13**

EPA - Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities - General Waste Analysis.

**40 CFR 264**

EPA - Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities

**40 CFR 265**

EPA - Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities

**40 CFR 273**

EPA - Standards for Universal Waste Management

**40 CFR 280**

EPA - Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST)

**40 CFR 280.20**

EPA - Technical Standards and Corrective Action Requirements for Owners and Operators of USTs - Performance Standards for New Underground Storage Tank Systems

**40 CFR 280.43**

EPA - Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks - Methods of Release Detection for Tanks

**40 CFR 300.120**

EPA - National Oil and Hazardous Substance Pollution Contingency Plan - On-scene Coordinators and Remedial Project Managers: General Responsibilities

**40 CFR 300.125**

EPA - National Oil and Hazardous Substance Pollution Contingency Plan - Notification and Communications

**40 CFR 300.155**

EPA - National Oil and Hazardous Substance Pollution Contingency Plan - Public Information and Community Relations

**40 CFR 300.211**

EPA - National Oil and Hazardous Substance Pollution Contingency Plan - Facility and Vessel Response Plans

**40 CFR 300.425**

EPA - National Oil and Hazardous Substance Pollution Contingency Plan - Establishing Remedial Priorities

**40 CFR 372**

EPA - Toxic Chemical Release Reporting: Community Right-to-Know

**40 CFR 503**

EPA - Standards for the Use or Disposal of Sewage Sludge

**40 CFR 761**

EPA - Polychlorinated Biphenyls (PCB) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions.

**40 CFR 761.20**

EPA - Polychlorinated Biphenyls (PCB) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions - Prohibitions and Exceptions.

**40 CFR 761.60b**

EPA - Polychlorinated Biphenyls (PCB) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions - Disposal Requirements.

**40 CFR 761.202**

EPA - Polychlorinated Biphenyls (PCB) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions - EPA Identification Numbers.

**40 CFR 761.205**

EPA - Polychlorinated Biphenyls (PCB) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions - Notification of PCB Waste Activity (EPA Form 7710-53)

**40 CFR 763**

EPA - Asbestos

**40 CFR 763.87**

EPA - Asbestos - Analysis

**43 CFR 5**

Subtitle A - Office of the Secretary of the Interior - Making Pictures, Television Productions or Sound Tracks on Certain Areas Under the Jurisdiction of the Department of the Interior

**43 CFR 6**

Subtitle A - Office of the Secretary of the Interior - Patent Regulations

**43 CFR 7**

Subtitle A - Office of the Secretary of the Interior - Protection of Archaeological Resources

**48 CFR 6**

Federal Acquisition Regulations - Competition Requirements

**49 CFR 106**

Pipeline and Hazardous Materials Safety Administration, Department of Transportation - Rulemaking Procedures

**49 CFR 130**

Pipeline and Hazardous Materials Safety Administration, Department of Transportation - Oil Spill Prevention and Response Plans

**49 CFR 171**

Pipeline and Hazardous Materials Safety Administration, Department of Transportation - Subtitle B - Other Regulations Relating to Transportation - General information, regulations, and definitions

**49 CFR 172**

Pipeline and Hazardous Materials Safety Administration, Department of Transportation - Subtitle B - Other Regulations Relating to Transportation - Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements

**49 CFR 173**

Pipeline and Hazardous Materials Safety Administration, Department of Transportation - Subtitle B - Other Regulations Relating to Transportation - Shippers—General Requirements for Shipments and Packagings

**49 CFR 174**

Pipeline and Hazardous Materials Safety Administration, Department of Transportation - Subtitle B - Other Regulations Relating to Transportation - Carriage by Rail

**49 CFR 175**

Pipeline and Hazardous Materials Safety Administration, Department of Transportation - Subtitle B - Other Regulations Relating to Transportation - Carriage by Aircraft

**49 CFR 176**

Pipeline and Hazardous Materials Safety Administration, Department of Transportation - Subtitle B - Other Regulations Relating to Transportation - Carriage by Vessel

**49 CFR 177**

Pipeline and Hazardous Materials Safety Administration, Department of Transportation - Subtitle B - Other Regulations Relating to Transportation - Carriage by Public Highway

**49 CFR 178**

Pipeline and Hazardous Materials Safety Administration, Department of Transportation - Subtitle B - Other Regulations Relating to Transportation - Specifications for Packagings

**50 CFR 222**

National Marine Fisheries Service, National Oceanic and Atmospheric Administration (NOAA), Department of Commerce (DOC) - General Endangered and Threatened Marine Species

**50 CFR 402.06**

Endangered Species Act of 1973, as amended - Coordination with Other Environmental Reviews.

**50 CFR 402.10**

Endangered Species Act of 1973, as amended - Conference on Proposed Species or Proposed Critical Habitat

**65 FR 62565–62572**

Unified Federal Policy for a Watershed Approach to Federal Land and Resource Management, 18 Oct 2000 (Available at [www.epa.gov/Fedrgstr/search/html](http://www.epa.gov/Fedrgstr/search/html).)

**31 USC 1341**

Anti-Deficiency Act

**33 USC 401**

Saint Lawrence Seaway Development Corporation, Department of Transportation - Seaway Regulations and Rules

**42 USC 300g–8**

The Public Health and Welfare - National Drinking Water Regulations

**42 USC 4331**

National Environmental Policy - Congressional Declaration of National Environmental Policy

**42 USC 9613**

Comprehensive Environmental Response, Compensation, and Liability - Civil Proceedings

**42 USC 9617**

Comprehensive Environmental Response, Compensation, and Liability - Public Participation

**42 USC 9620**

Comprehensive Environmental Response, Compensation, and Liability - Federal Facilities

**42 USC 9620h**

Comprehensive Environmental Response, Compensation, and Liability - Property Transferred by Federal Agencies

**49 USC 5102**

Transportation - Hazardous Material Transportation Act

**50 USC 1521**

Lethal Chemical Agents and Munitions

**Section III**

**Prescribed Forms**

This section contains no entries.

**Section IV**

**Referenced Forms**

DA Forms are available on the Army Publishing Directorate Web site [www.apd.army.mil](http://www.apd.army.mil): DD Forms are available from OSD Web site <http://www.dtic.mil/whs/directives/infomgt/forms/formsprogram.htm>.)

**DA Form 11-2-R**

Management Control Evaluation Certification Statement

**DD Form 1391**

FY\_ Military Construction Project Data



## **Appendix B Installation Management Control Evaluation Checklist**

### **B-1. Function.**

The function covered by this checklist is Environmental Management.

### **B-2. Purpose.**

The purpose of this checklist is to assist installation managers and staff in evaluating the key management controls listed below. It is not intended to cover all controls. The garrison commander (GC) or designated representative(s) will perform this checklist.

### **B-3. Instructions.**

Answers must be based on the actual testing of Key management controls (for example, document analysis, direct observation, sampling simulation, other). Answers which indicate deficiencies must be explained and corrective action indicated in supporting documentation. These management controls must be evaluated at least every five years. Certification that this evaluation has been conducted must be accomplished on DA Form 11-2-R, Management Control Evaluation Certification Statement.

### **B-4. Test Questions.**

#### *a. Program Performance.*

(1) Does the installation have an Environmental Quality Control Committee (EQCC), formally constituted and chaired by the garrison commander (GC), which provides a forum to enhance, address and resolve environmental issues?

(2) Is a multidisciplinary program in place to identify and proactively control environmental risks?

(3) Does the installation have pollution prevention policies and programs in place and operating to reduce pollution through source reduction, reuse, recycling, or energy/water use reduction?

(4) Does the installation have the requisite plans in place required by environmental permits?

(5) Are all personnel (including appointed environmental officers) trained and equipped sufficiently to execute their duties in an environmentally safe and compliant manner and to respond properly in case of environmental emergency?

(6) Are problems that are identified through internal audits, complaints, spills or enforcement actions (ENFs) investigated to determine systemic causes and promptly corrected? (PD/LD: DASA (ESOH) directive, 13 July 2001, and EO 13423)

(7) Does the installation have an installation internal assessment plan (IIAP)? (PD/LD: DASA (ESOH) directive, 13 July 2001, and EO 13423)

(8) Is the IIAP updated annually and included in the documentation of the installation Environmental Management System (EMS)? (PD/LD: DASA (ESOH) directive, 13 July 2001, EO 13423, and AR 11-2)

#### *b. Environmental Condition.*

(1) Are all solid waste streams systematically characterized to determine if they are hazardous? Is the basis for the determination (i.e. generator knowledge or analytical results) documented and the waste disposed of properly?

(2) Are all unit projects, activities and work requests coordinated with the environmental officer?

(3) Is adequate National Environmental Policy Act (NEPA) documentation routinely prepared and considered as an integral part of the planning process (NOTE: Overseas installations should follow the Environmental Review Guide (ERG) since NEPA does not apply overseas.)?

(4) Are Environmental Performance Assessment System (EPAS) evaluations and the corrective actions in the installation corrective action plan (ICAP) completed in a timely manner?

(5) Are deficiencies identified in the ICAP that require funds forwarded to the responsible proponent for inclusion in appropriate programming and budgeting documents?

#### *c. Mission Impact.*

(1) Are management practices in place in order to improve the C-rating of mission critical environmental areas?

(2) Does top management (that is, GC, EQCC) periodically review the IIAP?

(3) Does top management review the open findings in the ICAP and ensure that adequate efforts are being made to close them?

#### *d. Compliance.*

(1) Are required reports and records complete and accurate? Is required reporting submitted to regulators in a timely and accurate manner? Is required reporting submitted to higher headquarters in a timely and accurate manner? Does the installation and the higher headquarters review and approve environmental data reported to HQDA?

(2) Are physical inspections conducted on a regular basis? Do they detect environmental problems and are they tracked to ensure corrective action? Are environmental compliance deficiencies recorded in the ICAP?

**B-5. Supersession.**

This checklist replaces the checklist published in AR 200-1, dated 21 February 1997.

**B-6. Comments.**

Help make this a better tool for evaluating management controls. Submit comments to HQDA, Director of Environmental Programs (DEP), 600 Army Pentagon, Washington, DC 20310-0600.

## **Glossary**

### **Section I**

#### **Abbreviations**

**AAE**

Army Acquisition Executive

**AAFES**

Army and Air Force Exchange Service

**AAP**

Army alternate procedures

**AC**

hydrogen cyanide

**ACHP**

Advisory Council on Historic Preservation

**ACOM**

Army Command

**ACP**

Army cost position

**ACSIM**

Assistant Chief of Staff for Installation Management

**ACUB**

Army Compatible Use Buffer

**ADCON**

administrative control

**ADNL**

A-weighted day-night level

**ADUSD (E)**

Assistant Deputy Undersecretary of Defense (Environment) - now ADUSD (ESOH)

**ADUSD (ESOH)**

Assistant Deputy Undersecretary of Defense (Environment, Safety, and Occupational Health)

**AECS**

Army Environmental Cleanup Strategy

**AEDB**

Army Environmental Data Base

**AEDB-CC**

Army Environmental Data Base - Compliance-Related Cleanup

**AEDB-EQ**

Army Environmental Data Base - Environmental Quality

**AEDB-R**

Army Environmental Data Base - Restoration

**AEP**

Army Environmental Program

**AEPI**

Army Environmental Policy Institute

**AERO**

Army Environmental Reporting Online

**AERTA**

Army Environmental Requirements Technology Assessment

**AFH**

Army Family Housing

**AFJMAN**

Air Force Joint Manual

**AFPMB**

Armed Forces Pest Management Board

**AHERA**

Asbestos Hazard Emergency Response Act

**AHPA**

Archeological and Historical Preservation Act

**AIRFA**

American Indian Religious Freedom Act

**AKM**

Army Knowledge Management

**ALT**

Acquisition, logistics, and technology

**AMC**

Army Materiel Command

**AMEDD**

Army Medical Department

**ANSI**

American National Standards Institute

**APP**

Affirmative Procurement Program

**AR**

Army regulation

**ARIMS**

Army Records Information Management System

**ARNG**

Army National Guard

**AROC**

Army Requirements Oversight Council

**ARPA**

Archeological Resources Protection Act

**ARSIC**

Army Range Sustainment Integration Council

**ARSTAF**

Army staff

**ASA**

Assistant Secretary of the Army

**ASA (ALT)**

Assistant Secretary of the Army (Acquisition, Logistics and Technology)

**ASA (FM&C)**

Assistant Secretary of the Army (Financial Management & Comptroller)

**ASA (I&E)**

Assistant Secretary of the Army (Installations and Environment)

**ASARC**

Army System Acquisition Review Council

**ASARCCT**

Army System Acquisition Review Council Coordination Team

**ASC**

Army senior consultant

**ASCC**

Army Service Component Command

**ASEL**

a-weighted sound exposure level

**ASSON**

aerial spray statement of need

**AST**

aboveground storage tank

**ATEC**

Army Test and Evaluation Command

**ATSDR**

Agency for Toxic Substances and Disease Registry

**AWCF**

Army Working Capital Fund

**BCA**

Base Closure Account

**BCP**

base realignment and closure cleanup plan

**BD/DR**

building demolition/debris removal

**BMP**

best management practice

**BO**

biological opinion

**BOD**

board of directors

**BOS**

base operations support

**BRAC**

base realignment and closure

**BRAC**

Base Closure and Realignment Commission

**BT**

Business Transformation

**CA**

Comprehensive Agreement

**CA**

Cooperative Agreement

**CAA**

Clean Air Act

**CAIS**

chemical agent identification set

**CAR**

Chief, Army Reserve

**CBTDEV**

combat developer

**CC**

compliance-related cleanup

**CCMB**

Configuration Control Management Board

**CCR**

Consumer Confidence Report

**CEGS**

Corps of Engineers guide specification

**CERCLA**

Comprehensive Environmental Response, Compensation, and Liability Act

**CERFA**

Community Environmental Response Facilitation Act

**CEP**

Chief of Environmental Programs

**CFR**

Code of Federal Regulations

**CG**

Carbonyl dichloride (phosgene)

**CG**

commanding general

**CIO**

Chief Information Officer

**CK**

cyanogen chloride

**CN**

w-chloroacetophenone

**CONUS**

continental United States

**CPA**

Chief of Public Affairs

**CRB**

Cost Review Board

**CRM**

cultural resources manager

**CRP**

community relations plan

**CS**

o-chlorobenzylidenemalononitrile (tear gas)

**CSEL**

c-weighted sound exposure level

**CW**

civil works

**CWA**

Clean Water Act

**CWM**

chemical warfare materiel

**CWS**

community water system

**DA**

Department of the Army

**DA PAM**

Department of the Army pamphlet

**DARNG**

Director, Army National Guard

**DASA (ESOH)**

Deputy Assistant Secretary of the Army (Environment, Safety, and Occupational Health)

**dB**

decibel

**DC**

District of Columbia

**DCS**

Deputy Chief of Staff

**DD**

decision document

**DeCA**

Defense Commissary Agency

**DENIX**

Defense Environmental Network and Information Exchange

**DEP**

Director of Environmental Programs

**DERP**

Defense Environmental Restoration Program

**DFAS**

Defense Finance and Accounting Service

**DHP**

Defense Health Program

**DLAPS**

Defense Logistics Agency Publishing System

**DMM**

discarded military munitions

**DNL**

day-night level

**DOD**

Department of Defense

**DODD**

Department of Defense Directive

**DODI**

Department of Defense Instruction

**DOI**

Department of the Interior

**DPTMS**

Directorate of Plans, Training, Mobilization, and Security

**DRMO**

Defense Reutilization and Marketing Office

**DRMS**

Defense Reutilization and Marketing Service



**DRU**

Direct Reporting Unit

**DSMOA**

Defense and State Memoranda of Agreement

**DUSD**

Deputy Under Secretary of Defense

**EA**

executive agent or environmental assessment or enterprise architecture

**ECP**

Environmental Condition of Property

**EIS**

Environmental Impact Statement

**EITM**

Environmental Information Technology Management

**ELD**

Environmental Law Division

**EL/RAMP**

Environmental Legislative/Regulatory Analysis and Monitoring Program

**EM**

engineer manual

**EMS**

Environmental Management System

**ENF**

enforcement action

**EO**

executive order or environmental officer

**EOD**

explosive ordnance disposal

**EP**

engineer publication

**EPA**

Environmental Protection Agency

**EPAR**

Environmental Performance Assessment Report

**EPAS**

Environmental Performance Assessment System

**EPCRA**

Emergency Planning and Community Right-to-Know Act

**EQCC**

Environmental Quality Control Committee

**EQIA**

Environmental Quality Impact Analysis

**EQLCCE**

Environmental quality life cycle cost estimate

**EQT**

Environmental Quality Technology

**ER**

engineer regulation

**ER, A**

Environmental Restoration, Army

**ER, F**

Environmental Restoration, FUDS

**ERDC**

Engineer Research and Development Center

**ERIS**

Environmental Restoration Information System

**ERP**

Environmental Restoration Program

**ESA**

Endangered Species Act

**ESMC**

Endangered Species Management Component

**ESO**

Environmental Support Office

**ESTCP**

Environmental Security Technology Certification Program

**ETTC**

Environmental Technology Technical Council

**FAD**

Funding authorization document

**FDE**

Findings and Determination of Eligibility

**FFCA**

Federal Facilities Compliance Act

**FGS**

Final Governing Standards

**FIFRA**

Federal Insecticide, Fungicide, and Rodenticide Act

**FM**

field manual

**FMR**

financial management regulation

**FOA**

field operating agency

**FOIA**

Freedom of Information Act

**FORSCOM**

Forces Command

**FOSET**

finding of suitability for early transfer

**FOSL**

finding of suitability to lease

**FOST**

finding of suitability to transfer

**FOTW**

Federally-owned treatment works

**FOUO**

for official use only

**FUDS**

formerly used defense sites

**FUDSMIS**

Formerly Used Defense Sites Management Information System

**FWPCA**

Federal Water Pollution Control Act

**FY**

fiscal year

**GC**

garrison commander

**GOCO**

government-owned, contractor-operated

**GPP**

Green Procurement Program

**GSA**

General Services Administration

**HAP**

hazardous air pollutant

**HDBK**

Handbook

**HM**

hazardous material

**HMMP**

Hazardous Materials Management Program

**HN**

host nation

**HPC**

historic property component

**HQ**

Headquarters

**HQDA**

Headquarters, Department of the Army

**HQ IMCOM**

Headquarters, Installation Management Command

**HSMS**

Hazardous Substance Management System

**HSSA**

health service support area

**HSWA**

Hazardous and Solid Waste Amendments

**HTRW**

hazardous, toxic, and radioactive waste

**HW**

hazardous waste

**IAP**

installation action plan

**IC**

installation commander

**ICAP**

installation corrective action plan

**ICE**

independent cost estimate

**ICRMP**

integrated cultural resources management plan

**IDN**

initial distribution number

**IAP**

installation internal assessment plan

**II PEG**

Installations Program Evaluation Group

**IMCOM**

Installation Management Command

**INPR**

inventory project report

**INRMP**

integrated natural resources management plan

**IPM**

integrated pest management

**IPMC**

integrated pest management coordinator

**IPMP**

integrated pest management plan

**IPR**

in-progress review

**IR**

installation restoration

**IR**

interim reference

**IRP**

Installation Restoration Program

**ISMC**

invasive species management component

**ISO**

International Organization for Standardization

**ISR**

installation status report

**ISSA**

Installation Services Support Agreement

**IT**

information technology

**ITAM**

Integrated Training Area Management

**IWFMP**

integrated wildland fire management plan

**JCS**

Joint Chiefs of Staff

**JFLCC**

Joint Forces Land Component Command

**JP**

joint publication

**JTF**

Joint Task Force

**KISE**

known and imminent substantial endangerment

**LBP**

lead-based paint

**LD**

legal driver

**LCTA**

land condition trend analysis

**LEPC**

Local Emergency Planning Committee

**LLRW**

low-level radioactive waste

**LTR**

letter

**LUC**

land use control

**LUPZ**

land use planning zone

**MACT**

maximum achievable control technology

**MAIS**

Major Automated Information System

**MAP**

management action plan

**MBTA**

Migratory Bird Treaty Act

**MC**

munitions constituents

**MCA**

Military Construction, Army

**MCAR**

Military Construction, Army Reserve

**MCNG**

Military Construction, National Guard

**MDAP**

Major Defense Acquisition Program

**MEC**

Munitions and explosives of concern

**MEDCEN**

medical center

**MEDCOM**

Army Medical Command

**MEDDAC**

medical department activity

**MIDI**

Military Item Disposal Instructions

**MIL**

military

**MMRP**

Military Munitions Response Program

**MOA**

memorandum of agreement

**MOM**

measure of merit

**MOU**

memorandum of understanding

**MPRSA**

Marine Protection, Research, and Sanctuaries Act

**MS4**

Municipal Separate Stormwater Sewer System

**MSC**

major subordinate command

**MSWLF**

municipal solid waste landfill

**MTOE**

modified tables of organization and equipment

**MWR**

morale, welfare, and recreation

**NAF**

non-appropriated fund

**NAGPRA**

Native American Graves Protection and Repatriation Act

**NDAA**

National Defense Authorization Act

**NDCEE**

National Defense Center for Environmental Excellence

**NEPA**

National Environmental Policy Act

**NESHAP**

National Emissions Standards for Hazardous Air Pollutants

**NFES**

National Fire Equipment System

**NFPA**

National Fire Protection Association

**NGB**

National Guard Bureau

**NGB-ARNG**

National Guard Bureau - Army National Guard

**NGB-DARNG**

National Guard Bureau - Director, Army National Guard

**NHPA**

National Historic Preservation Act

**NLR**

noise level reduction

**NOAA-Fisheries**

National Oceanic and Atmospheric Administration - Fisheries

**NPDES**

National Pollutant Discharge Elimination System

**NPL**

National Priorities List

**NPS**

National Park Service

**NRC**

National Response Center

**NRCS**

Natural Resources Conservation Service

**NRHP**

National Register of Historic Places

**NRT**

National Response Team

**NTNCWS**

Non-Transient Non-Community Water System

**OACSIM**

Office of the Assistant Chief of Staff for Installation Management

**OASA (ALT)**

Office of the Assistant Secretary of the Army (Acquisition, Logistics, and Technology)

