## Tutorial: Operating the ANRPO Database

### Overview

The Army Natural Resources Program Database on Oʻahu (ANRPO 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 2007-2019 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 ANRPO Database is based upon the criteria established by the Hawaiʻi Rare Plant Restoration Group (HRPRG). As part of the Mākua and Oʻahu Implementation Plans, the Army Propagation database has been a 20 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 ANRPO 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 June 30, 2023.

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 Army Natural Resources Program on Oʻahu.

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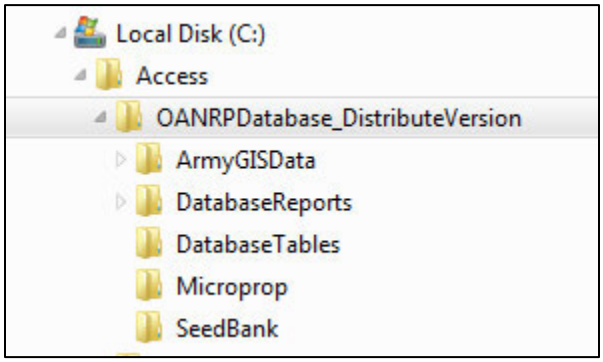
# I. Database Settings

## 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.accdb

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.accdb) 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.accdb

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

C:\Access\OANRPDatabase_DistributeVersion \Microprop\Microprop.accdb

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

C:\Access\OANRPDatabase_DistributeVersion
\SeedBank\SeedBankDataTables\SeedBankDataTables.accdb

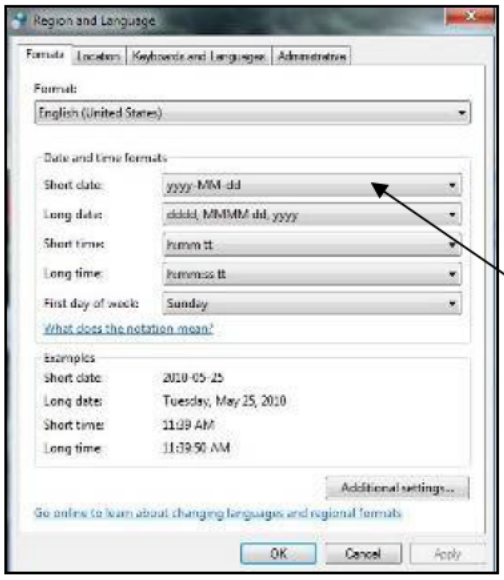
Army SeedLab Database data. Contact Tim Chambers for more information.

C:\Access\ OANRPDatabase_DistributeVersion \DatabaseReports

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. Examples assume you are using Windows 10.



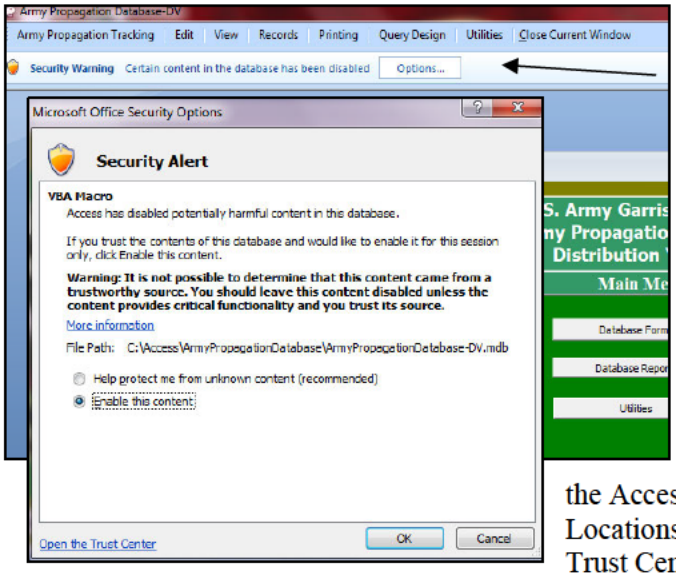

- Open Regional and Language Options by RIGHT clicking the **Start** button, clicking **Control Panel**, clicking **Clock, Language, and Region**, and then clicking **Region.** Under the Formats, change the **Short Date** to **yyyy-MM-dd.**

Change to yyyy-MM-dd

## Security Warning

Security features in Microsoft Access 2007, 2010, 2013, 2016, 2019 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 2007-2019 database content must be enabled when the Security Warning appears.



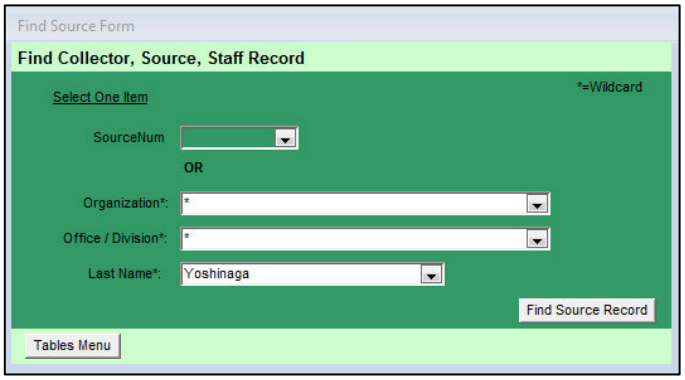

After opening the OANRPDatabase_DV.accdb file in Microsoft Access, click on Options when it appears at the top of your screen.

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.

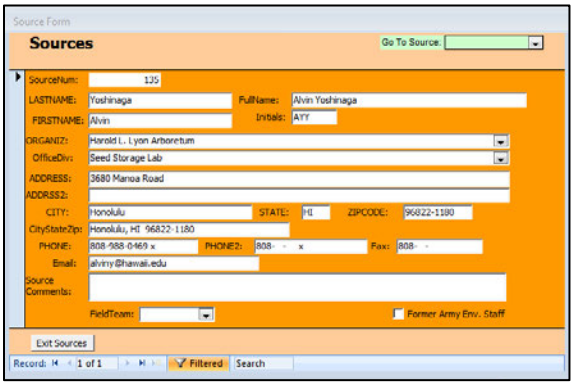
Enabling content will have to be done every time the database file is opened. You may avoid having this Security Warning appear if the Access subdirectory is added to the Trust Center Locations. Contact Roy Kam if you need to establish a Trust Center Location.

## 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.

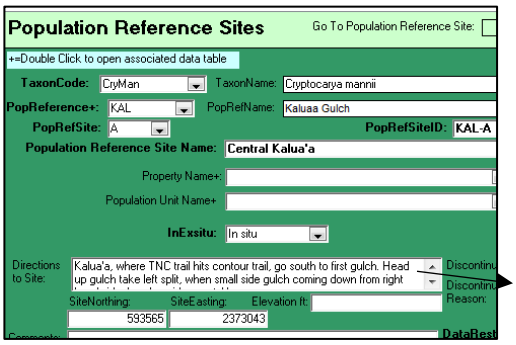


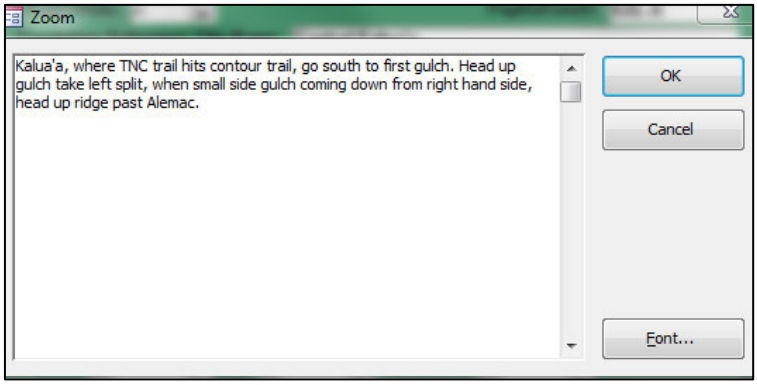

Using the * (asterisk), in a Find Form represents a wild card. Such as Organization *= Search for all Sources with any Organization. In this case, we will just search for the Last Name = Yoshinaga.




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.accdb** 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.

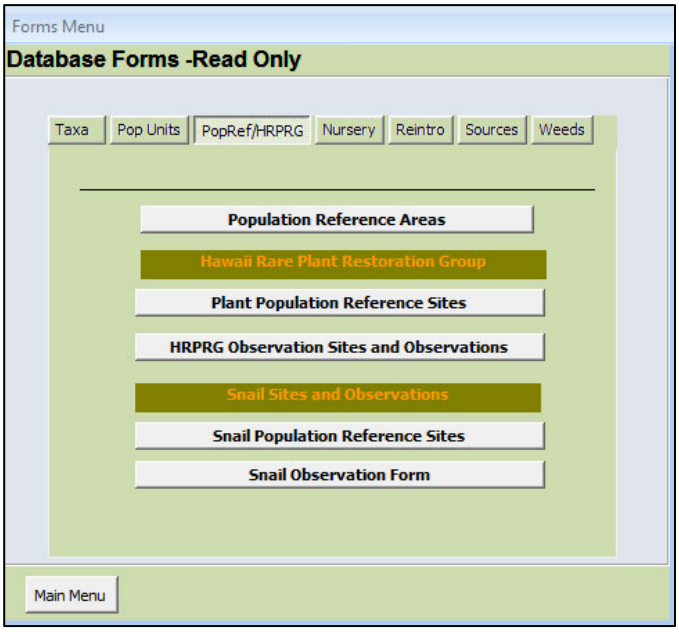
The database is broken up into 2 parts, Database Forms and Database Reports. We will primarily cover the Database reports. Database Forms are self-explanatory and is only for viewing purposes. The forms are provided for detailed review of individual observations. Only pertinent data fields will be discussed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

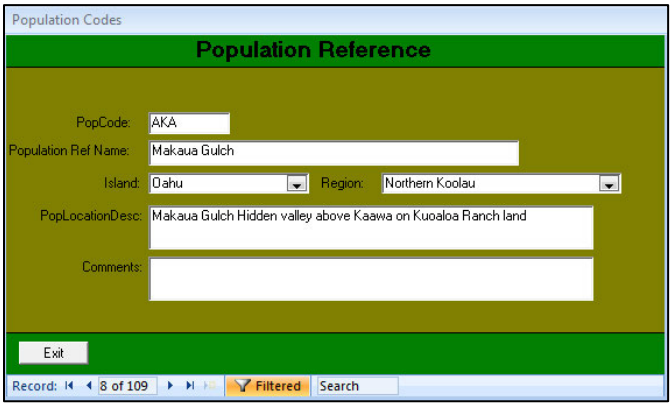
For the purpose of this tutorial, we will discuss forms of the PopRef/HRPRG tab with comprise of the Population Reference and Population Reference Sites. All other sections are supplemental and self-explanatory.



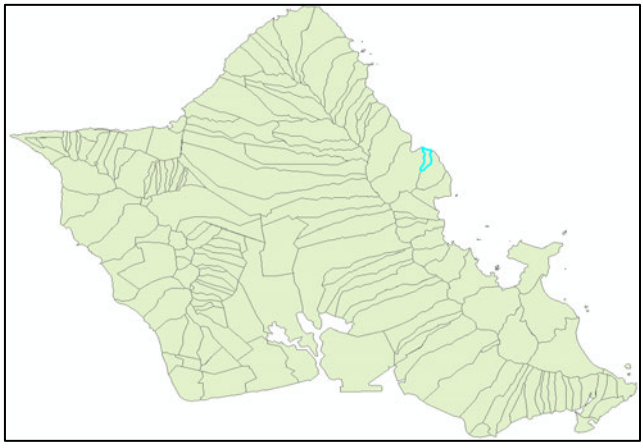

### PopRef, Sites, and Observations

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 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, ahupua‘a, bogs, or areas that biologists have continuously acknowledged within observations from past decades.

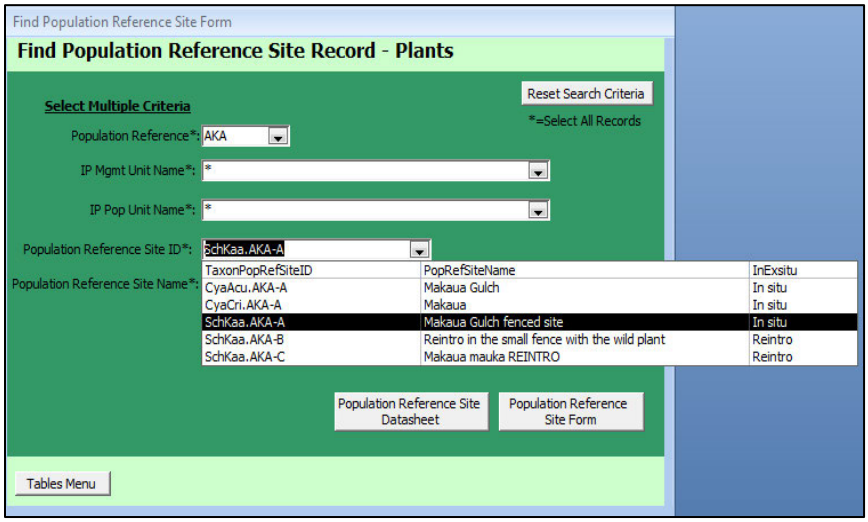


It should be noted that the Population Reference is not necessarily the name for any given population. It is only used as an identifier to compile different plant or animal populations within a given area. For example: Makaua on the Windward Ko‘olau of O‘ahu (highlighted in blue). The GIS boundary is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

**Population Reference Site (PopRefSite)**

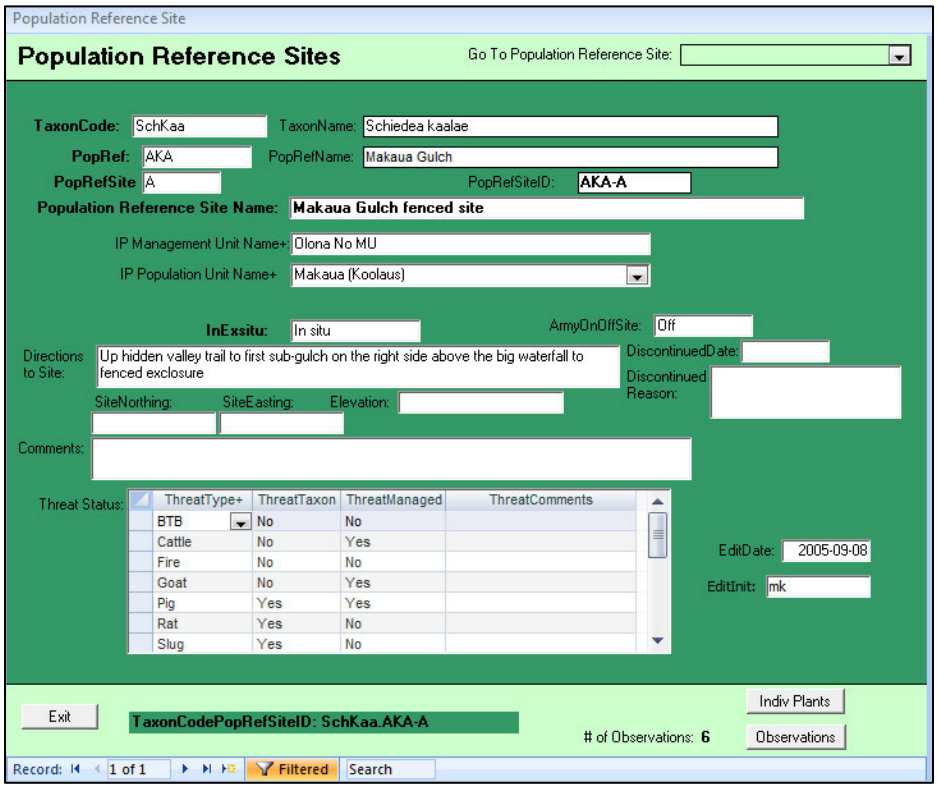
The Population Reference Site (PopRefSite) is the primary data table in establishing plant or animal population sites. The PopRefSite identifies the Population Name, whether it is In situ, Ex situ or Reintro, and provides directions to the site, etc. The PopRefSite is only site information; observation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




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.




**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 Wai‘anae Mountains, Northern Wai‘anae could be used as a PopUnit Name.

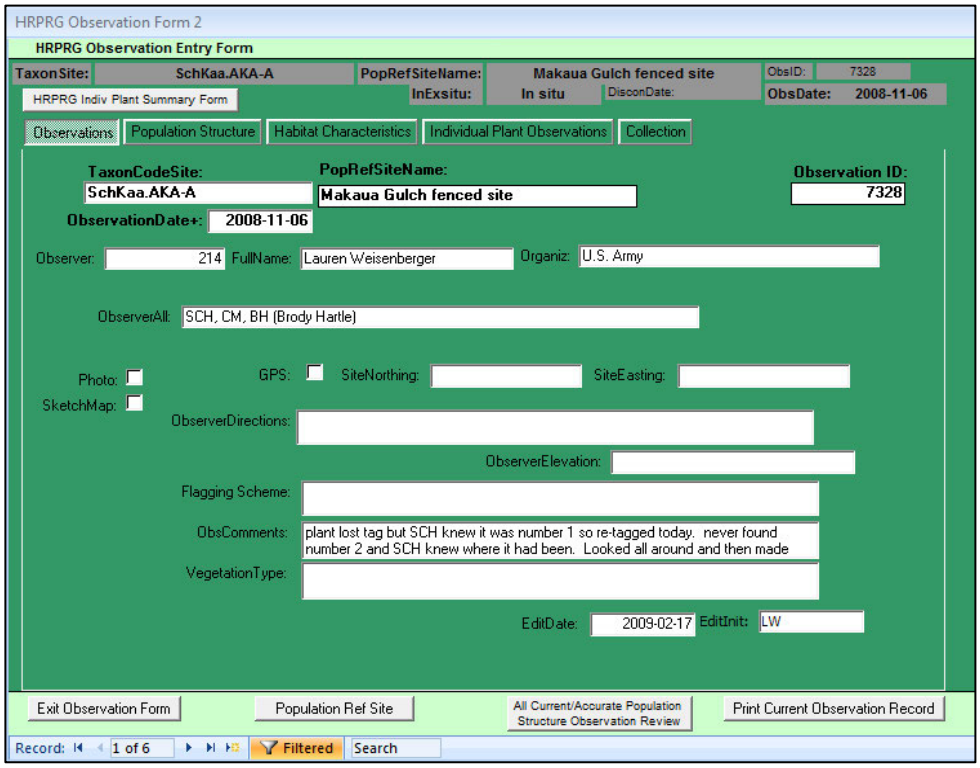
**InExsitu**: Identifies whether the PopRefSite is a naturally occurring wild (In situ), or Reintroduction (Reintro), etc.

**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.

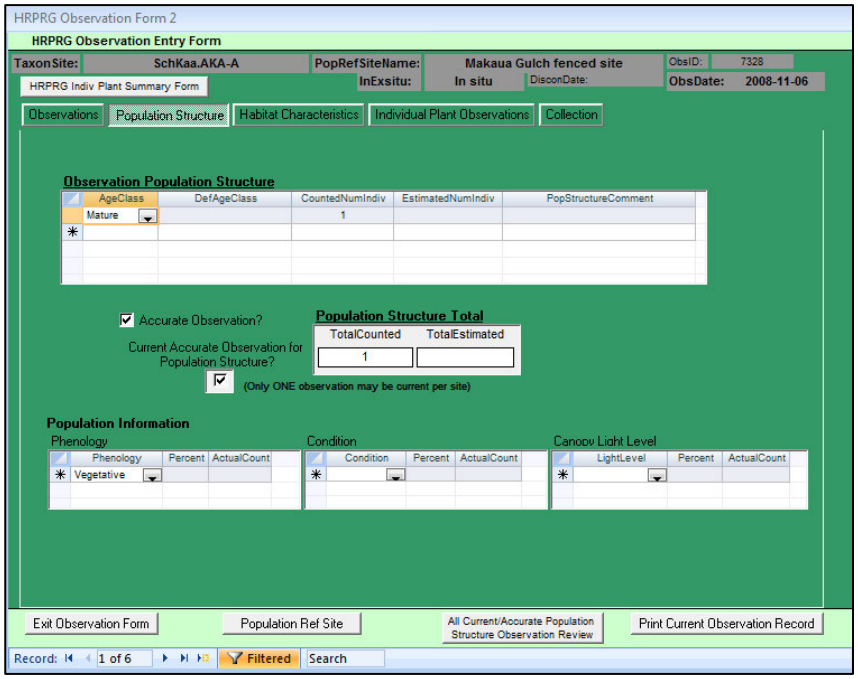



**ObservationDate**: Observations of the Population Reference Site are entered by the ObservationDate. Observation Date is normally the day that the Population Site was surveyed. If the individual(s) were not found during the survey, the observation date and record is still be filled out. If the survey 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.

## Population Structure

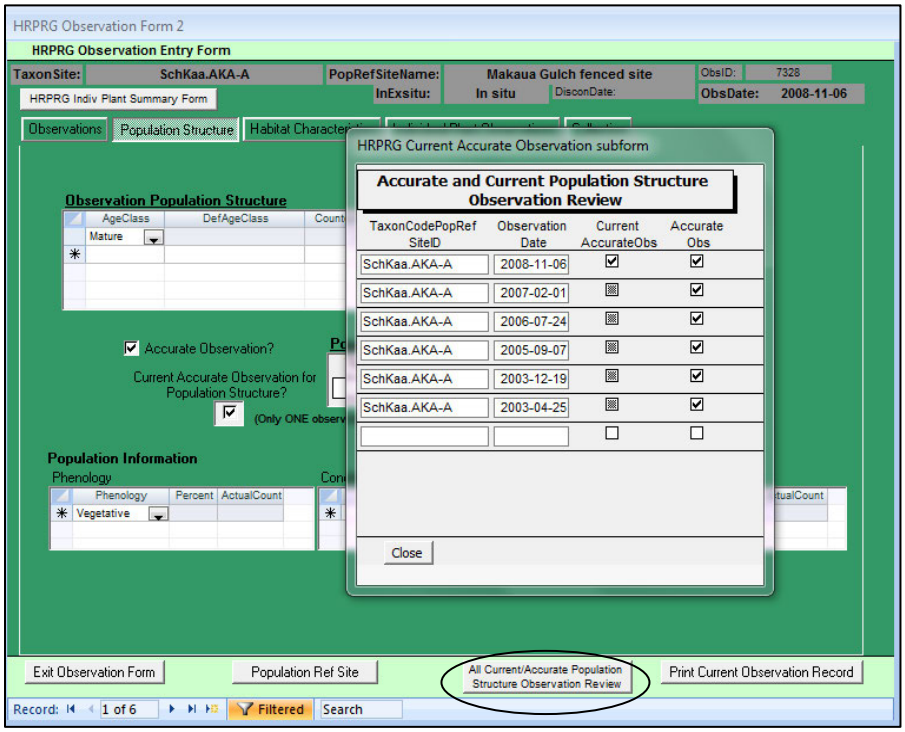
The Population Structure should are always entered for any observations, even if the number of plants observed are incomplete (not all plants observed).




**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.

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.

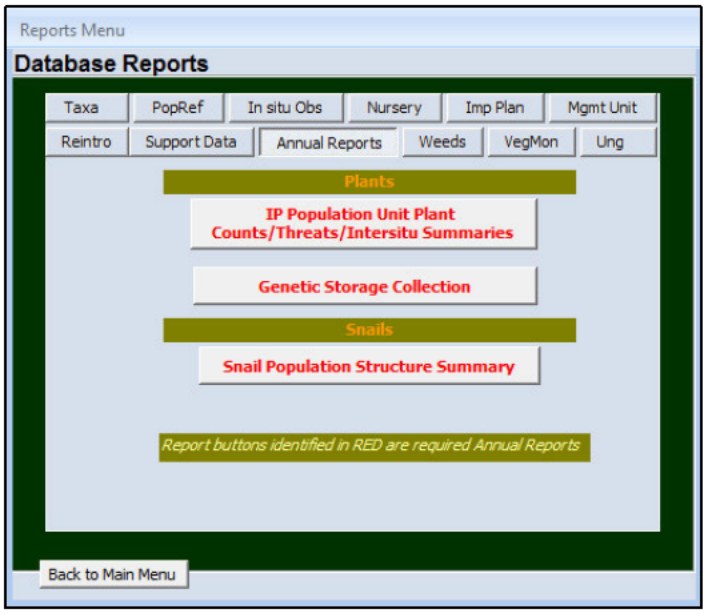



As opposed to the Accurate Observation check box, the **Current Accurate Observation** check off box may only have one observation checked. The Current Accurate represents the population structure that is considered both current and accurate. The most recent observation may not always be the Current 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

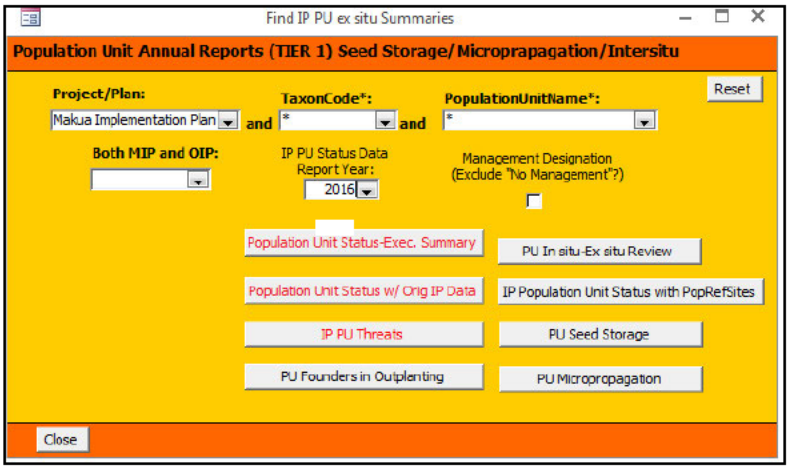
Starting from the Main Menu, click on the Database Reports button. The Database Reports menu provides reports for various sections of the database.




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.

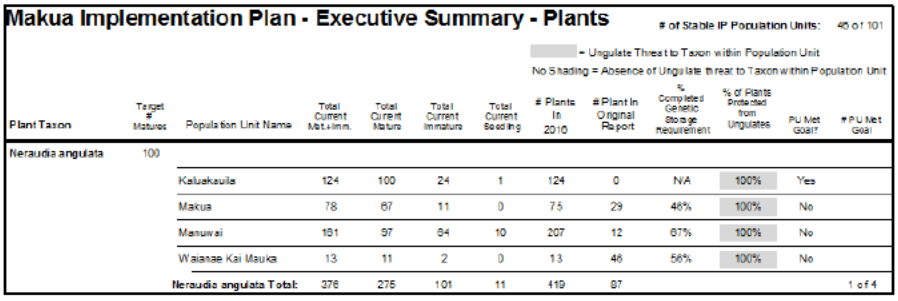



### Taxon Status and Threat Summaries

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 2021. Report Year is defined below under Total Mature, Immature and Seedling (Year).

### 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: 45 of 101

– 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 2010 | # Plant in Original Report | % Completed Genetic Storage Requirement | % of Plants Protected from Ungulates | PU Met Goal? | # PU Met Goal |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Neraudia angulata | 100 | | | | | | | | | | | |
| | | Kaluakauila | 124 | 100 | 24 | 1 | 124 | 0 | NA | 100% | Yes | |
| | | Makua | 78 | 67 | 11 | 0 | 75 | 29 | 46% | 100% | No | |
| | | Manuwai | 191 | 97 | 84 | 10 | 207 | 12 | 67% | 100% | No | |
| | | Waianae Kai Mauka | 13 | 11 | 2 | 0 | 13 | 46 | 56% | 100% | No | |
| | | Neraudia angulata Total: | 376 | 275 | 101 | 11 | 419 | 87 | | | | 1 of 4 |

## Population Unit Status Summary

**Population Unit Status - Makua Implementation Plan**

**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 2016 | Total Immature 2016 | Total Seedling 2016 | 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 | 75 | 36 | 0 | 70 | 36 | 0 | 6 | 11 | 0 | 64 | 25 | 0 | 2017-05-09 | Small changes were noted during monitoring in the last year |
| In Total: | | 22 | 24 | 0 | 75 | 36 | 0 | 70 | 36 | 0 | 6 | 11 | 0 | 64 | 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 2016 | Total Immature 2016 | Total Seedling 2016 | 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 | 124 | 17 | 0 | 124 | 17 | 0 | 2 | 1 | 0 | 122 | 16 | 0 | 2016-04-07 | A new census was initiated but not yet completed |
| Makaha | Genetic Storage | | | | 13 | 56 | 0 | 13 | 56 | 0 | 0 | 0 | 0 | 13 | 56 | 0 | 2016-02-09 | A new census was initiated but not yet completed |
| North branch of South Ekahanui | Manage reintroduction for stability | 5 | 0 | 0 | 82 | 65 | 0 | 82 | 65 | 0 | 0 | 0 | 0 | 82 | 65 | 0 | 2016-05-11 | A new census was initiated but not yet completed |
| Palikea (South Palawai) | Manage for stability | 3 | 60 | 0 | 120 | 19 | 1 | 911 | 10 | 0 | 8 | 4 | 0 | 903 | 6 | 0 | 2017-04-25 | Additional plants were reintroduced last year |
| Out Total: | | 8 | 60 | 0 | 339 | 157 | 1 | 1130 | 148 | 0 | 10 | 5 | 0 | 1120 | 143 | 0 | | |
| Total for Taxon: | | 30 | 84 | 0 | 414 | 193 | 1 | 1200 | 184 | 0 | 16 | 16 | 0 | 1184 | 168 | 0 | | |

The Population Unit 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 (Year):** 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 three columns can be compared with the previous columns 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 ANRPO monitoring data, data from the O‘ahu Plant Extinction Prevention Program (OPEP) and O‘ahu 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 ANRPO and no plants are listed in the population estimates. As these sites are monitored, estimates will be revised.

**Outplanted Current Mature, Immature, Seedling:** The last set of three columns display the numbers of individuals ANRPO 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

**Threat Control Summary** Makua Implementation Plan

**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 100% | Partial 0% | No | No |
| Makua | Manage for stability | 4 | Partial 100% | Partial 25% | 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 Waiell | Manage for stability | 3 | Partial 0% | Partial 0% | No | No | No |
| Makaha | Manage for stability | 29 | Yes | Partial 100% | Partial 100% | 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 with in 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

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 Oʻahu. 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 ANRPO 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.

**Slugs:** This threat is indicated for several IP taxa as confirmed by ANRPO staff. Currently, slug control is conducted under an Experimental Use Permit from Hawaiʻi State Department of Agriculture, which permits the use of Sluggo® around the recruiting seedlings of *Cyanea superba* subsp. *superba* in Kahanahāiki Gulch on Mākua 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 Mākua 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 Pūʻulu, Kihakapu, Palikea, Kaimuhole, Alaiheihe, Manuwai, Kaumoku iki, Kaumoku nui and Kaʻawa and PUs in the Puʻu Palikea area that were threatened by the Nānākuli fire. Threat control conducted by ANRPO 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

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**Genetic Storage Summary Makua Implementation Plan**

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Neraudia angulata** | | | | | | | | | | | | | | |
| Kapuna | Genetic Storage | 0 | 0 | 2 | 2 | 2 | 0 | 2 | 2 | 0 | 0 | 2 | 2 | 100% |
| Makua | Manage for stability | 21 | 4 | 34 | 2 | 2 | 0 | 37 | 1 | 0 | 0 | 23 | 23 | 46% |
| Punapohaku | Genetic Storage | 2 | 0 | 2 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 3 | 3 | 75% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Neraudia angulata** | | | | | | | | | | | | | | |
| Halona | Genetic Storage | 4 | 10 | 17 | 1 | 1 | 0 | 9 | 0 | 0 | 0 | 8 | 8 | 38% |
| Leeward Puu Kaua | Genetic Storage | 9 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 11% |
| Makaha | Manage for stability (backup site) | 3 | 8 | 12 | 3 | 2 | 0 | 15 | 2 | 1 | 0 | 14 | 14 | 93% |
| Manuwai | Manage for stability | 0 | 4 | 2 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 4 | 4 | 100% |
| Waianae Kai Makai | Genetic Storage | 13 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 8 | 8 | 62% |
| Waianae Kai Mauka | Manage for stability | 7 | 2 | 9 | 1 | 1 | 0 | 11 | 0 | 0 | 0 | 10 | 10 | 63% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 59 | 28 | 78 | 10 | 8 | 0 | 96 | 5 | 1 | 0 | 73 | 73 |

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 and Storage Goals:** 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 rosea | Jackson's Chameleon |
| **Achatinella mustelina** | | | | | | | | | | | | |
| **ESU: A** | **Pahole to Kahanahaiki** | | | | | | | | | | | |
| **MMR-A** Kahanahaiki Exclosure | Manage for stability | 215 | 2017-05-02 | 86 | 107 | 22 | 0 | Yes | Partial | Yes | Yes | No |
| **PAH-B** Pahole Exclosure | Manage for stability | 28 | 2016-06-20 | 8 | 13 | 7 | 0 | Yes | Partial | Yes | Yes | No |
| | **ESU Total:** | 243 | | 94 | 120 | 29 | 0 | | | | | |

*=Total Snails were Trans Located or Reintroduced

= 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

**Size Class Definitions**

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

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

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 Mākua 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.

**Appendix ES-2: ANRPO Organization Chart, 2022-2023 Report Year**
Includes all staff employed during the report year by their most recent position/job title, as of June 30, 2023. Positions staffed for part of the year, but vacant at the end of the year, have the most recent occupant noted in parentheses and italics.

| | |
|---|---|
| Vice President for Research & Innovation | Vassilis Syrmos |
| OVPRI Administrative Officer | Melissa Arakawa |
| OVPRI Fiscal Administrator | Rona Kobashigawa |

## OFFICE OF THE VICE PRESIDENT FOR RESEARCH AND INNOVATION

## PROGRAM MANAGER

### NATURAL RESOURCE FIELD PROGRAM

| | |
|---|---|
| NRM Field/Operations Manager | Jobriath Rohrer |
| NR Field Supervisor (Orange) | *(Kaia Kong)* |
| NR Field Team Leader | Wesley Shinsato |
| NRM Technician II | Cameron Young |
| NRM Technician II | Jenna Patague |
| NRM Technician I | Alanna Miyashiro |
| NRM Technician I | Kauila Tengan |
| NRM Technician I | *vacant* |
| NRM Technician I | *vacant* |
| NR Field Supervisor (Green) | *(Chelsea Tamayo)* |
| NR Field Team Leader | Kūpono Matsuoka |
| NRM Technician II | Nolan Caballero |
| NRM Technician II | Wesley Piena |
| NRM Technician II | Tazman Shim |
| NRM Technician I | Jocelyn Dunn |
| NRM Technician I | *vacant* |
| NRM Technician I | *vacant* |
| NR Field Supervisor (Blue) | David Hoppe-Cruz |
| NR Field Team Leader | Keith Adams |
| NRM Technician II | Katherine Cole |
| NRM Technician II | Aaron Pila |
| NRM Technician II | Krista Lizardi |
| NRM Technician II | Matthew Mancuso |
| NRM Technician II | Mānowai Morgan Kobashigawa |
| NRM Technician I | *vacant* |
| VR Field Supervisor | Michael Bohling |
| VR Technician II | Nathaniel Garrett |
| VR Technician I | Mckenzie Brown |
| VR Technician I | Nada McClellan |
| VR Technician I | Sara Van Gent |
| Outreach & Volunteer Program Specialist | Kimberly Welch |
| Safety and Logistics Associate | George Schneller |

### ADMINISTRATIVE OPERATIONS

| | |
|---|---|
| Administrative Associate | Rachel Zinberg |
| Administrative Associate | Yvonne Lopez-Radakovich |
| Administrative Associate | Brenna Keefe |

### PEST CONTROL PROGRAM

| | |
|---|---|
| Pest Control Program Technician I | Glacel Lopez |

### Supplemental Staff

| | |
|---|---|
| Part-Time Hires | Linda Koch |
| Student Hires | Tressa Hoppe (Rare Plant)<br>Nikki Preston<br>Storey Welch |
| Temp Hires | Madelyne Harding<br>Maggie O'Neill |
| Intermittent Hires | Daniel Tanji<br>Deena Gary<br>Samantha Shizuru<br>Chad Koide |
| Summer Interns 2023 & 2022 | Tori Budke<br>Kawohi Duvachelle<br>Ethan Hoppe-Cruz<br>Kainoa Paul<br>Sophia Schlenz<br>Kauhi Yim<br>Kai Binney<br>Makoa De Almeida |

### NATURAL RESOURCE CONSERVATION PROGRAM

| | |
|---|---|
| Natural Resource Conservation Manager | Jane Beachy |
| Animal Program Coordinator | Kaia Kong |
| Rare Snail Conservation Biologist | *(Deena Gary)* |
| Rare Insect Biologist | Tommy Russell |
| Rare Vertebrate Conservation Biologist | Philip Taylor |
| Invertebrate & Forest Invasive Species Biologist | Kevin Armstrong |
| Small Vertebrate Pest Biologist | Troy Levinson |
| Ungulate Biologist | Michael Gray |
| Cons/Control Technician II | Jonah Dedrick |
| Rare Plant Program Coordinator | Tim Chambers |
| Propagule Management Biologist | Makanani Akiona |
| Propagule Conservation Technician | Elizabeth Conlon |
| Horticulture Supervisor | Chris Wong |
| Horticulture Technician III | Rebecca Zoechbauer |
| Horticulture Technician II | Maxwell Bendes |
| Horticulture Technician I | Francis Joy |
| Vegetation Management Program Coordinator | Melissa Valdez |
| Vegetation Management Program Coordinator | Chelsea Tamayo |
| Native Plant Restoration Biologist | Chris Lum |
| Invasive Plant Biologist | *(Petelo Maosi)* |
| Monitoring Program Biologist | Michelle Akamine |
| Information Technology Systems Coordinator | Roy Kam |
| GIS Analyst | Petelo Maosi |
| Biocontrol Research Technician | Sean Kirkpatrick |

MEMORANDUM FOR RECORD

# Mākua Fire August 19-28, 2022

**August 19, 2022:**

The fire was reported at Mākua Military Reservation near the base of the Koʻiahi ridge, on its North exposure on August 19, 2022 at 1245 hrs. Range Control reported the fire to Army Wildland Fire (Army Fire) just before DPW Environmental was contacted. There was no training in the valley on August 19. Grass cutters were working inside the fire breaks. The ignition point was approximately 50-100 meters above the fire break road in an area dominated by *Leucaena leucocephala* and *Megathyrsus maximus*. Range control staff, Army Wildland Fire, and Environmental share the opinion that the fire was started by a UXO item that was activated in the heat of the day, though this cannot be verified.

Left: Picture taken by Range Control staff soon after ignition
Right: Picture taken at approximately 1315 as fire rapidly spread in dry fuels.
Both: Smoke direction indicates on-shore west wind pushing fire east into the valley

Kapua Kawelo and Joby Rohrer worked to coordinate fire response via the following actions:

- Pilot Josh Lang (K&S Helicopters) was notified and began preparations for response.
- Range access was confirmed through Army Fire and Range Control.
- OVPRI was informed that flight operations were going to likely be utilized to support fire fighting.
- Green Team Supervisor (Chelsea Tamayo) was contacted and queried about her availability to respond.
- Blue Team Supervisor (David Hoppe-Cruz) was contacted and queried about his availability to respond.
- Conservation Manager (Jane Beachy) was informed of the situation.

As ignition occurred on a state holiday, it was challenging to determine what resources to activate. David Hoppe-Cruz was able to go directly to Mākua from his house in Mākaha and was on site at 1320 hrs. David reported on the fire status and took pictures. Unfortunately, as he came from home he did not have the necessary equipment needed to manage flight operations. Based on David's report of the fire

behavior, Joby Rohrer reported to work from home at 1300 hrs. This timing worked out as Josh Lang was not available to report to Mākua until 1430 hrs. Joby Rohrer came to base, collected all the required gear using the SOP checklist, checked in with Range Control, and was at SBS LZ by 1420 hrs. Kapua Kawelo coordinated the Army response with Range Control and Army Fire and conducted flight following for Joby Rohrer. Kapua worked hard to get Army choppers on site asap. Initial estimate, because 19 Aug was an ADONSA day was 2 hr report time for the helicopters. Kapua also provided numerous updates to the IOC and range division regarding status of fire and helicopter support.

Joby Rohrer and Josh Lang entered Mākua Valley at 1445 hrs from the south, via Kolekole Pass. At that time, the fire was very active and the entire back of the valley was filled with smoke. At the time of ignition, the winds were blowing on-shore out of the west thus driving the fire east toward the back of the valley. As the fire spread east it moved under increasing amounts of upslope dry fuels (again *Leucaena leucocephala* and *Megathyrsus maximus*). These fuels were pre-heated and the flames rapidly spread up to the crest of Koʻiahi ridge. There was no way to stop this fire spreading up to the ridge crest.

Photo looking down at Koʻiahi ridge crest. Extreme fire behavior observed as west winds push fire up the valley to the east into and below heavy loads of dry fuel. The kukui canopies of Koʻiahi gulch are seen in the top of the photo.

Joby Rohrer and Josh Lang landed at the upper dip pond, configured the fire bucket and began water drops at 1455 hrs. Josh focused his efforts on preventing further spread up the valley on the eastern edge of the fire. Fortunately, the lower reaches of the Koʻiahi ridge are not known to support native resources. Thus, the area with the most extreme fire behavior was not a priority. Josh continued to focus his efforts for the remainder of the day on the east and north fronts of the fire, as these were threatening rare

resources (see summary of efforts below). Army Blackhawk 228 arrived in Mākua at 1554 hrs (see summary of efforts below). Army Blackhawk 483 arrived in Mākua at 1711 hrs (see summary of efforts below). Army CH 47 470 arrived in Mākua at 1745 hrs (see summary of efforts below).

Once the fire crested the Ko'iahi ridge, fire spread slowed on the northwest edge. Unfortunately, the fire was able to travel east below additional upslope fuels before the Army helicopters arrived. This resulted in another period of rapid spread to the north and east. This spread was slowed/stopped by a combination of grass-free rocky cliffs and forest. Once Army ships were on site, all air resources were directed by Army Fire and Environmental to focus suppression on the north and east fire fronts. Army Blackhawks were equipped with a 660 gallon bucket on a short lead line and the Chinook had a massive 2,000 gallon bucket on a long line. The Chinook was very impressive as its capacity is 20 times that of the Hughes 500 bucket and 3 times the Blackhawk bucket in volume. In addition, the long line configuration is far superior to the shorter lead on the Blackhawk as it prevents downdrafts from fanning the fire. All Army helicopters were very effective and took direction well from Army Fire and Josh. The team worked efficiently to combat further fire spread. At the end of the day there were no active flames but many hot-spots remained.

August 19, 2022 Air Asset Summary for K&S Helicopter N545PH

| Time | Note | Approximate number of water buckets completed on fuel cycle |
|---|---|---|
| 1430 | Arrive at SBS and pick-up Joby Rohrer | |
| 1445 | Arrive at Mākua and conduct aerial survey of fire | |
| 1455 | Aerial survey complete and water drops started. Worked north and east fire edges. | 25 |
| 1625 | Depart to DMR for fuel | |
| 1640 | Josh returns from fueling and continues bucket drops in areas noted above | 30 |
| 1819 | Depart to DMR for fuel | |
| 1830 | Josh returns from fueling and continues bucket drops in areas noted above | 30 |
| 1900 | Josh and Joby fly a quick perimeter of the fire and depart Mākua | |
| 1910 | Joby dropped at SBS and Josh headed to TBR | |

August 19, 2022 Air Asset Summary for Army Blackhawk 228

| Time | Note | Approximate number of water buckets completed on fuel cycle |
|---|---|---|
| 1543 | Arrive in Mākua and set up bucket | |
| 1554 | Begin water drops | 15 |
| 1645 | Packed bucket to depart | |
| 1657 | Depart Mākua | |

August 19, 2022 Air Asset Summary for Army Blackhawk 483

| Time | Note | Approximate number of water buckets completed on fuel cycle |
|---|---|---|
| 1711 | Arrive in Mākua and set up bucket | |
| 1734 | Begin water drops | 15 |
| 1830 | Packed bucket to depart | |
| 1842 | Depart Mākua | |

Army Chinook 470 drops 2000 gallons of water on the norther edge of the fire drenching downslope fuels and preventing further spread.

August 19, 2022 Air Asset Summary for Army Chinook 470

| Time | Note | Approximate number of water buckets completed on fuel cycle |
|---|---|---|
| 1735 | Arrive in Mākua with bucket on. Begin drops immediately. | 15 |
| 1856 | Depart Mākua | |

**August 20, 2022:**

Joby Rohrer debriefed operations with OVPRI and requested permission to park a truck at his private residence to facilitate an early morning response directly to Mākua. Permission was granted. Joby report to Mākua at 0700 hrs on the morning of August 20, 2022. Josh had been scheduled to return at 0730 hrs to ensure a quick response to any new fire flare-ups. Fortunately, the fire was not very active in the morning. Josh arrived as scheduled and picked up Joby to map the extent of the burn. The shape was synced to ArcGIS online and ANRPO GIS Analyst Linda Koch produced a map, which was used to report up the chain of command (Installation Operations Center). Once mapping was complete, Josh went directly into bucket drops.

Map of fire extent as of 0730 hrs on August 21, 2022. Rough perimeter based on beginning of day helicopter survey.

Fire as seen on Saturday August 20 at 0715 hrs. Some smoke is visible on the north and east edges of the fire (photo looks south; east is on the left of the photo).

Army Blackhawk 528 arrived in Mākua at 0809 hrs (see summary of efforts below). Army Blackhawk 483 arrived in Mākua at 0820 hrs (see summary of efforts below). All three ships worked to suppress occasional flare-ups on the north and east edges of the fire. When there were no flare-ups, they saturated the edges of the fire. Joby Rohrer was on site until 1200 hrs. Green Team Supervisor Chelsea Tamayo reported to Mākua at 1130 hrs and was briefed by Joby and Army Fire.

August 20, 2022 Air Asset Summary for K&S Helicopter N545PH

| Time | Note | Approximate number of water buckets completed on fuel cycle |
|---|---|---|
| 0730 | Arrive at Mākua and conduct mapping with Joby | |
| 0740 | Begin water buckets drops | 30 |
| 0925 | Depart to DMR for fuel | |
| 0935 | Josh returns from fueling and continues bucket drops | 30 |
| 1110 | Depart to TBR | |

August 20, 2022 Air Asset Summary for Army Blackhawk 528

| Time | Note | Approximate number of water buckets completed on fuel cycle |
|---|---|---|
| 0809 | Arrive in Mākua, recon, and set up bucket | |
| 0821 | Begin water drops | 15 |
| 0943 | Packed bucket to depart | |
| 0950 | Depart Mākua | |
| 1055 | Arrive in Mākua and setting up bucket | |
| 1105 | Begin water drops | 15 |
| 1330 | Packed bucket to depart to Schofield | |

August 20, 2022 Air Asset Summary for Army Blackhawk 483

| Time | Note | Approximate number of water buckets completed on fuel cycle |
|---|---|---|
| 0820 | Arrive in Mākua, recon, and set up bucket | |
| 0840 | Begin water drops | 15 |
| 0945 | Packed bucket to depart | |
| 0956 | Depart to Mākua | |
| 1030 | Arrive in Mākua and setting up bucket | |
| 1036 | Begin water drops | |
| 1140 | Departed for scheduled maintenance | |

**August 21, 2022:**

August 21, 2022 Air Asset Summary for K&S Helicopter N545PH

| Time | Note-GWS and JL Fly from SBS to Mākua | Approximate number of water buckets completed on fuel cycle |
|---|---|---|
| 1145 | GWS and JL Arrive at Mākua and relieve DHC | |
| 1200 | Begin water buckets drops and brief with Army Fire | 20 |
| 0130 | Depart to DMR for fuel | |
| 0145 | GWS and JL back to SBS | |
| 0200 | Pau ops JL headed back to TBR | |

August 21, 2022 Air Asset Summary for Army Blackhawk 424

| Time | Note-GWS and JL Fly from SBS to Mākua | Approximate number of water buckets completed on fuel cycle |
|---|---|---|
| 0725 | First UH60 arrives (442) | |
| 0730 | 442 begins drops | |
| 0925 | 442 departs for fuel | |
| 0955 | 442 back on site | |
| 1005 | 442 resumes drops | |
| 1130 | 442 Depart Mākua | |

August 21, 2022 Air Asset Summary for Army Blackhawk 528

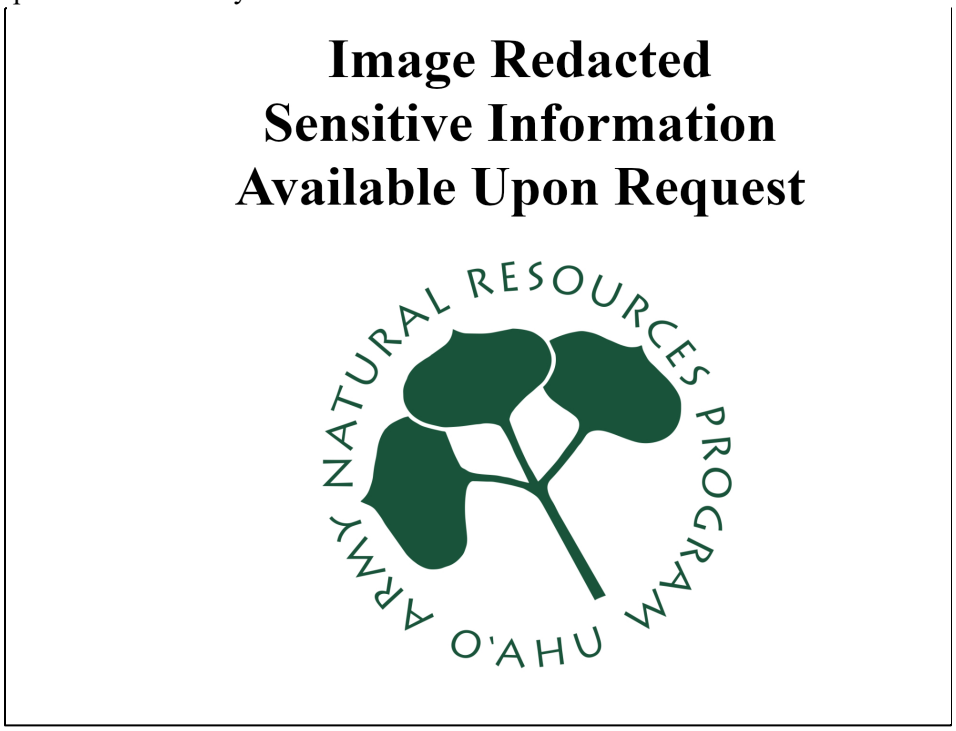
| Time | Note-GWS and JL Fly from SBS to Mākua | Approximate number of water buckets completed on fuel cycle |
|---|---|---|
| 0732 | UH60 528 arrives at Mākua | |
| 0736 | 528 begins drops, both ships dropping water | |
| 0900 | 528 departs for fuel | 35 (both ships) |
| 1025 | 528 back on site | |
| 1130 | 528 departs Mākua | |

**Key points from fire response:**

1. Deployment on a state holiday was slower than ideal. Had the fire started in a more critical site for rare resources a 2-3 hour deployment could cost valuable resources.
2. Army Fire is an outstanding resource. During the June fire, ANRPO made good contacts and were able to provide useful direction. This success clearly strengthened our relationship and made coordination even smoother on this August incident.
3. The upper dip pond position was key in enabling multiple ships to work the fire at the same time. Army helicopters are slower than Josh, and thus it is good for Josh to have a separate dip pond to use.
4. Filling the upper dip pond is clearly a limitation as there are no water lines plumbing it and thus must be filled by trucking or flying water in. This is ineffective and slow. We should support Army Fire's effort to get a permanent water source available to fill the pond.
5. Long line configuration on the Chinook was very effective. The combination of the long line and the 2,000 gallon bucket is by far the most superior air resource on island.
6. While Army helicopters were slow to respond on the 19th they were effective at their water delivery on Aug 19 and 20 while ANRPO was observing. This is an improvement from the June fire.
7. It is beneficial for Army Fire to send staff to meet Army helicopter crews in person on the ground to give an overview of the game plan, convey importance and engage them in the mission.

**August 29, Post-Fire Survey Results:**

Kapua Kawelo, Jessica Adinolfi and Clay Trauernicht conducted this post fire survey to document native species and federally listed taxa and critical habitat affected. This fire burned 132.6 acres.




Map below was produced using MAXAR satellite imagery, more accurate acreage.

Most of the area which burned on lower Koʻiahi ridge is dominated by introduced vegetation composed of *Megathyrsus maximus* and *Leucaena leucocephala.* Approximately 90% of the burned area occurred where introduced species are dominant. The remaining 10% affected cliffs, shrubland and forest that contained native vegetation. Small rocky ledges on the north side of Koʻiahi ridge had substantial cover of *Psydrax odoratum*, *Dodonaea viscosa* and *Diospyros sandwicensis*. In addition, on the eastern edge of the fire, native forest dominated by *Diospyros sandwicensis*, *Psydrax odoratum* and *Erythrina sandwicensis* was burned. While no occurrences of endangered plants, animals or critical habitat burned, the fire came within 100 m of four listed plant taxa; *Lobelia niihauensis*, *Korthalsella degeneri*, *Neraudia angulata* and *Melanthera tenuifolia*. Below is a species list of affected plant taxa, and photos of the fire and impacts observed.

# Ko‘iahi Fire: Plant Species Affected

| Scientific Name | Common Name |
|---|---|
| | |
| **NON-NATIVE PLANTS** | |
| *Aleurites molucanna* | kukui |
| *Ageratina adenophora* | Hāmākua pāmakani |
| *Cheilanthes viridis* | |
| *Coffea arabica* | coffee |
| *Cordyline fruticosa* | ti, lā‘ī |
| *Grevillea robusta* | silk oak |
| *Hyptis pectinata* | |
| *Lantana camara* | |
| *Leucaena leucocephala* | koa haole |
| *Melia azedarach* | pride of India |
| *Melinus repens* | natal redtop |
| *Neonotonia wightii* | |
| *Nephrolepis brownii* | |
| *Opuntia ficus-indica* | prickly pear |
| *Passiflora edulis* | liliko‘i |
| *Passiflora suberosa* | corky passionvine |
| *Psidium cattleianum* | strawberry guava |
| *Rivinia humilis* | |
| *Schinus terebinthifolius* | christmasberry |
| *Spathodea campanulata* | african tulip |
| *Stachytarpheta australis* | |
| *Stapelia gigantea* | |
| *Syzygium cumini* | java plum |
| *Toona ciliata* | australian red cedar |
| *Megathyrsus maximus* | guinea grass |

| Scientific Name | Common Name |
|---|---|
| | |
| **NATIVE PLANTS** | |
| *Artemisia australis* | ‘āhinahina |
| *Bidens cervicata* | ko‘oko‘olau |
| *Coleus australis* | ‘ala‘ala wai nui puakī |
| *Diospyros sandwicensis* | lama |
| *Dodonaea viscosa* | ‘a‘ali‘i |
| *Doryopteris decipiens* | |
| *Erythrina sandwicensis* | wiliwili |
| *Myoporum sandwicensis* | naio |
| *Osteomeles anthyllidifolia* | ‘ūlei |
| *Peperomia blanda* | ‘ala‘ala wai nui |
| *Plumbago zeylanica* | ‘ilie‘e |
| *Psilotum nudum* | moa |
| *Psydrax odoratum* | alahe‘e |
| *Sapindus oahuensis* | lonomea |
| *Schiedea mannii* | |
| *Sida fallax* | ‘ilima |
| *Waltheria indica* | ‘uhaloa |

**Ko‘iahi Fire Photos**

Ko‘iahi fire from firebreak road en route to blue trail.

Ko‘iahi fire from west.
View from base of ridge.

Native forest burned along blue trail, lama and wiliwili affected.

Lonomea, *Sapindus oahuensis*, burned along fire perimeter

Enclosure 9: Koiahi Fire Photos

Photos below and above: Alahe‘e, ‘a‘ali‘i, and lama tree burned above rocky ledges, Ko‘iahi north slope

Mixed native and koa haole forest burned below Ko‘iahi cliffs

View looking northeast below Ko‘iahi gulch at south side of ridge.

# Ecosystem Restoration Management Plan

## MIP Year 20-25, Oct. 2023 – Sept. 2028

## OIP Year 17-22, Oct. 2023 – Sept. 2028

## MU: ʻŌpaeʻula Lower I

### Overall MIP Management Goals:

- Form a stable, native-dominated matrix of plant communities which support stable populations of IP taxa.
- Control ungulate, weed, invasive invertebrate, rodent, and other threats in the next five years to allow for stabilization of IP taxa.

## Background Information

Location: Northern Koʻolau Mountains

Land Owner: Kamehameha Schools, U.S. Army Garrison – Hawaiʻi (Army) lease

Land Managers: Army Natural Resource Program - Oʻahu (ANRPO)

Acreage: 16 acres

Elevation Range: 1,920 ft. – 2,260 ft.

Description: ʻŌpaeʻula Lower is a 16-acre management unit (MU) located in the northern Koʻolau Mountain Range, on the island of Oʻahu. This MU is in the back of a side gulch off ʻŌpaeʻula stream. ʻŌpaeʻula is a part of the Kawailoa Training Area (KLOA) and is currently leased by the Army from Kamehameha Schools for natural resource management (expiring November 2030). The annual precipitation averages 3,816 millimeters (mm) (Giambelluca 2013) and elevation ranges between 1,920-2,260 feet. Because of the unique topography and the amount of precipitation in ʻŌpaeʻula Lower, is one pond with year-round standing water and another pond that is seasonal. The plant community is classified as a montane wet forest. The vegetation is thick/dense and comprised of a mixture of native and introduced species, however it is predominately native. Many slopes are uluhe (*Dicranopteris linearis*) dominated. For a mid-elevation area in the Koʻolau Range, this MU has extremely unique native forest patches that have tall koa (*Acacia koa*) and ʻōhiʻa (*Metrosideros* spp.) trees. The ʻŌpaeʻula Lower MU was accessed via the Peʻahināiʻa trail in the past, however due to the trail becoming impassible, ANRPO uses helicopters to access the MU for management. Due to lack of military training in KLOA, ANRPO is no longer required to manage Tier 2 or 3 taxa. However, these taxa and other rare taxa in ʻŌpaeʻula Lower benefit from management for Tier 1 taxa across the MU.

**Native Vegetation Types**

| Koʻolau Vegetation Types | |
|---|---|
| Wet forest | Canopy includes: *Acacia koa, Metrosideros* spp., *Syzygium sandwicense*, *Cheirodendron* spp., *Cibotium* spp., *Ilex anomala*, *Psychotria* spp., *Myrsine* sp., and *Melicope* spp.<br><br>Understory includes: *Dicranopteris linearis*, *Freycinetia arborea*, *Alyxia stellata*, *Dianella sandwicensis*, *Melicope* spp., *Psychotria* spp., *Cibotium chamissoi, Cibotium menziesii*, *Machaerina angustifolia*, Broussaisia *arguta*. |
| NOTE: For MU monitoring purposes vegetation type is mapped based on theoretical pre-disturbance vegetation. Alien species are not noted. | |

**Terrain and Vegetation Types at ʻŌpaeʻula Lower**

Top row- Typical vegetation at Opaeula Lower.
Bottom left- the larger of the two ponds in Opaeula Lower.
Bottom right- *Gardenia mannii* on Puu Melicope.

## MIP/OIP Rare Resources ʻŌpaeʻula Lower

| Organism Type | Species | Pop. Ref. Code | Population Units | Management Designation | Wild/ Reintroduction |
|---|---|---|---|---|---|
| Plant | *Cyrtandra dentata* | OPA-F | ʻŌpaeʻula | MFS /T1 | Wild |
| Plant | *Gardenia mannii* | OPA-A, B, OPA-T, PAA-K | Lower Peʻahināiʻa | MFS/T1 GSC/T1 | Wild and Reintroduction |
| Plant | *Melicope lydgatei* | OPA-D*, E*, F, M, PAA-L | Kawaiiki and ʻŌpaeʻula | MFS/T2 | Wild |
| Plant | *Myrsine juddii* | PAA-H | Kaukonahua to KamananuiKoloa | T2 | Wild |
| Plant | *Phyllostegia hirsuta* | OPA-G* | Helemano and ʻŌpaeʻula | GSC/T1 | Wild |
| Insect | *Drosophila substenoptera* | OPA-A | Lower ʻŌpaeʻula | MFS/T1 | Wild |

MFS= Manage for Stability
GSC= Genetic Storage Collection
*= Population Dead
T1 = Tier 1
T2 = Tier 2

## Other Rare Taxa at ʻŌpaeʻula Lower

| Organism Type | Species | Status |
|---|---|---|
| Plant | *Cyanea lanceolata* | Endangered |
| Plant | *Exocarpos gaudichaudii* | Endangered |
| Plant | *Joinvillea ascendens* subsp. *ascendens* | Endangered |
| Plant | *Lindsea repens var. macraeana* | Rare |
| Plant | *Melicope cornuta* subsp. *cornuta* | Endangered |
| Plant | *Stenogyne kaalae* subsp. *sherffii* | Endangered, outplanted in 2013 with Oʻahu Plant Extinction Prevention Program (OPEPP). |
| Snail | *Achatinella curta* | Extirpated; last observed by Dr. Hadfield in 1998. |
| Snail | *Achatinella sowerbyana* | Extirpated; last observed 1996 |
| Insect | *Drosophila craddockae* | Rare |

**Rare Resources at ʻŌpaeʻula Lower**

*Gardenia mannii*

*Stenogyne kaalae* subsp. *sherffii*

*Cyrtandra dentata*

*Drosophila substenoptera*

**Locations of Rare Resources at ʻŌpaeʻula Lower**

# Image Redacted Sensitive Information Available Upon Request

**Threats to MIP/OIP MFS Taxa**

| Threat | Rare Taxa Affected | Management Strategy | Current Status |
|---|---|---|---|
| Rats | All | A24 trapping grid | Rodent damage has been observed in the past on *Cyrtandra dentata*. Snap traps were established in 2016 around the population. In April 2018, the trapping grid was converted to 50 A24s encompassing the whole MU. |
| Pigs | All | Fence | Area fenced and ungulate-free. |
| Weeds | All | Focus on IP rare taxa sites primarily, across MU secondarily. | Regular maintenance required several times per year. Weeds are a threat to both understory and canopy across the whole MU. |
| Fire | None | N/A | Fire is expected to be highly unlikely given the wet habitat at ʻŌpaeʻula Lower. In the unlikely event of a fire, ANRPO will assist by providing information on rare resources and trails to incident command and may also provide air support. |
| Black Twig Borer (BTB) | *Melicope lydgatei* | No effective control methods available. | No control feasible currently, since the existing BTB control methods are not effective. In addition, *M. lydgatei* is a T2 OIP species and is not being actively managed. |

| Threat | Rare Taxa Affected | Management Strategy | Current Status |
|---|---|---|---|
| Slugs | *Cyrtandra dentata, Gardenia mannii, Phyllostegia hirsuta, Myrsine judii* | Yes. Treat IP rare plant sites with molluscide. | Area has been surveyed by an experienced malacologist to determine whether native snails are present. No native snails have been found. Currently, FerroxxAQ is applied quarterly only around the *C. dentata* population, which has had observed slug damage in the past. Slug damage has not been seen on other T1 taxa. |
| Ants | *Drosophila substenoptera* | Annual surveys | Only *Solenopsis papuana* is currently known from the area; may impact rare taxa populations Control may be warranted if more problematic species become established. |

**Management History**

- 1999- May 2001: Initial management began with the use of snares in the area. ANRPO ran the snare groups but removed them due to the area being accessed by hunters.
- 1998-2000: ANRPO surveys MU and proposed fence line for *A. sowerbyana* and *A. curta*, which was reported by Dr. Hadfield. No rare snails were found during those surveys.
- 2001: Funding for a portion of the MU fence from DLNR was funneled through the Koʻolau Mountain Watershed Partnership.
- 2002-2003: ANRPO begins weed control in flat portions of MU near the pond. However, it was soon discontinued as ANRPO observed severe pig damage in freshly weeded areas, and decided to postpone weed control actions until the fence was built.
- 2011: Staff conduct initial line clearing for fence construction in June. The fence construction was completed in December.
- 2011: During the fence construction, large stands of *Psidium cattleianum* are removed in order to create a camp site for ANRPO staff. The area soon turned into grass (*Megathrysus maximus* and *Paspalum conjugatum*). This was a major change to the MU's infrastructure and landscape.
- 2012: ANRPO resumes snaring to remove any ungulates from the MU. The unit was declared ungulate-free this year.
- 2012: A tree fall on fence was observed by staff in April during a routine fence check. Staff observed ungulate sign within the fence, so snare groups were promptly set. By June, ANRPO caught seven pigs in snares and the unit was deemed pig-free.
- 2012: ANRPO resumes ecosystem weed control in the flat areas of the MU.
- 2012: *Rhynchospora caduca*, an incipient weed species not found in ʻŌpaeʻula Lower, was first discovered by staff along the Peʻahināiʻa trail that follows the MU fence line.
- 2013: The Oʻahu Plant Extinction Prevention Program (OPEPP) reintroduced a population of *Stenogyne kaalae* subsp. *sherffii* in the MU with assistance from ANRPO staff.
- 2013: Due to Army training level changes and a decrease in funding, ANRPO no longer receive funding to work with T2/T3 taxa and work to stabilize these species halts; *Melicope lydgatei* and *Myrsine juddii* no longer managed. MIP/OIP taxa in Lower ʻŌpaeʻula only include *Cyrtandra dentata* and *Gardenia mannii*.

- 2013-2014: ANRPO conducted a *Miconia crenata* control trial to gain a better understanding of how quickly *M. crenata* grows in ʻŌpaeʻula Lower. Results from this trial helped to inform the most effective ways to control *M. crenata*.
- 2013: LZ Frog Pond was discontinued due to safety concerns of the unstable muddy grounds, the lack of wind for helicopter lift, and the tall trees surrounding the LZ. ANRPO began using LZ Puʻu Curta. Although LZ Frog Pond was discontinued as an LZ, it is still used as a drop zone for camping gear.
- 2015: Staff Surveyed for slugs and native snails in the MU, especially around *C. dentata* population, to gauge need for possible future slug control.
- 2015: ANRPO installed fickle fence skirting along the existing fence line to prevent piglets from entering unit along fence sections below pond/behind camp where pressure is highest.
- 2016: ANRPO installs a small, localized grid of Victor snap traps around the *C. dentata* population following observations of rat predation of the fruit.
- 2016: ANRPO reintroduced *G. mannii* (OPA-A) by the wild *G. mannii* (OPA-B) population. This is the first *G. mannii* reintroduction in this MU.
- 2016: ANRPO begins control for slugs around *C. dentata* using Sluggo.
- 2017: ANRPO constructed a Weather Port field shelter at the Frog Pond camp site due constant wet and muddy conditions.
- 2017: Two new *R. caduca* ICAs were found by staff by the newly constructed Weather Port and along the Melicope finger fence line. Because of the new discoveries, ANRPO starts to mix a preemergent pesticide (Sulfomet) to control the seed bank as well as the plants found
- 2017: Staff noticed fickle skirting beginning to deteriorate/fail due to the extreme soil moisture, but unit remains pig-free.
- 2017: ANRPO discovers *Setaria palmifolia* along the MU fence line and around the "little" pond. Although *S. palmifolia* is found elsewhere in the Koʻolau Mountain Range, it was never previously observed in this MU. Thus, a new ICA was created. Staff check and control ICA quarterly.
- 2017: The use of Sluggo is discontinued since Ferroxx AQ, a more effective and longer lasting molluscicide, was approved for forestry-use. ANRPO switches to quarterly Ferroxx AQ application at the *C. dentata* site.
- 2017: Seed sow trials were established in March 2017. 100 plots were established with 250 seeds each.
- 2018: ANRPO planted more *G. mannii* (OPA-A). To increase native habitat, staff also reintroduces common native shrub *Clermontia kakeana*. This was the first restoration action to occur within the MU. ANRPO to plant more common native species around the *G. mannii* and Weather Port in the following years.
- 2018: ANRPO converted the Victor snap trapping grid around the *C. dentata* to a GoodNature A24 grid of 50 traps across the MU.
- 2018: Common native restoration undertaken directly around GarMan OPA-A reintroduction in WCA 04. *Clermontia kakaeana* were planted in open areas within the site along with *Cherodendron trigynm* and other common natives. These common taxa, as well as *Acacia koa,* were also planted near camp in WCA 04.

- 2019: Staff replaced 320 meters of rusted fickling with new galvanized skirting.2019: Pig sign observed, and 34 snares were set out. Pig never caught but sign never found again.
- 2020: 55 additional *G. manii* were planted both in existing reintroduction site, and in a test planting on the small pu‘u near camp. Common native plantings continue in areas opened during ecosystem weeding in WCAs 03 and 04 to buffer both *C. dentata* and *G. mannii.*
- April 2021: 35 common native plants out planted around CyrDen.OPA-F population to jump start canopy where light gaps have persisted.
- July 2021: With help from the Vegetation Restoration Team, a large area of guava was cleared down slope from the wild *C. dentata* to improve habitat. Common native reintroductions in 2021 and 2022 were focused on filling the opening created at this new restoration site.
- November 2022: First planting of *C. dentata* (OPA-H) among the wild OPA-F population. 25 plants were planted among the existing wilds in WCA-03. Plants resulted from germination trials of seed collected from the OPA-F population.
- March 2023: First test planting of *G. mannii* into nurse logs. Due to the lack of success of reintroductions to date, 14 *G. mannii* were planted from 2” pots into nurse logs to try to replicate natural recruitment.

## Ungulate Control

Species: *Sus scrofa* (Pigs)

Threat Level: High

Management Objective:

- Maintain MU as ungulate-free.

Strategy and Control Methods:

- Fence constructed in 2011.
- Maintain the fenced area as ungulate-free by maintaining fence.
- Monitor for sign while checking the fence (inside/outside) and conducting other management actions. Outside activity is reported to gauge pig pressure.
- Conduct quarterly fence checks and monitor stream crossings after storms.
- Document pig sign during vegetation monitoring transects.
- As fickle skirting deteriorates, a suitable replacement may need to be found and installed in the future.

Discussion:

The MU fence is 1.397 kilometers long and encompasses 16 acres. The major threats to the perimeter fence are pig digging, tree falls, erosion, and weathering due to very wet conditions. After the fence was completed, snares were set and monitored for a year. No ungulates were caught during this time and there was no activity within the fence. In 2012, a fallen tree damaged the fence, ungulate sign was observed thereafter. Snares were set again and monitored. Several pigs were successfully caught and removed from the MU and the fence was then deemed ungulate-free. Snares were also set outside the fence to reduce pig pressure. The fence is currently ungulate free and all snares set outside the fence have been removed. The vegetation along the fence will continue to be cleared to facilitate quarterly monitoring. Weed control is discussed in the Weed Control section. Special emphasis will be placed on checking the fence after extreme weather events since part of the fence line runs through the “little” pond, which is often halfway submerged. This may deteriorate fence materials faster and erosion can occur from elsewhere in the MU that could cause debris to pile up creating high spots for pigs to climb over the fence. Like many other fences in the Koʻolau Mountains, the materials used in the MU have shown signs of weathering at a faster rate than fences constructed in the Waianae range. ANRPO will continue to investigate longer lasting materials to replace the deteriorating fickle and skirting which tend to deteriorate faster than the fence panels. Monitoring for ungulate sign will also continue, especially along the MU’s western boundary where sign is most prevalent. There are no plans to snare outside the fence. Staff will determine whether additional skirting should be used to prevent any undercutting at the base of the fence along the most trafficked areas.

# Ungulate Control Map

## Weed Control and Vegetation Restoration

Weed Control actions are divided into 4 subcategories:

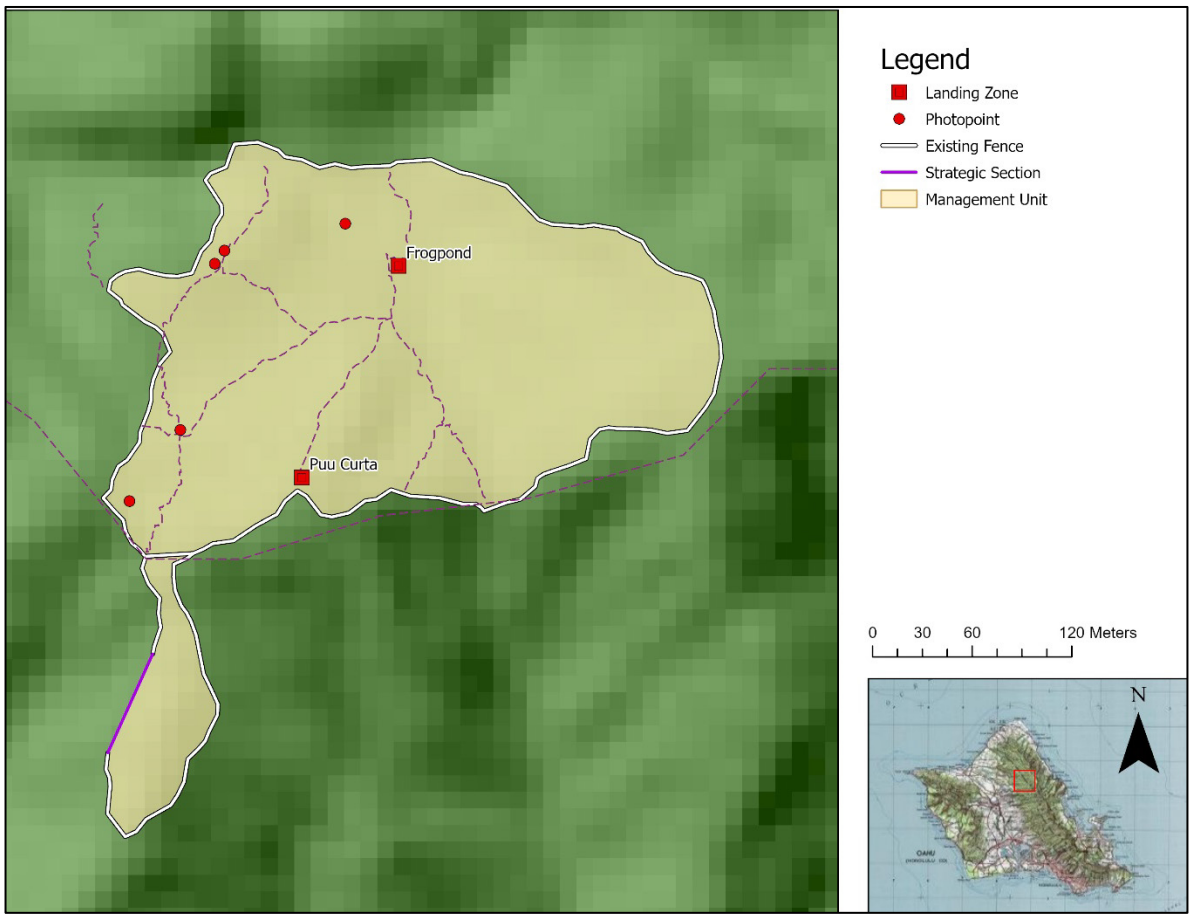
1) Vegetation Monitoring
2) Surveys
3) Incipient Taxa Control (Incipient Control Area - ICAs)
4) Ecosystem Management Weed Control (Weed Control Areas - WCAs)

These designations facilitate different aspects of MIP/OIP requirements.

### Vegetation Monitoring

Due to small size and high density of native vegetation in the MU, belt plot transect protocols implemented at other MUs are not appropriate here. Instead, ANRPO has adapted the photo point method of monitoring the changes of the plant community existing in the MU since this was the easiest monitoring method tool to use at the time. Photo points capture change in vegetation qualitatively, however these are not set up to be analyzed. Instead, these photo points were established in order to document the vegetation changes following weeding efforts and around the *Gardenia mannii* population. If the Blue team takes on more aggressive weeding control efforts by removing large stands of *Psidium cattleianum* and outplanting more native common species, ANRPO may choose to use point intercept monitoring to document vegetation changes quantitatively.

**Photo Points Map**



## Surveys

Potential Vectors. The Army conducts helicopter training in Kawailoa. The nearby Pu‘u Curta LZ is not currently used by the Army, however, ANRPO staff use this LZ to access ‘Ōpae‘ula Lower MU. In addition to the Pu‘u Curta LZ survey, the Frog Pond DZ and camp site are surveyed quarterly for new taxa inadvertently brought by field staff. Because of the difficulty of accessing the area via hiking, it is unlikely for recreational hikers to access the MU. However, the Pe‘ahināi‘a trail, which was a public trail, is nearby. The trail has since been overgrown and is not used. If recreational hikers are observed near the MU, a weed transect survey may be established to track the weed species seen in‘Ōpae‘ula ANRPO field crews, ungulates, and birds are all possible vectors of new weed species.

Management Objective:

- Prevent the establishment of any new invasive alien plant or animal species through regular surveys along trails, LZs, campsites and other high traffic areas (as applicable).

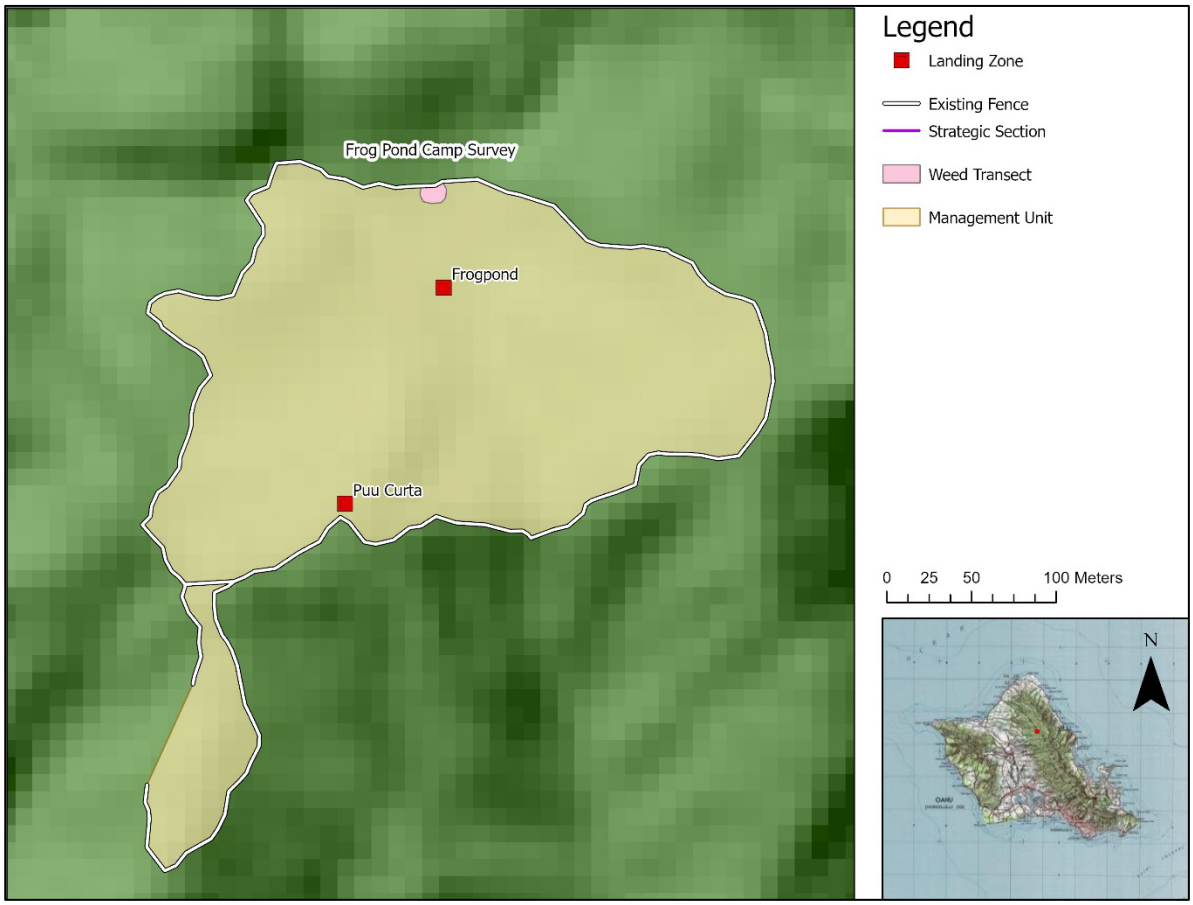
Strategy and Control Methods:

- Quarterly surveys of LZ PMH 190 (Poamoho Connex) and LZ KLO 33 (Pu‘u Curta).
- Quarterly survey of the Weather Port/camp (if used).
- Note unusual, significant or incipient alien taxa while conducting regular field work. Map and complete Target Species form to document sighting.
- Novel alien taxa found will be researched and evaluated for distribution and life history. If taxa found are to pose a major threat, control will begin and will be tracked via ICAs.
- Annual survey of Poamoho road.

Discussion:

Surveys are designed to be the first line of defense in locating and identifying potential new weed species. Staff should always be vigilant on finding any new weed species while working in the MU. During a quarterly fence check in 2012 *Rhynchospora caduca* was discovered along the fence line. This was most likely introduced to the MU by the fence materials that flew from an LZ that had *R. caduca*. *R. caduca* is established along the Poamoho road and the Poamoho Connex LZ. Both Poamoho road and Poamoho Connex LZ are high traffic points that may introduce new weed species to ‘Ōpae‘ula Lower MU. ANRPO will contact the State to discuss plans to increase awareness of weed spread at shared staging areas and landing zones and how to mitigate the potential risk of introductions into the wild.