**OASA (I&E)**

Office of the Assistant Secretary of the Army (Installations and Environment)

**OCONUS**

outside the continental United States



**ODEP**

Office of the Director of Environmental Programs

**ODS**

ozone depleting substances

**OEBGD**

Overseas Environmental Baseline Guidance Document

**OEESCM**

Operational and Environmental Executive Steering Committee on Munitions

**OIPT**

Overarching Integration Process Team

**OMB**

Office of Management and Budget

**OPA**

Oil Pollution Act

**OPLAN**

operation plan

**OPORD**

operation order

**OPTEMPO**

operating tempo

**OPTS**

Office of Pesticides and Toxic Substances

**ORV**

off-road vehicle

**OSC**

on-scene coordinator

**OSD**

Office of the Secretary of Defense

**OSHA**

Occupational Safety and Health Act or Occupational Safety and Health Administration

**OTJAG**

Office of the Judge Advocate General

**PA**

programmatic agreement

**PAA**

procurement Army ammunition

**PAM**

pamphlet

**PAO**

Public Affairs Office

**PCB**

polychlorinated biphenyl

**PD**

policy decision

**Pk**

peak sound pressure level

**PL**

public Law

**PLANTS**

Plant List of Accepted Nomenclature, Taxonomy, and Symbols

**PLS**

Planning Level Survey

**PMP**

program management plan

**PMS**

Publications Management System

**POL**

petroleum, oil, lubricants

**POM**

program objective memorandum

**POTW**

publicly-owned treatment works

**PPA**

Pollution Prevention Act

**PPBE**

planning, programming, budgeting, and execution

**PPMP**

professional pest management personnel

**PSD**

prevention of significant deterioration

**QA/QC**

quality assurance/quality control

**RAB**

Restoration Advisory Board

**RCRA**

Resource Conservation and Recovery Act

**RCS**

Reports Control System

**RDT&E**

research, development, test, and evaluation

**RDX**

cyclotrimethylenetrinitramine

**READ**

Repository of Environmental Army Documents

**REC**

regional environmental coordinator

**REO**

regional environmental office

**RFP**

request for proposal

**RMIS**

Restoration Management Information System

**RMP**

risk management plan

**RMW**

regulated medical waste

**ROA**

reports of availability

**ROD**

record of decision

**RPMP**

real property master plan

**RPTS**

Reimbursable Programs Tracking System

**RRC**

Regional Readiness Command

**RRC**

Reserve Readiness Command

**RRSC**

Regional Readiness Support Command

**RRT**

Regional Response Team

**RTLA**

range and training land assessment

**RTLTP**

Range and Training Lands Program

**SA**

Secretary of the Army

**SARA**

Superfund Amendments and Reauthorization Act

**SB**

supply bulletin

**SCP**

spill contingency plan

**SDD**

sustainable design and development

**SDWA**

Safe Drinking Water Act

**SDWAA**

Safe Drinking Water Act Amendments

**SEP**

supplemental environmental project

**SERC**

State Emergency Response Commission

**SERDP**

Strategic Environmental Research and Development Program

**SESCC**

Soil Erosion and Sediment Control Component

**SHPO**

State historic preservation officer

**SMC**

senior mission commander

**SOFA**

Status of Forces Agreement

**SPCC**

spill prevention, control and countermeasures

**SPCCP**

spill prevention, control, and countermeasures plan

**SPiRiT**

sustainable project rating tool

**SRP**

Sustainable Range Program

**STC**

Sound Transmission Class

**std**

standard

**SWARS**

Solid Waste Annual Reporting System

**SWPPP**

stormwater pollution prevention plan

**T&E**

threatened and endangered

**TAG**

The Adjutant General

**TB**

technical bulletin

**TB MED**

technical bulletin, medical

**TC**

training circular

**TDA**

tables of distribution and allowances

**TG**

technical guide

**TJAG**

The Judge Advocate General

**TM**

technical manual

**TMDL**

total maximum daily load

**TNCWS**

Transient Non-Community Water System

**TNT**

trinitrotoluene

**TO&E**

table of organization and equipment

**TRADOC**

Training and Doctrine Command

**TRC**

Technical Review Committee

**TRI**

toxic release inventory

**TSCA**

Toxic Substances Control Act

**TSG**

The Surgeon General

**TWCF**

transportation working capital funds

**USACE**

U.S. Army Corps of Engineers

**USACHPPM**

U.S. Army Center for Health Promotion and Preventive Medicine

**USAEC**

U.S. Army Environmental Command

**USAES**

U.S. Army Engineer School

**USC**

United States Code

**USCG**

U.S. Coast Guard

**USDA**

U.S. Department of Agriculture

**USFWS**

U.S. Fish and Wildlife Service

**USGS**

U.S. Geological Survey

**UST**

underground storage tank

**UXO**

unexploded ordnance

**VOC**

volatile organic compound

**WMM**

waste military munitions

**Section II**

**Terms**

**Acquisition, Real Estate**

Obtain, use, or control real property by purchase, condemnation, donation, exchange, easement, license, lease, permit, revestment and recapture as defined in AR 405–10.

**Acquisition, Life Cycle**

Applies to processes and procedures by which defense services identify requirements; conduct research, development, test and evaluation; develop logistics support; field and ultimately dispose of materiel systems and equipment; and upgrade existing systems/equipment.

**Action**

All activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies in the United States or upon the high seas.

**Action area**

All areas to be affected, directly or indirectly, by the Federal agency action and not merely the immediate area involved in the action.

**Activity**

A unit, organization, or installation that performs a function or mission.

**Adverse effect (under NHPA)**

A harmful or detrimental change in the character or use of historic properties. Adverse effects include, but are not

limited to, physical destruction, damage, or alteration; isolation from or alteration of the setting; introduction of visual, audible, or atmospheric elements that are out of character; neglect; and transfer, lease, or sale of historic property.

**Aerial Spray Statement of Need**

A formal document prepared by DOD pest management consultant with certification in DOD Category 11, Aerial Application. If this document states that the proposed project is justified, preparation of an environmental assessment or environmental impact statement (EIS) is initiated and prepared.

**Agency official (under NAGPRA)**

Any individual authorized by delegation of authority within a Federal agency to perform the duties relating to these regulations (43 CFR 10). (43 CFR 10.2 (a)(2)) For Army installations the garrison commander (GC) serves as the agency official under NAGPRA.

**Agricultural lease or outlease**

Use of Army lands under a lease to an agency, organization, or person for growing crops or grazing animals.

**Appropriate facilities**

For purposes of EMS implementation, appropriate facilities are defined as the Army major installations identified by ACSIM as having operations and activities with the potential to significantly impact human health and/or the environment. Appropriate facilities must fully comply with EMS implementation requirements specified in this regulation. ACSIM will periodically update the appropriate facilities listing and promptly advise those installations that are added or removed.

**Archaeological resource (under ARPA)**

Any material of human life or activities that is at least 100 years of age, and which is of archaeological interest.

**Army alternate procedures (AAP)**

Procedures that Army installations and facilities may elect to follow in lieu of Advisory Council on Historic Preservation (ACHP) regulations to comply with the goals and mandates of the National Historic Preservation Act (NHPA) Section 106.

**Army Command (ACOM)**

An Army force, designated by the Secretary of the Army, performing multiple Army Service Title 10 functions (3013b) across multiple disciplines. Command responsibilities are those established by the Secretary and normally associated with administrative control (ADCON).

**Army compatible use buffer (ACUB)**

Formal agreements between Army and eligible entities for acquisition by the entities of land or interest in land and water rights from willing sellers. Formal agreements include limiting encroachment through acquisition of development rights, cooperative agreements (CAs), conservation easements, and other means to support land acquisition or affect land use in accordance with applicable laws. Development and implementation of an ACUB does not constitute an acquisition of real property. Land conveyances for conservation may supplement ACUBs. Authority is 10 USC 2684a and 2694a.

**Army proponent**

The Army unit, element, or organization responsible for initiating or carrying out the proposed action.

**Army Senior Consultant**

The individual designated by the DEP, who serves as the senior Army staff officer for technical guidance and management of the Army Pest Management Program and as ACSIM representative to the Executive Council of the Armed Forces Pest Management Board.

**Army Service Component Command (ASCC)**

An Army force, designated by the Secretary of the Army, comprised primarily of operational organizations serving as an Army component for a combatant commander. If designated by the combatant commander, serves as a Joint Forces Land Component Command (JFLCC) or Joint Task Force (JTF). Command responsibilities are those established by the Secretary and normally associated with operational control (OPCON) and administrative control (ADCON).

**Best management practice**

Best management practices are methods that have been determined to be the most effective and practical means of preventing or reducing pollution and/or environmental impacts.

**Biological assessment**

Information prepared by or under the direction of a Federal agency using the procedures in 50 CFR 402.12 concerning listed and proposed species and designated and proposed critical habitat that may be present in the action area and the evaluation of potential effects of the action on such species and habitat.

**Biological diversity**

The variety of life and its processes. It includes the variety of living organisms, the genetic differences among them, and the communities and ecosystems in which they occur.

**Biological evaluation**

A written document setting forth an installation's biologically supportable rationale for determining the affects an action will have on a listed or proposed species or critical habitat. A biological evaluation is an informal document and is used for actions only if a biological assessment is not required.

**Biological opinion (BO)**

The document that states the opinion of the U.S. Fish and Wildlife Service (USFWS) or National Oceanic and Atmospheric Administration (NOAA) - Fisheries as to whether or not the Federal agency action is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat; a summary of the information on which the opinion is based and a detailed discussion of the effects of the action on listed species or designated critical habitat.

**Candidate species**

(see species designations)

**Certification as pesticide applicator**

The formal recognition of training and competency to perform pesticide applications per the DOD Instruction and Plan. DOD employees certified per the DOD Plan can, without obtaining additional State certification, use and supervise the use of restricted-use pesticides while engaged in performing their official duties.

**Certification official (pesticide applicators)**

The DOD professional pest management personnel (PPMP) who reviews and validates the qualifications of DOD pesticide applicators to meet the standards in the DOD Plan. In the Army, certification officials are nominated by the ASC through the DEP, for approval by the Executive Director, AFPMB. See Pest management consultant.

**Certified pesticide applicator**

Any individual who applies pesticides or supervises the use of pesticides by others and who has been authorized to do so by successfully completing a training program approved by the Environmental Protection Agency (EPA), followed by formal certification by DOD, State or for overseas, by the Installation Management Command (IMCOM) certification official.

**Chemical warfare agent**

A substance which, because of its chemical properties, is used in military operations or terrorist attacks to kill, seriously injure, or incapacitate humans or animals or deny use of water, food supplies, and/or other indigenous resources to combatants or civilian populations. Some types of pesticides and herbicides (especially organophosphate-based substances) were initially developed and tested for use as chemical warfare agents, and only later adapted for non-military and agricultural applications. Chemical warfare agents are the V- and G-series nerve agents; H-series (that is, "mustard" agents) and L-series (that is, lewisite) blister agents; and certain industrial chemicals, including: hydrogen cyanide (AC), cyanogen chloride (CK), or carbonyl dichloride (called phosgene or CG)), when contained in a military munition. Chemical warfare agents do not include: riot control agents (for example, w-chloroacetophenone (CN); o-chlorobenzylidenemalononitrile ((CS) tear gas); chemical herbicides; smoke or incendiary compounds; and industrial chemicals that are not configured as a military munition.

**Chemical warfare materiel**

Items generally configured as a munition containing a chemical substance that is intended to kill, seriously injure, or incapacitate a person through its physiological effects. CWM includes V- and G-series nerve agent; H-series (mustard) and L-series (lewisite) blister agent, in other-than-munition configuration; and certain industrial chemicals (for example, hydrogen cyanide (AC), cyanogen chloride (CK), or carbonyl dichloride (called phosgene or CG)) configured as a



military munition. Due to their hazards, prevalence, and military-unique application, chemical agent identification sets (CAIS) are also considered CWM. CWM does not include: riot control agents; chemical herbicides; industrial chemicals (for example, AC, CK, or CG) not configured as a munition; smoke and flame producing items; or soil, water, debris or other media contaminated with chemical warfare agents.

**Class I and Class II ozone depleting substances (ODS)**

Class I ODS have a greater ozone-depletion potential than Class II ODS. Class II ODS are generally considered safer than Class I ODS. Class I and Class II are defined in the Clean Air Act (CAA) Amendments of 1990. (See 40 CFR 82, Appendix A and B).

**Command**

A unit or units, an organization, or an area under the command of one individual.

**Community water system**

A public water system that supplies water to the same population year-round.

**Compliance agreement**

Any negotiated agreement between regulatory officials and regulatee for the purpose of attaining or maintaining compliance. Regulatee must have participated and influenced the terms of the agreement.

**Compliance-related cleanup**

Compliance-related cleanup (CC) includes actions to address contamination at Army facilities overseas; contamination resulting from operations that have occurred since October 1986 (i.e., non-DERP) at Army Active, Excess, and Special installations, and Army National Guard (ARNG) Federally-owned facilities; and contamination at Non-Federally owned, Federally-supported ARNG facilities. As a key element of the broader Army Environmental Cleanup Strategy (AECS) and its associated Environmental Cleanup Strategic Plan, the CC mission at Army installations and facilities is to perform appropriate, cost-effective cleanup to protect human health, safety, and the environment, and to sustain operational readiness and training. Specifically, for overseas facilities, the CC mission is to address contamination that resulted from Army operations, presents a known imminent and substantial endangerment to human health and safety, and is located on or emanates from an Army facility. The CC Guidance Manual, September 2004, provides specific guidance on CC procedures and project eligibility.

**Comprehensive agreement (under NAGPRA)**

Agreements developed regarding the treatment and disposition of human remains, funerary objects, sacred objects, or objects of cultural patrimony excavated intentionally or discovered inadvertently on Federal lands.

**Conference**

The process which involves informal discussions between a Federal agency and the USFWS or NOAA–Fisheries regarding the impact of an action on proposed species or proposed critical habitat and recommendations to minimize or avoid the adverse effects.

**Conservation**

The wise use and scientific management of natural and cultural resources according to principles that provide optimum public benefit, continued productivity and sustainability for present and future generations, and support of the military mission.

**Conservation law enforcement professional**

A DOD law enforcement professional with additional training in natural resources and Archaeological Resources Protection Act (ARPA) law enforcement training.

**Conservation Reimbursable and Fee Collection Programs**

Includes the Army's proceeds generating Forestry, Fish and Wildlife, and Agricultural/Grazing Outlease programs.

**Conserve/conservation (of species)**

To use and the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to 16 USC Chapter 35 (ESA) are no longer necessary.

**Construction**

Any land-disturbing activity.

### **Consumer Confidence Report**

A water quality report provided to consumers annually, as required under 40 CFR 141, Subpart O. All community water systems (CWS) are required to prepare and distribute annual CCRs that briefly summarize information regarding water sources, detected contaminants, compliance, and educational information.

### **Contaminant**

An undesirable substance (physical, chemical, biological, or radiological) not normally present, or an unusually high concentration of a naturally occurring substance in water or soil.

### **Contingency plan**

A document setting out an organized, planned, and coordinated course of action to be followed in case of a fire, explosion, or other accident that releases toxic chemicals, hazardous waste (HW), or radioactive materials that threaten human health or the environment.

### **Continual improvement**

The process of enhancing the environmental management system to achieve improvements in overall environmental performance in line with the organization's environmental policy.

### **Critical habitat**

Specific areas within the geographical area occupied by the species at the time it is listed in accordance with 16 USC Chapter 35 (ESA), on which are found those physical or biological features (1) essential to the conservation of the species, and (2) which may require special management considerations or protection. It also includes specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the 16 USC Chapter 35 (ESA), upon a determination by the Secretary of Interior or Commerce that such areas are essential for the conservation of the species. The areas formally designated as critical habitat by the USFWS or NOAA–Fisheries and listed in 50 CFR 17 and 226.

### **Cultural resources**

Historic properties as defined by the NHPA, cultural items as defined by NAGPRA, archeological resources as defined by ARPA, sacred sites as defined in EO 13007 to which access is afforded under AIRFA, significant paleontological items as described by 16 USC 431–433 (Antiquities Act of 1906), and collections and associated records as defined in 36 CFR 79.

### **Curation**

An integral element of the archaeological process that refers to the long term management and preservation of archaeological materials and their associated documentation.

### **Destruction or adverse modification**

The direct or indirect alteration that appreciably diminishes the value of critical habitat for both the survival and recovery of a listed species. Such alterations include, but are not limited to, alterations adversely modifying any of those physical or biological features that were the basis for determining T&E habitat to be critical.

### **Direct Reporting Unit (DRU)**

An Army organization comprised of one or more units with institutional or operational functions, designated by the Secretary of the Army, providing broad general support to the Army in a normally single, unique discipline not otherwise available elsewhere in the Army. DRUs report directly to a Headquarters, Department of the Army principal and/or Army Command and operate under authorities established by the Secretary of the Army.

### **Discarded military munitions**

Military munitions that have been abandoned without proper disposal or removed from storage in a military magazine or other storage area for the purpose of disposal. The term does not include unexploded ordnance (UXO), military munitions that are being held for future use or planned disposal, or military munitions that have been properly disposed of consistent with applicable environmental laws and regulations. (10 USC 2710(e)(2)).

### **Discharge**

A term that includes the accidental or intentional spilling, leaking, pumping, pouring, emitting, emptying, or dumping of a substance into or on any land or water (40 CFR 260.10).

### **Discharge classifications (for oil)**

The classifications of accidental discharges listed below, provided to guide the on-scene coordinator (OSC), are criteria for general response actions. They are not criteria for reporting, nor do they imply associated degrees of hazard to the

public health or welfare, nor are they measures of environmental damage. However, a discharge that is a substantial threat to the public health or welfare, or results in critical public concern, will be classed as a major discharge. Discharges are quantitatively measured as follows:

- a. Minor discharge: A discharge to the inland waters or less than 1,000 gallons of oil; or a discharge of less than 10,000 gallons of oil to the coastal waters.
- b. Medium discharge: A discharge of 1,000 gallons to 10,000 gallons of oil to the inland waters, or a discharge of 10,000 to 100,000 gallons of oil to coastal waters.
- c. Major discharge: A discharge of more than 10,000 gallons of oil to the inland waters, or more than 100,000 gallons of oil to the coastal waters.

**Disposal (real property)**

Any authorized method of permanently divesting DA of control of and responsibility for real property. Reference AR 405–90 for definition of real property.

**Disposal (waste)**

The discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or HW into or on any land or water. The act is such that the solid waste or HW, or any constituent thereof, may enter the environment or be emitted into the air or discharged into any waters, including ground water (40 CFR 260.10).

**Domestic sewage**

Waste and wastewater from humans or from household operations that are discharged to or otherwise enter treatment works.

**Ecosystem sustainability**

A condition of living communities that meets, or can be manipulated to meet, current mission, compliance, stewardship and production needs without compromising the future ability to meet those needs. Compliance and stewardship include the protection of all resources, especially soil, water, threatened and endangered (T&E) species, and wildlife.

**Effect (under NHPA)**

Alteration to the characteristics of a historic property qualifying it for inclusion in or eligibility for the National Register.

**Effluent limitation**

Any restriction established by the EPA on quantities, rates, and concentrations of chemical, physical, biological and other constituents which are discharged from point sources, other than new sources, into navigable waters, the waters of the contiguous zone or the ocean.

**Eligible entities**

As it pertains to Section 2684a, National Defense Authorization Act (NDAA) fiscal year (FY) 03, an eligible entity that can enter into cooperative agreements (CAs) with the military can be a State government or political subdivision, or a private entity whose purpose is land and natural resource conservations, restoration, or preservation. As it pertains to Section 2694a, NDAA FY03, an eligible entity can be a State government or political subdivision, or a non-profit organization whose primary purpose is natural resource conservation on real property.

**Emission standards**

Limits on the quality of emissions that may be discharged to the atmosphere from any regulated source, established by Federal, State, local, and host nation (HN) authorities.

**EMS Representative**

The individual(s) appointed in writing by an organization’s leadership who has defined roles, responsibilities, and authority for ensuring that EMS requirements are established, implemented, and maintained in accordance with ISO 14001 and this regulation. The EMS representative will report on the performance of the EMS to management for review and continual improvement of the EMS.

**Encroachment**

All external influences threatening or constraining testing and training activities required for force readiness and weapons acquisition. Such encroachment stems from environmental (for example, noise, endangered species, cultural resources, UXO, and munitions constituents (MC)), social (for example, urban sprawl), and economic (for example, changing land values) influences. Impacts include, but are not limited to, restrictions on available testing and training

locations; restrictions on available times and duration for testing and training; reduced effectiveness of testing and training activities; and restrictions on weapons systems, equipment, and munitions used during testing and training.

### **Enforcement action**

A formal, written notification by the EPA or other authorized Federal, State, inter-state, regional or local environmental regulatory agency of violation of any applicable statutory or regulatory requirement. Enforcement action does not include warning letters, notices to comply, notices of potential liability, notices of significant noncompliance, pre-enforcement conference letters, informal notices of deficiencies, or notices of deficiencies to permit applications. One written notice, regardless of the number of individual violations, findings, or citations listed in it, counts as one enforcement action. If the enforcement action cites violations in more than one statutory requirement, then count it as multiple enforcement actions, one under each of the applicable statutory requirement categories. Items found to be out of compliance during an internal or other DOD Component review, compliance reviews, or audits are not included in this definition of enforcement action.

### **Environment**

All of the following are elements of the natural and man-made environment:

- a.* Navigable waters.
- b.* Near-shore and open waters and any other surface water.
- c.* Groundwater.
- d.* Drinking water supply.
- e.* Land surface or subsurface area.
- f.* Ambient air.
- g.* Vegetation.
- h.* Wildlife.
- i.* Humans.
- j.* Noise.
- k.* Cultural resources.
- l.* Socioeconomics.
- m.* Coastal resources.

### **Environmental agreement**

Environmental agreements are formal agreements between the Army and other entities to address actual or potential environmental concerns, delineate roles and responsibilities related to specific actions of mutual interest, and/or to reach consensus on courses of action. Environmental agreements include but are not limited to consent orders, compliance agreements, consent agreements, settlements, Federal facility agreements, ACUB agreements, and inter-agency agreements.

### **Environmental aspect**

An element of an organization's activities, products, or services that can interact with the environment. A priority environmental aspect is an environmental aspect that has or can have an impact on the mission and/or the environment.

### **Environmental audit**

A systematic, documented, verification process of objectively obtaining and evaluating evidence to determine whether specified environmental activities, events, conditions, management systems, or information about these matters conform to audit criteria (for example, compliance with Federal, State, and local environmental regulations) and communicating the results of this process to management. These reviews are not audits as defined in DODI 7600.2.

### **Environmental awareness training**

Environmental knowledge conveyed by written or on-line information, hands-on training, or formal presentations. It is often provided outside a normal school classroom or regularly-scheduled class. It has limited applicability to teaching competence in specific job skills. It is intended to promote an environmental stewardship ethic and create an understanding of the importance of performing job skills in accordance with appropriate environmental requirements. It also encourages consultation with environmental staff and Army or local compliance publications to determine specific procedures.

### **Environmental condition of property**

The Army does not consider the transfer of property from the Army to another Federal agency for their end use to be a deed transfer. The Army must sufficiently document the environmental condition of property being transferred to another Federal agency; therefore, an Environmental Baseline Survey is required. Also, the Army requires an Environmental Condition of Property (ECP) report, a document similar to a finding of suitability to transfer (FOST).

a. An ECP is the same as a FOST, with the following exceptions:

(1) Regulatory participation/review should parallel DOD finding of suitability to lease (FOSL) guidance, which does not require mandatory 30-day review, but early document sharing is encouraged.

(2) IMCOM Regions sign the ECP for categories 1, 2, 3, and 4 (see category descriptions below). Regions may further delegate authority for ECP categories 1 and 2 to GCs. GCs should decide on a property's suitability for lease or transfer. During staffing of the real estate action, HQDA and the Regions, as appropriate, will review the ECP for concurrence.

(3) CERCLA covenant and warranty are not required, since there is no deed.

(4) Transfer prior to all cleanup being complete is allowed and is encouraged.

(5) The Army should negotiate responsibility for environmental cleanup and compliance requirements with the Federal agency acquiring the property.

b. DOD guidance defines seven categories for describing the ECP, based on the extent of environmental contamination on the property and on the status of any associated restoration activities. These categories are defined with respect to CERCLA hazardous substances:

c. Category 1: Areas where no release or disposal of hazardous substances or petroleum products has occurred (including no migration of these substances from adjacent areas).

d. Category 2: Areas where only release or disposal of petroleum products has occurred.

e. Category 3: Areas where release, disposal, and/or migration of hazardous substances has occurred, but at concentrations that do not require a removal or remedial response.

f. Category 4: Areas where release, disposal, and/or migration of hazardous substances has occurred and all removal or remedial actions to protect human health and the environment have been taken.

g. Category 5: Areas where release, disposal, and/or migration of hazardous substances has occurred and removal or remedial actions are under way, but where all required remedial actions have not yet been taken.

h. Category 6: Areas where release, disposal, and/or migration of hazardous substances have occurred, but where required actions have not yet been implemented.

i. Category 7: Areas that have not been evaluated or that require additional evaluation.

### **Environmental considerations**

The spectrum of environmental media resources, or programs that may impact on, or are affected by, the planning and execution of military operations. Factors may include, but are not limited to, environmental compliance, pollution prevention, conservation, protection of historical and cultural sites, and protection of flora and fauna (Joint Publication (JP) 1-02).

### **Environmental enhancement**

Actions taken to improve the environment. These actions include measures intended to prevent or abate environmental pollution and to meet environmental quality standards.

### **Environmental hazard**

Environmental hazards include all activities that may pollute, create negative noise related effects, degrade archeological/cultural resources, or negatively affect threatened or endangered species habitat. They may also include environmental health related hazards. (See FM 3-100.4, chap 2).

### **Environmental impact**

Any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's activities, products, or services.

### **Environmental management system (EMS)**

That part of an organization's overall management system that includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing, and maintaining the organization's environmental policy.

### **Environmental management system (EMS) audit**

A systematic and documented verification process of objectively obtaining and evaluating evidence to determine whether an organization's environmental management system (EMS) conforms to the EMS audit criteria set by the organization, and for communication of the results of this process to management.

### **Environmental objective**

An overall environmental goal, arising from the environmental policy, that an organization sets for itself to achieve, and which is quantified where practicable.

**Environmental officer**

An individual assigned to a table of organization and equipment (TO&E) or table of distributions and allowances (TDA) organization or unit to accomplish environmental compliance requirements on behalf of his or her responsible commander, director, or supervisor. Designated person also coordinates with supporting permanent installation environmental staff for requirements clarification and assistance. In the Army National Guard (ARNG), coordination is with NGB-ARNG State environmental staff; in the Reserves, with Regional Support Command environmental staff. Organizational levels, and required grade or rank, suitable for assignment of compliance officer duties will be determined by the commander. Commanders should consider mandatory Federal training requirements as well as mission workloads in determining assignment of environmental officers at Battalion and unit (Company, Battery, Troop) level.

**Environmental performance**

Measurable results of the environmental management system, related to an organization's control of its environmental aspects, based on its environmental policy, objective, and targets.

**Environmental planning**

Efforts that consider the impact of day-to-day base operations and activities, operational readiness activities, training, exercises, or weapons system introduction on the environment, and where necessary, allow decision makers to take early action to eliminate or mitigate those impacts. Additionally, environmental planning may require consultation or submission of documentation to demonstrate that environmental considerations have been taken.

**Environmental policy**

A statement by the organization of its intentions and principles in relation to its overall environmental performance that provides a framework for action and for the setting of its environmental objectives and targets.

**Environmental pollution**

The condition resulting from the presence of chemical, mineral, radioactive, or biological substances that

- a. Alter the natural environment.
- b. Adversely affect human health or the quality of life, biosystems, the environment, in structures and equipment, recreational opportunities, aesthetics, and/or natural beauty.

**Environmental target**

A detailed performance requirement based on ISO 14001, quantified where practicable, applicable to the organization or parts thereof, that arises from the environmental objectives and that needs to be set and met in order to achieve those objectives.

**Environmental training**

Instruction whose primary purpose is to provide measurable competence for doing specific environmental jobs or tasks. Some is mandated by law or regulation. Commonly taught in a classroom, by such methods as lecture, discussion, or practical exercise. However, other methods may also be used, including web-based or other "distance learning." Environmental training includes both separate environmental courses and environmental content in non-environmental courses.

**Environmental stewardship**

Management and oversight of environmental, natural and living resource assets including but not limited to land, air, water, soils, vegetation, and wildlife. The Army's objective is to plan, initiate, and carry out its actions and programs in a manner that minimizes adverse effects on the environment without impairing the mission and to manage impacts so as to sustain the capability of Army lands to support future as well as present mission uses of ranges and training lands. See also paragraph 1-1(a).

**EPA Identification Number**

The number assigned by EPA to each HW generator, transporter, and treatment, storage or disposal facility. Reference 40 CFR 260.10; 264.11; 265.11; TB 43-0244, Unit Level Procedures for Handling Service Supplies, Hazardous Materials, and Waste.

**Estuary**

Regions of interaction between rivers and near-shore ocean waters, where tidal action and river flow mix fresh and salt water. Such areas include bays, mouths of rivers, salt marshes, and lagoons. These brackish water ecosystems shelter and feed marine life, birds, and wildlife.

**Executive agent**

Executive agents (EA) are individuals designated by the Office of the Secretary of Defense (OSD) and are responsible for development, maintenance, oversight of and compliance with the Final Governing Standards (FGS) for specified foreign nations. Executive agents are also responsible for consulting with host-nation authorities on environmental issues, as required to maintain effective cooperation on environmental matters, and should coordinate with other DOD components in the specific nation.

**Explosives or munitions emergency response**

All immediate response activities by an explosives and munitions emergency response specialist to control, mitigate, or eliminate the actual or potential threat encountered during an explosives or munitions emergency. An explosives or munitions emergency response may include in-place, render-safe procedures, treatment or destruction of the explosives or munitions, and/or transporting those items to another location to be rendered safe, treated, or destroyed. Any reasonable delay in the completion of an explosives or munitions emergency response caused by a necessary, unforeseen, or uncontrollable circumstance will not terminate the explosives or munitions emergency. Explosives and munitions emergency responses can occur on either public or private lands and are not limited to responses at Resource Conservation and Recovery Act (RCRA) facilities. (Military Munitions Rule, 40 CFR 260.10).

**Extremely hazardous substance**

A substance included in appendix A or B of 40 CFR 355.

**Facility**

Facilities include buildings, structures, public works, equipment aircraft, vessels, and other vehicles and property under control of, or constructed or manufactured for leasing to the Army.

**Federal**

Of or pertaining to a department, agency, or instrumentality of the Federal Government of the United States.

**Federal agency official**

An individual designated by the head of any department, agency, or instrumentality of the United States (excluding the Smithsonian Institution) as having specific authority to represent the organization on official matters.

**Federal Land Manager**

An individual having specific authority to manage any land other than tribal lands which are controlled or owned by the United States, including lands selected by but not yet conveyed to Alaska Native Corporations and groups organized pursuant to the Alaska Native Claims Settlement Act of 1971.

**Federally-listed Species**

(see species designations)

**Federally-owned treatment works (FOTW)**

A facility that is owned and operated by a department, agency, or instrumentality of the Federal government treating wastewater, a majority of which is domestic sewage, prior to discharge in accordance with a permit issued under section 402 of the Federal Water Pollution Control Act (FWPCA).

**Fees**

Monetary charges by a regulator for some type of service. Examples include permits, registrations, and inspections.

**Final Governing Standards (FGS)**

The FGS are a comprehensive set of country-specific substantive environmental provisions, typically technical limitations on effluent, discharges, etc., or a specific management practice, with which all DOD components must comply in a given foreign nation. The FGS are developed by the DOD designated executive agent (EA) via a comparative analysis of standards in the Overseas Environmental Baseline Guidance Document (OEBGD), generally applicable host-nation laws, and relevant international agreements. The FGS generally include the standards determined by the EA to be more protective of human health and the environment.

**Finding of suitability for early transfer (FOSET)**

The primary purpose of a finding of suitability for early transfer (FOSET) is to document that the property is suitable for early transfer for the use intended by the transferee, and the intended use is consistent with protection of human health and the environment. A FOSET must demonstrate that the deed or other agreement proposed to govern the transfer between the United States and the transferee of the property contains the appropriate response action assurances specified in CERCLA Section 120(h)(3)(C)(ii): the Federal agency requesting the deferral has provided

notice, by publication in a newspaper of general circulation in the vicinity of the property, of the proposed transfer and of the opportunity for the public to submit, within a period of not less than 30 days after the date of the notice, written comments on the suitability of the property for transfer; and the deferral and the transfer of the property will not substantially delay any necessary response action at the property.

**Finding of suitability to lease (FOSL)**

A finding of suitability to lease (FOSL) is the document that conveys the result of the evaluation process used to determine that DOD property is environmentally suitable to lease. The determination of suitability to lease property is made only when the intended use of the leased property is consistent with protection of human health and the environment and will not interfere with any existing or planned environmental restoration activities. A FOSL is not required, unless deemed necessary by the DOD Component, for easements for use of real property. The FOSL and the process for preparing one are similar to the FOST and its preparation process. Similar to the FOST, preparation of a FOSL does not obviate the need to comply with the National Environmental Policy Act (NEPA).

**Finding of suitability to transfer (FOST)**

The primary purpose of a finding of suitability to transfer is to document that the property is environmentally suitable for transfer by deed under CERCLA and DOD FOST Guidance. The FOST process was developed to meet the statutory and regulatory requirements associated with transferring Federal real estate. A FOST must demonstrate that either the property is uncontaminated or that all necessary remediation has been completed or is in place and operating properly and successfully. These demonstrations are necessary to support the deed covenant required by CERCLA Section 120(h) that all remedial action necessary to protect human health and the environment has been taken. In addition, under CERCLA Section 120(3)(A), a deed to transfer property by the United States must contain (1) notice of the type and quantity of hazardous substances, (2) notice of the time at which such hazardous substance, storage, release, or disposal took place, and (3) a description of any remediation action taken.

**Fine**

Any monetary penalty or assessment levied for violation of any environmental law or regulation.

**Forest management**

The science, the art and the practice of managing the natural resources that occur on or in association with forest lands to achieve installation and Army goals.

**Forest products**

All plant materials in wooded areas that have commercial value.

**Formal consultation**

The process between the USFWS or NOAA–Fisheries and a Federal agency that commences with the Federal agency’s written request for consultation and concludes with the issuance of a BO from the USFWS or NOAA–Fisheries.

**Formerly used defense sites (FUDS)**

A FUDS is defined as a facility or site (property) that was under the jurisdiction of the Secretary of Defense and owned by, leased to, or otherwise possessed by the United States at the time of actions leading to contamination by hazardous substances. By DERP policy, the FUDS program is limited to those real properties that were transferred from DOD control prior to 17 October 1986. FUDS properties can be located within the 50 States, District of Columbia, Territories, Commonwealths, and possessions of the United States.

**Garrison commander (GC)**

The GC is a military officer, Lieutenant Colonel or Colonel, selected by the Department of the Army. The GC commands the garrison, and is responsible for day-to-day operations to maintain living and working conditions for all personnel on the installation. The GC is the lead for base support operations management for the senior mission commander/installation commander (SMC/IC). The GC is rated by the Regional Director and senior rated by the mission commander, either the IC or SMC, as applicable. The GC is IMCOM’s executive agent at installation level, providing IMCOM services and obtaining resources through IMCOM channels. The GC also provides continuity of installation command during mission activity deployments. The GC may be appointed as Summary Courts Martial convening authority or Special Courts Martial convening authority for the installation and its supported area. In some cases, the senior IMCOM official on an installation may be a civilian, the Garrison Manager (GM). A GM, as the civilian equivalent of a GC, has the same responsibility and authority as the military counterpart, with the exception of Uniform Code of Military Justice (UCMJ) and command authority, as defined by AR 600–20 (para 1–5a). The GC/GM:

- a. Commands the U.S. Army Garrison.
- b. Provides IMCOM services in accordance with respective guidance and common levels of support.



- c. Coordinates and integrates the delivery of garrison support activity services.
- d. Prioritizes requirements and support operations.

### **Generator**

See Hazardous waste generator.

### **Grounds**

This definition is used to classify installation acreage according to the level of grounds maintenance required and includes all land and water acreage for which an installation commander has responsibility (including satellite areas). Grounds are grouped into the following three categories:

a. Improved grounds. This category includes acreage on which intensive grounds maintenance activities must be planned and performed annually as fixed requirements. Activities include mowing, irrigation, fertilization, cultivation, aeration, seeding, sodding, spraying, pruning, trimming; weed, dust and erosion control; drainage, planting for landscape effect, wind and sound abatement, and other intensive practices.

b. Semi-improved grounds. This category includes areas on which periodic recurring grounds maintenance is performed but to a lesser degree than on improved grounds. Practices normally include such cyclic variables such as soil sterilization, weed and brush control, drainage maintenance, mowing for fire protection and major land repair/restoration/rehabilitation that may result from mission activities. Semi-improved grounds acreage may be combined with improved grounds acreage for reporting purposes only when two categories of grounds (improved and other than improved) are used.

c. Unimproved grounds. All other acreage (including water areas, areas under buildings and surfaced areas) not classified as improved or semi-improved. Practices and intervals of attention are generally unpredictable such as might evolve from flood, fire, insects, or disease epidemics

### **Groundwater**

Water contained within the earth's subsurface that is under pressure equal to or greater than atmospheric pressure.

### **Habitat**

An area where a plant or animal species lives, grows, and reproduces, and the environment that satisfies any of their life requirements.

### **Harmful discharge (of oil)**

Harmful discharges are such that they do at least one of the following:

- a. Violate applicable water quality standards.
- b. Cause a film or sheen upon, or discoloration of, the surface of the water or adjoining shorelines.

### **Hazardous chemical**

A hazardous chemical is defined in 40 CFR 355 and 370 which implement the Emergency Planning and Community Right-to-Know Act (EPCRA). Those sections define hazardous chemical as defined under Paragraph (c), Section 1200, Part 1910, Title 29, Code of Federal Regulations (29 CFR 1910.1200), except that such term does not include the following substances:

- a. Any food, food additive, color additive, drug, or cosmetic regulated by the Food and Drug Administration.
- b. Any substance present as a solid in any manufactured item to the extent exposure to the substance does not occur under normal conditions of use.
- c. Any substance to the extent it is used for personal, family, or household purposes, or is present in the same form and concentration as a product packaged for distribution and used by the general public.
- d. Any substance to the extent it is used in a research laboratory or a hospital or other medical facility under the direct supervision of a technically qualified individual.
- e. Any substance to the extent it is used in routine agricultural operations or is a fertilizer held for sale by a retailer to the ultimate customer.

### **Hazardous material**

A material as defined by Federal Standard, Material Safety Data, Transportation Data and Disposal Data for Hazardous Materials Furnished to Government Activities ((FED-STD-313C, 3 April 96) (The General Services Administration (GSA) has authorized the use of this Federal standard by all Federal agencies)).

a. Any item or chemical which is a "health hazard" or "physical hazard" as defined by the Occupational Safety and Health Act (OSHA) in 29 CFR 1910.1200, which includes the following:

(1) Chemicals which are carcinogens, toxic, or highly toxic agents, reproductive toxins; irritants, corrosives, sensitizers, nephrotoxins, neurotoxins, agents which act on the hematopoietic system, and agents which damage the lungs, skin, eyes, or mucus membranes.

(2) Chemicals which are combustible liquids, compressed gases, explosives, flammable liquids, flammable solids, organic peroxides, oxidizers, pyrophorics, unstable (reactive) or water-reactive.

(3) Chemicals which in the course of normal handling, use, or storage operations may produce or release dusts, gases, fumes, vapors, mists or smoke which have any of the above characteristics.

b. Any item or chemical which is reportable or potentially reportable or notifiable as inventory under the requirements of the Hazardous Chemical Reporting (40 CFR 370), or as an environmental release under the reporting requirements of the Toxic Chemical Release Reporting: Community Right To Know (40 CFR 372), which include chemicals with special characteristics which in the opinion of the manufacturer can cause harm to people, plants, or animals when released by spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment (including the abandonment or discarding of barrels, containers, and other receptacles).

c. Any item or chemical which, when being transported or moved, is a risk to public safety or an environmental hazard and is regulated as such by one or more of the following:

- (1) Department of Transportation Hazardous Materials Regulations (49 CFR 100–180).
- (2) International Maritime Dangerous Goods Code of the International Maritime Organization.
- (3) Dangerous Goods Regulations of the International Air Transport Association.
- (4) Technical Instructions of the International Civil Aviation Organization.
- (5) U.S. Air Force Joint Manual, Preparing Hazardous Materials for Military Air Shipments (AFJMAN 24–204).

### **Hazardous substance**

A substance as defined by section 101(14) of CERCLA.

a. For the purposes of this regulation a hazardous substance is any of the following:

- (1) Any substance designated pursuant to section 311(b)(2)(A) of the CWA.
- (2) Any element, compound, mixture, solution, or substance designated pursuant to section 102 of the CAA.
- (3) Any HW having the characteristics identified under the RCRA.
- (4) Any toxic pollutant listed under 15 USC 2601, et seq. (TSCA).
- (5) Any hazardous air pollutant (HAP) listed under section 112 of the CAA.
- (6) Any imminently hazardous chemical substance or mixture with respect to which the EPA Administrator has taken action pursuant to subsection 7 of 15 USC 2601, et seq. (TSCA).

b. The term does not include:

- (1) Petroleum, including crude oil or any fraction thereof, which is not otherwise specifically listed or designated as a hazardous substance in paragraph a above.
- (2) Natural gas, natural gas liquids, liquefied natural gas, or synthetic gas usable for fuel (or mixtures or natural gas and such synthetic gas usable for fuel).
- (3) A list of hazardous substances is found in Section 4, Part 302, Title 40, Code of Federal Regulations (40 CFR 302.4).

### **Hazardous waste (HW)**

A waste identified in Section 3, Part 261, Title 40, Code of Federal Regulations (40 CFR 261.3) or applicable foreign law, rule, or regulation (see also solid waste).