**Weed Survey Areas Map**




## Incipient Taxa Control

All weed control geared towards eradication of a particular invasive weed is tracked via Incipient Control Areas, or ICAs. Each ICA is species-specific and geographically defined. One infestation may be divided into several ICAs or one ICA, depending on infestation size, topographical features, and land ownership. Some ICA species are incipient island-wide and are a priority for ICA management whenever found. Others are locally incipient to the MU, but widespread elsewhere. In either case, the goal is eradication of the ICA. The goals, strategies, and techniques used vary between ICAs, depending on terrain, surrounding vegetation, target taxon, size of infestation, and a variety of other factors.

Management Objectives:

- Eradicate ICAs through regular and thorough monitoring and treatment. In the absence of any information about seed bank longevity for a particular species, eradication is defined as 10 years of consistent monitoring with no target plants found.
- Study seed bank longevity of ICA taxa, and revise eradication standards per taxon.
- Evaluate any invasive plant species newly discovered in MU and determine whether ICA-level control is warranted. Factors to consider include distribution, invasiveness, and location, and infestation size, availability of control methods, resources, and funding.

Strategy and Control Methods:

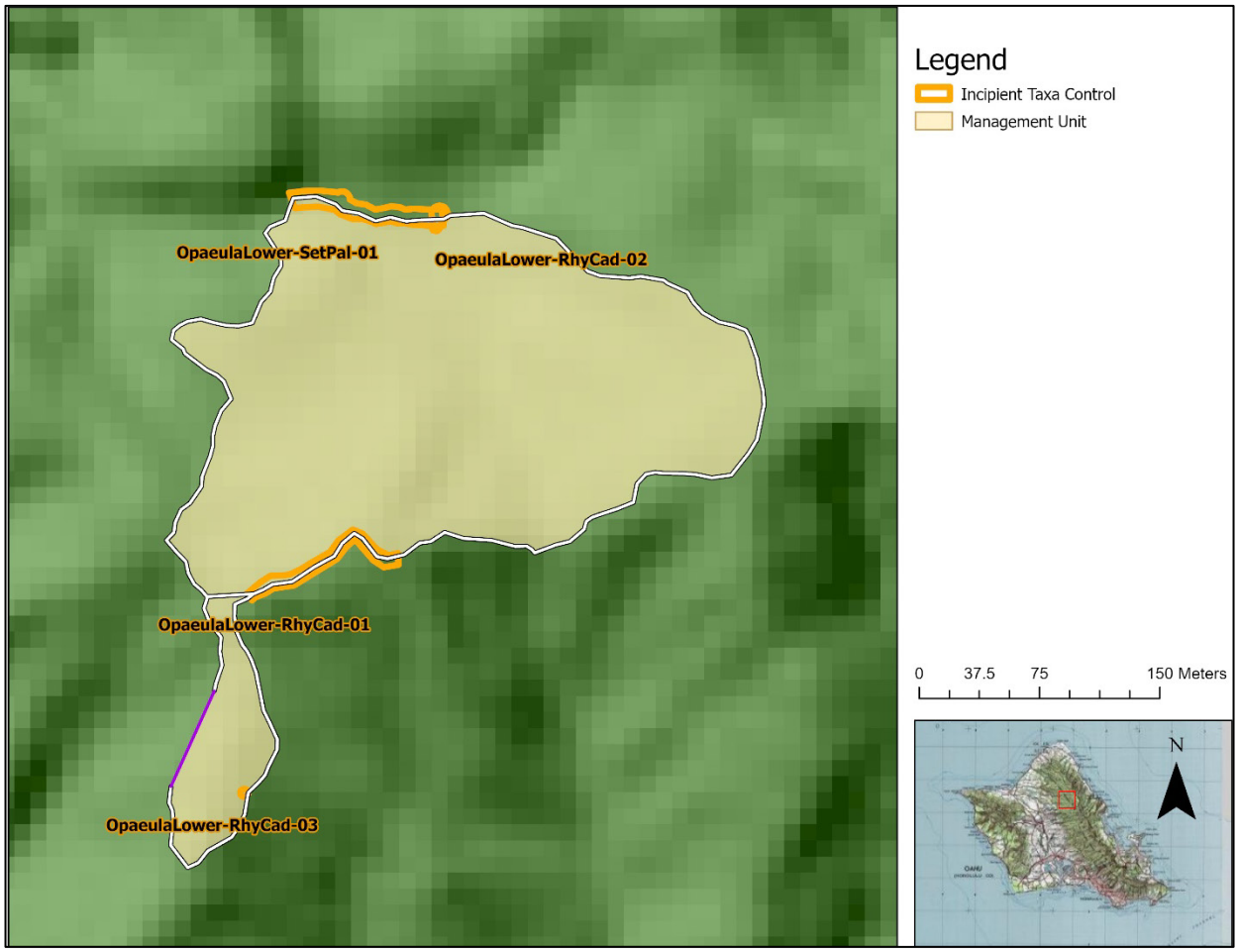
- Species and ICAs are listed in the table below. History and strategy is discussed for each species.

- Monitor the progress of management efforts and adjust visitation rates to allow staff to treat plants before they mature. Remember that one never finds 100% of all plants present.
- Use aggressive control techniques whenever possible.

Discussion:

Two incipient species *R. caduca* and *Setaria palmifolia* have been identified by ANRPO. There are currently three *R. caduca* ICAs and one *S. palmifolia* ICA that are being treated quarterly. ANRPO controls *R. caduca* in order to remove all matures within the MU. Quarterly checks will prevent immature individuals from reaching maturity. ANRPO will continue to monitor and consider control on other possible incipient plant species when appropriate.

**Incipient Control Areas Map**



## Summary of ICAs

| Taxon | ICA Code | Control Discussion |
|---|---|---|
| *Rhynchospora caduca* | Lower‘Ōpae‘ula-RhyCad-01 | All three ICAs are monitored and treated quarterly. *R. caduca* is a high priority for control as it is not found throughout the MU and thrives in wet environments. The Poamoho Connex LZ, used to access this MU, is infested with *R. caduca*. This ICA is found along the Pe‘ahināi‘a Trail. Five mature plants were discovered in 2012 and controlled by foliar application using a Ranger Pro, water, and pre-emergent mixture. Seed heads are removed and bagged. In 2021, plants were observed further east along the fence than previously known, leading to an expansion of the ICA. There are some areas in the ICA where it is difficult to search/see *R. caduca* since the uluhe can be quite thick. Staff will continue to control ICA and will GPS any hotspots. |
| | Lower‘Ōpae‘ula-RhyCad-02 | This ICA is located by the Weather Port where *R. caduca* was found in 2017. Three mature and about 30 immature plants were observed in the immediate vicinity of camp. Due to the presence of several naturalized sedge species at this ICA, definitive numbers of immature plants are difficult to access, however, there have been *R. caduca* found here consistently since the establishment of the ICA. |
| | Lower‘Ōpae‘ula-RhyCad-03 | This ICA is located along the *Melicope* finger fence. Two mature and 5 immature *R. caduca* were found in 2017 during a fence check. No plants have been observed since 2020 in this site and the shady habitat along with thick uluhe may be suppressing regeneration. |
| *Setaria palmifolia* | Lower‘Ōpae‘ula-SetPal-01 | There is one site of this taxon close to the Weather Port and it was first discovered in 2017 just outside the fence. About 10 *S. palmifolia* plants were found that time. A few months later, the *S. palmifolia* spread along the fence line. About 20 mature and 40 immature plants were found and treated. On recent checks, there have been few to no plants. This species is a high priority for control, as *S. palmifolia* is a highly invasive grass that is not found throughout the MU. *S. palmifolia* is effectively controlled through foliar application using Ranger Pro, water, and a pre-emergent pesticide. Seed heads are removed and bagged. |

## Incipient Weed Photos

Mature *Rhynchospora caduca*

## Ecosystem Management Weed Control

All weed control geared towards general habitat improvement is tracked in geographic units called Weed Control areas, or WCAs. The goals, strategies, and techniques used vary between WCAs, depending on terrain, quality of native habitat, and presence or absence of rare taxa.

MIP Goals:

- Within 2 m of rare taxa: 0% alien vegetation cover except where removal causes harm.
- Within 50 m of rare taxa: 25% or less alien vegetation cover
- Throughout the remainder of the MU: 50% or less alien vegetation cover

Management Objectives:

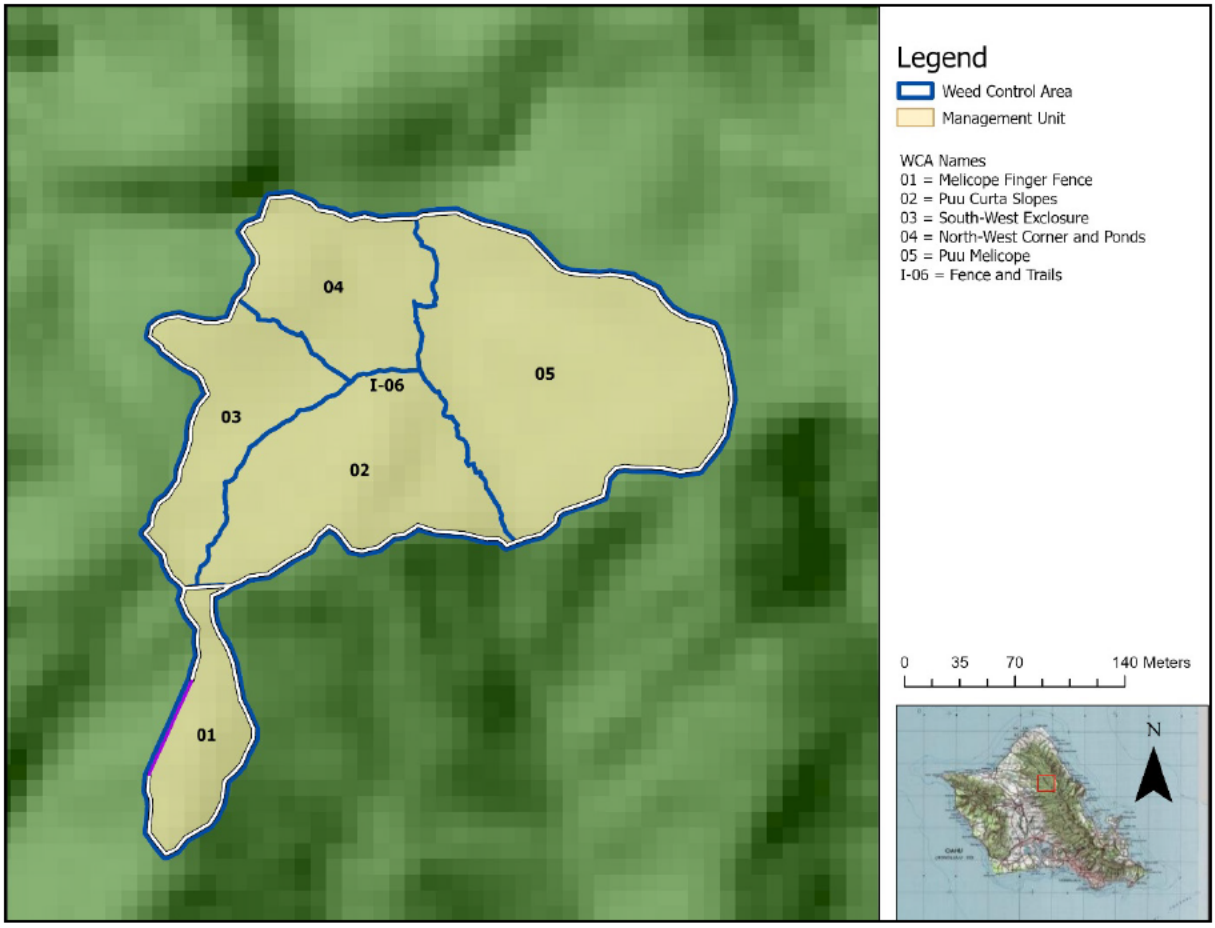
- Focus weeding around *Gardenia mannii* and *Cyrtandra dentata* populations to expand suitable native habitat.
- Maintain 50% or less alien vegetation cover in the understory across the MU.
- Reach 50% or less alien canopy cover across the MU in the next 5 years.
- In WCAs within 50m of rare taxa, work towards achieving 25% or less alien vegetation cover in understory and canopy.
- Modify weeding efforts if population monitoring indicates weed control efforts are not contributing to stable population growth.

Discussion:

ANRPO weed control at ʻŌpaeʻula Lower is focused on reducing alien vegetation encroachment on the populations of *C. dentata* and *G. mannii*, however T2/T3 OIP taxa also benefit from weeding throughout the MU. The major weed threats in the MU are *P. cattleianum* and *M. crenata*, which have the potential to form dense monotypic stands, and are a dominant presence in other areas of the Koʻolau Mountains. Recently, larger scale vegetation restoration projects have focused on removing large stands of *P. cattleianum* from directly around rare plant sites and high-quality habitat. This has mostly been performed in WCA 04 near camp and in WCA 03 near the *in-situ C. dentata* population. Due to changes in program restoration strategies, common natives may not be available to plant in this area for the near future. While planting may not occur soon, staff will be use of seed sows, divisions and transplants. Clearing operations will continue focused on stands of guava around native canopy trees, especialy *M. polymorpha* and *S. sandwichenses*. Another priority for weed control in ʻŌpaeʻula will focus on conducting ground sweeps across all portions of the MU where the more intact native forest patches are, targeting *Angiopteris evecta, Sphaeropteris cooperi, Citharexylum cadatum,* and other weeds (listed in the Summary Target Taxa table). The entire MU has been divided into Weed Control Areas (WCAs) to assist in tracking and scheduling control efforts. WCAs will be weeded on a rotational basis given the difficulty of access, terrain, and limited staff resources. The WCAs that are most accessible have the gentlest terrain, the rarest resources, and the fewest weeds or the highest possibility for positive returns will be prioritized for control.

The table below summarizes invasive weeds found at ʻŌpaeʻula Lower, excluding ICA species. While the list is by no means exhaustive, it includes the species targeted/prioritized for control. The distribution of each taxon is estimated as: Widespread (moderate to high densities of individuals, common across MU), Scattered (low densities across all or much of the MU), or Restricted (low or high densities, all in one discrete location).

## Weed Control Areas Map




## Summary of Target Taxa:

| Taxa | Distribution | Notes |
|---|---|---|
| *Angiopteris evecta* | Scattered | Incidental observations of *A. evecta* around the MU have been made. Plants seen should be GPSed and removed manually or with herbicide. The adjacent gulches are infested with this taxon, which feed spores into ʻŌpaeʻula Lower. Control is a high priority. Control any plants found during regular weed sweeps using Garlon 4 or Polaris (for large mature plants). Also control plants seen outside the MU, if near the fence. Conduct aerial surveys as needed to guide ground treatments. |
| *Ardisia elliptica* | Scattered | Not common in the MU but is found in high numbers along the Poamoho trail road and at the Connex LZ. Staff should remain vigilant for this species and control it as it is found. |
| *Blechnopsis orientalis* | Scattered | *B. orientalis* has yet to be found in the MU however, it scattered through most of the Koʻolau range. If found in the MU, this species is unlikely to cause any significant habitat change. It also responds well to mechanical treatments. |
| *Citharexylum caudatum* | Scattered | Trees are scattered across MU and the presence of numerous seedlings and saplings point to an increase of this taxa within ʻŌpaeʻula Lower. While not as prone to forming monotypic stands as *P. cattleianum*, this taxon should be controlled due to it having bird dispersed seeds and its aggressive competition with native shrubs and trees. |

| Taxa | Distribution | Notes |
|---|---|---|
| *Heliocarpus popayanensis* | Scattered | Not generally found in the MU in any significant number. Staff should make sure to be aware of the potential for finding this species. *H. popayanensis*, if left to establish, can become highly problematic. |
| *Lantana camara* | Widespread | One large patch was at campsite in ʻŌpaeʻula Lower-04 and has since been controlled. *L. camara* is scattered throughout the MU and should be targeted when weeding through the MU. |
| *Leptospermum scoparium* | Unknown | Not known in ʻŌpaeʻula Lower at this time, however, vigilance is important in keeping it out of the MU. *L. scoparium* is commonly found in the areas adjacent to this MU and the seeds are wind dispersed. There are known and managed ICAs along the Poamoho road. If found in the MU, it would be a priority for control and will be an ICA. |
| *Megathrysus maximus* | Scattered | One population treated at campsite in ʻŌpaeʻula Lower-04. While the habitat here is a little wet for this grass, its habitat-altering characteristics make it a control priority. Target when seen in MU. Possibility for eradication. |
| *Miconia crenata* | Widespread | Widespread throughout the MU. *M. crenata* has the potential to grow into monotypic stands. ANRPO targets this taxon around rare taxa and restoration sites. This species is typically the dominant weed species to colonize newly cleared zones and is very difficult to completely remove. |
| *Paspalum conjugatum* | Widespread | Found around the campsite, ponds and restoration zones in ʻŌpaeʻula Lower-03 and 04. *P. conjugatum* is controlled around the campsite, trails, and around rare taxa. Ranger Pro for Aquatic use is applied around the Weather Port and camp DZ to control *P. conjugatum*.<br>Fusilade sprayed around rare taxa to control *P. conjugatum* in the past but is now not labeled for forestry use. ANRPO will benefit greatly from the relabeling of this product for forestry use. |
| *Pterolepis glomerata* | Widespread | This melastome is ubiquitous across the Koʻolaus. It thrives in disturbed areas, particularly pig wallows. The further removed from pig exclusion the MU becomes, the more open sites are filling in with other weedy species, thinning *P. glomerata* slightly. Staff do not currently target it for control. Hopefully aided by general ecosystem weed control, native vegetation will colonize *P. glomerata* zones. |
| *Psidium cattleianum* | Widespread | Patches scattered across ʻŌpaeʻula Lower. Primary target of WCA sweeps for isolated stands in the more native and intact forest patches. In the Koʻolaus, *P. cattleianum* take on a multi-trunked clump form and have the proclivity for slash to re-sprout. The largest and thickest stands tend to be in gulches and draws. A cocktail of Garlon 4 (25%) and Milestone (1%) is most effective. |
| *Psidium guajava* | Widespread | *P. guajava* is found in relatively low numbers around the MU. This taxon does however create large canopies so targeting this species should be done when staff have adequate plants to fill newly opened canopy or around large ʻōhiʻa and koa. |
| *Sphaeropteris cooperi* | Scattered | Scattered individuals in the middle of the MU, especially in ʻŌpaeʻula Lower-03. Lower ʻŌpaeʻula has perfect habitat for *S. cooperii*, and many immature plants have already been removed from the MU. Few large, mature individuals have been found. Due to its documented invasiveness, it is a priority for control. The most effective control method is to cut stump with no herbicide application. |
| *Trema orientalis* | Scattered | Generally found during ecosystem weeds on a very infrequent basis. Staff have never found more than one at a time with sizes ranging from 6-10 inches from base to apical tip. Staff will continue to monitor incursion of *T. orientalis* and control where found; staff will also remain vigilant for any matures. |

Restoration activities are discussed in the notes section for each WCA. The table below contains specific notes on what native taxa and what type of stock may be appropriate for restoration projects at ʻŌpaeʻula Lower.

**Taxa Considerations for Restoration Actions**:

| Native Taxon | Outplant? | Seedsow/ Division/ Transplant? | Notes |
|---|---|---|---|
| *Acacia koa* | Yes | Seed sow* | Tree. Fast growing. Grow from seed. Recruits well in areas with known seed bank. |
| *Alyxia stellata* | No | Seed sow | Vine or subshrub. Grow from seed. Recruits well in areas with known seed bank. |
| *Cheirodendron trigynum* | Yes | No | Tree. Moderately fast growing. |
| *Cibotium* spp. | Yes | Transplant | Tree fern. Grow from spore. Can transplant if needed from fence line/trails. |
| *Clermontia kakeana* | Yes | Seed sow | Shrub. Grow from seed, scatter/smear when mature fruits encountered in field. |
| *Dianella sandwicensis* | Yes | Division | Herb. Grow from seed. Can also do divisions in field if needed. |
| *Freycinetia arborea* | Yes | Seeds sow | Liana. Grow from seed. Should trial seed sows. |
| *Ilex anomala* | Yes | No | Tree. Grow from seed. Seeds short-lived in storage. |
| *Metrosideros polymorpha* | Yes | No | Tree. Grow from seed. This includes all varieties. |
| *Microlepia strigosa* | Yes | Division | Fern. Grow from spore. Can also do divisions in field if needed. |
| *Phyllostegia grandiflora* | Yes | Transplants? | Liana. Grow from seed if possible. Can trial transplants or direct cuttings. |
| *Polyscias oahuensis* | Yes | No | Tree. Grow from seed. |
| *Pipturus albidus* | No | Seed sow | Shrub or Small Tree. Fast growing. Can do seed sows. Consider planting longer lived tree species in understory, planning for senescence. |
| *Psychotria* spp. | Yes | No | Tree. Grow from seed. |
| *Sadleria cyatheoides* | Yes | No | Fern. Grow from spore. |
| *Scaevola* spp. | Yes | Seed sow | Shrub. Grow from seed. Should trial seed sows in cleared areas. |
| *Wikstroemia oahuensis* | Yes | No | Shrub. Grow from seed. Transplant attempts failed. |

*Will experiment with seed sows to test for efficacy; plans to expand are dependent on results.

**WCA: ʻŌpaeʻulaLower-01 (Melicope Finger Fence)**

Veg Type: Wet Montane

OIP Goal: Less than 25% alien cover around rare plants. Less than 50% alien cover elsewhere.

Targets: All woody species, particularly *Psidium cattleianum, Miconia crenata,* and *Citharexylum caudatum*.

Notes: This is the southernmost WCA and encloses a declining *Melicope lydgatei* population. The majority of this WCA is dominated by *D. linearis*, with some *M. polymorpha* and *A. koa* overstory. Most of the weeds (*M. crenata, P. cattleianum* and *C. caudatum*) are concentrated at the southern tip of the WCA near the stream bottom and low-lying areas. This area was under consideration for additional *G. mannii* reintroduction with the hope of replicating wild sites and other successful reintroductions in West Range in *D. linearis* dominated habitat. This planting is on hold pending the result of the nurse log

plantings in ʻŌpaeʻulaLower-03. Weed control will concentrate on *M. crenata* and *C. caudatum* removal around rare taxa locations and native forest patches every 3-5 years. If it becomes appropriate to reintroduce *G. mannii* here, weeding efforts in WCA 01 will be increased.

**WCA: ʻŌpaeʻulaLower-02 (Puʻu Curta Slopes/Ridge)**

Veg Type: Wet Montane

MIP/OIP Goal: Less than 25% alien cover around rare plants. Less than 50% alien cover.

Targets: All woody species, particularly *P. cattleianum* and *M. crenata*.

Notes: Rare plants in this WCA include *C. dentata*, *M. lydgatei* and *E. gaudichaudii*. This WCA encompasses northern slopes of Puʻu Curta where the vegetation is predominantly native, with a heavy *D. linearis* understory. Weed control will focus on *P. cattleianum* and *M. crenata* around rare taxa sites in the lower parts of the WCA. This WCA also contains the main landing zone for the MU, as well as a *Rhynchospora caduca* ICA along the southwest fence line. The focus in this WCA is to minimize alien cover around the *C. dentata*. Staff will utilize spotters when conducting weed sweeps in native areas that are dominated by *D. lineraris* to minimize damage to this important ground cover. These sweeps are scheduled once every 3-5 years. Weed sweeps around the *C. dentata* are scheduled annually. Additionally, weeding canopy species should done carefully as the light gaps allow grasses and *M. crenata* to grow quicker and increased light levels could be detrimental to *C. dentata*.

**WCA: ʻŌpaeʻulaLower-03 (South-West exclosure)**

Veg Type: Wet Montane

OIP Goal: Less than 25% alien cover around rare plants. Less than 50% alien cover elsewhere.

Targets: *S. cooperi* and *A. evecta.* All woody species, particularly *P. cattleianum, C. caudatum*, and *M. crenata.*

Notes: The flatter areas of this WCA contain large stands of nearly monotypic *P. cattleianum* and *M. crenata.* Targeted removal of *P. cattleianum* and *M. crenata* began in 2021, west of the in-situ population of *C. dentata*. Removal of *P. cattleianum* will continue around native dominated forest patches, with the intention of opening area around *M. polymorpha* to promote their long-term survival. Mature and immature *S. cooperi* and immature *A. evecta* have also been observed in the WCA and will be controlled on weed sweeps once every 3-5 years. This WCA has an abundance of native species in some areas, including *M. polymorpha*, *A. platyphyllum*, and *C. platyphyllum* in the canopy, and *W. oahuensis*, *P. hathewayi*, and *Cibotium* spp. in the understory. Rare plants in this WCA include *C. dentata* (wild) and a *S. kaalae* var. *sherffii* (reintroduction). In November of 2022, staff established a reintroduction of *C. dentata* to augment the existing wild population. Since ANRPO does not manage *S. kaalae* var. *sherffii*, ANRPO will coordinate with the Oʻahu Plant Extinction Prevention Program on weeding efforts around the *S. kaalae* var. *sherffii*. Photopoints to document changes in vegetation after weeding have been set throughout the WCA.

**WCA: ʻŌpaeʻulaLower-04 (North-West Corner and Ponds)**

Veg Type: Wet Montane

OIP Goal: Less than 25% alien cover around rare plants. Less than 50% alien cover.

Targets: All woody species, particularly *P. cattleianum*, *Psidium guajava*, *C. caudatum*, and *M. crenata. P. conjugatum*, *M. maximus*, and *L.* will be targeted at the campsite and around the ponds.

Notes: This WCA is easy to access and weed sweeps can be conducted over the entire area. The "little" pond is in this WCA, which maintains an open area of a native aquatic fern and seasonal wetland weeds. This is the only area that will not be swept and will remain weedy. Weed sweeps covering the entire WCA will focus on select weed species, such as *A. evecta*, *C. caudatum*, and *S. cooperi* once every 3-5 years. Weed sweeps around the *G. manii* reintroduction site are scheduled annually and the focus is to control *P. cattleianum* and *M. crenata*. Other weeds including *P. conjugatum*, *M. maximus,* and *L. camara to* be targeted at the campsite and around the ponds. The western half of the WCA contains high amounts of native vegetation, including *W. oahuensis*, *Alyxia stellata, F. arborea*, and *A. platyphyllum*. Photo points to document changes in vegetation after weeding are monitored yearly and are located near the main pond. This WCA was the first area targeted for restoration work. Minimal restoration efforts in this WCA began in 2017 (ANRPO YER Restoration 2018). *C. kakeana* have been outplanted around the *G. mannii* reintroduction site. In March of 2023 an experimental out planting of *G. manii* was established near the existing reintroduction site. Plants in 2-inch pots were planted into nurse logs. When controlling weeds in the WCA, staff will pay special attention to this site as plants get established, conducting follow-up watering through the summer if needed.

**WCA: ʻŌpaeʻulaLower-05 (Puʻu Melicope Slopes/Fence line/Blue Puʻu Curta trail)**

Veg Type: Wet Montane

OIP Goal: Less than 50% alien cover elsewhere.

Targets: All woody species, particularly *P. cattleianum*, *P. guajava*, *C. caudatum*, and *M. crenata.*

Notes: This WCA contains a high percentage of native vegetation, including *D. linearis*, *M. polymorpha*, *A. koa,* and *F. arborea.* A part of the gulch along the trail dividing WCA 02 and 05 and has potential as a restoration site and/or additional rare taxa reintro sites. There is a *M. lydgatei* rare plant population on the southern fence line. Sweeps will be conducted to remove canopy weed species, every 3-5 years, across the WCA. Spotters with binoculars will be utilized to direct targeted weed control to minimize damage to *D. linearis*. Two large non-native palms in this WCA need to be identified and controlled. Understory weed control will be concentrated around the rare taxa and native forest patches.

**WCA: ʻŌpaeʻulaLower-06 (Infrastructure: Fence and Trail maintenance)**

Veg Type: Wet Montane

OIP Goal: N/A

Targets: *P. cattleianum*, *P. guajava*, *C. caudatum*, *M. crenata*, and alien grasses.

Notes: This WCA was created to track all maintenance of infrastructure including the main trails, LZs, Weatherport/camp, and the fence lines. The main trails are important to keep maintained since they are used as WCA boundaries, and to minimize spread of weeds throughout the MU. Coordinate with Vegetation Management Program Coordinator to identify best locations around fence line where T could be used to spread into the larger area.

## Small Vertebrate Control

Species: *Rattus rattus* (Black rat), *Rattus exulans* (Polynesian rat), *Mus musculus* (House mouse), *Herpestes auropunctatus* (Mongoose).

Threat level: High for *Rattus* spp. for *Cyrtandra dentata*. Unknown for *Gardenia mannii* and *Drosophila* spp.

Seasonality/Relevant Species Biology: Spikes in rodent population are often observed in other MUs following the fruiting season (about twice a year) of *P. cattleianum*, then followed by a return to normal activity levels. It is assumed rodent activity follows similar patterns in this MU, however, rodent monitoring is not conducted here.

Management Objectives:

- Mitigate threat of rodent activity to managed plants.
- Monitor managed taxa for rodent damage

Strategy and Control Methods:

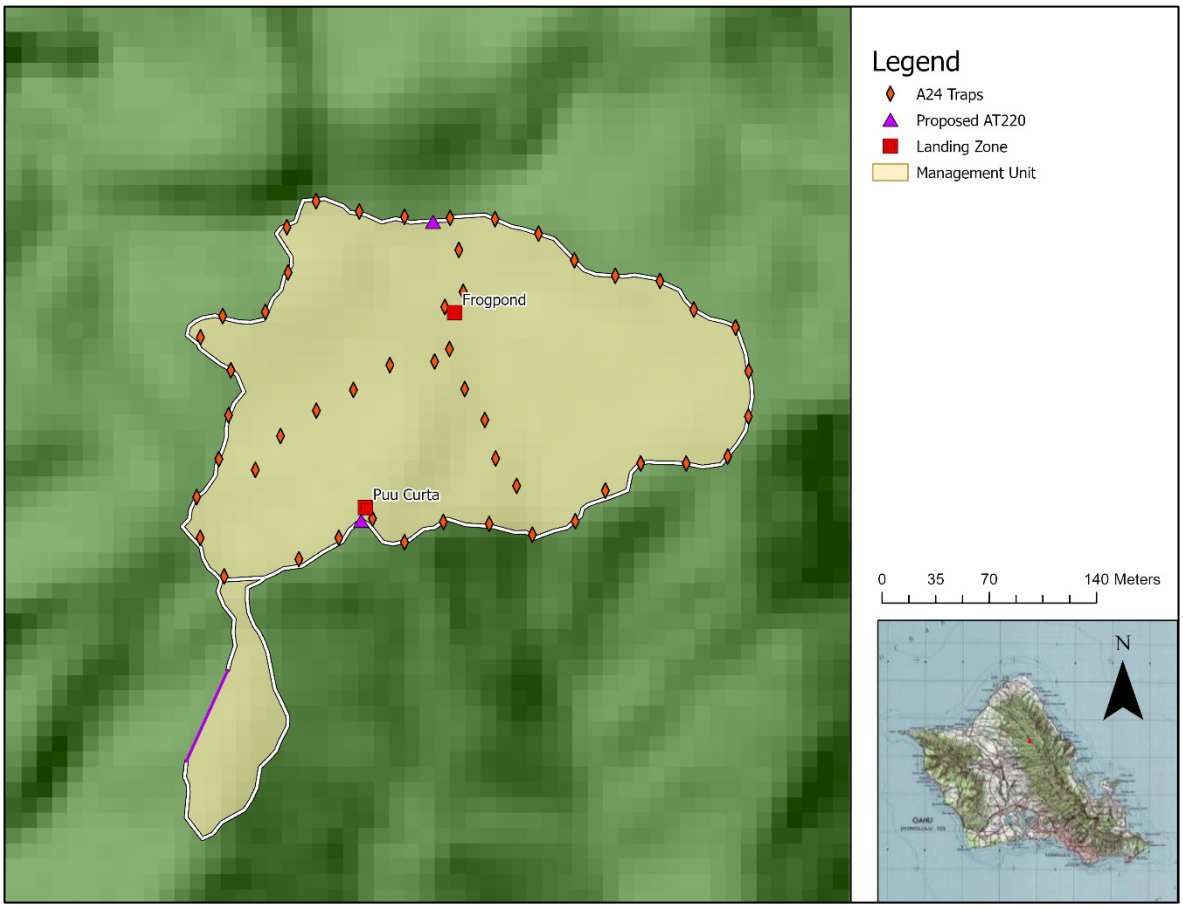
- Active GoodNature A24 (50) grid across the MU. Traps are deployed every 20 m along trails and the perimeter fence line.
- Monitor MIP/OIP rare plant (*C. dentata* and *Gardenia mannii*) populations, as well as other native species.

Discussion:

Formerly, rodent control was only conducted around the *C. dentata* reintroduction site using Victor snap traps. All Victor snap traps were replaced with GoodNature A24s to protect *C. dentata* year-round. Since this MU is relatively small in area, ANRPO created a GoodNature A24 trapping grid encompassing the whole MU excluding the *Melicope* finger, since there are no IP species located there.

ANRPO staff check A24s every 4 months. Deploying several AT-220 traps has been discussed and they may be deployed when more traps become available in 2024. This would provide additional rodent control and decrease mongoose and feral cat presence in the MU. In other MUs, mongoose have skewed or interfered with tracking data, however there is no rodent tracking taking place in ʻŌpaeʻula Lower MU currently. Should it be deemed necessary to collect this data, mongoose/feral cat control may become necessary.

# Small Vertebrate Management Map



## Ant Control

Species: *Solenopsis papuana* (Detected in August 2018)

Threat Level: High for endangered *Drosophila*.

Seasonality/Relevant Species Biology: Varies by species.

Management Objectives:

- Prevent spread of ant species into areas where not already established. Conduct annual surveys during the summer to determine what ant taxa are present in the MU.
- Implement control if incipient, high-risk species are found or if needed for *Drosophila* conservation.
- Detect incursions of new ant species and implement control strategies to reduce likelihood of establishment.

Strategy and Control Methods:

- Sample ants at human entry points using the standard survey protocol (Plentovich and Krushelnycky 2009) and *Drosophila* sites a minimum of once a year (see table below). Use samples to track changes in existing ant densities and to alert ANRPO to any new introductions.
- If incipient species are found and deemed to be a high threat and/or easily eradicated locally (<0.5-acre infestation), implement control strategies.
- Sample ants at campsite, LZ and Drosophila sites.

Discussion:

Surveying for ants at this MU was conducted twice in 2015 and 2016 around the campsite, no ants were detected. However, during *Drosophila* monitoring by the program's entomologist, *S. papuana* were observed at the *D. substenoptera* monitoring sites. *S. papuana* is a known threat to *Drosophila* populations and can reduce survival by as much as 58% (Krushelnycky *et al.* 2017). If present, this species could be locally controlled using Amdro (or other insecticides registered for forest use). ANRPO plans to conduct annual ant surveys at the Pu'u Curta LZ and the *D. substenoptera* monitoring sites.

**Ant Survey Site Table**

| Site description | Reason for survey |
|---|---|
| Pu'u Curta LZ | High risk of accidental ant introduction. |
| Frog Pond DZ and Weatherport | High risk of accidental ant introduction with camp gear. |
| *Drosophila substenoptera* area | *Drosophila* are sensitive to high ant abundance. |

**Ant Management Map**

# Image Redacted
# Sensitive Information
# Available Upon Request

ARMY NATURAL RESOURCES PROGRAM O'AHU

## Slug Control

Species: *Deroceras leave, Meghimatium biliniatum,* and *Limax maximus*

Threat level: High for *Cyrtandra dentata*.

Seasonality/Relevant Species Biology: Slugs are seasonally abundant during the wet season (September-May). However, due to the already wet environment in ʻŌpaeʻula Lower, slug population numbers can be sustained throughout the dry season.

Management Objectives:

- Control slugs locally to increase likelihood of germination and survival of *C. dentata*.
- Conduct annual census monitoring of T1 OIP rare plant taxa to look for seedling recruitment and slug herbivory.
- Pay close attention to *G. manii* planted in nurse logs for slug damage. Though plants rarely produce seed in either *in-situ* or reintroductions, slugs are strongly suspected to be a threat, especially to smaller plants.

Strategy and Control Methods:

- Slug Control Areas (SLCAs) around rare taxa locations were surveyed in 2015 and cleared for molluscicide use in the *C. dentata* site due to the absence of native snail species.
- FerroxxAQ is applied to these SLCAs once a quarter. FerroxxAQ is not applied within 20 m of known populations of native snails; however, surveys have indicated that no native snails are located in the MU.
- If new sites for rare plant reintroductions are chosen outside of the existing SLCAs, the areas will be surveyed by experienced malacologists for native snails prior to application of FerroxxAQ, per the Pre-Application Survey Protocol.

Discussion:

Based on sampling at the *Cyanea superba* subsp. *superba* seed sow trial sites, slugs are present, but not abundant, at this site (Appendix 4-4 ANRPO 2017). However, due to the low *C. dentata* recruitment, ANRPO controls for slugs around the *C. dentata* population using the molluscicide FerroxxAQ. Our current management action is to treat rare plant sites with molluscicide every quarter rather than every six weeks due to difficulties with site access. To date, direct slug herbivory to *C. dentata* has not been observed and quarterly application is believed to be sufficient to mitigate this threat. The recently planted *G. manii* will continue to be closely monitored for slug damage. Any findings of herbivory will trigger native snail surveys and mapping of the area for the creation of another SLCA for *G.manii*.

**Slug Control Area Locations Table**

| SLCA Code | Plant population reference codes | Date slug control begun |
|---|---|---|
| OPA-A | *C. dentata* (OPA-F, H) | 2016, 2023 |
| OPA-B | *G. manii* | NA |

**Slug Management Map**

# Image Redacted
# Sensitive Information
# Available Upon Request

ARMY NATURAL RESOURCES PROGRAM O'AHU

# Ecosystem Restoration Management Plan

## MIP Year 15-19, Oct. 2023 – Sept. 2028

## MU: Pahole

### Overall MIP Management Goals:

- Form a stable, native-dominated matrix of plant communities which support stable populations of IP taxa.
- Control ungulate, weed, invasive invertebrate, rodent, fire, and other threats in the next five years to allow for stabilization of IP taxa.

## Background Information

Location: Northern Waiʻanae Mountains

Landowner: State of Hawaiʻi (State)

Land Managers: State of Hawaiʻi: Natural Area Reserves System (NARS), Army Natural Resource Program - Oʻahu (ANRPO)

Acreage: 215 acres

Elevation Range: 1,500-2,400 ft.

Description: Pahole MU is the most western of three main gulches located in the Pahole Natural Area Reserve (NAR). Pahole NAR is managed by ANRPO, along with the State, so actions can be coordinated that are complementary to each other while avoiding any redundancy and confusion. Going from west to east within the NAR, the major gulch systems include Pahole, Kapuna, and Keawapilau. Kahanahāiki MU borders the west and Mākua Military Reservation borders the south of Pahole MU. The Pahole MU itself is divided into five gulches. When facing South, these five gulches are shaped like a left handprint, with Gulch 1 representing the thumb (see picture below). Gulch 1 ends in the main Waiʻanae Summit ridge separating Pahole from Kahanahāiki, Gulches 2 and 3 reach back to the Mākua rim, and gulches 4 and 5 end at the ridge that separates Pahole from Kapuna. The Pahole MU as a whole is diverse mesic forest and contains numerous rare taxa. The south-eastern section of Pahole contains many wild and reintroduced endangered MIP plant sites. The most intact native habitat is found above Gulches 2 and 3, while the weediest areas are in gulches 4 and 5. Pahole MU can be accessed two ways: through the gulch via Mokulēʻia Forest Reserve Access Road (a.k.a. Pahole Rd. or from the ridge via the Kahanahāiki overlook trail.

**Map of Pahole showing gulch system**

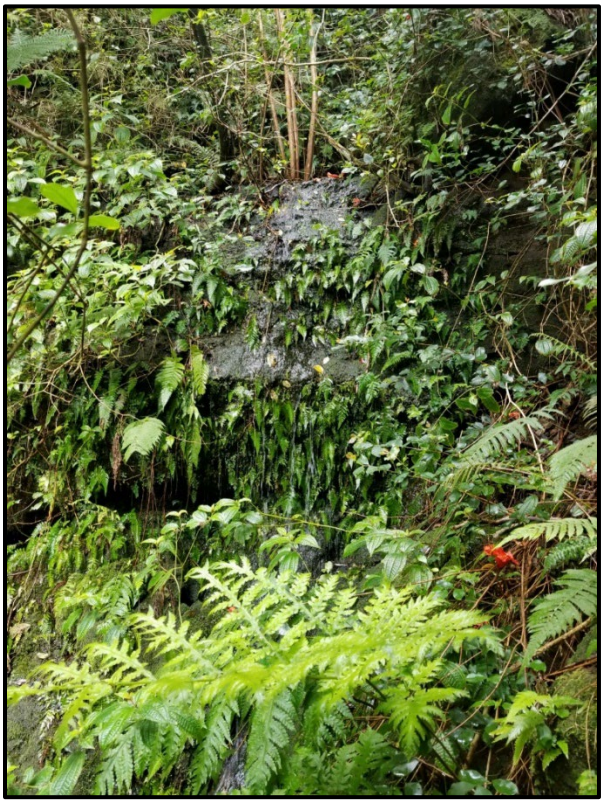
# Image Redacted
# Sensitive Information
# Available Upon Request

**Native Vegetation Types**

| Wai'anae Vegetation Types | | |
|---|---|---|
| Mesic mixed forest | Mesic ridge/crest | Canopy includes: The canopy is dominated by *Acacia koa* and/or *Metrosideros polymorpha.* Other canopy associates include *Psychotria* spp., *Antidesma platyphylum*, *Bobea elatio*r, and *Santalum freycinetianum* var. *freycinetianum*.<br>Understory includes: *Microlepia strigosa*, *Odontosoria chinensis*, *Alyxia stellata,* and *Coprosma* spp. |
| | Mesic slope | Canopy includes: *Diospyros sandwicensis*, *Diospyros hillebrandii, Sapindus oahuensis*, *Notelaea sandwichensis*, *Planchonella sandwicensis*, *Antidesma platyphylum*, and *Ceodes* spp.<br>Understory includes: *A. stellata*, *Psydrax odorata*, and *Bidens* spp. |
| | Mesic gulch | Canopy includes: *Ceodes* spp., *Charpentiera tomentosa*, *Psychotria* spp, and *D. hillebrandii*<br>Understory includes: *Diplazium sandwicensis*, *Microlepia strigosa* and *Tectaria gaudichaudii*, *Freycinetia arborea*, *Touchardia glabra*, *Pipturus albidus*, and *Coprosma* spp. |
| NOTE: For MU monitoring purposes vegetation type is mapped based on theoretical pre-disturbance vegetation. Alien species are not noted. | | |

**Terrain and Vegetation Types at Pahole**

Pahole gulch from Kahanahāiki/Pahole trail crossover (looking south).



Mesic gulch

## MIP/OIP Rare Resources at Pahole

| Organism Type | Species | Pop. Ref. Code | Population Unit | Management Designation | Wild/ Reintroduction |
|---|---|---|---|---|---|
| Plant | *Alectryon macrococcus* var. *macrococcus* | PAH-A*,B*,F*,G* | Kahanahāiki to West Makaleha | MFS | Wild* |
| Plant | *Cenchrus agrimonioides* var. *agrimonioides* | PAH-A,B,C,D,E*,F,T | Kahanahāiki and Pahole | MFS | Both |
| Plant | *Cyanea grimesiana* subsp. *obatae* | PAH-A*,B,C,D | Pahole to West Makaleha | MFS | Both |
| Plant | *Cyanea longiflora* | PAH-A,B*,C*,G*,H*,I,J | Pahole | MFS | Both |
| Plant | *Cyanea superba* subsp. *superba* | PAH-A,B | Pahole to Kapuna | MFS | Reintroduction, Wild* |
| Plant | *Cyrtandra dentata* | PAH-A,B,C,D,E,F,G | Pahole to Kapuna to West Makaleha | MFS | Wild |
| Plant | *Delissea waianaeensis* | PAH-B,C,E, F** | Kahanahāiki to Keawapilau | MFS | Both |
| Plant | *Euphorbia herbstii* | PAH-E*,F,G,H*,I*,R, S | Kapuna to Pahole | MFS | Both |
| Plant | *Flueggea neowawraea* | PAH-A*,C,D,E | Kahanahāiki to Kapuna | MFS | Both |
| Plant | *Kadua degeneri* subsp.*degeneri* | PAH-A,B | Kahanahāiki to Pahole | MFS | Wild |
| Plant | *Nototrichium humile* | PAH-A* | Pahole | GSC | Wild |
| Plant | *Phyllostegia kaalaensis* | PAH-A*,B* | Pahole | MFS | Reintroduction* Wild* |
| Plant | *Plantago princeps* var. *princeps* | PAH-A | Pahole | GSC | Wild |
| Plant | *Schiedea kaalae* | PAH-A*,B*,C*,D*,E*,F | Pahole | MFS | Reintroduction Wild* |
| Plant | *Schiedea nuttallii* | PAH-A,B,D,E | Kahanahāiki to Pahole | MFS | Both |
| Plant | *Schiedea obovata* | PAH-A*,C,D,E | Kahanahāiki to Pahole | MFS | Reintroduction Wild* |
| Snail | *Achatinella mustelina* | ESU-A | Kahanahāiki to Pahole | MFS | Wild |

MFS= Manage for Stability *= Extirpated **= Seed Sow
GSC= Genetic Storage Collection

## Other Rare Taxa at Pahole

| Organism Type | Species | Status |
|---|---|---|
| Plant | *Acacia koa* | SOC |
| Plant | *Antidesma pulvinatum* | SAR |
| Plant | *Asplenium dielfalcatum* | Endangered |
| Plant | *Asplenium kaulfussii* | SAR |
| Plant | *Bidens torta* | SAR |
| Plant | *Bobea brevipes* | SAR |
| Plant | *Bobea sandwicensis* | SAR |
| Plant | *Bonamia menziesii* | Endangered |
| Plant | *Charpentiera tomentosa* | SAR |
| Plant | *Claoxylon sandwicensis* | SAR |
| Plant | *Ctenitis squamigera* | Endangered |
| Plant | *Cyrtandra waiolani* | Endangered |
| Plant | *Diospyros hillebrandii* | SAR |
| Plant | *Dissochondrus biflorus* | SAR |
| Plant | *Exocarpos gaudichaudii* | SAR |
| Plant | *Geniostoma kaalae* | SAR |
| Plant | *Gouania meyenii* | Endangered |
| Plant | *Gynochthodes trimera* | SAR |
| Plant | *Isodendrion laurifolium* | Endangered |
| Plant | *Lobelia yuccoides* | SAR |
| Plant | *Lysimachia hillebrandii* | SAR |
| Plant | *Melicope cornuta var. decurrens* | Endangered |
| Plant | *Melicope makahae* | Endangered |
| Plant | *Melicope sandwicensis* | SAR |
| Plant | *Neraudia melastomifolia* | SAR |
| Plant | *Nothocestrum longifolium* | SAR |
| Plant | *Paratrophis pendulina* | SOC |
| Plant | *Phyllostegia kaalaensis* | Endangered |
| Plant | *Phyllostegia kaalaensis* | Endangered |
| Plant | *Phyllostegia parviflora var. lydgatei* | Endangered |
| Plant | *Polyscias kavaiensis* | SAR |
| Plant | *Pritchardia kaalae* | Endangered |
| Plant | *Pritchardia martii* | SAR |
| Plant | *Pteralyxia macrocarpa* | Endangered |
| Plant | *Rumex albescens* | SAR |
| Plant | *Santalum ellipticum* | SAR |
| Plant | *Sapindus oahuensis* | SAR |
| Plant | *Scaevola gaudichaudiana* | SAR |
| Plant | *Silene perlmanii* | Endangered |
| Plant | *Solanum sandwicense* | Endangered |
| Plant | *Stenogyne kaalae subsp. kaalae* | SAR |
| Plant | *Touchardia oahuensis* | SOC |
| Plant | *Urera kaalae* | Endangered |

SAR= Species at Risk SOC= Species of Concern

**Rare Resources at Pahole**

*Euphorbia herbstii*

*Kadua degeneri* subsp. *degeneri*

*Cyanea longiflora*

*Schiedea obovata*

**Locations of Rare Resources at Pahole**

# Image Redacted
# Sensitive Information
# Available Upon Request

**Threats to MIP/OIP MFS Taxa**

| Threat | Rare Taxa Affected | Management Strategy | Current Status, 2023 |
|---|---|---|---|
| Pigs | All | Fence | No animals within fence. |
| Weeds | All | Focus on rare taxa sites primarily, across MU secondarily. Plan effort complimentary with the State in the form of corresponding actions | Regular maintenance required several times per year. Weeds are both an understory and canopy threat across whole MU. |
| Black Rat | *Achatinella mustelina*, *Cyanea grimesiana* subsp. *obatae*, *Euphorbia herbstii*, *Cyanea longiflora*, *Cyanea superba* subsp. *superba*, *Delissea waianaeensis* | Localized grids near select resources | Trap grids maintained by State Native Ecosystems Protection and Management (NEPM). |
| Black twig borer (BTB) *Xylosandrus compactus* | *F. neowawraea*, *A. macrococcus* var. *macrococcus* | Monitor. Research new control methods. | Effective methods for control not available at this time. *A. macrococcus* var. m*acrococcus* was impacted but is no longer extant in MU. |

| | | | |
|---|---|---|---|
| Jackson's Chameleon | *Achatinella mustelina*, *Drosophila montgomeryi* | Predator-proof snail enclosure | No viable tools to control outside snail enclosure. No Jackson's Chameleons have been captured or observed in Pahole to date. The State, represented by the Snail Extinction Prevention Program (SEPP), maintains the snail enclosure. |
| Slugs | *Cyanea grimesiana* subsp. *obatae*, *Euphorbia herbstii*, *Cyanea longiflora*, *Delissea waianaeensis*, *Schiedea nuttallii*, *Schiedea obovata* | Molluscicide treatment at chosen rare taxa sites. | FerroxxAQ, a molluscicide is applied every 6 weeks to control slugs. |
| Rosy Wolf Snail | *Achatinella mustelina* | Predator-proof snail enclosure | No viable tools to control outside snail enclosure. State staff maintain the Pahole Snail Enclosure, which therefore is not discussed in this plan. ANRPO staff will assist the State with maintnenace as requested. |
| Ant | *Drosophila montgomeryi, Achatinella mustelina* | Survey rare taxa sites, and human entry point. Areas that have high risk of accidental ant introduction | Annual surveys conducted. Treatment options are being explored. |
| Vespula | *Drosophila montgomeryi* | No Control | |
| Introduced Galiformes | *Cyanea superba* subsp. *superba*, *D. waianaeensis, S. nuttallii* | No control currently. However, control to possibly be studied and developed. | *Pternistis erckelii* and *Lophura leucomelanos* are known to damage *D. waianaeensis* stems and eat leaves, fruit, and FerroxxAQ. Control should be investigated. |

## Management History

- 1981: Established as a NAR by the Governor's Executive Order 3098.
- 1989: First weeding begins by the State of Hawai'i Division of Forestry and Wildlife (DOFAW)
- 1996: First recorded rare plant monitoring by ANRPO.
- 1998: Pahole MU fence completed.
- 1998: Snail enclosure built.
- 1999: All pigs were removed by NARS.
- 2000: Initial CenAgrAgr.PAH-A reintroduction
    - Augmented: 2003, 2004, 2006, 2008 (2 separate out plantings), 2016, 2017
- 2000: Initial CyaSupSup.PAH-B reintroduction
    - Augmented: 2001
- 2001: Initial CyaSupSup.PAH-A reintroduction
    - Augmented: 2001 (after initial), 2004, 2008 (2 separate out plantings), 2009, 2010, 2011
- 2002: ANRPO begins extensive weed control in addition to previous small-scale efforts.
- 2003: Fire started in Mākua reaches 150m from the western portion of the MU.

- 2003: Initial CyaGriOba.PAH-C reintroduction
    - Augmented: 2003 (after initial), 2007, 2008 (2 separate out plantings), 2010, 2011, 2020, 2023
- 2003: Initial SchObo.PAH-D reintroduction
    - Augmented: 2006, 2007, 2008, 2009, 2011, 2023
- 2004: Initial SchNut.PAH-D reintroduction
    - Augmented: 2006, 2007, 2008 (2 separate out plantings), 2010, 2011, 2012, 2019, 2020, 2021 (2 separate out plantings),
- 2004: Initial PhyKaa.PAH-B reintroduction. Extirpated 2010
- 2006: Several small pigs breach the fence and were able to breed before detection.
- 2006: Initial EupHer.PAH-R reintroductions into gulch 3 around in-situ EupHer.PAH-G
    - Augmented: 2007 (2 separate out plantings), 2008 (2 separate out plantings), 2010, 2011, 2012, 2019, 2021, 2022
- 2006: Initial CenAgrAgr.PAH-D reintroduction
    - Augmented: 2008 (2 separate out plantings)
- 2006: Initial EupHer.PAH-R reintroduction
    - Augmented: 2007, 2008 (2 separate out plantings), 2010, 2011, 2012, 2019, 2021, 2022
- 2006: Initial SchKaa.PAH-E reintroduction. Extirpated 2017
- 2006: Initial SchObo.PAH-E reintroduction. Extirpated 2022
- 2007-2008: ANRPO partners with NARS to conduct herbicide trials on silky oak (*Grevillea robusta)*.
- 2007: Initial DelWai.PAH-C reintroduction
    - Augmented: 2007 (after initial), 2008 (2 separate out plantings), 2010, 2011, 2012, 2021, 2022
- 2007: Initial SchKaa.PAH-C reintroduction. Extirpated 2021
- 2007: Initial SchNut.PAH-E reintroduction
    - Additional individuals out planted: 2008 (2 separate out plantings), 2010, 2011, 2012, 2013
- 2008: All pigs removed after breach in 2006. A total of 23 pigs were removed via snares.
- 2008: Initial CenAgrAgr.PAH-F reintroduction
    - Augmented: 2008(after initial), 2011, 2019
- 2008: Initial CyaGriOba.PAH-D reintroduction
    - Augmented: 2008(after initial), 2010, 2011
- 2009: Rat, snail, and slug monitoring began as a part of the Kahanahāiki trap out study.
- 2012: Fence supplemented with skirting and Fickle Hill Deer Fence to prevent smaller piglets from breaching.

- 2012: Initial FluNeo.PAH-D reintroduction
    - Augmented: 2013, 2014, 2017
- 2013: DOFAW begins distribution of *Psidium cattleianum* biocontrol agent, *Tectococcus ovatus*, a scale insect.
- 2014: ANRPO continues work with *D. waianaeensis:* .
    - *D. waianaeensis* seed sow trial begun
    - DelWai.PAH-D reintroduction extablished. Extirpated 2021
    - DelWai.PAH-F reintroduction established. Extirpated 2017
- 2015: Initail EupHer.PAH-S reintroduction into gulch 2 around *in-situ* EupHer.PAH-F population
    - Augmented: 2018, 2019, 2020.
- 2016: The State releases Pahole NAR Management Plan
- 2017: Mokulēʻia fire burns within 1500m north of MU.
- 2018: Initial CyaLon.PAH-J reintroduction into gulch 2.
    - Augmented: 2020
- 2019: Initial SchKaa.PAH-F reintroduction
    - Augmented: 2020 (2 separate outplantings)
- 2019: NEPM begins reconstruction of Pahole Snail Enclosure.
- 2021: First MU wide vegetation monitoring.
- 2023: Initial FluNeo.PAH-E reintroduction into gulch 2.

* All reintroductions mentioned above were conducted by ANRPO

## Ungulate Control

Species: *Sus scrofa* (pigs)

Threat Level: High

Management Objectives:

- Maintain MU as ungulate free.
- Prevent ungulate ingress into enclosure.

Strategy and Control Methods:

- Exclusion of all ungulates from MU via large-scale fencing. The PAH-A fence was completed in 1998.
- Supplemented with skirting and Fickle Hill Deer Fence to prevent smaller piglets from breaching fence in 2012.
- Conduct quarterly fence checks.
- Note any pig sign while conducting day to day actions within fenced MU.
- If any pig activity is detected, work with the Ungulate Manager to implement hunting, snaring, or traping program.

Discussion:

There is a perimeter fence around this 215-acre MU with one major gulch crossing. The major threats to the perimeter fence include fallen trees and vandalism. There have been relatively few incidences of vandalism in the past; most of the fence damage is caused by fallen trees. At the gulch crossing there is a corrugated swing gate barrier which is constructed in such a way to allow water to pass under without opening access to pigs. It also makes repairs to the stream section of the fence convenient if there is an extreme flash flooding event. Three sides of Pahole are protected by shared fences with other pig-free or ungulated managed areas: Kahanahāiki, Kapuna, and Mākua. Mākua to the west is not ungulate free. Kapuna to the south is ungulate free, with the most recent incursion into the unit in 2022 which was caught in a snare. Control is ongoing at these sites. Kahanahāiki to the west of the MU has been ungulate free for many years. These fences add extra protection to the Pahole MU; only leaving the north side directly exposed to ungulate pressure.

Quarterly checks (including maintenance) of the fence's integrity will be conducted, as well as monitoring for ungulate sign concurrently with other field activities. Fences are also checked after extreme weather events. Special emphasis will be placed on monitoring the swing gate anytime there is an extreme amount of rainfall in the area. Given the moderate size of the fence, it is especially important to maintain the unit as ungulate free. As with any large MU, it would take a great effort to remove ungulates once inside the unit.

# Weed Control and Vegetation Restoration

Weed Control actions are divided into 4 subcategories:

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

These designations facilitate different aspects of MIP/OIP requirements.

## Vegetation Monitoring

Past Actions

Vegetation monitoring across Pahole NAR was first completed by Patricia Welton, a University of Hawai‘i Graduate student, using 25 400 $m^2$ circular relevé plots. The State's Pahole NAR Management Plan (2016) summarizes this study, identifying three possible native/non-native vegetation regimes:

● Native Vegetation - Native plants are dominant and there is 60% or more of native tree canopy cover

● Mixed Native/Non-Native - Native and nonnative species are co-dominant

● Nonnative – Mixed native/nonnative associations as well as forests dominated by nonnative species. Non-native species dominant in these areas include the following: Java Plum Forest, Eucalyptus, Silk Oak, Koa Haole, Strawberry Guava, and Kukui Forest.

In 2018, a student from the University of Hawai‘i began locating and monitoring the thirty-year old plots to compare vegetation changes since the last reading. However, only a subset of plots within Pahole MU were located, and analyses of vegetation change within the MU using such a small sample size are dubious. Since then, the State approved ANRPO plans to implement large scale MU-based vegetation monitoring.

Belt Plot monitoring

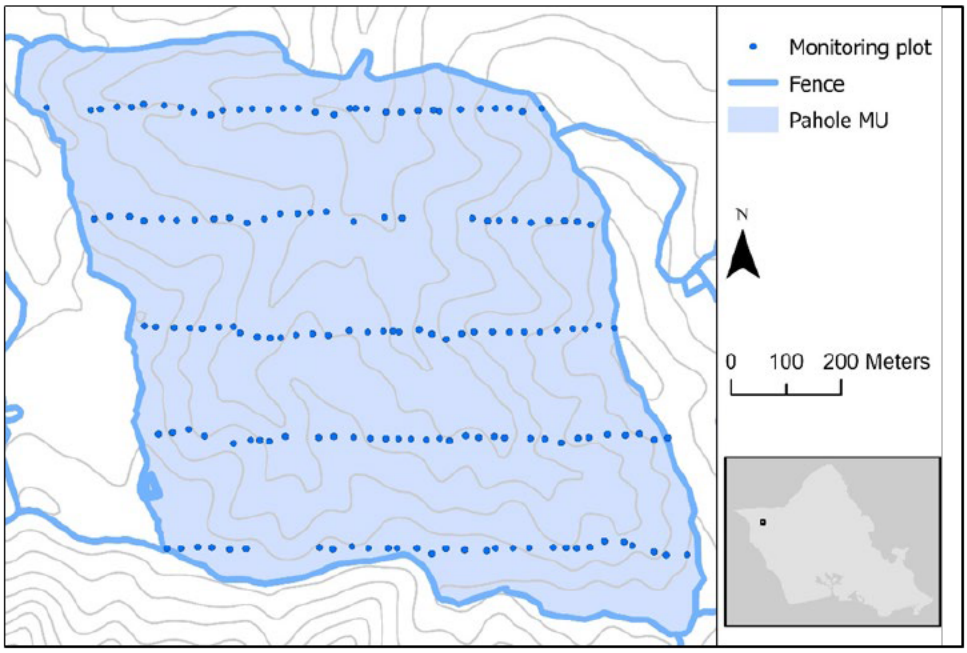
*Background*

Vegetation monitoring at Pahole MU occurs on a five-year interval in association with MIP/OIP requirements for long term monitoring of vegetation composition and change over time. The primary objective of MU monitoring is to assess if the percent cover of non-native plant taxa 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.

*Methods*

Baseline monitoring was conducted in 2021 in 155 plots, with plots generally located every 30 m along transects. Transects were spaced approximately 200 m apart within accessible portions of the MU. Vegetation was recorded by percent cover for all non-native and native species present. Summary percent cover by vegetation type (shrub, fern, and grass/sedge) in the understory, and overall summary percent cover of non-native and native vegetation in the understory and canopy, were also documented. Monitoring will next occur in 2026.

**Pahole MU Vegetation Monitoring Plot Locations**




*Summary results*

Management goals were met for non-native understory in 2021. Goals were not met for native understory, native canopy and non-native canopy. The extent to which management goals are applicable to this MU are debatable, as the habitat is heavily degraded, and weed control and restoration efforts are limited.

**Median cover (%) of vegetation in plots from 2010 to 2020**

| 2021 | |
|---|---|
| **Native understory** | **7.5 %** |
| **Non-native understory** | **45%** |
| **Native canopy** | **7.5%** |
| **Non-native canopy** | **95%** |

Weedy expansion of *P. cattleianum*, *G. robusta*, *T. ciliata*, *S. terebinthifolius*, *C. hirta*, *P. suberosa*, and *B. appendiculatum* have been challenging to control, even in ANRPO MUs with relatively high levels of vegetation management. These taxa, with the exception of *T. ciliata* and *P. suberosa*, are already widespread at Pahole, and are expected to get worse. Of particular concern is *T. ciliata*, which had low frequencies in the understory and canopy, but is likely to become a serious invader in the coming years if it is not controlled. As weed cover increases, native cover is expected to decline. Because limited vegetation management occurs at the MU, overall conditions are likely to deteriorate.

Some smaller scale positive aspects for the MU are that remnant high value native-dominated areas still remain in some areas (albeit these areas are patchy and not connected, which presents further management challenges), and areas with intensive vegetation management are seeing positive impacts. During monitoring, evidence of the biocontrol agent (*Tectococcus ovatus*, released by NEPM) for *P. cattleianum* was observed to have spread to several locations in the MU, which holds promise for reduced *P. cattleianum* recruitment while stunting plant growth in the coming years.

*Recommendations*

Progress towards meeting management goals is challenging, even in smaller MUs with better habitat and intensive vegetation management such as the adjacent Kahanahāiki MU. Given the highly degraded condition of the habitat and limited vegetation management at Pahole, progress towards meeting

management goals is unlikely to occur without massive effort, landscape level actions, and extensive collaboration with NEPM. Based on the results of vegetation monitoring, a number of recommendations were made with the aim of making progress towards improving habitat and mitigating the spread of problematic weeds in prioritized areas, particularly those with rare plants, to be discussed and coordinated with the NARS program:

- Continued general ecosystem weeding and grass control around rare plants and in prioritized areas
- Continued ICA control
- Considerations should be made for how to manage the inevitable invasion of *T. ciliata*. IPA control has not slowed its spread at Makaha, Manuwai, or Kaluaa and Waieli MUs, though it was already well established in those MU (all with canopy frequencies above 30%) when sweeps were conducted. Based on its current limited distribution, control efforts may be effective in preventing its spread. Aerial imagery may be one effective means of locating areas for control.
- Add *A. columnaris*, *C. falcatum*, *Phoenix* sp., *T. ciliata*, and *T. semitriloba* to the limited distribution target taxa weed list for Pahole MU, and consider adding *S. cumini* if more effective control measures are developed
- Consider sweeps for limited distribution target weeds, consider which WCAs or portions of WCAs are a priority for such sweeps, with a focus on taxa with low frequencies, perhaps aided by imagery and/or aerial surveys
- Consider management options and strategies for *G. robusta*. Targeted IPA sweeps have been very effective at controlling this taxon where it occurred in lower frequencies in other MUs. Given how widespread it is at Pahole, and prevalence of other non-native canopy taxa, determine to what extent and where it is a priority, and partner with NEPM to control if it is a priority for them, also.
- Release *T. ovatus* for biocontrol of *P. cattleianum* in areas where it has not yet been released or dispersed naturally, to get biocontrol more widely established in the MU
- Focus restoration actions to create more suitable habitat for rare plants and complement NEPM restoration efforts, to possibly include expanded efforts in the Gulch 2 area, areas adjacent to Kahanahāiki (possibly including the area between Puʻu 2210 and the Bill Garnett site), and along the Mākua rim. This will realistically be limited to 1 or 2 areas given limited time, funding, and priorities being greater in other MUs.
- Meet with NEPM to discuss monitoring results and determine how to address these results together, particularly management strategies for *T. ciliata* and *G. robusta*, discuss their management plans for the coming years, and discuss their priority management areas if there have been or will be any changes to them. Also discuss the monitoring interval, and the extent to which this will be a useful tool for tracking MU-scale change/decline over time. Discuss the possibility of efforts to manage low cover invasive species via grants from the Readiness and Environmental Protection Integration program, which funds management work in areas abutting military lands to improve environmental conditions on military land.

Since the time these recommendations were made NREM has conducted multiple large-scale restoration efforts in Pahole. A large-scale outplanting was conducted in 2022 in WCA Pahole-01, with 251 common natives outplanted amongst the existing DelWai.PAH-C population, in 2023 a large common native outplanting of 320 species were planted into WCA Pahole-03 amongst an existing in-situ EupHer.PAH-G and augmented EupHer.PAH-R population and FluNeo.PAH-E out-planting site.

## Surveys

Potential Vectors: ANRPO activity, hikers/hunters, pigs/goats, alien birds, wind, researchers, contractors (Snail enclosure construction), partner agencies.

Management Objective:

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

Strategy and Control Methods:

- Note unusual, significant, or incipient alien taxa during the course of regular field work. Map and complete Target Species form to document sighting.
- Drive Mokulēʻia Access Trail (Pahole Road), from the bottom gate to the Nike site annually. GPS roads driven to document extent of survey in a given year. The ANRPO Blue Team is responsible for this action, although use of the road is shared by many within and outside of the program.
- Survey one weed transect annually. This includes the access trail from the parking area to the Gulch 2/3 split.
- Quarterly surveys of the Nike site and Kahanahāiki overlook LZs (if used).
- Any significant alien taxa found will be researched and evaluated for distribution and life history. If found to pose a major threat, control will begin and tracked via ICAs.

Discussion:

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

In Pahole, one road survey is conducted on the paved section of the Mokulēʻia Access Trail (Pahole Road). Although the ANRPO Blue Team is responsible for conducting this survey, many use this road as a thoroughfare or for recreational activities (hiking, biking, exercising, etc.). For this reason, the possibility of spreading unwanted weeds near and/or into the unit is high. In addition to road surveys, the road is sprayed with herbicide as needed to maintain visibility around tight corners as well as keep unwanted weeds off the road to prevent them from spreading.

One weed transect survey is done annually, which covers the main access trail along the gulch bottom. Part of the survey starts outside the management unit and continues into the unit, which could help as a comparison as to what can be found inside versus outside the fence.

The Nike site is used on occasion as an LZ to access Ohikilolo, Mākua, and other nearby LZs. The LZ will be surveyed once a quarter, if used. There are no camp sites in Pahole.

**Survey Locations Map**

# Image Redacted
# Sensitive Information
# Available Upon Request

## Incipient Taxa Control

All weed control geared towards eradication of a particular invasive weed is tracked via Incipient Control Areas, or ICAs. Each ICA is species-specific and geographically defined. One infestation may be divided into several ICAs or one ICA, depending on infestation size, topographical features, and land ownership. Some ICA species are incipient island-wide and are a priority for ICA management whenever found. Others are locally incipient to the MU, but widespread elsewhere. In either case, the goal is eradication of the ICA. The goals, strategies, and techniques used vary between ICAs, depending on terrain, surrounding vegetation, target taxon, size of infestation, and a variety of other factors.

Management Objectives:

- Eradicate ICAs through regular and thorough monitoring and treatment. In the absence of any information about seed bank longevity for a particular species, eradication is defined as 10 years of consistent monitoring with no target plants found.
- Study seed bank longevity of ICA taxa, and revise eradication standards per taxon.
- Evaluate any invasive plant species newly discovered in MU and determine whether ICA-level control is warranted. Factors to consider include distribution, invasiveness, location, infestation size, availability of control methods, resources, and funding.

Strategy and Control Methods:

- Species and ICAs are listed in the table below. History and strategy are discussed for each species.

- Monitor the progress of management efforts and adjust visitation rates to allow staff to treat plants before they mature. Remember that one never finds 100% of all plants present.
- Use aggressive control techniques where possible. These include power spraying, applying pre-emergent herbicides, clearcutting, and frequent visits.

**Incipient Weed Photos**

*Pterolepis glomerata*

*Tecoma capensis*

*Elephantopus mollis*

*Chromolaena odorata*

## Summary of ICAs

| Taxon | ICA Code | Control Discussion |
|---|---|---|
| *Axonopus compressus* | Pahole-AxoCom-01 | Commonly known as carpet grass and is used for turf and pasture lands. Unusual to see in the forest setting, might have been an intentional planting. Medium size population located at the top of the Switchbacks near the water catchment and has recently been found in new areas along the trail. The population is recorded under the Kahanahāiki MU as an ICA. Recent control using a 2% concentration has shown little results. In the upcoming years we will be implementing new methods of control. New Control technique: Hand digging out, foliar spray with 0.58% Fusliade with added surfactant, if these techniques show little results a 1% foliar spray of Polaris will be used. |
| *Chromolaena odorata* | Pahole-Chrodo-01 | Commonly known as Devil Weed. An aggressive aster that is a pan-global weed of tropical areas. Only a single flowering-mature was found during a DelWai monitoring in 2021 in the Bill Garnetts site. Plant was manually removed from the field. Followed up with control efforts by conducting multi-day sweeps in efforts to finding targets within the vicinity of where the original plant found. Quarterly ICA checks are conducted. No targets have been seen since. |
| *Cryptostegia madagascariensis* | PaholeNoMU-CryMad-01 | Commonly known as rubber vine. A patch of 6 matures and 1 immature first found at this site along the Pahole Road, down in pasture lands below ranch gate on 7-16-09. More plants may be present on pastureland, but since they are far from the MU and access to private land may be difficult, control will be focused only along the road. Control technique: Clip and drip with 20% triclopyr and surfactant as needed to keep *C. madagascariensis* off of the road. |
| *Elephantopus mollis* | Pahole-EleMol-01<br>Pahole-EleMol-02<br>Pahole-EleMol-03 | Commonly known as soft elephant's foot. Aster from South America. Widespread in the Koʻolau mountain range, with very few locations in the Waiʻanae range. 1 immature plant was found in the middle of the Kahanahāiki/Pahole ridge fence trail in August of 2016. Another individual was found on Maile flats near the chipper site around the same time. None have been found along the ridge trail since the original sighting. However, sightings of *E. mollis* at both locations within the same time frame could suggest future incursion. Staff must be vigilant to prevent spread in the MU. High priority to control to prevent further spread of this species throughout the Waianae range. Control technique: hand pull, or clip and drip with 20% triclopyr and surfactant. |
| *Pterolepis glomerata* | Pahole-PteGlo-01 | Commonly known as false meadow beauty. Really aggressive weed that needs intense management and monitoring to eradicate. Widespread in the Koʻolau mountain range. Relatively few locations in the Waiʻanae range. First found at this site along the Mākua lookout trail. As *P. Glomerata* is in the family Melastomataceae, the taxon does have a very persistent seed bank, so use of pre-emergent is necessary. Control technique: hand pull, or foliar application with 2% glyphosate and water. Sulfomet (pre-emergent) should also be applied to the site at a minimum of twice per year, which may involve spraying bare ground. Control of surrounding weeds is essential to clear the search area and aid in detection. Effectively delimiting population and regular updating population area (occasional searching outside of known population) is critical in making sure populations don't expand unnoticed. In 2023 no plants were found in the ICA. |

| Taxon | ICA Code | Control Discussion |
|---|---|---|
| *Tecoma capensis* | Pahole-TecCap-01 | A prolifically growing vine, commonly known as Cape honeysuckle. *T. capensis* first found in February 2004 at this site along the south Kapuna/Pahole rim fenceline at the top of the ridge dividing gulch 2 and 3. *T. capensis* was last seen and controlled on 4-23-18. Potential for invasiveness has been observed elsewhere and is difficult to control. Staff suspect vegetative growth from roots left underground. Detection of small plants is also difficult in thick understory vegetation. Control technique: hand pull small individuals or clip and drip with 20% triclopyr and surfactant. Treat both ends if plant is stuck and growing up into a tree. A cocktail mixture of 1% aminopyralid, 2% triclopyr, and surfactant may also be used. Remove vegetative material from the field. |

ICAs Eradicated at MU: *Ehrharta stipoides* (Pahole-EhrSti-01, Pahole-EhrSti-02, Pahole-EhrSti-03, Pahole-EhrSti-04, Pahole-EhrSti-05; PaholeNoMU-EhrSti-01); Pahole-RhoTom-01, Pahole-DicChi-01, *Rubus argutus* (MMR-RubArg-05), *Albizia chinensis* (PaholeNoMU-AlbChi-01), *Setaria palmifolia* (PaholeNoMU-SetPal-01, Pahole-SetPal-01), *Cryptomeria madagascariensis* (PaholeNoMU-CryMad-01).

ICAs Discontinued at MU: *Triumfetta semitriloba* (Pahole-TriSem-01 and Pahole-TriSem-02) *Angiopteris evecta* (Pahole-AngEve-01, Pahole-AngEve-02, Pahole-AngEve-03, Pahole-AngEve-04, Pahole-AngEve-05, Pahole-AngEve-06, Pahole-AngEve-07, Pahole-AngEve-08)

**Pahole Incipient Control Areas Map**

**Image Redacted**
**Sensitive Information**
**Available Upon Request**

ARMY NATURAL RESOURCES PROGRAM O'AHU

## Ecosystem Management Weed Control

All weed control geared towards general habitat improvement is tracked in geographic units called Weed Control areas, or WCAs. The goals, strategies, and techniques used vary between WCAs, depending on terrain, quality of native habitat, and presence or absence of rare taxa.

MIP Goals:

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

Management Objectives:

- Work together with NEPM and NARS to define cohesive goals.
- Work towards making native canopy and understory dominant in rare plant areas, particularly reintroduction sites.
- Reduce grass cover in priority work areas.
- Reduce the frequency and cover of *S. campanulata* and *G. robusta*.

Discussion:

There are three separate access points in Pahole, one is located at the Mokulēʻia Nike Missile Site, another is located at the bottom of the Pahole gulch on the Pahole road, and the third (only occasionally used) is from the Mokulēʻia trail. Three of the WCAs (mauka) are accessed from either the Nike Missile Site or the Kapuna trailhead. The rest are accessed from the Pahole road. In 2013 NEPM released the bio-control *T. ovatus* for the control of *P. cattleianum* in the Pahole, the results of this release can be seen throughout the MU.

The vegetation in Pahole consists of weedy gulches (*P. cattleianum*, *C. hirta*, *R. rosifolius*, and non-native grasses) and intact native habitat on the ridges and North-facing mauka sections. Weed control in Pahole has mainly been around rare plant populations. Large scale *Toona ciliata* sweeps, and *G. robusta* trials have conducted by the State, as well as *Psidium cattleianum* removal by ANRPO. In recent years staff have noticed large *S.campanulata* in the gulches. If not controlled, rapid spreading and deep shading within the gulches can occur. *S.campanulata* is also wind dispersed, which could lead to greater repercussions if mature seeding trees are left within the unit. Staff have also recognized large *G. robusta* on ridges where many rare plant populations exist.

Results from the belt plot vegetation monitoring indicate that weed control methods have not met IP goals. Given the highly degraded condition of the habitat and limited vegetation management at Pahole, progress towards meeting management goals is unlikely to occur without massive effort, landscape level actions, and extensive collaboration with NEPM. Instead, efforts will focus on localized weed control around rare plant populations and small-scale common restoration. NARS staff and volunteers have been working in small restoration areas within the management unit, mainly in Pahole-01. ANRPO does not work in these restoration sites, however, habitat improvement efforts will help to work towards NARS management goals, as well as ANRPO goals. There has been one restoration site along the Kahanahāiki/Pahole ridge trail near a *C. agrimonioides* var. *agrimonioides* outplanting site. A total of 20 plants (*A. koa, K. affinis* and *M. lessertiana*) were planted in a small area (366 $m^2$) in December 2017 and are currently doing well.In addition, there has been a small restoration site in Gulch 3 near a *F. neowawraea* (FluNeo.PAH-E) and *E. herbstii* (EupHer.PAH-R) reintroduction.

The table below summarizes invasive weeds found at Pahole, excluding ICA species. While the list is by no means exhaustive, it includes the species targeted/prioritized for control. The distribution of each

taxon is estimated as: Widespread (moderate to high densities of individuals, common across MU), Scattered (low densities across all or much of the MU), or Restricted (low or high densities, all in one discrete location).

**Summary of Target Taxa:**

| Taxa | Distribution | Notes |
|---|---|---|
| *Acacia mearnsii* | Restricted | Located on the border of Kahanahāiki and Pahole at the top of the Schwepps trail. The population is recorded under the Kahanahāiki MU as an ICA. On both sides of the trail there is only a minute amount. |
| *Achyranthes aspera* | Localized | Small population located in the lower section of the Pahole NAR and in adjacent Kapuna upper MU. The objective is to keep it out of the Pahole MU by targeting this species when observed in WCAs. |
| *Blechnum appendiculatum* | Widespread | Groundcover found in wet areas and near rare plant populations. *B. appendiculatum* is spread vegetatively and by spore. It inhibits native recruitment with thick clump formation below native plants. ANRPO will control near rare plants to encourage recruitment. |
| *Araucaria columnaris* | Restricted | Along fencelines and Pahole Road up to the Nike site. Large woody tree species. Control by girdling or cut stump with 20% triclopyr. |
| *Cenchrus clandestinus* | Restricted | Known from one location on state land near the NIKE site. Population is not spreading, no seed produced. ANRPO will monitor to detect potential changes in behavior and work with State to determine level of control. |
| *Clidemia hirta* | Widespread | Widespread and often forming dense patches throughout the MU. Known to quickly invade and spread into canopy gaps. Control technique: Basal-bark or cut stump with 20% triclopyr, 80% biodiesel. Immatures can be hand-pulled. |
| *Cyrtomium falcatum* | Restricted | Known in a few locations in gulch bottoms. Tolerates many soil types and can produce vegetatively from rhizomes. There are no known control methods, however, many fern species are sensitive to Glyphosate. |
| *Grevillea robusta* | Widespread | Not targeted by ANRPO. NARS staff are currently treating large trees. Will continue communication with NARS staff to assess help needed. Control by girdling and IPA applications. |
| *Montanoa hibiscifolia* | Widespread | Known from multiple locations across MU, and appears to be widespread. Will be a targeted during weed sweeps at all weed control areas and all occurrences will be tracked via GPS. . |
| *Paspalum conjugatum* | Widespread | Commonly known as Buffalo grass, Hilo grass. Control is focused mostly along trails. Control with foliar application using 2% Glyphosate. |
| *Passiflora suberosa* | Localized | Observed on fenceline border of Kahanahāiki and Pahole. NARS staff has observed an incursion of *P. suberosa* throughout the MU and recent vegetation monitoring in neighboring Kahanahāiki and Kapuna shows an increase in frequency and distribution. Always target species during weed control efforts, use clip and drip method with 20% triclopyr or hand pull. |
| *Phoenix* spp. | Restricted | Anecdotally observed while vegetation monitoring in 2021. Phoenix is a genus of date palms found in diverse habitats. No efforts have been made to control *Phoenix* spp. |
| *Psidium cattleianum* | Widespread | Widespread and often forming dense patches throughout the MU. Control with cut stump method using 20% triclopyr. |
| *Oplismenus hirtellus* | Widespread | Commonly known as basket grass, control is focused mostly along trails. Control with foliar application using 2% Glyphosate. |
| *Rubus argutus* | Localized | One plant found on East rim of Pahole. Successful eradication at this site in May 2017 as an ICA (MMR-RubArg-05). Listed as a target since no longer considered an ICA. NARS staff have found more plants in their work areas and are actively controlling it. There is zero tolerance for this species within the NAR. |

| Taxa | Distribution | Notes |
|---|---|---|
| *Rubus rosifolius* | Widespread | Widespread and often forming dense patches throughout the MU. Known to quickly invade and spread into canopy gaps. Control manually, basal-bark or clip-and-drip with 20% triclopyr, particularly in areas sensitive to soil disturbance. |
| *Schinus terebinthifolia* | Widespread | Commonly known as Christmas berry, *S. terebinthifolia* is widespread and often forms dense patches throughout the MU. Especially abundant on southern-facing slopes. Control with 20% triclopyr using basal bark method. Large trees are controlled more effectively without cutting. |
| *Spathodea campanulata* | Localized | Found in gulch bottoms. Control during flowering season when large mature trees can be spotted from a far distance. IPA is an effective means for control. |
| *Sphaeropteris cooperi* | Restricted | Small infestation along gulch bottom trail. One mature found on 3-4-10 within the MU, but many individuals are North of the Nike site, outside the MU. Control by cutting if found during weed sweeps or opportunistically. |
| *Syzygium cumini* | Restricted | Along ridges within the MU. This is a tree species that has thick outer bark and is difficult to control. The most effective control method has been more than satisfactory using IPA with 100% aminopyralid on small trees. Large trees require manual removal. |
| *Tibouchina herbacea* | Restricted | One seedling was found by NEPM. If found again, this species would be of serious concern and control would be high priority as an ICA. As a member of the family Melastomataceae, the seed bank would likely be extremely persistent. |
| *Toona ciliata* | Widespread | Commonly known as Australian red cedar, *T. ciliata* is a fast growing, habitat-modifying tree that can produce a lot of seed and grow in high densities. It is a high priority for control. Target in canopy weed sweeps (including IPA) across higher elevation WCAs. Focus on large matures in lower elevations. Control technique: Cut stump or girdle with 20% triclopyr. Can also basal-bark immatures under 7.5 cm diameter with 20% triclopyr. Incision Point Application (IPA) with 100% imazapyr. |
| *Triumfetta semitriloba* | Restricted | Along Southern fenceline and gulch trailhead. This weed is spread by attaching its burred fruit to animals and humans. Control with clip and drip method using 20% triclopyr. Small plants can be manually removed. |
| *Zingiber zerumbet* | Restricted | One population along the trail to gulch 5, before SchKaa outplanting site. Used to be considered an ICA, but it is low priority for control and will be done opportunistically. |

Restoration activities are discussed in the notes section for each WCA. The table below contains specific notes on what native taxa and what type of stock may be appropriate for projects at Pahole. This is a lower priority MU for restoration actions.

**Taxa Considerations for Restoration Actions**:

| Native Taxon | Outplant? | Seed sow/ Division/ Transplant? | Notes |
|---|---|---|---|
| *Acacia koa* | Yes | Seed sow | Tree. Grow from seed. Recruits well in cleared areas with known seed bank. |
| *Bidens torta* | No | Seed sow | Herb. Grow from seed. Recruits well in areas with known seed bank. |
| *Carex wahuensis* | Yes | Seed sow | Sedge. Grow from seed. Seed sow in winter months to break dormancy quickly. |
| *Cibotium chamissoi* | Yes | No | Tree fern. Grow from spore. |
| *Coprosma foliosa* | Yes | No | Shrub. Grow from seed. |
| *Dianella sandwicensis* | Yes | Seed sow/ Division/ Transplant | Herb. Grow from seed. Divisions work well. |
| *Dodonaea visoca* | Yes | Seed sow | Shrub. Grow from seed. Should trial seed sows. |

| Native Taxon | Outplant? | Seed sow/ Division/ Transplant? | Notes |
|---|---|---|---|
| *Doodia kunthiana* | Yes | No | Fern. Grow from spore. |
| *Eragrostis grandis* | Yes | Seed sow | Grass. Grow from seed. Should trial seed sows. |
| *Hibiscus arnottianus* | Yes | No | Tree. Grow from seed when available. Cuttings also possible. |
| *Kadua affinis* | Yes | Seed sow | Shrub to small tree. Grow from seed. Should trial seed sows. |
| *Metrosideros polymorpha* | Yes | No | Tree. Slow growing. Grow from seed. This includes all varieties. |
| *Microlepia strigosa* | Yes | Division | Fern. Grow from spore. Divisions possible in mesic environments. |
| *Myrsine lessertiana* | Yes | No | Tree. Grow from seed. |
| *Notolea sandwicensis* | No | Transplant | Tree. Difficult to grow in greenhouse. Should try transplants. |
| *Pipturus albidus* | No | Seed sow/ Transplant | Small tree. Fast growing. Known to grow from seed sows. |
| *Ceodes spp.* | Yes | Seed sow/Transplant | Tree. Grow from seed when available. Cuttings also possible. Recruits well in areas with known seed bank. |
| *Psychotria spp.* | Yes | No | Tree. Grow from seed. |
| *Psydrax odorata* | No | Transplant | Tree. Grow from seed if possible. Fruits frequently bored by native moth larvae. Should trial transplants in field. |
| *Sapindus oahuensis* | Yes | Seed sow | Tree. Grow from seed. Should trial seed sows. |
| *Touchardia oahuensis* | Yes | No | Shrub. Grow from seed when available. Cuttings also possible and maybe more useful if tracking male/female. |

**Weed Control Areas at Pahole**

# Image Redacted
# Sensitive Information
# Available Upon Request

***Pahole-14 encompasses the entire MU to track all trail and fence weed control actions.

**WCA: Pahole-01 (Gulch 1)**

Veg Type: Mesic slope

MIP Goal: Less than 25% non-native cover

Targets: All weeds, focusing on *Schinus terebinthifolia*, *Psidium cattleianum*, *Montanoa hibiscifolia, R. rosifolius*, and *C. hirta*

Notes: This WCA encompasses Gulch 1 which includes the Kahanahāiki/Pahole crossover on the Northwest side of the MU to Puʻu 2210 and down the ridge to the gulch bottom. This is a large WCA, where priorities focus on understory and gradual control around rare plant taxa, grass control and canopy control. NEPM also conducts large scale restoration projects in adjacent areas of the WCA. There is a large patch of *Microlepia strigosa* in the area encompassing the *Delissea waianaensis* outplanting and controlling understory weeds may help this native understory expand. Habitat near the *Schiedea nuttallii* outplanting site is an intact native forest. Native canopy (*A. koa* and *M. polymorpha*) provides filtered light to support a thriving understory below (*S. nuttallii, Alyxia stellata, Kadua affinis, Asplenuim caudatum, Coprosma foliosa and Dianella sandwicensis*). Many areas along the rim just need periodic grass spray and minimal weeding of alien understory. A few small restoration sites are located in this WCA. A small restoration site on the main trail exists next to the *C. agrimonioides*/*S. obovata* outplanting. The Reintroduce of more common natives has been halted, however weed control in this area

will continue. Another small restoration area exists next to the *D. waianaensis* outplanting to provide better habitat for the outplants. This site is a short distance uphill from NEPM's Pisonia Flats restoration area and would be a good project to connect both sites. In 2022, a common native reintroduction took place within the *D. waianaensis* site. Weeding will continue here, around rare outplants, and the restoration area.

**WCA: Pahole-02 (Upper elevation Gulch 2)**

Veg Type: Mesic slope/ridge

MIP Goal: Less than 25% non-native cover

Targets: All weeds, focusing on *S. terebinthifolius*, *P. cattleianum*, *M. hibiscifolia, R. rosifolius*, and *C. hirta*.

Notes: This large WCA spans the north facing slope along the valley rim and includes the area from the Pahole Snail Enclosure to the *Kadua degeneri* subsp. *degeneri* population. The area surrounding the large *Cenchrus agrimonioides* var. *agrimonioides* outplanting site is native dominated and will be maintained. However, the surrounding area will require further weeding, including periodic grass spray, *B. appendiculatum,* and *P. cattleianum* control. *K. degeneri* subsp. *degeneri*, *Cyanea longiflora*, and *Plantago princeps* var. *princeps* are located on the eastern side of this WCA. Although portions of the WCA are dominated by native understory, there is a concern of removing too much canopy, allowing non-native and invasive canopy to move in. To mitigate this concern, outplants of *Acacia koa* will be considered following any significant canopy removal actions.

**WCA: Pahole-03 (Gulch 3 Eupher, Cyasupsup, Cenagragr, FluNeo)**

Veg Type: Mesic slope

MIP Goal: Less than 25% non-native cover

Targets: All weeds, focusing on *S. terebinthifolia*, *P. cattleianum*, *M. hibiscifolia*, *R. rosifolius*, and *C. hirta*.

Notes: This WCA spans the lower reaches of gulch 3, and is neighbor to Pahole-06 which spans the higher elevations of gulch 3. The WCA includes the gulch bottom *Cyanea superba* subsp. *superba* outplants, as well as *Euphorbia herbstii* outplants. The overstory consists mainly of large *P. cattleianum* stands and in most areas of the gulch, little light is able to penetrate through to the gulch bottom. Groundcover in the gulch is partially comprised of native taxa such as *M. strigosa*, *Asplenium macrei,* and *A. kaulfussii*. Control of non-native understory and ground cover, such as *Rubus rosifolius* and *B. appendiculatum* will promote seedling recruitment, especially for *C. superba* subsp. *superba* and *E. herbstii. M. hibiscifolia* will be targeted wherever seen in the gulch. With little to no recruit of *C. superba*, this population's priority has been lowered. This WCA also includes ridge habitat that divides the major gulches. The ridge dividing Gulches 2 and 3 includes the in-situ population of *C. agrimonioides* var. *agrimonoides* among other native grasses such as *Panicum nephilophilum*. In 2023, a population of *F. neowawraea* was reintroduced within the population of *E. herbstii.* Non-native grasses are also on the ridge, including *Melinis minutiflora.* Control is implemented as necessary and care is taken to reduce impacts to the native grasses if spraying is needed. Directly downslope of the *C. agrimonioides* var. *agrimonoides* population is a large stand of *P. cattleianum*. This should be replaced slowly with *A. koa* as weeds are removed, so as not to let *P. cattleianum* continually encroach upon the wild population. Continuing down this ridge in a southern direction is the *D. falcata*-PAH-A population. Weed control will focus on the various rare taxa sites described here. At the gulch bottom is the *C.superba* subs. *Superba* population augmented in 2001. This population currently still has a few

remaining individuals, but with its low recruitment numbers, it has been re-evaluated and gone down as a priority action. Restoration efforts began in this WCA in 2021 to buffer the edge of the *E. herbstii* population. Large *S. terebinthifolius* and *P. cattleianum* were removed, as well as standing dead *G. robusta*. Understory weeds like *R. rosifolius*, *S. australis* and *B. appendiculatum* were also controlled. In 2022 the first common native plant reintroduction occurred, there are no current plans for any additional reintroductions. The restoration area has a high percentage of native-canopy present; observations will be conducted to note percentage of native recruitment in areas that were cleared of dense *S.terebinthifolia*. Weed control in the restoration site will continue combined with target species sweeps will continue throughout the WCA, arget species sweeps throughout the WCA, focusing on *S.campanulata*, *M.hibiscifolia*, and *T.ciliata.*

**WCA: Pahole-05 (Gulch 4 and 5)**

Veg Type: Mesic Gulch

MIP Goal: Less than 25% non-native cover

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

Notes: The rare taxa in this WCA include , *C. agrimonioides* var. *agrimonoides* and *Cyanea grimesiana* subsp. *obatae*. *Phyllostegia kaalaensis* was reintroduced to gulch 4, but failed to maintain a population. *Schiedea kaalae* was reintroduced into Gulch 5, but like the *P. kaalaensis* in Gulch 4, failed to maintain a population. In Gulch 5 there are *C. grimesiana* subsp. *obatae* outplants in the gulch bottom. On the ridge between Gulches 4 and 5 is where the reintroduction population of *C. agrimonioides* var. a*grimonoides* are located. A small population of *Zingiber zerumet* is restricted to a small patch in Gulch 5. It is a target species and will be controlled as needed. In both Gulches 4 and 5 non-native taxa are the most dominant canopy species, including: *P. cattleainum*, *P. guajava*, *Aleurites molucanna* and *S. terebinthifolius.* The moist, dark gulch bottom is suitable habitat for *A. evecta*, other non-native ferns, and native ferns like *M. strigosa*. A mix of native and non-native shrubs exist in the gulch bottom including: *R. rosifolius*, *C. hirta*, *Buddleja asiatica*, and *Alyxia stellata*. Although there is a failed *P. kaalaensis* reintroduction in Gulch 4, other rare taxa can be found there, like *Cyrtandra dentata*. If *P. kaalaensis* is reintroduced to this site again, continual weeding of *R. rosifolius* and *B. appendiculatum* will be necessary, especially in the vicinity of the plants. Periodically *S.campanulata*, *M.hibiscifolia*, and *T.ciliata* are found in low densities near RP populations, targets are removed upon discovery. It would be prudent to target the non-native understory and then gradually aim towards non-native canopy removal. The goal in this WCA is to improve habitat by gradually controlling weedy understory and canopy without shocking area with major changes in light levels, especially around rare plant populations. In 2013, DOFAW released the bio-control *T. ovatus. S*ince its release *P.Cattlenium* throughout the MU are beginning to show signs of galls and infection. This is a promising sign, if *T. ovatus* proves effective at reducing *P.cattlenium* growth and fecundity this will allow NRM staff to reduce *P.cattlenium* numbers throughout the MU. The ridge dividing Gulches 4 and 5 has a reintroduced population of *C. agrimonioides* var. *Agrimonoides.*PAH-F. This is the only rare taxa in the immediate area, therefore the main focus of weeding is specific to this one population. Alien grasses are hand pulled near C. *agrimonioides* var. *agrimonoides* and grasses that are a safe distance away are sprayed. Continual weeding of *R. rosifolius* and *B. appendiculatum* is recommended. It would be prudent to target the non-native understory and then gradually work towards non-native canopy removal. Some of the canopy cover consists of non-natives, such as *P. cattleianum*, as well as native canopy, such as *A. koa*.

**WCA: Pahole-06 (Upper elevation Gulch 3/Cyalon-A and I)**

Veg Type: Mesic slope

MIP Goal: Less than 25% non-native cover

Targets: All weeds, focusing on *P. cattleianum R. rosifolius*, and *C. hirta*.

Notes: This WCA stretches from the eastern side of Gulch 3 up to the Pahole rim. This WCA is extremely sensitive due to steep, wet banks with *Cyanea longiflora,* a primary managed IP taxa, recruitment. Due to the sensitivity of the habitat, it is recommended that activities in the area, such as weeding (*P. cattleianum*) and plant monitoring, be coupled with plant collection trips to minimize the number of visits to the site. There are several pockets of native forest patches. Additional rare taxa in the WCA include populations of *C. longiflora*, *C. dentata*, one population of *S. nuttalii.* All of these plant populations are evenly dispersed among the WCA. The canopy consists of *M. polymorpha*, *A. koa*, *Cibotium glaucum*, *A. platyphylum*, and the understory consists of *A.stellata , Dicranopteris linearis*, *Asplenium ssp., Clidemia hirta*, and *B. appendiculatum*. Periodically *S.campanulata*, *M.hibiscifolia*, and *T.ciliata* are found in low densities near RP populations, targets are removed upon discovery.

**WCA: Pahole-12 (Gulch bottom/access trail)**

Veg Type: Mesic Gulch

MIP Goal: Less than 50% non-native cover

Targets: All weeds, focusing on *P. cattleianum*, *M. hibiscifolia*, *T. ciliata, R. rosifolius*, *C. hirta*, and *Triumfetta semitriloba*.

Notes: The WCA spans the main gulch bottom. There are no rare taxa within this WCA, but this large drainage is the most commonly used corridor that leads to the five gulches in Pahole, each of which contains rare managed taxa. The moisture of this gulch environment allows for a lush, generally native filled understory consisting of native ferns. One of the goals is to focus our attention on *M. hibiscifolius* sweeps, as well as searching for other target weeds including *T. ciliata*, *Triumfetta semitriloba,* and *Passiflora edulis*, which became a potential threat a year ago. Due to the fact that this gulch is the main pathway used to access the other gulches, it is pertinent to halt any further transport of the previously mentioned weeds by prioritizing treatment along these high-use corridors.

**WCA: Pahole-13 (Gulch 2 Eupher)**

Veg Type: Mesic Gulch

MIP Goal: Less than 25% non-native cover

Targets: All weeds, focusing on *P. cattleianum*, *M. hibiscifolia* and *C. hirta*.

Notes: *E. herbstii* PAH-F is managed within this WCA. *E. herbstii* growing in areas with open canopy or on slopes die more than plants with intermediate to closed canopies or in gulch bottoms, suggesting that drastic light changes are a concern in this WCA. Selective canopy control of *P. cattleianum* and *S. terebinthifolius* will be implemented to prevent major light changes around the *E. herbstii* population. Understory weeds such as *C. hirta, B. appendiculatum*, and *R. rosifolius* inhibit *E. herbstii* recruitment and frequent control is necessary. The bottom of Gulch 2 which includes Pahole-13 and Pahole-16 should be swept for *M. hibiscifolius*, *T. ciliata*, and *T. semitriloba* at least once a year.

**WCA: Pahole-14 (Fence line/trail)**

Veg Type: Mesic Gulch

MIP Goal: Less than 50% non-native cover

Targets: All weeds, especially those encroaching or breaching the fence line, focusing on non-native grasses (M. *maxima* and *M. minutiflora*), *P. cattleianum*, and *T. semitriloba*.

Notes: WCA 14 encompasses the entire Pahole fence including the Swing gate fence gulch crossing, it is important to maintain and clear the trails and fence line in this area that spans from gulch to ridge top. Target species such as *T. semitriloba* are removed if discovered on fence line/trail to avoid risk of NRM staff from spreading incipient species. Occasionally staff remove large fallen trees off the fence to maintain its integrity. Spraying grass and treating the thick invasive understory weeds will be done as needed in order to keep weeds at a manageable size and the fence clear for maintenance checks. WCA 14 also covers trail maintenance work throughout the MU.

**WCA: Pahole-15 (Gulch 2 Cyalon-J)**

Veg Type: Mesic slope/ridge

MIP Goal: Less than 25% non-native cover

Targets: All weeds, focusing on *S. terebinthifolia*, *P. cattleianum*, and *A. moluccana*.

Notes: This WCA spans the back of Gulch 2 where terrain is very steep. Large *A. moluccana*, *P. cattleianum* and *S. terebinthifolius* were cleared via intensive weeding for the most recent *C. longiflora* outplanting in Pahole. Selective removal of non-native trees, along with restoration efforts will be implemented at this site. A mix of native and non-native understory occurs in this WCA. Lack of light in the gulch bottom encourages fern growth including *Angiopteris evecta*. Control is being implemented at this ICA (Pahole AngEve-03) to prevent plants from reaching maturity. Target species sweeps are conducted annually throughout the WCA, focusing on *S.campanulata*, *M.hibiscifolia*, and *T.ciliata.*

**WCA: Pahole-16 (Gulch 2 Fluneo)**

Veg Type: Mesic Gulch

MIP Goal: Less than 25% non-native cover

Targets: All weeds, focusing on *P. cattleianum*, *M. hibiscifolia* and non-native grasses (*Oplismenus hirtellus*, *Paspalum conjugatum*)

Notes: *Fluggea neowawraea* is the managed taxa within this WCA and the reintroduction site is in the bottom of Gulch 2. Aggressive canopy control is necessary, since *F. neowawraea* has high light level requirements. As canopy species are removed non-native grasses, such as *O. hirtellus* and *P.conjugatum* need to be controlled regularly. Other understory species of concern are *C. hirta, B. appendiculatum*, and *R. rosifolius*, which should be controlled regularly. The bottom of Gulch 2, which includes Pahole-13 and Pahole-16 should be swept for *M. hibiscifolius*, *T. ciliata*, and *T. semitriloba* at least once a year.

**WCA: Pahole No MU-01 (Pahole Road)**

Veg Type: Mesic Forest

MIP Goal: N/A

Targets: Roadside weeds, focusing on M. *maxima*.

Notes: The goal of this WCA is to maintain the Pahole road and control/reduce of target weeds as a traffic safety issue. ANRPO staff sprays grass and herbaceous weeds along the road from Peacock Flats gate to the ranch gate as needed. Often, a power sprayer and weed whackers are used. These actions are shared between teams. Maintenance and weed control on other parts of the road occurs occasionally. It is

important to prevent spread of weeds on road, particularly since it is utilized by several organizations: ANRPO, State, HECO (Hawaiian Electric Company), Verizon Wireless, and HPD (Hawai‘i Police Department), as well as public hunters, and hikers.

**WCA: Pahole No MU-02 (Nike Site)**

Veg Type: Mesic Flat

MIP Goal: N/A

Targets: All weeds.

Notes: The goal of this WCA is to control weeds around the Nike site facility to prevent the spread of weeds to other areas. Weed control is focused around the LZ, ANRPO greenhouses, the upper building at Nike, and anywhere else needed. Some common weeds found on these WCA sites include: *P. cattleianum*, *P. guajava*, *S. terebinthifolius*, *R. rosifolius*, *C. hirta*, *Leucaena leucocephala*, *M. minutiflora*, M. *maxima* and *Erigeron karvinskianus.* ANRPO horticultural staff maintain this WCA with the help of the Green Team as needed

**WCA: Pahole No MU-03 (Cenagragr Reintro Outside Fence)**

Veg Type: Mesic Slope

MIP Goal: Less than 25% non-native cover

Targets: All weeds, focusing on *P. cattleianum* and grasses (*M. minutiflora*, *U. maxima*)

Notes: This WCA is located from Pahole Road (Nike building gate) to the Kahanahāiki/Pahole trail crossover. The managed rare taxa here are reintroduced *C. agrimonioides* var. *agrimonioides* and *S. obovata* in a steep terrain habitat. *S.obovata.*PAH-E population has been extirpated, *C. agrimonioides* var. *Agrimonioides.*PAH-D currently still has a stable population. The canopy is predominately *S. terebinthifolius* and is very open. The area is an exposed ridge top, and therefore, not much ground cover is present. Target understory and gradual canopy removal. As canopy species are removed non-native grasses, such as *M. minutiflora* and *U. maxima* need to be controlled regularly. Ungulate sign has never been observed near these rare plant populations. If ungulate sign is discovered mitigation efforts will be taken. This WCA spans the main trail and maintenance will be as needed. No ungulate sign has been observed around RP populations. If sign is detected ungulate control will be implemented.

**WCA: Pahole No MU-04 (Fig Gulch)**

Veg Type: Mesic Gulch

MIP Goal: Less than 50% non-native cover

Targets: All weeds, focusing on *M. hibiscifolius*, *T. semitriloba*, *P. cattleianum*, and *Achyranthes aspera*.

Notes: This WCA is located between the Pahole fence and the Pahole road. Any target species in this WCA should be killed including *M. hibiscifolius*, *T. semitriloba* and *A. aspera* to prevent these species from establishing and spreading into the MU. This area is fairly weedy with *M. hibiscifolia* and some *P. suberosa* intermixed along the slopes. The understory is comprised of mostly native taxa, *A. stellata* and *M. strigosa* and there are no rare taxa in the immediate area. Weed sweeps for *M. hibiscifolia* are on-going while conducting other MU actions and weed sweeps. Trail maintenance will be as needed for safe thoroughfare.

## Small Vertebrate Control

Species: *Rattus rattus* (Black rat), *Rattus exulans* (Polynesian rat), *Mus musculus* (House mouse), *Lophura leucomelanos* (Kalij Pheasant).

Threat Level: High threat from *Rattus spp.* to all members of the Campanulaceae including *Cyanea* and *Delissea* species. High threat to all *Schiedea* species. High for *A. mustelina.* Threat level unknown for *Lophura leucomelanos* (Kalij Phesant) on frugivory of Campanulaceae, but fruit consumption and physical stem damage have been documented on video.

Seasonality/Relevant Species Biology: ANRPO manages rats seasonally or year-round, depending on whether the rare taxa require protection seasonally or year-round. For example, *Achatinella mustelina* are protected from predation year-round with a small grid around the Pahole snail enclosure.

Management Objectives:

- Mitigate threat of vertebrate activity on managed plant and snail populations.

Strategy and Control Methods:

- Monitor rare plant (*C. superba* subsp. *superba*, *C. grimesiana*, *D. waianaeensis*, *E. herbstii*, *S. obovata*, *S. kaalae* and *S. nuttallii*.) populations, as well as other native species for evidence of rodent impacts.
- There are no immediate plans for a large-scale trapping grid in Pahole. If rodent damage on rare taxa is observed, staff will deploy a rapid response grid of Good Nature A24 traps.
- There are no plans to mitigate the effects of frugivory by *Lophura leucomelanos* (Kalij Phesant) and other non-native birds at this time, however ANRPO will continue to support research and monitor for impacts. If consistent impacts are seen, NEPM staff and develop a control plan.

Discussion:

Currently Goodnature A24 automatic rat traps currently is the most effective conservation tool for rodent control. The bait development of Goodnature A24's has vastly improved. The longevity has increased enough for ANRPO staff to check three times a year. Because of this new efficiency we may be able to expand protection to more areas for less cost. Currently there are no active A24 grids that is managed by ANRPO in Pahole MU. There is a smaller grid deployed around the Pahole NAR tree snail enclosure which is maintained every four months by SEPP (Snail Extinction Prevtion Program.

Additional rat control/research is ongoing at the Kahanahāiki MU which is directly adjacent to the Pahole MU. Previous studies on rodent birth control products were conducted at Kahanahāiki, which could have had a temporary spill over into the Pahole area. Monitoring fruit fate of *C. superba* subsp. *superba* during the 2009-2010 fruiting season revealed a high rate of rat predation on fruits within the Pahole MU. Based on those obervations, the status of *C. superba* subsp. *superba* in the Pahole was dropped in favor of the Kapuna PU and the new Palikea PU was established; therefore, rodent control is a low priority around this species.

Since 2016 research has been done by the Vertebrate Introductions and Novel Ecosystems (VINE) Hawai'i project to examine [1] how the structure and dynamics of seed dispersal networks vary across ecological contexts, [2] how seed dispersal competence of non-native species varies across ecological contexts to influence ecosystem functioning, and [3] how ecosystem functioning is maintained across new spatial and temporal extents through non-native birds. As part of the project motion-detection cameras are set up in the field to record the types of non-native frugivores and the different species of plants they visit. One of the cameras had detected *Lophura leucomelanos* (Kalij Pheasant) frugivory on *Delissea waianaeensis* (PAH-C) while producing heavy damage to the plant. This was the first recorded threat of the Kalij on *D. waianaeensis*; currently the problem is being investigated for the feasibility of control in

the future. There is no known control for Kalij in Pahole MU. However, the presence of *D. waianaeensis* seedlings in Pahole and in neighboring Kahanahāiki far from any known populations, could suggest that a frugivore is moving the seeds around. The VINE Hawai‘i project continues to collect data on non-native avian frugivores and study the viability of seeds through the avian digestive system.

Two rats consuming fruits from a population of *D. waianaeensis.*

## Slug Control

Species: *Deroceras leave*, *Limax maximus*, *Veronicella cubensis*, *Meghimatium biliniatum*

Threat Level: High threat to all members of the Campanulaceae including *Cyanea* and *Delissea* species. High threat to all *Schiedea* species. Unknown threat to all other rare plant species but could be a threat to *Euphorbia herbstii* seedlings.

Seasonality/Relevant Species Biology: Slugs are seasonally abundant during the wet season. In Pahole, slugs are present year-round, though less active in the hottest months (July and August).

Management Objectives:

- Eradicate slugs locally to ensure germination and survivorship *C. grimesiana*, *C. longiflora, D. waianaeensis*, *E. herbstii*, *S. obovata*, *S. kaalae*, and *S. nuttallii*.
- Ensure no rare snails are adversely impacted by slug control.
- Assess slug activity over time.
- Survey annually to ensure rare snails do not migrate into slug treatment areas.

Strategy and Control Methods:

- Slug Control Areas (SLCAs) have been delineated around rare taxa locations. These include not only the target plant but a buffer of 10 meters to kill slugs entering the rare plant vicinity. Apply FerroxxAQ every 6 weeks, buffering vulnerable plants by at least 5 meters. 10 meters is optimal. Prior to any control, day and nighttime surveys must be conducted in the proposed control area to ensure there are no rare snails are in the area, following the Pre-Application Survey Protocol.
- If rare snails are found in an established SLCA, treatment will be halted. Rare snails will be relocated to the MU snail enclosure. The site then will be resurveyed until there is a survey conducted where zero snails are found.
- Slug activity will be measured using baited pitfall traps set once a year in the wet season. Staff will also record and note any damage to target plants caused by slug feeding.

**Slug Control Area Locations Table**

| SLCA Code | Plant population reference codes | Date slug control began |
|---|---|---|
| PAH-A.2 | CyaSupSup.PAH-A | 2014-01-13/discontinued 2015-06-10 |
| PAH-A.3 | SchNut.PAH-D, SchNut.PAH-E and SchObo.PAH-E | 2014-01-13 |
| PAH-A.4 | CyaGriOba.PAH-D, SchKaa.PAH-C, SchKaa.PAH-A | 2015-09-16 |
| PAH-A.5 | EupHer.PAH-R and EupHer.PAH-G | 2015-06-10 |
| PAH-A.6 | EupHer.PAH-F, EupHer.PAH-S and | 2015-06-10 |
| PAH-A.7 | CyaLong.PAH-I, CyaLong.PAH-A and SchNut.PAH-A | 2015-10-12 |
| PAH-A.8 | DelWai.PAH-C and CyaSub.PAH-B | 2017-09-26 |
| PAH-A.11 | CyaLong.PAH-J | 2018-03-11 |

**Slug Management Map**

# Image Redacted
# Sensitive Information
# Available Upon Request

**Slug Photos**

*Deroceras laeve*, grey garden slug.
This is the most common slug in the MU.

*Limax maximus* (leopard slug) with eggs
This is the second most common slug in the MU.

*Veronicella cubensis* (Cuban slug). This slug is rare in the MU, it is restricted to the area above the road.

Discussion:

During annual rare plant monitoring, we will inspect plants for herbivory. If present, this will be noted. Indication that slugs are responsible includes the following: lower leaves closer to the ground are more damaged, slime is present, and leaf margins are consumed before the interior of the leaf (unless the midrib is resting on the ground while the margins are curled).

If slug herbivory is suspected, check for rare native snails within 20 meters of the rare plants before proceeding with a slug control program.

Sample slugs in the vicinity using baited beer traps. If the number of slugs captured per trap over two weeks exceeds one slug per trap, and, if no rare native snails are present, commence applying Ferroxx every 6 weeks year-round.

The Cyasupsup.PAH-A.2 was discontinued due to the change in management designation of this population. It transitioned from an MFS population to GS.

With recent outplantings of rare taxa, surveys need to be conducted for rare native snails within proposed Ferroxx application areas. The recommended buffer from a rare snail population in order to apply Ferrox is set at a minimum of 20 meters.

**Pre-Application Survey Protocol:**

For control only of slugs and non-native snails via listed, approved molluscicide application in forests, on offshore islands, and in other natural areas to protect threatened and endangered Hawaiian plants. Only Ferroxx AQ® Slug and Snail Bait is approved for use in forest areas in Hawai'i. Area must be thoroughly searched by experienced malacologists prior to application of Ferroxx AQ® granules to ensure that non-target native Hawaiian snail species are not impacted. Do not apply in areas where it may come into contact with known populations of endemic Hawaiian snail species from the following rare families or subfamilies: Amastridae, Achatinellinae and Endodontidae. Bait cannot be applied within 20 m of any tree known to harbor endangered Hawaiian tree snails (*Achatinella* spp.).

1. Conduct thorough day survey of proposed treatment area to include searching trees and all understory vegetation. The ground and rock talus areas will also be search. An effort to identify other snails found and their rarity will be made prior to Ferroxx use.
2. If proposed treatment area is known *Achatinella* spp. site or if *Achatinella* spp. is observed during day survey, then must conduct night survey and remove all *Achatinella* spp. to a snail enclosure/protected area prior to bait use.
3. Area will continue to be surveyed and *Achatinella* spp. translocated to enclosures until all *Achatinella* spp. are removed from the area and at least one survey is conducted where 0 snails are found within area.
4. If *Achatinella* spp. are abundant in large numbers or are found on multiple trips, use of Ferroxx will not be allowed in area.
5. If *Achatinella* spp. are located in the area in the course of other field work, then surveys and relocation efforts will resume.
6. An effort to identify other snails found and determine their rarity will be made prior to Ferroxx use.

## Ant Control

Species: *Solenopsis genimata, S. papuana, Paratrechina bourbonica, Anoplolepis gracilipes, Leptogenys falcigera.*

Threat Level: Low

Seasonality/Relevant Species Biology: Varies by species, but nest expansion is typically observed in late summer to early fall.

Management Objectives:

- Prevent spread of ant species into areas where not already established. Conduct annual surveys during the summer to determine what ant taxa are present in the MU.
- Detect incursions of new ant species prior to establishment.

Strategy and Control Methods:

- Sample ants at human entry points using the standard survey protocol (Plentovich and Krushelnycky 2009). Use samples to track changes in existing ant densities and to alert ANRPO to any new introductions
- If incipient species are found and deemed to be a high threat and/or easily eradicated locally (<0.5-acre infestation), begin control.
- Sample ants at snail enclosures, campsites, LZs, rare taxa sites, DZs, and fence lines to track changes in existing ant densities and to alert ANRPO to any new introductions.
- Look for evidence of ant tending of aphids or scales on rare plants during annual rare plant monitoring.

**Ant Survey Site Table**

| Site description | Reason for survey |
|---|---|
| Hypalon Fence | Human entry point. High risk of accidental ant introduction |
| *S*nail enclosure | Human entry point. High risk of accidental ant introduction |
| Pahole/Kahanahāiki Access Trial | High risk of accidental ant introduction |
| Mākua Overlook | Monitor whether ants are migrating up the ridge from Mākua Valley |

**Ant Photos**

*S. papuana* or the thief ant is the most common ant in the MU.

Discussion:

Ants have been documented to pose threats to a variety of resources, including native arthropods, plants (via farming of Hemipterian pests), and birds. It is therefore important to know their distribution and density in areas with conservation value. From 2008-2014 ants were sampled in high risk areas using the following method:

Vials are baited with SPAM, peanut butter and honey. We remove the caps and space vials along the edges of, or throughout, the area to be sampled. Vials are spaced at least 5 meters from each other. A minimum of 10 baited vials are deployed at each site, in a shaded area for at least 1 hour. Ant baiting takes place no earlier than 8:00 am in the morning and no sampling occurs on rainy, blustery or cold days as both rain and low temperatures reduce ant activity. Ants collected in this manner are returned to the base yard for later identification.

With the re-construction of the Pahole Snail Enclosure in 2020, NRM staff have agreed that ant surveys need to be conducted both before and after large amounts of material are moved into the MU. Further discussion with SEPP needs to occur to decide who will manage this action.

Standardized surveys have taken place in Pahole for 10 years. All species found listed at the beginning of this section.

# Black-Twig Borer (BTB) Control

Species: *Xylosandrus compactus*

Threat Level: High

Seasonality/Relevant Species Biology: Peaks have been observed from October-January

Management Objectives:

- During annual rare plant monitoring, look for signs of twig boring and damage at the rare plant populations commonly impacted by BTB (*Flueggea neowawraea*).

Strategy and Control Methods:

- If rare plant taxa that are monitored show any sign of boring, report to Rare Plant Program Coordinator immediately.
- If there is an urgency to collect any plant material (i.e. seed, cuttings, and saplings) for genetic storage, collect material.

Discussion:

The current control method available for BTB involves the deployment of traps equipped with high-release ethanol bait. However, it is unclear whether this method actually reduces BTB damage to target plants. Therefore, this control method is not used to control BTB in the field. Since this control method is not effective, ANRPO will continue to investigate other control methods. If there is a rare plant population threatened by BTB and there is an urgency to have the genetic material, ANRPO staff will collect any plant material to prevent losing the plant founder altogether.

## Fire Control

Threat Level: Medium

Seasonality/Potential Ignition Sources: Fire may occur whenever vegetation is dry. Generally, this happens in summer, but may occur at other times of the year, depending on variations in weather pattern. *Megathyrsus maxima* has a high fire index and is the dominant vegetation near the western and southern sides of this MU. In the past fires have come close to the MU, both from fires set by the military, by arsonists along Farrington Hwy, or nearby farmlands.

Management Objectives:

- To prevent fire from burning any portion of the MU at any time.
- To prevent fire from damaging any rare taxa locations.

Strategy and Control Methods:

- Reduce fuel loads within the MU, along the road, and along the fenceline.
- If a fire occurs, conduct a post-fire survey, including mapping the perimeter of the fire and document damage via photos.

**Fire Photos**

2003 fire near Pahole NAR's western boundary

2017 fire near Pahole NAR's eastern boundary.

Discussion:

The western and southern sides of the Pahole MU fall into the MMR Action Area. while dry pasture lands abut the eastern side of the MU. As a result, Pahole  is considered to have a medium to high risk of fire. In 2003, a prescribed burn in Mākua Valley got outside of the prescription area and burned within 150m of the Pahole NAR's western boundary.  Since the early 2000's, the military has changed its vegetation suppression strategies, moving from prescribed burns to mowing/spraying most of the vegetation in the firebreak road.  There have been several fires in Mākua since then that have started either from arsonist ignition along Farrington Highway, or suspected unexploded ordnance (UXO) detonating within Mākua Valley.  Though none of these fires reached the MU they still had potential to get into the management unit.  Below (east of) the Pahole NAR are farmlands and grassy gulches.  In 2017 a fire burned private and state land in Mokulēʻia, which was ignited by a farm vehicle on one of the agriculture lots.  Though no taxa were impacted, it could have potentially got into Pahole gulch.

Fire prevention for this MU depends on fire measures put in place in Mākua Valley, as well as other surrounding land owners.  As with all other fire prone MUs, the following preventative actions are important: fire prevention signage, trail and LZ maintenance, and reduction of grass and other fuel loads on ridges and fencelines. If there are any fires that occur on the windward side of the MU, it is important to notify and assist (as needed) the Hawaiʻi Fire Department (HFD) with the fire.

**Fire Management Map**

# Image Redacted Sensitive Information Available Upon Request

Previous Fires near Pahole

# Ecosystem Restoration Management Plan

## MIP Year 20-24, Oct. 2023 – Sept. 2028

## OIP Year 17-22, Oct. 2023 – Sept. 2028

## MU: Popouwela (Kaluaʻā and Waiʻeli).

### Overall MIP Management Goals:

- Form a stable, native-dominated matrix of plant communities which support stable populations of IP taxa.
- Control ungulate, weed, invasive invertebrate, rodent, fire, and other threats in the next five years to allow for stabilization of IP taxa.

## Background Information

Location: Southern Waiʻanae Mountains

Land Owner: State of Hawaiʻi

Land Managers: U.S. Army and State

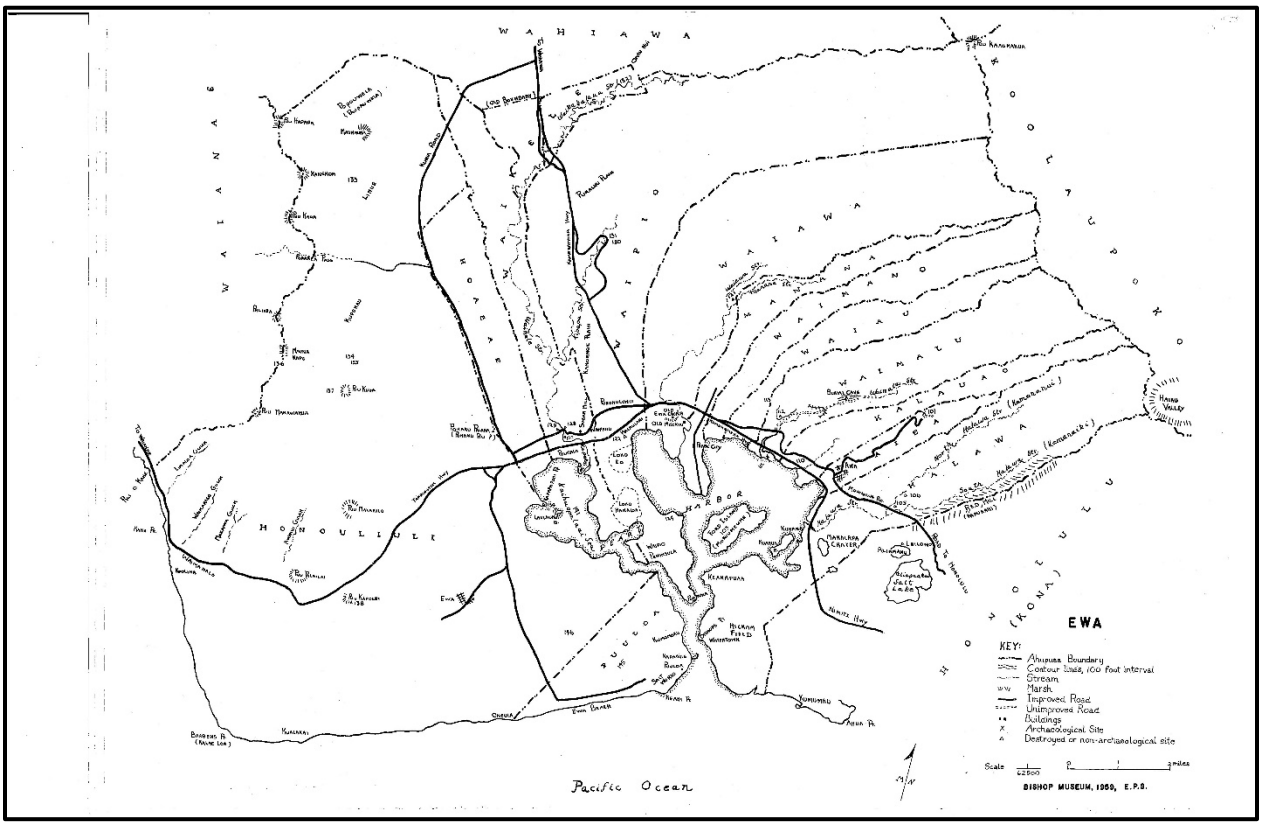
Acreage: 200 acres

Elevation Range: 1,800-2,883ft

Description:

Located in the moku of ʻEwa within Honouliuli ahupuaʻa is the ʻili ʻāina, or subdivision of an ahupuaʻa, of Popouwela, also referred to as Kaluaʻā and Waiʻeli by ANRPO. The name Popouwela is sometimes documented as Paupauwela, which we recognize as a variant of the name. Popouwela is listed with parentheses (Paupauwela) as the area beneath Puʻu Hāpapa on a map in the well known Sites of Oʻahu book. According to the *Traditional Cultural Property Study of Kūkaniloko*, the ʻili ʻāina of Paupauwela is located "between Hāpapa peak, the Kānehoa-Manauna spur ridge, and Waiʻeli Stream". Kaluaʻā refers to the stream that rises about 2200 ft. elevation under Puʻu Kānehoa, and then joins Waiʻeli Stream at about 930 ft (Hawaiian Place Names 2019) and may have been misinterpreted from D'alte A. Welch, who wrote the *Distribution and Variation of Achatinella mustelina Mighels in the Waiʻanae Mountains, Oʻahu*, who referred to the gulches located within Popouwela as Kaluaʻā. Waiʻeli, also written as Kawaiʻeli translates to "the dug water." The north fork of Waiʻeli stream rises at 2200 ft elevation under Puʻu Kūmakaliʻi; the south fork rises at 1550 ft at Kolekole Pass, which then joins Waikakalaua Stream at about 550 ft to form Waikele Stream.

**Land Divisions in Central Oʻahu**




(From Sterling, 1978)

The Popouwela Management Unit (MU) is part of the Honouliuli Forest Reserve, accessed via Schofield Barracks South range. Access is by 4WD road through the SR-1 gate and IED lanes. There are two main landing zones that allow access to Puʻu Hāpapa via helicopter, one at the beginning of the Popouwela trailhead, and one on the ridge near Puʻu Hāpapa. Terrain is varied, ranging from gradual slopes to vertical cliffs. The vegetation type at Puʻu Hāpapa is considered wet mesic, while the rest of Popouwela is mesic forest, with dominant native trees varying by aspect and elevation.

The Popouwela MU fence is comprised of three subunits, see map below. Subunit 1 (Central Kaluaʻā) on the southern end of the MU is the largest section encompassing four sub-gulches and extending from the bottom of the gulch system up to the ridgeline that spans across the Waianae and Ewa moku boundary. From south to north, the sub-gulches within Central Kaluaʻā are referred to as South Central Gulch, Gulch 1, Gulch 2, and Gulch 3. In the lower elevation of Central Kaluaʻā, before the Gulch 1-2-3 split, is a site referred to as Gulch 1A, a core outplanting site of The Nature Conservancy (TNC) later adopted and expanded by ANRPO. To the north of Central Kaluaʻā, the Subunit II fence encompasses the upper elevations of the North Kaluaʻā Gulch up to Puʻu Hāpapa. Below Puʻu Hāpapa, on a flatter area referred to as Hāpapa bench, is the Hāpapa snail enclosure. Subunit III encompasses the lower elevations of North Kaluaʻā Gulch as well as Waiʻeli Gulch to the north. North Kaluaʻā Gulch and Waiʻeli Gulch are divided by the Hāpapa Access Ridge.

Below and to the east of Popouwela MU runs the Honouliuli Contour Trail. This 16-mile-long trail extends throughout the Honouliuli Forest Reserve. It is intersected by the main Popouwela trail, which runs from the trailhead LZ up into North Kaluaʻā and Central Kaluaʻā.

## Native Vegetation Types

| Waianae Vegetation Types | |
|---|---|
| Mesic mixed forest | Canopy includes: *Acacia koa*, *Metrosideros polymorpha, Notolea sandwicensis, Diospyros* spp., *Planchonella sandwicensis, Charpentiera* spp., *Ceodes* spp., *Psychotria* spp., *Antidesma platyphylum*, *Bobea* spp., *Rockia sandwicensis*, and *Santalum freycinetianum*.<br><br>Understory includes: *Alyxia stellata, Bidens torta, Coprosma* spp., and *Microlepia strigosa* |
| Mesic-Wet forest | Canopy includes: *Metrosideros polymorpha polymorpha*. Typical to see *Cheirodendron trigynum*, *Cibotium* spp., *Melicope* spp., *Antidesma platyphyllum*, and *Ilex anomala*.<br><br>Understory includes: *Cibotium chamissoi*, *Hydrangea arguta*, *Dianella sandwicensis*, *Dubautia* spp. Less common subcanopy components of this zone include *Clermontia* and *Cyanea* spp. |
| NOTE: For MU monitoring purposes vegetation type is mapped based on theoretical pre-disturbance vegetation. Alien species are not noted. | |

## Terrain and Vegetation Types at Popouwela MU

Popouwela MU from east; the prominent, rounded peak on right is Pu‘u Hāpapa.

Popouwela and Pu‘u Kanehoa from Pu‘u Hāpapa looking south

Mesic forest within MU

Typical crest vegetation

Typical mesic gulch vegetation

**Gulches and Subgulches in MU**

# Image Redacted
# Sensitive Information
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## MIP/OIP Rare Resources at Popouwela MU

| Organism Type | Species | Pop. Ref. Code | Population Unit | Management Designation | Wild/ Reintroduction |
|---|---|---|---|---|---|
| Plant | *Alectryon macrococcus* var. *macrococcus* | KAL-A*,B*,C* ELI-A*,B* Reintro KAL-E* | Central Kalua‘ā to Central Wai‘eli | GS | Both |
| Plant | *Cenchrus agrimonioides var. agrimonioides* | Reintro KAL-A*, B, C | Kalua‘ā and Waieli | No Management | Both |
| Plant | *Cyanea grimesiana* subsp. *obatae* | KAL-A*, B Reintro KAL-C,D, E | Central Kalua‘ā | MFS | Both |
| Plant | *Cyanea superba* subsp. *superba* | KAL-A, B | Kalua‘ā | MFS | Reintroduction |
| Plant | *Delissea waianaeensis* | ELI-A KAL-B Reintro KAL-C,D, E* | Kalua‘ā | MFS | Both |
| Plant | *Euphorbia herbstii* | Reintro KAL-A | Kalua‘ā | MFS | Reintroduction |
| Plant | *Flueggea neowawraea* | KAL-A* | Kalua‘ā | | Wild |
| Plant | *Gardenia mannii* | KAL-A*, B* | Kalua‘ā and Maunauna | GS | Wild |
| Plant | *Phyllostegia hirsuta* | KAL-A* ELI-A,B*,C* SBS-A*,B* | Hāpapa to Kalua‘ā | MFS | Wild |
| Plant | *Phyllostegia mollis* | SBS-A*, B*, KAL-D* Reintro KAL-B*,C | Kalua‘ā | MFS | Both |
| Plant | *Plantago princeps* var. *princeps* | Reintro ELI-A | Wai‘eli | GS | Reintroduction |
| Plant | *Schiedea kaalae* | KAL-A* Reintro KAL-B,C | Kalua‘ā and Wai‘eli | MFS | Both |
| Plant | *Stenogyne kanehoana* | KAL-A* Reintro KAL-B,C*,D | Central Kalua‘ā | MFS | Both |
| Plant | *Viola chamissoniana subsp. chamissoniana* | SBS-A | Hāpapa | GS | Wild |
| Insect | *Drosophila montgomeryi* | n/a | Kalua‘ā and Wai‘eli | MFS | Wild |
| Snail | *Achatinella mustelina* | ELI-A, B KAL-A, B†,C†, D†,E,F†, G | ESU-D1 | MFS | Wild |

MFS= Manage for Stability
GSC= Genetic Storage Collection
*= Population Dead
†=Population translocated into enclosure

## Other Rare Taxa at Popouwela MU

| Organism Type | Species | Status |
|---|---|---|
| Plant | *Asplenium dielfalcatum* | Endangered |
| Plant | *Chrysodracon forbesii* | Endangered |
| Plant | *Cyanea calycina* | Endangered |
| Plant | *Cyanea membranacea* | No status |
| Plant | *Cryptocarya mannii* | Endangered |
| Plant | *Cyanea pinnatifida* | Endangered |
| Plant | *Cyanea superba* subsp. *superba* | Extinct in wild |
| Plant | *Dissochondrus biflorus* | No status |
| Plant | *Embelia pacifica* | No status |
| Plant | *Exocarpos gaudichaudii* | No status |
| Plant | *Gardenia brighamii* | Endangered |
| Plant | *Marattia douglasii* | No status |
| Plant | *Melicope christophersenii* | Endangered |
| Plant | *Melicope cornuta* var. *decurrens* | Endangered |
| Plant | *Neraudia melastomifolia* | No status |
| Plant | *Nothocestrum longifolium* | No status |
| Plant | *Panicum beecheyi* | No status |
| Plant | *Pteralyxia macrocarpa* | Endangered |
| Plant | *Schiedea hookeri* | Endangered |
| Plant | *Schiedea pentandra* | No status |
| Plant | *Solanum sandwicense* | Endangered |
| Plant | *Strongylodon ruber* | No status |
| Plant | *Tetramolopium lepidotum* subsp. *lepidotum* | Endangered |
| Plant | *Urera kaalae* | Endangered |
| Bird | *Chasiempis ibidis* | Endangered |
| Insect | *Drosophila divaricata* | No status |
| Insect | *Drosophila hemipeza* | Endangered |
| Snail | *Amastra intermedia* | No status |
| Snail | *Amastra spirazona* | No status |
| Snail | *Cookeconcha hystricella* | No status |
| Snail | *Laminella sanguinea* | No status |

**Rare Resources at Popouwela MU**

*Euphorbia herbstii*

*Stenogyne kanehoana*

*Cyanea grimesiana* subsp. *obatae*

*Achatinella mustelina*

*Drosophila montgomeryi*

*Schiedea kaalae*

**Locations of Rare Resources at MU**

# Image Redacted
# Sensitive Information
# Available Upon Request

**Threats to MIP/OIP MFS Taxa**

| Threat | Rare Taxa Affected | Management Strategy | Current Status, 2023 |
|---|---|---|---|
| Pigs | All | Across MU (fence) | No animals within fence. |
| Goats (known in Lualualei) | All | Across MU (fence) | No animals within fence. |
| Weeds | All | Focus primarily on rare taxa sites, across MU secondarily | Regular maintenance required several times per year. |
| Rodents | *Achatinella mustelina, Chasiempis ibidis, Cyanea grimesiana* subsp. *obatae, Cyanea superba* subsp. *superba, Delissea waianaeensis, Euphorbia herbstii, Schiedea kaalae* | Predator-proof snail enclosure, localized A24 + AT220 grids, localized D50 hand broadcast | Three A24 trap grids maintained tri-annually. |
| Feral Cat | *Chasiempis ibidis* | Partial control from localized AT220's | No control necessary at this time |
| Mongoose | *Chasiempis ibidis* | Partial control from localized AT220's | No control necessary at this time |

| Threat | Rare Taxa Affected | Management Strategy | Current Status, 2023 |
|---|---|---|---|
| Jackson's chameleon | *Achatinella mustelina* | Predator-proof snail enclosure, manual capture and removal | One female Jackson's chameleon was found 12/12/22 within snail enclosure. One intact dead male chameleon was found 5/11/23. Manual control conducted quarterly outside. |
| Rosy Wolf Snail | *Achatinella mustelina* | Predator-proof snail enclosure | No predatory snails within the enclosure. Enclosure inspected/maintained every 6 weeks and swept quarterly. |
| Slugs | *Cyanea grimesiana* subsp. *obatae, Cyanea superba* subsp. *superba, Delissea waianaeensis, Phyllostegia mollis, Plantago princeps* var. *princeps*, *Schiedea kaalae* | Affected rare taxa sites only | Ferroxx AQ slug toxicant applied every 6 weeks. |
| Ant | *Drosophila montgomeryi* | *D. montgomeryi* sites only | Amdro ant bait applied as needed. |
| Downy Mildew | *Phyllostegia hirsuta, Phyllostegia mollis, Plantago princeps* var. *princeps* | No control | Monitor rare plants. No tools to control in the field; research on-going. |

**Management History**

- 1860s-80s: The Popouwela area is severely degraded by overgrazing by unmanaged herds of cattle. James Campbell purchases Honouliuli and drives more than 30,000 head of cattle off the slopes and lets the land "rest."
- 1925: Honouliuli Forest Reserve is established for watershed protection purposes.
- 1930s-50s: Division of Forestry and Civilian Conservation Corps builds roads, trails and fences; continues removal of feral goats and cattle; and plants 1.5 million trees in the Honouliuli Forest Reserve, mainly below 800' elevation.
- 1940s: The area below the contour trail in Kalua‘ā is actively farmed and used for ranching by Leilehua Ranch.
- 1940s-50s: The area below the contour trail is first used for US Army training.
- 1970s: *Clidemia hirta* is first introduced to the Waianae Mountains in the South Kalua‘ā contour trail area.
- 1972: One individual of *Drosophila montgomeryi* is recorded from Kalua‘ā Gulch.
- 1990-2009: Honouliuli Preserve is managed by TNC after they obtain a conservation easement from the Campbell estate.
- 1996: TNC installs the 0.2 acre Ti Leaf Flats fence; *Delissea waianaeensis* and *Cyanea pinnatifida* are the first endangered plant reintroductions.
- 2000-2007: TNC management consists of installing an extensive catchment system, project stewardship plots, and field nursery; trail construction; reintroduction of several thousand

common and endangered natives (including *S. kaalae* and *S. kanehoana*); rat control for snail and elepaio protection; and a volunteer hunting program.

- 2001: The 115 acre Subunit I (Central Kaluaʻā) fence is completed by TNC staff, volunteers, and contractor John Hinton.
- 2002: ANRPO begins using the Central Kaluaʻā fence area for endangered reintroductions as part of the MIP plan. *Delissea waianaeensis*, *P. mollis*, and *U. kaalae* are planted.
- 2003: *Cyanea grimesiana* subsp. *obatae* reintroductions are planted in Central Kaluaʻā Gulch 1.
- 2003: Extensive archeological surveys in the area below the boundary of the TNC preserve document numerous cultural and historical sites.
- 2004: The US Army acquires the South Range Acquisition Area from James Campbell Estate for a second qualifying training range in the South Range area (now known as SRQTR2). This area consists mostly of old pineapple fields, but also some portions of the forested area as a buffer safety zone.
- 2006: The 25 acre Subunit II (Hāpapa/North Kaluaʻā) fence is completed by TNC, volunteers, and staff.
- 2007: *Plantago princeps* var. *princeps* are reintroduced at Hāpapa. This population is subsequently augmented in 2009 and 2013.
- 2007: *Angiopteris evecta* is first discovered in South Central Kaluaʻā gulch.
- 2007: An incipient control area (ICA) is created for *Casuarina equisetifolia* along the southern fence as a follow-up to eradication work done previously by TNC.
- 2007: ANRPO begins control of *Morella faya* in an area previously controlled by the Oahu Invasive Species Committee (OISC). An ICA is created in the flats between the Hāpapa access trail, the Kaluaʻā gulch trail and the contour trail.
- 2008: One mature *Clusia rosea* is found and controlled along the contour trail.
- 2008: Inherited *Solanum capsicoides* ICA from The Nature Conservancy. Several mature individuals are found along the stream bed below the management unit. This ICA is later extended further up into North Kaluaʻā Gulch as more plants are discovered.
- 2009: One mature *Arthrostemma ciliatum* is found along the trail by the TNC Ti Leaf Flats fence.
- 2009-2010: The Army Compatible Use Buffer Program purchases Honouliuli Preserve with assistance from State and private partners, and negotiation by Trust for Public Land, primarily for endangered species management. The title transfers to the State of Hawaii for management as a Forest Reserve with uses such as recreational hiking and hunting. This is done partially as a result of shifting management focuses within TNC, and their decision to discontinue work in Honouliuli Forest Reserve.
- 2010: *Drosophila montgomeryi* is documented by Karl Magnacca at one site in Kaluaʻā gulch and at a second site near the summit of Puʻu Hāpapa (2640 ft. elevation).
- 2010: ANRPO completes construction of the 56 acre Subunit III (Waiʻeli/ North Kaluaʻā) fence and all pigs are removed.
- 2010: MU vegetation monitoring is initiated on a 5-year interval via belt plot transects.
- 2011: A contracted New Zealand company, Xcluder, completes the 0.25 acre snail enclosure at Puʻu Hāpapa. Translocation of snails into the enclosure begins.

- 2011: In December, 6 Jackson's Chameleons (*Triceros jacksonii* subsp. *xantholophus*) are found and removed from the newly built snail enclosure. Manual search and removal, including tree-climbing, is implemented. A total of 32 chameleons are removed, with the last one found in May 2015.
- 2011: ANRPO begins active habitat management of *D. montgomeryi* sites via specific weed control efforts. Host plants *Urera kaalae* and *Touchardia oahuensis* are first planted by ANRPO at Hāpapa bench the following year (2012) in conjunction with other common native outplantings. *Urera* and *Touchardia* restoration areas are expanded in 2015 to include *D. montgomeryi* populations in North Kaluaʻā and Gulch 1.
- 2012: *Achatinella mustelina* are released into the Puʻu Hāpapa snail enclosure from the UH lab. Since its completion, 2,132 *A. mustelina* have been released into the Hāpapa enclosure.
- 2012: A single mature *M. faya* is found along the crest north of Puʻu Hāpapa.
- 2013: A small patch of *Dovyalis hebecarpa* is found in Waiʻeli gulch.
- 2013: One mature *Ehrharta stipoides* is found near the Hāpapa shelter.
- 2013: Incision point application (IPA) sweeps are first conducted by the ANRPO Ecosystem Restoration crew focusing on mature *Toona ciliata* and *Grevillea robusta* trees throughout the management unit.
- 2014: More *E. stipoides* is found along the Hāpapa access trail.
- 2015: Puʻu Hāpapa LZ is reconstructed.
- 2015: Monthly slug control using Sluggo is implemented at the Kaluaʻā Gulch 1A site to protect wild *C. grimesiana* subsp. *obatae* and a large reintroduction of *D. waianaeensis.*
- 2015: Outreach finds an immature *A. evecta* in a volunteer weeding area in lower Central Kaluaʻā gulch.
- 2016: An Army Engineer Unit improves Kaluaʻā access road. A new LZ was constructed on state land near the Kaluaʻā trailhead to facilitate helicopter operations and ease of access to the management unit.
- 2016: Localized rat control is implemented at the Kaluaʻā Gulch 1A and North Kaluaʻā *C. grimesiana* subsp. *obatae* sites. In 2017, these are converted to A24 grids.
- 2017: Ferroxx AQ Slug and Snail Bait is approved for use in natural areas in Hawaiʻi; its use is implemented within the MU and slug control is changed to a 6-week interval.
- 2017: The ANRPO ungulate team skirts a problem section of the fence in Waiʻeli gulch, where outside pressure is high and pig sign outside the fence is often observed.
- 2017: Paul Krushelnycky of University of Hawaiʻi at Mānoa confirms the adverse effects of the thief ant (*Solenopsis papuana*) on native *Drosophila*. One study site is Hāpapa bench.
- 2017: The first *E. herbstii* are planted in North Kaluaʻā. This population is augmented in 2018.
- 2018: Pig sign is detected in the upper North Kaluaʻā fence by the *C. grimesiana* subsp. *obatae* outplanting. This is the first pig in this section of the fence. It is successfully snared.
- 2018: *Chromolaena odorata* is found along the Hāpapa access trail. Buffer sweeps and trail surveys are implemented to determine further actions.
- 2018: The *E. stipoides* ICA (Kaluaʻā-EhrSti-01) at Hāpapa bench is eradicated.

- 2019: Fickling begins on north side of Wai‘eli fenceline.
- 2020: Began planting common natives around the *C. grimesiana* subsp. *obatae* KAL-D population.
- 2021: OPEPP observes piglets crossing in and out of fence near *Stenogyne kanehoana* reintroduction on South side of unit.
- 2021: Staff planted common natives around the *C. superba* subsp. *superba* KAL-A population, around the *D. waianaeensis* KAL-C population, and inside and outside of the Hāpapa Snail Enclosure.
- 2022: Fickling begins on South side of Popouwela fenceline.
- 2022: CyaSupSup.KAL-B was initially outplanted and Kaluaa replaced Manuwai as Manage for Stability Reintroduction for Stability PU.
- 2022: 143 *Urera kaalae* plants were out plants to support fly habitat around the Hapapa Snail enclosure. The majority of plants were supplied by DOFAW to ANRPO.
- 2022: Staff outplanted 50 *D. waianaeensis* at KAL-D site in North Gulch.
- 2023: Staff outplanted 25 *E. herbstii* at KAL-A site in North Gulch.
- 2023: North Gulch A24 + AT220 small vertebrate control grid established.
- 2022: Female Jackson’s chameleon found and removed by NRM Technician inside Hāpapa Snail Enclosure.
- 2023: Recently deceased male Jackson’s chameleon found during the quarterly *Euglandina rosea* sweep.
- 2023: Small patches of *E. stipoides* found on Hāpapa crestline near Waianae Mountain Watershed Program’s campsite and by Hāpapa snail enclosure.

## Ungulate Control

Species: *Sus scrofa* (pigs) and *Capra hircus* (goats)

Threat Level: High for pigs, Low for goats; goats known from Lualualei valley, but not from Popouwela and Puʻu Hāpapa

Management Objectives:

- To maintain all areas within fenced units as pig free.

Strategy and Control Methods:

- Conduct perimeter and centerline fence checks quarterly. Maintain fences and monitor for pig or goat ingress.
- Annually monitor interior fence section separating units II and III.
- Monitor for pig sign while conducting other management actions in the fence.
- If any pig activity is detected in the MU, implement snaring/trapping program or conduct control hunts with permission from the State of Hawaii.
- Conduct fence checks after storm events with emphasis at gulch crossings.
- Fickle northern Waiʻeli fenceline and southern Popouwela fenceline.
- Clear fence lines as needed from vegetation buildup.

Discussion:

Quarterly checks and maintenance are conducted along the perimeter and centerline (separating Subunit I from Subunits II and III) fences and after extreme weather events. The fences separating Subunits II and III are checked annually. Though not necessary to prevent ingress to the MU, this fence can make surveying and snaring easier if a pig does enter from the outside, as this keeps the animal contained to a smaller area. Staff monitors for pig sign during the course of other field activities.

The fence is especially vulnerable at its two stream crossings. Though water rarely flows here, there is typically water present, resulting in higher pig presence and can increase pressure from the outside. In addition, extreme weather events can cause water to rush down the gulches, collecting debris and pressuring the fence from the inside. To mitigate these threats, baffles are installed inside Subunits I and III where the Kaluaʻā gulch trail crosses into North and Central Kaluaʻā Gulches, and both stream crossings are skirted.

**Ungulate Management Map**

# Image Redacted
# Sensitive Information
# Available Upon Request

## Weed Control and Vegetation Restoration

Weed Control actions are divided into 4 subcategories:

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

These designations facilitate different aspects of MIP/OIP requirements.

### Vegetation Monitoring

Background

Vegetation monitoring at Popouwela MU occurs on a five-year interval in association with MIP/OIP requirements for long term monitoring of vegetation composition and change over time. The primary objective of MU monitoring is to assess if the percent cover of non-native plant taxa 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.

Methods

Monitoring was conducted in 2010, 2015, and 2020 in 147 plots, with plots generally located every 30 m along transects. Transects were spaced approximately 200 m apart within accessible portions of the MU. 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 (non-vegetated < 25 cm above ground level), were also documented. Monitoring will continue on the same interval, next occurring in 2025. Analysis included vegetation change over time, as well as exploring the influence of vegetation management on vegetation change.

**Popouwela MU Vegetation Monitoring Plot Locations**

# Image Redacted
# Sensitive Information
# Available Upon Request

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Summary results

Management goals were met for non-native understory in all of the years monitored. Goals were not met for native understory, native canopy and non-native canopy in any year.

**Median cover (%) of vegetation in plots from 2010 to 2020**

| | 2010 | 2015 | 2020 |
|---|---|---|---|
| Native understory | 15 | 7.5 | 7.5 |
| Non-native understory | 35 | 35 | 45 |
| Native canopy | 25 | 25 | 35 |
| Non-native canopy | 75 | 85 | 95 |

There were a number of noteworthy significant differences in vegetation between the years monitored, summarized in the following table.

**Summary of notable changes/analysis results since 2010.**
**Native taxa are in boldface. Arrows indicate increase (↑) or decrease (↓).**

| Data category | Notable change/analysis results |
|---|---|
| Categorical cover | ↑ Native canopy, non-native canopy |
| Richness | ↑ Native canopy, non-native canopy |
| | ↓ Native understory |
| Frequency | ↑ Understory PasSub<br>Canopy PsiCat, TooCil |
| | ↓ Understory **CarWah, CocOrb,** PhyPer |
| | New concerning taxa: ArdEll, BleOri |
| Species cover | ↑ Understory PsiCat<br>Canopy **AcaKoa, MetPol,** AleMol, PsiCat, SchTer, TooCil |
| Vegetation management | MU frequency and cover for GreRob and TooCil were not reduced despite IPA control |
| | IPA weeding did not influence changes in TooCil cover or frequency (increased both inside and outside of IPA controlled areas) |
| | IPA weeding influenced changes in GreRob canopy cover (more plots with decreased cover within than outside of IPA weeded areas) |
| | IPA weeding influenced changes in native canopy cover (more plots with decreased cover among plots within than plots outside IPA weeded areas, and a larger increase in cover among plots outside than plots inside IPA weeded areas) |
| | IPA weeding influenced changes in non-native canopy cover (more plots with decreased cover among plots within than plots outside IPA weeded areas, and a larger increase in cover among plots outside than plots inside IPA weeded areas) |
| | IPA weeding did not influence changes in non-native understory |

Aside from the increase in native canopy cover and richness, the notable changes in vegetation for Popouwela MU since 2010 have been largely unfavorable ones. The most prevalent weed taxa continued to spread in frequency and/or cover. Most notably, the continual substantial increase in non-native canopy cover over the last ten years, as *P. cattleianum*, *S. terebinthifolius* and *T. ciliata* continue to expand, is especially disheartening, considering the extensive IPA control efforts for *G. robusta*, *T. ciliata*, and other targets across much of the MU. Despite the IPA control efforts, overall frequency and cover for *G. robusta* and *T. ciliata* were not reduced in the MU, and both species continue to be found recruiting in plots. Rather, *T. ciliata* cover and frequency increased, even in IPA controlled areas. The increased canopy cover for *T. ciliata* even in plots within weed sweeps for that taxon is likely because only larger trees were targeted, and trees of smaller size classes are widespread and growing. Staff have anecdotally observed smaller *T. ciliata* trees surrounding treated trees respond by flushing and filling the gap. IPA control efforts did, however, result in a degree of reduced non-native canopy (including *G. robusta* and *T. ciliata*) for some plots in IPA controlled areas, which presumably would have only gotten worse otherwise, as occurred in plots in the areas outside of IPA control. Though staff have expressed concerns

that IPA efforts may cause the understory to become weedier, the non-native understory (including *G. robusta* and *T. ciliata*) did not get worse as a result of IPA control. Unexpectedly, there was a disproportionate decrease in native canopy cover inside as compared to outside IPA controlled areas, and the causes for this remain unknown. It is possible that fallen treated trees may have knocked down or uprooted native trees. Overall, though IPA control may have slowed the rate of worsening conditions for non-native canopy, it does not appear sufficient to substantially alter the course of the trend, and the apparent negative influence on native canopy is concerning. Popouwela MU is a fairly large MU with steep and challenging terrain and continued ongoing IPA control of aggressively invading target taxa such as *T. ciliata* as they grow to the targeted size/stage may be onerous. Given the highly degraded nature of the MU, management goals of < 50% non-native canopy cover is unrealistic, and efforts towards that end may be dubious. It is apparent from restored areas such as the Hāpapa snail enclosure that much can be gained from ecosystem restoration efforts at the MU. Continued small scale restoration efforts may be effective in improving habitat at the highest value locations of ANRPO managed rare taxa at Popouwela MU.

Recommendations

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

- Continued general ecosystem weeding, prioritized for areas with managed rare taxa
- Continued ICA control
- Control limited distribution target taxa when seen
- Target taxa: establish an ICA for *B. orientalis* (team has begun managing this as an ICA), and add *A. elliptica* to the limited distribution target taxa list (Figure 13)
- Continued and expanded small scale native ecosystem restoration efforts, limited to prioritized locations in association with rare plant and *Drosophila* stabilization
- Discuss feasibility of future IPA control efforts:
    - As *T. ciliata* is so widespread, the utility of IPA control of larger/mature trees during sweeps to prevent further spread is doubtful. There should be efforts to gain a better understanding of its life cycle and seed biology, its impact on ecosystems, and the impacts of current control strategies. A better understanding of this weed will facilitate the development of realistic tools and strategies for addressing it, as is spreading aggressively here and in other MUs. *T. ciliata* sweeps could still be useful at denser native zones such as at the Hāpapa bench or 1A site. There should also be an exploration for the potential for biocontrol.
    - Continued IPA control of *G. robusta* may still remain useful.
    - Evaluate several canopy taxa that currently have low cover which may respond better to IPA sweeps: *F. moluccana*, *M. phillippensis*, *P. guajava*, *H. popayanensis*, *S. campanulata*, *L. confertus*, *S. cooperi*, *P. americana*, *S. actinophylla*, *A. elliptica*, *M. azedarach*.
    - Take more target species GPS points for aforementioned species, aerial surveys may be helpful in taking these points before doing sweeps.
- Release *Tectococcus ovatus* for biocontrol of *P. cattleianum* in areas adjacent to priority zones and get biocontrol established in the MU.
- Request that Hawaii-Pacific Weed Risk Assessment personnel complete an assessment for *M. phillippensis* to better understand management concerns this taxon.

Since the time these recommendations were made, the *B. orientalis* ICA has been created. Staff have outplanted *Touchardia oahuensis* and common natives at the *Drosophila* stabilization sites at the Hāpapa bench and in Gulch 1. Staff have continued to do small scale ecosystem restoration near managed rare taxa sites, including the Vegetation Restoration team's Liana Lane site near CyaSupSup.KAL-A outplants, and have halted IPA sweeps for larger *T. ciliata* since 2020.

## Surveys

Potential Vectors: Army Training, ANRPO activity, hikers/hunters, pig, rodents, alien birds, wind

Management Objective:

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

Strategy and Control Methods:

- Quarterly surveys of LZs when used, to include: Waiʻeli-TNC Hāpapa LZ (151),Kaluaʻā Trailhead LZ (214), and Kaluaʻā South (216)
- Quarterly survey of Hāpapa shelter/campsite and Waiʻanae Mountain Watership Program campsite at Puʻu Hāpapa when used.
- Annually survey 3 weed transects along main Kaluaʻā gulch trail and Hāpapa access trail for incipient weeds (see map).
- Annually survey Kaluaʻā access road as part of the Schofield Barracks South range (SBS) road surveys.
- Note unusual, significant or incipient alien taxa during regular field work, and particularly when doing fence checks. Map and complete Target Species form to document sighting.

Discussion:

Surveys are designed to be the first line of defense in locating and identifying potential new weed species. At Popouwela, LZs, camp sites, trails, and the access road are inventoried regularly to facilitate early detection and rapid response. The only LZs approved for use within this MU are Waiʻeli-TNC Hāpapa LZ (151), Kaluaʻā Trailhead LZ (214), and Kaluaʻā South (216). In addition to LZ surveys, staff also conduct surveys at the Puʻu Hāpapa shelter (the primary campsite in the MU), the WMWP campsite, and along 3 heavily trafficked trails. The Kaluaʻā access road is also surveyed annually as part of the SBS road surveys.

**Survey Locations at Popouwela**

# Image Redacted Sensitive Information Available Upon Request

## Incipient Taxa Control

All weed control geared towards eradication of a particular invasive weed is tracked via Incipient Control Areas, or ICAs. Each ICA is species-specific and geographically defined. One infestation may be divided into several ICAs or one ICA, depending on infestation size, topographical features, and land ownership. Some ICA species are incipient island-wide and are a priority for ICA management whenever found. Others are locally incipient to the MU, but widespread elsewhere. In either case, the goal is eradication of the ICA. The goals, strategies, and techniques used vary between ICAs, depending on terrain, surrounding vegetation, target taxon, size of infestation, and a variety of other factors.

Management Objectives:

- Eradicate ICAs through regular and thorough monitoring and treatment. In the absence of any information about seed bank longevity for a particular species, eradication is defined as 10 years of consistent monitoring with no target plants found.
- Study seed bank longevity of ICA taxa, and revise eradication standards per taxon. We have a soil seed bank longetivity study underway for *Chromolaena odorata*, we can initiate experiments for other taxa, such as *Angiopteris evecta*.

- Evaluate any invasive plant species newly discovered in the MU and determine whether ICA-level control is warranted. Factors to consider include distribution, invasiveness, location, infestation size, availability of control methods, resources, and funding.

Strategy and Control Methods:

- Species and ICAs are listed in the table below. History and strategy are discussed for each species.
- Monitor the progress of management efforts and adjust visitation rates to allow staff to treat plants before they mature. Remember that one rarely finds 100% of all plants present.
- Use aggressive control techniques where possible. These include power spraying, applying pre-emergent herbicides, clearcutting, aerial spraying, and frequent visits.

**Incipient and Weed Control Areas Map**

**Image Redacted**
**Sensitive Information**
**Available Upon Request**

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## Summary of ICAs

| Taxon | ICA Code | Control Discussion |
|---|---|---|
| *Casuarina equisetifolia* | Kaluaa-CasEqu-01 | This ICA is along the southern side of the fence. It was established as a follow up to eradication work done here previously by TNC. It is currently monitored annually. Plants are controlled via cut stump with of 20% triclopyr, 80% biodiesel. An evergreen tree that resembles a conifer but is in its own family. Can form stands. It has a weed risk assessment score of 21 (*Casuarina equistifolia risk assessment, 2008*). Slated to be eradicated Q3 2024. |
| *Chromolaena odorata* | KaluaaNoMU-ChrOdo-01 | This highly invasive shrub is a major target. It was discovered in May 2018 along the Hāpapa access trail. Staff conducted 200m buffer surveys around the site, and a thorough trail survey from the parking area to Hāpapa snail enclosure. Two mature *C. odorata* were found, and immature plants are frequently found around the original mature plant by about 40 meters. 11 immatures were found on the last check 1/26/23. Given their proximity to a frequently travelled trail, these plants were likely introduced by staff. Seeds are primarily wind-dispersed, but can also spread via contaminated boots and gear. Seeds of *C. odorata* last at least 5 years in soil, and further seed bank longevity testing is underway. This ICA is a high priority. It is currently monitored quarterly. Plants are hand-pulled, seeds bagged and removed, or controlled via cut stump with 20% triclopyr, 80% biodiesel. Larger patches, or plants that have already dropped seeds should be controlled aggressively with a thorough spray of 2% glyphosate and a pre-emergent to prevent recruitment. |
| *Chromolaena odorata* | KaluaaNoMU-ChrOdo-02 | One mature plant was found during Schofield Barracks South Range road survey near a water tank to create this ICA. A 200 meter buffer survey was conducted but cut short due to some of the area being behind Seibert stakes. No plants have been found since. |
| *Dovyalis hebecarpa* | Kaluaa-DovHeb-01 | This ICA is located near Wai‘eli stream near our *Delissea waianaensis* DelWai.ELI-A outplanting. This invasive tree produces bird-dispersed edible purple fruit and has long sharp thorns. It is common outside the MU on the Schofield Barracks South Range road. It has a weed risk assessment level of 7 (*Taxon: Dovyalis hebecarpa*). Plants are found here fairly regularly. |
| *Ehrharta stipoides* | Kaluaa-EhrSti-02 | Although common in other MUs, this is only the second *E. stipoides* site found within Popouwela MU. This ICA is found along the trail to the Hāpapa snail enclosure; the first was at the enclosure. As it is common in other areas where snail management occurs (namely Palikea MU), and the seeds are readily spread when stuck to boots, clothing, or gear, it was likely spread by staff or others involved in snail conservation work. An invasive grass that can dominate understory even in the shade, *E. stipoides* is a high priority target. This ICA is currently monitored every 6 months. Control aggressively with a thorough spray of 2% glyphosate and pre-emergent to prevent recruitment. Mature seeds should be bagged and removed. |
| *Morella faya* | Kaluaa-MorFay-01 | This ICA encompasses the flats between the Hāpapa access trail, the Kalua‘ā gulch trail and the contour trail. This area was previously controlled by OISC. *Morella faya* is a significant habitat modifier. Although common in other areas along the Waianae mountains, its extent near the Popouwela MU is limited and therefore eradication is feasible. This ICA is currently swept annually. Control via basal-bark method or cut stump with 20% triclopyr, 80% biodiesel. |

| Taxon | ICA Code | Control Discussion |
|---|---|---|
| *Solanum capsicoides* | Kaluaa-SolCap-01 | This ICA follows the stream starting near the Kalua'ā trailhead and extending into North Kalua'ā Gulch. *S. capsicoides* have bright orange fruit suggesting bird-dispersal. *Solanum capsicoides* has a high fruit yield, and fruit have been observed to mature even after the plant is pulled; thus any fruit (immature or mature) should be bagged and removed to prevent recruitment. In addition, revisiting sites of mature plants should be prioritized to check for and control recruits. This ICA is currently surveyed annually. Its large area can possibly be decreased depending on future survey results and the extent of new plants found. |

ICAs Eradicated at Popouwela MU: *Arthostemma cilliatum* (Kaluaa-ArtCil-01); *Morella faya* (WaieliNoMU-MorFay-01)

ICAs Discontinued at Popouwela MU: *Angiopteris evecta* (Kaluaa-AngEve-01, 02, 03, 04); *Clusea rosea* (KaluaaNoMU-CluRos-01); *Dovyalis hebecarpa* (Kaluaa-DovHeb-02, 03)

## Ecosystem Management Weed Control

All weed control geared towards general habitat improvement is tracked in geographic units called Weed Control areas, or WCAs. The goals, strategies, and techniques used vary between WCAs, depending on terrain, quality of native habitat, and presence or absence of rare taxa.

MIP Goals:

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

Management Objectives:

- Maintain 50% or less alien vegetation cover in the understory across the MU.
- In WCAs within 50m of rare taxa, work towards achieving 25% or less alien vegetation cover in understory and canopy.
- Increase/expand/revise weeding efforts if MU vegetation monitoring (conducted every 5 years) indicates that goals are not being met.

Discussion:

The following is a discussion of unique considerations for managing the Popouwela MU. The habitat overall in this MU is patchy. The habitat along and just below ridge crest is largely native. In addition, there are belts of *Acacia koa* (koa) canopy which run along prominent ridgelines that are in relatively good condition, with many native components. The gulches and slopes within the MU are a mix of native and alien forest. Patches of intact diverse mesic forest remain within the unit. MIP and OIP taxa are found across these zones and thus most of the Popouwela MU is important for stabilization. We designated WCAs 2, 4, 6, 8, and 10 as priority areas for weed control based on rare plant taxa sites and denser native forest patches.

The majority of management actions are focused directly around rare taxa. However, the expansion of the Vegetation Restoration crew (VegRest) and the implementation of new weed-control techniques, have made possible more MU-scale management. One of these techniques is incision point application (IPA) sweeps. First implemented in 2013, use of IPA sweeps has resulted in over 268 acres surveyed and controlled with over 1025 staff hours. Target species include *T. ciliata* and *G. robusta*. IPA sweeps had been implemented in every WCA within the Popouwela fence. However, vegetation monitoring showed

that the utility of IPA control of larger/mature *T. ciliata* trees to prevent further spread is doubtful and no future actions are planned.