### **Hazardous waste disposal**

As defined in 40 CFR 260.10, disposal means the discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or HW into or on any land or water so that such solid waste or HW or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including ground waters.

### **Hazardous waste generator**

The HW generator is defined in 40 CFR 260.10 and DOD 4715.5–G (OEBGD) C6.2.3. Any person or activity (unit, organization, or tenant), whose act or process produces HW identified or listed in part 261.10 or whose act first causes a HW to become subject to regulation. For reporting purposes in the Army, the GC is considered the generator. For fiscal purposes, the generator is the unit.

### **Hazardous waste storage**

As defined in 40 CFR 260.10, the holding of HW for a temporary period, at the end of which the HW is treated, disposed of, or stored elsewhere.

### **Hazardous waste treatment**

As defined in 40 CFR 260.10, any method, technique, or process, including neutralization, designed to change the physical, chemical, or biological character or composition of any HW so as to neutralize such waste, or so as to recover

energy or material resources from the waste, or so as to render such waste non-hazardous or less hazardous; safer to transport, store, or dispose of; or amenable for recovery, amenable for storage, or reduced in volume.

**Historic district (under NHPA)**

A geographical area encompassing a number of historic properties (see historic properties below).

**Historic property (under NHPA)**

Any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the National Register of Historic Places (NRHP) maintained by the Secretary of the Interior. This term includes artifacts, records, and remains that are related to and located within such properties. The term includes properties of traditional religious and cultural importance to an Indian Tribe or Native Hawaiian organization and that meet the National Register criteria.

**Inadvertent discovery (under NAGPRA)**

Inadvertent discovery means the unanticipated encounter or detection of human remains, funerary objects, sacred objects, or objects of cultural patrimony found under or on the surface of Federal or tribal lands.

**Incidental take**

For 16 USC Chapter 35 (ESA) incidental take is defined as “take of a listed fish or wildlife species that results from , but is not the purpose of, carrying out an otherwise lawful activity by the Federal Agency or applicant (50 CFR 402.02).

**Indian Tribe**

Indian Tribe means an Indian or Alaska Native Tribe, band, nation, pueblo, village, or community that the Secretary of the Interior acknowledges to exist as an Indian Tribe pursuant to the Federally Recognized Indian Tribe List Act of 1994, 25 USC 479a.

**Inspection**

Any visit by a regulatory agency, with legal authority, for the purpose of assessing regulatory compliance.

**Installation**

An aggregation of contiguous, or near contiguous, real property holdings commanded by a centrally-selected commander. Installations represent management organizations. An installation may be made of one or more sites. In addition, two types of “virtual” installations exist within the Army. The Army National Guard has virtual installations, identified as each state commanded by the Adjutant General, under which are Readiness Centers or sites. Each Army Reserve regional readiness command is, likewise, defined as a virtual installation under which Reserve centers are identified as sites.

**Installation Commander (IC)**

The IC is usually the senior mission commander (SMC) residing on the installation or in the surrounding community. The IC is responsible for mission activity services. The IC may be appointed as General Courts Martial convening authority for the installation and its support area.

a. The IC’s installation management responsibilities include:

- (1) Senior rate the GC.
- (2) Act as principal customer advocate to the GC.
- (3) Serve as the senior Army spokesperson to the surrounding community.
- (4) Provide installation management services that are the responsibility of the senior mission activity.
- (5) Oversee and prioritize force protection implementation.
- (6) Approve priorities for training and training support services, mission support, MCA projects, well being programs and force protection.
- (7) Approve installation-level policies for Soldiers in accordance with respective Army regulations.

b. The IC’s responsibilities may change in instances where the IC is remotely located away from the installation and does not have day-to-day oversight of installation activities.

**Installation corrective action plan (ICAP)**

A comprehensive plan developed by each installation that lists Environmental Performance Assessment System (EPAS) findings, proposed corrective actions, and the status of the findings. Installations are required to enter the ICAP in the EPAS software, and provide a copy to their commanders for review every year.

### **Installation Engineer**

The installation level engineer responsible for the management, operation and maintenance of all real property to include: buildings, pavements, utility systems, natural and cultural resources, and environmental programs.

### **Installation Pest Management Coordinator**

The individual officially designated by the installation commander to coordinate and oversee the installation pest management program and installation pest management plan. Pest management coordinators will be certified as pesticide applicators if their job responsibilities require them to apply or supervise the use of pesticides.

### **Integrated cultural resources management plan (ICRMP)**

A 5-year plan developed and implemented by an installation commander to provide for the management of cultural resources in a way that maximizes beneficial effects on such resources and minimizes adverse effects and impacts without impeding the mission.

### **Integrated natural resources management plan (INRMP)**

The installation commander's adaptive plan for managing natural resources to support and be consistent with the military mission while protecting and enhancing those resources for multiple use, sustainable yield, and biological integrity. The management of natural resources is a series of processes over a long period. The INRMP provides incremental steps to achieve those long-term goals, and normally includes a five-year schedule of activities.

### **Integrated pest management**

Integrated pest management (IPM) is a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks.

### **Integrated pest management plan**

The IPMP is a long-range, comprehensive, planning and operational document required by DODI 4150.7 to ensure the establishment and maintenance of a safe, effective, and environmentally sound program for preventing and controlling damage to human health, facilities, infrastructure, materiel, or the environment that may be caused by problem species of insects, plants, animals, etc.

### **Integrated solid waste management**

A practice using several alternative waste management techniques to manage and dispose of specific components of the municipal solid waste stream. Waste management alternatives include source reduction, recycling, composting, energy recovery, and land filling. (From EPA, Decision Maker's Guide, Volume II).

### **Integrated Training Area Management (ITAM) Program**

The Army program for the management and sustainment of military training and testing lands, and other land uses which provides for: standardized range and training land assessment (RTLA) to inventory and monitor land; rehabilitation, revegetation and maintenance technologies; sustainable range awareness; decision support systems; and integration of military training requirements with land capabilities.

### **International agreement**

An international agreement is a multilateral or bilateral treaty, a base rights or access agreement, a Status of Forces Agreement (SOFA), including practices and standards established pursuant to such agreement.

### **Invasive species**

An alien species whose introduction causes or is likely to cause economic or environmental harm or harm to human health. Alien species means with respect to a particular ecosystem, any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem.

### **International Organization for Standardization (ISO) 14000/14001**

ISO 14000 is a group of voluntary international standards addressing environmental management systems, environmental auditing, environmental labeling, environmental performance evaluation, and life cycle assessments. The standards were developed by the International Organization for Standardization (ISO) and are commonly referred to as the ISO 14000 series. The series provides an organization with a systematic approach to environmental management. ISO 14001 provides the detailed specifications and requirements for an environmental management system, or EMS. A complete copy of the standard is available on the Defense Environmental Network and Information Exchange (DENIX).

### **Jeopardize the continued existence of**

To engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of

both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species.

**Land Condition Trend Analysis (LCTA) methods**

Standardized land (soil, vegetation, topographic and wildlife) inventory and monitoring procedures used for the analysis and comparability of Army lands over time.

**Land management**

The planning and execution of programs to improve, utilize and maintain all land and water areas for the greatest long-term net public benefit while supporting the military mission. Included are subordinate land uses that are mutually compatible and consistent with maintaining environmental qualities.

**Land use planning zone (LUPZ)**

A contour that is used to account for days of higher than average operations. Noise sensitive land uses are compatible within the LUPZ.

**Leak (release) detection system**

A system capable of detecting the failure of either the primary or secondary containment structure or the presence of a release of product waste or accumulated liquid in the secondary containment structure. Such a system must employ operational controls (for example, daily visual inspections for releases into the secondary containment system of the aboveground tank) or consist of an interstitial monitoring device designed to continuously and automatically detect the failure of the primary or secondary containment structure in the presence of a release of HW into the secondary containment structure.

**Lease**

A written agreement which conveys a possessory interest in real property, usually exclusive, for a period of time for a specified purpose.

**Lifecycle cost analysis**

Determination of expenses incurred of a product or process over its entire existence. It includes all the cost of mining the raw materials to the eventual destruction and/or disposal of the product or process.

**Listed hazardous substance**

A substance designated under any of the following (any HW listed under or having the HW characteristics identified according to section 3001 of the RCRA & any substance listed under section 102 of CERCLA):

- a. Sections 307(a) and 311(b)(2)(A) of CWA.
- b. Section 112 of CAA.
- c. Section 7 of 15 USC 2601, et seq. (TSCA).

**Listed species**

Any species of fish, wildlife, or plant which has been determined to be endangered or threatened under section 4 of 16 USC 35 (ESA). Listed species are found in 50 CFR 17.11–17.12.

**Low-level radioactive waste (LLRW)**

Radioactive waste not classified as high level radioactive waste, transuranic waste, or a byproduct material as defined in subsection 11(i)(2) of Section 2011, Title 42, United States Code, (42 USC 2011, Atomic Energy Act). See also radioactive material below.

**Materiel**

All items (including ships, tanks, self propelled weapons, aircraft, etc., and related spares, repair parts, and support equipment, but excluding real property, installations, and utilities) necessary to equip, operate, maintain, and support military activities without distinctions as to its application for administrative or combat purposes.

**Measure of merit (MOM)**

An objective criterion used to measure progress in achieving established DOD environmental performance goals.

**Memorandum of agreement (under NHPA)**

The document that records the terms and conditions agreed upon to resolve the adverse effects of an undertaking upon historic properties.

**Memorandum of understanding (MOU)**

A written document executed by the parties which establishes policies or procedures of mutual concern. It does not require either party to obligate funds and does not create a legally binding commitment.

**Military munitions**

Military munitions means all ammunition products and components produced for or used by the armed forces for national defense and security, including ammunition products or components under the control of the DOD, the USCG, the Department of Energy, and the ARNG. The term includes confined gaseous, liquid, and solid propellants, explosives, pyrotechnics, chemical and riot control agents, smokes, and incendiaries, including bulk explosives and chemical warfare agents, chemical munitions, rockets, guided and ballistic missiles, bombs, warheads, mortar rounds, artillery ammunition, small arms ammunition, grenades, mines, torpedoes, depth charges, cluster munitions and dispensers, demolition charges, and devices and components thereof. The term does not include wholly inert items, improvised explosive devices, and nuclear weapons, nuclear devices, and nuclear components, except that the term does include non-nuclear components of nuclear devices that are managed under the nuclear weapons program of the Department of Energy after all required sanitization operations under 42 USC 2011 (Atomic Energy Act) have been completed. (10 USC 2710(e)(3)(A) and (B)).

**Military munitions response**

DOD response actions (removal or remedial) to investigate and address the explosives safety, human health, or environmental risks presented by munitions and explosives of concern (MEC), discarded military munitions (DMM) and MC. (The response could be as simple as a notification to the community with an education program about the hazards posed by military munitions and how to avoid them, or as complicated as a long-term response action involving sophisticated technology, specialized expertise, and significant resources.)

**Monitoring**

The assessment of emissions and ambient air quality conditions. The following monitoring techniques are used:

- a. Emission estimates.
- b. Visible emission readings.
- c. Diffusion or dispersion estimates.
- d. Sampling or measurement with analytical instruments.

**Multiple use**

The integrated management of all natural resources, each with the other, to achieve the optimum use and enjoyment while maintaining the environmental qualities, ecological relationships and aesthetic values in proper balance.

**Municipal Separate Storm Sewer System (MS4)**

Any conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels or storm drains) owned by a state, city, local municipality, or Federal government and that is designed for the collection and conveyance of storm water, which is not combined with a sanitary sewer and not part of a publicly-owned treatment works (POTW).

**Munitions and explosives of concern (MEC)**

This term, which distinguishes specific categories of military munitions that may pose unique explosives safety risks, means:

- a. UXO, as defined in 10 USC 101(e)(5)(A);
- b. Discarded military munitions (DMM), as defined in 10 USC 2710(e)(2); or
- c. MC (e.g., trinitrotoluene (TNT), cyclotrimethylenetrinitramine (RDX)), as defined in 10 USC 2710(e)(3), present in high enough concentrations to pose an explosive hazard.

**Munitions constituents (MC)**

Any material originating from UXO, discarded military munitions (DMM), or other military munitions, including explosive and non-explosive materials, and emission, degradation, or breakdown elements of such ordnance or munitions. (10 USC 2710)

**Munitions response**

Response actions, including investigations, removal actions, and remedial actions to address the explosives safety, human health, or environmental risk presented by MEC, DMM, or MC.

**National Environmental Policy Act (NEPA)**

U.S. statute that requires all Federal agencies to consider the potential effects of proposed actions on the human and natural environment.

**National Pollutant Discharge Elimination System (NPDES) permit**

A permit issued pursuant to section 402 of the FWPCA. A NPDES permit is required for the discharge of pollutants from any point source into waters of the United States.

**National Register of Historic Places (NRHP)**

The nation's inventory of known historic properties that have been formally listed by the National Park Service (NPS). The NRHP is administered by the NPS on the behalf of the Secretary of the Interior. National Register listings include districts, landscapes, sites, buildings, structures, and objects that meet the set of criteria found in 36 CFR 60.4

**National Response Team (NRT)**

A team of representatives from the primary and advisory agencies that serves as the national policy-making body for planning and preparedness actions to prevent and minimize accidental pollution discharges.

**Native American Graves Protection and Repatriation Act (NAGPRA) Items**

Human remains, funerary objects, sacred objects, or objects of cultural patrimony that are excavated intentionally from or inadvertently discovered on Federal or tribal lands.

**Native Hawaiian Organization**

Any organization that serves and represents the interests of, has a primary stated purpose to provide services to, and has expertise in Native Hawaiians and Native Hawaiian affairs. Such organizations must include the Office of Hawaiian Affairs and Hui Malama I Na Kupuna 'O Hawaii Nei.

**Natural resources**

The viable and/or renewable products of nature and their environments of soil, air, and water. Included are the plants and animals occurring on grasslands, rangelands, croplands, forests, lakes, and streams.

**Noise zones I, II, and III**

Land use planning areas for the purpose of maintaining uses that are compatible with the existing and future noise environments.

**Non-Federal**

Any entity that is not part of a department, agency, or instrumentality of the Federal government of the United States.

**Non-point source**

Diffuse sources of pollution (that is, without a single point of origin or not introduced into a receiving water from a discrete conveyance). Pollutants are generally carried off the land by stormwater or snow melt. Common non-point sources include agriculture, forestry, urban, construction, dams, channels, land disposal, saltwater intrusion, and city streets.

**Noxious weed**

Plant species identified by Federal or State agencies as requiring control or eradication.

**Off-road vehicle (ORV)**

A vehicle designed for travel on natural terrain. The term excludes a registered motorboat confined to use on open water and a military, emergency, or law enforcement vehicle during use by an employee or agent of the Government or one of its contractors in the course of employment or agency representation.

**Oil**

Oil or petroleum products of any kind or in any form, and oil mixed with wastes other than dredged spoil.

**On-scene coordinator (OSC)**

The Federal official pre-designated by EPA or USCG to coordinate and direct Federal responses under subpart D, and removals under subpart E, of 40 CFR 300 (National Oil and Hazardous Substances Pollution Contingency Plan); or

- a. The DOD or U.S. Department of Energy official designated to coordinate and direct the removal actions from releases of hazardous substances, pollutants, or contaminants where either the release is on, or the sole source of the release is from, any facility or vessel under the jurisdiction, custody, or control of their departments respectively; or,
- b. The official designated by any other Federal department or agency to coordinate and direct removal actions other

than emergencies where either the release is on, or the sole source of the release from, any facility or vessel under the jurisdiction, custody, or control of those departments and agencies.

### **Open burning**

The combustion of any material without the characteristics below:

- a. Control of combustion air to maintain adequate temperature for efficient combustion.
- b. Containment of the combustion reaction in an enclosed device to provide enough residence time and mixing for complete combustion.
- c. Control of emission of the gaseous combustion products.

### **Operating tempo (OPTEMPO)**

Operating tempo is the pace of unit training that the Army believes it needs to conduct to maintain its fleet of tracked and wheeled vehicles at a prescribed readiness level. Stated another way, it is a resource gauge the Army measures to indicate the amount of miles or operating hours required to execute a unit commanders training strategy to achieve a given specific readiness level.

### **Operational noise**

The outdoor noise environment consisting of the noise, including ambient noise, from all sources. The noise environment of the work place is not considered operational noise.

### **Operational range**

A range that is under the jurisdiction, custody, or control of the Secretary of Defense and that is used for range activities; or although not currently being used for range activities, that is still considered by the Secretary to be a range and has not been put to a new use that is incompatible with range activities (10 USC 101(e)(3)(A) and (B)). Also includes "military range," "active range," and "inactive range" as those terms are defined in 40 CFR 266.201.

### **Operational readiness**

The umbrella term and supporting program that encompasses all the resources required of a unit to maintain readiness standards.

### **Organization**

Company, corporation, authority, or institution, or part or combination thereof, whether incorporated or not, public or private, that has its own functions and administration.

### **Outdoor recreation**

Recreational program, activity, or opportunity that is dependent on the natural environment. Examples are hunting, fishing, trapping, picnicking, bird-watching, ORV use, hiking and interpretive trails use, wild and scenic river use, and underdeveloped camping areas. Developed or constructed activities such as golf courses, lodging facilities, boat launching ramps, and marinas are not included.

### **Outgrant**

Reference AR 405–80 for specific definitions. A real property legal document which conveys or gives the right to use Army-controlled real property, including leases, permits, licenses, and easements.

### **Overseas Environmental Baseline Guidance Document (OEBGD)**

A set of objective criteria and management practices developed by the DOD, to protect human health and the environment at overseas installations, and to be used by the designated EA during the comparative analysis process used to develop FGS. In addition, the OEBGD contains implementing guidance for executive agents, garrison commanders and DOD components.

### **Permanent installation**

An aggregation of real property holdings under the jurisdiction of the DOD, controlled by and at which an Active Army unit or activity is permanently assigned.

### **Pest management**

The prevention and control of animal and insect disease vectors and other pests that may adversely affect the DOD mission or military operations; the health and well-being of people; or structures, materiel, or property.

### **Pest management consultant**

Personnel who meet the DOD educational and experience criteria for PPMP and who serve at IMCOM, USACHPPM regions, National Guard Bureau (NGB) and higher Army-levels of command. Pest management consultants interpret



and establish program standards for installation programs and are responsible for evaluating and providing technical guidance to support these programs.

**Pest management quality assurance evaluator**

Personnel technically qualified in the management and oversight of pesticide applicators and pest management contracts by training, per DOD standards, which protect the Government's interest through on-site performance evaluation of commercial contracts involving pest management or other contracts that involve the use of pesticides. See AR 5-20.

**Pesticide**

Any substance or mixture of substances, including chemical biological control agents, that may prevent, destroy, repel, or mitigate pests and are specifically labeled for use by the EPA. Also, any substance or mixture of substances used as a plant regulator, defoliant, desiccant, disinfectant, or biocide.

**Pesticide security**

The prevention of intrusion to areas used to store pesticides and other toxic chemicals to ensure that they have appropriate security protections to prevent intruder access to equipment used in mixing, loading, and applying pesticides. Pesticide applicators must have proper authorization and identification.

**Pests**

Arthropods, birds, rodents, nematodes, fungi, bacteria, viruses, algae, snails, marine borers, snakes, weeds, mollusks, and other organisms (except for excluding microbial/bacterial/viral disease pathogens, but including organisms that may transmit human or animal disease-causing organisms) that adversely affect readiness, military operations, or the well-being of personnel and animals; attack or damage real property, supplies, equipment, or vegetation; or are otherwise undesirable.

**Point source**

Any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharged.

**Pollutant (water)**

Dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal and agricultural waste discharged into water. A broad term which generally encompasses most material which is added to the water constitutes a pollutant.

**Pollution**

See environmental pollution.

**Pollution prevention**

Use of processes, materials, or products that avoid, reduce, or control pollution, which may include recycling, treatment, process changes, control mechanisms, efficient use of resources and material substitution.

**Pollution prevention opportunity assessment**

Provides the technical and economic information necessary for selecting appropriate pollution prevention techniques.

**Pollution prevention plan**

A plan developed and maintained by an installation commander that sets forth the installation's contribution to the goals and requirements established by EO 13423, including reductions in use and release of toxic chemicals and ODS and in the generation of HW.

**Prescribed burning**

Skillful application of fire to natural fuels under conditions of weather, fuel moisture, soil moisture, etc., to allow confinement of the fire to a predetermined area while producing the intensity of heat and rate of spread required to accomplish certain planned benefits. These benefits may include all or one or more objectives of silviculture, wildlife management, grazing, hazard reduction, etc. Its objective is to employ fire scientifically to realize maximum net benefits at minimum damage (if any) and acceptable cost.

**Pretreatment (wastewater)**

The reduction of the amount of pollutants, the elimination of pollutants, or the alteration of the nature of pollutant

properties in wastewater prior to or in lieu of discharging or otherwise introducing such pollutants into a treatment works.

**Pretreatment standard**

Any regulation containing pollutant discharge limits promulgated by the EPA in accordance with section 307(b) and (c) of the FWPCA, which applies to Industrial Users. This includes prohibitive discharge limits established pursuant to Section 5, Part 403, Title 40, Code of Federal Regulations (40 CFR 403.5).

**Primary agencies (for NRT)**

The Federal departments or agencies comprising the National Response Team (NRT); i.e., the Departments of Commerce, Interior, Transportation, and Defense; and the EPA. These agencies have primary responsibility and resources to promote effective operation of the national oil and hazardous substances pollution contingency plan.