*Native Drosophila*

One unique consideration in Popouwela MU is picture-wing *Drosophila* habitat. Picture wing flies require particular host plants to complete their lifecycles. The endangered *Drosophila montgomeryi* is found within the Popouwela MU and is an OIP stabilization species. *Drosophila montgomeryi* breed in rotting plant material of *Touchardia oahuensis* and *Urera kaalae*. While *T. oahuensis* occurs widely across the Waianae range, it often occurs as scattered clumps of one or a few individuals, unsuited for survival of *D. montgomeryi* and probably not viable for long-term survival of this dioecious, wind-pollinated tree. *Urera kaalae* is critically endangered and only a handful of wild plants remain. Therefore, the remnant patches of these plants should be maintained and expanded. Since 2002, staff have planted over 250 *U. kaalae* and 337 *T. oahuensis*. Active management of *D. montgomeryi* habitat began in 2011 with specified weed actions, as well as augmentations and outplantings of these host trees. One of these reintroductions was in response to a large tree-fall in North Gulch that opened a canopy gap in the middle of existing *D. montgomeryi* habitat. *Urera* and *Touchardia* species should be considered in any future restoration outplantings where they might serve to maintain or restore possible *D. montgomeryi* habitat. *Drosophila montgomeryi* habitat is currently managed in WCA-02 (Hāpapa bench), WCA-04 (North Gulch), WCA-07 (Gulch 2; weed actions focused around PEPP (Plant Extinction Prevention Program) *U. kaalae* reintroductions), and WCA-08 (Gulch 1).

*Stenogyne kanehoana*

*Stenogyne kanehoana* prefers the koa forest zone along ridges that contain large amounts of *Dicranopteris linearis* (uluhe) in the understory. This habitat requires delicate management to ensure the uluhe is not disrupted. Anecdotal evidence suggests *D. linearis* is sensitive to trampling, and gaps made while weeding or monitoring are often re-vegetated with much less desirable weeds, such as *C. hirta*. ANRPO does not have the capacity to actively restore uluhe and thus should conduct weed control and outplanting very carefully and with minimal impact to the fern cover. Conversations with horticulturists around the state suggest that uluhe is very difficult to propagate. Reintroductions of *S. kanehoana* are currently managed in WCA-02 (along the ridge crest above Hāpapa bench) and WCA-10 (along the southern fence line).

*Hāpapa bench habitat*

Another unique consideration for the Popouwela MU is the Hāpapa bench habitat (WCA-02). This zone has a unique set of conditions that support numerous rare native tree and ground snail species, as well as the endangered *D. montgomeryi*. Rare native ground snails in the genus *Amastra* require unique food. They browse fungi growing in leaf litter of plants in the family Urticaceae such as *Pipturus albidus* (māmaki), *Urera kaalae,* and *Touchardia oahuensis*. Native *Achatinella* can also live happily on *Urera and Touchardia*, and, as mentioned earlier, these taxa are essential for the life cycle of *D. montgomeryi*.

While not MIP or OIP taxa, considerations should be made to not affect ground dwelling snails as their habitat can be negatively impacted by digging activities associated with outplanting and fence construction. Particular caution should be taken to survey sites prior to conducting any digging and tree felling activities. These actions should be planned in collaboration with the Snail Extinction Prevention Program (SEPP).

The table below summarizes invasive weeds found at Popouwela MU, excluding ICA species. While the list is by no means exhaustive, it includes the species targeted/prioritized for control. The distribution of each taxon is estimated as: Widespread (moderate to high densities of individuals, common across MU), Scattered (low densities across all or much of the MU), or Restricted (low or high densities, all in one discrete location).

## Summary of Target Taxa

| Taxa | Distribution | Notes |
|---|---|---|
| *Angiopteris evecta* | Widespread | A large invasive fern with wind-dispersed spores. Seen sporadically within MU. Concentrated in South-Central Kalua'ā Gulch. Control whenever encountered.<br>Control technique: manual control, make sure to smash meristem and stipules, as these can grow vegetatively. Can bag large reproductive fronds and hike out if feasible. |
| *Ardisia elliptica* | Restricted | Seen sporadically within MU. Concentrated in South Kalua'ā. Target whenever seen inside MU.<br>Control technique: Cut stump with 20% triclopyr, 80% biodiesel. |
| *Blechnum appendiculatum* | Widespread | An invasive fern that can create a thick ground cover and hinder recruitment, control with priority directly around rare taxa.<br>Control technique: Foliar spray with 2% glyphosate is most effective, clip-and-drip with 20% triclopyr, 80% biodiesel is moderately successful. |
| *Buddleja asiatica* | Widespread | A fast-growing shrub, *B. asiatica* produces a lot of seed.<br>Control technique: Basal-bark or cut stump with 20% triclopyr, 80% biodiesel. |
| *Clidemia hirta* | Widespread | Widespread and often forming dense patches throughout the MU. Known to quickly invade and spread into canopy gaps.<br>Control technique: Basal-bark or cut stump with 20% triclopyr, 80% biodiesel. Immatures can be hand-pulled. |
| *Clusia rosea* | Restricted | An ornamental tree that is also spread by birds and spreads from initial plantings. It is naturalized and can form dense thickets. Control where seen. Previously an ICA on the trail to Hāpapa. Discontinued (not eradicated) as it was determined this was not an isolated site. |
| *Christella parasitica* | Widespread | Though easily overlooked, this invasive fern can grow in dense patches and replace natives such as *Microlepia strigosa* (palapalai).<br>Control technique: 20% triclopyr, 80% biodiesel applied to tips of rhizomes. |
| *Dicliptera chinensis* | Restricted | Not known inside MU. Control along access trail to prevent spread into MU.<br>Control technique: Foliar spray with 2% glyphosate. |
| *Erigeron karvinskianus* | Widespread | Establishes a thick ground cover, spreading by seed and runners. Control in WCAs. Target in cliff and bench areas in habitat for MFS plant taxa (e.g. *Plantago princeps* var. *princeps*).<br>Effective control achieved with 2% glyphosate spray. Trial lower concentrations to avoid negative impacts on native recruits. |
| *Falcataria moluccana* | Scattered | Fast growing, habitat-modifying tree. Not known inside MU, but well established below. Treat as part of WCA work. Kill all mature trees within fence. Can be a possible target as part of REPI grant.<br>Control technique: Cut stump or girdle with 20% triclopyr, 80% biodiesel. Can also IPA with 100% aminopyralid. |
| *Grevillea robusta* | Widespread | Commonly known as silk oak, *G. robusta* is a large tree, widespread across the MU. Control in WCA sweeps (including IPA). Priority to kill matures.<br>Control technique: Cut stump or girdle with 20% triclopyr, 80% biodiesel; IPA with 100% aminopyralid. |
| *Heliocarpus popayanensis* | Widespread | Commonly called moho, this tree is concentrated in the northern part of the unit, North Kalua'ā and Hāpapa bench. Target matures as a priority and in canopy weed sweeps across WCAs.<br>Control technique: IPA with 100% imazapyr. |
| *Lantana camara* | Widespread | Widespread throughout the MU, this shrub can form dense thickets and climb into the canopy. Its thorns are a hazard to staff when along trails or survey areas. Larger plants have been observed to re-root in sufficient moisture at Hāpapa when cut and left on the ground.<br>Control technique: Cut stump with 20% triclopyr, 80% biodiesel. Stack large stumps off the ground or apply herbicide. |

| Taxa | Distribution | Notes |
|---|---|---|
| *Mallotus philippensis* | Scattered | Seedling/saplings are observed in low densities across the MU. Abundant in Lualualei, so re-invasion is likely. Control whenever found.<br>Control technique: Cut stump or girdle with 20% triclopyr, 80% biodiesel. |
| *Morella faya* | Scattered | Can be a habitat-modifying species, and can create dense monotypic stands. It is known from Palikea and Puali'i in Honouliuli, but found very sporadically outside the Popouwela fence. Previously an ICA on the trail to Hāpapa and North of the WMWP campsite on Hāpapa ridge. Control whenever spotted. |
| *Melinis minutiflora* | Widespread | Commonly known as molasses grass, *M. minutiflora* can form a thick ground cover impeding recruitment and choking out native plants.<br>Control technique: Foliar spray with 1% glyphosate. Manual control has also been used effectively, and grass-specific herbicides (e.g. Fusilade) should be used in sensitive areas. |
| *Oplismenus hirtellus* | Widespread | Commonly known as basket grass, control is focused mostly along trails.<br>Control technique: Foliar spray with 1% glyphosate. |
| *Paspalum conjugatum* | Widespread | Commonly known as Hilo grass, control is focused mostly along trails.<br>Control technique: Foliar spray with 1% glyphosate. |
| *Passiflora suberosa* | Widespread | A vigorous vine, *P. suberosa* can form dense curtains smothering native plants, and causing a tripping hazard for staff.<br>Control technique: Cut stump with 20% triclopyr, 80% biodiesel. Can be time-consuming to find where all stalks enter the ground. |
| *Psidium cattleianum* | Widespread | Widespread and often forming dense patches throughout the MU. Rare tree snails have been observed on this taxa. Take care when controlling in known snail sites. There are plans to release scale insect *Tectococcus ovata* as a biocontrol.<br>Control technique: Cut stump or girdle with 20% triclopyr, 80% biodiesel. |
| *Rubus rosifolius* | Widespread | Widespread and often forming dense patches throughout the MU. Known to quickly invade and spread into canopy gaps.<br>Control technique: Hand-pull. Can also basal-bark or clip-and-drip with 20% triclopyr, 80% biodiesel in areas sensitive to soil disturbance. |
| *Schefflera actinophylla* | Widespread | Bird dispersed and well established below MU. Target matures as a priority and in canopy weed sweeps across WCAs.<br>Control technique: IPA with 100% aminopyralid, 100% imazapyr, or 100% glyphosate (glyphosate is the cheapest option). |
| *Schinus terebinthifolius* | Widespread | Commonly known as Christmas berry, *S. terebinthifolius* is widespread and often forms dense patches throughout the MU. Especially abundant on southern-facing slopes.<br>Control technique: Basal-bark with 20% triclopyr, 80% biodiesel. Even large trees are controlled more effectively without cutting. |
| *Setaria palmifolia* | Scattered | Commonly known as palm grass, *S. palmifolia* is a shade tolerant grass that can form dense patches with dense root masses. Within the MU, it is most commonly found in the gulch bottoms (especially North Kalua'ā), and in one location at Hāpapa bench. It is found in higher densities below the MU. High priority to control around rare taxa and along trails to minimize spread.<br>Control technique: Foliar spray with 2% glyphosate. |
| *Spathodea campanulata* | Widespread | Commonly known as African tulip, *S. campanulata* is a vigorous, easily dispersed tree. It is well established below the MU and found throughout. Target matures as a priority and in canopy weed sweeps across WCAs.<br>Control technique: Cut stump immature trees with 20% triclopyr, 80% biodiesel. IPA larger trees with 100% imazapyr. Follow-up monitoring may be necessary to avoid vigorous re-sprouting from root suckers. May not be effective for trees over 160cm diameter (though these are rare within the MU). Further trials are needed. |

| Taxa | Distribution | Notes |
|---|---|---|
| *Sphaeropteris cooperi* | Scattered | A tree fern with wind-dispersed spores that can travel over 7 miles from parent plant. Can be very invasive and outcompete the native tree ferns and understory. Treat when encountered.<br>Control technique: Cut stump ferns below where fronds emerge and cut up meristem. |
| *Toona ciliata* | Widespread | Commonly known as Australian red cedar, *T. ciliata* is a fast growing, habitat-modifying tree that can produce a lot of seed and grow in high densities. It is a high priority for control. Target in canopy weed sweeps (including IPA) across higher elevation WCAs. Focus on large matures in lower elevations.<br>Control technique: Cut stump or girdle with 20% triclopyr, 80% biodiesel. Can also basal-bark immatures under 7.5 cm diameter with 20% triclopyr, 80% biodiesel. IPA with 100% imazapyr. |
| *Triumfetta semitriloba* | Scattered | Commonly known as Sacramento bur, seeds are easily dispersed hitchhiking on hikers, gear, or pigs. Not known in high densities in the MU, it should be controlled whenever seen, and with priority along trails.<br>Control technique: Clip-and-drip or basal-bark with 20% triclopyr, 80% biodiesel. Immatures can be hand-pulled. |
| *Megathrysus maximus* | Widespread | Seen in its highest densities along the ridges and fence lines, control of *M. maximus* (Guinea grass) is needed in these areas to facilitate monitoring and maintenance of affected fences, and to prevent spread throughout the MU. There are multiple water catchments available for use in Popouwela, and existing catchments should be maintained as needed. While rarely seen around rare resources, the habitat-altering characteristics of M. *maximus* and its ability to quickly invade light gaps also make it a target for sprays within the gulches.<br>Control technique: Foliar spray with 2% glyphosate. 1% may be used in more sensitive areas. |

Restoration activities are discussed in the notes section for each WCA. Future restoration projects are still to be determined for upcoming years. The table below contains specific notes on what native taxa and what type of stock may be appropriate for projects at Popouwela.

**Taxa Considerations for Restoration Actions**

| Native Taxon | Outplant? | Seedsow/ Division/ Transplant? | Notes |
|---|---|---|---|
| *Acacia koa* | Yes | Seed sow? | Tree. Grow from seed. Recruits well in cleared areas with known seed bank. |
| *Antidesma platyphyllum* | Yes | Seed sow? | Tree. Grow from seed. Seeds recalcitrant/short lived. Do not collect large batches for storage. |
| *Bidens torta* | No | Seed sow | Herb or Subshrub. Easily grown via seed sows. |
| *Carex wahuensis* | Yes | Seed sow | Sedge. Grow from seed. Seed sows slow to germinate. Should be sown in winter months to break dormancy as fast as possible. |
| *Clermontia persicifolia* | Yes | No | Shrub. Grow from seed. |
| *Coprosma foliosa* | Yes | No | Shrub. Grow from seed. |
| *Dianella sandwicensis* | Yes | Seed sow/Division/ Transplant | Herb. Grow from seed when possible. Field divisions also an option for restoration purposes |
| *Dodonaea viscosa* | Yes | Seed sow | Shrub. Grow from seed. Use across all sites, especially on open ridges and drier sections. |
| *Doodia kunthiana* | Yes | No | Fern. Grow from spore. Use in understory to replace *Blechnum appendiculatum*. |
| *Eragrostis grandis* | Yes | Seed sow | Grass. Grow from seed. Can be used in seedsows potentially. |
| *Freycinetia arborea* | Yes | Seed sow | Woody vine. Grow from seed. |

| Native Taxon | Outplant? | Seedsow/ Division/ Transplant? | Notes |
|---|---|---|---|
| *Kadua cordata* subsp. *cordata* | No | Transplant | Subshrub. Grow from seed if desired. |
| *Geniostoma kaalae* | No | No | Shrub or Tree. Grow from seed if desired |
| *Metrosideros polymorpha* | Yes | No | Shrubs or Trees. Grow from seed. This includes all varieties. |
| *Microlepia strigosa* | Yes | Division/Transplant | Fern. Grow from spore for outplants. Survives division and transplanting in mesic environments. |
| *Myrsine lessertiana* | Yes | No | Tree. Grow from seed. |
| *Perrottetia sandwicensis* | Yes | No | Shrub or Tree. Grow from seed or cutting. Mature fruiting period very short. Prioritize fruit collections in December/January. |
| *Pipturus albidus* | No | Seed sow | Small tree. Fast growing. Known to grow from seed sows. Consider planting longer lived tree species underneath and planning for senescence after year three. |
| *Ceodes umbellifera (Pisonia umbellifera)* | Yes | Seed sow/Transplant | Tree. Fast growing. Easy to propagate. Known to grow from seed sows. |
| *Planchonella sandwicensis* (*Pouteria sandwicensis*) | No | Seed sow?/ Transplant | Tree. Slow growing. Consider testing seedsows or transplants of saplings. |
| *Psychotria hathewayi/ mariniana)* | Yes | No | Tree. Grow from seed. |
| *Rumex albescens* | Yes | Seed sow? | Herb or Subshrub. Grow from seed when possible. Very useful species for steep sections. |
| *Scaevola gaudichaudiana* | Yes | Seed sow? | Shrub. Grow from seed. Potentially trial seedsows in cleared areas. |
| *Touchardia oahuensis (Urera glabra)* | Yes | No | Shrub or Small tree. Grow from seed when possible. Cuttings also possible, maybe more useful if selecting for male/female. |
| *Urera kaalae* | Yes | No | Shrub. Grow from seed or cutting. |

**WCA: KaluaaandWaieli-01 (North of Pu‘u Hāpapa)**

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native cover

Targets: Canopy weeds include *S. terebinthifolius, Psidium cattleianum, H. popayanensis,* mature *T. ciliata* and *G. robusta*. Understory weeds include *R. rosifolius*, *C. hirta*, *E. karvinskianus,* and *M. minutiflora*.

Notes: *Achatinella mustelina* were historically abundant in the area, but most have been translocated into Hāpapa snail enclosure. Ground/arboreal dwelling snails were also moved (*Laminella sanguinea* and *Cookeconcha* sp.). Much of this WCA is steep and difficult to move around. Access is also limited as it is partially in the Safety Danger Zone (SDZ) of South Range. Though there are still rare native taxa in the area (i.e. *Lobelia yuccoides*, *Phyllostegia hirsuta,* and *Cyanea calycina*), weed efforts here are minimized.

**WCA: KaluaaandWaieli-02 (Hāpapa Bench)**

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native cover

Targets: Canopy weeds include large *S. terebinthifolius, P. cattleianum,* mature *T. ciliata, S. campanulata, M. phillipensis*, and *G. robusta*. Understory weeds include *S. palmifolia*, *R. rosifolius*, *C. hirta*, *P. suberosa*, *L. camara*, *C. parasitica, B. appendiculatum, E. karvinskianus*, *M. minutiflora, M. maximus, P. conjugatum.*

Notes: This large WCA is home to several rare plant wild sites and reintroductions sites, as well as the largest population of *A. mustelina* in the Waianae Mountains. The Hāpapa snail enclosure is included in this WCA. Ground dwelling snails and *Drosophila* are also present. For these reasons, it is the major focus of restoration activities within Popouwela MU. Rare plant taxa (wild and reintroduced) include: *D. waianaeensis*, *P. princeps* var. *princeps*, *S. kaalae*, *S. kanehoana*, *U. kaalae, C. membranacea*, *Melicope cornuta* var. *decurrens*, *L. yuccoides, G. kaalae*, and *Embelia pacifica.*

Due to the presence of such a variety of rare and endangered taxa, care must be taken in replacing weeds with natives, and when conducting any ground disturbance. Conduct gradual removal of canopy weeds, focusing on *S. terebinthifolius,* mature *T. ciliata* and *G. robusta,* to foster native recruitment. Remove understory weeds, focusing on shrubs, herbs, and *C. parasitica.* Snails in the area are sometimes found on *S. terebinthifolius* and control of this taxa should be strategic. The entire WCA should be swept for target canopy species, such as *S. campanulata* and *T. ciliata*. At rare plant sites, both understory and canopy control should be conducted. IPA sweeps have been conducted here in 2016 and 2018, but it is possible that we could do selective IPA's here in the future.

*Setaria palmifolia* has been found on the trail from the Hāpapa enclosure up to the Hāpapa LZ. There is zero tolerance for this target taxa in this WCA.

Restoration here has been primarily focused on the vegetation surrounding the snail enclosure and weatherport. As the program switches outplanting practices to focus on different seed zones by year, it is important to continue with other types of restoration like seedsows, divisions, and transplants to supplement weed control efforts until it is seed zone OA-08's turn.

**WCA: KaluaaandWaieli-03 (South Wai'eli)**

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 50% non-native cover

Targets: Canopy weeds include mature *T. ciliata, G. robusta, S. actinophylla, S. campanulata,* and *H. popayanensis*. Understory weeds include *C. hirta*, *B. asiatica*, *C. parasitica* and *R. rosifolius*.

Notes: Weed control is focused around reintroduced *D. waianaeensis.* This area is a priority for control. Understory weeds are targeted in addition to limited canopy control. This WCA encompasses the south branch of Wai'eli, which is dominated by large *T. ciliata* with nice remnant patches of *Ceodes* spp., *Rockia sandwichensis* and *Diospyros* spp. The back wall of the gulch, just below the Hāpapa bench WCA, is very steep and dominated by *S. terebinthifolius*. IPA sweeps were done in this gulch in 2013 and 2014, but are currently discontinued.

**WCA: KaluaaandWaieli-04 (Upper North Kalua'ā)**

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native cover

Targets: Canopy weeds include mature *T. ciliata, G. robusta,* and *S. terebinthifolius.* A variety of understory weeds include *P. suberosa*, *R. rosifolius*, *L. camara*, *C. hirta*, *P. cattleianum, B. asiatica, B. appendiculatum, M. maximus*, and *S. palmifolia.*

Notes: This WCA encompasses reintroductions of *D. waianaeensis*, *C. grimesiana* subsp. *obatae*, *E. herbstii, S. kaalae, U. kaalae and T. oahuensis.* Wild trees of *A. macrococcus* var. *macrococcus* were historically found within this WCA. In addition, there are a few large wild *T. oahuensis* trees which are appropriate habitat for *D. montgomeryi*. Weed control should be focused on both canopy and understory species around these rare taxa.

The western portion (higher elevations) of this WCA is very steep and dominated by *S. terebinthifolius* canopy. IPA sweeps were conducted here in 2016 through 2018, but have since been discontinued. It is possible that we will be doing IPA's for different target taxa here in the future.

*Setaria palmifolia* and *M. maximus* are known within this WCA and should be controlled with priority along trails and around rare taxa.

**WCA: KaluaaandWaieli-05 (North Kalua'ā below old fence)**

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 50% non-native cover

Targets: *G. robusta*, *S. actinophylla, S. campanulata, H. popayanensis*, *M. maximus* and *S. palmifolia* to prevent/minimize spread throughout the MU.

Notes: There are no managed rare taxa within this WCA. Control is focused on preventing spread of target weeds and reducing recruitment pressure on adjacent WCAs. Canopy sweeps were conducted with priority on mature, fruiting *T. ciliata*, as well as *G. robusta*, *S. actinophylla, S. campanulata,* and *H. popayanensis.* IPA sweeps have been conducted here 2014 through 2019, but are now discontinued. *H. popayanensis* should be chainsawed down and treated 20% G4 Ultra, to avoid creating hazard trees on the trail.

*M. maximus* and *S. palmifolia* are abundant within this WCA and should be controlled with priority along trails and fences to prevent spread throughout the MU.

**WCA: KaluaaandWaieli-06 (Gulch 3)**

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native cover

Targets: Canopy weeds include mature *T. ciliata, G. robusta,* and *S. terebinthifolius.* A variety of understory weeds include *Erechtites valerianifolius*, *Emilia fosbergii*, *P. suberosa, R. rosifolius*, *L. camara*, *C. hirta*, *B. asiatica*, *T. semitriloba*, *P. cattleianum, C. parasitica, M. maximus,* and *M. minutiflora.*

Notes: Weeding in this WCA is focused around reintroductions of *P. mollis*, *C. grimesiana* subsp. *obatae*, and *S. kaalae*. The back of Gulch 3, where most of these rare taxa are concentrated, is dominated by native *Cedoes* spp. patches. Habitat on the native slopes contains rock talus substrate which can be challenging for weed control. Care should be taken to avoid harm to ground snails, which are known from this area. Canopy is thick and predominately native within the *Ceodes* patches, minimizing the need for aggressive weed control. Weeding efforts are focused on maintaining understory around rare taxa.

Restoration work has occurred around the CyaGriOba.KAL-D population totalling about 0.68 acres. So far, 1056 common natives have been planted in this location, including 89 *Touchardia oahuensis*.

Weeding in this open canopy often results in booms of weedy asters, especially *E. valerianifolius*. Seed sows may be a great idea after weeding these areas, as there is also a lot of *P. albidus* recruitment here.

Further upslope, there is also a wild population of *D. waianaeensis*. The slope here is especially steep, and the canopy open. Staff should consider erosion and rock fall hazards while conducting weed control. Control is focused on understory weeds such as *M. minutiflora*. Canopy species should be targeted selectively to avoid sudden light changes or canopy gaps that would boost invasion of understory weeds. This is a possible site for restoration focusing on understory species to prevent erosion.

*Megathrysus maximus* is also present in this WCA along the fence bordering WCA-05. It should be maintained to facilitate monitoring and maintenance of the fence line, and to prevent spread throughout the MU. Sprays here are logistically difficult because water needs to be hiked or flown in. Use of water catchments should be investigated, and existing catchments rehabilitated as needed.

IPA sweeps have been conducted in WCA-06 since 2014 through 2020 and have since been discontinued. It is possible that we will be doing IPA's for different target taxa here in the future.

Restoration goals for this WCA continue to be buffering out the CyaGriOba.KAL-D population. Utilize seedsows, divisions, and transplants until outplants are avaiable for this seedzone.

**WCA: KaluaaandWaieli-07 (Gulch 2)**

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 50% native cover.

Targets: Canopy weeds include mature *T. ciliata, G. robusta,* and *S. terebinthifolius*, and understory weeds include *L. camara*, *P. conjugatum*, and *R. rosifolius.*

Notes: There are no managed taxa in this WCA. There is a substantial patch of *T. oahuensis* trees, which have been augmented by a PEPP outplanting of *U. kaalae*. Although no *D. montgomeryi* are known from this area, it is viable habitat and other rare *Drosophila* are present. Weeding is conducted annually to support this potential habitat. IPA sweeps were conducted in WCA-07 in 2016 through 2020, and have since been discontinued.

**WCA: KaluaaandWaieli-08 (Gulch 1)**

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native cover

Targets: Canopy weeds include mature *T. ciliata, G. robusta, P. cattleianum,* and *S. terebinthifolius*. Understory weeds include *P. suberosa*, *C. hirta, E. valerianifolius*, *E. fosbergii*, and *R. rosifolius.*

Notes: This WCA contains a core TNC outplanting site which was adopted and expanded by ANRPO. A large concentration of rare taxa are found in the lower gulch at the 1A site. These are a combination of reintroductions by TNC, ANRPO and PEPP. They include a large outplanting of *D. waianaeensis, S. kaalae, S. sandwicensis, Cyanea pinnatifida* and *U. kaalae*. Also present nearby is the only wild location of *C. grimesiana* subsp. *obatae* in Popouwela MU. There is an intact canopy of native trees, which include *Acacia koa* (koa), *C. umbellifera, Psychotria mariniana*, *Metrosideros polymorpha, Planchonella sandwicensis,* and *Antidesma platyphyllum.*

Weed control is a high priority in the 1A site. It is a large area, requiring substantial maintenance. Understory weeds, particularly *C. hirta*, grow aggressively in areas where *P. cattleianum* canopy was removed. However, removal of *C. hirta* is often followed by rapid germination of weedy asters, *E.*

fosbergii and *E. valerianifolius*. Common native seed sows might be a good idea after *C. hirta* weeding. Planting understory and canopy common natives would likely reduce understory weed prevalence.

Weed control in this WCA also takes place around *Touchardia* outplantings in the back of the gulch as part of *Drosophila* habitat stabilization.

The final area of focus for weed control in WCA-08 extends below the 1A site to the stair trail. Weed control in this area is managed by Outreach and the Vegetation Restoration Team. The Vegetation Restoration team named this area "Liana Lane", converting invasive dominated forest into native forest. This involves removing all non-native vegetation within the area and replacing it with outplants of native vegetation. This project was planted throughout the 2022-2023 outplanting season. Seedsows, divisions, and transplants will once again be used to continue restoration in this area until outplants are ready and needed. The area includes a population of *Cyanea superba* subsp. *superba* planted by TNC, and there are former project stewardship sites located here. In addition, there is a unique grove of *Pittosporum flocculosum*, *Gynochthodes trimera* and *P. mariniana*. The terrain is generally conducive to volunteer project weed control, though areas of appropriate terrain should be carefully chosen as the slope gets progressively steeper away from the gulch bottom.

IPA sweeps were conducted in 2015 through 2020, and have since been discontinued. It is possible that we will be doing IPA's for different target taxa here in the future.

**WCA: KaluaaandWaieli-09 (Lower Gulch Gate)**

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 50% native cover

Targets: Canopy weeds include *T. ciliata, G. robusta, P. cattleianum,* and *S. terebinthifolius*. Understory weeds include *P. suberosa*, *C. hirta, R. rosifolius, B. appendiculatum* and *O. hirtellus*.

Notes: This WCA encompasses the lowest elevations of Central Kalua'ā gulch. There are no managed taxa within the WCA, but there is a population of *Cyanea superba* subsp. *superba* planted by TNC. This WCA is a focal site for outreach activities. Current weed control, conducted by volunteers, is focused primarily around native forest patches as an extension of WCA-08, and secondly in adjacent weedy zones. Non-native understory, including ferns, is targeted with gradual control of canopy weeds. Common native reintroductions will be used where necessary to support restoration activities.

Along the ridge crest leading up the southern fence line, a fairly intact canopy and seed bank of koa remains. This taxon will be used in restoration efforts to replace alien vegetation. A strategy of peeling back alien vegetation beginning at the koa dominated ridge crest first, and moving down slope as koa saplings come up could also be employed in restoring this WCA, and the adjacent WCA-10.

The outreach program formerly targeted *T. ciliata* in the upper portions of the WCA to minimize spread into higher WCAs. IPA sweeps were conducted by the Vegetation Restoration Team in 2015 through 2020 and have since been discontinued. IPA targets include mature *T. ciliata*, *G. robusta*, *S. campanulata*, *H. popayanensis*, and *S. actinophylla.*

**WCA: KaluaaandWaieli-10 (South Central/Catchment Ridge)**

Veg Type: Mesic Mixed Ridge

MIP Goal: Less than 25% non-native cover

Targets: Mature *T. ciliata, P. cattleianum*, *G. robusta*, *S. terebinthifolius, C. hirta*, *L. camara, R. rosifolius,* and *P. suberosa*

Notes: Weed control in this WCA is concentrated around rare taxa: a reintroduction of *S. kanehoana,* and wild population of *Phyllostegia hirsuta.* Both are located along the southern-most ridge in Popouwela MU. As explained earlier, *S. kanehoana* are planted in sensitive uluhe habitat, and care should be taken to avoid trampling which would encourage incursion of weedy species. In addition, *S. kanehoana* have a sprawling habit and delicate canes that weave throughout the uluhe making it difficult to move among them without breaking them. Weed efforts here are better spent buffering the reintroduction zone to expand native habitat and decrease chances of non-native recruitment into the uluhe. Weed control around the *P. hirsuta* focuses on understory taxa with selective canopy control. There is also potential for volunteer weed control efforts lower on this ridge. IPA sweeps have been conducted here 2019 and 2020, but have since been discontinued. It is possible that we will be doing IPA's for different target taxa here in the future. The gulch habitat in this WCA is largely degraded. There is potential for a *Drosophila* restoration site in this gulch, but other WCAs (02, 04, 07, and 08) are more promising.

**WCA: KaluaaandWaieli-11 (Kalua'ā and Wai'eli Trails and Fence)**

Veg Type: Mesic Mixed Ridge and Mesic Mixed Forest

MIP Goal: Less than 50% non-native cover

Targets: Weeds along fenceline, particularly *M. maximus, S. palmifolia, and C. hirta*

Notes: This infrastructure WCA includes perimeter fenceline and any trails within it, including the trail to Hāpapa Bench. Weeds which impede the trail or block visual inspection of the fence will be controlled as needed.

**WCA: KaluaaNoMU-01 (Kalua'ā Access Road)**

Veg Type: Mesic Mixed Forest

MIP Goal: None

Targets: *M. maximus*

Notes: This WCA follows the Kalua'ā access road from the water tank to the trailhead. Road improvements in 2016 have minimized the need for extensive maintenance. *M. maximus* is power sprayed and/or backpack sprayed, and downed-trees cleared as needed

**WCA: KaluaaNoMU-02 (CryMan)**

Veg Type: Mesic Mixed Forest

MIP Goal: None

Targets: *B. asiatica*, *R. rosifolius*, *T. ciliata*

Notes: No current MIP or OIP goals for this site. Visits were historically conducted to collect from *A. macrococcus* var. *macrococcus* in the area, which has since died, and weed control was conducted in conjunction with PEPP management for *Cryptocarya manii*.

**WCA: KaluaaNoMU-03 (Ti Leaf Flats)**

Veg Type: Mesic Mixed Forest

MIP Goal: None

Targets: *T. ciliata*, *S. terebinthifolius, S. actinophylla, C. hirta, R. rosifolius, L. camara, C. parasitica, D. chinensis, O. hirtellus,* and *P. conjugatum*

Notes: This WCA includes the TNC Ti Leaf Flats fence located along the access trail before the contour trail junction. The goal of weed control within this WCA is to ensure continued survival of *Abutilon sandwicense* reintroductions (planted by TNC). The habitat is alien dominated and most of the native plants within the enclosure were planted. This is a low priority action as there are no current MIP goals for this *A. sandwicense* population.

**WCA: KaluaaNoMU-04 (Kalua‘ā Access Trail)**

Veg Type: Mesic Mixed Forest

MIP Goal: None

Targets: *T. semitriloba*, *D. chinensis, O. hirtellus, M. maximus,* and *S. palmifolia*

Notes: The trail corridor is managed annually or as needed to facilitate access by staff, and minimize the movement of weeds into the MU. *Triumfetta semitriloba, D. chinensis, M. maximus,* and *S. palmifolia* are of particular concern as they are easily spread and not yet well-established in the fence. In addition, the Kalua‘ā trailhead LZ is included in this WCA; it is a priority to maintain vegetation on and around it as needed.

**WCA: KaluaaNoMU-05 (GarMan)**

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native cover

Targets: Mature *T. ciliata, P. cattleianum*, *G. robusta*, and *C. hirta*

Notes: Weed control used to be conducted around the wild endangered *G. mannii* at this site, which unfortuately died in 2021.

**WCA: SBSNoMU-02: (‘Ie‘ie Patch)**

Veg Type: Mesic Mixed Forest

MIP Goal: None

Targets: *P. cattleianum*, *S. terebinthifolius*, and *C. parasitica*

Notes: A small fence once protected a patch of *Frecinetium arborescens*, outplanted *T. oahuensis*, and a small patch of native forest. *Achatinella mustelina*, *A. micans*, and *L. sanguinea* are known historically from this location, but are no longer extant. This site is not in an MU, and is not a priority for management. Some weed control may be conducted here in conjunction with other rare taxa monitoring activities. Access to the site is limited, as it lies behind a live fire training range and the area is frequently closed to ANRPO.

# Small Vertebrate Control

Species: *Rattus rattus* (Black rat), *Rattus exulans* (Polynesian rat), *Mus musculus* (House mouse), *Herpestes auropunctatus* (Small Indian Mongoose), *Felis catus* (Feral cats), *Pternistis erckelii* (Erckel's francolin).

Threat level: High for *A. mustelina*, *C. grimesiana* subsp. *obatae*, and *D. waianaeensis*

Seasonality: Year-round

Management Objectives:

- Maintain low levels of rat activity around localized control grids.
- Zero-tolerance for rats and mice within the Puʻu Hāpapa snail enclosure.

Strategy and Control Methods:

- Keep sensitive snail populations safe from rat predation via predator proof fence (*Achatinella mustelina* enclosure completed in 2011).
- Monitor rare plants and rare snails for damage from game birds. If observed, investigate control options and bring up to NEPM.
- Maintain predator fence to ensure no breaches occur. Hand-broadcasts of D50 inside and outside snail enclosure can be applied if breaches occur.
- Monitor ground shell plots for predation of *A. mustelina* by rats.
- Quarterly census monitoring of *A. mustelina* population within the Hāpapa snail enclosure to determine population trend and determine if any new threats are present.
- Annual census monitoring of rare plants during fruiting season (*D. waianaeensis*, *C. grimesiana* subsp. *obatae*,) with particular focus on detecting rat damage (gnawed fruit or stalks).
- Maintain 3 localized A24 grids around Hāpapa bench, Kaluaʻā Gulch 1A *D. waianaeensis*, and North Kaluaʻā *Cyanea grimesiana* subsp. *obatae* sites.
- Keep trails clear and GPS traps to facilitate grid maintenance.

Discussion:

Rats pose a high threat to both rare plants and invertebrates. They negatively impact rare and endangered plants, such as *D. waianaeensis* (pictured below) by consuming fruit and seeds and consequentially decreasing seedling recruitment. Rats will also gnaw plants to obtain moisture, especially in drier months, effectively girdling or even chewing through the affected stalk. In addition, rats are known to eat rare snails, as evidenced by predated shells of *A. mustelina* (also pictured below).

Most *A. mustelina* within the MU are protected from rats by the Hāpapa snail enclosure. The enclosure is inspected every 6 weeks and after major rain events. It is inspected for premature rust or weathering of material and erosion that might compromise integrity of the wall. The hood is checked to ensure rats and Jackson's chameleons cannot enter, and surrounding trees are kept well-trimmed to ensure rats cannot jump over the wall.

However, there have been at least two rats found in the Hāpapa Snail Enclosure and there has been consistent mice tracks on tracking cards since September 2022. We have installed 6 A24's and 1 AT-220 inside the snail enclosure, 1 AT-220 outside the snail enclosure, and have been hand-broadcasting D50 inside and outside the snail enclosure as a result.

Other rodent control in Popouwela MU is currently focused into small-scale grids around affected taxa. There are three grids of automatic self-resetting A24 traps: KAL-A, KAL-D and KAL-E. The KAL-A grid is comprised of 12 traps at Hāpapa bench around the snail enclosure; these are intended to protect rare snails in the area that were not translocated into the enclosure, and to reduce outside pressure on the enclosure and possibility of rodent incursion. The KAL-D grid was updated in 2023 to 31 A24's and 1 AT-220 from 6 A24's arranged around outplanted *C. grimesiana* subsp. *obatae* and *D. waianaensis* in upper North Kaluaʻā. The KAL-E grid in Kaluaʻā gulch 1 has 30 traps. It was established to protect a large outplanting of *D. waianaeensis* and wild *C. grimesiana* subsp. *obatae*. Other rare taxa protected by this grid are outplanted *S. kaalae*, S*olanum sandwicense*, *U. kaalae*, and *C. pinnatifida*. We will be installing more AT-220's to the grids as inventory becomes available.

Limited research has been done on rat densities or frequencies within Popouwela MU specifically. However, population spikes are known to occur in other areas during the summer coinciding with increased availability of resources, such as *Psidium cattleianum* fruit. With the implementation and improvement of A24 traps, year-round protection for affected taxa is now more efficient and effective. Automatic lure pumps (ALPs) allow constant protection with decreased staff time and maintain efficacy despite seasonal population spikes. A24s require minimal maintenance. The baits are currently changed on a 4-month interval, and trails are maintained as needed. Effectiveness of rodent control is measured by observed impacts (or lack thereof) on target taxa.

A REPI grant may be able to fund up to 320 A24s in the future for Honouliuli ecosystem protection. It could fund a team of 6 staff members for 2 years on a 5 year budget. Reference fiscal year 2023 REPI grant.

**Rat Photos**

Rat predation of *D. waianaeensis* caught on a game camera

Predated *D. waianaeensis* fruit

Gnaw marks on *Coffea arabica*

Evidence of rat predation on *A. mustelina* shells

## Slug Control

Species: *Deroceras laeve*, *Limax maximus*, *Meghimatium biliniatum*

Threat level: High for *C. grimesiana* subsp. *obatae*, *C. superba* subsp. *superba, D. waianaeensis, Phyllostegia mollis, Schiedea kaalae, and Stenogyne kanehoana*

Seasonality: Wet season

Management Objectives:

- Eradicate slugs locally to increase the likelihood of *C. grimesiana* subsp. *obatae, Cyanea superba* subsp. *superba, D. waianaeensis, and Schiedea kaalae* population growth.
- Minimize impacts on rare snails.

Strategy and Control Methods:

- Control slugs at sensitive plant populations via Ferroxx AQ application every 6 weeks. A buffer of at least 5 meters around vulnerable plants is recommended. 10 meters is optimal.
- If rare snails are found in an established Slug Control Area (SLCA), treatment will be halted. Rare snails will be relocated to the Hāpapa snail enclosure. Area will continue to be surveyed and *Achatinella* spp. translocated to enclosures until all *Achatinella* spp. are removed from the area and at least one survey is conducted where no *Achatinella* spp. are found within area.
- Annual census monitoring of rare plant seedling recruitment following fruiting events (*U. kaalae*, *D. waianaeensis*, *C. grimesiana* subsp. *obatae*, *Plantago princeps* var. *princeps*, *Phyllostegia mollis*, *P. hirsuta* and *Schiedea kaalae*) with particular focus on detecting evidence of slug feeding (slime trails, leaf margins and lower leaves consumed, upper surface of thicker-leaved species scraped off.)
- If new outplantings of plants vulnerable to slug attack take place, or if existing sites are enlarged, the Rare Snail Specialist must complete a day and nighttime survey to ensure there are no rare snails in the area. If no native snails are found, apply Ferroxx AQ every 6 weeks.

Discussion:

Invasive, herbivorous slugs are known to prey upon rare managed plant taxa within this MU. Seedlings are especially vulnerable and it is imperative to control slug populations when seedlings are present. In 2022, multiple SLCA surveys across the Popouwela MU were conducted to update Ferroxx AQ applications around wild and outplanted rare taxa populations. Localized slug control is now currently being implemented at four sites. New SLCA shapes were drawn on ArcGIS to include the expansion of multiple rare plant taxa populations and update Ferroxx AQ applications. Future SLCA surveys will determine if slug control in North Kalua‘ā at the EupHer KAL-A population is feasible.

Special considerations must be taken when controlling slugs in the Popouwela MU due to the historically wide distribution of native snails. Staff should be aware of the possibility of native snails within the SLCA and be attentive when working in this area. Thorough snail surveys will always be conducted prior to the establishment of a new SLCA, per the Pre-Application Survey Protocol.

**Slug Control Area Locations Table**

| SLCA Code | Plant Population Reference Codes | Date Slug Control Began |
|---|---|---|
| KAL-A-1 | DelWai KAL-C, CyaGriOba KAL-B, SchKaa KAL-B | 2015-05-25 |
| KAL-A-2 | PhyMol KAL-C, SchKaa KAL-C | 2022-11-07 |
| KAL-A-4 | CyaGriOba KAL-E, DelWai KAL-D | 2022-09-26 |

| SLCA Code | Plant Population Reference Codes | Date Slug Control Began |
|---|---|---|
| KAL-A-5 | CyaGriOba KAL-D | 2022-09-26, but discontinued after *Achatinella mustelina* found 6/23. |
| KAL-A-6 | CyaSupSup KAL-B | 2022-08-16 |

**Slug Management Map**

# Image Redacted
# Sensitive Information
# Available Upon Request

**Slug photos**

*L. maximus* and eggs

*M. biliniatum* (Yeung, 2020)

*D. laeve* and typical damage from feeding behavior

Possible slug damage on *C. grimesiana*

**Pre-Application Survey Protocol:**

For control only of slugs and non-native snails via listed, approved molluscicide application in forests, on offshore islands, and in other natural areas to protect threatened and endangered Hawaiian plants. Only Ferroxx AQ® Slug and Snail Bait is approved for use in forest areas in Hawaii. Area must be thoroughly searched by experienced malacologists prior to application of Ferroxx AQ® granules to ensure that non-target native Hawaiian snail species are not impacted. Do not apply in areas where it may come into contact with known populations of endemic Hawaiian snail species from the following rare families or subfamilies: Amastridae, Achatinellinae and Endodontidae. Bait cannot be applied within 20 m of any tree known to harbor endangered Hawaiian tree snails (*Achatinella* spp.).

1. Conduct thorough day survey of proposed treatment area to include searching trees and all understory vegetation. The ground and rock talus areas will also be search. An effort to identify other snails found and their rarity will be made prior to Ferroxx use.
2. If proposed treatment area is known *Achatinella* spp. site or if *Achatinella* spp. is observed during day survey, then must conduct night survey and remove all *Achatinella* spp. to a snail enclosure/protected area prior to bait use.
3. Area will continue to be surveyed and *Achatinella* spp. translocated to enclosures until all *Achatinella* spp. are removed from the area and at least one survey is conducted where 0 snails are found within area.
4. If *Achatinella* spp. are abundant in large numbers or are found on multiple trips, use of Ferroxx will not be allowed in area.
5. If *Achatinella* spp. are located in the area in the course of other field work, then surveys and relocation efforts will resume.
6. An effort to identify other snails found and determine their rarity will be made prior to Ferroxx use.

## Ant Control

Species: *Pheidole fervens*, *Pheidole megacephala*, *Plagiolepis alluaudi*, *Solenopsis papuana*, *Technomyrmex albipes*

Threat level: High for *S. papuana* on rare *Drosophila*, unknown for other species

Seasonality/Relevant Species Biology: Varies by species, but nest expansion is typically observed in late summer to early fall

Management Objective:

- Prevent spread of ant species into areas where not already established. Conduct annual surveys during the summer to determine what ant taxa are present in the MU.
- Implement control if incipient, high-risk species are found or as needed for *Drosophila* conservation.
- Detect incursions of new ant species prior to establishment.

Strategy and Control Method:

- Continue to sample ants at human entry points using the standard survey protocol (Appendix 6-1 2010 Year End Report) and *D. montgomeryi* sites a minimum of once a year. Use samples to track changes in existing ant densities and to alert staff to any new introductions.
- Use AMDRO to minimize the impacts of invasive ants on *D. montgomeryi*.

Discussion:

Ants have been documented to pose threats to a variety of resources, including native arthropods, plants (via farming of Hemipteran pests), and birds. It is therefore important to know their distribution and density in areas with conservation value. This is accomplished using a survey methodology outlined in Appendix 6-1 2010 Year End Report.

In 2017, Paul Krushelnycky (2017 Status Report for the Makua and Oahu Implementation Plans, Appendix ES-10) conducted research at Pu‘u Hāpapa and found conclusive evidence that *S. papuana* negatively affects native *Drosophila* survival. The study showed survival was reduced by 58% in the presence of *S. papuana,* whereas, survival was increased 2.4 fold when localized ant control was implemented. *Drosophila* are susceptible to these negative impacts in the larval and pupal stages of development.

A follow-up study completed in 2020 found that AMDRO ant killer is an effective insecticide for invasive ants in areas where *D. montgomeryi* are present (reference in lit. Cited). AMDRO was found to be effective at controlling a variety of invasive ants while having little to no non-target effects.

Ant surveys are currently scheduled annually at 2 LZs: Wai‘eli-TNC Hāpapa LZ (151), Kalua‘ā Trailhead LZ (214), and the snail enclosure. It is also in the works to survey the Wai‘anae Mountain Watershed Partnership Campsite. Other surveys around *D. montgomeryi* populations may be implemented as deemed necessary by the Rare Insect Biologist and the Invertebrate & Forest Invasive Species Biologist.

**Ant Survey Site Table**

| Site description | Reason for survey |
|---|---|
| Wai‘eli-TNC | Human entry point. High risk of accidental ant introduction |
| *S*nail enclosure | Habitat for at-risk endangered snails |
| Hāpapa LZ | Human entry point. High risk of accidental ant introduction |
| Kalua‘ā Trailhead LZ | Human entry point. High risk of accidental ant introduction |

**Ant Control Plans**

| Site description | Area (sq. m) | Application rate (g) | Application rate (oz) |
|---|---|---|---|
| North Kalua‘ā | 600 | 73-146 | 2.6-5.2 |
| Central Kalua‘ā | 760 | 93-186 | 3.3-6.6 |

**Ant Management Map**

# Image Redacted
# Sensitive Information
# Available Upon Request

ARMY NATURAL RESOURCES PROGRAM O'AHU

# Predatory Snail Control

Species: *Euglandina rosea* (rosy wolf snail)

Threat level: High for *A. mustelina* and other native snails present in the MU

Seasonality: Peak numbers recorded March through June

Management Objective:

- Maintain enclosure as *E. rosea*-free and reduce numbers outside to promote *A. mustelina* survival.
- Maintain enclosure to ensure no breaches occur.

Strategy and Control Methods:

- Quarterly census monitoring of *A. mustelina* population within the Hāpapa snail enclosure to determine population trend and determine if any new threats are present.
- Quarterly sweeps for predatory snails within the entire Hāpapa snail enclosure. Include searching for *E. rosea* in trees where feasible. If snails or egg caches are found during a quarterly sweep, multiple surveys will be initiated with approximately a week apart until the area has been clear of snails.
- Close inspection of *Euglandina* barriers using a telescoping mirror to look under the angle and making sure electrified copper wires are not overlapping or crusty with dead invertebrates.
- Close inspection of any tools, gear, outplantings or transplanted material to prevent introduction of *E. rosea* into the snail enclosure.

Discussion:

*Euglandina rosea* is one of the biggest threats to native snails and the most difficult to control. Predator resistant fences, such as the Hāpapa snail enclosure, are currently the only viable method of satisfactory control. No baits have been developed for the control of predatory snails that would not also adversely affect native snails. Little is known regarding their distribution and prey preference. Control is limited to hand removal. Visual searches are time-consuming and difficult, but effective when used in conjunction with a well-maintained snail enclosure. Thus, staff time should be prioritized to maintain an *E. rosea*-free enclosure through thorough quarterly sweeps of the enclosure, and close inspection and maintenance of the enclosure barriers.

***Euglandina rosea* Photos**

*E. rosea*

*E. rosea* predating *A. mustelina*

# Jackson's Chameleon Control

Species: *Triceros jacksonii* subsp. *xantholophus* (Jackson's Chameleon)

Threat level: High for *A. mustelina* and other native snails present in the MU

Seasonality: Year-Round

Management Objective:

- Keep sensitive snail populations safe from Jackson's Chameleon via predator proof fence (*A. mustelina* enclosure).
- Reduce numbers in proximity to outside snails to reduce predation risk.

Strategy and Control Methods:

- Maintain enclosure to ensure no breaches occur.
- Note and remove any chameleons when surveying for native snails or conducting any other field work in the MU.
- Quarterly census monitoring of *A. mustelina* population within the Hāpapa snail enclosure to determine population trend and determine if any new threats are present.
- Record locations of captured chameleons to track changes in their distribution and proximity to native snails. Follow numbers of captured animals over time to estimate density.

Discussion:

*Triceros jacksonii* subsp. *xantholophus* are known to consume native snails, including *A. mustelina*, and inhabit many of the same areas. Chameleons were first detected in Popouwela MU in December 2011 after the completion of the Hāpapa snail enclosure. Subsequent surveys, which included tree-climbing were conducted through May 2015 which resulted in 32 total chameleons removed from the enclosure and was thought to be chameleon free until December 2022 with the finding of a live female chameleon during a timed count monitoring of *Achantinella mustelina.* A male chameleon carcass was found shortly after during a *Euglandina rosea* sweep in May 2023. Over 600 individuals have since been found and removed from the area surrounding the enclosure.

A naturalized chameleon population is located directly outside the Hāpapa snail enclosure. Control is limited to hand removal. Spot-lighting at night is the most effecting survey method. Spot-lighting involves pointing flashlights in trees at night to find chameleons on branches and coaxing them off with a stick or other object for extraction. It is unlikely manual control is effective in decreasing overall populations of chameleons, since detectability is thought to be low, but due to their high fecundity and the high risk they pose, it remains a priority to remove them whenever seen in the field.

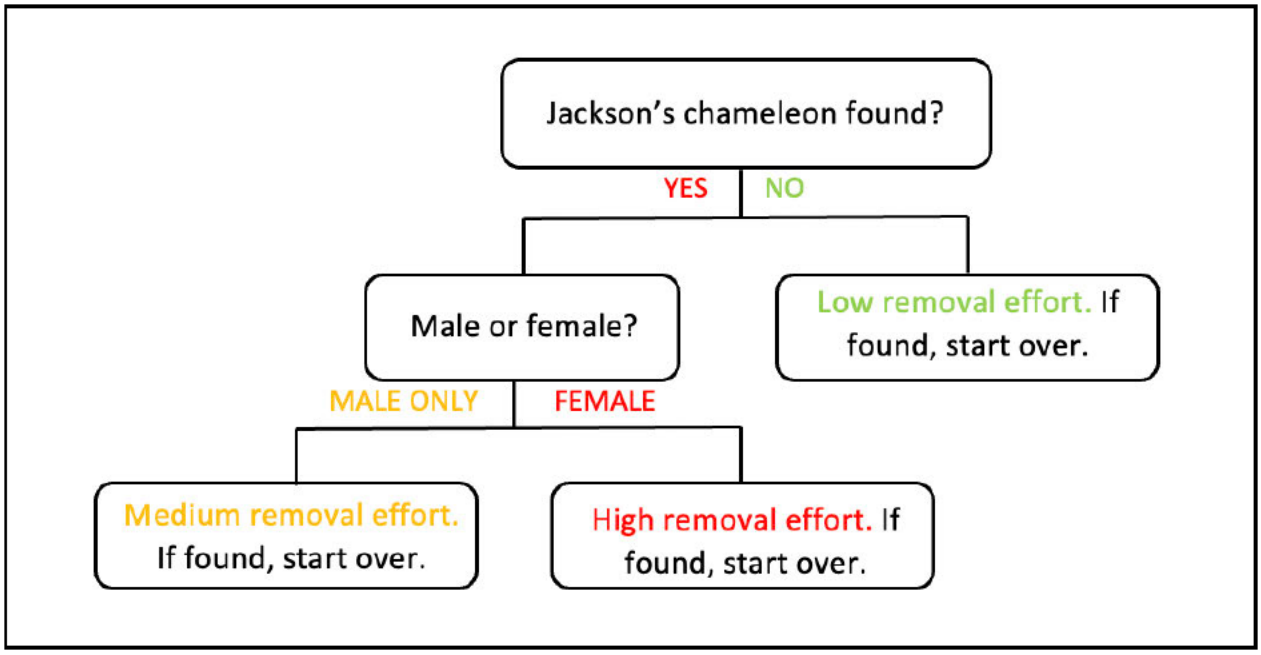
Night searches for chameleons occur at least quarterly at the Hāpapa bench in conjunction with census monitoring of *A. mustelina*. No scheduled control takes place at other *A. mustelina* sites throughout the MU, however chameleons are removed whenever and wherever found during the course of other field work.

Protocol has been developed for removal of Jackson's chameleons if found within the snail enclosure:

High removal effort = once chameleon(s) found, full search of enclosure to be scheduled ASAP. Full search includes staff searching on foot as well as tree climbers searching in trees* until all areas/trees have been searched. After this initial search, full searches will continue quarterly for a year. Searches may be conducted during quarterly snail TCM, however, observers should be dedicated to a single target.

Medium removal effort = once chameleon(s) found, full search of enclosure to be scheduled ASAP. Full search includes staff searching on foot as well as tree climbers searching in trees until all areas/trees have been searched. After this initial search, on-foot searches only (no tree climbers) will continue during the course of quarterly snail TCM; these searches should cover the entirety of the enclosure.

Low removal effort = on an annual basis: for 3 of the 4 quarterly TCM trips to each enclosure, on-foot searches to occur during the course of quarterly TCM, in the areas where snails are being counted. For one of the quarterly TCM trips to each enclosure, a full search will be conducted.



**Chameleon photos**

Chameleon with dissected stomach contents (including *A. mustelina* and other native snails)

Juvenile chameleon found in North Kaluaʻā

Male chameleon found in North Kaluaʻā

Female chameleon (note lack of horns) at Hāpapa

Male chameleon carcass found in Hāpapa Snail Enclosure May 2023

Female chameleon found in Hāpapa Snail Enclosure December 2022

## Fire Control

Threat Level: Low

Seasonality/Potential Ignition Sources: Ignition sources could be from military training although direction of fire from South range is to the north, away from the Popouwela MU. There is currently limited public access to this unit and therefore the threat of arson is low; however, campfires are a possible threat and fire pits have been observed (e.g. Hāpapa LZ, Contour trail, Kaluaʻā trailhead).

Management Objectives:

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

Strategy and Control Methods:

- Staff to remain vigilant of campfires and other possible ignition sources seen when working within the MU.
- Monitor fires in surrounding areas to prevent spread into MU.
- Emergency landing zones were previously cleared and maintained by TNC on Maunauna and the Hāpapa Access Ridge but have since become overgrown. These could be cleared again as needed should fires break out in the MU.

Discussion:

Fire threat in Popouwela MU is low due to lack of nearby ignition sources, low fuel loads within the MU, and its generally wet gulch habitat. There is no recent history of fires burning near the MU; the closest fires have occurred over 1 km away on Schofield Barracks South Range. These are generally well contained and fire response is quick. This MU is easy to monitor from both ANRPO baseyards and is within close proximity to the Army Wildland Fire baseyard. Since Honouliuli is State land, the Popouwela MU is within DOFAW's primary response area, and they would also respond in the event of a fire inside the MU.

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# Ecosystem Restoration Management Plan

## MIP Year 20-25, Oct. 2023 – Sept. 2028

## MU: Manuwai, Manuwai No MU, Alaiheihe No MU

## Overall MIP Management Goals:

- Form a stable, native-dominated matrix of plant communities, which support stable populations of IP taxa.
- Control ungulate, weed, invasive invertebrate, rodent, fire, and other threats in the next five years to allow for stabilization of IP taxa.

## Background Information

Location: Northern Waiʻanae Mountains

Land Owner: State of Hawaiʻi

Land Managers: Department of Land and Natural Resources (DLNR) – Natural Area Reserve System (NARS), DLNR – Land Division, DLNR – Forest Reserve, Army Natural Resource Program – Oʻahu (ANRPO)

Acreage: 300 Acres

Elevation Range: 1000ft-3000ft

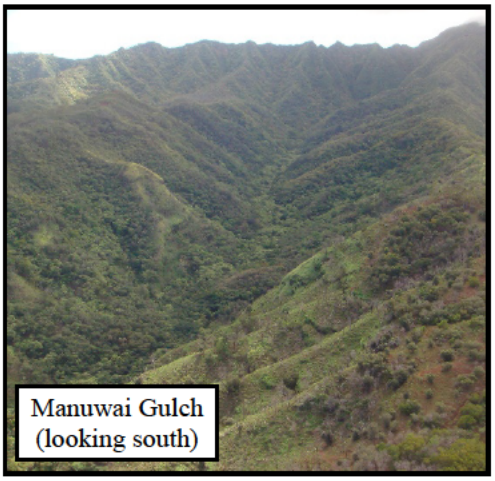
Description: Manuwai Gulch is located in the northern Waiʻanae Mountains. It is one in a series of adjacent, parallel gulches that drain off the side of Kamaohanui Ridge, which extends eastward from Kaʻala. The Manuwai Management Unit (MU) consists of the fenced upper half of Manuwai Gulch, and a side gulch that drains into Alaiheihe Gulch, formed off the dividing ridge between Manuwai and Alaiheihe Gulch. Most of the upper portion of the MU is within the Lower Kaʻala Natural Area Reserve (NAR); the rest is in the State Forest Reserve. There are three landowners (Bob Cherry, Mike Pietsch, and the Kaukonahua Ranch), who allow ANRPO staff to access the MU via a ranch road. This ranch road connects to a 4x4 contour dirt road managed by The State of Hawaiʻi. Access via the west road, which connected to the western ridge of the MU, has been discontinued due to safety concerns. There is no formal easement for use of the roads for Lower Kaʻala NAR Road access, however, consistent communication with Kaʻala Ranch has allowed for reliable access via these roads. Recent helicopter access to the MU has either been from Dragon X LZ on Schofield or from LZ Gordon, on Kamananui Ranch property. Any air access to Manuwai LZ enters controlled airspace (R-3109C), therefore an airmobile request must be filed for each operation within that airspace.

Much of Manuwai Gulch is steep, with some areas that are only safely accessible with ropes. The elevation gradient of the MU is dramatic, and the vegetation types within the MU span from Mesic-wet Forest to Lowland Dry Shrubland. There are multiple *in situ* rare and endangered plant populations scattered throughout the MU. Overall, the MU is dominated by invasive canopy weeds. There are pockets of forest with high levels of native canopy diversity including several sites chosen for MFS reintroductions of *Delissia waianaensis, Neraudia angulata, Nototrichium humile,* and *Hibiscus brackenridgeii* subsp. *mokuleianus*.

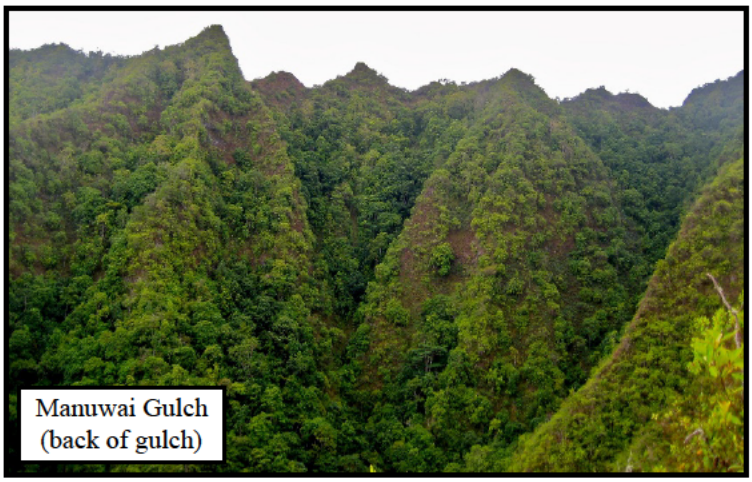
## Native Vegetation Types

| Wai'anae Vegetation Types | |
|---|---|
| Lowland dry shrubland | Canopy includes: *Diospyros* sp., *Dodonaea viscosa, Myoporum sandwicense, Erythrina sandwicensis, Polyscias sandwicensis, Rauvolfia sandwicensis, Santalum ellipticum*, *Psydrax odorata, Notelaea sandwicensis, Sapindus oahuensis* and *Myrsine lanaiensis*.<br><br>Understory includes: *Dodonaea viscosa, Sida fallax,* and *Bidens* spp. |
| Mesic mixed forest | Canopy includes: *Acacia koa*, *Metrosideros polymorpha, Notelaea sandwicensis, Diospyros* spp., *Planchonella sandwicensis, Charpentiera* spp., *Ceodes spp., Rockia sandwicensis Psychotria* spp., *Antidesma platyphylum*, *Bobea* spp. and *Santalum freycinetianum*.<br><br>Understory includes: *Alyxia stellata, Bidens torta, Coprosma* spp., and *Microlepia strigosa* |
| Mesic-Wet forest | Canopy includes: *Metrosideros polymorpha* var. *polymorpha*. Typical to see *Cheirodendron trigynum*, *Cibotium* spp., *Melicope* spp., *Antidesma platyphyllum*, and *Ilex anomala*.<br><br>Understory includes: *Cibotium chamissoi*, *Broussaisia arguta*, *Dianella sandwicensis*, and *Dubautia* spp. Less common subcanopy components of this zone include *Clermontia* spp. and *Cyanea* spp. |
| NOTE: For MU monitoring purposes vegetation type is mapped based on theoretical pre-disturbance vegetation. Alien species are not noted. | |

**Terrain and Vegetation Types at Manuwai**



Manuwai Gulch (looking south)

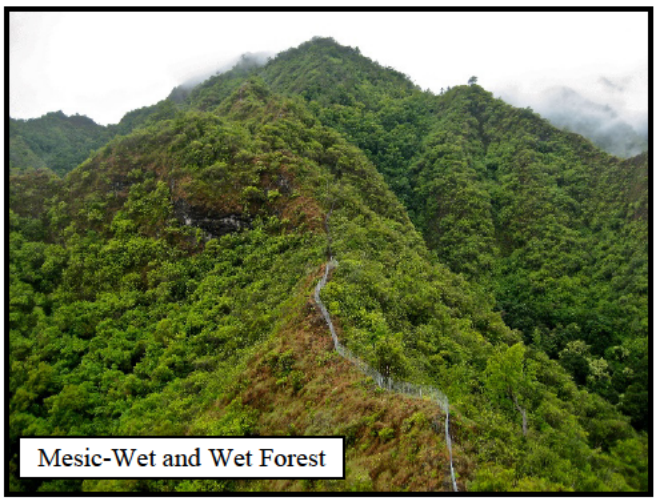


Manuwai Gulch (back of gulch)

Lowland Dry Shrubland/Grassland

Dry Forest

Mesic Mixed



Mesic-Wet and Wet Forest

## MIP/OIP Rare Resources

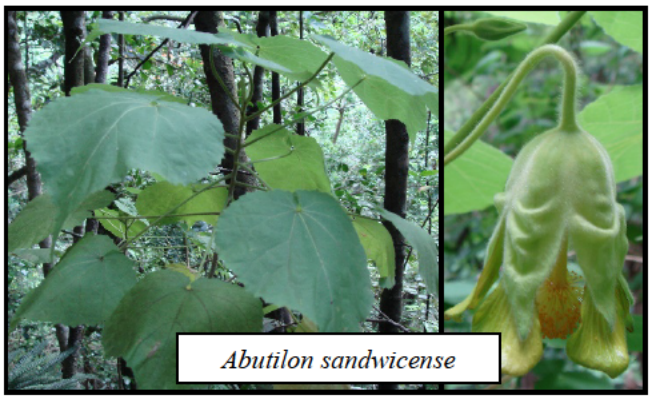
| Organism Type | Species | Pop. Ref. Code | Population Unit | Management Designation | Wild/ Reintroduction |
|---|---|---|---|---|---|
| Plant | *Abutilon sandwicense* | ANU-A, B, C, D, E, F, G, H, J | Ka‘awa to Pū‘ulu | MFS/GS | Wild |
| Plant | *Alectryon macrococcus* var. *macrococcus* | ANU-A*, B*, C* & IHE-A, B, C | Alaiheihe and Manuwai | No Management | Wild |
| Plant | *Cyanea superba* subsp. *superba* | ANU-A | Manuwai | No Management | Reintroduction |
| Plant | *Delissea waianaeensis* | ANU-A, B | Manuwai | MFS | Reintroduction |
| Plant | *Flueggea neowawraea* | ANU-A*, B, C* | Manuwai | MFS | Both |
| Plant | *Kadua degeneri* subsp. *degeneri* | ANU-A, B & IHE-A, B*, C, D | Alaiheihe and Manuwai | MFS | Both |
| Plant | *Hibiscus brackenridgei* subsp. *mokuleianus* | ANU-A, B | Kaimuhole and Palikea Gulch | MFS | Reintroduction |
| Plant | *Wollastonia tenuifolia* | ANU-A, B | Manuwai | GS | Wild |
| Plant | *Neraudia angulata* | ANU-A, ANU-B, ANU | Manuwai | MFS | Both |
| Plant | *Nototrichium humile* | ANU-A | Manuwai | MFS | Reintroduction |
| Plant | *Phyllostegia kaalaensis* | ANU-B* | Manuwai | MFS | Reintroduction (failed) |
| Plant | *Pritchardia kaalae* | ANU-A, B | Makaleha to Manuwai | MFS | Wild |
| Plant | *Wollastonia tenuifolia* | ANU-A, B | Mt. Ka‘ala NAR | MFS | Wild |
| Snail | *Achatinella mustelina* | ANU-A* | ESU-C | MFS | Extirpated |

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

## Other Rare Taxa at Manuwai MU

| Organism Type | Species | Status |
|---|---|---|
| Plant | *Bobea sandwicensis* | Endangered |
| Plant | *Colubrina oppositifolia* | Endangered |
| Plant | *Cyanea calycina* | Endangered |
| Plant | *Dracena forbseii* | Endangered |
| Plant | *Dracena halapepe* | Vulnerable |
| Plant | *Dubautia sherffiana* | Vulnerable |
| Plant | *Exocarpos gaudichaudii* | Rare |
| Plant | *Lobelia niihauensis* | Endangered |
| Plant | *Mezoneuron kavaiensis* | Endangered |
| Plant | *Polycias kavaiensis* | Endangered |
| Plant | *Pteralyxia macrocarpa* | Endangered |
| Plant | *Schiedea hookeri* | Endangered |
| Plant | *Sideroxylon polynesicum* | Rare on Island |
| Plant | *Strongylodon ruber* | Rare |
| Arthropod | *Drosophila flexipes* | Rare |
| Arthropod | *Drosophila obatai* | Endangered |
| Arthropod | *Drosophila paucicilia* | Rare |
| Arthropod | *Drosophila pilimana* | Rare |
| Arthropod | *Drosophila reynoldsiae* | Rare |
| Arthropod | *Drosophila turbata* | Rare |
| Bird | *Chasiempis ibidis* | Endangered |

**Rare Resources at Manuwai**



*Abutilon sandwicense*

*Kadua degeneri* subsp. *degeneri*

*Alectryon macrococcus* var. *macrococcus*

*Hibiscus brackenridgei* subsp. *mokuleianus*

*Neraudia angulata* var. *dentata*

*Flueggea neowawraea*

*Delissea waianaeensis*

**Locations of Rare Resources at Manuwai**

# Image Redacted
# Sensitive Information
# Available Upon Request

**Threats to MIP/OIP MFS Taxa**

| Threat | Taxa Affected | Management Strategy | Current Status, 2018 |
|---|---|---|---|
| Pigs | All | Fence | MU fenced. No animals within fence. |
| Goats | All | Fence | MU fenced. No animals within fence. |
| Rodent | *Delissea waianaeensis*, *N. angulata* | Localized trapping grids at chosen rare taxa sites. | Two localized A24 trapping grids around *D. waianaeensis* populations, one of which encompasses a *Drosophila obatai* monitoring site. |
| Slugs | *D. waianaeensis*, *N. angulata*, *K. degeneri* subsp. *degeneri* | Localized control treatment with molluscicide at chosen rare taxa sites. | FerroxxAQ is applied around *D. waianaeensis* population quarterly. No evidence of slug damage to *N. angulata* and *K. degeneri* subsp. *degeneri*. |
| Introduced Galiformes | *Cyanea superba* subsp. *superba*, *D. waianaeensis*, *N. angulata* | No control currently. However, control to possibly be studied and developed. | *Pternistis erckelii* and *Lophura leucomelanos* are known to damage *D. waianaeensis* stems and eat leaves, fruit, and FerroxxAQ. Control should be investigated. |

| Threat | Taxa Affected | Management Strategy | Current Status, 2018 |
|---|---|---|---|
| Coconut Rhinoceros Beetle (CRB) | *P. kaalae* | No control currently | No known control known for *O. rhinoceros*. *P. kaalae* in Manuwai are not accessible from the ground, aerial surveys may be required to determine damage to palms. |
| Black Twig Borer | *F. neowawraea*, *N. angulata**, *Abutilon sandwicense* | Monitor and research new control methods. | There is no current effective control method. |
| Ants | *Drosophila obatai* | Survey high traffic and rare taxa sites annually. | *Anoplolepis gracilipes* are invading from below due to the increase in invasive scale insects. Localized control may be possible if they reach higher elevation sites. |
| Weeds | All | Focus on rare taxa sites primarily, across MU secondarily | Regular maintenance required several times per year. |
| Fire | All | Reduce grass cover on the southern edge of MU and participate in Wildland Fire groups. | Fuel pre-suppression via grass control, and rapid response and control of potentially threatening fires |

*Threat suspected. Field observation necessary.

## Management History

- 1986: Botanist Steve Perlman conducted surveys in area. Manuwai is noted as having patches of the rare forest type, O‘ahu Diverse Mesic Forest.
- 1990: Mount Ka‘ala Natural Area Reserve Management Plan was written by the Natural Area Reserves System Program.
- 1999-2010: ANRPO visited historical rare plant populations, collected fruit from MIP species, and surveyed for new populations.
- 2000-2005: Snaring regime established along the SBW border east of Kamaohanui in order prevent goats from entering Schofield West Base. Snares removed in 2005.
- 2000-2006: Annual or semi-annual hunts for goats were conducted in the general Lower Ka‘ala NAR region.
- 2007: In August, a wildfire burnt the ridges below the MU, stretching from Ka‘awa gulch in the west, across Manuwai, to Pū‘ulu gulch in the east, and SBW. Many rare taxa were affected. The most significant taxon affected was the *H. brackenridgei* subsp. *mokuleianus*. The fire destroyed about 90% of the total number of *H. brackenridgei* subsp. *mokuleianus* on O‘ahu.
- 2010: Initial vegetation monitoring across the MU was conducted.
- 2010: ANU-A/B fence construction started.
- 2011: MU fence completed.
- 2011: First discovery of *Pterolepis glomerata* was found on the east fenceline along the ridge. *P. glomerata.* Contaminated work gear was most likely the cause of this introduction.
- 2011-2012: Ungulate eradication began via snaring.
- 2013: Ungulate sign decreased significantly; only a few pigs and goats were caught during this year.

- 2013: *D. waianaeensis* (ANU-A)*, C. superba* subsp*. superba* (ANU-A), *P. Ka'alaensis (*ANU-A), *N. angulata* (ANU-B), *F. neowawraea* (ANU-B and ANU-C) were outplanted.
- 2013: *K. degeneri* subsp. *degeneri* are reintroduced in two locations. One on the east fenceline (IHE-D) and the other along the interior fenceline on the West side of the MU (ANU-B).
- 2013: *H. brackenridgei* subsp. *mokuleianus* (ANU-A) plants from the wild populations that were located in the gulches, which burnt in 2007 were reintroduced in the south-west portion of the MU. This was the first *H. brackenridgei* subsp. *mokuleianus* reintroduction into a forested gulch habitat in order to reduce the likelihood that *H. brackenridgei* subsp. *mokuleianus* would be destroyed again by a fire.
- 2014: Fence was deemed ungulate free.
- 2014: *P. glomerata* first discovered on the Kamaohanui LZ.
- 2014: IPA/Targeted taxa sweeps for select canopy weeds on landscape scale begun in walkable portions of MU.
- 2014: *N. angulata* ANU-B population supplemented.
- 2015: Portion of fence in gulch bottom blew out due to flood. Fence was repaired and no pig sign was detected in the MU.
- 2015: *P. glomerata* first discovered during a fence check from Kamaohanui LZ along the west side of the MU.
- 2016: Fence crossing the gulch bottom was replaced with hypalon material allowing water to flow better, which should prevent fence from being blown out again after heavy rains.
- 2016: The 2nd monitoring of the vegetation belt plots was conducted.
- 2017: *Chromolaena odorata* found at the perimeter/interior fenceline crossing.
- 2017: *P. glomerata* first discovered on the east fenceline further away from an existing known *P. glomerata* site also located on the east fenceline.
- February 2017: *C. superba* subsp. *superba* (ANU-B) seed sow trials established; 100 plots, 250 seeds each.
- March 2017: Fresh pig sign was found during a *C. odorata* survey. Snares were set.
- August 2017: One pig was successfully removed using snares. No ungulate sign was observed following the captured ungulate.
- September 2017: Fickle fencing was added to fenceline on the East side close to access road where pig activity on the outside of the fence seems to be high.
- June 2018: *Schizachyrium condensatum* first detected in the MU by ANRPO staff conducting an IPA sweep for Target Canopy Species.
- 2018: Although one pig was removed in 2017 and the fence was assumed to be pig-free, pig activity was found in Manuwai gulch, snares remain in place. Further inspection of the MU fence has not revealed any intrusion locations.
- 2018: Fickle fencing was installed along the fence line to cover the entire east and west sides of the MU.
- 2019: West Access Road survey established.

- 2020: West Access Road abandoned due to difficulty in performing maintenance/ and fixing steep, rutted sections. West Manuwai access restricted to flying or hiking across unit from the east ridge.
- February 2021: The 3rd monitoring of vegetation belt plots was conducted during two camp trips in February and an additional mop-up day trip in April.
- March 2021: Due to poor recruitment and difficulty maintaining acceptable weed levels within the *Hibiscus brackenridgeii* subsp. *mokuleianus* (ANU-A) site on the west side of Manuwai gulch, a new reintroduction site on the east ridge (ANU-B) was selected. The initial planting was conducted on the 31st of March, 2021.
- June 2021: An additional population of *Pterolepis glomerata* was discovered at the northwest end of the ANU-B (interior) fence. This led to the establishment of the fifth *Pterolepis* ICA in Manuwai. Likely this population established accidentally when the area was used as a DZ for the KadDegDeg ANU-B or while constructing the ANU-B fence
- 2022: Due to poor performance at *C. superba* subsp. superba ANU-A population, Managed For Stability designation dropped and moved to population at Kaluaa MU. Manuwai now designated as "No Management" for *C. superba* subsp. s*uperba.*
- February 2022 and January 2023: Two additional *Neraudia angulata* plantings were conducted to bolster numbers at the ANU-B site.
- March 2022: *H. brackenridgeii* subsp. *mokuleianus* ANU-B population supplemented with 79 plants. *K. degeneri* subsp. *degeneri* IHE-D population supplemented with 14 plants.
- May 2022: Because of the difficulty in accessing sites on the west side of Manuwai gulch, an LZ and camp were established near the most frequently visited rare plant sites. After consulting with DOFAW/NARS staff, *Acacia confusa* and other weed trees were removed to establish an LZ and camp. During this time, an LZ was also established on private land owned by Kamananui Ranch land further improving ANRPOstaff access to the unit.
- May 2022: Members of the Animal Team joined the Blue Team to install a hypalon barrier (like the one at the bottom of the unit) where the ANU-B fence crosses the gulch bottom. This will ensure debris can pass in flood situations without compromising the interior as well as perimeter fence.
- December 2022: *H. brackenridgeii* subsp. *mokuleianus* ANU-B population supplemented, for the third time, with 76 plants.

## Ungulate Control

Species: *Sus scrofa* (pigs), *Capra hircus* (goats)

Threat Level:

- *Sus scrofa:* High
- *Capra hircus*: High

Management Objectives:

- Maintain the Subunit I/II enclosures as ungulate free.

Strategy and Control Methods:

- Remove pigs from Subunit II with hunts and traps, and Subunit I with hunts, traps and snares as needed if pig sign is detected in the fence.
- Supplement existing fence with fickle fence.
- Conduct fence checks quarterly around entire MU, including strategic section along entire southern ridge.
- Monitor for ungulate sign while conducting other management actions in the fence.
- Check fences, especially gulch crossings (hypalons), after heavy rains and/or severe weather.

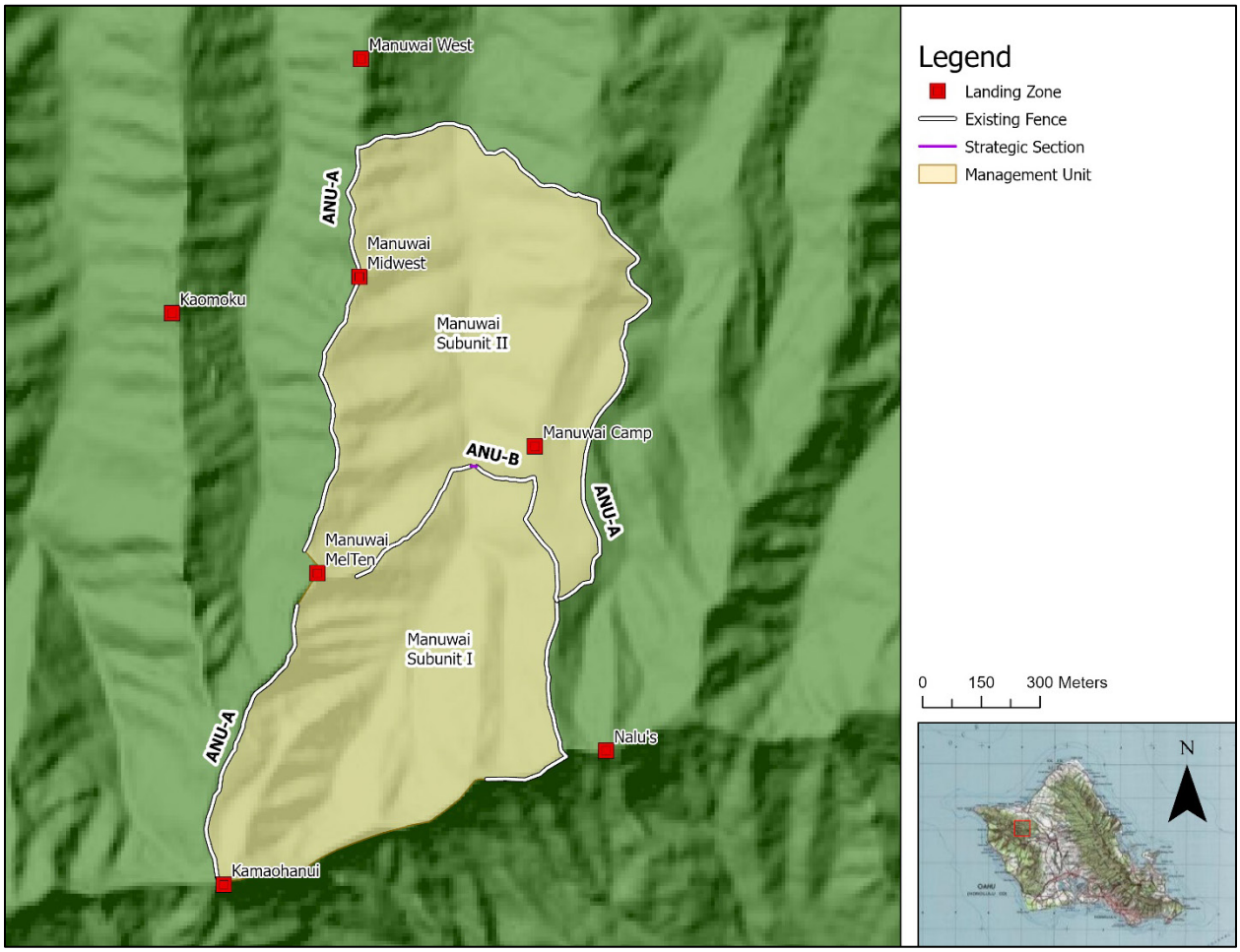
Discussion:

Several sections of the fence are 'strategically' fenced, where natural barriers and geography (cliffs and pinnacle rocks) are used instead of actual fences to prevent ungulate ingress. Much of the southern edge of the MU is strategically fenced, since the topography along this ridge is extremely steep, and pigs and goats are not expected to be able to traverse it. There is a strategic break in fencing around a large rock section on the western fence line as well. Special attention will be given to the strategic portions of the fence during fence checks to ensure that the barriers are effective in keeping ungulates out of the MU.

Ungulate pressure is concentrated along portions of the western fence line (goat) where it is open and exposed, the eastern fence line (pig) upslope of the parking spot, and along the north side (pig) of the fence where it turns up from the access road. Adjacent to Manuwai, Līhu'e (the forested gulches behind Schofield Barracks West Range) is fenced but pigs are still present. There are very few pigs remaining in Līhu'e, so the chances of ingress into Manuwai are very low. There is no snaring along fence lines outside of the main gulch and the fence is skirted along its western and eastern sides. Fickle fencing has been applied along the portion of the fence that parallels the access road. Pig sign has not been observed since the spring of 2017; inconclusive observation was reported but not substantiated.

Aside from the intrusion by ungulates, the fence is under constant pressure of damage from treefalls and erosion. Treefalls take place, most often, along the portions of fence following steep slopes and at gulch bottoms. ANRPO staff cannot remove these trees in a proactive manner for the safety of field staff so most fence work remains reactive once a tree has fallen. Erosion along the portions of fence following exposed ridgelines has continued to prove difficult to manage. Field staff will be trialing "sprouted" jute mat in an area along the western fence line where erosion has continually undermined the foundation of the fence. The "sprouted" jute will consist of 10-15 feet of jute mat with a 1-2" layer of potting mix where native species will be sown, germinated, then rolled up to be applied to the erosion scar on the interior of the fence. The lower sections of the fence that cross the gulch are at high risk of washing out during heavy rainfall. Hypalon barriers and baffles were installed at fence stream crossings to mitigate damage from high water events in the gulch bottom.

# Ungulate Management Map



## Weed Control and Vegetation Restoration

Weed Control actions are divided into 4 subcategories:

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

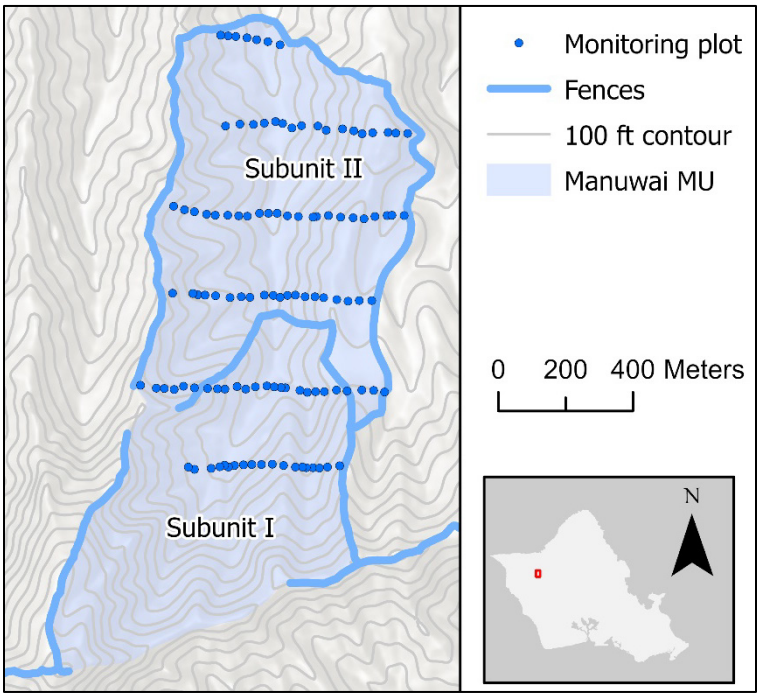
These designations facilitate different aspects of MIP/OIP requirements.

### Vegetation Monitoring

Background

Vegetation monitoring at Manuwai MU occurs on a five-year interval in association with MIP/OIP requirements for long term monitoring of vegetation composition and change over time. The primary objective of MU monitoring is to assess if the percent cover of non-native plant taxa 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.

**Manuwai MU Vegetation Monitoring Plot Locations**




Methods

Monitoring was conducted in 2011, 2016, and 2021 in 111 plots, with plots generally located every 40 m along transects. Transects were spaced approximately 250 m apart within accessible portions of the MU. 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 (non-vegetated < 25 cm

above ground level), were also documented. Monitoring will continue at the same interval, next occurring in 2026. Analysis included vegetation change over time, as well as exploring the influence of vegetation management on vegetation change.

Summary results

Management goals were met for non-native understory in 2021. Goals were not met for native understory, native canopy and non-native canopy in any year.

**Median cover (%) of vegetation in plots from 2010 to 2020.**

| | 2011 | 2016 | 2021 |
|---|---|---|---|
| Native understory | 7.5 | 3 | 3 |
| Non-native understory | 55 | 65 | 45 |
| Native canopy | 15 | 15 | 15 |
| Non-native canopy | 75 | 85 | 95 |

There were a number of noteworthy significant differences in vegetation between the years monitored, summarized in the following table.

**Summary of notable changes/analysis results since 2011.**
**Arrows indicate increase (↑) or decrease (↓).**

| Data category | Notable change/analysis results |
|---|---|
| Categorical cover | ↑ Non-native canopy |
| | ↓ Non-native understory |
| Richness | ↑ Non-native understory, non-native canopy |
| | ↓ Native understory |
| Frequency | ↑ Understory AdiHis, CliHir, PasSub, PsiCat, TooCil<br>Canopy PsiCat, TooCil |
| Species cover | ↑ Canopy PsiCat. TooCil |
| Vegetation management | TooCil and overall non-native canopy cover increased both within and outside of IPA controlled areas |
| | IPA weeding influenced changes in TooCil canopy cover (more plots with decreased cover within than outside of IPA weeded areas) |
| | IPA weeding did not influence changes in GreRob canopy cover (though there were more plots with decreased cover within than outside of IPA weeded areas) |
| | IPA weeding did not influence changes in non-native understory |
| | Increased non-native canopy cover associated with decreased native understory cover |

Aside from the decrease in non-native understory in the last five years, the notable changes in vegetation for Manuwai MU since 2011 have been largely unfavorable ones. Several of the most prevalent weed taxa continued to spread in frequency and/or cover. Most dispiriting for the understory is the continued expansion of *C. hirta*, *A. hispidulum*, *P. suberosa*, and *T. ciliata* across the MU. The continual substantial increase in non-native canopy cover over the last ten years, as *P. cattleianum* and *T. ciliata* in particular continue to expand, is especially disheartening, considering the extensive IPA control efforts for *G. robusta*, *T. ciliata*, and other targets across much of the MU. Despite the IPA control efforts, overall frequency and cover for *G. robusta* and *T. ciliata* were not reduced in the MU, and both species continue to be found recruiting in plots. Rather, *T. ciliata* cover and frequency increased, even in IPA controlled areas. The increased canopy cover for *T. ciliata* even in plots within IPA sweeps is likely because only larger trees were targeted, and trees of smaller size classes are widespread and growing. IPA control efforts did, however, result in a degree of reduced *G. robusta* and *T. ciliata* for some plots in IPA controlled areas, which presumably would have only gotten worse otherwise, as occurred in plots in the areas outside of IPA control. Though staff have expressed concerns that IPA efforts may cause the understory to become weedier, the non-native understory did not get worse as a result of IPA control.

Overall IPA control does not appear sufficient to substantially alter the course of the trend in increased non-native canopy cover, and the apparent negative influence of non-native canopy changes on native understory is concerning. Manuwai MU is a fairly large MU with steep and challenging terrain, and continued ongoing IPA control of target taxa as they grow to the targeted size/stage may be onerous. Given the highly degraded nature of the MU, management goals of < 50% non-native canopy cover is unrealistic, and efforts towards that end may be dubious. It is apparent from other MUs that much can be gained from ecosystem restoration efforts, however, such efforts on a large scale may be more suitably prioritized at other MUs. Small scale restoration efforts may be effective in improving habitat at high value locations of ANRPO managed rare taxa at Manuwai MU.

Recommendations

Based on the results of vegetation monitoring, several recommendations were made with respect to making progress towards meeting management goals:

- Continued efforts for general ecosystem weeding and ICA control, as well as control of limited distribution target taxa when seen. Prioritize weed control efforts at WCAs with the rarest taxa (WCAs-06, 10, 04, 03). Identify high value, minimally invaded, native forest patches with diverse canopy for weed actions. Scheduling more camp trips may help maximize efficiency in accomplishing planned weeding actions. Though no restoration is planned for Manuwai in the near-term, small scale restoration efforts limited to prioritized locations in association with rare taxa stabilization, could improve habitat at those sites.
- Discuss feasibility of future IPA control efforts:
    - As *T. ciliata* is so widespread, the utility of IPA control of larger/mature trees during sweeps to prevent further spread is doubtful. There should be efforts to gain a better understanding of its life cycle and seed biology, its impact on ecosystems, and the impacts of current control strategies. A better understanding of this weed will facilitate the development of realistic tools and strategies for addressing it, as it is spreading aggressively here and in other MUs. There should also be an exploration for the potential for biocontrol.
    - There are several spreading canopy taxa that currently have low cover which may respond better to IPA sweeps: *S. campanulata*, *S. actinophylla*, *T. orientalis*, *P. guajava*, *M. azedarach*, and *F. microcarpa*. It is possible that prioritized WCA sweeps may reduce the spread of these species.
    - Continued IPA control of *G. robusta* may still remain useful, with control prioritized by WCA.
- Release *Tectococcus ovatus* for biocontrol of *P. cattleianum* in areas adjacent to priority zones and get biocontrol established in the MU.
- Determine the identity of the unknown tree taxon along Transect 4.
- Add *Ardisia elliptica* and *Heliocarpus popayanensis* to LDT target list.

Since the time these recommendations were made, discussions occurred focusing on restarting target species sweeps limited to WCAs where “recoverable habitat” may be highest and would most effectively benefit managed taxa.

## Surveys

Potential Vectors: ANRPO staff, State Biologists, ungulates, non-native birds, wind.

Survey Locations: Landing zones, fence lines, access roads, and high potential traffic areas.

Management Objective:

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

Strategy and Control Methods:

- Quarterly surveys of LZs (East Ridge Camp, Nalu's, Kamaohanui, Midwest Camp, Gordon & Bob Cherry's, if used).
- Surveys of access roads (Lower Ka'ala NAR road) every other year.
- Quarterly surveys of campsites (East ridge camp & Manuwai Midwest; if used).
- Note unusual, significant or incipient alien taxa during the course of regular field work, particularly when walking the fence line.
- Survey high traffic areas (Weed Transect Survey on East Side) annually.
- Any significant alien taxa found will be researched and evaluated for distribution and life history. If found to pose a major threat, control will begin and will be tracked via Incipient Control Areas (ICAs).

Discussion:

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

In Manuwai, LZs are surveyed when used, and the Lower Ka'ala NAR Road is surveyed every other year. The Weed Transect runs along the main access trail from the parking spot on the road over the saddle and into the gulch bottom; it is surveyed annually. ANRPO will consider installing additional surveys in other high traffic areas, however, incidental observations during regular field management are also important to document new incipient taxa and potential new ICAs.

**Survey Locations Map**

# Image Redacted
# Sensitive Information
# Available Upon Request

## Incipient Taxa Control

All weed control geared towards eradication of a particular invasive weed is tracked via Incipient Control Areas, or ICAs. Each ICA is species-specific and geographically defined. One infestation may be divided into several ICAs or one ICA, depending on infestation size, topographical features, and land ownership. Some ICA species are incipient island-wide and are a priority for ICA management whenever found. Others are locally incipient to the MU, but widespread elsewhere. In either case, the goal is eradication of the ICA. The goals, strategies, and techniques used vary between ICAs, depending on terrain, surrounding vegetation, target taxon, size of infestation, and a variety of other factors.

Management Objectives:

- Eradicate ICAs through regular and thorough monitoring and treatment. In the absence of any information about seed bank longevity for a particular species, eradication is defined as 10 years of consistent monitoring with no target plants found.
- Study seed bank longevity of ICA taxa, and revise eradication standards per taxon.
- Evaluate any invasive plant species newly discovered in MU and determine whether ICA-level control is warranted. Factors to consider include distribution, invasiveness, location and infestation size, availability of control methods, resources, and funding.

Strategy and Control Methods:

- Species and ICAs are listed in the table below. History and strategy are discussed for each species.
- Monitor the progress of management efforts and adjust visitation rates to allow staff to treat plants before they mature. Remember that one never finds 100% of all plants present.
- Use aggressive control techniques where possible. These include power spraying, applying pre-emergent herbicides, clearcutting, aerial spraying, and frequent visits.

**Summary of ICAs**

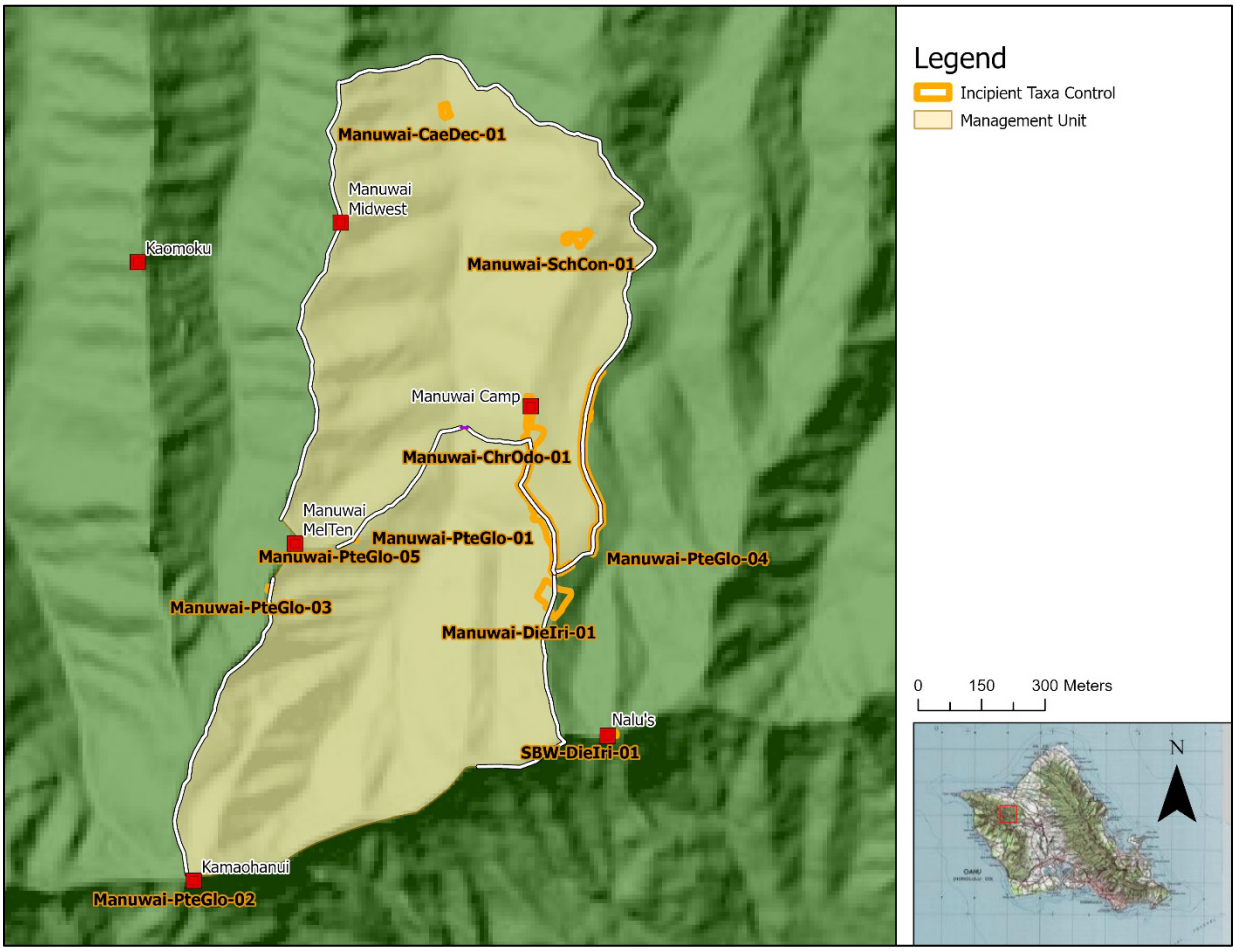
| Taxon | ICA Code | Control Discussion |
|---|---|---|
| *Chromolaena odorata* | Manuwai-ChrOdo-01 | This highly invasive shrub is a major target at KTA and SBW. When an immature plant was discovered in 2017 along a highly trafficked fence line, staff conducted 200m buffer surveys around the site, and swept areas that the Vegetation Restoration Team had conducted IPA treatment during the time period of the suspected dispersal. *C. odorata* was likely introduced to Manuwai by the Vegetation Restoration Team because of their frequent work in *C. odorata* infested areas (KTA) and the timing of their work trips between KTA and Manuwai. *C. odorata* seeds last at least 5 years in soil, and further seed bank longevity testing is underway. Staff have monitored this site regularly, with no plants found since 2017. June 2023 will mark 5 years since the initial buffer sweep, another sweep will be conducted in quarter two or three, 2023. *Of note is the finding of a population of *C. odorata* on private land adjacent to the access road used by field crews to access Manuwai and Lower Ka‘ala Natural Area Reserve. With the landowner’s permission, all plants were treated but there is no plan currently to schedule quarterly checks or designate an ICA. |
| *Caesalpinia decapetala* | Manuwai-CaeDec-01 | One population known from bottom of gulch on north end. Staff should be confident about identifying between *Caesalpinia bonduc* and *C. decapetala*, since there has been misidentification in the past. Annual. |
| *Dietes iridioides* | Manuwai-DieIri-01 | One population known along the east fence line. Staff have been controlling and monitoring this site quarterly. ANRPO staff have controlled this ICA by foliar application using Ranger Pro and a pre-emergent mixture. This technique has reduced the numbers of matures and immatures found however, it has not completely controlled this incipient taxon. ANRPO will investigate a more effective weed control technique by testing a 1% Polaris foliar spray. Further investigation should take seed longevity into consideration. Reduce to twice a year. |
| *Pterolepis glomerata* | Manuwai-PteGlo-01 | Located along the East fence line. This ICA is treated quarterly. However, a significant expansion of the search area of PteGlo-01 occurred when significant numbers were discovered on the south facing slope below the Manuwai Camp LZ found in 2018. Given the presence of *P. glomerata* on the LKN road (although not widespread on the road itself) and likelihood of spread by ungulate activity, reevaluation of control intensity and scope may be required. The focus of control should be to make sure no *P. glomerata* is found on trails or fence lines. |
| | Manuwai-PteGlo-02 | This population was found on Kamaohanui LZ in 2015. Initially staff had found 10 mature and 4 immature individuals. The ICA is checked and/or treated quarterly. Last PteGlo found was August 2017. |
| | Manuwai-PteGlo-03 | This ICA is located on the West fence line near MelTen LZ. The ICA is checked and/or treated quarterly. The only time *P. glomerata* was observed at this ICA was back in 2015 when *P. glomerata* was first discovered. Initial discovery was of 2 mature individuals. |

| Taxon | ICA Code | Control Discussion |
|---|---|---|
| | Manuwai-PteGlo-04 | This ICA exists outside the fence along the Alaiheihe side of the fence line. The ICA is checked and/or treated quarterly. Focus of management is to maintain a clear fence line to prevent further spread. Initial find consisted of 200 matures and 200 immatures. Numbers like the initial find have never reached that threshold again. Staff found 2 immatures in March of 2023. |
| | Manuwai-PteGlo-05 | This ICA is located just below where the ANU-B fence dies into MelTen Pu'u on the west side of the unit, it was first detected in June 2021, since then staff have found 5 matures in May of 2023. |
| *Schizachyrium condensatum* | Manuwai-SchCon-01 | First detected by ANRPO staff in 2018 during an IPA sweep in the north side of the MU. A few mature and immature plants were found. Staff in 2021 found mature plants outside of the "known" extent and expanded the survey area to account for this. This ICA is checked quarterly. |

## Incipient Weed Photos

The two immature *C. odorata* found March 2, 2017 at Manuwai.

**Incipient Control Areas at Manuwai**




## Ecosystem Management Weed Control

All weed control geared towards general habitat improvement is tracked in geographic units called Weed Control areas, or WCAs. The goals, strategies, and techniques used vary between WCAs, depending on terrain, quality of native habitat, and presence or absence of rare taxa.

MIP Goals:

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

Management Objectives:

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

**Weed Control Areas Map**

# Image Redacted
# Sensitive Information
# Available Upon Request

Discussion:

The entire Manuwai MU was broken up into WCAs to ease data tracking. Due to the highly degraded nature of much of the MU, weeding efforts are focused primarily on rare plant sites. In the past, target species sweeps were conducted across the unit, mostly focused on *Toona ciliata* and *Grevillea robusta.* Sweeps are not currently a management focus but may be used in the future due to the ingress of several target weed taxa across the MU. Sweeps will be highly focused around rare taxa sites and other important forest areas and are unlikely to take place across the entire unit.

In addition to smaller scale weed sweeps, ANRPO will also conduct small scale, localized, intensive control primarily around wild and reintroduced sites of rare taxa, as well as in areas with high levels of native canopy. WCAs 06 and 10 have historically received the most attention since rare taxa are found there (see Weed Control Areas Map). With the creation of two new rare plant population reference sites, *D. waianaeensis* and *H. brackenredgei* ANU-B, weed control will be expanded into Manuwai-04 and 08. Canopy weed control should be conducted in advance of plant reintroductions so as not to disrupt rare plants after they are already in the ground. Understory weeds will be controlled continually as needed. Rare plant reintroductions should avoid large patches of *Blechnum appendiculatum*. It is, however, feasible to effectively remove smaller patches of this weed and it should be targeted in all rare plant zones. Additionally, *B. appendiculatum* herbicide trials demonstrated that using 10% Garlon4 spray mix is an effective herbicide to control larger patches of this weedy fern (ANRPO 2015).

The WCAs along Kamaohanui Ridge as well as some others are very steep. Ground-based weed control will be difficult or impossible in these areas and in most cases, control may only be achieved via methods such as aerial ball sprays or Herbicide Ballistic Technology (still in development). Aerial surveys of these areas is still needed to document distribution of priority weeds.

The table below summarizes invasive weeds found at Manuwai, excluding ICA species. While the list is by no means exhaustive, it includes the species targeted/prioritized for control. The distribution of each taxon is estimated as: Widespread (moderate to high densities of individuals, common across MU), Scattered (low densities across all or much of the MU), or Restricted (low or high densities, all in one discrete location). WCA control refers to only targeting taxa during scheduled WCA weeding around rare taxa.

**Summary of Target Taxa:**

| Taxa | Distribution | Notes |
|---|---|---|
| *Acacia confusa* | Widespread | Widespread on ridges. Target during weed control sweeps in priority WCAs. Cut and apply Garlon4 20%. |
| *Ardesia eliptica* | Scattered | Found throughout MU in small numbers, typically a seedling. It is controlled as ANRPO staff find it. |
| *Begonia vitifolia* | Scattered | Treat during WCA control around rare taxa. |
| *Blechnum appendiculatum* | Widespread | Widespread and often forming dense patches around rare plant taxa. Known to inhibit rare plant recruitment. Effective control by 10 % Garlon4 foliar application. |
| *Clidemia hirta* | Widespread | Widespread and often forming dense patches throughout the MU. *Clidemia* is best treated by using the clip-and-drip method (cutting stump and applying Garlon4 herbicide). |
| *Clusia rosea* | Scattered | Noted from Lower Ka‘ala NAR. Not detected during MU monitoring or initial surveys. If found, will treat as a WCA target. Effective control by IPA coupled with 100% Ranger Pro. |
| *Coffea arabica* | Widespread | Treat during WCA control. Forms dense stands. Effective control using IPA method coupled with 100% Polaris or cut-stump/basal coupled with 20% Garlon4. |
| *Cupressus lusitanica* | Scattered | Treat as MU target. Not documented as being highly invasive in Hawai‘i, but staff have noted related species spreading in other areas. |
| *Ficus microphylla* | Scattered | Limited distributions, this species has potential to target. IPA control method coupled with 100% Ranger Pro. |
| *Fraxinus uhdei* | Unknown | Noted from Lower Ka‘ala NAR. Not detected during MU monitoring. Staff have found along “10 Webbings” in very limited numbers. If found, will treat as WCA target. *F. uhdei* is best treated by using the girdle method and applying 20% Garlon4. Due to limited numbers this species could have potential for targeted control. |
| *Heliocarpus popayanus* | Unknown | Noted in the Vegetation Monitoring plan as a taxa with limited distribution that should be monitored and controlled to limit spread. |
| *Juniperus bermudiana* | Scattered | Treat as MU target. Determine if present; easily confused with *C. lusitanica* |
| *Lophospermum erubescens* | Unknown | Treat as MU target. Distribution in the MU is unknown. GPS any plants found. Evaluate effective treatment methods. |
| *Melaleuca quinquenervia* | Unknown | Treat as MU target. None found during vegetation monitoring but known from MU. Has potential to spread quickly in appropriate habitat, especially at upper elevations. Effective control by IPA coupled with 100% Milestone or Polaris. |
| *Melia azedarach* | Scattered | Target during weed control sweeps in priority WCAs. Effective control using cut stump coupled with 20% Garlon4 application. |
| *Montanoa hibiscifolia* | Scattered | Target during weed control sweeps in priority WCAs. Seed is wind dispersed. *M. hibiscifolia* is known to inhabit shady areas and has the |

| Taxa | Distribution | Notes |
|---|---|---|
| | | potential to become a dominant specie in both the understory and canopy. Thus, making it a priority for control. Map when flowering, control near priority zones. |
| *Psidium cattleianum* | Widespread | Widespread and often forming dense patches throughout the MU. Control in rare plant zones and native forest patches. Identify areas for *T. o*vatus releases. |
| *Megathyrsus maximus* | Widespread | Important to strategically treat patches of *M. maximus* for fire suppression (see fire section). Target in WCAs as needed by foliar spray. Priority to control along the fencelines and in the rare plant zones. |
| *Roystonia regia* | Restricted | Only a few individuals known. Potential CRB food. Will treat as MU target. |
| *Rubus argutus* | Restricted | Target in new locations. Frequent retreatment is often required for control of this species. Use effective control measures such as digging out tubers and coupled with 40% Garlon4. Only known from the first 100 m of the fenceline from Kamaohanui LZ. |
| *Schefflera actinophylla* | Widespread | Immature plants are somewhat widespread through MU, and there are not many mature individuals. Control as needed in priority areas within WCAs. Known to be ecosystem altering, fast growing, fruits prolifically, and disperses widely via birds. Effective IPA treatment known. |
| *Schinus terebinthifolius* | Widespread | Target during weed control sweeps in priority WCAs. Best treatment is either cut-stump or basal method coupled with 20% Garlon4. |
| *Spathodea campanulata* | Scattered | Many individuals throughout MU. High concentrations in Subunit II. Treat as MU target, then control as needed in WCAs. Effective IPA treatment known. Low density, potential target species. |
| *Syzygium cumini* | Widespread | Target in WCAs during weed control around rare taxa using IPA method and 100% Milestone application for smaller diameter stems. Continue to investigate an effective treatment for larger stems. |
| *Toona ciliata* | Widespread | Target in WCAs. There are high levels of this weed in the MU; it occurred in the overstory in 44% of vegetation survey plots, and 48% in the understory in survey plots. The tree is fast growing, and mature trees readily produce lots of offspring nearby. Where possible, target small stands entirely where possible around rare IP taxa. Target large trees during WCA sweeps to decrease reproducing trees in MU. Small trees can be controlled using cut-stump and 20% Garlon4 application. Larger trees are effectively controlled using IPA method. |
| *Trema orientalis* | Scattered | Treat as MU target. Many large mature trees seen during vegetation surveys and visual surveys from ridges. Potential species to target if distribution is found to be limited. Will use Polaris IPA. |
| *Triumphetta semitrilobata* | Scattered | Target during weed sweeps in high priority WCAs, and target along trails, LZs, and campsites. *Triumphetta* is best treated by using the clip-and-drip method (cutting stump and applying Garlon4 herbicide). |

**WCA: Manuwai-01 (Alaiheihe fork)**

Vegetation Type: Mesic Ridge

MIP Goal: Less than 50% alien cover (no rare taxa in WCA).

Targets: *Schinus terebinthifolius, Syzygium cumini, Toona ciliata, Psidium cattleianum,* and *Coffea arabica*.

Notes: The Alaiheihe fork of Manuwai is not visited often, if at all, by ANRPO staff. Currently, the Vegetation Management Team have the only action to visit this WCA occuring every 5 years. This WCA

encompasses a large area of steep and mostly heavily degraded *Psidium Cattleianum* forest but still includes some patches of native dominated forest including areas with *Acacia koa* canopy, stands of *Diospyros sandwicensis* and a nice short stature ridge habitat of *Leptecophylla tameiameiae, Metrosideros tremuloides,* and *Dodonea viscosa.* ANRPO staff will reevaluate whether staff time should be spent elsewhere before initiating any further efforts here.

**WCA: Manuwai-02 (Upper East slope/East Fenceline)**

Vegetation Type: Mesic Ridge

MIP Goal: Less than 25% alien cover around rare plants. Less than 50% alien cover elsewhere.

Targets: *T. ciliata*, *S. terebinthafolius, Clidemia hirta*, and *Blechnum appendiculatum*.

Notes: This WCA contains the *K. degeneri* subsp. *degeneri* IHE-D reintroduction. The reintroduction site and a portion of the Manuwai DieIri-01 are the only areas within the WCA that ANRPO staff work. Sweeps across the WCA have taken place before but are being reevaluated moving forward. This WCA, like WCA 1, is extremely hard to work in and is dominated by non-native canopy, in this case *T. ciliata.* Much of the native canopy found here is highly fragmented but is relatively comparable to that found in WCA 1.

**WCA: Manuwai-03 (Mideast slope)**

Vegetation Type: Mesic Ridge

MIP Goal: Less than 50% alien cover (no rare taxa in WCA).

Targets: *S. terebinthifolius*, *S. cumini*, *T. ciliata*, *P. cattleianum*, and *C. arabica*.

Notes: There was a population of *Alectryon macrococcus* var. *macrococcus* known from this WCA, however it is no longer alive. Unless sites for rare taxa reintroduction or common native restoration are identified, no regular weed control will take place in this WCA.

**WCA: Manuwai-04 (Kauila slope)**

Vegetation Type: Mesic Ridge

MIP Goal: Less than 25% alien cover around rare plants. Less than 50% alien cover elsewhere.

Targets: *Aleurites moluccanus*, *S. terebinthifolius*, *S. campanulata, S. cumini*, *T. ciliata*, *P. cattleianum*, and *C. arabica*.

Notes: This WCA has several current and historic rare plant populations. At present, *in-situ* populations of *Mezoneuron kavaiense, Colubrina oppositifolia, Abutilon sandwicense,* and *Sideroxylon polynesicum* (rare on island) can be found here, as well as a population of reintroduced *Delissia waianaensis* established in March 2023 and a reintroduced population of *Hibiscus brackenridgii* subsp. m*okuleianus* established in March 2021. Both of these reintroductions were established in response to a lack of recruitment at the original sites on the western side of the MU as well as the intense weed pressure at the original *H. brackenridgii* site and difficulty accessing it.

Though close in proximity to other non-managed rare taxa in the area, only *D. waianaensis, A. sandwicense,* and *H. brackenridgii* subsp. *mokuleianus* will receive direct management by ANRPO, but the proximity of the *D. waianaensis* to *in-situ,* non-managed rare taxa could contribute to overall improvement of habitat through weed and rodent control. ANRPO coordinated with the O‘ahu Plant Extinction Prevention Program and the Division of Forestry and Wildlife (DOFAW) in the lead up to

selecting this site for a *D. waianaensis* reintroduction and will continue to coordinate for future plantings and weeding efforts in the area. The majority of these rare plants occur across a mostly native, *Diospyros sandwicensis* dominated slope. The highly intact nature of this area contributed to ANRPO management choosing this site to expand *D. waianaeensis.* In addition, this location is the only location in Manuwai where *D. obatae* were found. Planting species like *D. halapepe* into the area to create appropriate brood material should be considered.

**WCA: Manuwai-05 (Lower East Manuwai gulch/Fenceline)**

Vegetation Type: Mesic Ridge

MIP Goal: Less than 25% alien cover around rare plants. Less than 50% alien cover elsewhere.

Targets: *S. terebinthifolius*, *S. cumini*, *T. ciliata*, *P. cattleianum*, *U. maxima*, and *C. arabica* in the understory.

Notes: This WCA has several steep, grassy ridges and is largely degraded. There are two populations of *A. sandwicenses* in this WCA and weed control efforts in this WCA are focused at these two sites. The main weed pressure at both sites is from *M. maxima,* which is sprayed/manually removed during annual rare plant monitoring. The high fuel load, relative dryness, and possible access by recreational hikers/hunters makes it a likely entry point for fire should one occur. Fuel load control is a high priority along the fence line. A catchment was installed in 2017 along the lower east fence line specifically to mix herbicide for grass suppression. There are high levels of *M. maxima* throughout the WCA but due to presence of spotty native canopy amid the grass, aerial sprays to reduce fuel load may cause more damage than desired.

**WCA: Manuwai-06 (Lower West Manuwai gulch/Fenceline)**

Vegetation Type: Mesic Ridge

MIP Goal: Less than 25% alien cover around rare plants. Less than 50% alien cover elsewhere.

Targets: *S. terebinthifolius*, *S. actinophyla, S. cumini*, *T. ciliata*, *P. cattleianum*, *M. maxima*, and *C. arabica*.

Notes: This WCA contains several rare plant reintroductions along with several *in situ* rare plant populations. There are high levels of *M. maximus* in the northern half of this WCA. The 2007 Waialua fire burned the northern edge of this WCA, and *M. maxima* has filled in all the burned area. There is a sizeable stand of *C. oppositifolia* on the ridge that is divided by the northern fence line. Currently, this WCA still contains a few wild *N. angulata* and *Abutilon sandwicense* plants. In addition to *in-situ* rare plant populations, there are several reintroductions in this WCA. The *N. humile* and *N. angulata* reintroductions have been relatively successful while the *F. neowrawrea* and *H. brackenridgeii* subsp. *mokuleianus* have been less so. The *F. neowrawrea* reintroductions have all failed and due to little or no recruitment, the *H. brackenridgeii* subsp. *mokuleianus* is being maintained in this WCA but new reintroductions will continue at the site in Manuwai-04. In 2021 and 2022, ANRPO staff augmented the *N. angulata* reintroduction in response to heavy die-off at the site. Weeding efforts around the rare plant reintroductions, prioritizing *N. angulata* and *N. humile,* are one of the highest priorities in this WCA for the Blue team.

**WCA: Manuwai-07 (Abutilon gulch)**

Vegetation Type: Mesic Ridge

MIP Goal: Less than 25% alien cover around rare plants. Less than 50% alien cover elsewhere.

Targets: *S. terebinthifolius*, *S. cumini*, *T. ciliata*, *P. cattleianum*, and *C. arabica*.

Notes: The boundaries of this WCA run from the fence line down two ridges towards the main gulch and surround one large side gulch. The majority of this WCA is very degraded with *T. ciliata* and other alien trees dominating the canopy. This WCA contains several rare plant taxa that are not managed including *C. oppositifolia* and *Bobea sandwichensis*. The largest single population of *A. sandwicense* in Manuwai MU occurs in this WCA. Blue Team weed control will focus on the *A. sandwicense* at least once a year during rare plant monitoring.

**WCA: Manuwai-08 (West slope- North)**

Vegetation Type: Mesic Ridge

MIP Goal: Less than 50% alien cover (no rare taxa in WCA).

Targets: *S. terebinthifolius*, *S. cumini*, *T. ciliata*, *Grevillea robusta, P. cattleianum*, and *C. arabica*.

Notes: The boundaries of this WCA run from the fence line down two ridges towards the main gulch and surround one large side gulch. These ridges are mostly native mid-slope (low diversity: *D. sandwichensis, D. viscosa. L. tameameae*), but are thick with coffee closer to the gulch. No work has been conducted in this WCA since a Target Canopy Sweep in 2014. Due to the highly degraded nature of this WCA, it is unlikely there will be any work conducted here in the foreseeable future.

**WCA: Manuwai-09 (West slope- South)**

Vegetation Type: Mesic Ridge

MIP Goal: Less than 50% alien cover (no rare taxa in WCA).

Targets: *S. terebinthifolius*, *S. cumini*, *T. ciliata*, *G. robusta*, *P. cattleianum*, and *C. arabica*.

Notes: The boundaries of this WCA run from the fence line down two ridges towards the main gulch bottom, and surround one large side gulch. At mid-slope these ridges are mostly native (low diversity: *D. sandwichensis, D. viscosa. L. tameameae*), but are thick with coffee closer to the gulch. ANRPO will not commit much time to working here.

**WCA: Manuwai-10 (MelTen gulch/KadDegDeg reintro)**

Vegetation Type: Mesic Ridge

MIP Goal: Less than 25% alien cover around rare plants. Less than 50% alien cover elsewhere.

Targets: *S. terebinthifolius*, *S. cumini*, *T. ciliata*, *G. robusta*, *C. hirta*, *M. maxima*, *Melinis minutiflora*, *P. cattleianum*, and *C. arabica*.

Notes: Weeding will be limited to rare plant sites. There are side gulches with *Ceodes spp.*, *Rockia sandiwicensis* and *Cyanea angustifolia* scattered throughout the upper regions. There is also large population of *Wollastonia tenuifolia* on and around the cliff that forms at the back of the gulch in the WCA with several *Schiedea hookeri* interspersed. There is suitable habitat for rare plants here, but reintroduction performance has been poor for multiple taxa. There are still many of the reintroduced *D.*

*waianaeensis* (ANU-A), but the *Phyllostegia kaalaensis* (ANU-B) failed immediately and the *Cyanea superba* subsp. *superba* (ANU-A), and *F. neowawraea* (ANU-B) reintroductions have all but failed, with one plant remaining of each. Also present in this WCA is a *K. degeneri* subsp. *degeneri* (ANU-B) reintroduction site along the interior fenceline near the top of the ridge. This *K. degeneri* subsp. *degeneri* population is shared between this WCA and Manuwai-11. Ongoing weeding efforts have been conducted to reduce non-native cover around these rare plant populations, with less emphasis on the *F .neowrawrea* and *C. superba* subsp. *superba* plantings at the back of the subgulch. Restoration via clearing and common native planting could benefit overall MU goals, however, restoration efforts in the Manuwai MU are a lower priority since the habitat is highly degraded and access is difficult. Unless radical changes to restoration efforts are made, it is not likely that there will be active restoration in this WCA or Manuwai MU generally.

**WCA: Manuwai-11 (Midwest Slope/KadDegDeg reintro)**

Vegetation Type: Mesic Ridge

MIP Goal: Less than 25% alien cover around rare plants. Less than 50% alien cover elsewhere.

Targets: *S. terebinthifolius*, *S. cumini*, *P. cattleianum*, *T. ciliata*, *C. Arabica, C. hirta*, *M. maxima*, *M. minutiflora*, and *Paspalum conjugatum*.

Notes: This WCA shares the native forest in WCA 10 along the ridgeline interior fence and has patches of native forests. Most of the *K. degeneri* subsp. *degeneri* (ANU-B) reintroduction in Manuwai is in this WCA. The population of this managed taxa has remained relatively stable through time, with recruitment and retention observed. Staff controls weeds in this WCA annually during the *K. degeneri* subsp. *degeneri* rare plant monitoring and during quarterly ICA checks at PteGlo-05.

**WCA: Manuwai-12 (*Kadua*/Central ridge)**

Vegetation Type: Mesic Ridge

MIP Goal: Less than 25% alien cover around rare plants. Less than 50% alien cover elsewhere.

Targets: *S. terebinthifolius*, *S. cumini*, *T. ciliata*, *G. robusta*, *U. maxima*, *Melinis minutiflora*, *P. cattleianum*, *Ageratina riparia, C. hirta*, and *C. arabica*.

Notes: The boundaries of this WCA run down two drainages and encompass a ridge with an MFS Population Unit of *K. degeneri* subsp. *degeneri* (ANU-A). Weed control will be conducted mostly around these rare plants. There are also other rare plants on the slopes of the ridge including: *Bobea sandwichensis*, *Pteralyxia macrocarpa*, *Polyscias kavaiensis*, and *Schiedea hookeri*. There were previously *A. macrococcus* var. *macrococcus, F. neowrawrea,* and *Dubautia sherffiana* in this WCA, but surveys of points for these taxa either found dead trees or no evidence of live plants. This is a large WCA with the southern edge consisting of very steep and largely inaccessible terrain making widespread weeding efforts impossible. Dead *G. robusta* with evidence of IPA treatment dot the ridgeline among and below the population of *K. degeneri* subsp. *degeneri* are evidence of past target species sweeps. Sweeps along the northern aspect of the ridge could delay further ingress of target alien taxa into scattered native forest patches.

**WCA: Manuwai-13 (Manuwai cliffs)**

Vegetation Type: Mesic Ridge

MIP Goal: Less than 50% alien cover (no rare taxa in WCA).

Targets: *S. terebinthifolius*, *S. cumini*, *T. ciliata*, *P. cattleianum*, and *C. arabica*.

Notes: This WCA encompasses the cliffs abutting Kamaohanui ridge. The terrain is very steep, or vertical and is mostly inaccessible. This is a large WCA, and the southern edge of this WCA is very steep and largely inaccessible. There are currently no weeding actions scheduled for this WCA. This WCA is home to scattered individuals of *Pritchardia kaalae,* mostly on cliff faces. Due to the threat to *P. kaalae* from the Coconut Rhinoceros Beetle, these plants may be visited in the future to assess if they have been damaged by this pest. It is possible that aerial surveys may accomplish this, but this is the most likely upcoming action to be conducted in this WCA.

**WCA: Manuwai-14 (Kamaohanui)**

Vegetation Type: Wet Forest

MIP Goal: Less than 50% alien cover (no rare taxa in WCA).

Targets: *S. terebinthifolius*, *S. cumini*, *T. ciliata*, *P. cattleianum*, *A. evecta,* and *C. arabica*.

Notes: This WCA includes the highest elevations in the MU and is mostly a wet-mesic forest. Since this WCA has extremely steep areas, remote weed control technologies will be required for control of MU wide target species. However, the Ecosystem restoration team will sweep in accessible areas for Target Canopy Species, such as large *T. ciliata* and/or any other uncommon alien plant species, every 3-5 years. This is the only WCA with *Rubus argutus* located on the Kamaohanui LZ and down the fenceline ~100m, so the Blue Team will continue to monitor this population. If *R. argutus* continues to spread or is found in new locations in the MU, Blue team will take immediate action to control this plant species, since it is known to form dense thickets where it is found elsewhere.

**WCA: Manuwai-15 (Manuwai Midwest LZ, Manuwai Camp LZ, trails, and fences)**

Vegetation Type: N/A

MIP Goal: Keep clear of vegetation for access

Targets: *M. maxima, S. terabinthifolius, P. cattleianum*

Notes: This WCA was created to facilitate weed control along trails, fence lines, the recently established Manuwai Midwest LZ/camp, and the Manuwai Camp LZ on the east ridge. Due to aggressive growth and high fuel index, *M. maxima* is the primary target of weed control in this WCA. Grass control along the lower fence line is critical to limiting spread of any future fire into the unit. Other targets include *S. terabinthafolius* and *P. cattleianum* that can slow fence checks and trip personnel on narrow ridge trails. This WCA also includes two landing zones which require maintenance to remain serviceable and safe for use.

**WCA: ManuwaiNoMU-01 (Spider Camp Road) (Discontinued)**

Vegetation Type: N/A

MIP Goal: N/A

Targets: *U. maxima*

Notes: This WCA was created to control grass and other weed species to keep the road clear and accessible for vehicles. The access road has not been used since 2020 and there are no plans to reopen it. The road became too degraded and was deemed unsafe, so the Manuwai Midwest LZ and camp were established to ensure more reliable access this side of the unit.

**WCA: ManuwaiNoMU-02 (Manuwai West LZ)**

Vegetation Type: N/A

MIP Goal: N/A

Targets: *U. maxima*

Notes: This WCA was created to control grass and other weed species to keep the trail and LZ clear for use. With the creation of the Manuwai Midwest LZ and camp further up ridge, this LZ will likely not be used further. Staff will keep open for emergencies.

**WCA: LKNARNoMU-01 (Lower Ka‘ala NAR Access Road)**

Vegetation Type: N/A

MIP Goal: N/A

Targets: *U. maxima*

Notes: This WCA was created to control grass and other weed species to keep the road clear and accessible for vehicles. Controlling grass also reduces the fuel load below the MU and provides access for fire-fighters responding to a fire.

**WCA: AlaiheiheNoMU-01 (KadDeg IHE-C)**

Vegetation Type: Mesic

MIP Goal: Less than 25% alien cover around rare plants. Less than 50% alien cover elsewhere.

Targets: *S. terebinthifolius*, *S. cumini*, *T. ciliata*, *G. robusta*, *U. maxima*, *M. minutiflora*, *P. cattleianum*, *A. riparia, C. hirta*, *D. iridiodes,* and *C. arabica*.

Notes: This WCA encompasses the wild *K. degeneri* subsp. *degeneri* site outside of the MU fence in Alaiheihe. There are stands of *Metrosideros polymorpha*, *D. sandwicensis*, *D. viscosa*, *Psychotria hathewayi.* Weeding efforts here are infrequent and will only coincide with the scheduled *K. degeneri* subsp. *degeneri* monitoring action (time permitting), since this population is maintained for genetic storage collection.

## Small Vertebrate Control

Species: *Rattus rattus* (Black rat), *Rattus exulans* (Polynesian rat), *Mus musculus* (House mouse), *Pternistis erckelii* (Erckel's francolin), *Lophura leucomelanos* (Kalij Pheasant), and *Herpestes javanicus* (Mongoose).

Threat Level: High for *Rattus* spp. on *Cyanea superba* subsp. *superba*, and *Delissea waianaensis*, moderate on *Dracena* spp. Unknown for *M. musculus*, *P. erckelii*, *L. leucomelanos*, and *H. javanicus*.

Seasonality/Relevant Species Biology: Spikes in rodent population are often observed in other MUs following the fruiting season (about twice a year) of *Psidium cattleianum*, then followed by a return to normal activity levels. It is assumed that other pest species follow similar patterns. *P. erckelii* and *L. leucomelanos* numbers are unknown in the MU; however, these ground birds remain threats to rare plant IP taxa since there have been observations in other MUs of damage and fruit predation caused by these birds.

Management Objectives:

- Limit rodent predation on *D. waianaensis* plants and *D. halapepe* seeds (*Dracaena* sp. are the primary host for *D.obatai*).
- Mitigate threat of rodent activity on managed plants. IP goal is having 10% rat activity or less. No population data are recorded here since MU wide control is not occurring.
- Monitor rare plant IP taxa populations, that do not have rodent control, for rodent damage; promptly initiate control if damage is noted.
    - Rare plant IP taxa not receiving rodent control- *C. superba* subsp. *superba*, *Kadua degeneri* subsp. *degeneri*, *Hibiscus brackenridgei* subsp. *mokuleianus*, *Neraudia angulata* var. *dentata*, *Abutilon sandwicense*, *Flueggea neowawraea*, and *Nototrichium humile*.
- Monitor rare plant IP taxa for damage from *P. erckelii* and *L. leucomelanos*.

Strategy and Control Methods:

- Control rodents annually around *D. waianaensis* plants and *D. halapepe* seeds using a small localized A24 trapping grid.

**Small Vertebrate Management Map**

# Image Redacted
# Sensitive Information
# Available Upon Request

Discussion:

Rodent control in Manuwai MU will be expanded to the new *D. waianaensis* reintroduction (ANU-B). A small grid around the original *D. waianaensis* reintroduction (ANU-A) will be maintained as long as plants survive there. The new *D. waianaensis* planting is in an area with an existing small A24 grid, mainly to try to facilitate *D. halapepe* reproduction by reducing rat predation on fruit. ANRPO does not directly manage *D. halapepe*, but it is the primary host for the endangered *D. obatai.* In May of 2023, staff expanded this grid with 25 A24 traps arranged in a grid around the core *D. obatai* and *D. waianeensis* area. The addition of these traps may allow *D. halapepe* to produce mature fruit which will be collected and propagated to hopefully provide future brood material for the *D. obatai.* The ANU-B A24 grid will be serviced on a four-month interval, the ANU-A grid will continue to be serviced when staff ANRPO staff are in the area. IP taxa also face threats from various introduced ground birds including the Kalij Phesant, *Lophura leucomelanos* and Erckell's Francolin, *Pternistis erckelii.* If damage to rare IP plant taxa from ground birds are observed, ANRPO will have to acquire permits to manage these birds and investigate control methods.

## Slug Control

Species: *Deroceras laeve* and *Limax maximus*

Threat Level: Low, due to low counts of slugs in this MU. If slug activity rises, slugs could threaten *Delissea waianaeensis, Neraudia angulata, and Nototrichium humile.*

Seasonality/Relevant Species Biology: Slugs are seasonally abundant during the wet season. We know that in some areas slugs are abundant even during the dry season (for example, West Makaleha and Palikea). In those areas, dry season application of molluscicide is needed. However, slugs were only detected three times over two years of sampling in Manuwai MU prior to the initiation of slug control at the first *D. Wai'anaensis* reintroduction. Surveys will be required prior to the initiation of any molluscicide at the second *D.Wai'anaensis* planting.

Management Objectives:

- Control slugs locally to increase the likelihood of germination and survival of *D. Waianaeensis* recruits.
- During annual rare plant monitoring, look for seedling recruitment and slug herbivory.

Strategy and Control Methods:

- Slug Control Areas (SLCAs) around rare taxa locations have been surveyed and cleared of native snails.
- Apply FerroxxAQ to SLCA once a quarter. FerroxxAQ is not applied within 20 m of known populations of native snails.
- If new sites for rare plant reintroductions are chosen outside of the existing SLCAs, areas will be searched thoroughly by an experienced malacologists for slug densities and native snails during the day and at least one night prior to application of FerroxxAQ per the Pre-Application Survey Protocol.

**Slug Control Area Locations Table**

| SLCA Code | Plant population reference codes | Date slug control begun |
|---|---|---|
| ANU-A-1 | DelWai ANU-A | 2012 January |
| Proposed: ANU-B | DelWai ANU-B | Awaiting native snail survey |

Discussion:

During annual rare plant monitoring, ANRPO staff will inspect plants for herbivory. If present, this will be noted. Indications of slug damage includes the following: lower leaves closer to the ground are more damaged than upper leaves, slime is present, and leaf margins are consumed before the interior of the leaf (unless the midrib is resting on the ground while the margins are curled).

If slug herbivory is suspected and rare native snails are not present in an area, then molluscicide may be applied. FerroxxAQ should be applied at the label rate every 6 weeks. However, since this MU is often difficult to access via 4x4 roads and slug counts are low, FerroxxAQ application is scheduled for once a quarter instead of the 6-week interval that is required elsewhere. If molluscicide is applied, then some weeds may flourish so more weeding should be planned if treatments take place.

Currently, slugs are managed at the *D. waianaeensis* ANU-A population where FerroxxAQ is thrown quarterly. Management will also take place at the newly established ANU-B population. A pre-application survey must be completed to inventory all native and non-native mollusks to prevent any incidental take (see survey procedure below).

**Slug Management Map**

# Image Redacted
# Sensitive Information
# Available Upon Request

ARMY NATURAL RESOURCES PROGRAM O'AHU

**Pre-Application Survey Protocol:**

For control only of slugs and non-native snails via listed, approved molluscicide application in forests, on offshore islands, and in other natural areas to protect threatened and endangered Hawaiian plants. Only Ferroxx AQ® Slug and Snail Bait is approved for use in forest areas in Hawai‘i. Area must be thoroughly searched by experienced malacologists prior to application of Ferroxx AQ® granules to ensure that non-target native Hawaiian snail species are not impacted. Do not apply in areas where it may come into contact with known populations of endemic Hawaiian snail species from the following rare families or subfamilies: Amastridae, Achatinellinae and Endodontidae. Bait cannot be applied within 20 m of any tree known to harbor endangered Hawaiian tree snails (*Achatinella* spp.).

1. Conduct thorough day survey of proposed treatment area to include searching trees and all understory vegetation. The ground and rock talus areas will also be search. An effort to identify other snails found and their rarity will be made prior to Ferroxx use.
2. If proposed treatment area is known *Achatinella* spp. site or if *Achatinella* spp. is observed during day survey, then must conduct night survey and remove all *Achatinella* spp. to a snail enclosure/protected area prior to bait use.
3. Area will continue to be surveyed and *Achatinella* spp. translocated to enclosures until all *Achatinella* spp. are removed from the area and at least one survey is conducted where 0 snails are found within area.
4. If *Achatinella* spp. are abundant in large numbers or are found on multiple trips, use of Ferroxx will not be allowed in area.
5. If *Achatinella* spp. are located in the area in the course of other field work, then surveys and relocation efforts will resume.
6. An effort to identify other snails found and determine their rarity will be made prior to Ferroxx use.

## Ant Control

Species: *Anoplolepis gracilipes*

Threat Level: High for endangered *Drosophila*.

Seasonality/Relevant Species Biology: Varies by species, but nest expansion is typically observed in late summer to early fall.

Management Objectives:

- Prevent spread of ant species into areas where they are not already established. Conduct annual surveys during the summer to determine what ant taxa are present in the MU.
- Implement control if incipient, high-risk species are found or if needed for *Drosophila* conservation.
- Detect incursions of new ant species prior to establishment.

Strategy and Control Methods:

- Sample ants at human entry points using the standard survey protocol (Plentovich and Krushelnycky 2009) and *Drosophila* sites a minimum of once a year (see table below). Use samples to track changes in existing ant densities and to alert ANRPO to any new introductions.
- If incipient species are found and deemed to be a high threat and/or easily eradicated locally (<3-acre infestation), begin control.
- Sample ants at campsite, LZ and Drosophila sites.
- If ants are present, determine the impacts to rare plants (are ants farming on the plants?)
- Partner with the DOFAW to survey and manage any *S. papuana* (if found) around *D. obatai* populations.

**Ant Survey Site Table**

| Site description | Reason for survey |
|---|---|
| East ridge camp site | High risk of accidental ant introduction |
| Manuwai Midwest LZ/camp | High risk of accidental ant introduction |
| Halapepe *Drosophila* area | *Drosophila* are sensitive to high ant abundance |
| Trailhead/parking lot | High risk of accidental ant introduction |

Discussion:

Historically, ant sampling has not been conducted in this MU. However, during *Drosophila* monitoring by the program's entomologist, the yellow crazy ant, *A. gracilipes,* was detected. There is concern about yellow crazy ants invading higher elevations and impacting native arthropods. There are currently no known effective control methods for yellow crazy ants. Yellow crazy ants are present in the gulch near the *Drosophila* monitoring sites and staff may need to coordinate with DOFAW to control the yellow crazy ant population. Yellow crazy ant treatment options are being trialed at the Kahanahaiki snail enclosure and the results of trials here may be able to inform ANRPO on the best control methods for yellow crazy ants in Manuwai. Another ant species, *Solenopsis papuana* is a known threat to Drosophila populations. If present, this species would be locally controlled using Amdro (registered for forest use). Unlike *A. gracilipes*, *S. papuana* is an aggressive ant species that is known to reduce *Drosophila* survival by 58% (Krushelnycky *et al.* 2017).

Surveying for ants will continue during *Drosophila* monitoring. In addition, annual formal ant surveys at high traffic areas, i.e., east and west ridge camps as well as the less trafficked halapepe *Drosophila* site, where *D. obatai* (IP rare taxon369) occurs, will be conducted to determine what ant species occur if any.

If *S. papuana* is found during these surveys, Amdro will be used in attempts to control this species. ANRPO will partner with DOFAW on managing ants around any *D. obatai* sites.

**Ant Management Map**

# Image Redacted
# Sensitive Information
# Available Upon Request

ARMY NATURAL RESOURCES PROGRAM O'AHU

# Black-Twig Borer (BTB) Control

Species: *Xylosandrus compactus*

Threat Level: High

Seasonality/Relevant Species Biology: Peaks in BTB activity have been observed from October-January

Management Objectives:

- During annual rare plant monitoring, look for signs of twig boring and damage at the rare plant populations commonly impacted by BTB (*Abutilon sandwicense* and *Flueggea neowawraea*).

Strategy and Control Methods:

- If rare plant taxa that are monitored show any sign of boring, report to Rare Plant Program Coordinator immediately.
- If there is an urgency to collect any plant material (i.e. seed, cuttings, and saplings) for genetic storage, collect material.

**BTB Photos**

Photos of BTB damage (arrows) on *Abutilon sandwicense*.

Discussion:

The current control method available for BTB involves the deployment of traps equipped with high-release ethanol bait. However, it is unclear whether this method reduces BTB damage to target plants. Therefore, this control method is not used to control BTB in the field. Since this control method is not effective, ANRPO will continue to investigate other control methods. If there is a rare plant population threatened by BTB and there is an urgency to secure its genetic material, ANRPO staff will collect any plant material to prevent losing the plant founder altogether.

## Coconut Rhinoceros Beetle (CRB)

Species: *Oryctes rhinoceros*

Threat Level: High for *P. kaalae*

Seasonality/Relevant Species Biology: Known to cause severe to fatal damage to palm species including *Pritchardia* spp via burrowing into and feeding on meristem.

Management Objectives:

- Detect CRB presence within the MU by periodically surveying *P. kaalae* populations on the Manuwai cliffs for damage. Note damage to alien fan palms encountered in the course of other field work.
- Document *O. rhinoceros* damage to *in-situ P. kaalae* and minimize damage if possible

Strategy and Control Methods:

- Due to steep/vertical terrain, aerial surveys may be required
- Assess if rodent control/fruit collection is even possible at these populations.
- No control currently exists for *O. rhinoceros*
- Map locations of non-native palms
- Monitor non-native palms for CRB damage and evaluate removal of these palms
- Assess whether initiating rodent control at sites is required to enable fruit to mature for collection.

*Pritchardia kaalae* **in Manuwai MU**

# Image Redacted
# Sensitive Information
# Available Upon Request

ARMY NATURAL RESOURCES PROGRAM O'AHU

## Fire Control

Threat Level: High

Seasonality/Potential Ignition Sources: Fire may occur whenever vegetation is dry. Generally, this happens in summer, but may occur at other times of the year, depending on variations in weather pattern. *Megathyrsus maximus* has a high fire index and is the dominant vegetation across the MU. This site has burned in the past from fires set by arsonists along Kaukonahua Hwy.

Management Objectives:

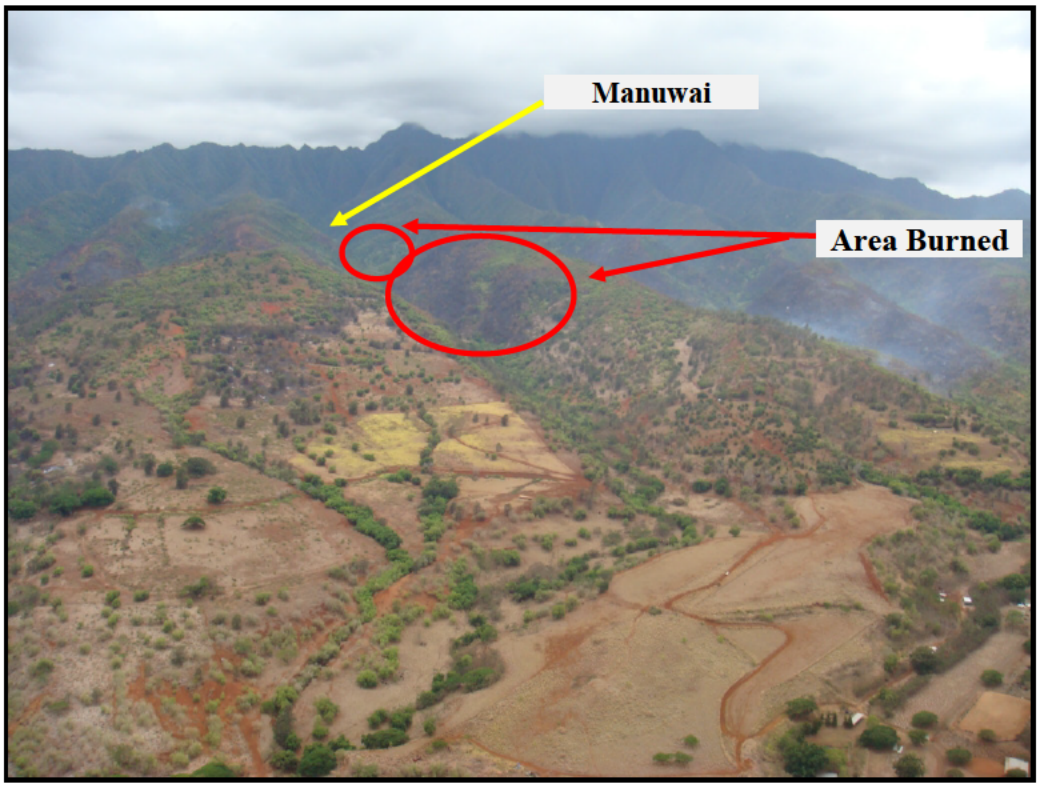
- To prevent fire from burning any portion of the MU at any time.
- To prevent fire from damaging any IP rare taxa locations.

Strategy and Control Methods:

- Reduce fuel loads by grass control along the fence line and access roads.
- If a fire occurs, conduct a post-fire survey, including mapping the perimeter of the fire and document damage via photos. If possible, rehabilitate burned areas within the fuel break with native species.
- Establish a fuel break corridor along the north fence line, possibly via aerial spray outside the fence.

**2007 Fire Management Map**

**Photo of area burned in Manuwai Gulch in 2007 fire**




Discussion:

In 2007, a fire started in Waialua, crossed Kaukonahua Road and burned through ranch land, to State Forest Reserve and Natural Area Reserve Land. ANRPO staff and other knowledgeable resource managers guided helicopter water drops to priority areas around natural resources for eight days as the fire burned. Prior to 2007, no fires had burned through this area in at least 50 years. The southernmost gulches below the Manuwai MU were burned and many rare plant taxa were impacted, including *Hibiscus brackenridgei* subsp. *mokuleianus*, *C. oppositifolia*, *Abutilon sandwicense*, *Bobea sandwicensis*, *Bonamia menziesii*, *Eugenia koolauensis*, *Euphorbia haeleeleana*, *Nototrichium humile*, and *Schiedea hookeri*. The most impacted rare plant taxa were the wild *H. brackenridgei* subsp. *mokuleianus* populations, which accounted for about 90% of all *H. brackenridgei* subsp. *mokuleianus* on O‘ahu. No rare plants were affected in the fenced Manuwai MU, although the fire reached as close as 100 meters to known rare plant populations in the MU. However, there is evidence that it burned into the *C. oppositifolia* stand at the northwest corner of the fence. The burned area quickly filled back in with *M. maximus,* which serves as a large fuel load at the bottom of the MU.

From 2007-2014 , ANRPO contracted discing of grass growing in fallow fields along Kaukonahua Road. This created a wider and continuous fire break at the site where the fire jumped the road in 2007. Currently the land adjacent to Kaukonahua is under new ownership and is being grazed and the fire threat is minimalANRPO staff manage fuel loads along the access roads, northern fence lines, and around managed rare plant taxa sites in the MU. It is also important to maintain roads and LZs for fire access and as fire escape routes. The addition of LZ Gordon, which is directly adjacent to a reservoir and has an unobstructed view of much of Lower Ka‘ala NAR, will aid in response to future fires in the area. The help of ANRPO staff and other knowledgeable resource managers to direct helicopter water drops to priority areas around natural resources is key in dealing with fires across the area. Additionally, it will be important to work with DOFAW to develop a fire management plan for the entire Mokulē‘ia Forest Reserve and Lower Ka‘ala NAR. One of the landowners, Kaukonahua Ranch, who acquired land adjacent to the forestry area in 2017, has incorporated fire mitigation in their development plan. This plan includes controlling grass and *Eucalyptus* spp. and planting native dry-forest plants.

O'AHU INVASIVE SPECIES COMMITTEE

# Survey and Control of *Chromolaena odorata* in the Kahuku Training Area, O'ahu, Hawai'i

## Annual Progress Report
## to
## The Army Natural Resource Program on O'ahu (ANRPO)

## October 1, 2022—September 30, 2023

**OISC outreach staff and volunteers reviewing data after removing a large amount of devil weed from a trailside population.**

**Summary of Project Objectives:**
The aim of this project is to contain *Chromolaena odorata,* commonly called devil weed, within the Kahuku Training Area (KTA). Containment at KTA will reduce the threat of this species spreading to natural areas that may contain protected species. With other funds, control operations toward eradication are taking place at locations outside of KTA where *C. odorata* has been found.

*Chromolaena odorata* is a state-listed noxious weed that is toxic to livestock, people, and other plants. It is widespread on Guam and other Pacific territories and under control programs in Australia and several African countries. It poses a threat to natural and agricultural systems due to its ability to form dense thickets and crowd out native plants. It is a threat to ranching because of its toxicity to livestock. Current populations of *C. odorata* are located at several locations across Oʻahu: the Kahuku Training Area, Kahana State Park, ʻAiea, Pūpūkea, and Malaekahana. Isolated plants have been found in Mākaha, Lanikai, and Hauʻula.

Between 2006 and 2009, botanical surveys of all publicly accessible roads on Oʻahu were conducted by OISC's Oʻahu 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 widely dispersed pest on the island of Guam, and units from Hawaiʻi 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. The Biological Opinion for military activities on Oʻahu 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 (KTA) and that *C. odorata* was introduced to KTA because of military activities.

At KTA, OISC has historically conducted sweeps of designated subunits and flagged patches with a high density of plants that are most efficiently treated with a power or aerial spray. These patches are called "hotspots" and up until this year had been primarily treated at a later date by ANRP. This year, ANRP tasked OISC with power-spraying some of the high-priority hotspots and conducting outreach regarding devil weed. The action plan is as follows:

- Treat accessible *C. odorata* "hotspots" as designated by ANRP-O within subunits 3, 4, and 7 in the Alpha 1 Range of KTA. This includes state land leased by the military and used by the public as a motocross recreational area on the weekends. Hotspots are defined as areas with more than five plants are areas that would be inefficient to treat without a power sprayer or aerial spray.
- Flag borders of hotspots and include population and treatment information.
- Monitor hotspot treatment and record amount of re-growth after treatment. Treat re-growth if this can be accomplished within 3 camping operations.
- Provide public outreach for *C. odorata* at agricultural events including farm fairs, farmer's markets, or similar events regarding species identification, species impacts, and control methods.
- Provide direct outreach to farms and ranches pertaining to species identification, control methods, and the opportunity for a "train the trainer" seminar by request.

**Project Accomplishments: October 1, 2022—September 30, 2023**

OISC conducted three multi-day trips to control *C. odorata*. During the worktrips the crew:

- Conducted survey and power-spray treatments over 38.74 KTA acres
- Treated a total 61 mature and 386 immature devil weed throughout KTA. It should be noted that these numbers are not a reflection on the total amount of plants detected or that actually exist within the subunits OISC and Army Natural Resources Program manage, just the total that were treated by OISC staff.

**Devil weed plant removed during a volunteer operation.**

**Staff power-spraying a devil weed hotspot during a KTA camping operation.**

OISC outreach staff also conducted in-person outreach at four separate community events, reaching an estimated 375 individuals and facilitated volunteer work trips for a total of 148

volunteer work hours. OISC will continue working to complete the remaining expected outcomes due to account opening delays detailed in the **Challenges** section of this report.

Devil weed survey and control efforts outside of KTA are detailed later in the report, within the section titled ***C. odorata* Activites Supported Outside of KTA**.

**Challenges:**

One of the main challenges during this reporting period was the delayed account opening to begin work on this proposal. The delay occurred during the processing of the account through the University's Office of Research Services (ORS). KTA camping operations that were scheduled January through March were cancelled initially and further delays prevented camping operations scheduled for May and April. Due to the delay, OISC will complete the remaining expected outcomes listed in the proposal by March 2024, including one camping operation and several outreach outcomes.

In addition to the account delays, Range Control denied our request to camp in June and July. Although Range Control permitted day-trips in place of a June camping operation, no day trips were permitted in July. The progress report submitted in April 2023 reflects the lack of work and details these issues as well. Intermittent access to KTA makes completing field operations very difficult as these operations have a lot of moving parts and must be thoroughly planned out to not jeopardize other OISC operations that relay on access permission to private lands.

**Staff decontaminating work vehicles from potential *C. odorata* contamination.**

Account opening delays in concert with the outbreaks of little fire ant and coqui frog have prevented OISC from completing direct outreach to the six farms detailed in the proposal. This includes training for farmers to survey, identify, and control devil weed on their properties. OISC will identify and conduct the direct outreach to north shore farms by March 2024 and will be able to complete those expected outcomes by that deadline.

The lack of water access also increased operational inefficiencies for these spray operations. While the wash-rack can be utilized, it is often unusable and requiring repairs. Initially OISC attempted to bring up the necessary amount of water needed but lack of vehicle capacity from our aging fleet and a stolen pickup truck during the reporting period made it difficult to bring the amounts

needed for the operation. Range Control did permit us to use their water source on one occasion, and if that continues, this barrier will be resolved.

Initial strategy outlined hotspots needed for power-spraying, but reconnaissance during the initial camping operation demonstrated that hotspots 53 and 75 were inaccessible due to insufficient roadways needed to get the sprayer close enough to treat the hotspot. Hotspots 40, 41, and 126 were removed from consideration due to the steepness of the terrain. Given the workload reduction, OISC consulted with ANRPO representatives to determine additional tasks to fill out the remaining camping operation.

*C. odorata* is now too widespread across the island to eradicate island-wide. OISC's core mission is to eradicate species island-wide and it is no longer feasible to do that on Oʻahu for this species. Since there is a biocontrol that has already been tested for host-specificity and released with good results elsewhere, OISC and partner agencies will continue to work together with ANRP in order to get the agent approved for release on Oʻahu.

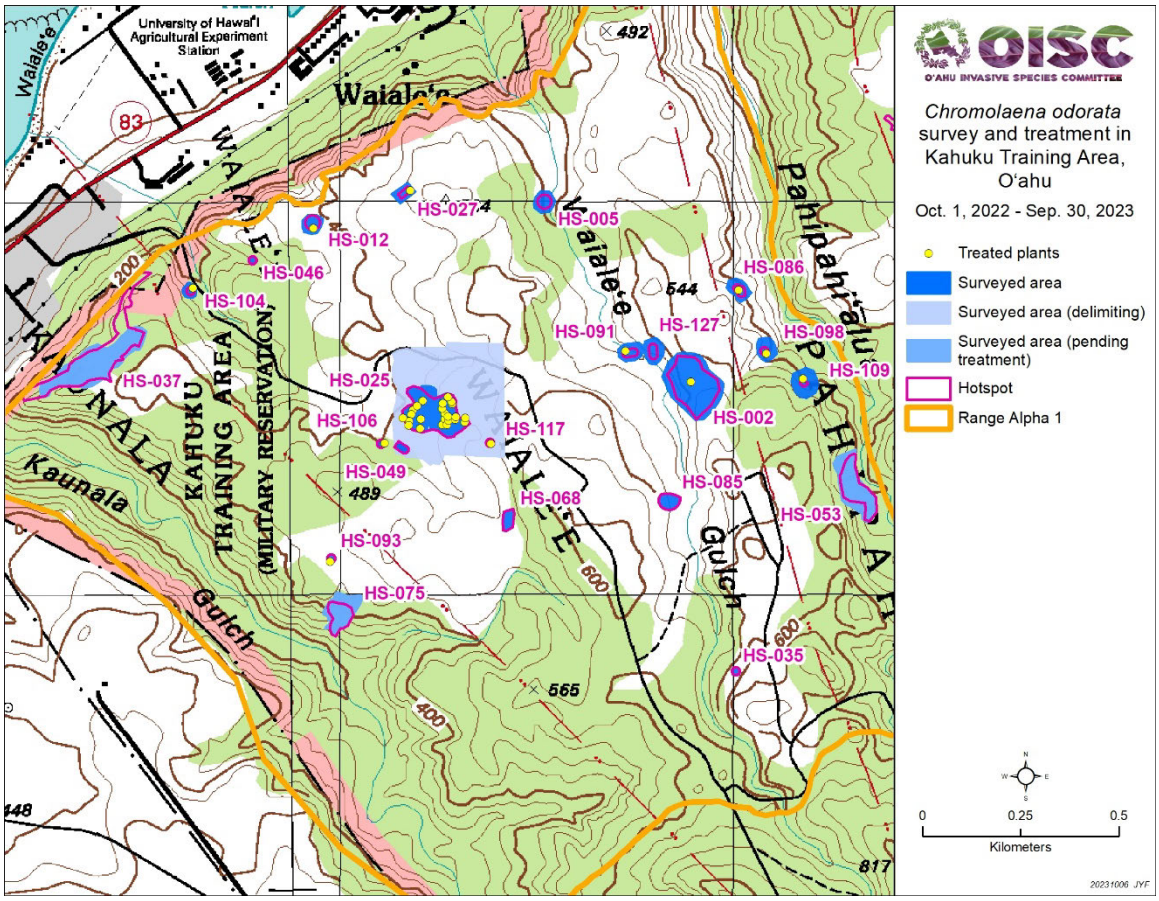
**Table 1: OISC *Chromolaena odorata* Work Effort Summary at Kahuku Training Area October 1, 2022—September, 2023**

| Timeframe | Acres Surveyed | Mature Plants Treated | Immature Plants Treated | Total Plants Treated | Effort (Hours) |
|---|---|---|---|---|---|
| 10/1/22 - 3/31/23 | 0 | 0 | 0 | 0 | 16 |
| 4/1/23 - 9/30/23 | 39 | 61 | 386 | 447 | 407 |
| Total | 39 | 61 | 386 | 447 | 423 |

**Data Management and Coordination:**
During the reporting period, OISC staff entered data and observations into the OISC database and into ArcGIS. The GIS Specialist quality controlled data from the field entered into the database and ArcGIS, and the spatial data is included with this report via shapefiles. In Figure 1 below, you can see the visual representation of the spatial data in the map.

**Compliance:**
OISC is a project of the Pacific Cooperative Studies Unit through the Research Corporation of the University of Hawai'i, 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.

**Figure 1: OISC *Chromolaena odorata* Work Effort in Kahuku Training Area**
**October 1, 2022 – September 30, 2023**




## *C. ODORATA* ACTIVITES SUPPORTED OUTSIDE OF KTA

**Surveys and Control for *C. odorata* outside of the Kahuku Training Area (KTA)**
OISC conducted 212 acres of ground surveys and treatment outside of KTA, controlling 153 mature and 2,350 immature plants. Unfortunately, much of the surveys need to be done on private property and acquiring access permission is time-consuming; therefore, there are still areas that may contain *C. odorata* but have not been surveyed.

Specific to the Kahana Valley population, OISC treated 9 mature and 306 immature plants across 68.52 ground acres. Aerial treatments have yet to be completed, but will be before the end of the calendar year. Results from that aerial treatment will be included in the next report.

**Outreach and Education regarding *C. odorata* outside of the Kahuku Training Area (KTA)**
OISC maintains a robust outreach program that works to educate the community about the threats of invasive species and what actions community members can take to help fight the spread and harmful effects of invasive species. OISC messaging regarding devil weed encourages public reporting of potential devil weed to OISC, removal wherever possible, and emphasizes early management before it gets out of control. In the wake of the global COVID-19 pandemic, OISC has incorporated expanded virtual and digital outreach, even as in-person outreach events and volunteer outings have restarted.

In order to address increasing devil weed populations island-wide, OISC outreach staff facilitate the Devil Weed Crew (DWC) citizen-science program through an active Facebook group that has grown to 71 members. DWC members submit data via the AllTrails mobile phone application and OISC reviews data for accuracy before incorporating that data into our database. Volunteers are also directed to OISC's YouTube channel where the staff have created four video tutorials along with a field guide that is mailed to participants after signing up for the program. These videos include virtual guides for species identification, a case study of invasive species as they pertain to agriculture, a field orientation video, and a species botanical breakdown.

During the reporting period, outreach staff led 37 DWC volunteers across 148 volunteer hours of survey and control and DWC volunteers removed 142 mature and 2,043 immature devil weed

**Outreach staff lead volunteers in devil weed removal.**

plants across 39.7 acres of North Shore trails. OISC also provided in-person devil weed outreach to the public at 4 separate community events reaching an estimated 375 individuals. These events included the Farmer's Resource Fair facilitated by the O'ahu Agriculture & Conservation Association (75), the University of Hawai'i Volunteer and Engagement Fair (50), the Windward Community College Earth Day Fair (50), and the Hawaiian Honeycreepers Celebration (50). In-person outreach includes answering questions from the public, providing brochures regarding devil weed identification and control, displaying pressed plants, and encouraging self-survey and reporting potential devil weed to OISC.

**Table 2: OISC *Chromolaena odorata* Work Effort Summary on non-KTA lands October 1, 2022 – September 30, 2023:**

| Watershed | Ground Acres Surveyed | Aerial Acres Surveyed | Mature Plants Treated | Immature Plants Treated | Total Plants Treated | Effort (Hours) |
|---|---|---|---|---|---|---|
| Kahana | 68.52 | 0 | 9 | 306 | 315 | 366 |
| Kalunawaika'ala | 10.76 | 0 | 0 | 22 | 22 | 32 |
| Mākaha | 103.81 | 0 | 2 | 1 | 3 | 254 |
| Paumalū (non KTA) | 28.94 | 0 | 142 | 2,021 | 2,163 | 113 |
| Waimānalo | 0 | 0 | 0 | 0 | 0 | 6 |
| **Total** | **212.02** | **0** | **153** | **2,350** | **2,503** | **770.5** |

**Figures 2 & 3: *C. odorata* Hot Spot Activity in Kahana**

**DEFINITIONS**

**New** = A newly identified hotspot defined as containing five or more mature and/or greater than 150 immature, less than five mature but really old and set seed more than once, or less than five mature but outlying area. Spray needed to address seed bank.

**Active high** = Existing hotspot with at least one mature plant old enough to set seed at least once and/or at least 30 immature detected. Spray needed to address seed bank.

**Active low** = Existing hotspot with fewer than 30 immature plants, or containing a small number of newly mature plants that has not set seed. In general, less than two years since 'active high.' Spray typically needed on at least the first year classified as low to address seed bank.

**Inactive** = Existing hotspot at least two years after an 'Active high' or NEW designation with 'Active low' criteria. An exception for earlier designation would be if fewer than five immature detected with no previous history of spray treatment and following one year of 'Active low'. Spray not needed.

**Unknown** = No data available.

Figure 2:

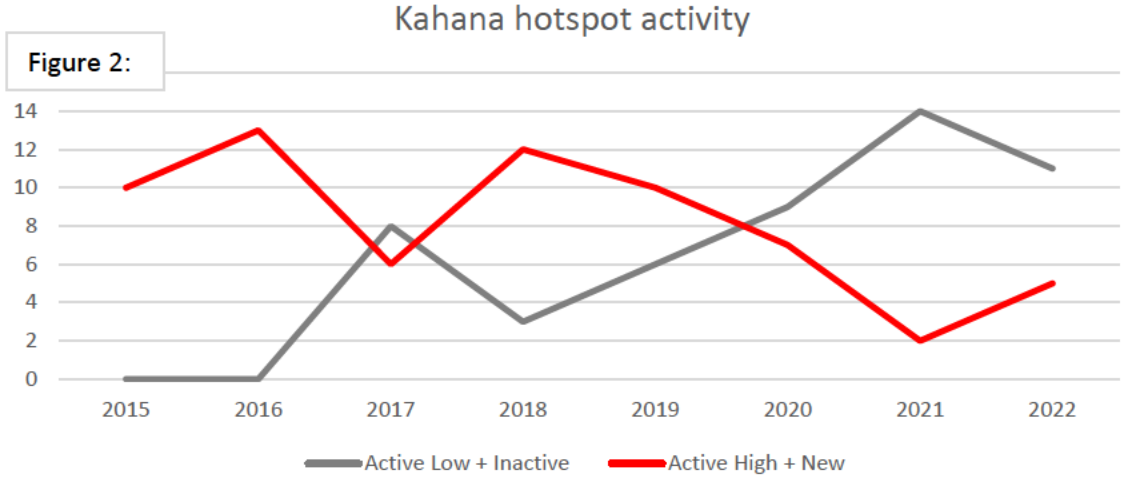
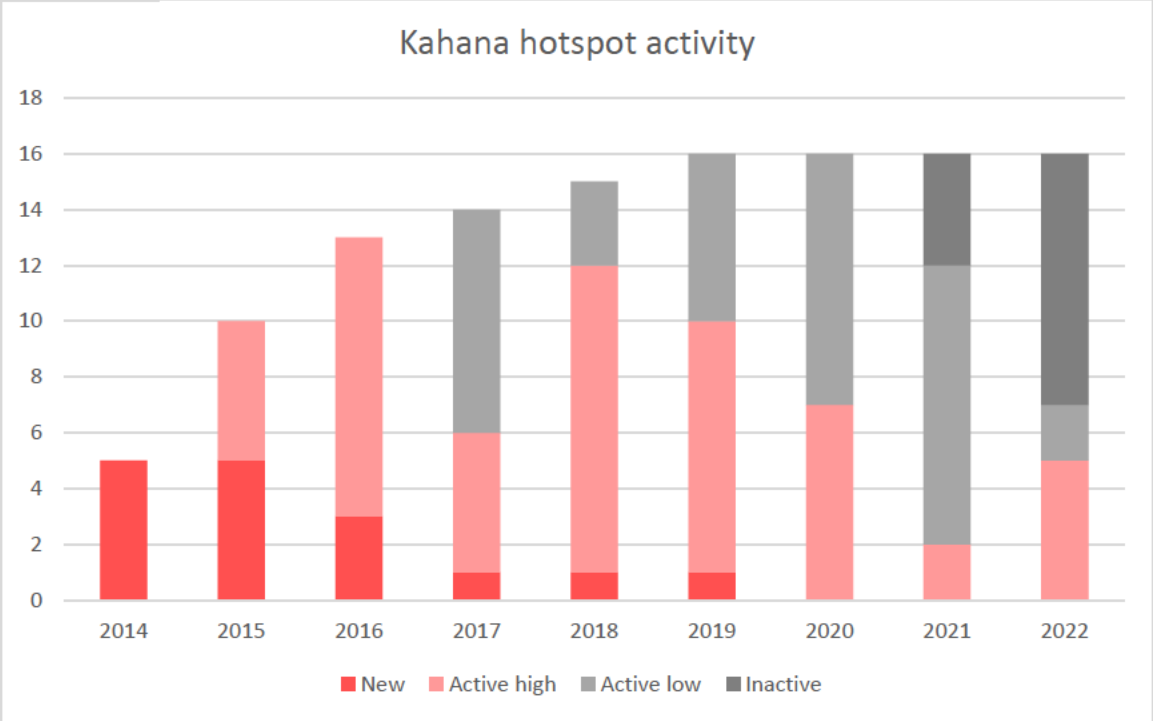


Figure 3:

Figure 3:



ARMY NATURAL RESOURCES PROGRAM ON O‘AHU
VEGETATION MANAGEMENT AND MONITORING PROGRAMS

# THE EFFICACY OF ALL-NATURAL HERBICIDES TO CONTROL *CHROMOLAENA ODORATA*

## INTRODUCTION

The Army Natural Resources Program on O‘ahu (ANRPO) conducted a controlled study to explore the efficacy of five all-natural herbicides to control variously sized *Chromolaena odorata*. Due to the highly invasive and ecosystem altering characteristics associated with *C. odorata*, it is on the Hawai‘i Noxious Weed List, considered a high risk weed species (Division of Plant Industry 2003; Hawai‘i-Pacific Weed Risk Assessment 2009), and a high priority for extirpation by ANRPO. While the conventional herbicide Glyphosate is known to effectively result in plant mortality (Priority O‘ahu Native Ecosystems 2013), ANPRO sought to explore the utility of all-natural alternatives. Concerns over the use of conventional herbicides (manufactured using synthetic chemicals) to control *C. odorata* prompted the exploration of alternative all-natural products (made using naturally occurring substances) for its control. Herbicides were chosen based on input from ANRPO staff, partner agencies, and community members. All are contact, non-selective, broad spectrum, foliar-applied herbicide products. They were also selected so that each herbicide had unique active ingredients or unique combinations of ingredients. The objectives of this study were as follows:

**Primary Objective:** Determine if any among a varied assortment of all-natural alternatives are effective at controlling *C. odorata*, which ANRPO may consider as viable alternatives to conventional herbicides for use in ANRPO managed areas.