**Primary drinking water standards**

Standards for those contaminants in drinking water, which may cause an adverse health effect on the consumer. In the form of maximum contaminant levels, treatment, techniques, or action levels, these standards are federally enforceable.

**Proactive**

Taking the initiative by acting rather than reacting to events.

**Professional pest management professional**

The DOD military officers commissioned in the Medical Service or Biomedical Sciences Corps or DOD civilian personnel with college degrees in biological or agricultural sciences that are in a current assignment that includes pest management responsibilities exercised regularly. The DOD civilian employees also will meet Office of Personnel Management qualification standards. Based on assignment, some PPMP are Certifying Officials.

**Programmatic agreement (PA) (under NHPA)**

A document that records the terms and conditions agreed upon to resolve the potential adverse effects of a Federal agency program, complex undertaking or other situations in accordance with 36 CFR 800.14(b), NHPA.

**Proponent**

Proponent identification depends on the nature and scope of a proposed action. Any Army organization may be a proponent (for example, for a project, program, or regulation). In general, the proponent is the unit, element, or organization that is responsible for initiating and/or carrying out the proposed action. The proponent is responsible for programming and/or securing funding for such actions.

**Proposed species**

A fish, wildlife, or plant species that is proposed in the Federal Register to be listed as endangered or threatened under 16 USC 35 (ESA).

**Publicly-owned treatment works (POTW)**

Any device or system used in the treatment (including recycling and reclamation) of municipal sewage or industrial wastes of a liquid nature which is owned by a State or municipality.

**Public water systems**

Systems that provide water for human consumption through pipes or other constructed conveyances to at least 15 service connections or serves an average of at least 25 people for at least 60 days a year. There are three types of public water systems:

- a. Community Water System (CWS): A public water system that supplies water to the same population year-round.
- b. Non-Transient Non-Community Water System (NTNCWS): A public water system that regularly supplies water to at least 25 of the same people at least six months per year, but not year-round. Some examples are schools, factories, office buildings, and hospitals which have their own water systems.
- c. Transient Non-Community Water System (TNCWS): a public water system that does not regularly supply water to at least 25 of the same persons over six months per year.

**Quarantine**

A restraint placed upon the activities or communication of persons or the transport of goods designed to prevent the spread of disease or pests.

**Radioactive material**

Any material or combination of materials that spontaneously emit ionizing radiation.

**Range**

A designated land or water area that is set aside, managed, and used for range activities of the DOD. The term includes firing lines and positions, maneuver areas, firing lanes, test pads, detonation pads, impact areas, electronic scoring sites, buffer zones with restricted access, and exclusionary areas. The term also includes airspace areas designated for military use in accordance with regulations and procedures prescribed by the Administrator of the Federal Aviation Administration.

**Range activities**

Research, development, testing, and evaluation of military munitions, other ordnance, and weapons systems; and the training of members of the armed forces in the use and handling of military munitions, other ordnance, and weapons systems.

**Real property**

This includes the definition for real property found in the Federal Property Management Regulations, 41 CFR 101–47.103.12.

**Reclamation**

Regeneration of a material, or processing of a material to recover a usable product. Examples include recovery of lead from spent batteries, or the regeneration of spent solvents.

**Recovery**

The improvement in the status of listed species to the point at which listing is no longer appropriate under the criteria set out in section 4(a)(1) of 16 USC 35 (ESA).

**Recovery plan**

A plan developed by the USFWS or NOAA–Fisheries, as required by 16 USC 35 (ESA), for the conservation, survival, and recovery of a listed species.

**Recreational waters**

Recreational waters are water bodies that are commonly used for recreational purposes. They include, but are not necessarily limited to, swimming pools, water parks, hot tubs, lakes, rivers, and the ocean.

**Recycling**

The process by which materials otherwise destined for disposal are collected, reprocessed, or remanufactured, and are reused. A distinction exists between onsite recycling (that is, where a waste is discharged from a process, but not from the installation, for recycling) and off-site recycling (that is, where the waste is transported from the generating activity to an off-site recycler).

**Regional administrator**

The regional administrator of the EPA regional office in which the subject property is located.

**Regional Response Team (RRT)**

A team of regional Federal representatives of the primary or selected advisory agencies. It acts within its region as an emergency response team that performs functions like those of the NRT.

**Regulated tank**

A tank constructed above, below, or on the ground, which is regulated by Federal or State authorities because it contains an oil or hazardous substance. Above ground tank requirements are found at 40 CFR 110, underground storage tank (UST) requirements at 40 CFR 280. Exceptions for heating oil tanks are found at 40 CFR 280.12. State regulations may be more stringent.

**Release**

A discharge of one or more hazardous substances into the environment by any means. Excluded are minor releases within the workplace, emissions from engine exhaust, and normal applications of fertilizer.

**Reportable spill or event**

A release of a reportable quantity of oil or hazardous substance into the environment. The EPA National Response Center (NRC) is to be notified immediately.

*a.* For oil (defined by 40 CFR 110): A discharge of such quantities of oil into or upon the navigable waters of the United States, its adjoining shorelines, or the contiguous zone so as to meet the qualifications listed in harmful discharge (of oil) into navigable waters or into or beyond the contiguous zone above.

*b.* For hazardous substances: Any release of one or more reportable substances in reportable quantities into the environment.

### **Response action**

The cleanup or removal of released hazardous substances from the environment. This includes actions necessary in the event of the threat of release of hazardous substances into the environment; such actions as may be necessary to monitor, assess, and evaluate the release or threat of release of hazardous substances; the disposal of removed material; or the taking of such other actions as may be necessary to prevent, minimize, or mitigate damage to the public health or welfare or to the environment, which may otherwise result from a release or threat of release.

### **Resource recovery**

A term describing the extraction and use of materials and energy from the waste stream. The term is sometimes used synonymously with energy recovery.

### **Restoration Advisory Board (RAB)**

A RAB is a forum of representatives of the DOD, EPA, State and local government, and public representative(s) of the potentially affected community. RAB members can provide input to the Army's environmental restoration program (ERP) at both operating and closing or realigning installations. The RAB reflects the diverse makeup of the community, gives all stakeholders the opportunity to participate in the cleanup process, and make their views known to decision makers.

### **Reuse**

A material is used or reused if it is either:

*a.* Used as an ingredient (including use as an intermediate) in an industrial process to make a product (for example, distillation bottoms from one process used as a feedstock in another process).

*b.* Used in a particular function or application as an effective substitute (for example, spent battery acid accumulated by the DRMO could be used in industrial waste-water treatment facilities to precipitate phosphorous, and act as a sludge conditioner).

### **Risk assessment**

Environmental risk assessment is the formal systematic evaluation of any environmental hazard that may pose a risk to human health or the environment. It may include an on-site investigation to determine the existence, nature, severity, and location of hazards and options for reducing the hazards.

### **Sacred site**

Any site that traditional Native American religious leaders use for the practice of traditional Native American religions by their present-day adherents.

### **Secondary drinking water standards**

Standards for those contaminants in drinking water, which may affect the aesthetic quality of the water, but have no adverse health effects. In the form of secondary maximum contaminant levels, these standards are not federally enforceable, but may be enforced by a State regulatory agency.

### **Senior mission commander (SMC)**

The SMC will be a General Officer and designated by Senior Army Leadership. The SMC is responsible for the primary mission activity on several installations. The SMC provides executive level oversight of installation management services to the mission activities and other customers. The SMC need not reside or work on the installation. SMC installation management responsibilities are to:

*a.* Assist the GC in obtaining resources by advocating priority needs through the Army Commands (ACOMs), Army Service Component Commands (ASCCs), Direct Reporting Units (DRUs), and the IMBOD.

*b.* Act as the principal customer advocate to the IC and GC.

*c.* Approve the priorities for mission support, MCA projects, well-being programs and force protection requirements.

*d.* Provide overall force protection guidance.

*e.* Senior rate the GC.

### **Sewage sludge**

Any solid, semi-solid, or liquid residue removed during the treatment of municipal wastewater or domestic sewage.

### **Significant paleontological resources**

Paleontological resources (i.e., fossil remains) associated with events that have made an important contribution to the broad pattern of history or the lives of persons who were of importance in the past, or that yield or may yield information that is important to history or pre-history.

### **Site**

A physically defined location which can be supported by a legal boundary survey which closes a polygon. It can be owned, leased, or otherwise possessed or used. A site may exist in one of three forms: land only; facility or facilities only; or land and all the facilities on it. A site is the sum of all real property at a specific location.

### **Sludge**

Any solid, semi-solid, or liquid waste generated from a municipal, commercial, or industrial wastewater treatment plant, water supply treatment plant, or air pollution control facility exclusive of the treated effluent from a wastewater treatment plant (40 CFR 260.10).

### **Sole source aquifer**

A groundwater source demonstrated to be the only or primary viable source of drinking water for a community or an aquifer that supplies 50 percent or more of the drinking water of an area.

### **Solid waste**

Any discarded material that is not excluded by 40 CFR 261.4(a) or that is not excluded by variance granted under 40 CFR 260.30 and 260.31 (40 CFR 261.2).

### **Source reduction**

Any practice which reduces the amount of any hazardous substance, pollutant, or contaminant entering any waste stream or otherwise released to the environment prior to recycling, treatment, or disposal; or, any practice which reduces the hazards to public health and the environment associated with the release of such substances, pollutants, or contaminants (Pollution Prevention Act (PPA) of 1990).

### **Source water**

The water taken from rivers, reservoirs, or wells for use as drinking water.

### **Special installation**

Special installations are generally very small, mostly industrial, and typically do not have a stand-alone installation staff. Command, control, manpower, and funding remain with the Army Commands (ACOMs), Army Service Component Commands (ASCCs), and Direct Reporting Units (DRUs), while traditional base operations support (BOS) oversight is provided by the IMCOM. These installations primarily use funds other than operation and maintenance funds (i.e., mission funds) to conduct traditional garrison operations in support of its primary mission. Several mission fund types are used in the operation of these installations, including: Army Working Capital Funds (AWCF); transportation working capital funds (TWCF); chemical program funds; Defense Health Program (DHP) funds; procurement Army ammunition (PAA) funds; and research, development, test, and evaluation (RDT&E) funds.

### **Special State (installation) license**

A license prepared and issued by the installation in accordance with 10 USC 670 and the fish and wildlife cooperative plan to individuals participating in hunting, fishing, or trapping activities. It is valid only on the installation where issued. A fee is collected and used for fish and wildlife management activities in accordance with the integrated natural resources management plan (INRMP).

### **Species designations**

The following species designations apply.

*a.* 16 USC Chapter 35 (ESA).

(1) Endangered species. Any species, plant or animal, which is in danger of extinction throughout all or a significant portion of its range, as listed by the U.S. Department of Interior (DOI).

(2) Threatened species. Any species, plant or animal, which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range, as listed by the DOI.

(3) Candidate species. Plant or animal taxa considered for possible addition to the List of T&E Species. These are taxa for which the USFWS has on file sufficient information on biological vulnerability and threats to support issuance of a proposal to list, but issuance of a proposed rule is currently precluded by higher priority actions.

*b.* State listed species. Any species, plant or animal, which is listed by the appropriate State as threatened or endangered within the State. (Note: these species may not be federally listed).

*c.* Species At Risk or Habitats. Plant and animal species and associated habitats that are not federally listed as

threatened or endangered under 16 USC Chapter 35 (ESA), but are either federally listed as candidates or are ranked by NatureServe as critically imperiled or imperiled throughout their range.

*d. Army Species At Risk or Habitats.* Species at risk or habitats that could be listed in the near future and/or for which the listing could have significant impact on military readiness and which are designated by HQDA.

### **Spill**

A generic term, as used in this regulation, which encompasses the accidental and the deliberate but unpermitted discharge or release of a pollutant. For distinction, see discharge classifications, harmful discharge and so forth, potential discharge, release, and reportable spill or event. For comparison, see discharge and federally permitted release.

### **State historic preservation officer (SHPO) (under NHPA)**

The official appointed or designated pursuant to section 101(b)(1) of the act to administer the State historic preservation program or a representative designated to act for the SHPO.

### **Status of Forces Agreement (SOFA)**

Agreement on the stationing or operations of forces to which the United States is a party, such as:

- a.* Multilateral or bilateral stationing or base rights agreement.
- b.* Arrangements or understanding concluded there under.

### **Storage**

The holding of hazardous substances (as defined in this section), other than for a temporary period of less than 30 days, prior to the hazardous substance being either used, neutralized, disposed of, or stored elsewhere.

### **Storage tank system**

Storage tank systems include the tank(s), all connected piping, any ancillary equipment, and the containment system.

### **Sub-Installation**

A grouping of facilities that are under the control of an installation garrison, but are not physically located within the principal installation boundary.

### **Surface water**

All water naturally open to the atmosphere (rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, and so forth) and all springs, wells, or other collectors directly influenced by surface water.

### **Surveillance**

Thorough inspections or surveys made before and after pest management treatments to determine the presence and prevalence of pests or disease vectors.

### **Sustainability**

Meeting present needs without compromising the ability of future generations to meet their own needs.

### **Sustainable yield**

The production of renewable resources a land or water area can maintain in perpetuity at a given intensity of management without impairment of the resource.

### **Take**

Take means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. Harm is further defined to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering. Harass is defined as actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering.

### **Tank**

Any stationary device designed to contain an accumulation of used oil (40 CFR 279.1) or HW (260.10), oil (40 CFR 112 and 40 CFR 280.12) or regulated substance (40 CFR 280.12) which is constructed primarily of non-earthen materials (for example, wood, concrete, steel, plastic) which provides structural support.

### **Technical guide (TG)**

Technical guidance prepared by the AFPMB on specific pest management and disease vector control topics. TMs are

available from the DOD AFPMB, Forest Glen Section, Walter Reed Army Medical Center, Washington, DC 20307-5001.

**Technical Review Committee (TRC)**

TRCs are established as required by CERCLA Section 211 to facilitate review and comment on response actions and proposed actions at Army installations. The Army establishes TRCs for installations where there is no community interest towards establishment of a RAB. Note, however, that the TRC is being replaced by the RAB where appropriate. Installations that already have TRCs should consider converting the committee to a RAB (see Restoration Advisory Board for additional information).

**Tenant**

An authorized activity located on an installation that is not part of the garrison organization. Tenants include, but are not limited to, military units, the Army and Air Force Exchange Service (AAFES), and the Defense Commissary Agency (DeCA).

**Toxic chemical**

A chemical listed in 40 CFR 372.65 or added to that list by the EPA and required to be reported yearly in the EPCRA Toxic Releases Inventory.

**Toxic pollutant**

Those pollutants or combinations of pollutants, including disease-causing agents which, after discharge and upon exposure, ingestion, inhalation or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, will cause death; disease; behavioral abnormalities; cancer; generic mutations physiological malfunctions, including malfunctions in reproduction; or physical deformations in such organisms or their offspring.

**Transfer**

Reference AR 405-90. Change in jurisdiction over real property from one Federal agency or department to another, including military departments and defense agencies.

**Treatment**

Any method, technique, or process, including neutralization, designed to change the physical, chemical, or biological character or composition of any HW so as to neutralize such waste, or so as to recover energy or material resources from the waste, or so as to render such waste non-hazardous, or less hazardous; safe to transport, store, or dispose of; or amenable for recovery, amenable for storage, or reduced in volume.

**Underground injection**

Subsurface emplacement of fluids, often wastes, through a bored, drilled or driven well.

**Undertaking**

A project, activity, or program funded in whole or in part under the direct or indirect jurisdiction of a Federal agency, including those carried out by or on behalf of a Federal agency; those carried out with Federal financial assistance; and those requiring a Federal permit, license or approval.

**Unexploded ordnance (UXO)**

UXO are military munitions that:

- a. Have been primed, fused, armed, or otherwise prepared for action.
- b. Have been fired, dropped, launched, projected, or placed in such a manner as to constitute a hazard to operations, installations, personnel, or material.
- c. Remain unexploded, either by malfunction, design, or any other cause. (10 USC 101(e)(5)).

**Unintentional Take**

As defined for migratory birds (Migratory Bird Treaty Act (MBTA)) - take, that results from, but is not the purpose of, the activity in question, take of this type is sometimes referred to as incidental or indirect.

**Unit commander**

A commissioned officer of the United States armed forces designated to command a military unit.

**U.S. jurisdiction**

The 50 states, the District of Columbia, the commonwealths of Puerto Rico and the Northern Mariana Islands, the

territories of Guam and American Samoa, the U.S. Virgin Islands, and any other territory or possession over which the United States has jurisdiction.

**Vessel**

Any type of watercraft or other artificial contrivance used, or capable of being used, as a means of transportation on water, other than a public vessel.

**Vulnerability assessment**

An assessment of elements in the community that are susceptible to damage if hazardous materials are released.

**Waste minimization**

Two definitions are:

*a.* Any source reduction or recycling activity that is undertaken by a generator that results in the reduction of the quantity of HW, or the reduction in toxicity of HW, that is either generated or subsequently treated, stored, or disposed of. Such activities must be consistent with the goals of minimizing present and future threats to human health and the environment.

*b.* A working definition of waste minimization reflects two types of activities, source reduction or elimination of waste at the point of generation (for example, within a process), and recycling.

**Wastewater**

The spent or used water from individual homes, a community, a farm, or an industry that contains dissolved or suspended matter.

**Water conservation**

The beneficial reduction of water uses or water losses.

**Water resource**

Any groundwater or surface water source and associated (lake or ocean) shoreline. See also surface water, and groundwater.

**Watershed**

A region or area bounded peripherally by a water parting and draining ultimately to a particular watercourse or body of water.

**Waterworks permit**

Any permit required to operate a drinking water treatment facility, such as a source water appropriation permit or an operating permit.

**Weed**

A plant growing where it is not desired.

**Wellhead protection area**

The surface and subsurface area surrounding a water well or well field supplying a public water system, through which contaminants are reasonably likely to move toward and reach such well or well field.

**Wetlands**

Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Common terms used to describe various wetlands include marshes, bogs, swamps, small ponds, sloughs, potholes, river overflows, oxbows, mud flats, and wet meadows.

**Wildland fire**

Any non-structural fire that occurs on unimproved grounds. This includes wildfires and prescribed fires.

**Wildlife management**

The practical application of scientific and technical principles to wildlife populations and habitats so as to maintain such populations essentially for ecological, recreational, and/or scientific purposes.

**Section III**

**Special Abbreviations and Terms**

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Star Involvement



REPLY TO  
ATTENTION OF

**DEPARTMENT OF THE ARMY**  
**US ARMY INSTALLATION MANAGEMENT COMMAND, PACIFIC REGION**  
**HEADQUARTERS, UNITED STATES ARMY GARRISON, HAWAII**  
**745 WRIGHT AVENUE, BUILDING 107, WHEELER ARMY AIRFIELD**  
**SCHOFIELD BARRACKS, HAWAII 96857-5000**

IMHW-ZA

MEMORANDUM FOR All Military Personnel, Contractors and Department of Defense Civilian Employees within United States Army Garrison, Hawaii (USAG-HI) Installations

SUBJECT: Policy Memorandum USAG-HI-72, Tree Cutting Moratorium

1. References.

a. Army Regulation (AR) 200-1, Environmental Protection and Enhancement, 13 Dec 07.

b. Federal Endangered Species Act (1973).

2. Applicability. This policy applies to all Soldiers, civilians, family members, contractors, and other personnel who work on, reside on, or visit any U.S. Army installation, facility, or work site on the Island of Oahu.

3. Policy.

a. In February, 2014, the Natural Resource Program (NRP) discovered the presence of the Federally-listed endangered species, Hawaiian Hoary Bat, *Lasiurus cinereus semotus*, at Schofield Barracks West Range. In addition, the NRP discovered the presence of the bat in Schofield Barracks East Range in Spring 2013. Bats have also been found by the US Geological Survey in numerous locations on Oahu spanning from Waikiki to Ford Island to the Waianae Mountains to the North Shore of Oahu. For this reason, bats are now considered to be ubiquitous on Oahu.

b. The Army is required to consult with the US Fish and Wildlife Service (USFWS) anytime an action may affect a listed threatened or endangered species or their critical habitat. In the meantime, the Army must practice avoidance.

c. The NRP is in the process of preparing a formal consultation package for the USFWS. Until a Biological Opinion is received from the USFWS, the following measures must be followed to maintain compliance with the Federal Endangered Species Act of 1973:

(1) During the bat pupping season, 1 June to 15 September, there shall be no cutting or trimming of any tree over 15 feet tall.

(2) If a tree falls on its own that is over 15 feet tall, the Army may remove the tree.

IMHW-ZA

SUBJECT: Policy Memorandum USAG-HI-72, Tree Cutting Moratorium

(3) In case of an emergency situation, e.g., a tree larger than 15 feet tall is threatening a power line, the staff must contact the Natural Resource Program for guidance prior to cutting the tree.

(4) This policy applies to all Army installations on the island of Oahu, including housing. The policy pertains to cantonment as well as to the actual training areas.

(5) This policy is effective immediately and remains in effect until rescinded or superseded in writing.

4. Proponent. The proponent for administration of the Tree Cutting Moratorium is the DPW Environmental Division, at 655-9189.