**Secondary Objectives:**

1. Assess whether the product is similarly effective on small, medium, and large growth forms. All-natural herbicides tend to be more effective on younger, smaller, less woody plants.
2. Assess if repeat applications are necessary. All-natural herbicides are contact-based, wherein damage (“burning”) is limited to the parts of the plant that come into direct contact with the herbicide. Conversely, conventional herbicides more typically are systemic, where damage may occur throughout the plant, including the root system, via translocation of the product within the plant. For this reason, all-natural herbicides often require repeated applications, especially for larger plants.
3. Provide evidence for the efficacy of these products for controlling *C. odorata*, so other agencies or individuals interested in controlling *C. odorata* using an organic product will have a viable option. This would be of particular relevance for the O‘ahu Invasive Species Committee’s (OISC) efforts to control *C. odorata* infestations on private land, in areas used by recreationalists and/or in close-proximity to the community, with the ultimate goal of cooperatively achieving control of the infestations in high-trafficked areas of the Kahuku Training Area (KTA) and Kahuku Motocross Track.

As not all of the products in the study are approved for use in natural areas, ANRPO received approval from the U.S. Army Environmental Command (AEC) to apply these products on Army land for the purposes of the trial (see attached memo). For any herbicides found to be effective, considerations must be made for those with product labels that are not approved for use in natural areas. The products must

either be exempt from EPA registration, or for those registered with the EPA, a Special Local Needs label (SLN) will need to be pursued to allow use in natural areas. In addition, ANRPO also will need to request AEC add them to the USAG-Hawai'i Pesticide Use List for use on Army land.

## METHODS

**Location**: The *C. odorata* plants used in this trial were propagated at the ANRPO seed laboratory beginning in March 2021, using seeds collected from KTA. Since the majority of tested products were not approved for application in Forestry settings as per the Hawai'i Department of Agriculture, the trial was conducted on Schofield Barracks at the ANRPO greenhouse and at the ANRPO Kahua seed orchard and living collection site between August 2021 and September 2022. Trials for small and medium plants were completed in the greenhouse, and the trial for the large plants occurred at Kahua. Aside from label restriction considerations, these locations were preferable to field sites at KTA due to the inability to prevent motocross or Army soldier traffic through the study plots. Conditions at the greenhouse and Kahua were similar to sites where *C. odorata* is known to thrive, as both are located less than a quarter mile from known infestation areas.

**Trial Design**: Five all-natural herbicides were compared with a control group (no herbicide applied) for efficacy on *C. odorata* (Table 1). The herbicides contained acid-based (citric and acetic acids), fatty acid/soap-based (pelargonic and related fatty acids – naturally occurring in many plants) and/or oil-based (citric, clove, and cinnamon oils) active ingredients. Three plant size classes were used in the trial including small (approx. 2-15 cm in height), medium (approx.15-40 cm), and large (approx. 40-75 cm) ($n \geq 20$ plants per treatment for each size) (Figures 1 and 2). Herbicide treatments occurred progressively in three phases by size class (Figure 3). Within each treatment phase, a second application was administered for products that were effective (no green foliage or live cambium remaining) at for at least 50% of the plants following the first application. Only those herbicides found effective (no green foliage or live cambium remaining) in treating at least 90% of the small size class (the most vulnerable stage) were used for the medium class, and only those similarly effective for the medium size were used for the large class (the hardiest stage). All surviving treated plants were destroyed at the end of each trial phase (i.e., treated plants were not re-used in later stages of the trial). Small plants (134 total) were in 2-inch celled trays, medium plants (75 total) were in individual 6-inch pots, and large plants (46 total) were planted in rows with approximately 30 cm spacing. All plants were marked by treatment type. Soil moisture was maintained using automated overhead irrigation for the small and medium potted plants in the greenhouse. Large plants outplanted at Kahua were watered weekly for one month prior to trial initiation to facilitate their establishment in the soil, as some plants were observed to have become root-bound within the pots. To replicate natural field conditions of moisture regimes, large plants were not watered following the start of the trial. Staff inspected these plants weekly to remove inflorescences if necessary, to mitigate the spread of seeds.

**Table 1:** Herbicides used in trial.

| Herbicide | Active ingredients | Dilution | EPA Reg. No. | Signal Word | Registered for forestry use |
|---|---|---|---|---|---|
| Avenger | d-limonene (Citric Oil) 70% | 25%* | 82052-1 | Caution | No |
| BurnOut | Citric Acid 24%<br>Clove Oil 8% | 33%* | NA** | NA | NA |
| Scythe | Pelargonic Acid 57%<br>Related Fatty Acids 3% | 10%* | 62719-529 | Warning | No |
| Vinagreen | Acetic Acid 20% | 100% | 85208-1 | Danger | No |
| Weed Zap | Clove Oil 45%<br>Cinnamon Oil 45% | 5%* | NA** | NA | NA |

*Diluent is water.

**Exempt from registration with the Federal EPA under section 25 (b) of FIFRA.

**Figure 1:** Small (top) and medium (bottom) sized *Chromolaena odorata* prior to treatment at the ANRPO greenhouse.

**Figure 2:** Large sized *Chromolaena odorata* at Kahua, showing plants in the control group (marked with pink flags) and the Scythe (marked with orange flags) treatment group.

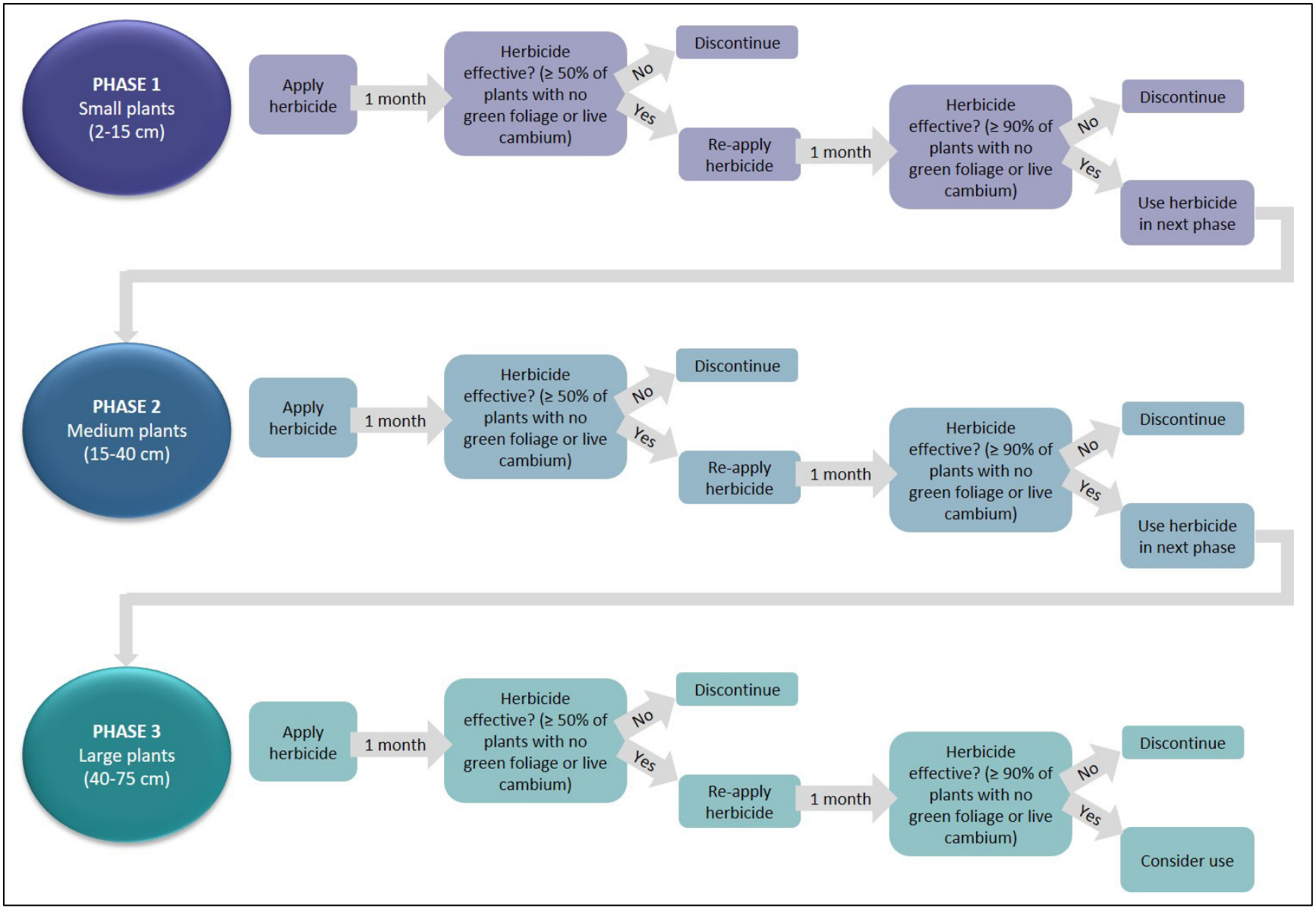



**Figure 3:** Trial design workflow for each herbicide used in study.

**Application**: Herbicides were applied using hand sprayers (Figure 4). Turf Mark blue spray indicator was added to facilitate visual verification of adequate coverage of the herbicide on the plants. Spray was ensured by the wetting of all foliage, as per label directions. Application occurred during dry weather and calm wind. Chemical resistant nitrile rubber gloves, long sleeves, long pants, covered shoes with socks, and eye protection were used for personal protective equipment for all herbicides, with the additional use of a face shield for Vinagreen, as per label instructions.

The highest possible concentration in accordance with label specifications was used for each herbicide. Comparisons of different dilution rates were not made, as ANRPO sought to determine which, if any, of the products are effective at their maximum strength as recommended by their respective labels. Refinement of dilution rates necessary to achieve mortality could be examined at a later time for any found to be effective at maximum strength.

**Figure 4:** Application of Scythe to *Chromolaena odorata* plants at Kahua.

**Monitoring**: For each treatment phase, plants were monitored one month after the initial herbicide applications, and one month after any re-applications. During monitoring, health status was documented for each plant as healthy, moderate, poor, or dead. Plants with no remaining green foliage or live cambium were presumed to be dead, with the assumption that plants would not re-sprout from the roots.

**Assessment:** Herbicide efficacy was based on mortality rates, with 50% mortality as the minimum acceptable level after one application, and 90% mortality as the minimum acceptable level after re-application. Minimum acceptable levels of mortality were based on ANRPO's determination that 1) it was impractical to re-apply an herbicide if the first application killed less than half the plants, and 2) herbicides that did not kill the vast majority of relatively smaller plants with multiple applications were impractical to use on relatively larger plants. Statistical analysis included Fisher's exact tests for mortality data after re-application for Phases 1 and 2, and after three months from initial application for Phase 3. Significance determinations were based on $\alpha = 0.05$. Statistical analyses were performed using the software R, Version 4.2.2 (R Core Team 2022).

## RESULTS

### Phase 1: Small plants

Impacts from the initial herbicide application were apparent within the first week for all products tested, with many plants exhibiting leaf and stem wilting and "burning." Some plants appeared to be completely wilted/burned, but soon re-sprouted, particularly those treated with Avenger and Weed Zap (Figure 5). After one month, two products (BurnOut and Scythe) had acceptable mortality rates (61% and 68%, respectively), and were candidates for re-application (Figure 6). Vinagreen was the least effective, with only 13% mortality. One month following re-application of BurnOut and Scythe, both products resulted in 100% mortality, differed significantly from the control (Fisher's exact: $p = 0.000$ each), and were candidates for Phase 2 testing. No mortality occurred in the control group.

**Figure 5:** Small size *Chromolaena odorata* one week after treatment with Weed Zap (left), showing most plants severely wilted/burned, and one re-sprouting by two weeks (right) after treatment.

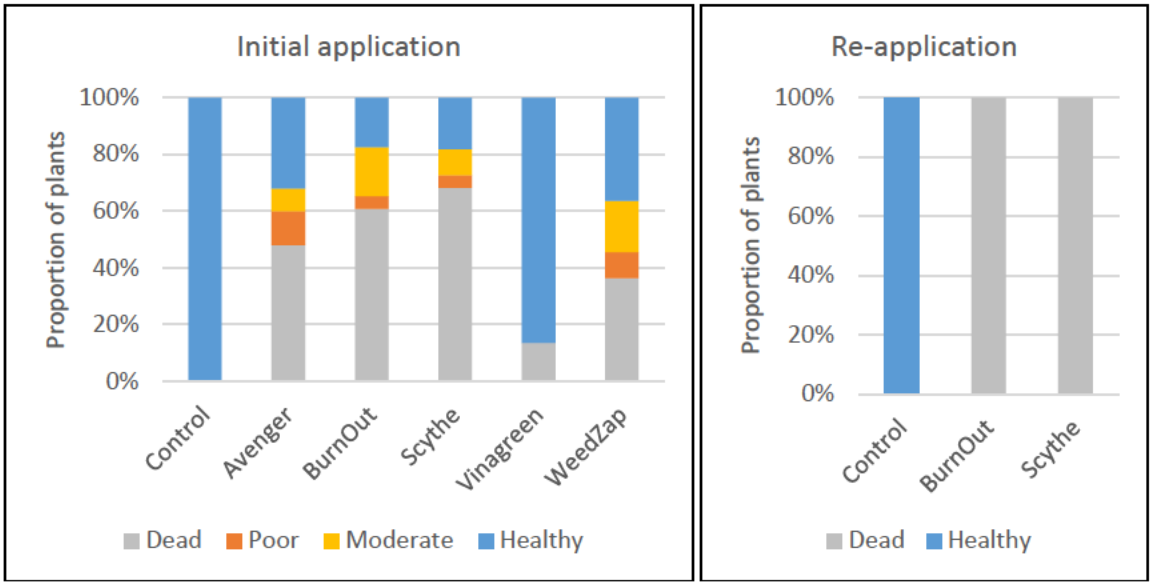



**Figure 6:** Condition of small size plants one month following initial herbicide application (left), and one month following re-application (right).

**Phase 2: Medium plants**

In the early weeks after the initial applications, several treated plants were at least partially wilted/burned, but later re-bounded. One month after initial application of BurnOut and Scythe, only Scythe had an acceptable mortality rate (92%), and qualified for re-application (Figure 7). Though BurnOut had a mortality rate of only 40%, very few healthy plants remained (12%), and a determination was made to re-apply this product as well. One month following re-application of BurnOut and Scythe, only Scythe had an acceptable mortality rate (92%), differed significantly from the control (Fisher's exact: $p = 0.000$), and qualified for Phase 3 testing. Plants re-treated with BurnOut did not fare worse, but rather re-bounded; mortality dropped to 16% and the amount of healthy plants increased to 48% one month after re-application, and did not differ significantly from the control (Fisher's exact: $p = 0.110$). No mortality occurred in the control group.

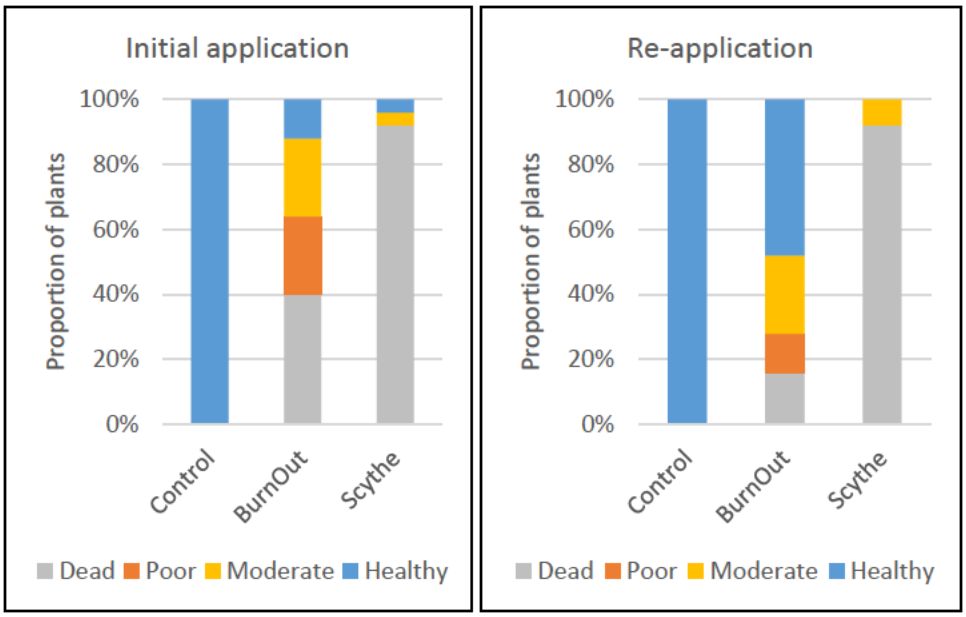



**Figure 7:** Condition of medium size plants one month following initial herbicide application (left), and one month following re-application (right).

**Phase 3: Large plants**

In the early weeks after the initial application, several treated plants were at least partially wilted/burned, but later re-bounded. One month after initial application of Scythe, the mortality rate was low (30%), and all surviving plants were healthy (Figures 8 and 9). Re-application was not warranted. No mortality occurred in the control group. All vegetated plants were destroyed, while those determined as "dead" were left in the ground. Upon monitoring two months later, nearly half the "dead" plants had re-sprouted. Ultimately, the mortality rate was found to be very low (17%), and did not differ significantly from the control (Fisher's exact: $p = 0.109$). It was suspected that the treated plants that died were ones that had been root-bound upon planting, and were perhaps less healthy from the start.

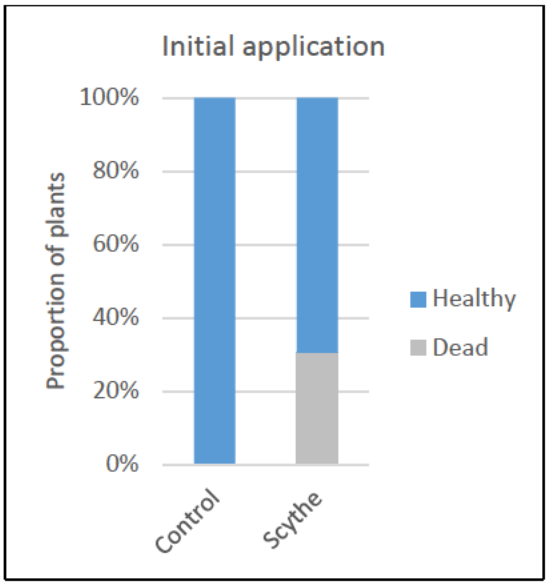



**Figure 8:** Condition of large size plants one month following initial herbicide application. Re-application did not occur, as the mortality rate for Scythe was low.

**Figure 9:** Wilted/burned large *Chromolaena odorata* 1-month after Scythe treatment (orange pin flags) that were presumed to be dead, alongside healthy control plants (pink pin flags). Some of these wilted/burned plants later re-sprouted.

## SUMMARY AND DISCUSSION

None of the all-natural products were effective at controlling *C. odorata* for all plant sizes. Scythe was effective at controlling small and medium plants, though re-treatment was necessary to achieve high levels of mortality for small plants. BurnOut was effective at controlling small plants, and also required re-treatment to achieve high mortality. Interestingly, medium size plants treated with BurnOut came back with a vengeance after re-application. Avenger, Vinagreen, and Weed Zap were ineffective for controlling small plants, which is presumably the most vulnerable size class.

Though Scythe was the most effective all-natural product, because it was ineffective on large plants, and repeat applications were necessary even for small plants, it is not practical for ANRPO to use this product to manage *C. odorata* infestations. Though partner agencies may elect to use this product, its efficacy limitations should be taken into consideration. Partner agencies, homeowners, and community groups may find it helpful to treat large patches of small plants with Scythe or BurnOut, as an alternative to labor-intensive manual control (hand-pulling) or conventional herbicide. These results also suggest that using all-natural products on medium to large sized plants is an ineffective use of time and resources. Further, an SLN label must be acquired to use Scythe in natural areas. Safety considerations for the applicator should also be evaluated. This product has the signal word "Warning" on its label, and hazard statements that the product is harmful if inhaled and causes skin irritations. This level of risk for the applicator is greater than that of the conventional herbicide Ranger Pro (active ingredient: Glyphosate) used by ANRPO to control *C. odorata*, which only has the signal word "Caution" on its label, and a hazard statement that the product caused eye irritation. It is important to note that some all-natural products pose serious risks to the applicator as well as to the environment. Vinagreen, the least effective product tested here, was also the most dangerous one, with the signal word "Danger" on its label, and hazard statements that the product causes irreversible eye damage, is harmful if absorbed through skin or if swallowed, and is toxic to birds, fish, and aquatic invertebrates. The active ingredient in Vinagreen is acetic acid (20%), which may seem fairly benign to users unaware of the importance of the active ingredient percentage, though it is four times greater than the percentage found in common food-grade vinegars. It should also be noted that personal protective equipment (PPE) required for each of the all-natural products used in the trial is same as the PPE required for Ranger Pro (chemical resistant nitrile rubber gloves, long sleeves, long pants, covered shoes with socks, and eye protection), though additional PPE (face shields) is required for Vinagreen.

This study upholds the consensus among natural resource managers on Oʻahu that treatment using conventional herbicides containing Glyphosate continues to be the most effective method for successful control of *C. odorata*.

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## Restoration Project Phases

Last year's annual report displayed a flow chart of the phases a restoration project progresses through over time (Figure 1) prompting some questions as to the state of each restoration project described. To clarify things, a table listing all the restoration projects ANRPO is managing can be found in this appendix (Table 1). Each restoration project's area is calculated by summarizing all outplanting and SDT efforts and this area is a merged total so that no overlapping efforts are double counted. In addition, each project is labeled with a Current Phase; options include: not started, new, continuation, continuation(expansion), maintenance, or completed. The category continuation (expansion) implies that a project would have otherwise moved to the maintenance phase, but staff decided to expand on the original footprint of the site, thus requiring more active restoration and weeding efforts.

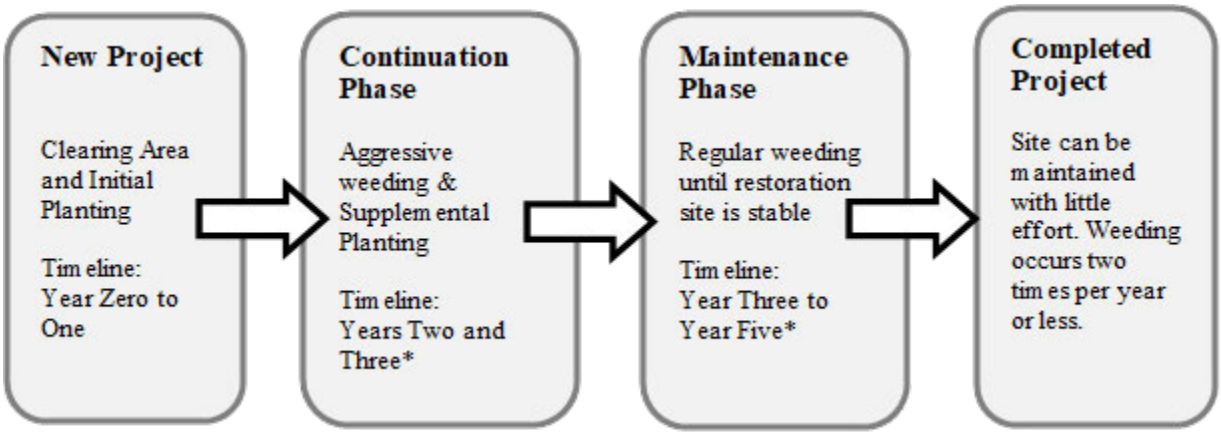


**Figure 1:** Restoration phase progression.

Table 1 lists 46 different restoration projects ANRPO is either working on or has completed and two additional projects, listed as not started that will be started within report year 2024. Not listed in the table are some of the smaller efforts ANRPO has undertaken years ago but have since been neglected; either poor site selection, other priorities, or unforseen circumstances have forced teams to strategically withdraw from some projects that were underperforming. Some of the lines listed as a single project are, in actuality, multiple projects that have bled into each other geographically and have become difficult to tease apart. So, the actual number of projects is greater than this, and upwards of 50 depending how you define a project.

In total, the area impacted by ANRPO restoration efforts is 34.86 acres. Kahanahāiki has the most area under restoration with 9.1 acres, followed by Palikea with 5.5 acres, Mākaha and Kaluaʻā & Waiʻeli with nearly 3.5 acres each, and Makaleha West with 2.2 acres.

Looking closely at completed projects reveals a surprisingly small amount of area, with only two projects meeting the goals. One site is the South Palikea Snail Enclosure (SOPA), where the area was selected in part due to the already existing native vegetation in the canopy. The other site is "Skyrim", where *Acacia koa* canopy has filled in so well that leaf litter effectively blocks most weeds from germinating. Restoration sites that rely heavily on koa canopy may be completed within a few years, but other species may take decades to reach canopy height, so one must be patient with other slower growing trees like *Metrosideros* or *Psychotria* species.

Overall, while this may sound discouraging, keep in mind that the restoration process takes time and nearly all of these projects have been started within the last eight years. It is also important to note that timelines can vary drastically depending on pre-existing vegetation composition or slope. Dry forest restoration is typically slower than in mesic forests. Older restoration sites that did not entirely remove alien canopy can be difficult to manage due to seed rain, standing dead trees, or damage from dead trees to outplants after storms. Similarly, sites with steep slopes are difficult to manuever in and are prone to erosion problems. Each situation presents its own set of challenges and it is important for staff to anticipate them when selecting a site for restoration.

Goals for projects can also vary heavily. Some projects designed as buffers around rare plants have canopy compositions that are dominated by *Psidium cattleianum*. These projects may never reach programmatic canopy goals due to the risk of damaging rare taxa in removal, so improving understory composition becomes the priority. Other projects are much more directed at improving canopy composition to meet MU goals and these projects remove all non-native canopy, eventually replacing it with natives. With enough time, hopefully these sites will harbor rare plants similar to “The Shire” where staff have observed one *Delissea waianaeensis* recruit.

As restoration efforts evolve, ANRPO will continue to adapt strategies, improving the odds of reaching ambitious goals for MU-wide restoration. With enough dedication and innovation, there just might be a chance. Look at the progress so far (Figure 2).

**Table 1**: Restoration Projects and Phases.

| Management Unit | WCA | Project Nickname | Team | Report Year Started | Area total ($m^2$) | Current Phase | Notes |
|---|---|---|---|---|---|---|---|
| ʻĒkahanui | ʻĒkahanui-13 | Bump Out | Blue | 2019 | 1103 | Continuation (Expansion) | Small site that is continuously expanded, revisit in a few years. |
| Haili to Keālia | HailitoKeālia-04 | HibBra Hill | Orange | 2018 | 3358 | Continuation | Dry forest site around HibBraMok, needs continued habitat improvement |
| Kahanahāiki | Kahanahāiki-03 | Skyrim | Blue | 2018 | 1991 | Completed | Small site with lots of Koa leaf litter, little weeding needed |
| Kahanahāiki | Kahanahāiki-03 | Schobo Baggins | VegRest | 2019 | 3621 | Continuation | Large site full of outplants. Need to keep weeding. Koa canopy filling in. |
| Kahanahāiki | Kahanahāiki-04 | The Shire/Aunty Desma's/Mirkwood | VegRest/Blue | 2016 | 8000 | Maintenance | Large complex, lines are blurred together between sites. Some more "completed" than others. One DelWai recruit in the Shire. |
| Kahanahāiki | Kahanahāiki-07 | Henеʻiwa | Blue | 2019 | 985 | Maintenance | Small site buffering a SchObo outplanting, still has PsiCat canopy. |
| Kahanahāiki | Kahanahāiki-08 | Thunderdome | Green | 2022 | 329 | Continuation | Small site but may expand to the north and west in the future. |
| Kahanahāiki | Kahanahāiki-09 | Nalu's | Blue/VegRest | 2021 | 1106 | Continuation | May need additional plants in the future. |
| Kahanahāiki | Kahanahāiki-09 | Kiki SnaJa | Blue | 2021 | 748 | Continuation | Snail Enclosure revegetation project. May need additional plants in the future. |
| Kahanahāiki | Kahanahāiki-10 | Tacky-10 | Green | 2019 | 4082 | Continuation (Expansion) | Continuously growing site that will blend into the rest of WCA-10 restorations. |
| Kahanahāiki | Kahanahāiki-10 | Helm's Deep/ WesTen | VegRest/Green | 2024 | 3753 | Not Started | New site planned for 2024 outplanting season connecting to MFCS. VegRest side will go to WCA 9/10 boundary. Green's side will abut Tacky-10 boundary. |
| Kahanahāiki | Kahanahāiki-07/08/09/10 | Maile Flats Chipper Site (MFCS) | Green/Blue | 2010 | 9874 | Maintenance | Small amount of outplanting and seedsows conducted in area, but mainly passive recovery. Needs follow up understory weeding and outplanting. |

**Table 1** (continued).

| Management Unit | WCA | Project Nickname | Team | Report Year Started | Area total ($m^2$) | Current Phase | Notes |
|---|---|---|---|---|---|---|---|
| Kahanahāiki | Kahanahāiki-15 | Plane Crash | Green | 2022 | 333 | Continuation | Small restoration site to reduce needed grass control but may expand in future. |
| Kahanahāiki | Kahanahāiki-16 | Schweppes/Canada Dry | VegRest | 2015 | 5829 | Continuation | Large old sites that need continuous weeding. May need additional clearing and plants in future. |
| Kalua‘ā and Wai‘eli | Kalua‘āandWai‘eli-02 | Hāpapa SnaJa | Orange | 2016 | 1824 | Maintenance | Snail Enclosure is filled with plants. Just needs weed maintenance occassionally. Jackson‘s chameleons area still being found inside. |
| Kalua‘ā and Wai‘eli | Kalua‘āandWai‘eli-02 | Hāpapa Bench | Orange | 2018 | 1654 | Continuation (Expansion) | Keep expanding from the jail outward. Area also serves as Drosophila habitat as host plants were used. |
| Kalua‘ā and Wai‘eli | Kalua‘āandWai‘eli-06 | Family Den | Orange | 2021 | 2920 | Continuation | Buffer of rare plants, revisit for expansion in a few years. Also serving as a potential habitat construction for *Drosophila* species as host plants were used. |
| Kalua‘ā and Wai‘eli | Kalua‘āandWai‘eli-08 | Central Gulch | Orange | 2016 | 6135 | Continuation | DelWai and CyaSupSup areas. Intended as buffers but also serve as *Drosophila* habitat as host plants were used. May need more plants. Revisit in a few years. |
| Kalua‘ā and Wai‘eli | Kalua‘āandWai‘eli-08 | Liana Lane | VegRest | 2023 | 1640 | New | Team says area is full of plants and CL agrees. Still need to monitor closely as site is prone to erosion. |
| Kaluakauila | Kaluakauila-02 | Upper Patch | Orange | 2018 | 5737 | Continuation | Dry forest site where things are slow to establish. Trying to revegetate two spots with groundcovers and shrubs. |
| Kamā‘ili | Kamā‘ili-02 | NerAng patch | Orange | 2021 | 1312 | Continuation | Rare and common native plants are getting hammered by peafowl. Restoration is slow due to rocky terrain. |

**Table 1** (continued).

| Management Unit | WCA | Project Nickname | Team | Report Year Started | Area total ($m^2$) | Current Phase | Notes |
|---|---|---|---|---|---|---|---|
| Kapuna Upper | UpperKapuna-03 | SchNut Shaft | Blue | 2020 | 1564 | Continuation | Continue to clear and expand to nearby mini gulches. |
| Kea‘auHibiscus | Kea‘auHibiscus-01 | The Wilds/reintros | Blue | 2019 | 6821 | Continuation (Expansion) | Team always wants to continue expanding the area as a buffer around HibBraMoks. |
| Lower ‘Ōhikilolo | Lower‘Ōhikilolo-02 | Upper ‘Akoko | Green | 2016 | 6557 | Continuation (Expansion) | Nice DodVis patch, team is trialing shade cloth as an option to help initial outplant survival. |
| Lower ‘Ōhikilolo | Lower‘Ōhikilolo-03 | Hibiscus Patch | Green | 2016 | 7471 | Continuation | Burned in 2022, still need to nail down future plans moving forward. |
| Mākaha | Mākaha-02 | Radagast | VegRest | 2018 | 6019 | Continuation (Expansion) | Original area for Radagast complete. Extension focused on Eastern edge of ridge. |
| Mākaha | Mākaha-08 | Tickten's | VegRest | 2017 | 812 | Maintenance | Older site just west of Giant ‘Ōhi‘a. No current plans of expansion. |
| Mākaha | Mākaha-09 | Giant ‘Ōhi‘a/Fangorn | VegRest | 2017 | 4972 | Maintenance | Giant ‘Ōhi‘a is completed. Fangorn need maintenance still. No current plans of more plants. |
| Mākaha | Mākaha-10 | Mākaha 5 & 10 SchNuts | Orange | 2020 | 1208 | Maintenance | SchNut population split between two WCAs, common natives used for habitat improvement. |
| Mākaha | Mākaha-14 | SchObo/CenAgrAgr | Orange | 2021 | 1014 | Maintenance | Buffer of rare plants with PsiCat canopy |
| Mākaha | Mākaha-18 | Michael's Jackson's | Orange | 2024 | 1357 | Not Started | Opening up new area for future RP reintros |
| Makaleha West | MakalehaWest-02 | Okazu bowls/ Volunteer spot | Orange | 2016 | 4054 | Continuation (Expansion) | Continuously growing complex. Okazu bowls filling in, considering expansion toward western edge (volunteer spot) to cherry out area. |

**Table 1** (continued).

| Management Unit | WCA | Project Nickname | Team | Report Year Started | Area total ($m^2$) | Current Phase | Notes |
|---|---|---|---|---|---|---|---|
| Makaleha West | MakalehaWest-02 | Snail Jail | Orange | 2016 | 2019 | Maintenance | Snail Enclosure is mostly vegetated. May need additional plants in the future to fill in spots. |
| Makaleha West | MakalehaWest-03 | CyrDen gulches | Orange | 2023 | 198 | New | Rare plant buffer project. No major changes to canopy, just planted understory mix around RPs |
| Makaleha West | MakalehaWest-04 | ʻIʻi nui | VegRest | 2022 | 2642 | Continuation | Planting mostly done, but still need to get RubArg out of site. Consider expansion effort next OA-02 cycle. |
| ʻŌhikilolo | ʻŌhikilolo-13 | Mauka Patch | Blue | 2016 | 6317 | Continuation (Expansion) | Blue Team keeps expanding restoration efforts across the Mauka Patch, with smaller plantings in other WCAs of ʻŌhikilolo |
| ʻŌpaeʻula Lower | ʻŌpaeʻulaLower-03 | CyrDungeon | Blue | 2020 | 1701 | Continuation | Trying to connect the CyrDen and GarMan areas removing PsiCat. |
| ʻŌpaeʻula Lower | ʻŌpaeʻulaLower-04 | The Swamp | Blue | 2018 | 2242 | Continuation | Pushing back the CliHir in spots behind the weatherport and in the little pond and filling in with common natives as can. |
| Pahole | Pahole-01 | Switchbacks/ Bill Garnett | Green | 2019 | 670 | Maintenance | Rare plant buffering project. Was never cleared of weeds in canopy. No plans to do so. |
| Palikea | Palikea-01 | South Palikea Snail Enclosure (SOPA) | Green | 2012 | 1250 | Completed | SOPA has been densely filled with plants for many years. Occasional weed actions are needed. Staff will monitor as new walls are constructed. |
| Palikea | Palikea-01 | Meadows | Green | 2019 | 764 | Continuation (Expansion) | Meadows keeps expanding into nearby PsiCat stand downslope. |
| Palikea | Palikea-02 | Banyan Breezeway/ H-line/ Erosion Scar | Green | 2015 | 3747 | Maintenance | Banyan Breeze could benefit from continued expansion from older efforts. Area also serves as *Drosophila* habitat as host plants were used. Will revisit during OA-08 restoration cycle. |

**Table 1** (continued).

| Management Unit | WCA | Project Nickname | Team | Report Year Started | Area total ($m^2$) | Current Phase | Notes |
|---|---|---|---|---|---|---|---|
| Palikea | Palikea-03 | Slope of Hope | Green | 2016 | 990 | Continuation (Expansion) | This area is a constant battle against erosion. Will continue in OA-08 cycle. |
| Palikea | Palikea-06 | Fern Gully | VegRest | 2016 | 5956 | Maintenance | Need to figure out canopy for this area. Area also serves as *Drosophila* habitat as host plants were used. Standing dead CryJap. |
| Palikea | Palikea-07 | Norfolk | VegRest | 2017 | 2405 | Maintenance | Still need to figure out what we would like to do with this area |
| Palikea | Palikea-08 | ʻIeʻie site | VegRest | 2021 | 1871 | Continuation | Let site rest for a bit and revisit for expansion efforts in OA-08 cycle. Otherwise progressing nicely. |
| Palikea | Palikea-09 | Koa site | VegRest | 2018 | 2189 | Maintenance | Site has dusty, hydrophobic soil that outplants struggle to establish in but koa canopy is filled in. |
| Palikea | Palikea-11 | North Palikea Snail Enclosure (NOPA) | Green | 2018 | 3032 | Maintenance | Site is resting, waiting for canopy to fill in. Staff will monitor progress and decide if more plants are needed in the future. |

**Figure 2:** Schobo Baggins Pole 1 West Photopoint. Dates in clockwise order are 02/2019, 05/2019, 06/2020, 04/2023.

ARMY NATURAL RESOURCES PROGRAM ON O‘AHU
MONITORING PROGRAM

# KAPUNA UPPER MANAGEMENT UNIT VEGETATION MONITORING, 2022

## INTRODUCTION

The Army Natural Resources Program on O‘ahu (ANRPO) conducted vegetation monitoring at Kapuna Upper Management Unit (MU) in 2022 in association with Implementation Plan (IP) requirements for long term monitoring of vegetation composition and change over time (ANRPO 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. Monitoring took place twice previously (in 2011 and 2017), and will proceed on a five-year interval (ANRPO 2018). Previous monitoring indicated that none of the MU cover goals were met. The MU fence lines were completed in 2007.

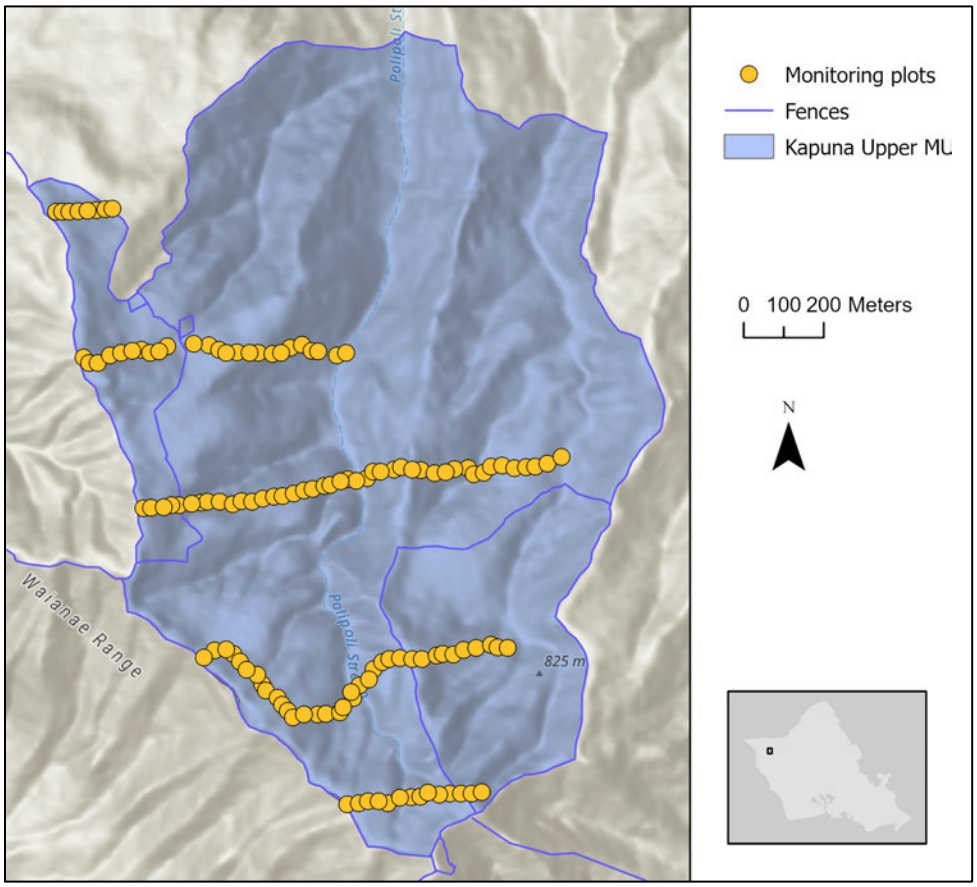


**Figure 1:** Kapuna Upper MU vegetation monitoring plot locations.

## METHODS

In October of 2022, 126 permanent plots in 5 transects were monitored at Kapuna Upper MU (Figure 2). Plots measuring 5 x 10 m were generally located every 20 or 30 m along transects. Transects were spaced approximately 350 m apart. Vegetation monitoring was limited to the higher elevations of the MU, as the lower elevations receive limited direct management, and are largely dominated by non-

native vegetation. Understory (0 – 2 m above ground level (AGL), including low branches from canopy species) and canopy (> 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, and overall summary percent cover of non-native and native vegetation in the understory and canopy, were also documented. Percent cover categories were recorded in 10% intervals between 10 and 100%, and on finer intervals (0-1%, 1-5%, and 5-10%) between 0 and 10% cover. Understory recruitment (defined as seedlings or saplings < 2 m AGL) frequency data for tree species was also recorded, though observations in 2011 were incomplete. Monitoring results were compared with data from prior years. Based on IP recommendations, p-values < 0.05 were considered significant, and only absolute cover changes ≥ 10% were recognized. Additional methodology information is detailed in Monitoring Protocol 1.2.1 (ANRPO 2008). All analyses were performed in IBM SPSS Statistics Version 29. These included Friedman's tests with Bonferroni adjusted post-hoc pairwise comparisons and Wilcoxon signed ranks tests for cover and richness data; McNemar's tests for frequency data; and generalized linear modeling (GLM) to assess influences on cover change. For species frequency analyses, comparisons were made between 2011 and 2022 for taxa with ≥ 10% difference in frequency. For species cover analyses, comparisons were made between 2011 and 2022 for taxa with frequencies ≥ 20% in either 2011 or 2022. Median numbers reported do not always correspond to MU-wide trends as reflected by statistical results (median values may remain unchanged despite statistically significant result, or vice versa). P-values represent the likelihood (scaled from 0 to 1) that there is no difference in compared data, where higher values indicate a greater likelihood of no difference occurring.

**Figure 2:** ANRPO staff members Krista Lizardi and Kapua Kawelo collecting field data at vegetation monitoring plots in a NEPM restoration site (left) and in a less inspiring location (right) at Kapuna Upper MU.

## RESULTS

### Understory and canopy cover categories

Management goals of having < 50% non-native understory and canopy and > 50% native understory and canopy cover were only met for the non-native understory (35% median cover), but were not met for the native understory (3%) and canopy (7.5%) or non-native canopy (95%) (Table 1). There were significant changes in percent cover of vegetation since 2011 that met the 10% standard for recognized change in cover. These included cover declines for non-native shrubs and total non-native understory, increases for non-native canopy, and inconsistent trends (possibly an artifact of observer differences) for native canopy (Figure 3). In 2022, locations of low to high native and non-native percent cover were patchily distributed, though native understory cover was mostly consistently low, and non-native canopy cover was mostly consistently high (Figure 4).

**Table 1:** Median percent cover over time for native and non-native vegetation categories in the canopy and understory at Kapuna Upper MU. Categories specifically addressed in management goals are shaded in blue. Statistically significant values for categories that meet the 10% standard for recognized change in cover are in boldface. Arrows indicate increase (↑), decrease (↓), or inconsistent trend (↕) in cover.

| | 2011 | 2017 | 2022 | p* | $X^2$ | Years that differed significantly | p (post-hoc)** | Management goal currently met? |
|---|---|---|---|---|---|---|---|---|
| ***Understory*** | | | | | | | | |
| Native shrubs | 3.0 | 3.0 | 0.5 | 0.000↓ | 74.907 | 2011-2017<br>2011-2022<br>2017-2022 | 0.000↓<br>0.000↓<br>0.004↓ | |
| Native ferns | 3.0 | 3.0 | 0.5 | 0.000↓ | 27.398 | 2011-2022<br>2017-2022 | 0.000↓<br>0.012↓ | |
| Native grass/sedges | 0.0 | 0.0 | 0.0 | 0.073 | 5.247 | | | |
| Total native understory | 11.3 | 3.0 | 3.0 | 0.000↓ | 56.952 | 2011-2017<br>2011-2022<br>2017-2022 | 0.001↓<br>0.000↓<br>0.011↓ | No |
| Non-native shrubs | 35.0 | 25.0 | 15.0 | **0.000**↓ | 28.112 | 2011-2022<br>2017-2022 | **0.000**↓<br>**0.001**↓ | |
| Non-native ferns | 0.5 | 1.7 | 0.5 | 0.000↕ | 21.615 | 2011-2017 | 0.001↑ | |
| Non-native grass/sedges | 0.5 | 0.5 | 0.5 | 0.000↓ | 43.614 | 2011-2017<br>2011-2022 | 0.002↓<br>0.000↓ | |
| Total non-native understory | 55.0 | 55.0 | 35.0 | **0.000**↓ | 32.897 | 2011-2022<br>2017-2022 | **0.000**↓<br>**0.001**↓ | Yes |
| ***Canopy*** | | | | | | | | |
| Native canopy | 15.0 | 25.0 | 7.5 | **0.002**↕ | 12.654 | 2017-2022 | **0.010**↓ | No |
| Non-native canopy | 85.0 | 95.0 | 95.0 | **0.001**↑ | 52.319 | 2011-2017<br>2011-2022 | **0.000**↑<br>**0.000**↑ | No |
| Total canopy | 95.0 | 95.0 | 95.0 | 0.000 | 30.296 | 2011-2017<br>2011-2022 | 0.005<br>0.027 | |

*From Friedman's test, asymptotic significance

**From post-hoc pairwise comparisons with Bonferroni adjustment

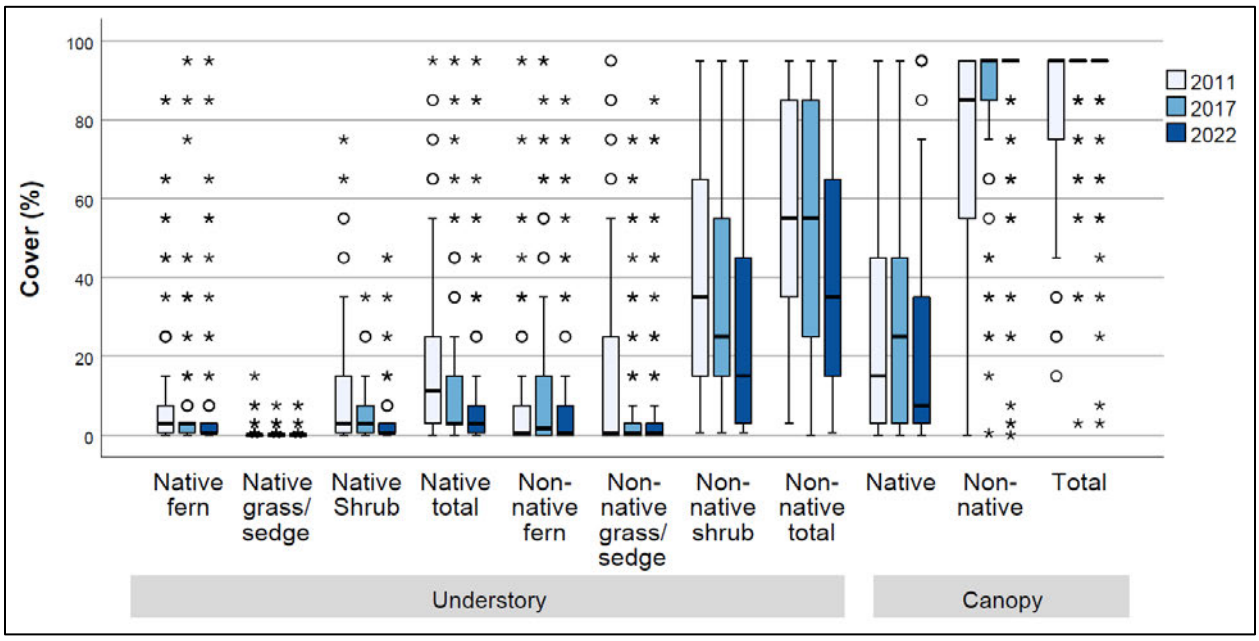


**Figure 3:** Boxplots for cover of native and non-native taxon categories over time in Kapuna Upper MU. *Note: Boxplots illustrate the range of values of variables. The boxes depict the middle 50% of the data values, and the horizontal line inside the box represents the median value. The range in values for all remaining data are indicated by the vertical lines, circles (outliers), and stars (extreme outliers).*

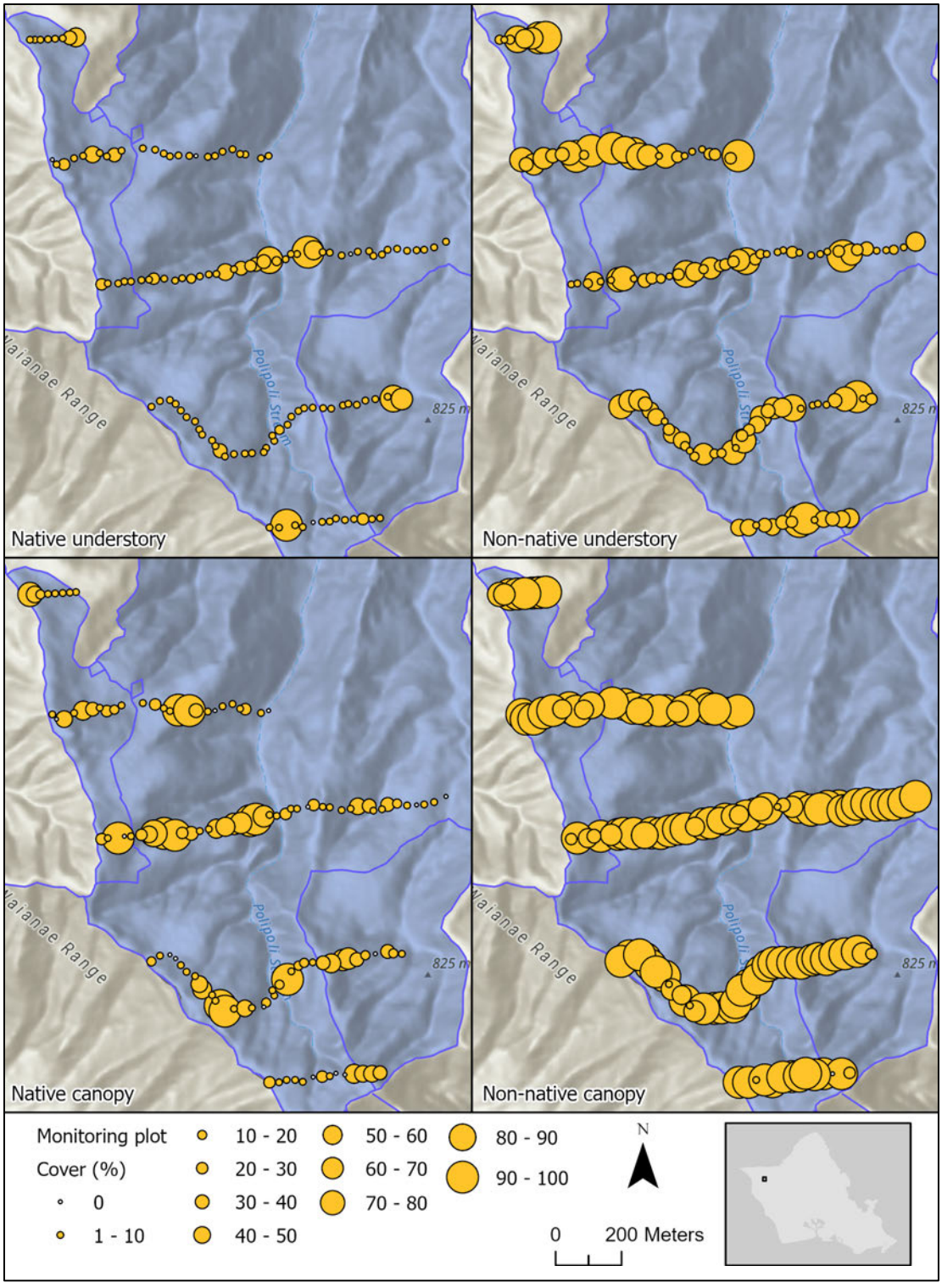


**Figure 4:** Locations of low to high percent cover of native and non-native understory and canopy vegetation among monitored plots at Kapuna Upper in 2022. Larger circles denote higher percent cover, while smaller circles represent lower cover.

**Species richness**

During monitoring in 2022, 108 species were recorded in the understory (60% native taxa), and 56 were identified in the canopy (66% native). Locations of high and low species richness were patchily distributed across the MU, (Figure 5). Overall diversity for the MU was highest for the native understory, though within plot richness was highest for the non-native understory (Table 2). Species richness within plots differed significantly between the years monitored, with decreases for the native and non-native understory, and increases for the non-native canopy, and inconsistent trends for the native canopy (Table 2 and Figure 6). Most notable was the decline in within plot richness for native understory.

**Species frequency**

Non-native species that occurred most frequently in plots (present in more than half the plots) in the understory in 2022 included *Psidium cattleianum*, *Clidemia hirta*, and *Blechnum appendiculatum*, while *P. cattleianum* and *Schinus terebinthifolius* occurred most commonly in the canopy (Table 3). The most frequent native understory species (in more than a third of the plots) included *Microlepia strigosa*, *Alyxia stellata*, and *Nephrolepis exaltata* subsp. *hawaiiensis*, while *Metrosideros polymorpha* and *A. stellata* occurred most commonly in the canopy. One rare taxon, *Cyrtandra dentata*, was recorded in plots during monitoring in 2022. Numerous target weed taxa (taxa of special concern for weed management, ranging from incipient species to those with widespread distributions) (ANRPO 2022) for Kapuna Upper MU were present in monitored plots in 2022 in either the understory or canopy, though most were those with widespread distributions. No Incipient Control Area (ICA) targets were present in plots in 2022 (Figure 7). Seven limited distribution target (LDT) taxa were recorded in plots, including *Adiantum hispidulum*, *Commelina diffusa*, *Montanoa hibiscifolia*, *Passiflora suberosa*, *Schefflera actinophylla*, *Spathodea campanulata*, and *Toona ciliata*, most of which were in relatively low frequencies (< 5%) with the exception of *A. hispidulum* and *T. ciliata*, which were in 10 % and 11% (respectively) of all plots collectively in the understory and/or canopy. At least one limited distribution target taxon was present in 23% of the plots. The most notable changes since 2011 included the continual spread of *A. hispidulum* and *T. ciliata*.

Eight species (75% native) were newly recorded in plots in 2022, and 24 taxa (75% native) were recorded in prior years but not observed in plots in 2022 (Table 4). One newly recorded non-native taxon, *Cyrtomium falcatum* (found in a single plot), has concerning potential for invasiveness (WRA score of 14.0, high risk; invasive in dry, mesic, and wet forests) (Hawai‘i-Pacific Weed Risk Assessment 2018). A substantial infestation of *Achyranthes aspera* was found adjacent to one plot, and also has a concerning potential for invasiveness (WRA score of 19.0, high risk; spine tipped seeds stick to clothes, fur and feather and are easily spread, forms persistent seed bank) (Hawai‘i-Pacific Weed Risk Assessment 2020). Aside from the direct or indirect result of management actions and/or natural processes (weeding, outplanting, dispersal, death, etc.), the presence or absence of species may be due in part to human error such as misidentification, observer bias regarding plot boundaries or amount of time spent searching, or accidental non-recording. Misidentifications are possible and/or suspected for some (e.g., some fern species). All species that were not recorded in 2022 were uncommon in prior years (frequencies < 4%), as were those newly documented in 2022 (all with frequencies < 2%).

Analysis of frequency change was limited to taxa with at least ten percent change between 2011 and 2022. Among native taxa, there were significant frequency decreases for *Cocculus orbiculatus* and *M. polymorpha* in the understory (Figure 8). Among non-native taxa in the understory, there were significant frequency increases for *B. appendiculatum* and *C. hirta*, and decreases for *Melinis minutiflora*, *Paspalum conjugatum*, and *S. terebinthifolius*. Among non-native taxa in the canopy, there was a significant increase in *P. cattleianum*.

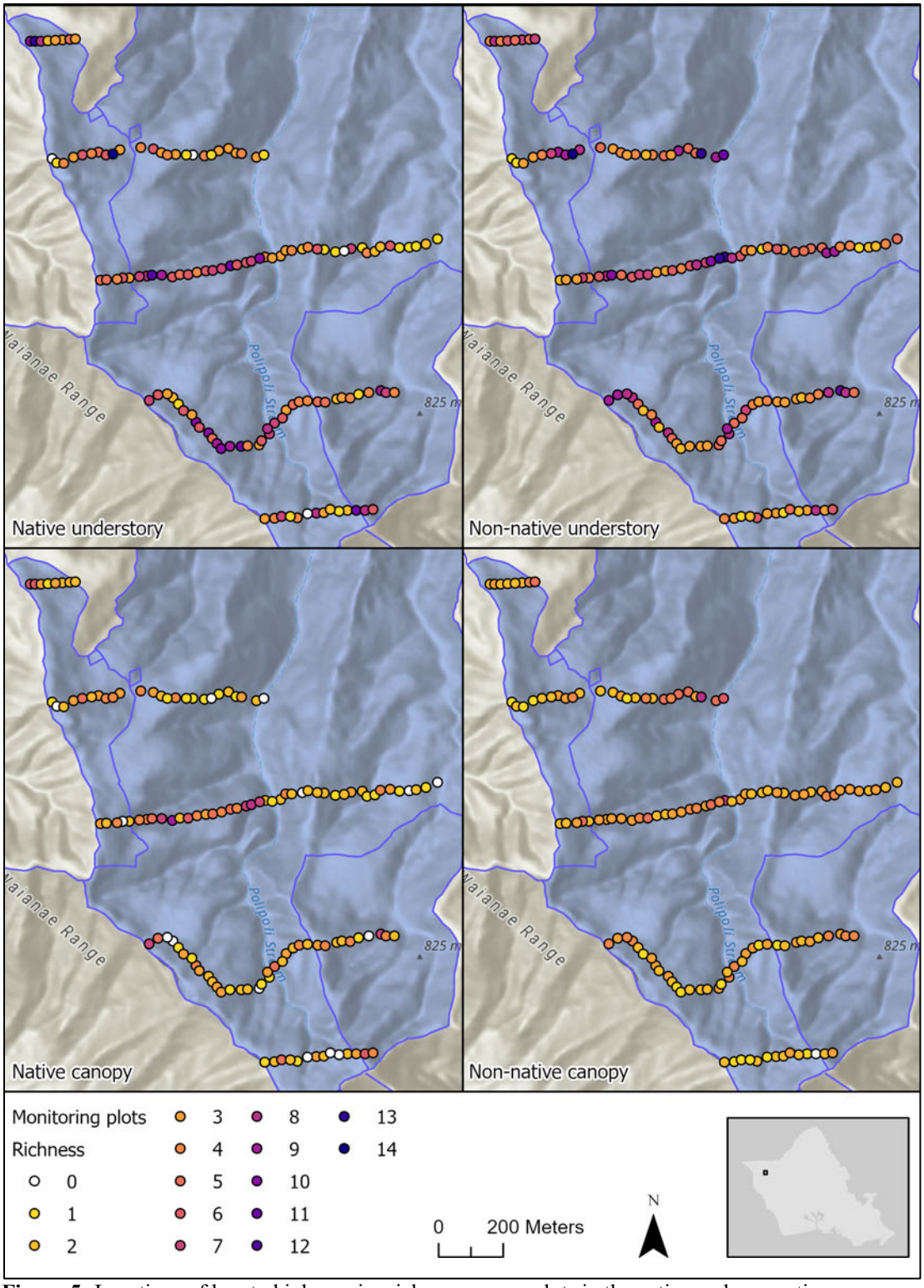


**Figure 5:** Locations of low to high species richness among plots in the native and non-native understory and canopy in Kapuna Upper in 2022. Color gradients of yellow to purple indicate low to high values, respectively, of the number of species occurring in plots (i.e., yellow indicates low diversity, while purple indicates relatively higher diversity).

**Table 2:** Kapuna Upper MU understory and canopy species richness over time. Median species richness per plot during vegetation monitoring is shown by year, with the total number of species recorded among all plots in parenthesis. Statistically significant values are in boldface. Arrows indicate increase (↑), decrease (↓), or inconsistent trend (↕) in cover.

| | 2011 | 2017 | 2022 | p* | $X^2$ | Years that differed significantly | p (post-hoc)** |
|---|---|---|---|---|---|---|---|
| Native understory | 5 (69) | 5 (64) | 4 (65) | **0.000↓** | 29.885 | 2011-2022 | **0.000↓** |
| | | | | | | 2017-2022 | **0.015↓** |
| Non-native understory | 6 (40) | 5 (43) | 5 (43) | **0.000↓** | 15.769 | 2011-2022 | **0.022↓** |
| | | | | | | 2017-2022 | **0.003↓** |
| Native canopy | 2.5 (36) | 3 (42) | 2 (37) | **0.000↕** | 15.640 | 2011-2017 | **0.042↑** |
| | | | | | | 2017-2022 | **0.007↓** |
| Non-native canopy | 2 (14) | 3 (23) | 3 (19) | **0.000↑** | 25.684 | 2011-2017 | **0.001↑** |

*From Friedman's test for differences across all years, asymptotic significance
**From post-hoc pairwise comparisons with Bonferroni adjustment

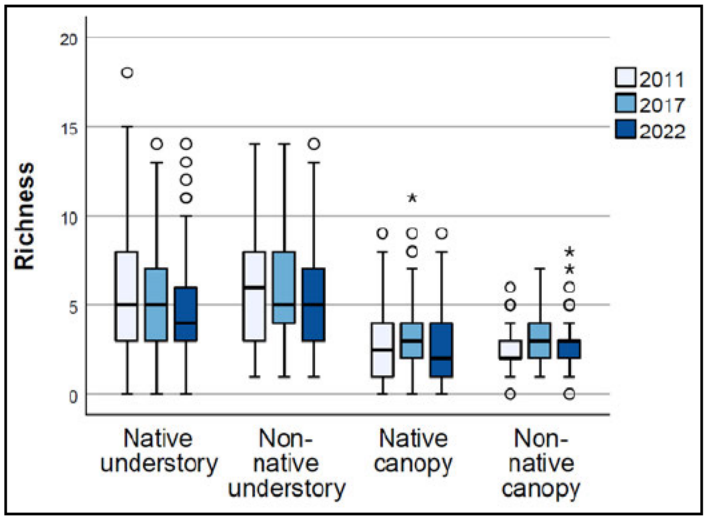


**Figure 6:** Boxplots for native and non-native richness in the understory and canopy over time in Kapuna Upper MU.

**Table 3:** Species frequencies over time in the understory and canopy in Kapuna Upper MU. Taxa are ordered by highest to lowest frequency in 2022. Only taxa with at least 10% change in frequency between 2011 and 2022 were analyzed. Statistical comparisons are between 2011 and 2022 data. P-values obtained from McNemar's tests. Arrows indicate increase (↑) or decrease (↓) in frequency for statistically significant results. Native species are in boldface. ‡Rare taxa. Target weed taxa: *ICA, **LDT.

| Taxon | 2011 | 2017 | 2022 | p | $X^2$ |
|---|---|---|---|---|---|
| Understory | | | | | |
| *Psidium cattleianum* | 87.3 | 92.9 | 95.2 | | |
| *Clidemia hirta* | 75.4 | 89.7 | 88.1 | 0.002↑[a] | NA |
| *Blechnum appendiculatum* | 51.6 | 59.5 | 62.7 | 0.003↑[a] | NA |
| ***Microlepia strigosa*** | 49.2 | 51.6 | 51.6 | | |
| ***Alyxia stellata*** | 54.8 | 52.4 | 49.2 | | |
| ***Nephrolepis exaltata* subsp. *hawaiiensis*** | 52.4 | 52.4 | 45.2 | | |
| *Schinus terebinthifolius* | 52.4 | 50.8 | 42.1 | 0.097↓[b] | 2.75 |
| *Oplismenus hirtellus* | 45.2 | 42.1 | 41.3 | | |
| *Christella parasitica* | 26.2 | 38.9 | 31.7 | | |
| ***Metrosideros polymorpha*** | 42.1 | 33.3 | 30.2 | 0.003↓[a] | NA |
| ***Doodia kunthiana*** | 26.2 | 27.8 | 22.2 | | |

**Table 3** (continued).

| Taxon | 2011 | 2017 | 2022 | p | $X^2$ |
|---|---|---|---|---|---|
| Understory | | | | | |
| ***Coprosma foliosa*** | 30.2 | 22.2 | 20.6 | | |
| *Rubus rosifolius* | 24.6 | 27.8 | 19.0 | | |
| *Psidium guajava* | 27.0 | 21.4 | 19.0 | | |
| ***Psydrax odorata*** | 25.4 | 19.8 | 19.0 | | |
| ***Kadua affinis*** | 27.0 | 24.6 | 18.3 | | |
| *Paspalum conjugatum* | 31.0 | 21.4 | 14.3 | 0.031↓[a] | NA |
| ***Psychotria mariniana*** | 11.1 | 13.5 | 13.5 | | |
| *Lantana camara* | 20.6 | 19.8 | 11.9 | | |
| ***Antidesma platyphyllum*** | 14.3 | 18.3 | 11.9 | | |
| ***Diospyros hillebrandii*** | 15.1 | 12.7 | 11.9 | | |
| ***Notelaea sandwicensis*** | 14.3 | 13.5 | 11.1 | | |
| ***Carex wahuensis*** | 7.9 | 8.7 | 10.3 | | |
| *Adiantum hispidulum*** | 4.8 | 8.7 | 10.3 | | |
| ***Wikstroemia oahuensis* var. *oahuensis*** | 9.5 | 11.1 | 9.5 | | |
| ***Psilotum nudum*** | 5.6 | 11.9 | 8.7 | | |
| ***Diospyros sandwicensis*** | 10.3 | 9.5 | 8.7 | | |
| ***Acacia koa*** | 8.7 | 7.1 | 8.7 | | |
| ***Cocculus orbiculatus*** | 21.4 | 15.1 | 7.9 | 0.003↓[b] | 8.828 |
| ***Lepisorus thunbergianus*** | 7.1 | 10.3 | 7.9 | | |
| *Triumfetta semitriloba* | 11.9 | 8.7 | 7.9 | | |
| *Phlebodium aureum* | 3.2 | 4.8 | 7.9 | | |
| ***Sapindus oahuensis*** | 7.1 | 7.1 | 7.1 | | |
| *Grevillea robusta* | 11.1 | 4.8 | 7.1 | | |
| ***Ceodes brunoniana*** | 1.6 | 4.8 | 7.1 | | |
| *Melinis minutiflora* | 17.5 | 12.7 | 6.3 | 0.000↓[a] | NA |
| ***Cibotium chamissoi*** | 4.0 | 6.3 | 6.3 | | |
| *Toona ciliata*** | 5.6 | 2.4 | 6.3 | | |
| ***Dicranopteris linearis*** | 5.6 | 7.9 | 5.6 | | |
| *Christella dentata* | 5.6 | 4.0 | 5.6 | | |
| ***Odontosoria chinensis*** | 12.7 | 8.7 | 4.8 | | |
| *Passiflora suberosa*** | 0.0 | 4.8 | 4.8 | | |
| ***Asplenium macraei*** | 4.8 | 7.9 | 4.0 | | |
| *Cordyline fruticosa* | 3.2 | 7.1 | 4.0 | | |
| ***Planchonella sandwicensis*** | 4.8 | 6.3 | 4.0 | | |
| *Ageratina adenophora* | 7.1 | 5.6 | 4.0 | | |
| ***Freycinetia arborea*** | 4.8 | 5.6 | 4.0 | | |
| *Nephrolepis brownii* | 1.6 | 5.6 | 4.0 | | |
| ***Carex meyenii*** | 8.7 | 4.8 | 4.0 | | |
| ***Xylosma hawaiiense*** | 6.3 | 4.0 | 4.0 | | |
| *Syzygium cumini* | 7.9 | 5.6 | 3.2 | | |
| ***Euphorbia multiformis*** | 7.1 | 5.6 | 3.2 | | |
| ***Elaphoglossum aemulum*** | 0.0 | 2.4 | 3.2 | | |
| ***Asplenium caudatum*** | 4.0 | 1.6 | 3.2 | | |
| *Megathyrsus maximus* | 1.6 | 1.6 | 3.2 | | |
| ***Bidens torta*** | 8.7 | 4.0 | 2.4 | | |
| *Stachytarpheta australis* | 5.6 | 4.0 | 2.4 | | |
| *Adiantum raddianum* | 4.0 | 3.2 | 2.4 | | |
| ***Cyperus hillebrandii* subsp. *decipiens*** | 6.3 | 2.4 | 2.4 | | |
| ***Melicope oahuensis*** | 3.2 | 2.4 | 2.4 | | |
| ***Tectaria gaudichaudii*** | 3.2 | 2.4 | 2.4 | | |
| ***Elaeocarpus bifidus*** | 2.4 | 2.4 | 2.4 | | |
| *Aleurites moluccana* | 1.6 | 2.4 | 2.4 | | |
| ***Psychotria hathewayi*** | 0.8 | 1.6 | 2.4 | | |

**Table 3** (continued).

| Taxon | 2011 | 2017 | 2022 | p | $X^2$ |
|---|---|---|---|---|---|
| Understory | | | | | |
| ***Ceodes umbellifera*** | 0.8 | 0.8 | 2.4 | | |
| *Polystachya concreta* | 0.0 | 0.0 | 2.4 | | |
| *Buddleja asiatica* | 6.3 | 5.6 | 1.6 | | |
| *Ageratina riparia* | 7.1 | 4.8 | 1.6 | | |
| ***Rockia sandwicensis*** | 5.6 | 2.4 | 1.6 | | |
| ***Dodonaea viscosa*** | 3.2 | 2.4 | 1.6 | | |
| *Montanoa hibiscifolia*** | 1.6 | 1.6 | 1.6 | | |
| ***Viola chamissoniana* subsp. *tracheliifolia*** | 1.6 | 1.6 | 1.6 | | |
| *Spathodea campanulata*** | 0.8 | 1.6 | 1.6 | | |
| ***Cyrtandra dentata*‡** | 0.8 | 1.6 | 1.6 | | |
| ***Paratrophis pendulina*** | 2.4 | 0.8 | 1.6 | | |
| ***Hibiscus arnottianus* subsp. *arnottianus*** | 1.6 | 0.8 | 1.6 | | |
| ***Scaevola gaudichaudiana*** | 1.6 | 0.8 | 1.6 | | |
| *Pluchea carolinensis* | 0.8 | 0.8 | 1.6 | | |
| *Ipomoea cairica* | 0.0 | 0.8 | 1.6 | | |
| *Melinis repens* | 0.0 | 0.8 | 1.6 | | |
| ***Dianella sandwicensis*** | 0.0 | 0.0 | 1.6 | | |
| ***Vandenboschia cyrtotheca*** | 0.0 | 0.0 | 1.6 | | |
| *Deparia petersenii* | 4.0 | 4.8 | 0.8 | | |
| *Conyza bonariensis* | 9.5 | 3.2 | 0.8 | | |
| ***Dryopteris fusco-atra*** | 2.4 | 3.2 | 0.8 | | |
| *Oxalis debilis* | 2.4 | 2.4 | 0.8 | | |
| ***Myrsine lessertiana*** | 2.4 | 2.4 | 0.8 | | |
| ***Vandenboschia davallioides*** | 2.4 | 2.4 | 0.8 | | |
| *Oxalis corniculata* | 4.0 | 1.6 | 0.8 | | |
| *Commelina diffusa*** | 0.8 | 1.6 | 0.8 | | |
| ***Elaphoglossum crassifolium*** | 0.8 | 1.6 | 0.8 | | |
| ***Elaphoglossum alatum*** | 2.4 | 0.8 | 0.8 | | |
| ***Charpentiera tomentosa*** | 1.6 | 0.8 | 0.8 | | |
| ***Pteridium aquilinum*** | 0.8 | 0.8 | 0.8 | | |
| ***Asplenium contiguum*** | 0.0 | 0.8 | 0.8 | | |
| ***Pittosporum glabrum*** | 0.0 | 0.8 | 0.8 | | |
| *Emilia sonchifolia* | 0.8 | 0.0 | 0.8 | | |
| *Schefflera actinophylla*** | 0.8 | 0.0 | 0.8 | | |
| ***Bobea elatior*** | 0.8 | 0.0 | 0.8 | | |
| ***Doryopteris decipiens*** | 0.8 | 0.0 | 0.8 | | |
| ***Panicum nephelophilum*** | 0.8 | 0.0 | 0.8 | | |
| *Cyrtomium falcatum* | 0.0 | 0.0 | 0.8 | | |
| *Erechtites valerianifolia* | 0.0 | 0.0 | 0.8 | | |
| ***Claoxylon sandwicensis*** | 0.0 | 0.0 | 0.8 | | |
| ***Cyperus polystachyos*** | 0.0 | 0.0 | 0.8 | | |
| ***Kadua acuminata*** | 0.0 | 0.0 | 0.8 | | |
| ***Microlepia speluncae*** | 0.0 | 0.0 | 0.8 | | |
| ***Polyscias oahuensis*** | 0.0 | 0.0 | 0.8 | | |
| *Passiflora edulis* | 2.4 | 0.8 | 0.0 | | |
| ***Charpentiera obovata*** | 0.8 | 0.8 | 0.0 | | |
| ***Dryopteris glabra*** | 0.8 | 0.8 | 0.0 | | |
| ***Korthalsella cylindrica*** | 0.8 | 0.8 | 0.0 | | |
| *Andropogon virginicus* | 0.0 | 0.8 | 0.0 | | |
| *Angiopteris evecta** | 0.0 | 0.8 | 0.0 | | |
| *Coffea arabica*** | 0.0 | 0.8 | 0.0 | | |
| *Rubus argutus*** | 0.0 | 0.8 | 0.0 | | |
| ***Asplenium kaulfussii*** | 0.0 | 0.8 | 0.0 | | |

**Table 3** (continued).

| Taxon | 2011 | 2017 | 2022 | p | $X^2$ |
|---|---|---|---|---|---|
| Understory | | | | | |
| ***Dryopteris sandwicensis*** | 0.0 | 0.8 | 0.0 | | |
| ***Gahnia beecheyi*** | 0.0 | 0.8 | 0.0 | | |
| ***Melicope kaalaensis*** | 0.0 | 0.8 | 0.0 | | |
| ***Pipturus albidus*** | 0.0 | 0.8 | 0.0 | | |
| ***Selaginella arbuscula*** | 0.0 | 0.8 | 0.0 | | |
| *Youngia japonica* | 3.2 | 0.0 | 0.0 | | |
| ***Psilotum complanatum*** | 2.4 | 0.0 | 0.0 | | |
| ***Asplenium dielfalcatum*‡** | 1.6 | 0.0 | 0.0 | | |
| ***Asplenium nidus*** | 1.6 | 0.0 | 0.0 | | |
| ***Leptecophylla tameiameiae*** | 1.6 | 0.0 | 0.0 | | |
| ***Peperomia tetraphylla*** | 1.6 | 0.0 | 0.0 | | |
| *Justicia betonica*** | 0.8 | 0.0 | 0.0 | | |
| ***Diplazium sandwichianum*** | 0.8 | 0.0 | 0.0 | | |
| ***Elaphoglossum paleaceum*** | 0.8 | 0.0 | 0.0 | | |
| ***Korthalsella complanata*** | 0.8 | 0.0 | 0.0 | | |
| ***Melicope peduncularis*** | 0.8 | 0.0 | 0.0 | | |
| ***Myrsine lanaiensis*** | 0.8 | 0.0 | 0.0 | | |
| ***Smilax melastomifolia*** | 0.8 | 0.0 | 0.0 | | |
| Canopy | | | | | |
| *Psidium cattleianum* | 81.7 | 90.5 | 93.7 | 0.000↑[a] | NA |
| *Schinus terebinthifolius* | 73.0 | 78.6 | 76.2 | | |
| ***Metrosideros polymorpha*** | 53.2 | 54.8 | 50.0 | | |
| ***Alyxia stellata*** | 35.7 | 42.1 | 33.3 | | |
| *Grevillea robusta* | 19.8 | 23.8 | 24.6 | | |
| *Psidium guajava* | 27.0 | 27.0 | 23.8 | | |
| ***Psydrax odorata*** | 23.8 | 27.0 | 23.0 | | |
| ***Notelaea sandwicensis*** | 15.9 | 15.1 | 15.9 | | |
| ***Psychotria mariniana*** | 11.9 | 14.3 | 13.5 | | |
| ***Lepisorus thunbergianus*** | 3.2 | 14.3 | 12.7 | | |
| ***Coprosma foliosa*** | 14.3 | 17.5 | 11.9 | | |
| ***Acacia koa*** | 12.7 | 15.1 | 11.9 | | |
| *Syzygium cumini* | 17.5 | 9.5 | 11.1 | | |
| ***Diospyros sandwicensis*** | 11.1 | 11.1 | 10.3 | | |
| ***Antidesma platyphyllum*** | 13.5 | 14.3 | 9.5 | | |
| *Clidemia hirta* | 0.8 | 23.0 | 8.7 | | |
| ***Sapindus oahuensis*** | 8.7 | 6.3 | 8.7 | | |
| ***Diospyros hillebrandii*** | 8.7 | 7.1 | 7.9 | | |
| *Toona ciliata*** | 2.4 | 7.1 | 7.9 | | |
| *Aleurites moluccana* | 7.1 | 5.6 | 7.9 | | |
| ***Kadua affinis*** | 12.7 | 13.5 | 7.1 | | |
| ***Planchonella sandwicensis*** | 9.5 | 9.5 | 6.3 | | |
| *Phlebodium aureum* | 2.4 | 4.0 | 4.8 | | |
| ***Cibotium chamissoi*** | 0.0 | 4.0 | 4.0 | | |
| ***Hibiscus arnottianus* subsp. *arnottianus*** | 3.2 | 3.2 | 4.0 | | |
| ***Dicranopteris linearis*** | 0.8 | 3.2 | 4.0 | | |
| ***Xylosma hawaiiense*** | 5.6 | 4.8 | 3.2 | | |
| ***Myrsine lessertiana*** | 1.6 | 4.8 | 3.2 | | |
| ***Ceodes brunoniana*** | 0.0 | 2.4 | 3.2 | | |
| *Passiflora suberosa*** | 0.0 | 0.8 | 3.2 | | |
| ***Dodonaea viscosa*** | 1.6 | 3.2 | 2.4 | | |
| ***Elaeocarpus bifidus*** | 3.2 | 2.4 | 2.4 | | |
| *Lantana camara* | 1.6 | 1.6 | 2.4 | | |
| *Spathodea campanulata*** | 1.6 | 1.6 | 2.4 | | |

**Table 3** (continued).

| Taxon | 2011 | 2017 | 2022 | p | $X^2$ |
|---|---|---|---|---|---|
| Canopy | | | | | |
| *Buddleja asiatica* | 5.6 | 4.0 | 1.6 | | |
| ***Rockia sandwicensis*** | 3.2 | 2.4 | 1.6 | | |
| *Montanoa hibiscifolia*** | 1.6 | 2.4 | 1.6 | | |
| *Cordyline fruticosa* | 0.0 | 2.4 | 1.6 | | |
| ***Wikstroemia oahuensis* var. *oahuensis*** | 0.8 | 1.6 | 1.6 | | |
| ***Psychotria hathewayi*** | 0.0 | 1.6 | 1.6 | | |
| ***Euphorbia multiformis*** | 0.8 | 0.8 | 1.6 | | |
| ***Melicope oahuensis*** | 0.0 | 0.8 | 1.6 | | |
| *Schefflera actinophylla*** | 0.0 | 0.0 | 1.6 | | |
| ***Cocculus orbiculatus*** | 4.0 | 5.6 | 0.8 | | |
| *Passiflora edulis* | 1.6 | 4.0 | 0.8 | | |
| ***Freycinetia arborea*** | 1.6 | 2.4 | 0.8 | | |
| *Polystachya concreta* | 0.0 | 2.4 | 0.8 | | |
| ***Gynochthodes trimera*** | 2.4 | 1.6 | 0.8 | | |
| ***Bobea elatior*** | 1.6 | 0.8 | 0.8 | | |
| ***Santalum freycinetianum* var. *freycinetianum*** | 0.8 | 0.8 | 0.8 | | |
| ***Paratrophis pendulina*** | 1.6 | 0.0 | 0.8 | | |
| ***Korthalsella complanata*** | 0.8 | 0.0 | 0.8 | | |
| *Vanda tricolor* | 0.0 | 0.0 | 0.8 | | |
| ***Peperomia tetraphylla*** | 0.0 | 0.0 | 0.8 | | |
| ***Pittosporum glabrum*** | 0.0 | 0.0 | 0.8 | | |
| ***Viola chamissoniana* subsp. *tracheliifolia*** | 0.0 | 0.0 | 0.8 | | |
| *Melinis minutiflora* | 0.0 | 2.4 | 0.0 | | |
| ***Bidens torta*** | 3.2 | 1.6 | 0.0 | | |
| ***Pipturus albidus*** | 0.8 | 1.6 | 0.0 | | |
| *Nephrolepis brownii* | 0.0 | 1.6 | 0.0 | | |
| *Rubus rosifolius* | 0.0 | 1.6 | 0.0 | | |
| ***Nephrolepis exaltata* subsp. *hawaiiensis*** | 0.0 | 1.6 | 0.0 | | |
| ***Korthalsella cylindrica*** | 1.6 | 0.8 | 0.0 | | |
| ***Scaevola gaudichaudiana*** | 0.8 | 0.8 | 0.0 | | |
| *Megathyrsus maximus* | 0.0 | 0.8 | 0.0 | | |
| *Stachytarpheta australis* | 0.0 | 0.8 | 0.0 | | |
| *Triumfetta semitriloba* | 0.0 | 0.8 | 0.0 | | |
| ***Charpentiera tomentosa*** | 0.0 | 0.8 | 0.0 | | |
| ***Cyrtandra dentata*‡** | 0.0 | 0.8 | 0.0 | | |
| ***Dianella sandwicensis*** | 0.0 | 0.8 | 0.0 | | |
| ***Melicope kaalaensis*** | 0.0 | 0.8 | 0.0 | | |
| ***Psilotum nudum*** | 0.0 | 0.8 | 0.0 | | |
| ***Myrsine lanaiensis*** | 1.6 | 0.0 | 0.0 | | |
| ***Smilax melastomifolia*** | 0.8 | 0.0 | 0.0 | | |

[a]Exact significance

[b]Asymptotic significance

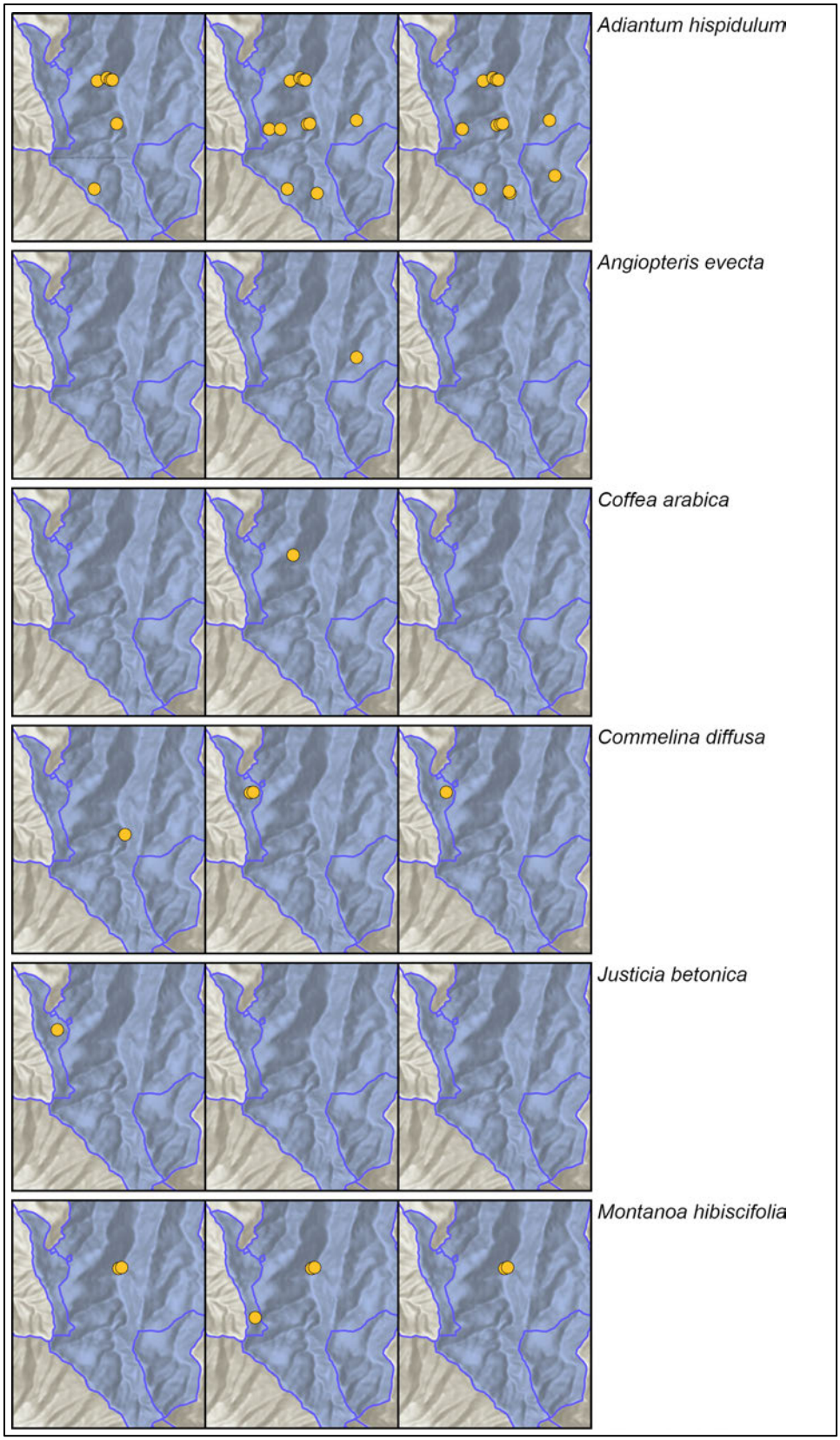


**Figure 7:** Locations of ICA and LDT target taxa in the understory and/or canopy found in monitoring plots at Kapuna Upper MU from 2011 to 2022.