RICHARD A. FROMM  
COL, AD  
Commanding

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## OANRP Diaphacinone-50 Hand Broadcast Study

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## EXECUTIVE SUMMARY

The Army is required to stabilize populations of endangered species and their habitat as per Biological Opinions issued by the U.S. Fish and Wildlife Service. Introduced rats (*Rattus* spp.) are one of the largest threats to endangered plants, snails and birds. Oahu Army Natural Resources Program (OANRP) has been engaged in rodent control since 1995 using various techniques including snap traps, automatic traps, rodenticide applied in bait stations and physical barriers. Since 2012, OANRP halted rodenticide use because of a change in the Special Local Needs (SLN) label that makes bait-station application unfeasible in the steep, rugged terrain where the work is conducted. Relying solely on traps has not been effective in keeping populations below the targeted 10% tracking in monitoring tunnels, particularly during the period of peak rat abundance (typically Fall/Winter). In attempt to combat this problem in Hawaiian habitats, OANRP would like to determine the effectiveness of a “one-time” two-application hand-broadcast (applications spaced approximately 5-7 days apart) and canopy baiting of rodenticide bait (Diphacinone-50) during a period of high rat abundance within Kahanahaiki Management Unit (a fenced Unit where ungulates are excluded) in the Waianae Mountains. Hand broadcast application will involve OANRP staff walking a grid of trails while evenly distributing rodenticide bait; canopy baiting involves placing bait, held in small cloth bags, into trees within the grid. These application methods comply within the Diphacinone-50 label (EPA Registration No. 56228-35). Hand broadcast method of rat control was assessed in the Programmatic Environmental Assessment for the Final Implementation Plan for Oahu Training Areas, March 2010, FNSI June 2010. USDA National Wildlife Research Center (NWRC) will provide the monitoring associated with this study (e.g., bait application according to label, efficacy of this rat-reduction method, and non-target impacts).

## 1. INTRODUCTION to Project Plan

This is the project plan to study a hand broadcast and canopy baiting application of Diaphacinone-50 for control of *Rattus* spp. at Kahanahaiki Management Unit, northern Waianae Mountains, Oahu. The project plan includes two parts: 1) the operational plan, and 2) the monitoring plan (inserted as an Appendix to this document; NWRC Study Protocol QA-2523). This project plan was written collaboratively by Oahu Army Natural Resources Program (OANRP), with funding from the Army, and the USDA APHIS Wildlife Services (WS), and USDA APHIS WS National Wildlife Research Center (NWRC). The OANRP will lead in the operation, particularly bait application, whereas WS/NWRC will provide project oversight and will lead in the monitoring of this study.

## 2. GOAL, OBJECTIVES and OUTCOMES

### 2.1. Goal

The goal of this project is:

“To study if a hand broadcast and canopy baiting application of Diphacinone-50 in combination with a grid of mechanical traps (already in operation) has a seasonal knockdown effect on the rat population at Kahanahaiki (ideally <10% tracking activity through the winter).”

### 2.2. Objectives and Outcomes

Objectives	Outcomes
1. To determine if a 2-application hand broadcast of Diphacinone-50 is an effective method for seasonal knockdown of <i>Rattus</i> spp. at Kahanahaiki	1.1 Reduction of rat activity (ideally <10% measured by tracking tunnels, corriflute tabs and GoodNature chew cards), and >80% local mortality of rats (using fates of rats with radio collars).
2. Study non-target effects	2.1 Gain information on non-target effects (carcasses searches, tests of diphacinone residues through food web)
3. Use results to make management decisions and develop protocols for other MU's	3.1 Determine if seasonal hand broadcast is a safe and effective option for seasonal control of rats.
	3.2 Staff will have skills and knowledge to undertake other hand broadcast operations at other Management Units (MUs).

### 3. THE SITE, TARGET SPECIES, and NEED for SUPPLEMENTAL RAT CONTROL USING SEASONAL BAIT APPLICATION

#### 3.1. The Site and Rat Management History

The Kahanahaiki Management Unit (MU) is located at 500-660 m elevation in the Waianae mountain range (21° 32' N, 158° 11' W), within the Makua Military Reservation (MMR), on Oahu, Hawaii (Figure 1). The rat control area within the MU is approximately 70 acres and is fenced to exclude ungulates. Overall, the north and east aspects are relatively native while the south and west exposures are dominated by weeds. Kahanahaiki is home to many rare taxa, including plants and snails; 12 plant species and two animals are listed as endangered (Joe and Daehler 2008). Non-native rodents are ubiquitous at Kahanahaiki, including black rats (*Rattus rattus*), Pacific rats (*R. exulans*), and house mice (*Mus musculus*); black rats are numerically dominant, outnumbering Pacific rats by >10-fold (Shiels 2010). Negative impacts of each of these three rodent species at Kahanahaiki has been reported to span native plants, insects, snails, and birds (Meyer and Shiels 2009; Shiels et al. 2013). One endangered plant, *Cyanea superba*, is highly vulnerable to black rat predation, and large-scale and intensive snap-trapping at Kahanahaiki reduced seed predation by rats from 47% to just 4% in one season (Pender et al. 2013). Several additional native plants receive high predation by black rats at Kahanahaiki (Shiels and Drake 2011), implying that these native forests may potentially experience a shift in species composition attributable to invasive rats (particularly black rats).

The U.S. Army is required to stabilize populations of endangered species and their habitat as per Biological Opinions issued by the U.S. Fish and Wildlife Service. Due to the large negative effects of introduced rats on natural resources at Kahanahaiki, Oahu Army Natural Resources Program (OANRP) has been engaged in rodent control since 1995 using various techniques including snap traps, automatic traps, rodenticide applied in bait stations and physical barriers. Due to the high habitat quality and small size of the Kahanahaiki, a large scale Victor Snap grid of 402 traps was installed in May 2009 for Kahanahaiki-wide protection (Figure 1). In general, these traps were re-baited twice per month. After a general knock-down in the rat population in 2009, much fluctuation had occurred and the targeted levels of rat suppression were not always being met with the large-scale snap-trapping (Pender et al. 2013); this resulted in noticeable losses of native and endangered seeds and predation of native snails by rats.



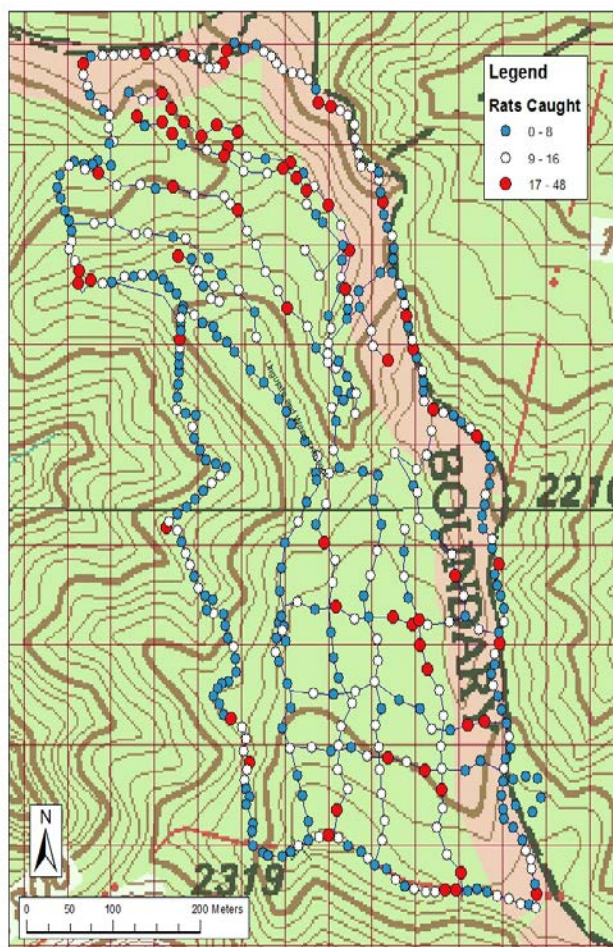


Figure 1. Map of Kahanahaiki snap-trap grid displaying total rat catches (2009-2014).

OANRP rat-control tools became more limited in 2012, which was when OANRP halted rodenticide use because of a change in the Special Local Needs (SLN) label that made bait-station application unfeasible in the steep, rugged terrain where the work (at the MU and elsewhere) is conducted. During a trial in 2012 and 2013, Goodnature A24 rat + stoat traps (Goodnature Limited, Wellington, NZ), which are self-resetting traps that can fire 24 times with one CO<sub>2</sub> cartridge, were shown to be effective in controlling rat activity at a nearby site, Pahole gulch. Because of these results a grid of A24s was installed at Kahanahaiki and snap-traps were discontinued. In July 2014, 83 Goodnature A24s were installed on existing trails at a spacing of approximately 50 x 100 meters. In December 2014, an additional 36 A24s were installed within the gulch area to achieve a device spacing of 25 x 100meters (Figure 2).

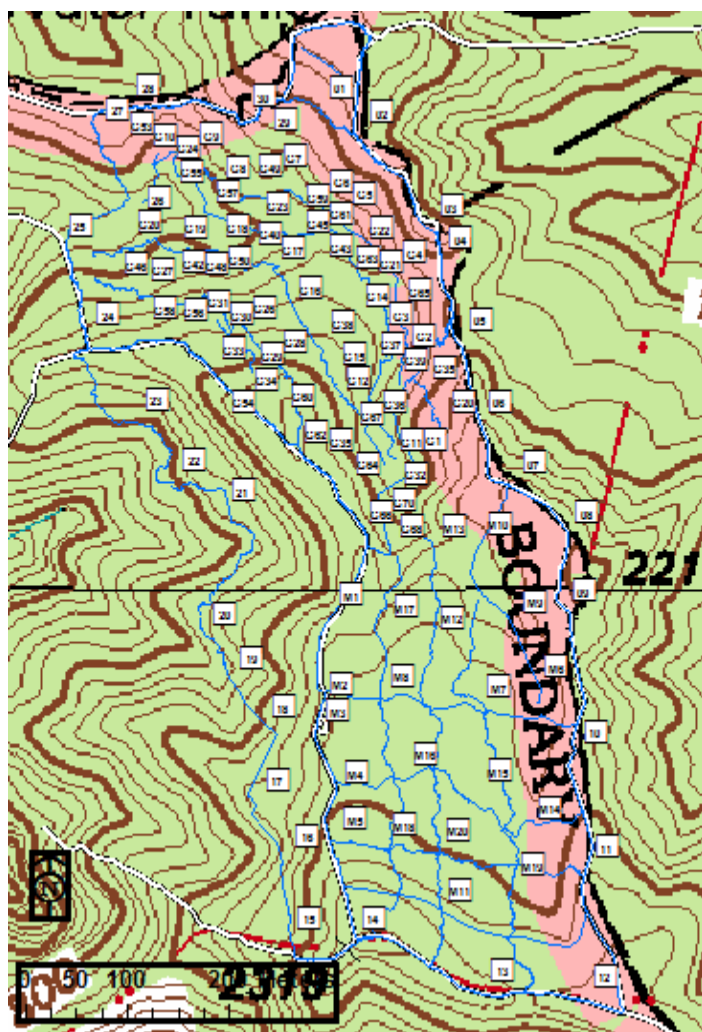


Figure 2. Map of Kahanahaiki Goodnature A-24 trap grid.

Monitoring of rat activity at Kahanahaiki as well as a control site via tracking tunnels was implemented to determine efficacy of trapping devices. The management objectives for this MU articulate that there should be less than 10% activity levels in rat tracking tunnels. An acceptable level of rat activity, which promotes stable or increasing native/endangered snail (*Achatinella mustelina*) and plant (*Cyanea. 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 (Innes et al. 1999). A 10% activity level may also be the most achievable level using a large scale trapping grid. Results of the past six years of monitoring of the snap-trap grid (May 2009-April 2014) and the subsequent A-24 grid (May 2014 to present) show seasonal winter spikes of rat activity up to 78.4% (Figure 3). Therefore, relying solely on traps (snap-traps or A24s) has not been effective in keeping populations below the targeted 10% tracking in monitoring tunnels, particularly during the period of peak rat abundance (typically Fall/Winter; Figure 3). The goal of this project will be to reduce the rat population (and therefore tracking) at Kahanahaiki during the seasonal peaks (roughly November-February; Figure 3).

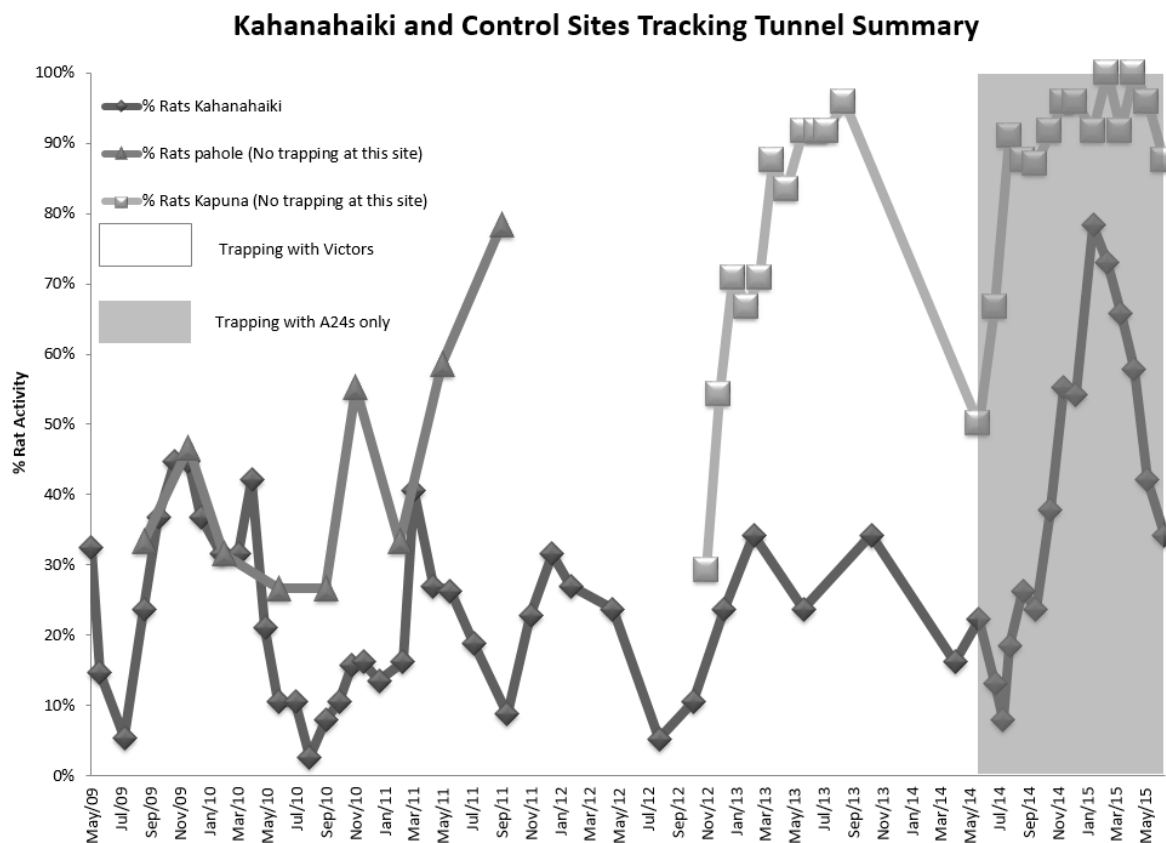


Figure 3. Percent rat activity (based on tracking tunnels) at Kahanahaiki (the rat-trapping site), and two sites where no rat trapping occurs (Pahole and Kapuna). The shaded area from May 2014-May 2015 is when only A24 traps were used at the rat-trapping site; whereas the non-shaded (May 2009-April 2014) was when only Victor snap-traps were used at the rat-trapping site.

Upon recent assessment of OANRP rat control at Kahanahaiki, and the conclusion that it is not meeting targeted rat suppression (i.e., tracking tunnels are rarely <10%), three rat control techniques were considered at Kahanahaiki:

1. A seasonal Hand Broadcast and Canopy Baiting Application of Diphacinone-50 over the Kahanahaiki along a pre-established grid of trails, with the continuation of mechanical trapping.
  2. Continuous bait stations filled with Ramik rodenticide, and set in accordance with the SLN.
  3. Exclusive use of mechanical traps placed along a grid of trails.
- **Technique 1 – Hand Broadcast and Canopy Baiting Application:** This method may be considered the most appropriate option and be the most efficient and effective way of adequately controlling the seasonal spike in rat activity within the MU. This method allows for greater bait interaction than bait boxes (bait boxes deter some individuals from entry; Recht 1988), thus potentially a better control method for suppressing rat populations. In addition to the hand broadcast, we will also be employing canopy bags to increase our effectiveness in targeting any rats that favor the arboreal habitat. Through several tracking methods, Shiels (2010) found that rats at Kahanahaiki frequent the arboreal, ground, and underground (burrowing) habitats. Mechanical traps would be used prior to, during, and after the broadcast to provide year round control. In addition, traps would only be required to be

deployed at densities adequate to control moderate to low levels of rats as the combination approach will be used during the high spikes.

- **Technique 2 – Use of Bait Stations of Ramik:** This technique has been considered but it has been determined that it is not possible to adhere to the 225m buffer requirement in the SLN given the location of resources to be protected and the surrounding cliffs and steep terrain.
- **Technique 3 – Exclusive Use of Mechanical Traps:** This has been the only method used at this site for the past six years. Tracking tunnel data shows that this method alone is not adequate to meet management goals at the current trap density.

## 4. Methods for the Hand Broadcast and Canopy Bait Application

### Establishment of baiting transects

Trails that have already been established at Kahanahaiki for snap-trapping (Figure 1) and A24s (Figure 2) will be used as baiting transects in this study. These trails (transects) are generally <50 meters apart. Spreading bait along and adjacent to these transects will generally leave <30 meters between baits, which should minimize chances that a given rat will not interact with bait based on rat home range sizes at Kahanahaiki (average of 4 ha for black rats, and 1.8 ha for Pacific rats; Shiels 2010), as well as linear distance moved in a night from point of capture (black rat: mean 20 m, maximum 30 m; Pacific rats: mean 25 m, maximum 40 m; Shiels 2010). Installing additional trails for this two-bait application study is not warranted given the significant disturbance to the fragile habitat and native/rare species that is caused by installing trails.

### Applicator training

All OANRP staff (~40 personnel) are certified for applying diphacinone rodenticide (i.e., a license to “purchase and use restricted pesticides” issued as the “State of Hawaii, Dept. of Agriculture, Division of Plant Industry, CERTIFICATION FOR COMMERCIAL APPLICATORS OF RESTRICTED PESTICIDES”). There are 7-10 OANRP personnel anticipated to be applying the bait for this study. In addition to each of the personnel being licensed to apply/use restricted pesticides, they will get additional training in advance of the applications that will clarify methodological details specific to application and bait distribution pattern (see below) within Kahanahaiki forest. Included in this training will be throwing dog-food pellets (a surrogate to Diphacinone-50 bait) on flat ground that has markings out to 10 m; such calibration for each personnel will help ensure even spread of bait in the field at the proper application rate (i.e., according to the Diphacinone-50 label; see below).

### Bait staging

Once bait arrives in Hawaii, it will be stored according to the label and in a cool dry place. Because of the difficulty of navigating the terrain at Kahanahaiki, bait caches will be established prior to the beginning of the study. Bait will be flown by helicopter on-site ~1-7 days prior to the initial hand broadcast application. These bait caches (stockpile locations) will consist of metal trash cans with locking lids filled with the bait in original closed container, providing tamper resistant storage. Locations will be selected to allow the applicators to carry 13.8 kg of bait before arriving at the next station. We estimate approximately 14 stations will be needed. GIS will be used to identify the areas to place bait stockpile locations.

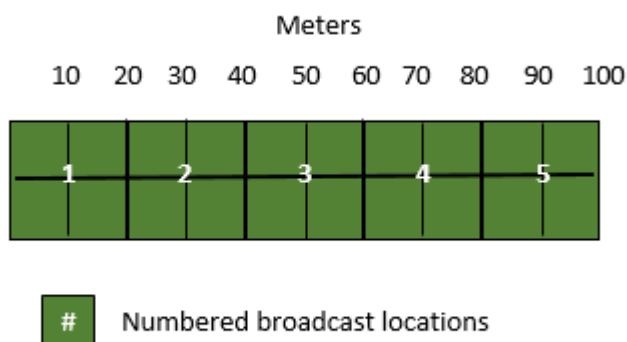


Figure 4. Example of how bait will be stockpiled in “broadcast locations”. At each broadcast station, bait will be distributed in all directions within a 20 meter square (530 g of bait at odd numbered stations and 439 g of bait for even numbered stations).

### Bait application

All application amounts will be according to the label (Diphacinone 50: Conservation, EPA Reg. No.: 56228-35, State of Hawaii Lic. No. 8600.1). For ground broadcast the rate is 11.1 to 13.8 kg bait/ha per treatment for the first treatment, and no more than 13.8 kg/ha for the second treatment. At Kahanahaiki, bait will be spread 10 meters in all directions at “broadcast locations”, every 20 meters along the trails (Figure 4). This will make for continuous baiting in a 10 m distance from each side of the trail throughout the trail system (Figure 5). At all “broadcast locations” 495 g of bait will be distributed equally in all directions within a 20 meter square, making the application rate to the ground for all locations 12.375 kg/ha. To ensure equal amounts of bait being distributed at each broadcast location, staff will have a plastic container/scoop that measures out the appropriate amount to be broadcasted. Staff will then reach into the container with a gloved hand and hand broadcast the bait as equally as possible throughout the area.

At all even numbered “broadcast locations” a canopy bag containing 113 g of bait will be tied onto a tree (see below). Thus, the application rate of bait at even stations to the ground (12.375 kg/ha) is combined with canopy (1.356 kg/ha) is 13.731kg/ha (i.e., under the maximum “Aerial and Ground Broadcast” rate according to label).

Using the 10 meter buffer this will equal 25 broadcast locations or 500 meters of trail per/ha. The total area of the trails with a 10 meter buffer on each side equals 14.16 ha. For this area we will be broadcasting to the ground at a rate of 12.375 kg/ha for a total of 175.23 kg, and hanging canopy bags at every other broadcast location (the evens) for a total of 19.20 kg.

In some areas there are cliffs and terrain that do not allow for the addition of trails, however because of the steepness it is possible for applicators to broadcast much farther than 10 meters from the already established trails. This area is in green (Figure 5) and contributes 6.11 ha. Special instructions on how much additional bait to broadcast in the green areas will be provided to the staff that will apply the bait. In these areas canopy bags will not be used so the application rate will be the label maximum of 13.8 kg/ha for a total of 84.32 kg.

We will also be using 22 g of bait at 90 bait availability monitoring plots for a total of 1.98 kg.

Although the entire fenced unit of Kahanahaiki is approximately 36 ha, the total area to be broadcasted equals 20.27 ha. When all methods are combined a total amount of 280.73 kg of bait will be needed per broadcast. Because two broadcasts will occur, 561.46kg or 1237.81lbs of total bait will be needed.

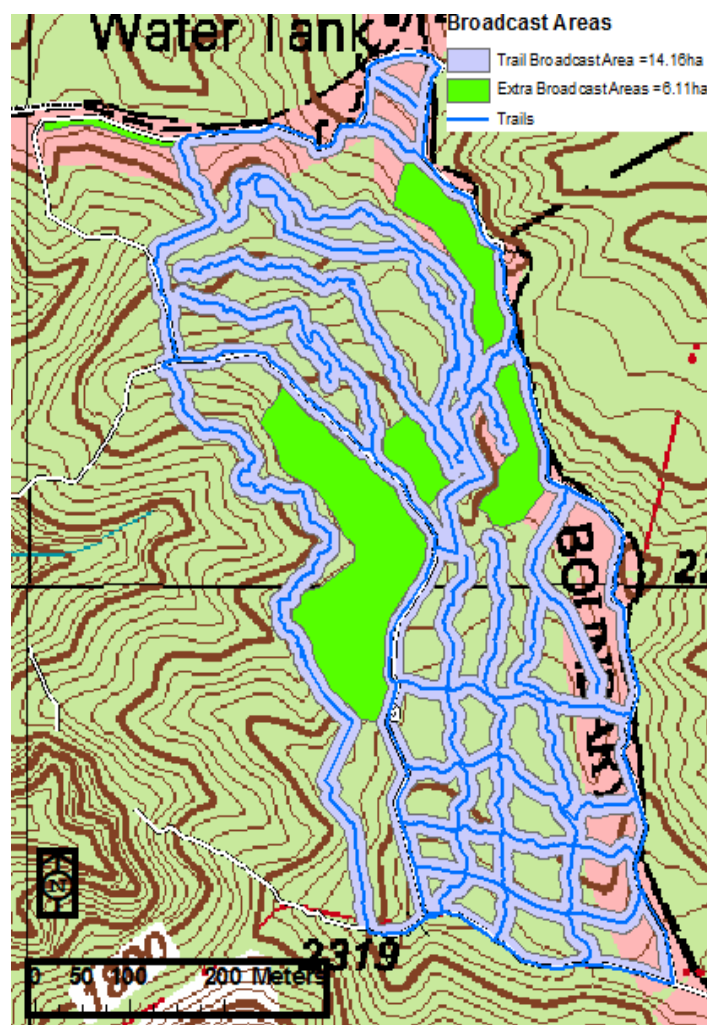


Figure 5. Map of Kahanahaiki with 10 meter buffers (light blue) associated with trails (dark blue) and extra broadcast areas (green). Although the entire fenced unit of Kahanahaiki is approximately 36 ha, the total area to be broadcasted (blue+green) equals 20.27 ha.

The label recommends the addition of canopy baiting in areas where sufficient food and cover are available to harbour populations of rodents in canopies of trees and shrubs. According to the label 113 g to 200 g of bait should be placed in each cloth bag (Figure 6). At all even numbered “broadcast locations” (Figure 6) a canopy bag containing 113 g of bait will be placed in the canopy. This amount and spacing is according to the label; the label states that canopy bags should be placed at intervals of 50 m or less. The bags will be tied to the trees at < 3 m height (target of 2-3 m height, based on Shiels (2010) average black rat activity above ground of 2.8 m, Pacific rat is 0.3 m).



Figure 6. Example of cloth canopy bags that will be used for canopy baiting.

### Timing of Operation

We plan to conduct broadcast applications in October 2015. This timing coincides with the disappearance of strawberry guava (*Psidium cattleianum*) fruit, which is one of the major food sources for rats at Kahanahaiki (Shiels 2010; Shiels and Drake 2011). Strawberry guava fruiting normally occurs June-September (peaking in July/August), and September/October is generally the beginning of increased rodent activity measured in the tracking tunnels (Figure 3).

### Signage

Warning signs will be posted along the fence line and on the trail leading to Kahanahaiki (Figure 7). Signs will include the date of the broadcast and they will remain on site for 2 months following the first bait application.

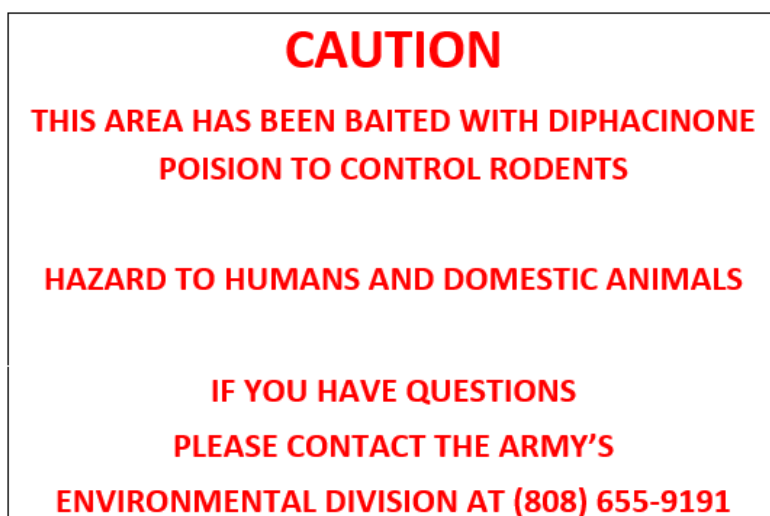


Figure 7. Warning sign that will be posted along the trails leading to Kahanahaiki, and the fence line that surrounds Kahanahaiki.

## 5. Monitoring Efforts

As stated in the Introduction, OANRP will be conducting (taking lead on) the operational aspects of this study that are outlined above, whereas WS/NWRC will lead in the monitoring of this study. For objectivity and best practice procedures, the agency leading the operational aspects of the study should be different than those leading in the monitoring (Pitt et al. 2015). A detailed Monitoring Plan can be found in Appendix 1, which also constitutes the WS/NWRC study protocol (QA-2523). A summary of the main aspects of the Monitoring Plan are briefly listed below, but refer to the full monitoring plan in Appendix 1 for full details.

Monitoring for this study will include the following:

- 1) Abidance by the Diphacinone-50 label's application rate. NWRC/WS staff will measure bait densities in established plots throughout Kahanahaiki to ensure bait was applied to the site at a rate of no greater than 13.8 kg/ha per application.
- 2) Bait fate will be monitored by revisiting plots at set intervals after each bait application and bait densities will be measured. Motion cameras will also monitor subsets of bait to determine the types of animals consuming or removing bait.
- 3) Rodent monitoring will occur before, during, and after hand broadcast by use of rodent tracking tunnels (ink cards baited and inserted into tunnels to establish rodent activity based on foot-tracks), as well as chew cards and tabs. Such monitoring will occur at Kahanahaiki, and a nearby site (Kapuna) that does not have any rodent control. OANRP staff will help collect the tracking and chew cards and tabs and give them to NWRC/WS at the end of the day for NWRC/WS analysis. These monitoring techniques will help to assess the efficacy of the rodenticide application on the rat population.
- 4) Rodent fates will be assessed by attaching radio-collars to a subset of rats and mice captured prior to the bait application. These individuals will be followed in the subsequent days/weeks following the bait applications in order to assess the proportion of collared rodents in the study area that did not survive the effects of rodenticide baiting. Rodent carcass searches will also be conducted before, during, and after bait application.
- 5) Non-target effects. As will any project that uses toxicant bait, we expect that there will be some negative effects to non-target organisms (see Pitt et al. 2015). Justification for proceeding with such a control tool that harms some non-target species is that the longer-term effects of a reduced rat population will provide greater benefit to the native species and habitat that goes beyond the number (and types) of non-target mortalities. There are no expected negative impacts to threatened or endangered species as a result of this hand broadcast. There are expected non-target impacts and this study will monitor those (see monitoring section for more information; Appendix 1). These impacts would include some species being affected by eating the bait directly or consuming any animal that has consumed the toxicant. Briefly, in our non-target monitoring at Kahanahaiki, we will: 1) conduct carcass searches before, during, and after bait application, and 2) assess the levels of diphacinone



residue in the food web by sampling (pre- and post-bait application), game birds, lizards, and invertebrates (slugs and insects).

### **Rodent monitoring**

Three monitoring methods will be used to track the % change of rodent activity before, during, and after the hand broadcast (Figure 8). Chew cards and corriflute chew tabs will be left out for 3 nights while tracking tunnel cards will be left out for 1 night.



Figure 8. Tracking tunnel, GoodNature Chew card, and Corriflute chew tab.

At Kahanahaiki we will use 42 tracking tunnels, 38 GoodNature Chew cards, and 38 corriflute chew tabs (Figure 9). 38 Tracking tunnels are currently being monitored on site however for this project an additional four will be added to cover the Unit II line.

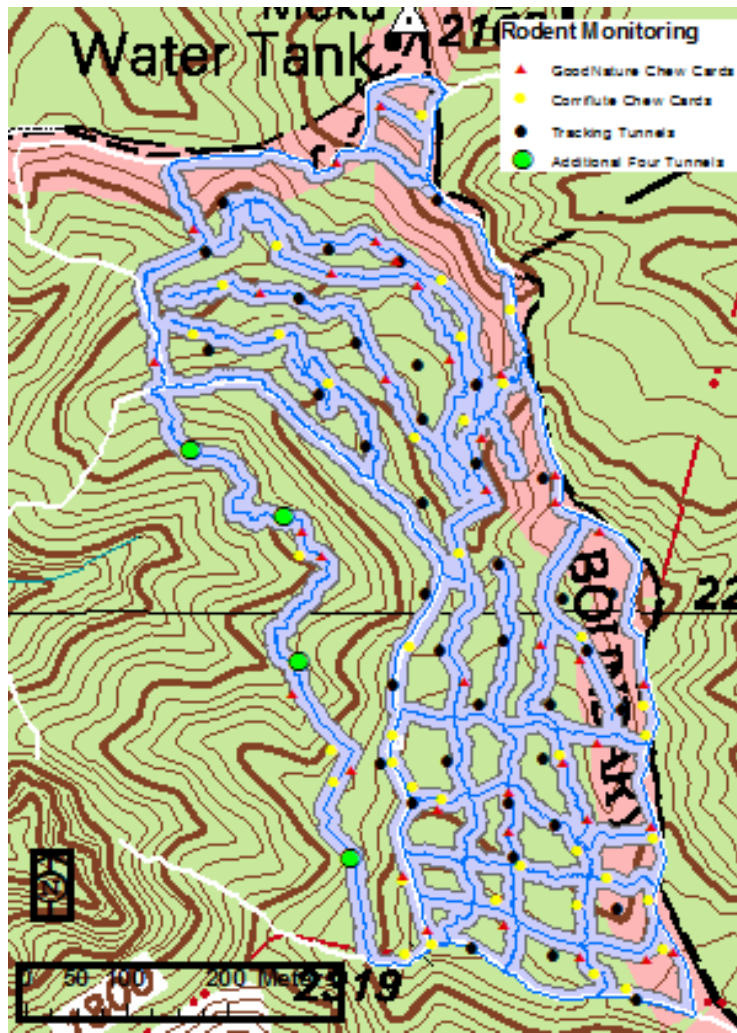


Figure 9. Locations of three rodent monitoring methods at Kahanahaiki.

Monitoring at a control site will also be conducted on the same schedule as the study site. The control site will include 24 tracking tunnels, 24 Good Nature Chew cards, and 24 corriflute chew tabs (Figure 10).

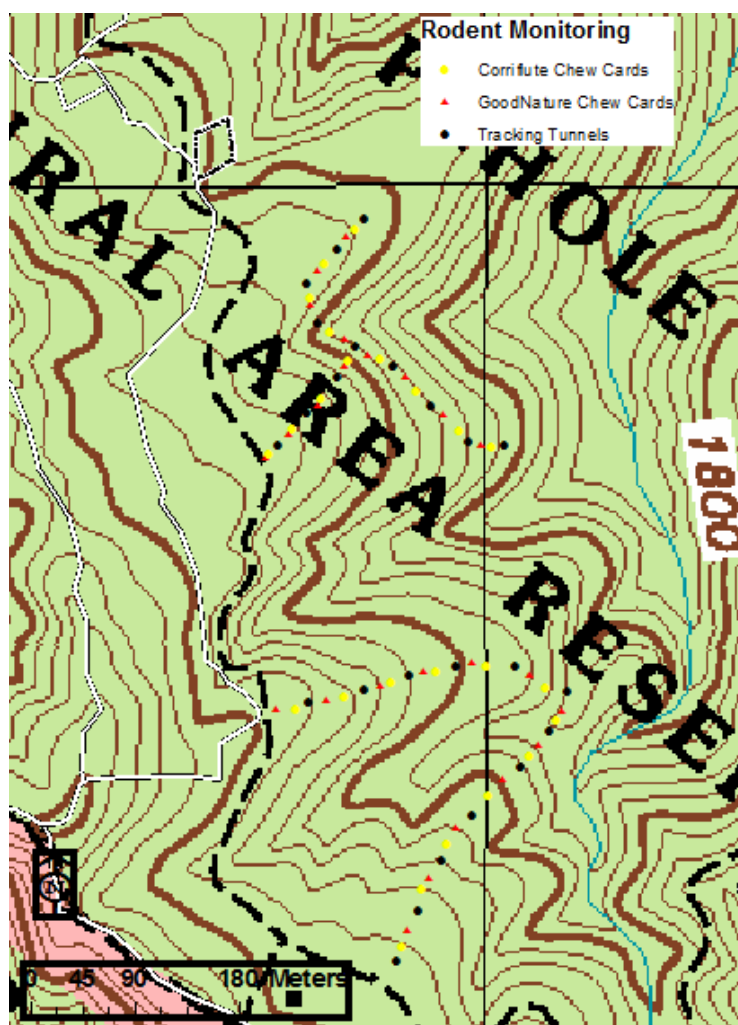


Figure 10. Rodent monitoring device locations at the control site Kapuna.

All three rodent monitoring methods will be initiated one month before the 1<sup>st</sup> hand broadcast and be used for the duration of the project. Rodent monitoring will be done on the following schedule:

1. 1 month prior to the 1<sup>st</sup> broadcast
2. The day before the 1<sup>st</sup> broadcast
3. The day before the 2<sup>nd</sup> broadcast
4. 7 days after the 2<sup>nd</sup> broadcast
5. 21 days after the 2<sup>nd</sup> broadcast
6. 7 weeks after the 2<sup>nd</sup> broadcast
7. Monthly thereafter with the method deemed most sensitive

#### **Bait availability monitoring**

Bait availability monitoring will be initiated on the day of the 1<sup>st</sup> hand broadcast and continue for 14 days. We don't have plans of doing pre broadcast bait availability monitoring with a non-toxic bait as we will be applying the recommended amount on the label 11.1 to 13.8kg/ha. We have

established 90, 1-meter square monitoring plots within the broadcast area using ArcGIS random point generator (Figure 11).

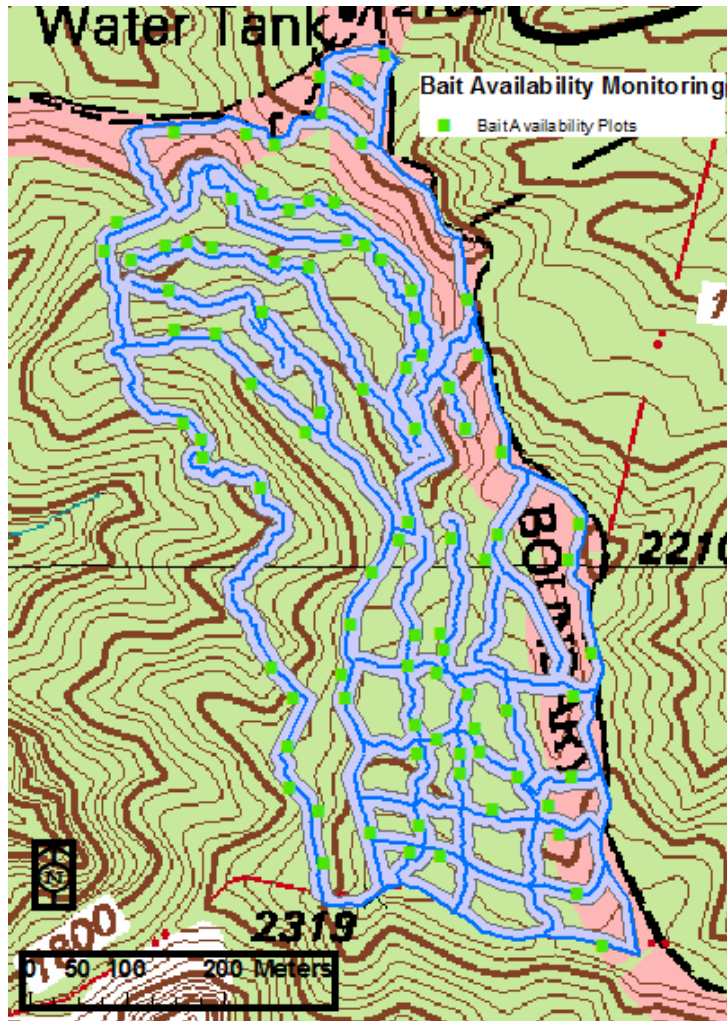


Figure 11. Bait availability monitoring plot locations.

Plots will be denoted with pin flags at each corner. Due to the low amount of bait that could be hand broadcasted into a 1-meter plot, assuming that a completely equal distribution of pellets will result in ~2.5 pellets per monitoring plot, twenty pellets (.022kg) will be manually placed in a regular pattern within each plot (Figure 12).

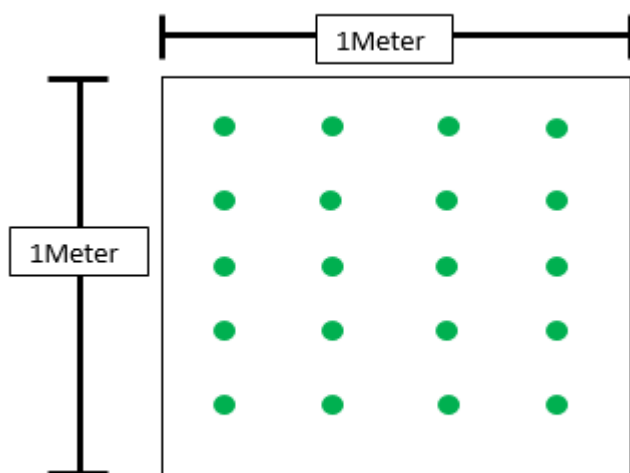


Figure 12. Example of distribution of baits within bait availability monitoring plot.

This bait will be subtracted from the bait broadcasted from the odd numbered locations. Any bait from the hand broadcast that is found in the plots before the twenty baits are manually placed will be broadcasted out of the plot. These procedures will be followed for the 2<sup>nd</sup> broadcast as well.

During the monitoring period all bait within the plots will be counted and recorded, any partial pellet will be recorded to the nearest 25%. Any pellets that appear to be wet or mouldy will be recorded and noted (Figure 13). Monitoring will begin on the first day soon after the pellets have been broadcasted to obtain an accurate baseline. Plots will then be read daily for 14 days from the first broadcast.

**Bait availability monitoring form**

**Date:**

**Observer:**

Plot #	# Of Good Bait (to nearest .25)	# Of Wet/Moldy Bait	Comments
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Figure 13. Example of Bait availability monitoring form

The monitoring team will also be visually inspecting the canopy bags for signs of take. All canopy bags will be checked daily for 14 days from the first broadcast. An approximation of % bait remaining will be recorded as well as any signs of take or disturbance (Figure 14).

**Canopy Bag monitoring form**

**Date:**

**Observer:**

Bag #	~% Bait Remaining	Comments
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Figure 14. Example of Canopy monitoring form.

**Monitoring the area for dead animals**

The label states that “For all methods of baiting, monitor the baited area periodically and, using gloves, collect and dispose of any dead animals and spilled bait properly. Dead animals and spilled bait may be buried on site if the depth of burial makes excavation by non-target animals extremely unlikely.” The crew responsible for bait availability monitoring will also be responsible for searching all trails for any dead animals and will dispose them according to the label. A gps point, species, sex and condition will be recorded for all carcasses found. Training will be given to staff on properly identifying and recording this information.

**Issues with the proposed method**

There are no expected negative impacts to threatened or endangered species as a result of this hand broadcast. There are expected non-target impacts and this study will monitor those, see monitoring section for more info. These impacts would include some species being affected by eating the bait directly or consuming any animal that has consumed the toxin.