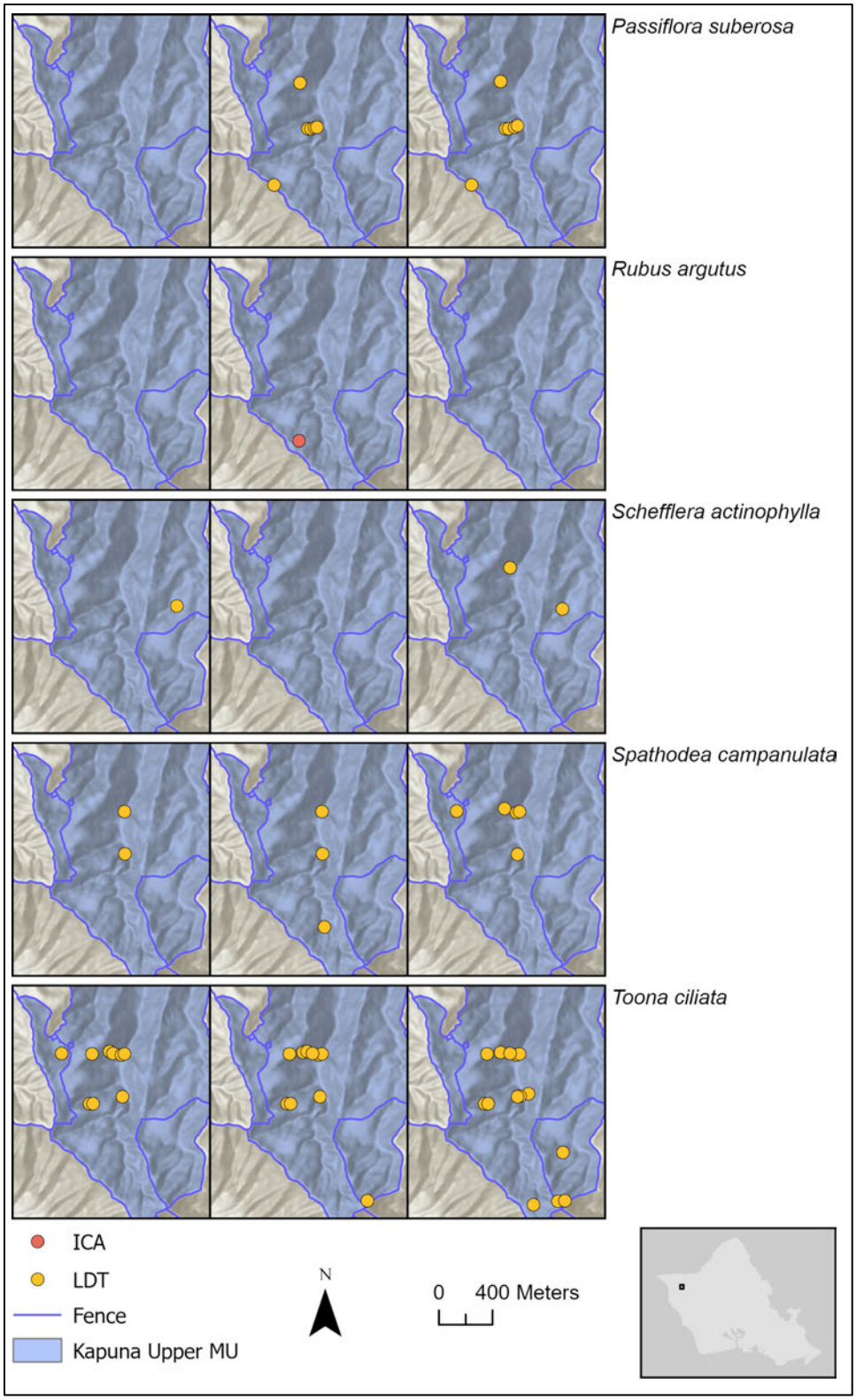


**Figure 7** (continued).

**Table 4:** Taxa no longer present, and newly recorded, in plots from 2022 Kapuna Upper MU monitoring in the understory and/or canopy. Native taxa are in boldface. Frequency (the percent of plots in which species are present) values are represented. **LDT target taxa. ‡Rare taxa.

| Species not recorded in 2022, but observed in plots previously | 2011 | 2017 | New species recorded in plots in 2022 | 2022 |
|---|---|---|---|---|
| *Andropogon virginicus* | 0.0 | 0.8 | ***Claoxylon sandwicensis*** | 0.8 |
| *Angiopteris evecta** | 0.0 | 0.8 | ***Cyperus polystachyos*** | 0.8 |
| ***Asplenium dielfalcatum‡*** | 1.6 | 0.0 | *Cyrtomium falcatum* | 0.8 |
| ***Asplenium kaulfussii*** | 0.0 | 0.8 | *Erechtites valerianifolia* | 0.8 |
| ***Asplenium nidus*** | 1.6 | 0.0 | ***Kadua acuminata*** | 0.8 |
| ***Charpentiera obovata*** | 0.8 | 0.8 | ***Microlepia speluncae*** | 0.8 |
| *Coffea arabica*** | 0.0 | 0.8 | ***Polyscias oahuensis*** | 0.8 |
| ***Diplazium sandwichianum*** | 0.8 | 0.0 | ***Vandenboschia cyrtotheca*** | 1.6 |
| ***Dryopteris glabra*** | 0.8 | 0.8 | | |
| ***Dryopteris sandwicensis*** | 0.0 | 0.8 | | |
| ***Elaphoglossum paleaceum*** | 0.8 | 0.0 | | |
| ***Gahnia beecheyi*** | 0.0 | 0.8 | | |
| *Justicia betonica** | 0.8 | 0.0 | | |
| ***Korthalsella cylindrica*** | 0.8 | 0.8 | | |
| ***Leptecophylla tameiameiae*** | 1.6 | 0.0 | | |
| ***Melicope kaalaensis*** | 0.0 | 0.8 | | |
| ***Melicope peduncularis*** | 0.8 | 0.0 | | |
| ***Myrsine lanaiensis*** | 0.8 | 0.0 | | |
| ***Pipturus albidus*** | 0.0 | 0.8 | | |
| ***Psilotum complanatum*** | 2.4 | 0.0 | | |
| *Rubus argutus** | 0.0 | 0.8 | | |
| ***Selaginella arbuscula*** | 0.0 | 0.8 | | |
| ***Smilax melastomifolia*** | 0.8 | 0.0 | | |
| *Youngia japonica* | 3.2 | 0.0 | | |

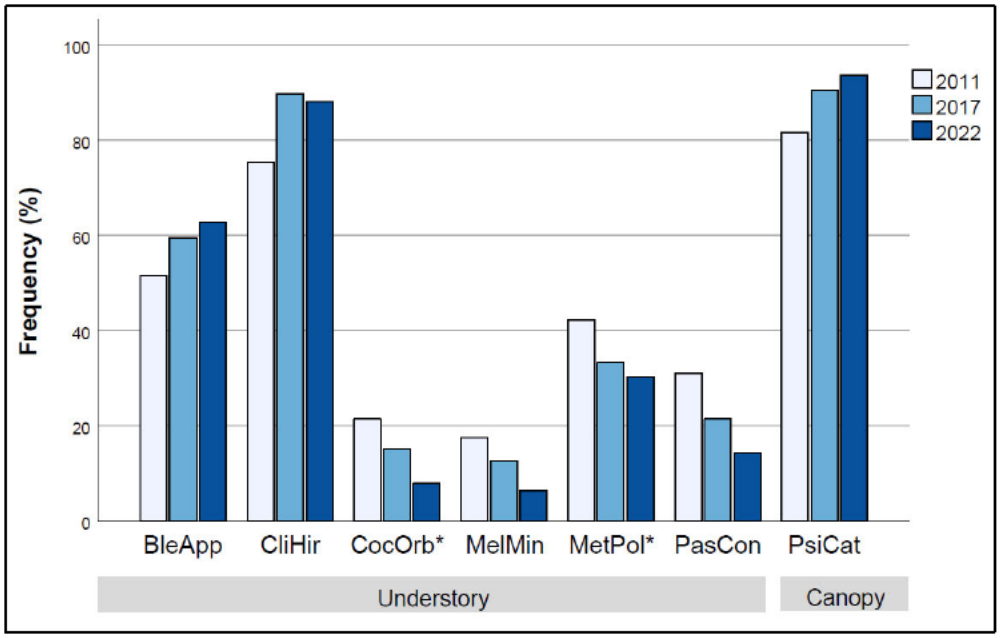


**Figure 8:** Species frequencies at Kapuna Upper MU between 2011 and 2022, among taxa with significant changes over time. Frequency values represent the proportion of plots in which species are present. *Native.

**Species cover**

Significant cover changes in the understory included declines for nine native and four non-native taxa. Significant cover changes in the canopy included increases for two non-native taxa (Table 5 and Figure 9). However, for many of those taxa, cover changes were small (primarily ≤ 10% absolute change within plots), and at times more a reflection of frequency change than expansive increased cover within plots. Most notable among the changes with respect to sizable differences in cover among native taxa was the decrease for *N. exaltata* subsp. *hawaiiensis* in the understory. Most notable changes in cover among non-native taxa were decreases in *P. cattleianum* in the understory, and increases for *P. cattleianum* and *S. terebinthifolius* in the canopy.

**Table 5:** Species with significant cover change between 2011 and 2022 at Kapuna Upper MU. Only taxa with > 20% frequency in either 2011 or 2022 were analyzed (Wilcoxon signed ranks test, asymptotic significance). Arrows indicate increase (↑) or decrease (↓) in cover. Native species are in boldface.

| Taxon | p* | Z |
|---|---|---|
| Understory | | |
| ***Alyxia stellata*** | 0.000↓ | -5.143 |
| ***Cocculus orbiculatus*** | 0.002↓ | -3.157 |
| ***Coprosma foliosa*** | 0.000↓ | -3.821 |
| ***Doodia kunthiana*** | 0.000↓ | -3.872 |
| ***Kadua affinis*** | 0.022↓ | -2.285 |
| *Lantana camara* | 0.020↓ | -2.321 |
| ***Metrosideros polymorpha*** | 0.000↓ | -4.693 |
| ***Microlepia strigosa*** | 0.010↓ | -2.576 |
| ***Nephrolepis exaltata* subsp. *hawaiiensis*** | 0.000↓ | -4.345 |
| *Paspalum conjugatum* | 0.000↓ | -4.928 |
| *Psidium cattleianum* | 0.000↓ | -3.821 |
| ***Psydrax odorata*** | 0.001↓ | -3.182 |
| *Rubus rosifolius* | 0.003↓ | -2.928 |
| Canopy | | |
| *Psidium cattleianum* | 0.000↑ | -6.719 |
| *Schinus terebinthifolius* | 0.003↑ | -2.997 |

*From Wilcoxon signed ranks test, asymptotic significance

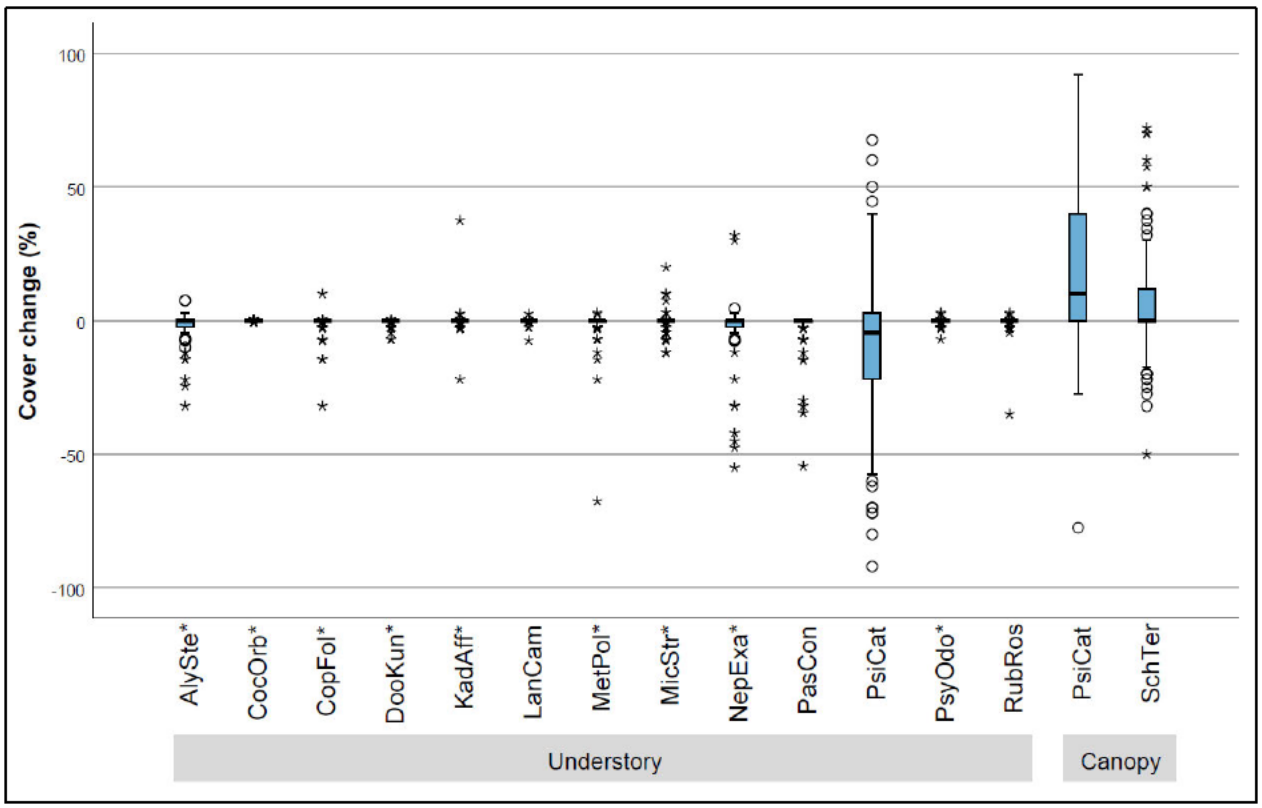


**Figure 9:** Boxplots of cover change between 2011 and 2022 for taxa with significant changes in percent cover at Kapuna Upper MU. Values > 0 represent increased cover in plots, while those < 0 represent decreased cover. Values equaling 0 represent no change. *Native.

## Canopy replacement

In 2022, 30 tree taxa (70% native) were found recruiting in the understory (Table 6). *Psidium cattleianum* was the most commonly recruiting tree species, occurring in nearly 90% of the plots, followed by *S. terebinthifolius*, recruiting in nearly one-quarter of the plots. Native tree taxa with no recruitment in the understory were relatively infrequent in the canopy (with frequencies < 4%). Three LDT weed taxa (*M. hibiscifolia*, *S. campanulata*, and *T. ciliata*) were found recruiting in plots, and recruitment frequencies for these taxa were low (< 6%). It should be noted that the age of saplings may vary greatly, from less than one year to decades, in accordance with differing species growth rates, complicating interpretations of presence/absence and change over time with respect to concerns over long term canopy replacement.

**Table 6:** Tree species recruitment frequencies at Kapuna Upper MU in 2017 and 2022 among understory taxa. Taxa are ordered by highest to lowest recruitment frequency 2022. P-values obtained from McNemar's tests (exact significance). Native species are in boldface. **LDT target taxa.

| Tree taxon | 2017 | 2022 | p |
|---|---|---|---|
| *Psidium cattleianum* | 77.8 | 88.9 | 0.625 |
| *Schinus terebinthifolius* | 23.8 | 24.6 | |
| ***Psydrax odorata*** | 12.7 | 8.7 | |
| *Psidium guajava* | 10.3 | 8.7 | |
| ***Acacia koa*** | 7.1 | 7.9 | |
| ***Diospyros hillebrandii*** | 6.3 | 7.9 | |
| ***Metrosideros polymorpha*** | 7.9 | 5.6 | |

**Table 6** (continued).

| Tree taxon | 2017 | 2022 | p |
|---|---|---|---|
| ***Psychotria mariniana*** | 7.9 | 5.6 | |
| *Toona ciliata*** | 1.6 | 5.6 | |
| ***Diospyros sandwicensis*** | 5.6 | 4.8 | |
| ***Ceodes brunoniana*** | 4.0 | 4.8 | |
| *Grevillea robusta* | 3.2 | 4.8 | |
| ***Kadua affinis*** | 14.3 | 4.0 | 0.500 |
| ***Antidesma platyphyllum*** | 7.1 | 3.2 | |
| ***Sapindus oahuensis*** | 5.6 | 2.4 | |
| ***Notelaea sandwicensis*** | 3.2 | 2.4 | |
| *Syzygium cumini* | 0.8 | 2.4 | |
| ***Planchonella sandwicensis*** | 4.0 | 1.6 | |
| ***Xylosma hawaiiense*** | 2.4 | 1.6 | |
| *Spathodea campanulata*** | 1.6 | 1.6 | |
| ***Melicope oahuensis*** | 0.8 | 1.6 | |
| ***Ceodes umbellifera*** | 0.0 | 1.6 | |
| *Montanoa hibiscifolia*** | 0.0 | 1.6 | |
| *Aleurites moluccana* | 2.4 | 0.8 | |
| ***Paratrophis pendulina*** | 0.8 | 0.8 | |
| ***Claoxylon sandwicensis*** | 0.0 | 0.8 | |
| ***Cyperus polystachyos*** | 0.0 | 0.8 | |
| ***Dodonaea viscosa*** | 0.0 | 0.8 | |
| ***Hibiscus arnottianus* subsp. *arnottianus*** | 0.0 | 0.8 | |
| ***Psychotria hathewayi*** | 0.0 | 0.8 | |
| *Coffea arabica*** | 0.8 | 0.0 | |
| ***Melicope kaalaensis*** | 0.8 | 0.0 | |
| ***Myrsine lessertiana*** | 0.8 | 0.0 | |
| ***Pipturus albidus*** | 0.8 | 0.0 | |
| ***Pittosporum glabrum*** | 0.8 | 0.0 | |
| ***Bobea elatior*** | 0.0 | 0.0 | |
| ***Elaeocarpus bifidus*** | 0.0 | 0.0 | |
| ***Rockia sandwicensis*** | 0.0 | 0.0 | |
| *Schefflera actinophylla*** | 0.0 | 0.0 | |

## VEGETATION MANAGEMENT

Weed control efforts between 2011 and 2022 at Kapuna Upper MU consisted of Weed Control Area (WCA) and ICA weeding (Figure 10). WCA efforts included general ecosystem weeding, grass sprays, and limited sweeps for control of targeted taxa. Only a limited areal extent of WCA control occurred, primarily in proximity to rare plant populations, as ANRPO weed management efforts at Kapuna Upper MU are primarily focused on rare plant stabilization. WCA weeding actions between 2011 and 2022 crossed through only 4% of plots. Additional weed control has also been conducted by the Department of Land and Natural Resources Division of Forestry and Wildlife (DOFAW) Native Ecosystems Protection and Management (NEPM) primarily within designated NEPM zones at Kapuna Upper MU. Given the limited amount of weeding that occurred by ANRPO, and the lack of complete GIS data for areas weeded by the NEPM program, analysis was not conducted to discern the impacts of general ecosystem weed control on the native and non-native understory and canopy.

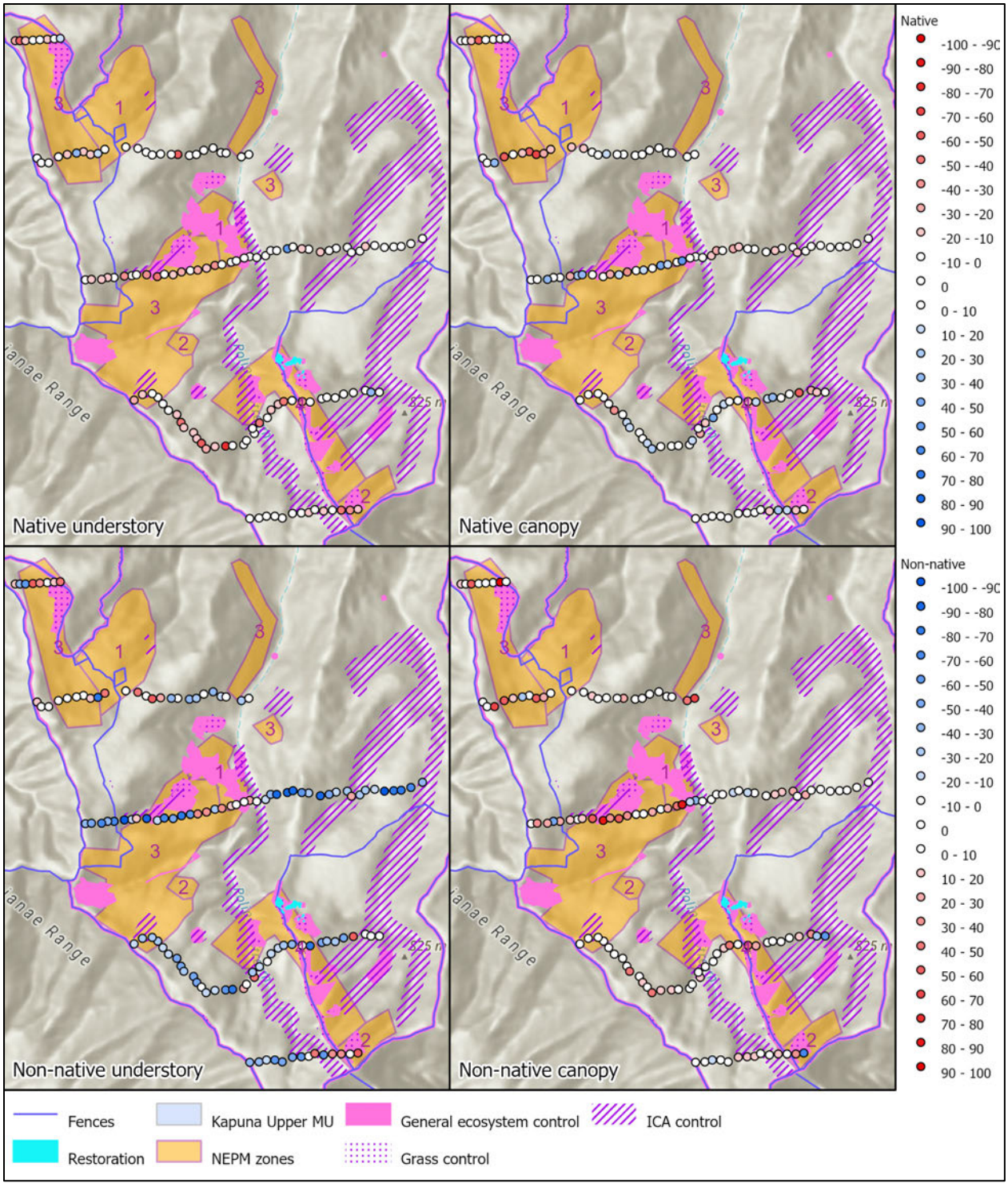


**Figure 10:** Locations of vegetation management efforts between 2011 and 2022 in relation to cover change in monitored plots. Cover change color gradients are inverted for native and non-native vegetation, such that blue indicates beneficial change, and red depicts worsening conditions. Cover change of 0 indicates there was no change in percent cover. Cover change of 0 ± 10% remains uncolored, as absolute cover change of ≤ 10% is not recognized. NEPM management zones are also shown, labeled according to class rankings of 1 (highest priority, most intact remaining native habitat) to 4.

Kapuna Upper MU has not been prioritized for native ecosystem restoration by ANRPO, as management efforts there are focused on rare plant stabilization, ecosystem weed control primarily in the vicinity of rare plants, and ungulate control. To date, only very small scale restoration efforts have been undertaken by ANRPO, beginning in 2018. This included common native outplanting (1,439 plants, 20 taxa) and seed sowing (one taxon). No plots fall within these restoration areas. NEPM also conducts limited restoration efforts within the NEPM zones in the MU (Figure 10). Given the lack of plots that fell within ANRPO restoration areas, and the lack of complete GIS data for the NEPM program restoration areas, analysis was not conducted to discern the influence of restoration efforts on cover change.

## SUMMARY AND DISCUSSION

At Kapuna Upper MU, management goals were only met for non-native understory cover. Goals remained unmet for native understory, native canopy, and canopy cover. However, the extent to which management objectives are applicable to this MU are debatable, as the habitat is heavily degraded, and vegetation management efforts are limited. There were a number of significant differences in vegetation data over the years, many of which were relatively small. The most noteworthy changes are included in Table 7 below.

**Table 7:** Summary of notable changes since 2011 at Kapuna Upper MU. Native taxa are in boldface. Arrows indicate increase (↑) or decrease (↓).

| Data category | Notable change |
|---|---|
| Categorical cover | ↑ Non-native canopy |
| | ↓ Non-native shrubs, non-native understory |
| Richness | ↓ Native understory |
| Frequency | ↑ Understory BleApp, CliHir<br>Canopy PsiCat |
| | ↓ Understory **CocOrb, MetPol,** MelMin, PasCon, SchTer |
| | New concerning taxon CyrFal |
| Species cover | ↑ Canopy PsiCat, SchTer |
| | ↓ Understory **NepExa,** PsiCat |

Aside from the decrease in non-native understory cover and frequency for a few taxa, most notable changes in vegetation at Kapuna Upper MU since 2011 include largely unfavorable ones. The steady progression of increased non-native canopy cover occurred in parallel with a steady downward progression in native understory diversity, reduced frequency and cover for some native understory taxa, and increased frequency of understory weed taxa. The decline in *C. orbiculatus*, though perhaps not the biggest player in native ecosystems, is nonetheless also unfortunate, particularly as it has also declined at ʻĒkahanui MU, Kahanahāiki MU, and Kaluaʻā and Waiʻeli MU (ANRPO 2019, 2021, and 2022b). This is the first time that management goals were met for non-native understory cover at Kapuna Upper MU. However, the decrease in non-native understory was influenced by the decrease in *P. cattleianum* cover in the understory (GLM: $p = 0.000$). *Psidium cattleianum* naturally thins out in the understory as trees grow into the canopy (Figure 11). Non-native canopy cover, already prevalent in 2011, now predominates, as the two most prevalent canopy taxa for the MU, *P. cattleianum* and *S. terebinthifolius*, continued to expand in cover, and had the most prevalent recruitment by far in comparison with other species. As observed in other MU, non-native canopy cover change significantly influenced native understory cover change, as native understory cover declined with increased non-native canopy cover (GLM: $p = 0.037$). Of additional concern is *T. ciliata*, which had low frequencies in the understory and canopy, but is likely to become a serious invader in the coming years if it is not controlled. As weed cover increases, native cover is expected to decline. Because limited vegetation management occurs at the MU, overall conditions are likely to deteriorate.

**Figure 11:** Photographs of a monitored plot at Kapuna Upper showing *Psidium cattleianum* thinning out in the understory as trees grew into the canopy between 2011 (left) and 2022 (right).

## RECOMMENDATIONS

Based on the results of vegetation monitoring, a number of recommendations were made with the goal of making progress towards meeting management goals, to be discussed and coordinated with the NEPM program:

- Continued planned general ecosystem weeding at rare taxa and restoration sites, grass control, target taxa, and ICA control.
- Add *C. falcatum* and *A. aspera* to the limited distribution target taxa weed list for Kapuna Upper MU.
- Discuss priorities and strategies for general ecosystem weeding outside of rare taxa and restoration sites.
- Discuss priorities and strategies for continued or expanded native ecosystem restoration efforts.
- Consider the utility of and programmatic capacity for conducting vegetation monitoring at ANRPO's areas of focused vegetation management to assess the impact of efforts in those areas, taking into account monitoring needs in higher priority MUs.
- Meet with NEPM to discuss monitoring results and determine how to address these results together.
- Discuss with NEPM the need for additional releases of *Tectococcus ovatus* for biocontrol of *P. cattleianum*, and find out where NEPM has done releases so ANRPO can avoid damaging any of those sites.
- Discuss the possibility of efforts to manage low cover invasive species via grants from the Readiness and Environmental Protection Integration (REPI) program, which funds management

work in areas abutting military lands to improve environmental conditions on military land. DOFAW will be receiving REPI funds, and discussions with NEPM would be worthwhile regarding ANRPO ideas about where these efforts could focus and the potential for partnership. This may include sweeps either throughout the MU or in specific areas for low frequency non-native trees *Grevillea robusta*, *M. hibiscifolia*, *Psidium guajava*, *S. actinophylla*, *S. campanulata*, *Syzygium cumini*, and *T. ciliata*.

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ARMY NATURAL RESOURCES PROGRAM ON O‘AHU
MONITORING PROGRAM

# ‘ŌHIKILOLO UPPER MANAGEMENT UNIT VEGETATION MONITORING, 2022

## INTRODUCTION

The Army Natural Resources Program on O‘ahu (ANRPO) conducted vegetation monitoring at ‘Ōhikilolo Upper Management Unit (MU) in 2022 in association with Implementation Plan (IP) requirements for long term monitoring of vegetation composition and change over time (ANRPO 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. The MU is subdivided into priority areas: Priority Area 1 includes portions of the MU which receive the majority of management actions; Priority Area 2 (the remainder of the MU) receives relatively less management. ‘Ōhikilolo Upper MU vegetation monitoring occurs and on a six-year interval for both Priority Areas 1 and 2 (hereafter collectively referred to as the MU), and on a three-year interval for Priority Area 1. Monitoring took place twice for the MU (in 2010 and 2016) and four times previously for Priority Area 1 (in 2010, 2013, 2016, and 2019) (ANRPO 2010, 2013, 2017, 2020). Previous monitoring for the MU indicated that cover goals were met for only the non-native canopy. Previous monitoring for Priority Area 1 indicated that cover goals were only met for the non-native understory and non-native canopy. The ‘Ōhikilolo ridge line fence was completed, and ungulates removed in 2001.

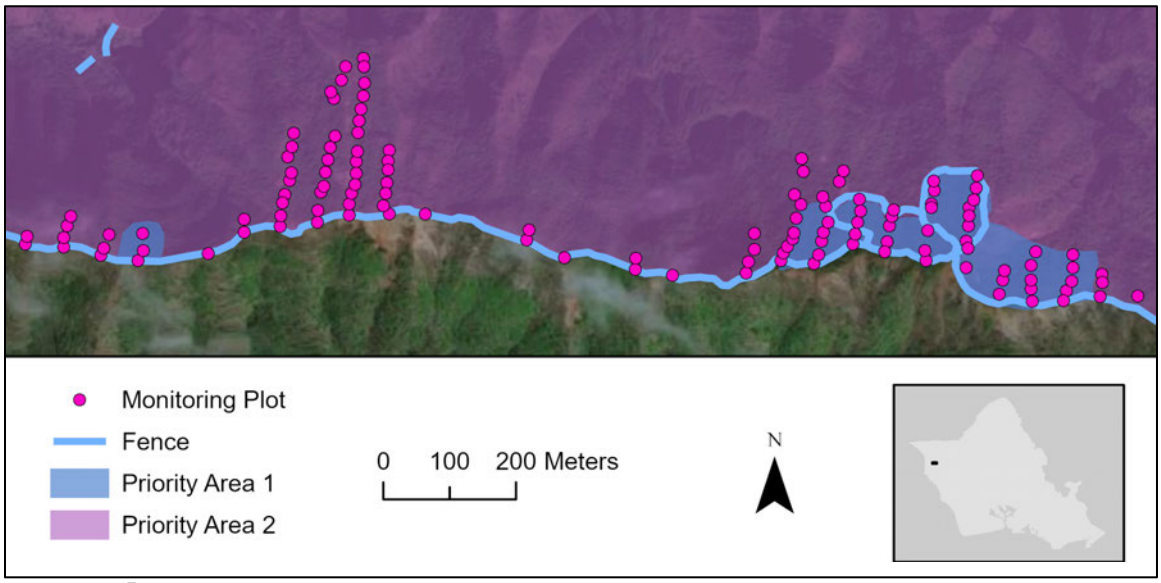


**Figure 1:** ‘Ōhikilolo Upper MU vegetation monitoring plot locations.

## METHODS

In May and June of 2022, 130 permanent plots (50 in Priority Area 1, and 80 in Priority Area 2) in 27 transects were monitored at ‘Ōhikilolo Upper MU (Figure 2). Plots measuring 5 x 10 m were generally located every 20 m along transects. Transects were located in accessible areas (as the majority of the MU is too steep to access), spaced approximately 50 m apart. Understory (0 – 2 m above ground level (AGL), including low branches from canopy species) and canopy (> 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, and overall summary percent cover of non-native and native vegetation in the understory and canopy, were also documented. Percent cover categories were recorded in 10% intervals between 10 and 100%, and on finer intervals (0-1%, 1-5%, and 5-10%) between 0 and 10% cover. Understory recruitment (defined as seedlings or saplings < 2 m AGL) data for tree species was recorded beginning in 2013, though observations in 2013 and 2016 were incomplete. Monitoring results were compared with data from prior years. Based on IP recommendations, p-values < 0.05 were considered significant, and only absolute cover changes ≥ 10% were recognized. Additional methodology information is detailed in Monitoring Protocol 1.2.1 (ANRPO 2008). All analyses were performed in IBM SPSS Statistics Version 29. These included Friedman's tests with Bonferroni adjusted post-hoc pairwise comparisons and Wilcoxon signed ranks tests for cover and richness data; McNemar's tests for frequency data; and generalized linear modeling (GLM) for the influence of vegetation management efforts on vegetation cover change. The best explanatory models were selected for inclusion in the results, and were chosen based on Akaike Information Criterion scores. Model predictors included all weeded areas, general ecosystem weeded areas, target taxon weeded areas, restoration areas, Priority Areas, and interactions between predictors. For species frequency analyses, comparisons were made between 2010 and 2022 for taxa with ≥ 10% difference in frequency. For species cover analyses, comparisons were made between 2010 and 2022 for taxa with frequencies ≥ 20% in either 2010 or 2022. Median numbers reported do not always correspond to MU-wide trends as reflected by statistical results (median values may remain unchanged despite statistically significant result, or vice versa). P-values represent the likelihood (scaled from 0 to 1) that there is no difference in compared data, where higher values indicate a greater likelihood of no difference occurring.

**Figure 2**: ANRPO staff members Krista Lizardi (left, at *Pritcharia kaalae* MMR-A wild site) and Melissa Valdez (right, in the "Makai Forest Patch" below *Dracaena forbesii* MMR-Y reintroduction site) collecting field data at vegetation monitoring plots at ʻŌhikilolo Upper MU.

## RESULTS: MU

### Understory and canopy cover categories

Management goals of having < 50% non-native understory and canopy and > 50% native understory and canopy cover were met for the non-native understory (40% median cover) and canopy (15%), but were not met for the native understory (35%) and canopy (15%) (Table 1). There were significant changes in percent cover of vegetation since 2010 that met the 10% standard for recognized change in cover. These included cover declines for native grasses/sedges, total native understory, non-native shrubs, and total non-native understory; and increases for native canopy as well as total canopy (Figure 3). In 2022, locations of low to high native and non-native percent cover were somewhat patchily distributed, though higher native cover was mostly concentrated in Priority Area 1, and higher non-native cover was mostly in Priority Area 2 (Figure 4).

**Table 1:** Median percent cover over time for native and non-native vegetation categories in the canopy and understory at ʻŌhikilolo Upper MU. Categories specifically addressed in management goals are shaded in blue. Statistically significant values for categories that meet the 10% standard for recognized change in cover are in boldface. Arrows indicate increase (↑), decrease (↓), or inconsistent trend (↕) in cover.

| | 2010 | 2016 | 2022 | p* | $X^2$ | Years that differed significantly | p (post-hoc)** | Management goal currently met? |
|---|---|---|---|---|---|---|---|---|
| ***Understory*** | | | | | | | | |
| Native shrubs | 7.5 | 7.5 | 11.3 | 0.010↑ | 9.173 | 2016-2022 | 0.025↑ | |
| Native ferns | 7.5 | 3.0 | 3.0 | 0.000↓ | 23.414 | 2010-2016<br>2010-2022 | 0.001↓<br>0.004↓ | |
| Native grass/sedges | 15.0 | 3.0 | 3.0 | **0.000**↓ | 41.104 | 2010-2016<br>2010-2022 | **0.000**↓<br>**0.000**↓ | |
| Total native understory | 45.0 | 35.0 | 35.0 | **0.000**↓ | 18.540 | 2010-2016 | **0.000**↓ | No |
| Non-native shrubs | 25.0 | 15.0 | 7.5 | **0.000**↓ | 39.059 | 2010-2016<br>2010-2022<br>2016-2022 | **0.010**↓<br>**0.000**↓<br>0.039↓ | |
| Non-native ferns | 7.5 | 7.5 | 7.5 | 0.000↓ | 14.098 | 2010-2022 | 0.003↓ | |
| Non-native grass/sedges | 15.0 | 11.3 | 7.5 | 0.000↓ | 29.830 | 2010-2022<br>2016-2022 | 0.001↓<br>0.000↓ | |
| Total non-native understory | 65.0 | 65.0 | 40.0 | **0.000**↓ | 60.376 | 2010-2022<br>2016-2022 | **0.000**↓<br>**0.000**↓ | Yes |
| ***Canopy*** | | | | | | | | |
| Native canopy | 3.0 | 7.5 | 15.0 | **0.000**↑ | 71.438 | 2010-2016<br>2010-2022<br>2016-2022 | 0.003↑<br>**0.000**↑<br>**0.000**↑ | No |
| Non-native canopy | 15.0 | 15.0 | 15.0 | 0.001↑ | 13.054 | 2010-2022 | 0.009↑ | Yes |
| Total canopy | 45.0 | 55.0 | 65.0 | **0.000**↑ | 58.851 | 2010-2016<br>2010-2022<br>2016-2022 | **0.001**↑<br>**0.000**↑<br>**0.007**↑ | |

*From Friedman's test, asymptotic significance

**From post-hoc pairwise comparisons with Bonferroni adjustment

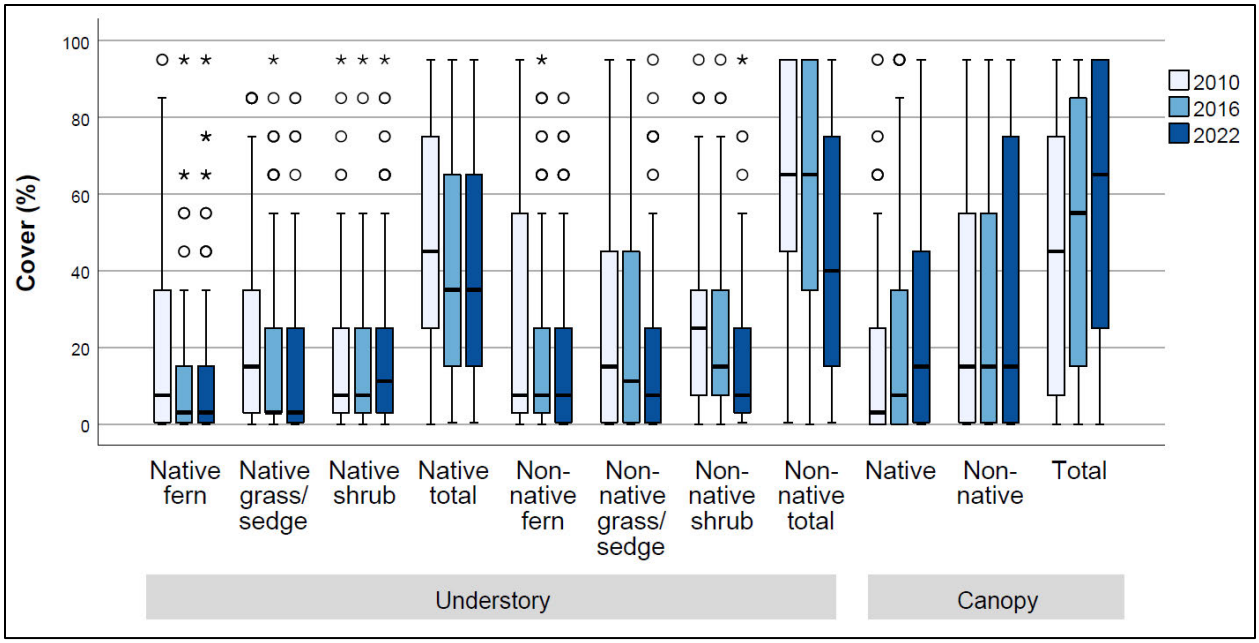


**Figure 3:** Boxplots for native and non-native cover over time in ʻŌhikilolo Upper MU. *Note: Boxplots illustrate the range of values of variables. The boxes depict the middle 50% of the data values, and the horizontal line inside the box represents the median value. The range in values for all remaining data are indicated by the vertical lines, circles (outliers), and stars (extreme outliers).*

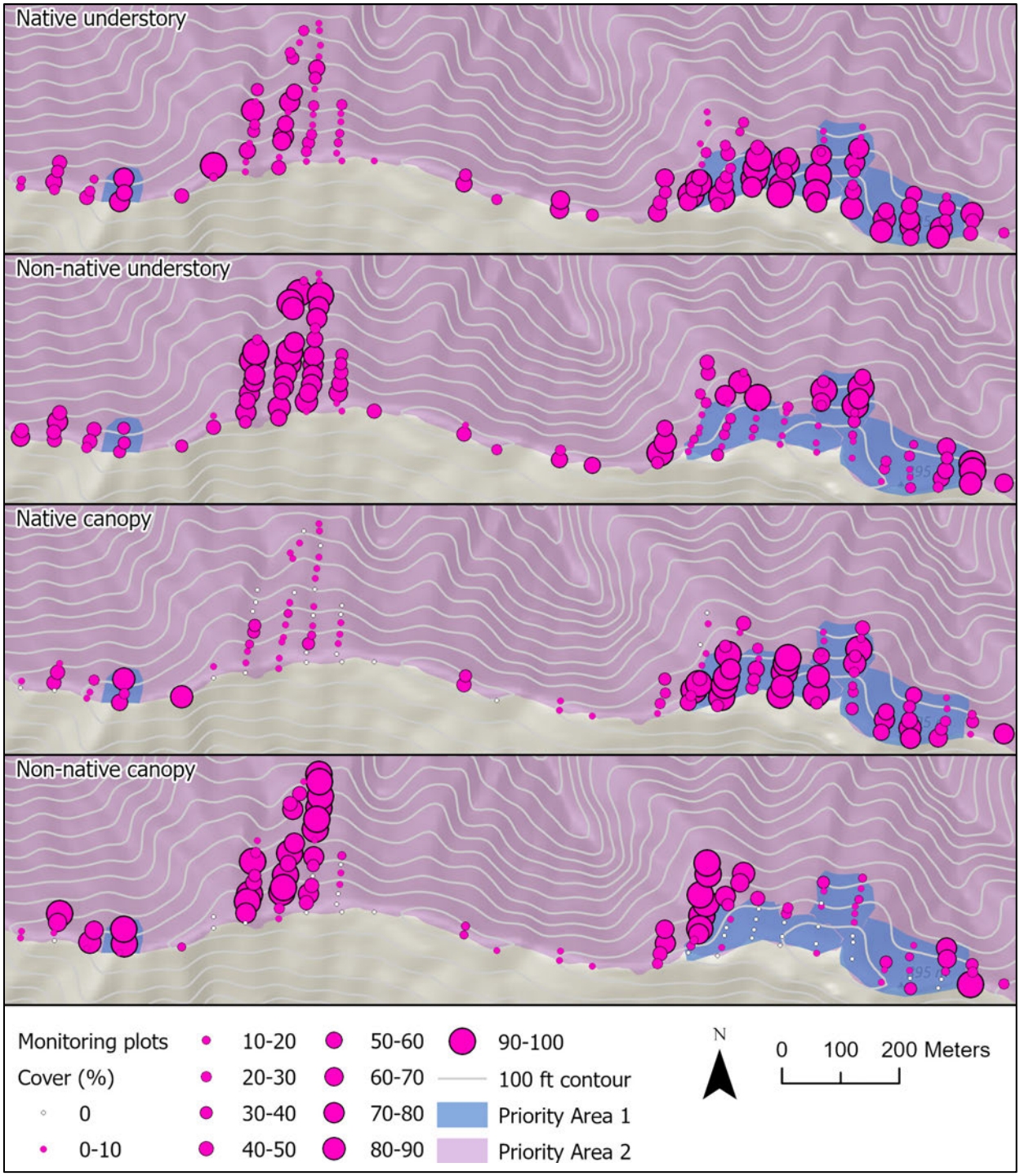


**Figure 4:** Locations of low to high percent cover of native and non-native understory and canopy vegetation among monitored plots at ʻŌhikilolo Upper MU in 2022. Larger circles denote higher percent cover, while smaller circles represent lower cover.

## Species richness

During monitoring in 2022, 149 species were recorded in the understory (50% native taxa), and 42 were identified in the canopy (79% native). The native and non-native understory had similarly high levels of diversity both within plots and for the MU overall, while the native canopy diversity was twice as high within plots and more than three times higher for the MU overall compared with the non-native canopy (Table 2). Species richness within plots differed significantly between the years monitored, with a decrease for the non-native understory, inconsistent trends for the native understory, and increases for both the native and non-native canopy (Table 2 and Figure 5). Most notable was the steady increase in plot richness for native canopy. Notable differences among years in overall diversity for the MU included increases for the non-native understory and canopy. Locations of high and low species richness were somewhat patchily distributed across the MU, though native understory and canopy richness tended to be higher in Priority Area 1 and non-native canopy richness tended to be higher in Priority Area 2 (Figure 6).

**Table 2:** ʻŌhikilolo Upper MU understory and canopy species richness over time. Median species richness per plot during vegetation monitoring is shown by year, with the total number of species recorded among all plots in parenthesis. Statistically significant values are in boldface. Arrows indicate increase (↑), decrease (↓), or inconsistent trend (↕) in cover.

| | 2010 | 2016 | 2022 | p* | $X^2$ | Years that differed significantly | p (post-hoc)** |
|---|---|---|---|---|---|---|---|
| Native understory | 9 (77) | 10 (77) | 9 (75) | **0.026**↕ | 7.302 | 2010-2016 | 0.043↑ |
| Non-native understory | 10 (62) | 10 (70) | 9 (74) | **0.000**↓ | 22.590 | 2010-2022 | 0.025↓ |
| | | | | | | 2016-2022 | 0.000↓ |
| Native canopy | 1 (31) | 2 (30) | 2 (33) | **0.000**↑ | 76.784 | 2010-2016 | 0.017↑ |
| | | | | | | 2010-2022 | 0.000↑ |
| | | | | | | 2016-2022 | 0.000↑ |
| Non-native canopy | 1 (5) | 1 (9) | 1 (9) | **0.012**↑ | 8.779 | NA | NA |

*From Friedman's test for differences across all years, asymptotic significance
**From post-hoc pairwise comparisons with Bonferroni adjustment

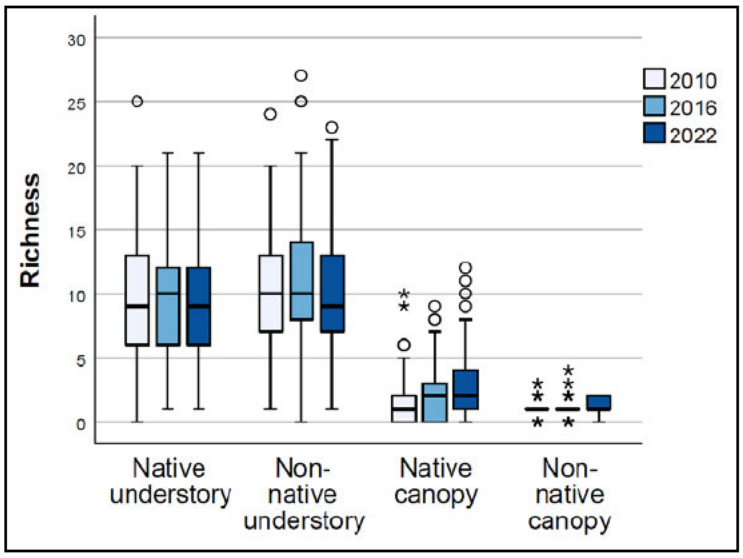


**Figure 5:** Boxplots for native and non-native richness in the understory and canopy over time in ʻŌhikilolo Upper MU.

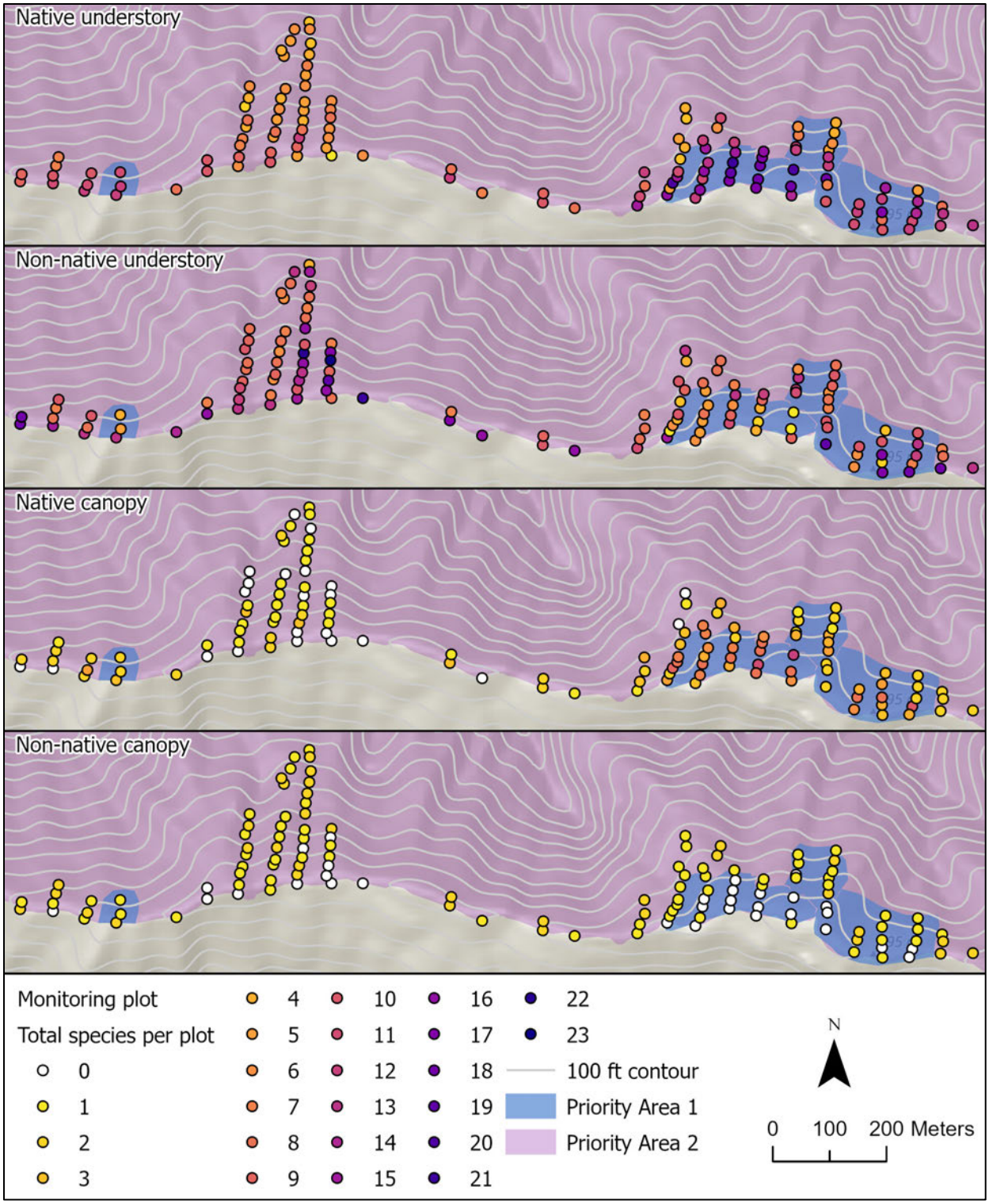


**Figure 6:** Locations of low to high species richness among plots in the native and non-native understory and canopy in ʻŌhikilolo Upper MU in 2022. Color gradients of yellow to purple indicate low to high values, respectively, of the number of species occurring in plots (i.e., yellow indicates low diversity, while purple indicates relatively higher diversity).

**Species frequency**

Non-native species that occurred most frequently in plots (present in more than half the plots) in the understory in 2022 included *Blechnum appendiculatum*, *Melinis minutiflora*, *Schinus terebinthifolius*, *Stachytarpheta australis*, *Ageratina adenophora*, and *Ageratina riparia*, while *S. terebinthifolius* also occurred most commonly in the canopy (Table 3). The most frequent native understory species (in more than half the plots) included *Carex meyenii*, *Metrosideros polymorpha*, and *Dodonaea viscosa*, while *M. polymorpha* and *Metrosideros tremuloides* occurred most commonly (in over a quarter of the plots) in the canopy. Six rare taxa (outplanted and or wild populations) were recorded in plots during monitoring in 2022, including *Dracaena forbesii*, *Dubautia herbstobatae*, *Melicope cornuta* var. *decurrens*, *Melicope makahae*, *Neraudia angulata*, and *Pritchardia kaalae*. Numerous target weed taxa (taxa of special concern for weed management, ranging from incipient species to those with widespread distributions) (ANRPO 2022a) for ʻŌhikilolo Upper MU were present in monitored plots in 2022 in either the understory or canopy, though most were those with widespread distributions. One Incipient Control Area (ICA) target, *Ehrharta stipoides*, was present in three plots (in existing ICAs) (Figure 7). Nine limited distribution target taxa were recorded in plots, including *Araucaria columnaris*, *Clidemia hirta*, *Grevillea robusta*, *Passiflora suberosa*, *Psidium cattleianum*, *Psidium guajava*, *Spathodea campanulata*, *Syzygium cumini*, and *Toona ciliata*, most of which were in relatively low frequencies (< 5%) with the exception of *G. robusta* and *C. hirta*, which were in 30% and 15% (respectively) of all plots collectively in the understory and/or canopy. At least one limited distribution target taxon was present in 64% of the plots. The most notable change since 2010 included the continual spread of *C. hirta* (absent in 2010, but widespread in/near Priority Area 1 by 2022).

Thirteen species (38% native) were newly recorded in plots in 2022, and 29 taxa (59% native) were recorded in prior years but not observed in plots in 2022 (Table 4). Aside from the direct or indirect result of management actions and/or natural processes (weeding, outplanting, dispersal, death, etc.), the presence or absence of species may be due in part to human error such as misidentification, observer bias regarding plot boundaries or amount of time spent searching, or accidental non-recording. Misidentifications are possible and/or suspected for some (e.g., some grass and fern species). Most species that were not recorded in 2022 were uncommon in prior years (frequencies < 4%), as were those newly documented in 2022 (all with frequencies < 4%).

Analysis of frequency change was limited to taxa with at least ten percent change between 2010 and 2022. Among native taxa, there were significant frequency decreases for *Bidens torta* and *Doryopteris decipiens* in the understory; and increases for *Coprosma foliosa*, *Lepisorus thunbergianus*, *M. polymorpha*, and *Wikstroemia oahuensis* var. *oahuensis* in the understory, and for *C. foliosa*, *D. viscosa*, *M. polymorpha*, *M. tremuloides*, and *Myrsine lessertiana* in the canopy (Figure 8). Among non-native taxa, there were significant frequency increases for *C. hirta*, *Polystachya concreta*, and *Rubus rosifolius* in the understory, and decreases for *Centaurium erythraea*, *Festuca bromoides*, *Kalanchoe pinnata*, *Lythrum maritimum*, *Setaria parviflora*, and *Sporobolus indicus* in the understory.

**Table 3:** Species frequencies over time in the understory and canopy in ʻŌhikilolo Upper MU. Taxa are ordered by highest to lowest frequency in 2022. Only taxa with at least 10% change in frequency between 2010 and 2022 were analyzed. Statistical comparisons are between 2010 and 2022 data. P-values obtained from McNemar's tests. Arrows indicate increase (↑) or decrease (↓) in frequency for statistically significant results. Native species are in boldface. ‡Rare taxa. Target weed taxa: *ICA, **LDT.

| Taxon | 2010 | 2016 | 2022 | p | $X^2$ |
|---|---|---|---|---|---|
| Understory | | | | | |
| *Blechnum appendiculatum* | 85.4 | 90.0 | 89.2 | | |
| ***Carex meyenii*** | 86.9 | 87.7 | 86.9 | | |
| *Melinis minutiflora* | 81.5 | 81.5 | 81.5 | | |
| *Schinus terebinthifolius* | 86.2 | 80.0 | 79.2 | | |
| *Stachytarpheta australis* | 77.7 | 77.7 | 76.9 | | |
| *Ageratina adenophora* | 73.8 | 73.8 | 68.5 | | |
| *Ageratina riparia* | 75.4 | 64.6 | 68.5 | | |
| ***Metrosideros polymorpha*** | 47.7 | 47.7 | 59.2 | **0.007↑**[a] | 7.259 |
| ***Dodonaea viscosa*** | 55.4 | 59.2 | 54.6 | | |
| ***Pteridium aquilinum*** | 51.5 | 50.0 | 47.7 | | |
| ***Metrosideros tremuloides*** | 41.5 | 49.2 | 43.1 | | |
| ***Myrsine lessertiana*** | 33.1 | 43.1 | 40.0 | | |
| ***Cocculus orbiculatus*** | 44.6 | 39.2 | 40.0 | | |
| ***Doodia kunthiana*** | 38.5 | 37.7 | 36.2 | | |
| *Erigeron karvinskianus* | 38.5 | 35.4 | 34.6 | | |
| ***Carex wahuensis*** | 37.7 | 28.5 | 33.1 | | |
| ***Alyxia stellata*** | 27.7 | 26.2 | 33.1 | | |
| ***Odontosoria chinensis*** | 35.4 | 33.8 | 32.3 | | |
| ***Coprosma foliosa*** | 20.0 | 30.0 | 30.8 | **0.003↑**[b] | NA |
| *Conyza bonariensis* | 24.6 | 39.2 | 26.9 | | |
| *Andropogon virginicus* | 21.5 | 30.0 | 26.2 | | |
| *Rubus rosifolius* | 13.1 | 26.2 | 25.4 | **0.000↑**[b] | NA |
| ***Wikstroemia oahuensis* var. *oahuensis*** | 13.1 | 19.2 | 25.4 | **0.000↑**[b] | NA |
| *Lantana camara* | 26.9 | 26.9 | 23.8 | | |
| *Setaria parviflora* | 39.2 | 30.8 | 23.1 | **0.001↓**[a] | 11.429 |
| *Melinis repens* | 24.6 | 18.5 | 21.5 | | |
| ***Nephrolepis exaltata* subsp. *hawaiiensis*** | 16.2 | 18.5 | 21.5 | | |
| *Lythrum maritimum* | 32.3 | 36.2 | 20.8 | **0.004↓**[b] | NA |
| *Grevillea robusta*** | 25.4 | 27.7 | 20.8 | | |
| ***Eragrostis grandis*** | 23.1 | 20.0 | 20.0 | | |
| ***Freycinetia arborea*** | 19.2 | 17.7 | 20.0 | | |
| *Youngia japonica* | 10.8 | 29.2 | 19.2 | | |
| ***Dryopteris sandwicensis*** | 20.8 | 23.1 | 19.2 | | |
| *Kalanchoe pinnata* | 46.2 | 44.6 | 17.7 | **0.000↓**[a] | 33.231 |
| ***Lepisorus thunbergianus*** | 7.7 | 23.8 | 17.7 | **0.015↑**[b] | NA |
| ***Microlepia strigosa*** | 23.1 | 17.7 | 17.7 | | |
| *Christella parasitica* | 15.4 | 16.2 | 16.9 | | |
| ***Psychotria mariniana*** | 6.2 | 10.0 | 14.6 | | |
| *Clidemia hirta*** | 0.0 | 6.2 | 14.6 | **0.000↑**[b] | b |
| ***Antidesma platyphyllum*** | 8.5 | 9.2 | 13.8 | | |
| *Oxalis corniculata* | 16.2 | 21.5 | 13.1 | | |
| ***Cibotium chamissoi*** | 10.8 | 11.5 | 13.1 | | |
| ***Osteomeles anthyllidifolia*** | 6.9 | 10.0 | 13.1 | | |
| ***Selaginella arbuscula*** | 20.8 | 23.1 | 12.3 | | |
| ***Psilotum nudum*** | 11.5 | 12.3 | 12.3 | | |
| *Centaurium erythraea* | 26.2 | 29.2 | 11.5 | **0.001↓**[a] | 12.000 |
| *Gamochaeta purpurea* | 20.0 | 23.8 | 11.5 | | |
| *Cheilanthes viridis* | 10.8 | 16.2 | 11.5 | | |

**Table 3** (continued).

| Taxon | 2010 | 2016 | 2022 | p | $X^2$ |
|---|---|---|---|---|---|
| Understory | | | | | |
| *Adiantum hispidulum* | 4.6 | 6.9 | 11.5 | | |
| ***Acacia koa*** | 5.4 | 3.8 | 11.5 | | |
| ***Psychotria hathewayi*** | 10.8 | 8.5 | 10.8 | | |
| ***Kadua affinis*** | 2.3 | 4.6 | 10.8 | | |
| ***Bidens torta*** | 26.2 | 23.8 | 10.0 | **0.000↓**[a] | 13.793 |
| ***Lachnagrostis filiformis*** | 13.1 | 17.7 | 10.0 | | |
| *Linum trigynum* | 13.1 | 10.0 | 10.0 | | |
| ***Pritchardia kaalae*‡** | 9.2 | 10.0 | 10.0 | | |
| *Polystachya concreta* | 0.0 | 1.5 | 10.0 | **0.000↑**[b] | NA |
| ***Elaeocarpus bifidus*** | 10.8 | 10.8 | 9.2 | | |
| *Bidens alba* | 0.0 | 0.8 | 9.2 | | |
| *Lysimachia arvensis* | 13.8 | 13.1 | 8.5 | | |
| ***Elaphoglossum paleaceum*** | 7.7 | 8.5 | 8.5 | | |
| *Triumfetta semitriloba* | 6.2 | 5.4 | 8.5 | | |
| ***Viola chamissoniana* subsp. *tracheliifolia*** | 9.2 | 9.2 | 7.7 | | |
| ***Dryopteris fusco-atra*** | 5.4 | 9.2 | 7.7 | | |
| *Pityrogramma austroamericana* | 4.6 | 9.2 | 7.7 | | |
| ***Lysimachia hillebrandii*** | 4.6 | 5.4 | 7.7 | | |
| *Chamaecrista nictitans* | 9.2 | 9.2 | 6.9 | | |
| *Paspalum conjugatum* | 6.2 | 7.7 | 6.9 | | |
| ***Dianella sandwicensis*** | 2.3 | 3.8 | 6.9 | | |
| ***Pipturus albidus*** | 2.3 | 3.1 | 6.9 | | |
| *Sporobolus indicus* | 17.7 | 11.5 | 6.2 | **0.000↓**[b] | NA |
| *Emilia sonchifolia* | 6.9 | 10.8 | 6.2 | | |
| ***Doryopteris decipiens*** | 18.5 | 10.0 | 6.2 | **0.000↓**[b] | NA |
| *Emilia fosbergii* | 4.6 | 4.6 | 6.2 | | |
| *Festuca bromoides* | 21.5 | 16.9 | 4.6 | **0.000↓**[a] | 16.962 |
| *Cyperus brevifolius* | 0.0 | 16.2 | 4.6 | | |
| ***Athyrium microphyllum*** | 6.9 | 5.4 | 4.6 | | |
| *Verbena litoralis* | 8.5 | 4.6 | 4.6 | | |
| *Psidium cattleianum*** | 5.4 | 4.6 | 4.6 | | |
| *Cuphea carthagenesis* | 0.8 | 3.8 | 4.6 | | |
| *Oplismenus hirtellus* | 1.5 | 3.1 | 4.6 | | |
| ***Dryopteris glabra*** | 9.2 | 8.5 | 3.8 | | |
| ***Deparia prolifera*** | 3.8 | 4.6 | 3.8 | | |
| ***Paspalum scrobiculatum*** | 1.5 | 3.8 | 3.8 | | |
| ***Scaevola gaudichaudiana*** | 3.8 | 1.5 | 3.8 | | |
| *Phaius tankervilleae* | 0.0 | 0.8 | 3.8 | | |
| ***Luzula hawaiiensis*** | 10.0 | 10.0 | 3.1 | | |
| ***Kadua acuminata*** | 3.1 | 5.4 | 3.1 | | |
| ***Melicope oahuensis*** | 5.4 | 4.6 | 3.1 | | |
| *Ageratum conyzoides* | 3.1 | 4.6 | 3.1 | | |
| ***Gahnia beecheyi*** | 4.6 | 3.8 | 3.1 | | |
| *Psidium guajava*** | 3.8 | 3.8 | 3.1 | | |
| ***Diospyros sandwicensis*** | 2.3 | 3.1 | 3.1 | | |
| *Christella dentata* | 1.5 | 2.3 | 3.1 | | |
| ***Dicranopteris linearis*** | 1.5 | 2.3 | 3.1 | | |
| ***Sadleria cyatheoides*** | 0.0 | 1.5 | 3.1 | | |
| *Polygala paniculata* | 0.0 | 0.0 | 3.1 | | |
| *Toona ciliata*** | 1.5 | 3.1 | 2.3 | | |
| *Bidens pilosa* | 2.3 | 2.3 | 2.3 | | |
| ***Nestegis sandwicensis*** | 1.5 | 2.3 | 2.3 | | |
| ***Dracaena forbesii*‡** | 0.8 | 1.5 | 2.3 | | |

**Table 3** (continued).

| Taxon | 2010 | 2016 | 2022 | p | $X^2$ |
|---|---|---|---|---|---|
| Understory | | | | | |
| *Ehrharta stipoides** | 0.0 | 0.8 | 2.3 | | |
| *Pluchea carolinensis* | 0.8 | 0.0 | 2.3 | | |
| *Digitaria violascens* | 0.0 | 0.0 | 2.3 | | |
| *Spathoglottis plicata* | 0.0 | 0.0 | 2.3 | | |
| *Sonchus oleraceus* | 5.4 | 2.3 | 1.5 | | |
| *Buddleja asiatica* | 2.3 | 2.3 | 1.5 | | |
| *Passiflora suberosa*** | 0.8 | 2.3 | 1.5 | | |
| *Adiantum raddianum* | 3.1 | 1.5 | 1.5 | | |
| ***Melicope makahae*‡** | 1.5 | 1.5 | 1.5 | | |
| ***Menisciopsis cyatheoides*** | 1.5 | 1.5 | 1.5 | | |
| *Salvia coccinea* | 1.5 | 1.5 | 1.5 | | |
| ***Peperomia membranacea*** | 1.5 | 0.8 | 1.5 | | |
| ***Syzygium sandwicense*** | 1.5 | 0.8 | 1.5 | | |
| ***Tectaria gaudichaudii*** | 1.5 | 0.8 | 1.5 | | |
| ***Panicum nephelophilum*** | 0.8 | 0.8 | 1.5 | | |
| *Phlebodium aureum* | 0.8 | 0.8 | 1.5 | | |
| *Arundina graminifolia* | 0.0 | 0.8 | 1.5 | | |
| *Deparia petersenii* | 0.0 | 0.0 | 1.5 | | |
| ***Myoporum sandwicense*** | 0.0 | 0.0 | 1.5 | | |
| ***Neraudia angulata*‡** | 0.0 | 0.0 | 1.5 | | |
| *Plantago lanceolata* | 0.0 | 0.0 | 1.5 | | |
| *Sacciolepis indica* | 0.0 | 0.0 | 1.5 | | |
| *Castilleja arvensis* | 0.0 | 4.6 | 0.8 | | |
| ***Cyrtandra waianaeensis*** | 0.8 | 2.3 | 0.8 | | |
| *Cyperus mindorensis* | 6.2 | 1.5 | 0.8 | | |
| ***Polypodium pellucidum* var. *pellucidum*** | 3.1 | 1.5 | 0.8 | | |
| *Araucaria columnaris*** | 1.5 | 1.5 | 0.8 | | |
| ***Planchonella sandwicensis*** | 1.5 | 1.5 | 0.8 | | |
| ***Korthalsella complanata*** | 0.8 | 1.5 | 0.8 | | |
| ***Melicope cornuta* var. *decurrens*‡** | 0.8 | 1.5 | 0.8 | | |
| ***Pteris cretica*** | 0.0 | 1.5 | 0.8 | | |
| ***Asplenium caudatum*** | 3.8 | 0.8 | 0.8 | | |
| ***Waltheria indica*** | 2.3 | 0.8 | 0.8 | | |
| ***Dubautia herbstobatae*‡** | 1.5 | 0.8 | 0.8 | | |
| ***Ctenitis latifrons*** | 0.8 | 0.8 | 0.8 | | |
| *Indigofera spicata* | 0.8 | 0.8 | 0.8 | | |
| *Leucaena leucocephala* | 0.8 | 0.8 | 0.8 | | |
| *Mesosphaerum pectinatum* | 0.8 | 0.8 | 0.8 | | |
| *Desmodium sandwicense* | 0.0 | 0.8 | 0.8 | | |
| ***Melicope kaalaensis*** | 0.0 | 0.8 | 0.8 | | |
| *Opuntia ficus-indica* | 0.0 | 0.8 | 0.8 | | |
| *Spathodea campanulata*** | 0.0 | 0.8 | 0.8 | | |
| ***Xylosma hawaiiense*** | 0.0 | 0.8 | 0.8 | | |
| *Syzygium cumini*** | 0.8 | 0.0 | 0.8 | | |
| *Crassocephalum crepidioides* | 0.0 | 0.0 | 0.8 | | |
| *Cynodon dactylon* | 0.0 | 0.0 | 0.8 | | |
| ***Korthalsella cylindrica*** | 0.0 | 0.0 | 0.8 | | |
| ***Vaccinium dentatum*** | 0.0 | 0.0 | 0.8 | | |
| ***Coleus australis*** | 1.5 | 1.5 | 0.0 | | |
| *Axonopus fissifolius* | 0.8 | 1.5 | 0.0 | | |
| *Epidendrum x obrienianum* | 0.0 | 1.5 | 0.0 | | |
| ***Artemisia australis*** | 1.5 | 0.8 | 0.0 | | |
| ***Boehmeria grandis*** | 0.0 | 0.8 | 0.0 | | |

**Table 3** (continued).

| Taxon | 2010 | 2016 | 2022 | p | $X^2$ |
|---|---|---|---|---|---|
| Understory | | | | | |
| *Cinnamomum burmannii*** | 0.0 | 0.8 | 0.0 | | |
| *Erechtites valerianifolia* | 0.0 | 0.8 | 0.0 | | |
| ***Euphorbia celastroides* var. *amplectens*** | 0.0 | 0.8 | 0.0 | | |
| ***Kadua parvula*‡** | 0.0 | 0.8 | 0.0 | | |
| ***Santalum ellipticum*** | 0.0 | 0.8 | 0.0 | | |
| *Sida rhombifolia* | 0.0 | 0.8 | 0.0 | | |
| *Stapelia gigantea* | 0.0 | 0.8 | 0.0 | | |
| ***Adenophorus tenellus*** | 3.8 | 0.0 | 0.0 | | |
| *Cerastium fontanum* | 1.5 | 0.0 | 0.0 | | |
| ***Bobea elatior*** | 0.8 | 0.0 | 0.0 | | |
| *Cordyline fruticosa* | 0.8 | 0.0 | 0.0 | | |
| ***Elaphoglossum alatum*** | 0.8 | 0.0 | 0.0 | | |
| ***Euphorbia multiformis*** | 0.8 | 0.0 | 0.0 | | |
| ***Myrsine lanaiensis*** | 0.8 | 0.0 | 0.0 | | |
| ***Pteris irregularis*** | 0.8 | 0.0 | 0.0 | | |
| *Rhynchospora* sp. | 0.8 | 0.0 | 0.0 | | |
| ***Sadleria pallida*** | 0.8 | 0.0 | 0.0 | | |
| *Salvia occidentalis* | 0.8 | 0.0 | 0.0 | | |
| *Santalum album* | 0.8 | 0.0 | 0.0 | | |
| *Trianthema portulacastrum* | 0.8 | 0.0 | 0.0 | | |
| ***Zanthoxylum dipetalum* var. *dipetalum*‡** | 0.8 | 0.0 | 0.0 | | |
| Canopy | | | | | |
| *Schinus terebinthifolius* | 73.1 | 72.3 | 71.5 | | |
| ***Metrosideros polymorpha*** | 33.8 | 33.8 | 43.8 | **0.007↑[b]** | NA |
| ***Metrosideros tremuloides*** | 30.0 | 38.5 | 40.8 | **0.030↑[a]** | 4.694 |
| ***Dodonaea viscosa*** | 11.5 | 23.1 | 24.6 | **0.000↑[b]** | NA |
| ***Myrsine lessertiana*** | 7.7 | 12.3 | 23.8 | **0.000↑[a]** | 14.815 |
| *Grevillea robusta*** | 16.2 | 22.3 | 21.5 | | |
| ***Coprosma foliosa*** | 6.2 | 8.5 | 19.2 | **0.000↑[b]** | NA |
| ***Freycinetia arborea*** | 11.5 | 13.1 | 16.9 | | |
| ***Alyxia stellata*** | 5.4 | 10.0 | 13.8 | | |
| ***Acacia koa*** | 4.6 | 6.9 | 13.1 | | |
| ***Cibotium chamissoi*** | 6.2 | 8.5 | 11.5 | | |
| ***Elaeocarpus bifidus*** | 9.2 | 8.5 | 10.8 | | |
| ***Lepisorus thunbergianus*** | 0.8 | 7.7 | 9.2 | | |
| ***Psychotria hathewayi*** | 5.4 | 6.2 | 7.7 | | |
| ***Psychotria mariniana*** | 5.4 | 4.6 | 7.7 | | |
| ***Antidesma platyphyllum*** | 5.4 | 3.8 | 3.8 | | |
| ***Nestegis sandwicensis*** | 1.5 | 3.1 | 3.1 | | |
| ***Pritchardia kaalae*‡** | 1.5 | 2.3 | 3.1 | | |
| ***Pipturus albidus*** | 1.5 | 0.8 | 3.1 | | |
| ***Diospyros sandwicensis*** | 1.5 | 2.3 | 2.3 | | |
| ***Melicope oahuensis*** | 1.5 | 1.5 | 2.3 | | |
| ***Cocculus orbiculatus*** | 0.0 | 0.0 | 2.3 | | |
| ***Planchonella sandwicensis*** | 0.8 | 1.5 | 1.5 | | |
| ***Kadua affinis*** | 0.0 | 1.5 | 1.5 | | |
| *Psidium cattleianum*** | 0.0 | 1.5 | 1.5 | | |
| *Stachytarpheta australis* | 0.0 | 0.8 | 1.5 | | |
| ***Wikstroemia oahuensis* var. *oahuensis*** | 0.0 | 0.8 | 1.5 | | |
| *Ageratina adenophora* | 0.8 | 0.0 | 1.5 | | |
| ***Lysimachia hillebrandii*** | 0.0 | 0.0 | 1.5 | | |
| *Polystachya concreta* | 0.0 | 0.0 | 1.5 | | |
| ***Syzygium sandwicense*** | 2.3 | 1.5 | 0.8 | | |

**Table 3** (continued).

| Taxon | 2010 | 2016 | 2022 | p | $X^2$ |
|---|---|---|---|---|---|
| Canopy | | | | | |
| *Lantana camara* | 0.0 | 1.5 | 0.8 | | |
| ***Sadleria cyatheoides*** | 0.0 | 1.5 | 0.8 | | |
| ***Cyrtandra waianaeensis*** | 0.8 | 0.8 | 0.8 | | |
| ***Korthalsella complanata*** | 0.8 | 0.8 | 0.8 | | |
| *Toona ciliata*** | 0.8 | 0.8 | 0.8 | | |
| *Rubus rosifolius* | 0.0 | 0.8 | 0.8 | | |
| ***Dicranopteris linearis*** | 0.0 | 0.0 | 0.8 | | |
| ***Dracaena forbesii‡*** | 0.0 | 0.0 | 0.8 | | |
| ***Kadua acuminata*** | 0.0 | 0.0 | 0.8 | | |
| ***Melicope kaalaensis*** | 0.0 | 0.0 | 0.8 | | |
| ***Urera glabra*** | 0.0 | 0.0 | 0.8 | | |
| *Melinis minutiflora* | 0.0 | 2.3 | 0.0 | | |
| ***Bobea elatior*** | 0.8 | 0.8 | 0.0 | | |
| ***Boehmeria grandis*** | 0.0 | 0.8 | 0.0 | | |
| ***Santalum ellipticum*** | 0.0 | 0.8 | 0.0 | | |
| ***Scaevola gaudichaudiana*** | 0.0 | 0.8 | 0.0 | | |
| *Triumfetta semitriloba* | 0.0 | 0.8 | 0.0 | | |
| ***Bidens torta*** | 1.5 | 0.0 | 0.0 | | |
| *Buddleja asiatica* | 0.8 | 0.0 | 0.0 | | |
| ***Melicope makahae‡*** | 0.8 | 0.0 | 0.0 | | |
| ***Myrsine lanaiensis*** | 0.8 | 0.0 | 0.0 | | |
| ***Perrottetia sandwicensis*** | 0.8 | 0.0 | 0.0 | | |
| ***Psydrax odorata*** | 0.8 | 0.0 | 0.0 | | |
| ***Smilax melastomifolia*** | 0.8 | 0.0 | 0.0 | | |
| ***Xylosma hawaiiense*** | 0.8 | 0.0 | 0.0 | | |

[a]Asymptotic significance
[b]Exact significance

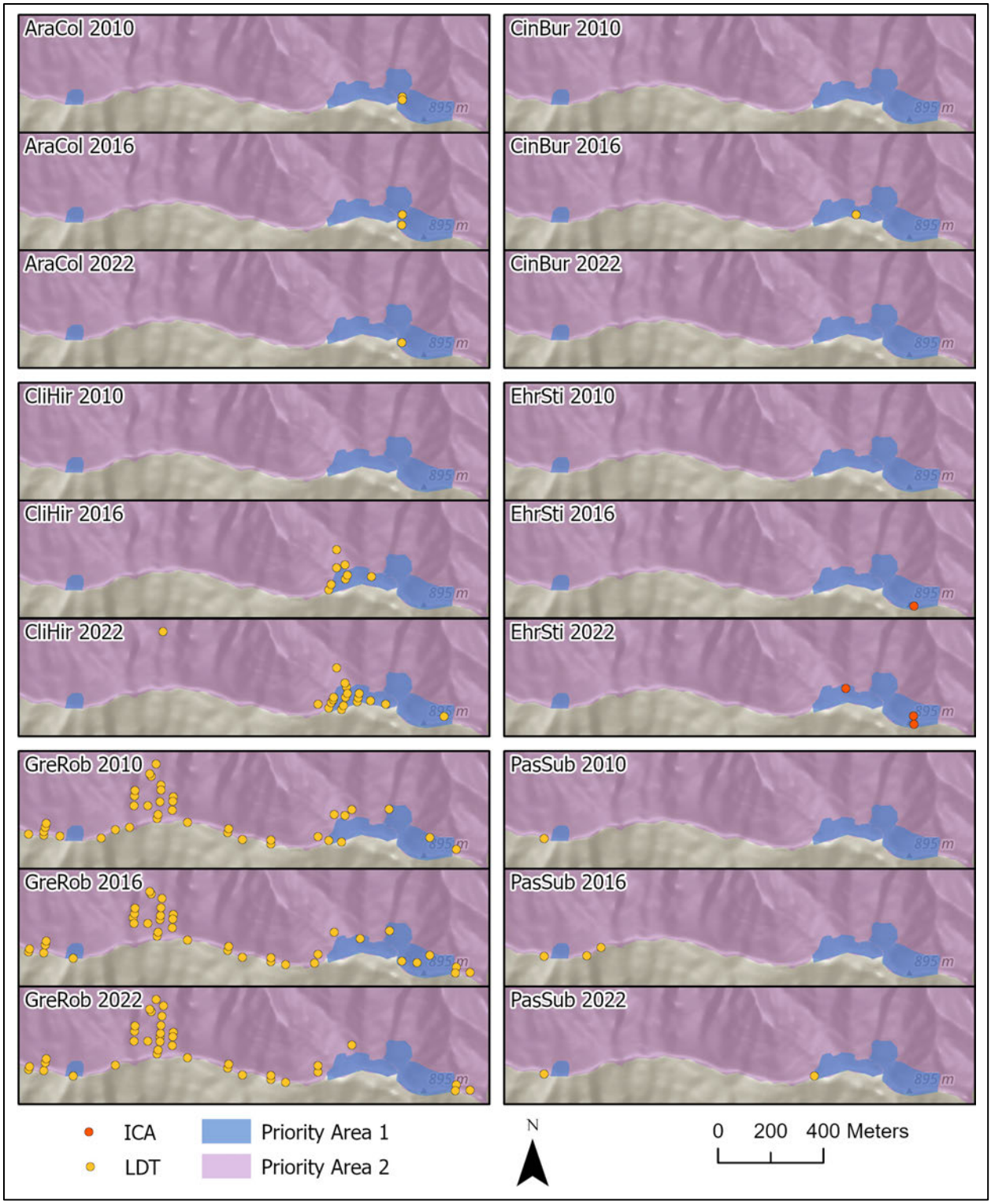


**Figure 7:** Locations of ICA and LDT target taxa in the understory and/or canopy found in monitoring plots at ʻŌhikilolo Upper MU from 2010 to 2022.