**6. PROJECT TIMELINE**

**Table 1. Project Milestones**

Milestone	Date	Responsible
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<b>Operational Planning Stage</b>		
Site Visit	5/14/15	OANRP/USDA
Complete Project Plan	July/August	OANRP/USDA
Order bait	August	USDA
<b>Implementation Stage - pre-operation phase</b>		
Trails and pickup stations	August	OANRP
Establish bait availability plots	August	OANRP/USDA
Conduct pre-broadcast non-target monitoring	September	OANRP/USDA
Attach radio collars to a subset of rats and mice	September	USDA
Conduct pre-broadcast %rat activity monitoring	September	OANRP/USDA
<b>Implementation Stage – Operational phase</b>		
Conduct Hand Broadcast	October	OANRP
Conduct associated monitoring activities including non-target effects	October	USDA
<b>Sustaining the Project Stage</b>		

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- Shiels, A.B., and D.R. Drake. 2011. Are introduced rats (*Rattus rattus*) both seed predators and dispersers in Hawaii? *Biological Invasions* 13: 883-894.
- Shiels, A.B., C.A. Flores, A. Khamsing, P.D. Krushelnycky, S.M. Mosher, and D.R. Drake. 2013. Dietary niche differentiation among three species of invasive rodents (*Rattus rattus*, *R. exulans*, *Mus musculus*). *Biological Invasions* 15: 1037-1048.





REPLY TO  
ATTENTION OF

DEPARTMENT OF THE ARMY  
US ARMY INSTALLATION MANAGEMENT COMMAND, PACIFIC REGION  
HEADQUARTERS, UNITED STATES ARMY GARRISON, HAWAII  
745 WRIGHT AVENUE, BUILDING 107, WHEELER ARMY AIRFIELD  
SCHOFIELD BARRACKS, HAWAII 96857-5000

24 Jul 15

IMHW-ZA

MEMORANDUM FOR All Military Personnel and Department of Defense Civilian Employees within United States Army Garrison, Hawaii (USAG-HI) Installations [MSE Hawaii, IPC, DPW, AFFES]

SUBJECT: Policy Memorandum USAG-HI-71, Avoidance of Little Fire Ant Introduction

1. References.

- a. Army Regulation (AR) 200-1, Environmental Protection and Enhancement, 13 Dec 07.
- b. Sikes Act, 16 USC 670a-670o, as amended through Public Law 118-84, Enacted 28 Oct 09.
- c. Department of Defense Instruction (DODI) 4715.03, 18 Mar 11.
- d. Executive Order 13112, Invasive Species, 3 Feb 99.
- e. USAG-HI Integrated Natural Resources Management Plan, 2010-2014.

2. Applicability. This policy applies to all Soldiers, Civilians, Family members, contractors, and any other person, ("covered person"), who installs landscaping on any U.S. Army installation, facility, housing area, or work site in the State of Hawaii, ("covered area"). This policy also applies to all products sold at the Army and Air Force Exchange Service, including but not limited to: plants, mulch, and wood products.

3. Policy.

a. Protecting our environment is one of the most important aspects of accomplishing the USAG-HI mission. USAG-HI is committed to reducing the spread of invasive species that harm the local Hawaiian environment. Invasive species are often unintended hitchhikers on cargo and other trade conveyances. Still more species are deliberately introduced as pets, ornamental plants, crops, food, or for recreation, pest control or other purposes. Most non-native species, including most of our sources of food and fiber, are not harmful, and many are highly beneficial. A small percentage of non-native species cause great harm to the environment, the economy or human health. Non-native species that cause harm are collectively known as invasive species.

b. USAG-HI aims to ensure that the Little Fire Ant (LFA), *Wasmannia punctata*, an invasive species that was recently introduced to the State of Hawaii, does not become established on U.S. Army installations. LFA has the potential to infest homes and cause painful stings on both adults and children. The LFA also stings pets, such as dogs or cats on their eyes, which has the potential to cause blindness.

c. Pursuant to a Biological Opinion with the U.S. Fish and Wildlife Service, USAG-HI must monitor invasive species and develop methods to eradicate invasive species. To achieve this end, all new USAG-HI landscaping projects must be sourced from LFA free nurseries. For confidentiality reasons, the Hawaii Department of Health has not published a formal list of nurseries that are not fire ant free. However, the agency has disclosed that these nurseries are located in the Waimanalo area on the Windward coast of Oahu. Therefore, it is *strongly* recommended that the covered persons not purchase or install any landscaping products purchased from the Waimanalo area until further notice.

d. Any individual who proposes or initiates a new landscaping project is required to contact the Directorate of Public Works Natural Resource Program (NRP), at 655-9189 or 655-9191, to obtain an approval certificate for the project prior to purchasing the landscaping materials.

e. Once the landscaping materials are installed, the project proponent must provide NRP personnel access to survey and inspect the newly landscaped sites. The purpose of the inspection is to look for LFA. If LFA are found, the project proponent or contractor who installed the plants must provide the labor and funding to remove the LFA. Under these circumstances, the responsible party may only use pest management controls that comply with the current USAG-HI Pest Management Plan and obtain approval from the Installation Pest Management Coordinator (IPMC) prior to any treatment. A copy of the Pest Management Plan may be obtained at Building 104 on Wheeler Army Airfield from the Pest Management Program Manager, 656-3093. The IPMC can provide guidance on how to comply with the Pest Management Plan.

f. The enclosures to this policy memorandum contain additional information about LFA and how to test plants for their presence.

g. This policy memorandum is effective immediately and remains in effect until cancelled or superseded in writing.

IMHW-ZA

SUBJECT: Policy Memorandum USAG-HI-71, Avoidance of Little Fire Ant Introduction

4. The proponent for administration of the Avoidance of Little Fire Ant Introduction policy is the DPW Environmental Division, at 655-9189 or 655-9191.

2 Encls

1. Little Fire Ant Brochure
2. Little Fire Ant Testing Brochure



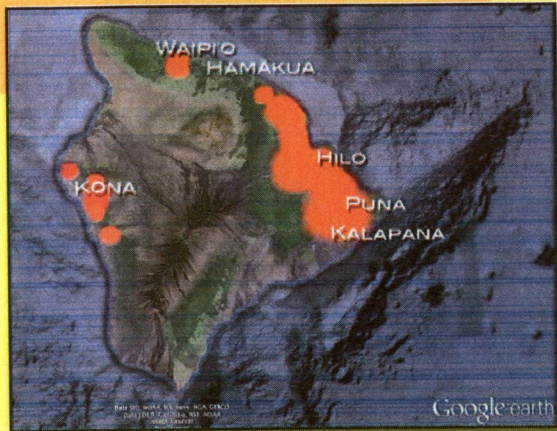
RICHARD A. FROMM  
COL, AD  
Commanding

DISTRIBUTION  
Electronic Media

## What is the Little Fire Ant?

Little Fire Ants (LFA) are a new, invasive stinging ant that will spread across the Hawaiian islands if we don't take action now.

LFA infest yards, houses, farms and forests. Their powerful stings harm people and wildlife. LFA sting the eyes of pets, leading to blindness. LFA damage crops, food production, and the economy everywhere they have spread. LFA alter (or impact) people's lives because their stings are unavoidable.



Hawaii Island LFA infested areas (2014)

LFA was discovered in the Puna area of Hawaii Island in 1999 and has since spread, hidden in plants, logs, greenwaste, gravel, and even cars. Interisland spread has been somewhat limited by plant treatment and inspection, but LFA continue to spread.

In December 2013, LFA were discovered in hapuu logs at nurseries and garden shops on Oahu and Maui, and in landscaping on Lanai. Many of the hapuu sold to the public remain unaccounted for. There are many other pathways that LFA may be transported and introduced to other islands.

A multi-agency response has been launched to survey and treat potential LFA locations not found on Hawaii Island. Everyone needs to test their homes and yards and report possible LFA. We need your kokua.

## Detect - Report - Stop the Little Fire Ant

### DETECT

**HDOA locations for dropping off or mailing samples:**

**Kauai:** 4398A Pua Loke Street  
Lihue, HI 96766

**Oahu:** 1428 S. King St  
Honolulu, HI 96814

**Maui:** 635 Mua Street  
Kahului, HI 96732

**Molokai:** (call 643-PEST for instructions)

**Hawaii Island:** Hawaii Ant Lab / HDOA  
16 E. Lanikaula St  
Hilo, HI 96720

### REPORT

**Immediately report suspected LFA to any of the following places:**

**Hawaii Department of Agriculture  
Statewide Hotline: 643-PEST (7378)**

Kauai Invasive Species Committee: 821-1490

Oahu Invasive Species Committee: 266-7994

Maui Invasive Species Committee: 573-6472

Molokai Invasive Species Committee: 553-5236

Big Island Invasive Species Committee: 933-3340

Hawaii Ant Lab: 315-5656 (Hawaii Island)

### LEARN MORE

For more information about LFA, visit:  
**[www.littlefireants.com](http://www.littlefireants.com) or [www.LFAHawaii.org](http://www.LFAHawaii.org)**

*Partners and Contributors: Hawaii Department of Agriculture, Department of Land and Natural Resources, US Fish & Wildlife Service, Hawaii Ant Lab, Hawaii Invasive Species Council, Coordinating Group on Alien Pest Species, the Invasive Species Committees of Hawaii, College of Tropical Agriculture and Human Resources, University of Hawaii, The Nature Conservancy, Oahu Army Natural Resources Program, Pacific Cooperative Studies Unit, City and County of Honolulu,*

## Little Fire Ant

*Wasmannia auropunctata*

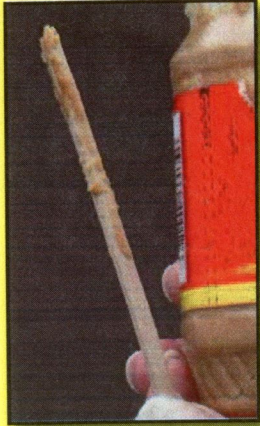


**Detect - Report - Stop  
Little Fire Ant!**

# Protect Your Family

## DETECT

Supplies: peanut butter, disposable chopsticks, zip top bags, and a pen.



1. Place sticks with a **thin** smear of peanut butter\* every few feet in and around plants in your yard, garden, and lanai. Focus on shady, moist areas, the bottoms of pots, and where plants' leaves meet the stem.

\*Regular peanut butter, not natural or fat free.

\*\*For those with a peanut allergy, use pieces of luncheon meat.

2. Leave the sticks in place for **1 hour** during the cool part of the day.

3. Check sticks without moving them. Collect the stick if:

- The ants are uniformly orange/red and VERY small.
- You are unsure about the ants.

4. Very carefully place it directly into the bag (so ants don't fall off).

5. Seal the bag, label it with your name, address and phone number, and **put it in your freezer overnight** to kill the ants.

\*View *How to Survey for LFA* video at <http://vimeo.com/97558997>

## REPORT

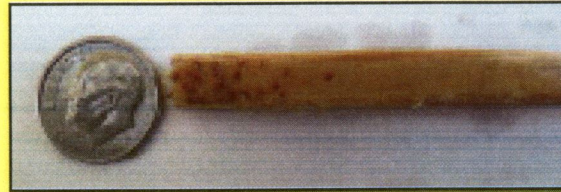
Call the Hawaii Department of Agriculture (HDOA) statewide **pest hotline at 643-PEST** to report that you might have LFA. Drop off (or mail) the sample (zip top bag with frozen ants) at any HDOA office (see back for locations).

HDOA will contact you when the ants are identified. **Do not disturb the ants and do not control or treat the area.** This will make the nests difficult to find and possibly spread them further.

## STOP LFA

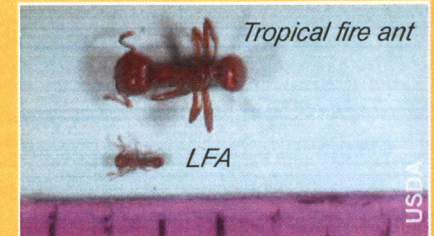
If HDOA confirms you don't have LFA, congratulations and thank you! Remain vigilant. **Always quarantine and test any new plants, cut flowers, plant materials, mulch, soil and other items.**

**If you do have LFA, call HDOA** about what to do next. We can help you control it, but we need your help to map and control every location of LFA to help prevent it from spreading.



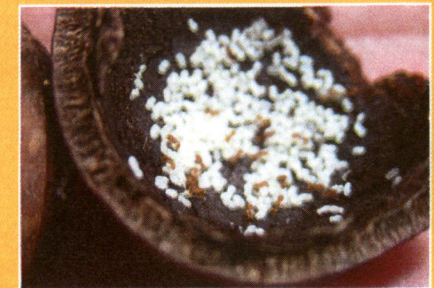
### How to identify LFA:

- Tiny ants:  $\frac{1}{16}$  inch, as long as a penny is thick
- Orange-red in color
- Slow-moving



### Look-alike: Tropical fire ant

- Common larger stinging ant
- Widespread
- Builds ground nests in sunny, dry areas
- Nests have distinct openings



### An entire LFA colony can fit in macadamia nut shell

- LFA don't form mounds
- Nests don't have distinct openings
- Nests in moist, shady areas, in trees, under tree bark, under rocks, within logs & in leaf litter



## Little Fire Ants are on the move, and could be in your plants or yard. Find out today using this simple test.



1. Smear a very thin coat of peanut butter on disposable chopsticks. Place them every few feet in and around plants in shady, moist areas, and up in banana leaf axles. Be sure peanut butter is in contact with surface of test site. (You can substitute spam or lunch meat for peanut butter.)
2. Leave the peanut butter chopsticks out for an hour during the day.
3. Check all chopsticks. If the ants you see are any one or more of the of the following, they are NOT LFA;
  - black -large head with a small body
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6. The next day, deliver or mail your sample to the nearest Hawai'i Department of Agriculture (HDOA) office. You can also call the HDOA pest hotline at 643-PEST (643-7378), or the Oahu Invasive Species Committee at 266-7994 to make a report and get help. DO NOT move or spray infested materials, and do not move live ants! You are seeing the workers, and we need them alive to help us get to the queens.
7. Always quarantine and test your new plants and plant materials and other items from infested areas, because LFA will continue to be a threat to ALL our islands.

On Oahu, mail or drop off your samples at:  
 HDOA Plant Pest Control OR HDOA Plant Quarantine Branch  
 1428 S. King Street 1849 Auiki Street  
 Honolulu, HI 96814 Honolulu, HI 96819



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EARLY DETECTION IS OAHU'S GREATEST CHANCE OF CONTROLLING LITTLE FIRE ANT.

- Little Fire Ants (LFA) are new to Oahu.
- Arrived in December 2013 on hapuu logs from Hawaii Island.
- Unknown how many hapuu logs were sold before LFA were detected.
- LFA are one color...orange.
- LFA are tiny, about 1/16<sup>th</sup> of an inch...that's the thickness of a penny.
- LFA are very slow-moving and don't cling to surfaces very well.
- LFA live not only on the ground, but also in the trees.
- LFA fall from trees, stinging whomever happens to be underneath.
- LFA deliver painful stings that can look like a rash and last for days.
- LFA can sting animals in their eyes, causing pain and blindness.
- LFA farm agriculture pests such as mealy bugs and scale, causing decreased crop production.
- Large LFA infestations are difficult and expensive to control.

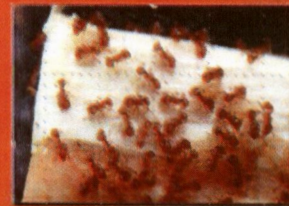


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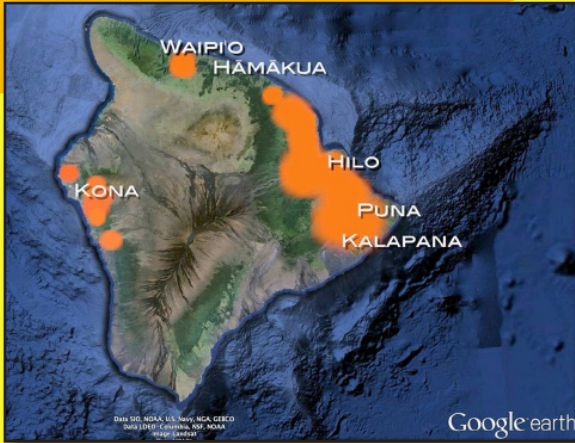
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## What is the Little Fire Ant?

Little Fire Ants (LFA) are a new, invasive stinging ant that will spread across the Hawaiian islands if we don't take action now.

LFA infest yards, houses, farms and forests. Their powerful stings harm people and wildlife. LFA sting the eyes of pets, leading to blindness. LFA damage crops, food production, and the economy everywhere they have spread. LFA alter (or impact) people's lives because their stings are unavoidable.



Hawaii Island LFA infested areas (2014)

LFA was discovered in the Puna area of Hawaii Island in 1999 and has since spread, hidden in plants, logs, greenwaste, gravel, and even cars. Interisland spread has been somewhat limited by plant treatment and inspection, but LFA continue to spread.

In December 2013, LFA were discovered in hapuu logs at nurseries and garden shops on Oahu and Maui, and in landscaping on Lanai. Many of the hapuu sold to the public remain unaccounted for. There are many other pathways that LFA may be transported and introduced to other islands.

A multi-agency response has been launched to survey and treat potential LFA locations not found on Hawaii Island. Everyone needs to test their homes and yards and report possible LFA. We need your kokua.

## Detect - Report - Stop the Little Fire Ant

### DETECT

**HDOA locations for dropping off or mailing samples:**

**Kauai:** 4398A Pua Loke Street  
Lihue, HI 96766

**Oahu:** 1428 S. King St  
Honolulu, HI 96814

**Maui:** 635 Mua Street  
Kahului, HI 96732

**Molokai:** (call 643-PEST for instructions)

**Hawaii Island:** Hawaii Ant Lab / HDOA  
16 E. Lanikaula St  
Hilo, HI 96720

### REPORT

**Immediately report suspected LFA to any of the following places:**

**Hawaii Department of Agriculture  
Statewide Hotline: 643-PEST (7378)**

Kauai Invasive Species Committee: 821-1490

Oahu Invasive Species Committee: 266-7994

Maui Invasive Species Committee: 573-6472

Molokai Invasive Species Committee: 553-5236

Big Island Invasive Species Committee: 933-3340

Hawaii Ant Lab: 315-5656 (Hawaii Island)

### LEARN MORE

For more information about LFA, visit:

**[www.littlefireants.com](http://www.littlefireants.com) or [www.LFAHawaii.org](http://www.LFAHawaii.org)**

*Partners and Contributors: Hawaii Department of Agriculture, Department of Land and Natural Resources, US Fish & Wildlife Service, Hawaii Ant Lab, Hawaii Invasive Species Council, Coordinating Group on Alien Pest Species, the Invasive Species Committees of Hawaii, College of Tropical Agriculture and Human Resources, University of Hawaii, The Nature Conservancy, Oahu Army Natural Resources Program, Pacific Cooperative Studies Unit, City and County of Honolulu,*

## Little Fire Ant

*Wasmannia auropunctata*



**Detect - Report - Stop  
Little Fire Ant!**



# Protect Your Family

## DETECT

Supplies: peanut butter, disposable chopsticks, zip top bags, and a pen.



1. Place sticks with a **thin** smear of peanut butter\* every few feet in and around plants in your yard, garden, and lanai. Focus on shady, moist areas, the bottoms of pots, and where plants' leaves meet the stem.

*\*Regular peanut butter, not natural or fat free.*

*\*\*For those with a peanut allergy, use pieces of luncheon meat.*

2. Leave the sticks in place for **1 hour** during the cool part of the day.

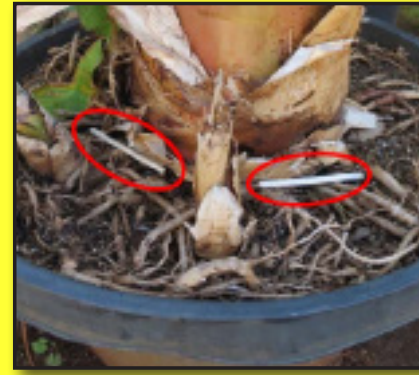
3. **Check sticks** without moving them. Collect the stick if:

- The ants are uniformly orange/red and VERY small.
- You are unsure about the ants.

4. Very carefully place it directly into the bag (so ants don't fall off).

5. Seal the bag, label it with your name, address and phone number, and **put it in your freezer overnight** to kill the ants.

\*View **How to Survey for LFA** video at <http://vimeo.com/97558997>



### How to identify LFA:

- Tiny ants:  $\frac{1}{16}$  inch, as long as a penny is thick
- Orange-red in color
- Slow-moving



### Look-alike: Tropical fire ant

- Common larger stinging ant
- Widespread
- Builds ground nests in sunny, dry areas
- Nests have distinct openings

## REPORT

Call the Hawaii Department of Agriculture (HDOA) statewide **pest hotline at 643-PEST** to report that you might have LFA. Drop off (or mail) the sample (zip top bag with frozen ants) at any HDOA office (see back for locations).

HDOA will contact you when the ants are identified. **Do not disturb the ants** and **do not control or treat the area**. This will make the nests difficult to find and possibly spread them further.

## STOP LFA

If HDOA confirms you don't have LFA, congratulations and thank you! Remain vigilant. **Always quarantine and test any new plants**, cut flowers, plant materials, mulch, soil and other items.

**If you do have LFA, call HDOA** about what to do next. We can help you control it, but we need your help to map and control every location of LFA to help prevent it from spreading.



### An entire LFA colony can fit in macadamia nut shell

- LFA don't form mounds
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