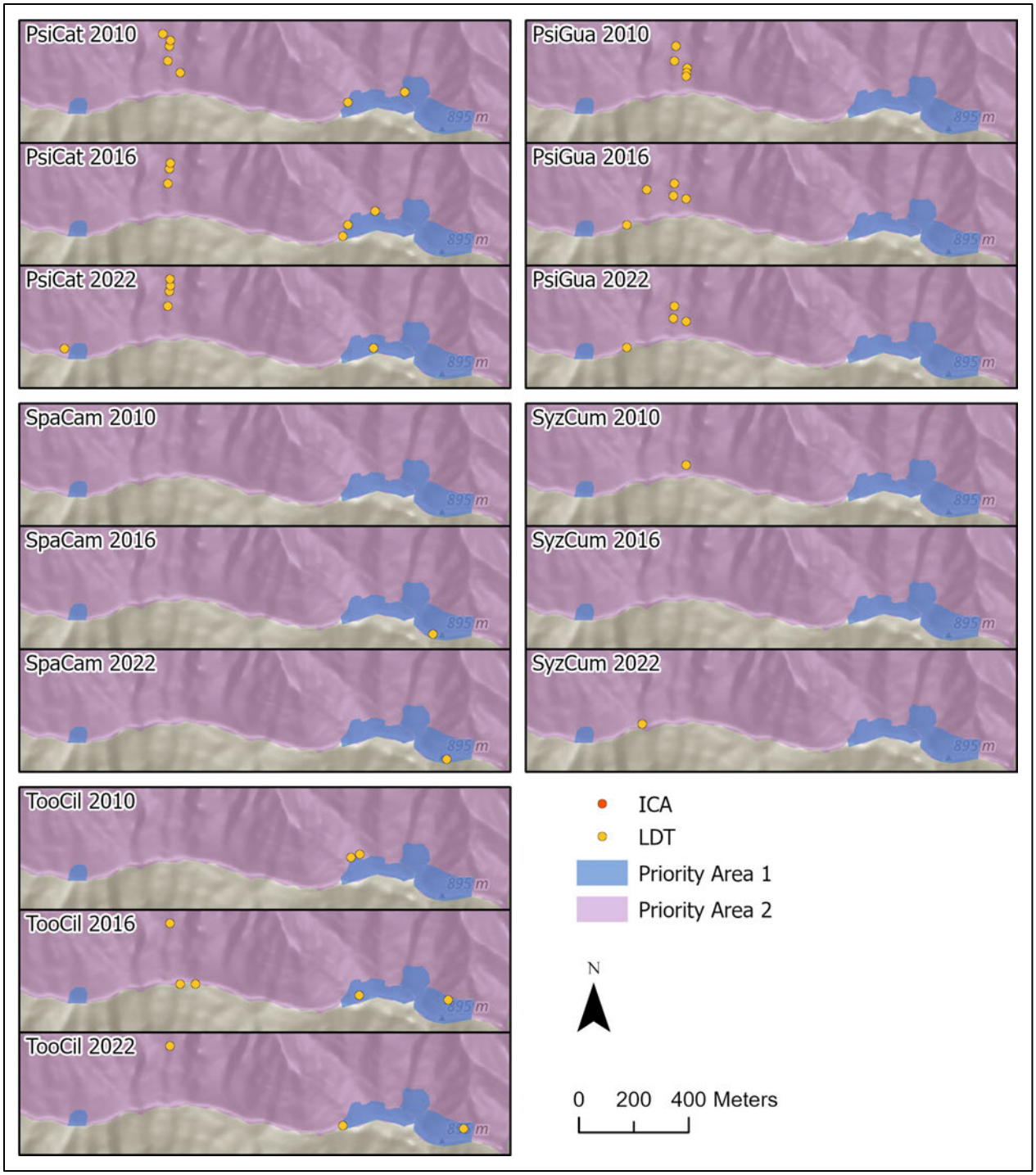


**Figure 7** (continued).

**Table 4:** Taxa no longer present, and newly recorded, in plots from 2022 ʻŌhikilolo Upper MU monitoring in the understory and/or canopy. Native taxa are in boldface. Frequency (the percent of plots in which species are present) values are represented. **LDT target taxa. ‡Rare taxa.

| Species not recorded in 2022, but observed in plots previously | 2010 | 2016 | New species recorded in plots in 2022 | 2022 |
|---|---|---|---|---|
| ***Adenophorus tenellus*** | 3.8 | 0.0 | *Crassocephalum crepidioides* | 0.8 |
| ***Artemisia australis*** | 1.5 | 0.8 | *Cynodon dactylon* | 0.8 |
| *Axonopus fissifolius* | 0.8 | 1.5 | *Deparia petersenii* | 1.5 |
| ***Bobea elatior*** | 0.8 | 0.8 | *Digitaria violascens* | 2.3 |
| ***Boehmeria grandis*** | 0.0 | 0.8 | ***Korthalsella cylindrica*** | 0.8 |
| *Cerastium fontanum* | 1.5 | 0.0 | ***Myoporum sandwicense*** | 1.5 |
| *Cinnamomum burmannii*** | 0.0 | 0.8 | ***Neraudia angulata‡*** | 1.5 |
| ***Coleus australis*** | 1.5 | 1.5 | *Plantago lanceolata* | 1.5 |
| *Cordyline fruticosa* | 0.8 | 0.0 | *Polygala paniculata* | 3.1 |
| ***Elaphoglossum alatum*** | 0.8 | 0.0 | *Sacciolepis indica* | 1.5 |
| *Epidendrum x obrienianum* | 0.0 | 1.5 | *Spathoglottis plicata* | 2.3 |
| *Erechtites valerianifolia* | 0.0 | 0.8 | ***Touchardia oahuensis*** | 0.8 |
| ***Euphorbia celastroides* var. *amplectens*** | 0.0 | 0.8 | ***Vaccinium dentatum*** | 0.8 |
| ***Euphorbia multiformis*** | 0.8 | 0.0 | | |
| ***Kadua parvula‡*** | 0.0 | 0.8 | | |
| ***Myrsine lanaiensis*** | 0.8 | 0.0 | | |
| ***Perrottetia sandwicensis*** | 0.8 | 0.0 | | |
| ***Psydrax odorata*** | 0.8 | 0.0 | | |
| ***Pteris irregularis*** | 0.8 | 0.0 | | |
| *Rhynchospora* sp. | 0.8 | 0.0 | | |
| ***Sadleria pallida*** | 0.8 | 0.0 | | |
| *Salvia occidentalis* | 0.8 | 0.0 | | |
| *Santalum album* | 0.8 | 0.0 | | |
| ***Santalum ellipticum*** | 0.0 | 0.8 | | |
| *Sida rhombifolia* | 0.0 | 0.8 | | |
| ***Smilax melastomifolia*** | 0.8 | 0.0 | | |
| *Stapelia gigantea* | 0.0 | 0.8 | | |
| *Trianthema portulacastrum* | 0.8 | 0.0 | | |
| ***Zanthoxylum dipetalum* var. *dipetalum‡*** | 0.8 | 0.0 | | |

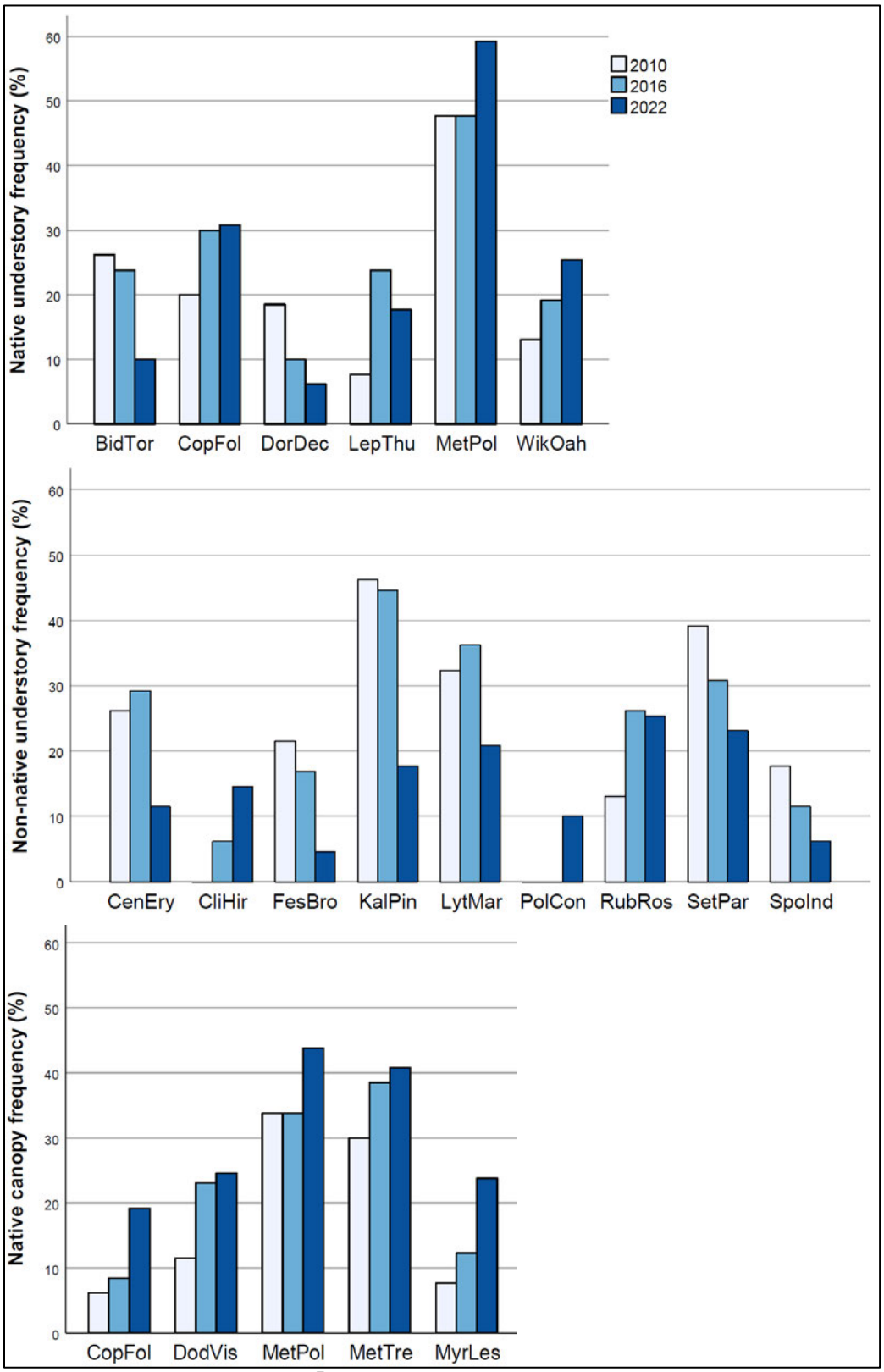


**Figure 8:** Species frequencies at ʻŌhikilolo Upper MU between 2010 and 2022, among taxa with significant changes over time. Frequency values represent the proportion of plots in which species are present.

**Species cover**

Significant cover changes in the understory included declines for six native and twelve non-native taxa, and increases for one native and one non-native taxa. Significant cover changes in the canopy included increases for four native and one non-native taxa (Table 5 and Figure 9). However, for many of those taxa, cover changes were small (primarily ≤ 10% absolute change within plots), and at times more a reflection of frequency change than expansive increased cover within plots. Most notable among the changes with respect to sizable differences in cover among native taxa were the decreases for *C. meyenii* and *Pteridium aquilinum* in the understory, and increases for *Freycinetia arborea* (heavily browsed prior to ungulate exclusion) in the understory as well as *D. viscosa*, *M. polymorpha*, *M. tremuloides*, and *M. lessertiana* in the canopy. Most notable changes in cover among non-native taxa were decreases in *A. adenophora*, *A. riparia*, *B. appendiculatum*, and *S. terebinthifolius* in the understory, and increases for *S. terebinthifolius* in the canopy.

**Table 5:** Species with significant cover change between 2010 and 2022 at ʻŌhikilolo Upper MU. Only taxa with > 20% frequency in either 2010 or 2022 were analyzed (Wilcoxon signed ranks test, asymptotic significance). Arrows indicate increase (↑) or decrease (↓) in cover. Native species are in boldface.

| Understory taxa | p* | Z | Canopy taxa | p* | Z |
|---|---|---|---|---|---|
| *Ageratina adenophora* | 0.000↓ | -3.955 | ***Dodonaea viscosa*** | 0.001↑ | -3.481 |
| *Ageratina riparia* | 0.000↓ | -6.089 | ***Metrosideros polymorpha*** | 0.000↑ | -4.897 |
| *Andropogon virginicus* | 0.037↑ | -2.087 | ***Metrosideros tremuloides*** | 0.012↑ | -2.509 |
| ***Bidens torta*** | 0.000↓ | -3.884 | ***Myrsine lessertiana*** | 0.000↑ | -3.634 |
| *Blechnum appendiculatum* | 0.000↓ | -4.757 | *Schinus terebinthifolius* | 0.011↑ | -2.539 |
| ***Carex meyenii*** | 0.000↓ | -5.502 | | | |
| ***Carex wahuensis*** | 0.044↓ | -2.011 | | | |
| *Centaurium erythraea* | 0.000↓ | -3.652 | | | |
| ***Dodonaea viscosa*** | 0.012↓ | -2.498 | | | |
| ***Dryopteris sandwicensis*** | 0.000↓ | -3.582 | | | |
| *Festuca bromoides* | 0.000↓ | -4.184 | | | |
| ***Freycinetia arborea*** | 0.01↑ | -2.572 | | | |
| *Gamochaeta purpurea* | 0.016↓ | -2.400 | | | |
| *Kalanchoe pinnata* | 0.000↓ | -5.947 | | | |
| *Lantana camara* | 0.046↓ | -1.997 | | | |
| *Lythrum maritimum* | 0.001↓ | -3.328 | | | |
| *Melinis minutiflora* | 0.001↓ | -3.437 | | | |
| ***Pteridium aquilinum*** | 0.000↓ | -4.152 | | | |
| *Schinus terebinthifolius* | 0.000↓ | -5.147 | | | |
| *Setaria parviflora* | 0.002↓ | -3.048 | | | |

*From Wilcoxon signed ranks test, asymptotic significance

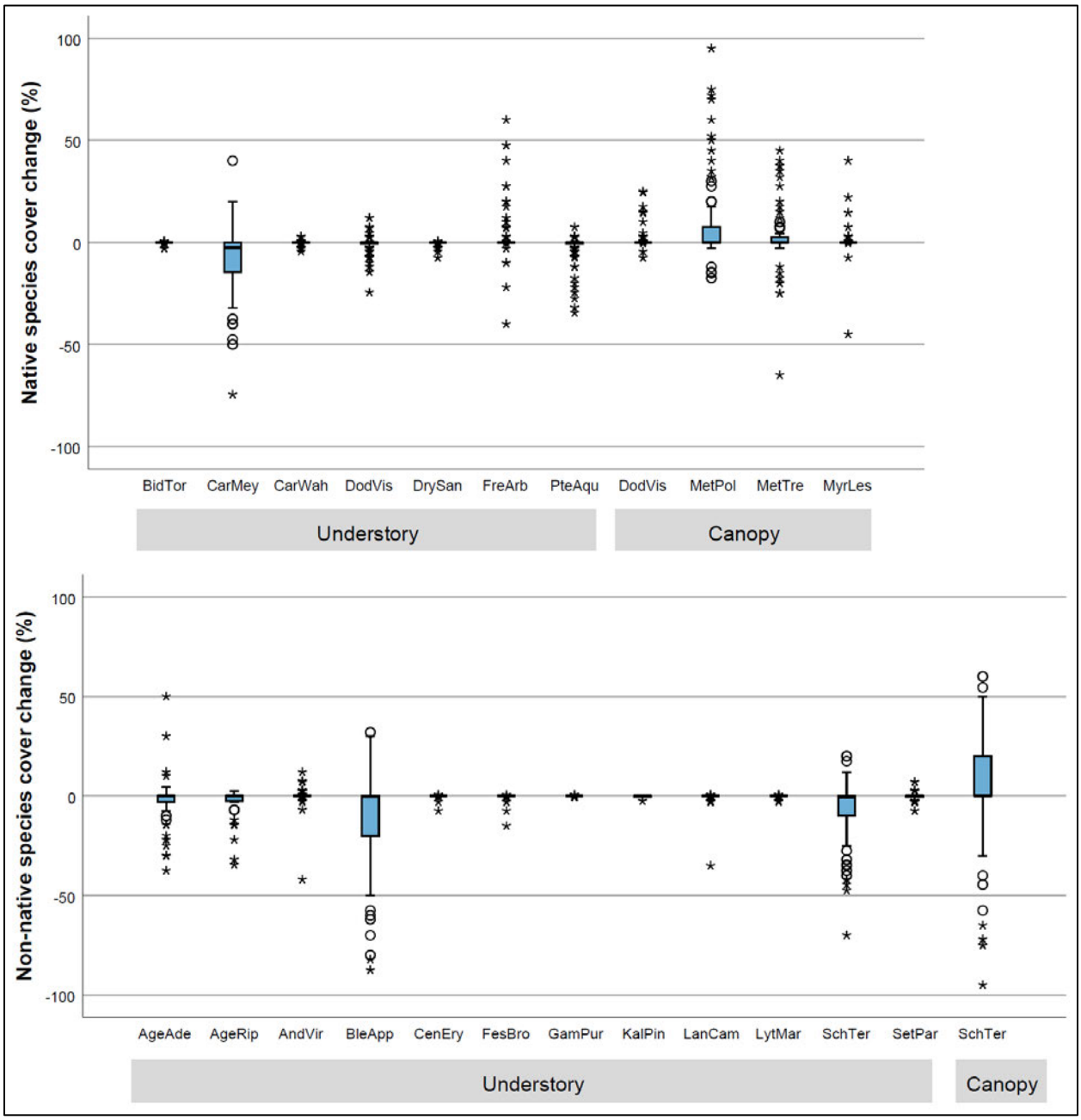


**Figure 9:** Boxplots of cover change between 2010 and 2022 for taxa with significant changes in percent cover at ʻŌhikilolo Upper MU. Values > 0 represent increased cover in plots, while those < 0 represent decreased cover. Values equaling 0 represent no change.

### Canopy replacement

In 2022, 26 tree taxa (65% native) were found recruiting in the understory (Table 6). *Schinus terebinthifolius* was the most commonly recruiting tree species, occurring in two-thirds of the plots, followed by *D. viscosa*, *M. polymorpha*, *M. lessertiana*, and *M. tremuloides*, which were recruiting in over one-quarter of the plots. Three rare taxa (*D. forbesii*, *M. makahae*, and *P. kaalae*) were found recruiting. Native tree taxa with no recruitment in the understory were relatively infrequent in the canopy (with frequencies < 4%). Seven LDT weed taxa (*A. columnaris*, *G. robusta*, *P. cattleianum, P. guajava*, *S. campanulata*, *S. cumini*, and *T. ciliata*) were found recruiting in plots. Recruitment frequencies within plots for LDT taxa were low (< 4%) with the exception of *G. robusta*, which was recruiting in 11% of plots. It should be noted that the age of saplings may vary greatly, from less than one year to decades, in accordance with differing species growth rates, complicating interpretations of presence/absence and change over time with respect to concerns over long term canopy replacement.

**Table 6:** Tree species recruitment frequencies at ʻŌhikilolo Upper MU from 2022 among understory taxa. Taxa are ordered by highest to lowest recruitment frequency. Native species are in boldface. **LDT target taxa. ‡Rare taxa.

| Tree taxon | Freq. | Tree taxon | Freq. |
|---|---|---|---|
| *Schinus terebinthifolius* | 66.2 | *Toona ciliata*** | 2.3 |
| ***Dodonaea viscosa*** | 43.8 | ***Diospyros sandwicensis*** | 1.5 |
| ***Metrosideros polymorpha*** | 40.8 | ***Melicope oahuensis*** | 1.5 |
| ***Myrsine lessertiana*** | 32.3 | *Araucaria columnaris*** | 0.8 |
| ***Metrosideros tremuloides*** | 30.8 | ***Elaeocarpus bifidus*** | 0.8 |
| ***Psychotria mariniana*** | 11.5 | *Leucaena leucocephala* | 0.8 |
| ***Antidesma platyphyllum*** | 10.8 | ***Melicope makahae‡*** | 0.8 |
| *Grevillea robusta*** | 10.8 | *Spathodea campanulata*** | 0.8 |
| ***Kadua affinis*** | 6.9 | *Syzygium cumini*** | 0.8 |
| ***Acacia koa*** | 5.4 | ***Syzygium sandwicense*** | 0.8 |
| ***Pipturus albidus*** | 3.8 | ***Melicope kaalaensis*** | 0.0 |
| ***Psychotria hathewayi*** | 3.8 | ***Myoporum sandwicense*** | 0.0 |
| ***Pritchardia kaalae‡*** | 3.1 | ***Nestegis sandwicensis*** | 0.0 |
| *Psidium cattleianum*** | 3.1 | ***Planchonella sandwicensis*** | 0.0 |
| *Psidium guajava*** | 3.1 | ***Xylosma hawaiiense*** | 0.0 |
| ***Dracaena forbesii‡*** | 2.3 | | |

## RESULTS: PRIORITY AREA 1

### Understory and canopy cover categories

Management goals of having < 50% non-native understory and canopy and > 50% native understory and canopy cover were met for the non-native understory (15% median cover) and canopy (0.5%), as well as for the native understory (70%) and canopy (55%) (Table 7). There were significant changes in percent cover of vegetation since 2010 that met the 10% standard for recognized change in cover. These included cover declines for native grasses/sedges and ferns, but an overall increase in native shrubs; a steady decline in total non-native understory cover; a steady increase for native canopy cover; and a steady decline in non-native canopy cover (Figure 10).

**Table 7:** Median percent cover over time for native and non-native vegetation categories in the canopy and understory at ʻŌhikilolo Upper Priority Area 1. Categories specifically addressed in management goals are shaded in blue. Statistically significant values for categories that meet the 10% standard for recognized change in cover are in boldface. Arrows indicate increase (↑), decrease (↓), or inconsistent trend (↕) in cover.

| | 2010 | 2013 | 2016 | 2019 | 2022 | p* | $X^2$ | Years that differed significantly | p (post-hoc)** | Management goal currently met? |
|---|---|---|---|---|---|---|---|---|---|---|
| ***Understory*** | | | | | | | | | | |
| Native shrubs | 20.0 | 25.0 | 15.0 | 15.0 | 35.0 | **0.000**↕ | 34.673 | 2010-2022<br>2013-2019<br>2016-2022<br>2019-2022 | **0.006**↑<br>**0.044**↓<br>**0.000**↑<br>**0.000**↑ | |
| Native ferns | 25.0 | 25.0 | 15.0 | 15.0 | 15.0 | **0.000**↓ | 25.979 | 2010-2019<br>2013-2019 | **0.000**↓<br>**0.016**↓ | |
| Native grass/sedges | 15.0 | 7.5 | 3.0 | 3.0 | 3.0 | **0.000**↓ | 40.946 | 2010-2016<br>2010-2019<br>2010-2022<br>2013-2016<br>2013-2019<br>2013-2022 | **0.014**↓<br>**0.000**↓<br>**0.002**↓<br>0.030↓<br>0.001↓<br>0.006↓ | |
| Total native understory | 65.0 | 65.0 | 45.0 | 45.0 | 70.0 | **0.000**↕ | 26.604 | 2010-2019<br>2013-2019<br>2019-2022 | **0.014**↓<br>**0.006**↓<br>**0.001**↑ | Yes |
| Non-native shrubs | 7.5 | 7.5 | 7.5 | 5.3 | 3.0 | 0.000↓ | 25.798 | 2010-2022<br>2010-2019<br>2016-2022 | 0.004↓<br>0.040↓<br>0.005↓ | |
| Non-native ferns | 3.0 | 11.3 | 3.0 | 5.3 | 5.3 | 0.000↓ | 23.390 | 2010-2016<br>2013-2016<br>2013-2019 | 0.044↓<br>0.019↓<br>0.036↓ | |
| Non-native grass/sedges | 3.0 | 7.5 | 3.0 | 3.0 | 3.0 | 0.000↓ | 33.918 | 2010-2022<br>2013-2022<br>2013-2019 | 0.010↓<br>0.000↓<br>0.014↓ | |
| Total non-native understory | 45.0 | 45.0 | 35.0 | 15.0 | 15.0 | **0.000**↓ | 44.823 | 2010-2019<br>2010-2022<br>2013-2019<br>2013-2022<br>2016-2019<br>2016-2022 | **0.010**↓<br>**0.000**↓<br>**0.001**↓<br>**0.000**↓<br>**0.044**↓<br>**0.002**↓ | Yes |
| ***Canopy*** | | | | | | | | | | |
| Native canopy | 25.0 | 25.0 | 35.0 | 45.0 | 55.0 | **0.000**↑ | 69.936 | 2010-2016<br>2010-2019<br>2010-2022<br>2013-2019<br>2013-2022<br>2016-2022<br>2019-2022 | **0.017**↑<br>**0.001**↑<br>**0.000**↑<br>**0.027**↑<br>**0.000**↑<br>**0.001**↑<br>**0.014**↑ | Yes |
| Non-native canopy | 15.0 | 15.0 | 7.5 | 5.3 | 0.5 | **0.026**↓ | 11.054 | | NA | Yes |
| Total canopy | 55.0 | 55.0 | 65.0 | 65.0 | 60.0 | **0.008**↕ | 13.882 | 2010-2022 | 0.049↑ | |

*From Friedman's test, asymptotic significance

**From post-hoc pairwise comparisons with Bonferroni adjustment

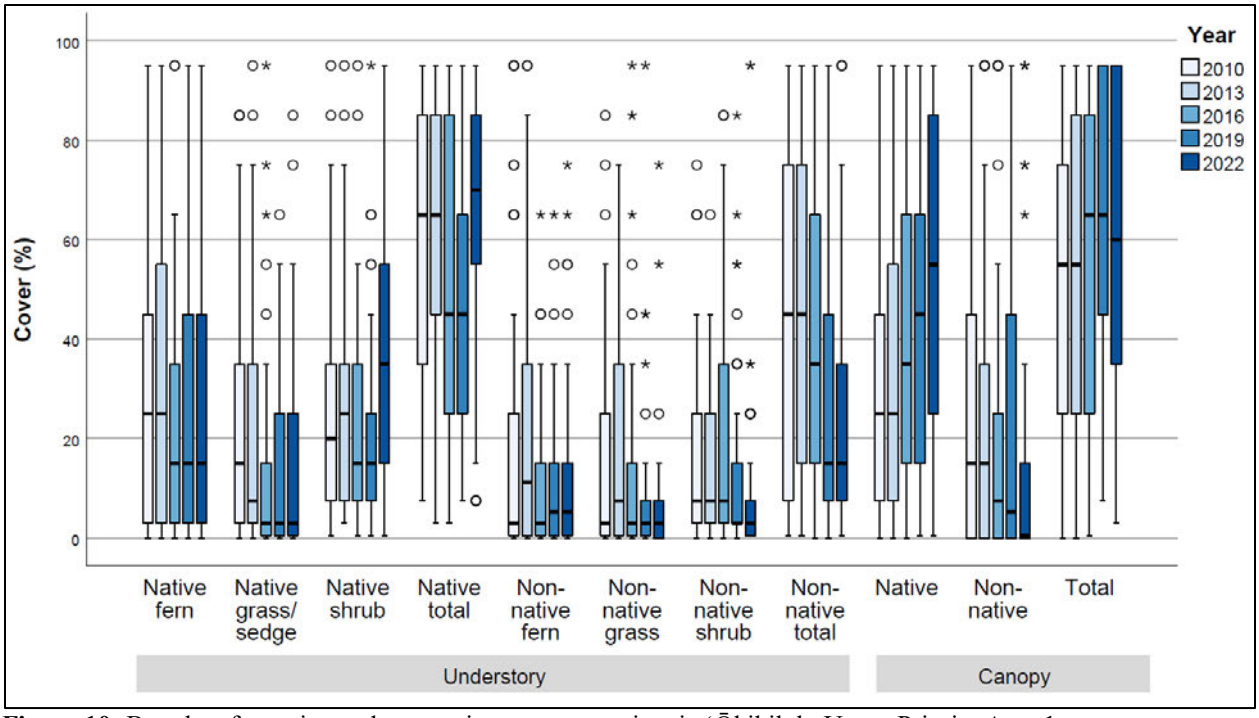


**Figure 10:** Boxplots for native and non-native cover over time in ʻŌhikilolo Upper Priority Area 1.

## Species richness

During monitoring in 2022, 123 species were recorded in the understory (55% native taxa), and 38 were identified in the canopy (84% native). The native understory had higher levels of diversity both within plots and for the MU overall compared to the non-native understory, while the native canopy diversity was four times as high within plots and more than five times higher for Priority Area 1 overall compared with the non-native canopy (Table 8). Species richness within plots differed significantly between the years monitored, with an increase for the native canopy over time (Table 8 and Figure 11). Notable differences among years in overall diversity for the MU included increases for the non-native understory as well as for the native and non-native canopy.

**Table 8:** ʻŌhikilolo Upper Priority Area 1 understory and canopy species richness over time. Median species richness per plot during vegetation monitoring is shown by year, with the total number of species recorded among all plots in parenthesis. Statistically significant values are in boldface. Arrows indicate increase (↑), decrease (↓), or inconsistent trend (↕) in cover.

| | 2010 | 2013 | 2016 | 2019 | 2022 | p* | $X^2$ | Years that differed significantly | p (post-hoc)** |
|---|---|---|---|---|---|---|---|---|---|
| Native understory | 12.5 (67) | 12.5 (65) | 12.5 (64) | 13 (59) | 12 (68) | 0.181 | | | |
| Non-native understory | 9 (47) | 8 (43) | 9 (54) | 9 (52) | 8.5 (55) | 0.081 | 8.309 | | |
| Native canopy | 3 (25) | 3 (28) | 3 (26) | 4.5 (31) | 4 (32) | **0.000**↑ | 97.988 | 2010-2019 | **0.000**↑ |
| | | | | | | | | 2010-2022 | **0.000**↑ |
| | | | | | | | | 2013-2019 | **0.000**↑ |
| | | | | | | | | 2013-2022 | **0.000**↑ |
| | | | | | | | | 2016-2019 | **0.000**↑ |
| | | | | | | | | 2016-2022 | **0.000**↑ |
| Non-native canopy | 1 (2) | 1 (3) | 1 (6) | 1 (11) | 1 (6) | 0.101 | 7.761 | | |

*From Friedman's test for differences across all years, asymptotic significance
**From post-hoc pairwise comparisons with Bonferroni adjustment

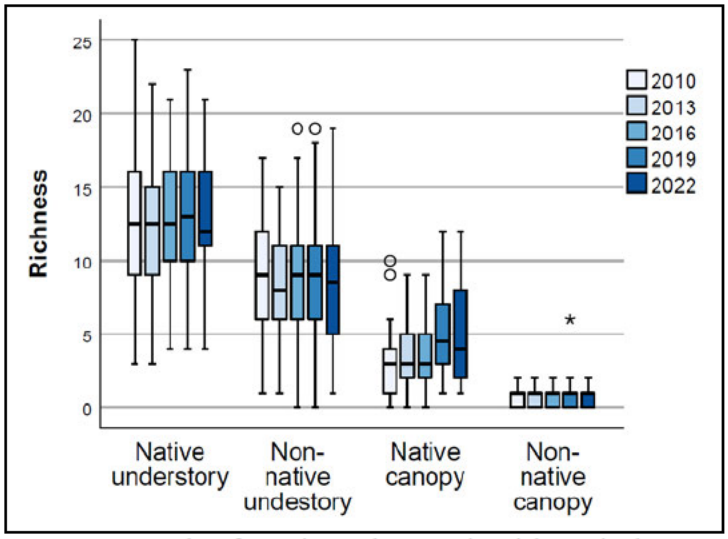


**Figure 11:** Boxplots for native and non-native richness in the understory and canopy over time in ʻŌhikilolo Upper Priority Area 1.

## Species frequency

Non-native species that occurred most frequently in plots (present in more than half the plots) in the understory in 2022 included *B. appendiculatum*, *S. australis*, *M. minutiflora*, *R. rosifolius*, and *S. terebinthifolius*, while *S. terebinthifolius* also occurred most commonly in the canopy (Table 9). The most frequent native understory species (in more than half the plots) included *C. meyenii*, *M. polymorpha*, *C. foliosa*, *Doodia kunthiana*, *Alyxia stellata*, *M. lessertiana*, *D. viscosa*, and *W. oahuensis* var. *oahuensis*, while *M. polymorpha*, *C. foliosa*, *D. viscosa*, *M. tremuloides*, *F. arborea*, *M. lessertiana*, *Acacia koa*, *A. stellata*, *Cibotium chamissoi*, and *Elaeocarpus bifidus* occurred most commonly (in over a quarter of the

plots) in the canopy. Four rare taxa were recorded in plots during monitoring in 2022, including *D. forbesii*, *M. cornuta* var. *decurrens*, *N. angulata*, and *P. kaalae*. The one ICA target found in the MU in 2022, *E. stipoides*, was found exclusively in Priority Area 1, present in three plots (in existing ICAs) (Figure 7). Seven LDT taxa were recorded in plots, including *A. columnaris*, *C. hirta*, *G. robusta*, *P. suberosa*, *P. cattleianum*, *S. campanulata*, and *T. ciliata* (Figure 7), most of which were in relatively low frequencies (≤ 6%) with the exception of *C. hirta*, which occurred in 28% of the plots. Notably, as mentioned above, *C. hirta* was not present in any plots in the MU in 2010.

Analysis of frequency change was limited to taxa with at least ten percent change between 2010 and 2022. Among native taxa, there were significant frequency decreases for *B. torta* and *Microlepia strigosa* in the understory; and increases for *A. koa*, *C. foliosa*, *Kadua affinis*, *Pipturus albidus*, *Psychotria mariniana*, and *W. oahuensis* var. *oahuensis* in the understory, and for *A. koa*, *A. stellata*, *C. chamissoi*, *C. foliosa*, *D. viscosa*, and *M. lessertiana* in the canopy (Figure 12). Among non-native taxa, there were significant frequency increases for *C. hirta* and *R. rosifolius* in the understory; and decreases for *A. adenophora*, *F. bromoides*, *K. pinnata*, *L. maritimum*, and *S. terebinthifolius* in the understory, and for *S. terebinthifolius* in the canopy.

**Table 9:** Species frequencies over time in the understory and canopy in ʻŌhikilolo Upper Priority Area 1. Taxa are ordered by highest to lowest frequency in 2022. Only taxa with at least 10% change in frequency between 2010 and 2022 were analyzed. Statistical comparisons are between 2010 and 2022 data. P-values obtained from McNemar's tests (exact significance). Arrows indicate increase (↑) or decrease (↓) in frequency for statistically significant results. Native species are in boldface. ‡Rare taxa. Target weed taxa: *ICA, **LDT.

| Taxon | 2010 | 2013 | 2016 | 2019 | 2022 | p |
|---|---|---|---|---|---|---|
| Understory | | | | | | |
| ***Carex meyenii*** | 92 | 92 | 88 | 88 | 88 | |
| *Blechnum appendiculatum* | 82 | 84 | 84 | 82 | 84 | |
| *Stachytarpheta australis* | 74 | 74 | 76 | 76 | 76 | |
| ***Metrosideros polymorpha*** | 58 | 66 | 54 | 70 | 68 | 0.227 |
| ***Coprosma foliosa*** | 42 | 46 | 58 | 52 | 64 | **0.003**↑ |
| *Melinis minutiflora* | 68 | 72 | 68 | 68 | 62 | |
| ***Doodia kunthiana*** | 66 | 68 | 64 | 60 | 62 | |
| ***Alyxia stellata*** | 56 | 58 | 52 | 68 | 60 | |
| *Rubus rosifolius* | 32 | 34 | 56 | 68 | 58 | **0.000**↑ |
| ***Myrsine lessertiana*** | 60 | 66 | 66 | 64 | 56 | |
| ***Dodonaea viscosa*** | 56 | 56 | 56 | 52 | 54 | |
| ***Wikstroemia oahuensis var. oahuensis*** | 30 | 42 | 44 | 46 | 54 | **0.002**↑ |
| *Schinus terebinthifolius* | 78 | 68 | 62 | 62 | 52 | **0.007**↓ |
| ***Freycinetia arborea*** | 42 | 42 | 40 | 48 | 48 | |
| *Erigeron karvinskianus* | 36 | 40 | 40 | 48 | 46 | 0.267 |
| ***Cocculus orbiculatus*** | 54 | 56 | 42 | 50 | 44 | 0.302 |
| ***Nephrolepis exaltata subsp. hawaiiensis*** | 36 | 36 | 38 | 42 | 44 | |
| *Ageratina adenophora* | 58 | 48 | 50 | 42 | 42 | **0.021**↓ |
| ***Odontosoria chinensis*** | 46 | 46 | 46 | 44 | 40 | |
| *Ageratina riparia* | 56 | 56 | 38 | 44 | 40 | 0.096 |
| ***Pteridium aquilinum*** | 40 | 42 | 38 | 32 | 38 | |
| ***Metrosideros tremuloides*** | 38 | 42 | 46 | 44 | 32 | |
| ***Psychotria mariniana*** | 14 | 30 | 24 | 32 | 32 | **0.012**↑ |
| ***Cibotium chamissoi*** | 26 | 26 | 28 | 28 | 32 | |
| ***Antidesma platyphyllum*** | 18 | 26 | 24 | 24 | 32 | 0.065 |
| *Youngia japonica* | 16 | 16 | 36 | 24 | 28 | 0.210 |
| *Clidemia hirta*** | 0 | 2 | 10 | 22 | 28 | **0.000**↑ |
| ***Acacia koa*** | 12 | 14 | 8 | 20 | 28 | **0.021**↑ |
| *Setaria parviflora* | 36 | 42 | 20 | 28 | 26 | 0.267 |

**Table 9** (continued).

| Taxon | 2010 | 2013 | 2016 | 2019 | 2022 | p |
|---|---|---|---|---|---|---|
| Understory | | | | | | |
| ***Pritchardia kaalae‡*** | 24 | 28 | 26 | 22 | 26 | |
| *Christella parasitica* | 30 | 22 | 24 | 32 | 24 | |
| ***Dryopteris sandwicensis*** | 28 | 26 | 30 | 30 | 24 | |
| *Conyza bonariensis* | 18 | 26 | 26 | 20 | 24 | |
| ***Elaeocarpus bifidus*** | 26 | 28 | 26 | 24 | 22 | |
| ***Kadua affinis*** | 6 | 8 | 8 | 16 | 22 | **0.021↑** |
| ***Dryopteris fusco-atra*** | 12 | 26 | 24 | 24 | 20 | |
| *Lantana camara* | 30 | 26 | 22 | 24 | 20 | 0.267 |
| ***Psychotria hathewayi*** | 20 | 16 | 16 | 18 | 20 | |
| ***Carex wahuensis*** | 24 | 16 | 18 | 12 | 20 | |
| ***Microlepia strigosa*** | 32 | 24 | 22 | 24 | 18 | **0.016↓** |
| *Triumfetta semitriloba* | 10 | 16 | 12 | 22 | 18 | |
| ***Viola chamissoniana subsp. tracheliifolia*** | 18 | 14 | 16 | 16 | 18 | |
| ***Pipturus albidus*** | 2 | 2 | 6 | 14 | 16 | **0.016↑** |
| ***Lepisorus thunbergianus*** | 12 | 10 | 24 | 10 | 16 | |
| ***Selaginella arbuscula*** | 20 | 14 | 24 | 24 | 14 | |
| *Paspalum conjugatum* | 14 | 16 | 18 | 22 | 12 | |
| *Lythrum maritimum* | 28 | 20 | 22 | 20 | 12 | **0.008↓** |
| *Andropogon virginicus* | 8 | 12 | 14 | 10 | 12 | |
| *Cuphea carthagenesis* | 2 | 2 | 10 | 10 | 12 | 0.063 |
| ***Athyrium microphyllum*** | 16 | 12 | 12 | 16 | 10 | |
| ***Deparia prolifera*** | 10 | 10 | 12 | 12 | 10 | |
| ***Elaphoglossum paleaceum*** | 10 | 8 | 12 | 12 | 10 | |
| ***Eragrostis grandis*** | 8 | 8 | 8 | 10 | 10 | |
| ***Lysimachia hillebrandii*** | 6 | 6 | 6 | 10 | 10 | |
| *Oxalis corniculata* | 12 | 4 | 8 | 6 | 10 | |
| *Melinis repens* | 10 | 12 | 6 | 4 | 10 | |
| ***Dryopteris glabra*** | 22 | 22 | 16 | 0 | 10 | 0.070 |
| *Kalanchoe pinnata* | 48 | 38 | 48 | 36 | 8 | **0.000↓** |
| ***Melicope oahuensis*** | 14 | 10 | 12 | 12 | 8 | |
| ***Gahnia beecheyi*** | 12 | 14 | 10 | 12 | 8 | |
| *Ageratum conyzoides* | 8 | 2 | 6 | 8 | 8 | |
| ***Scaevola gaudichaudiana*** | 10 | 6 | 4 | 6 | 8 | |
| ***Dicranopteris linearis*** | 4 | 4 | 6 | 4 | 8 | |
| *Christella dentata* | 0 | 6 | 4 | 2 | 8 | |
| *Gamochaeta purpurea* | 14 | 6 | 16 | 0 | 8 | |
| ***Kadua acuminata*** | 6 | 8 | 12 | 8 | 6 | |
| *Emilia fosbergii* | 2 | 2 | 0 | 6 | 6 | |
| *Cheilanthes viridis* | 6 | 6 | 10 | 4 | 6 | |
| *Oplismenus hirtellus* | 2 | 4 | 4 | 4 | 6 | |
| ***Dianella sandwicensis*** | 0 | 0 | 4 | 4 | 6 | |
| *Phaius tankervilleae* | 0 | 2 | 2 | 4 | 6 | |
| *Centaurium erythraea* | 8 | 2 | 8 | 2 | 6 | |
| *Verbena litoralis* | 12 | 8 | 2 | 2 | 6 | |
| *Ehrharta stipoides** | 0 | 0 | 2 | 2 | 6 | |
| *Bidens alba* | 0 | 0 | 0 | 2 | 6 | |
| ***Menisciopsis cyatheoides*** | 4 | 4 | 4 | 6 | 4 | |
| *Cyperus brevifolius* | 0 | 0 | 4 | 6 | 4 | |
| *Buddleja asiatica* | 2 | 2 | 2 | 6 | 4 | |
| ***Nestegis sandwicensis*** | 2 | 4 | 4 | 4 | 4 | |
| ***Syzygium sandwicense*** | 4 | 4 | 2 | 4 | 4 | |
| ***Diospyros sandwicensis*** | 2 | 4 | 2 | 4 | 4 | |
| *Sonchus oleraceus* | 10 | 2 | 2 | 4 | 4 | |

**Table 9** (continued).

| Taxon | 2010 | 2013 | 2016 | 2019 | 2022 | p |
|---|---|---|---|---|---|---|
| Understory | | | | | | |
| *Adiantum hispidulum* | 2 | 2 | 2 | 4 | 4 | |
| *Toona ciliata*** | 0 | 2 | 2 | 4 | 4 | |
| ***Myoporum sandwicense*** | 0 | 0 | 0 | 4 | 4 | |
| ***Peperomia membranacea*** | 4 | 2 | 2 | 2 | 4 | |
| ***Osteomeles anthyllidifolia*** | 0 | 2 | 2 | 2 | 4 | |
| *Linum trigynum* | 2 | 0 | 2 | 2 | 4 | |
| *Digitaria violascens* | 0 | 0 | 0 | 2 | 4 | |
| ***Lachnagrostis filiformis*** | 8 | 0 | 6 | 0 | 4 | |
| ***Panicum nephelophilum*** | 2 | 4 | 2 | 0 | 4 | |
| ***Neraudia angulata‡*** | 0 | 0 | 0 | 0 | 4 | |
| *Plantago lanceolata* | 0 | 0 | 0 | 0 | 4 | |
| *Polygala paniculata* | 0 | 0 | 0 | 0 | 4 | |
| *Sacciolepis indica* | 0 | 0 | 0 | 0 | 4 | |
| ***Bidens torta*** | 14 | 8 | 8 | 4 | 2 | **0.031↓** |
| ***Doryopteris decipiens*** | 8 | 4 | 6 | 4 | 2 | |
| *Araucaria columnaris*** | 4 | 4 | 4 | 4 | 2 | |
| *Psidium cattleianum*** | 4 | 2 | 4 | 4 | 2 | |
| ***Psilotum nudum*** | 2 | 2 | 4 | 4 | 2 | |
| *Emilia sonchifolia* | 2 | 0 | 2 | 4 | 2 | |
| *Castilleja arvensis* | 0 | 0 | 2 | 4 | 2 | |
| *Grevillea robusta*** | 6 | 8 | 10 | 2 | 2 | |
| ***Cyrtandra waianaeensis*** | 2 | 2 | 6 | 2 | 2 | |
| ***Korthalsella complanata*** | 2 | 2 | 4 | 2 | 2 | |
| ***Melicope cornuta* var. *decurrens‡*** | 2 | 2 | 4 | 2 | 2 | |
| ***Melicope kaalaensis*** | 0 | 4 | 2 | 2 | 2 | |
| ***Tectaria gaudichaudii*** | 2 | 2 | 2 | 2 | 2 | |
| *Opuntia ficus-indica* | 0 | 2 | 2 | 2 | 2 | |
| ***Paspalum scrobiculatum*** | 2 | 0 | 0 | 2 | 2 | |
| *Crassocephalum crepidioides* | 0 | 0 | 0 | 2 | 2 | |
| *Deparia petersenii* | 0 | 0 | 0 | 2 | 2 | |
| *Polystachya concreta* | 0 | 0 | 0 | 2 | 2 | |
| ***Ctenitis latifrons*** | 2 | 2 | 2 | 0 | 2 | |
| ***Polypodium pellucidum var. pellucidum*** | 2 | 2 | 2 | 0 | 2 | |
| ***Sadleria cyatheoides*** | 0 | 2 | 2 | 0 | 2 | |
| *Lysimachia arvensis* | 0 | 0 | 2 | 0 | 2 | |
| *Spathodea campanulata*** | 0 | 0 | 2 | 0 | 2 | |
| ***Xylosma hawaiiense*** | 0 | 0 | 2 | 0 | 2 | |
| ***Dracaena forbesii‡*** | 0 | 0 | 0 | 0 | 2 | |
| ***Korthalsella cylindrica*** | 0 | 0 | 0 | 0 | 2 | |
| *Passiflora suberosa*** | 0 | 0 | 0 | 0 | 2 | |
| ***Vaccinium dentatum*** | 0 | 0 | 0 | 0 | 2 | |
| ***Pseudognaphalium sandwicensium var. molokaiense*** | 0 | 0 | 0 | 8 | 0 | |
| *Sporobolus indicus* | 8 | 4 | 4 | 6 | 0 | |
| ***Planchonella sandwicensis*** | 2 | 4 | 2 | 2 | 0 | |
| *Axonopus fissifolius* | 2 | 0 | 2 | 2 | 0 | |
| *Chamaecrista nictitans* | 2 | 0 | 2 | 2 | 0 | |
| *Cinnamomum burmannii*** | 0 | 0 | 2 | 2 | 0 | |
| *Festuca bromoides* | 20 | 0 | 8 | 0 | 0 | **0.002↓** |
| *Bidens pilosa* | 2 | 2 | 2 | 0 | 0 | |
| *Cyperus mindorensis* | 8 | 0 | 2 | 0 | 0 | |
| ***Coleus australis*** | 2 | 0 | 2 | 0 | 0 | |
| *Pityrogramma austroamericana* | 2 | 0 | 2 | 0 | 0 | |
| *Epidendrum x obrienianum* | 0 | 0 | 2 | 0 | 0 | |

**Table 9** (continued).

| Taxon | 2010 | 2013 | 2016 | 2019 | 2022 | p |
|---|---|---|---|---|---|---|
| Understory | | | | | | |
| ***Asplenium caudatum*** | 8 | 4 | 0 | 0 | 0 | |
| ***Bobea elatior*** | 2 | 2 | 0 | 0 | 0 | |
| ***Artemisia australis*** | 0 | 2 | 0 | 0 | 0 | |
| *Asclepias physocarpa* | 0 | 2 | 0 | 0 | 0 | |
| ***Cyrtomium caryotideum*** | 0 | 2 | 0 | 0 | 0 | |
| *Erechtites valerianifolia* | 0 | 2 | 0 | 0 | 0 | |
| ***Nephrolepis cordifolia*** | 0 | 2 | 0 | 0 | 0 | |
| ***Adenophorus tenellus*** | 4 | 0 | 0 | 0 | 0 | |
| *Cerastium fontanum* | 2 | 0 | 0 | 0 | 0 | |
| ***Elaphoglossum alatum*** | 2 | 0 | 0 | 0 | 0 | |
| ***Melicope makahae‡*** | 2 | 0 | 0 | 0 | 0 | |
| *Mesosphaerum pectinatum* | 2 | 0 | 0 | 0 | 0 | |
| ***Pteris irregularis*** | 2 | 0 | 0 | 0 | 0 | |
| *Rhynchospora sp.* | 2 | 0 | 0 | 0 | 0 | |
| *Santalum album* | 2 | 0 | 0 | 0 | 0 | |
| ***Zanthoxylum dipetalum var. dipetalum‡*** | 2 | 0 | 0 | 0 | 0 | |
| Canopy | | | | | | |
| ***Metrosideros polymorpha*** | 54 | 52 | 56 | 68 | 66 | 0.070 |
| *Schinus terebinthifolius* | 72 | 68 | 70 | 68 | 56 | **0.012↓** |
| ***Coprosma foliosa*** | 12 | 12 | 14 | 30 | 46 | **0.000↑** |
| ***Dodonaea viscosa*** | 26 | 36 | 36 | 42 | 42 | **0.021↑** |
| ***Metrosideros tremuloides*** | 36 | 38 | 40 | 42 | 38 | |
| ***Freycinetia arborea*** | 26 | 30 | 30 | 34 | 36 | 0.063 |
| ***Myrsine lessertiana*** | 14 | 20 | 18 | 34 | 34 | **0.013↑** |
| ***Acacia koa*** | 10 | 14 | 16 | 20 | 32 | **0.001↑** |
| ***Alyxia stellata*** | 12 | 18 | 20 | 30 | 28 | **0.039↑** |
| ***Cibotium chamissoi*** | 14 | 20 | 20 | 28 | 28 | **0.016↑** |
| ***Elaeocarpus bifidus*** | 22 | 22 | 22 | 26 | 26 | |
| ***Psychotria mariniana*** | 14 | 14 | 12 | 24 | 18 | |
| ***Lepisorus thunbergianus*** | 2 | 0 | 8 | 16 | 12 | 0.125 |
| ***Psychotria hathewayi*** | 8 | 6 | 8 | 8 | 12 | |
| ***Antidesma platyphyllum*** | 8 | 6 | 8 | 12 | 10 | |
| ***Pritchardia kaalae‡*** | 4 | 4 | 6 | 8 | 8 | |
| ***Cocculus orbiculatus*** | 0 | 4 | 0 | 8 | 6 | |
| ***Nestegis sandwicensis*** | 2 | 4 | 6 | 6 | 6 | |
| ***Melicope oahuensis*** | 4 | 4 | 4 | 6 | 6 | |
| ***Pipturus albidus*** | 2 | 0 | 0 | 6 | 6 | |
| ***Wikstroemia oahuensis var. oahuensis*** | 0 | 2 | 2 | 8 | 4 | |
| *Stachytarpheta australis* | 0 | 0 | 2 | 6 | 4 | |
| ***Kadua affinis*** | 0 | 2 | 4 | 4 | 4 | |
| *Ageratina adenophora* | 0 | 0 | 0 | 2 | 4 | |
| ***Syzygium sandwicense*** | 6 | 6 | 4 | 6 | 2 | |
| *Lantana camara* | 0 | 0 | 0 | 6 | 2 | |
| *Grevillea robusta*** | 6 | 6 | 4 | 4 | 2 | |
| ***Korthalsella complanata*** | 2 | 2 | 2 | 4 | 2 | |
| ***Dicranopteris linearis*** | 0 | 2 | 0 | 4 | 2 | |
| ***Cyrtandra waianaeensis*** | 2 | 2 | 2 | 2 | 2 | |
| ***Planchonella sandwicensis*** | 0 | 0 | 2 | 2 | 2 | |
| *Rubus rosifolius* | 0 | 0 | 2 | 2 | 2 | |
| ***Diospyros sandwicensis*** | 0 | 2 | 0 | 2 | 2 | |
| ***Melicope kaalaensis*** | 0 | 2 | 0 | 2 | 2 | |
| ***Kadua acuminata*** | 0 | 0 | 0 | 2 | 2 | |
| ***Lysimachia hillebrandii*** | 0 | 0 | 0 | 2 | 2 | |

**Table 9** (continued).

| Taxon | 2010 | 2013 | 2016 | 2019 | 2022 | p |
|---|---|---|---|---|---|---|
| Canopy | | | | | | |
| ***Sadleria cyatheoides*** | 0 | 0 | 2 | 0 | 2 | |
| ***Dracaena forbesii‡*** | 0 | 0 | 0 | 0 | 2 | |
| ***Xylosma hawaiiense*** | 2 | 2 | 0 | 2 | 0 | |
| *Psidium cattleianum*** | 0 | 2 | 0 | 2 | 0 | |
| *Buddleja asiatica* | 0 | 0 | 0 | 2 | 0 | |
| *Conyza bonariensis* | 0 | 0 | 0 | 2 | 0 | |
| *Polystachya concreta* | 0 | 0 | 0 | 2 | 0 | |
| *Triumfetta semitriloba* | 0 | 0 | 0 | 2 | 0 | |
| ***Bobea elatior*** | 2 | 2 | 2 | 0 | 0 | |
| ***Scaevola gaudichaudiana*** | 0 | 2 | 2 | 0 | 0 | |
| *Melinis minutiflora* | 0 | 0 | 2 | 0 | 0 | |
| *Toona ciliata*** | 0 | 0 | 2 | 0 | 0 | |
| ***Perrottetia sandwicensis*** | 2 | 0 | 0 | 0 | 0 | |
| ***Psydrax odorata*** | 2 | 0 | 0 | 0 | 0 | |

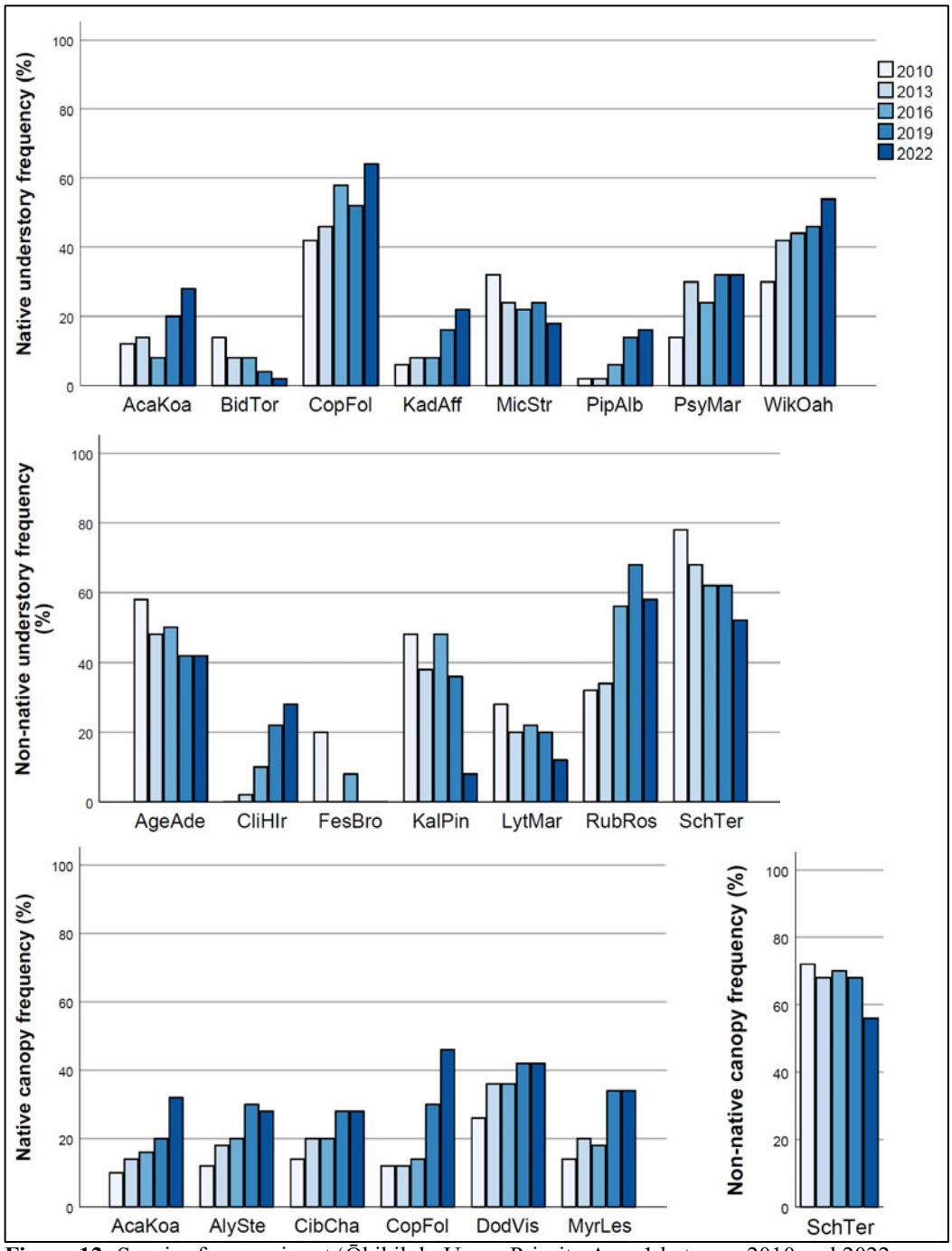


**Figure 12:** Species frequencies at ʻŌhikilolo Upper Priority Area 1 between 2010 and 2022, among taxa with significant changes over time. Frequency values represent the proportion of plots in which species are present.

**Species cover**

Significant cover changes in the understory included declines for three native and eight non-native taxa, and increases for four native and one non-native taxa. Significant cover changes in the canopy included increases for eight native taxa, and a decrease for one non-native taxon (Table 10 and Figure 13). However, for many of those taxa, cover changes were small (primarily ≤ 10% absolute change within plots), and at times more a reflection of frequency change than expansive increased cover within plots. Most notable among the changes with respect to sizable differences in cover among native taxa were the decrease for *C. meyenii* in the understory, and increases for *F. arborea* in the understory as well as *A. koa*, *C. chamissoi*, *D. viscosa*, *F. arborea*, *M. polymorpha*, and *M. lessertiana* in the canopy. Most notable changes in cover among non-native taxa were decreases in *B. appendiculatum*, *M. minutiflora*, and *S. terebinthifolius* in the understory, and for *S. terebinthifolius* in the canopy.

**Table 10:** Species with significant cover change between 2010 and 2022 at ʻŌhikilolo Upper Priority Area 1. Only taxa with > 20% frequency in either 2010 or 2022 were analyzed (Wilcoxon signed ranks test, asymptotic significance). Arrows indicate increase (↑) or decrease (↓) in cover. Native species are in boldface.

| Understory taxa | p | Z | Canopy taxa | p | Z |
|---|---|---|---|---|---|
| ***Acacia koa*** | 0.033↑ | -2.130 | ***Acacia koa*** | 0.004↑ | -2.874 |
| *Ageratina adenophora* | 0.024↓ | -2.250 | ***Alyxia stellata*** | 0.008↑ | -2.632 |
| *Ageratina riparia* | 0.009↓ | -2.618 | ***Cibotium chamissoi*** | 0.005↑ | -2.828 |
| *Blechnum appendiculatum* | 0.016↓ | -2.417 | ***Coprosma foliosa*** | 0.000↑ | -3.891 |
| ***Carex meyenii*** | 0.000↓ | -3.573 | ***Dodonaea viscosa*** | 0.015↑ | -2.444 |
| *Clidemia hirta*** | 0.000↑ | -3.742 | ***Freycinetia arborea*** | 0.003↑ | -2.951 |
| ***Dryopteris glabra*** | 0.011↓ | -2.539 | ***Metrosideros polymorpha*** | 0.000↑ | -4.150 |
| ***Dryopteris sandwicensis*** | 0.008↓ | -2.671 | ***Myrsine lessertiana*** | 0.003↑ | -2.929 |
| *Festuca bromoides* | 0.004↓ | -2.911 | *Schinus terebinthifolius* | 0.004↓ | -2.874 |
| ***Freycinetia arborea*** | 0.018↑ | -2.365 | | | |
| ***Kadua affinis*** | 0.011↑ | -2.530 | | | |
| *Lantana camara* | 0.025↓ | -2.235 | | | |
| *Lythrum maritimum* | 0.007↓ | -2.714 | | | |
| *Melinis minutiflora* | 0.005↓ | -2.831 | | | |
| ***Psychotria mariniana*** | 0.000↑ | -3.328 | | | |
| *Schinus terebinthifolius* | 0.000↓ | -3.875 | | | |

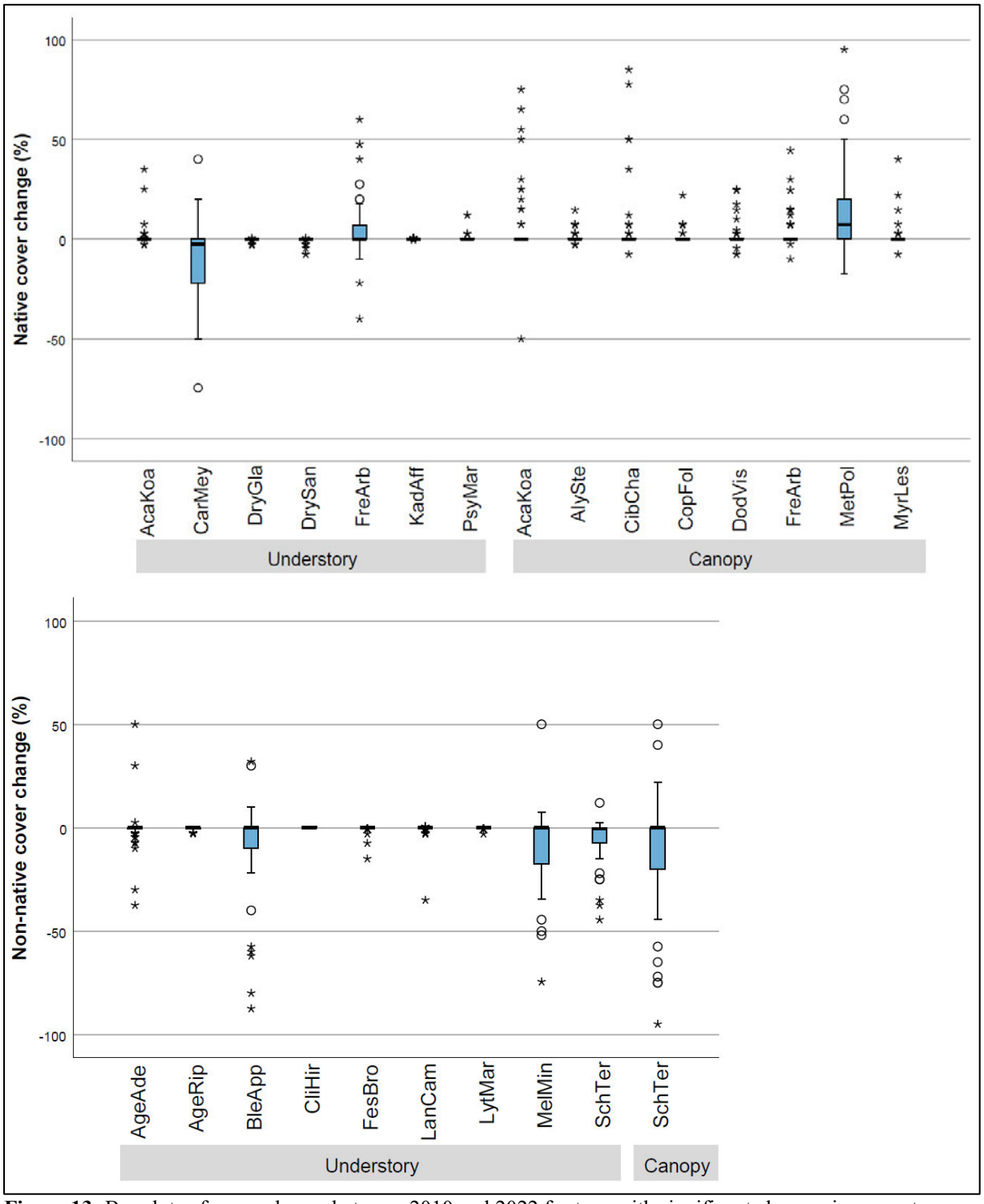


**Figure 13:** Boxplots of cover change between 2010 and 2022 for taxa with significant changes in percent cover at ʻŌhikilolo Upper Priority Area 1. Values > 0 represent increased cover in plots, while those < 0 represent decreased cover. Values equaling 0 represent no change.

## Canopy replacement

In 2022, 20 tree taxa (75% native) were found recruiting in the understory (Table 11). *Myrsine lessertiana*, *S. terebinthifolius D. viscosa*, and *M. polymorpha* were the most commonly recruiting tree species, occurring in over two-thirds of the plots, followed by *P. mariniana* and *Antidesma platyphyllum*, which were recruiting in over one-fifth of the plots. Two rare taxa (*D. forbesii* and *P. kaalae*) were found recruiting. Most native tree taxa with no recruitment in the understory were relatively infrequent in the canopy (with frequencies ≤ 6%), with the exception of *E. bifidus*, which was fairly common in the canopy (26 % of plots). Four LDT weed taxa (*A. columnaris*, *P. cattleianum, S. campanulata*, and *T. ciliata*) were found recruiting in plots. Recruitment frequencies within plots for LDT taxa were low (< 5%). Tree species recruitment frequencies in 2022 were generally similar to those in 2019, with the exception of *A. platyphyllum*, which was found recruiting in several more plots in 2022, though the difference was not significant.

**Table 11:** Tree species recruitment frequencies at ʻŌhikilolo Upper Priority Area 1 between 2019 and 2022. Taxa are ordered by highest to lowest recruitment frequency in 2022. Only taxa with at least 10% change in frequency were analyzed. P-values obtained from McNemar's tests (exact significance). Native species are in boldface. **LDT target taxa. ‡Rare taxa.

| Tree taxon | 2019 | 2022 | p |
|---|---|---|---|
| ***Myrsine lessertiana*** | 46 | 42 | |
| *Schinus terebinthifolius* | 36 | 40 | |
| ***Dodonaea viscosa*** | 30 | 38 | |
| ***Metrosideros polymorpha*** | 40 | 36 | |
| ***Psychotria mariniana*** | 22 | 26 | |
| ***Antidesma platyphyllum*** | 14 | 24 | 0.227 |
| ***Metrosideros tremuloides*** | 18 | 18 | |
| ***Acacia koa*** | 18 | 14 | |
| ***Kadua affinis*** | 10 | 14 | |
| ***Pipturus albidus*** | 14 | 10 | |
| ***Pritchardia kaalae‡*** | 12 | 8 | |
| ***Psychotria hathewayi*** | 10 | 8 | |
| ***Melicope oahuensis*** | 2 | 4 | |
| *Toona ciliata*** | 0 | 4 | |
| *Araucaria columnaris*** | 4 | 2 | |
| ***Diospyros sandwicensis*** | 2 | 2 | |
| ***Dracaena forbesii‡*** | 0 | 2 | |
| *Psidium cattleianum*** | 0 | 2 | |
| *Spathodea campanulata*** | 0 | 2 | |
| ***Syzygium sandwicense*** | 0 | 2 | |
| ***Elaeocarpus bifidus*** | 4 | 0 | |
| ***Myoporum sandwicense*** | 4 | 0 | |
| *Cinnamomum burmannii*** | 2 | 0 | |
| *Grevillea robusta*** | 2 | 0 | |
| ***Melicope kaalaensis*** | 0 | 0 | |
| ***Nestegis sandwicensis*** | 0 | 0 | |
| ***Planchonella sandwicensis*** | 0 | 0 | |
| ***Xylosma hawaiiense*** | 0 | 0 | |

## VEGETATION MANAGEMENT: MU

Weed control efforts between 2010 and 2022 at ʻŌhikilolo Upper MU consisted of Weed Control Area (WCA) and ICA weeding (Figures 14-17). WCA efforts included general ecosystem weeding, grass sprays, and sweeps for control of targeted taxa (primarily for *C. hirta*, but also for mature *G. robusta*, *P.*

*cattleianum*, and *S. terebinthifolius*, and to a lesser extent for *Erigeron karvinskianus* and *R. rosifolius*). Most of the WCA and ICA control occurred in Priority Area 1. From 2010 to 2022, 2,875 hours were spent on WCA weeding, with 72% of those hours occurring between the 2016 and 2022 monitoring interval. WCA weeding actions between 2010 and 2022 crossed through more than half of all plots (Table 12), including all plots in Priority Area 1, and a quarter of Priority Area 2 plots.

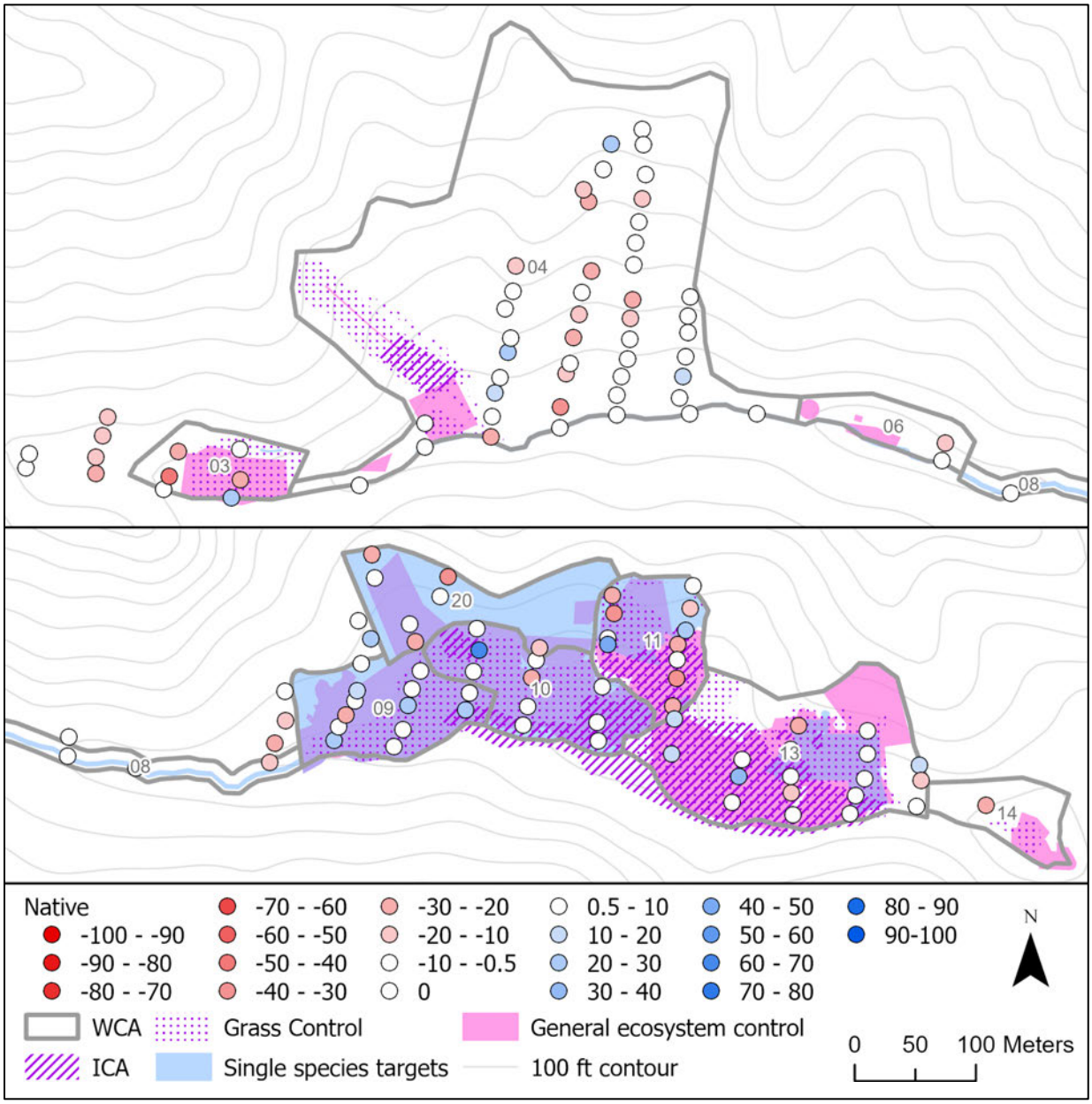


**Figure 14:** Locations of weed control efforts in relation to change in percent cover for native understory vegetation in monitored plots between 2010 and 2022 in the west (top) and east (bottom) halves of ʻŌhikilolo Upper MU. Blue indicates beneficial change, and red depicts worsening conditions. Cover change of 0 indicates there was no change in percent cover. Cover change of 0 ± 10% remains uncolored, as absolute cover change of ≤ 10% is not recognized.

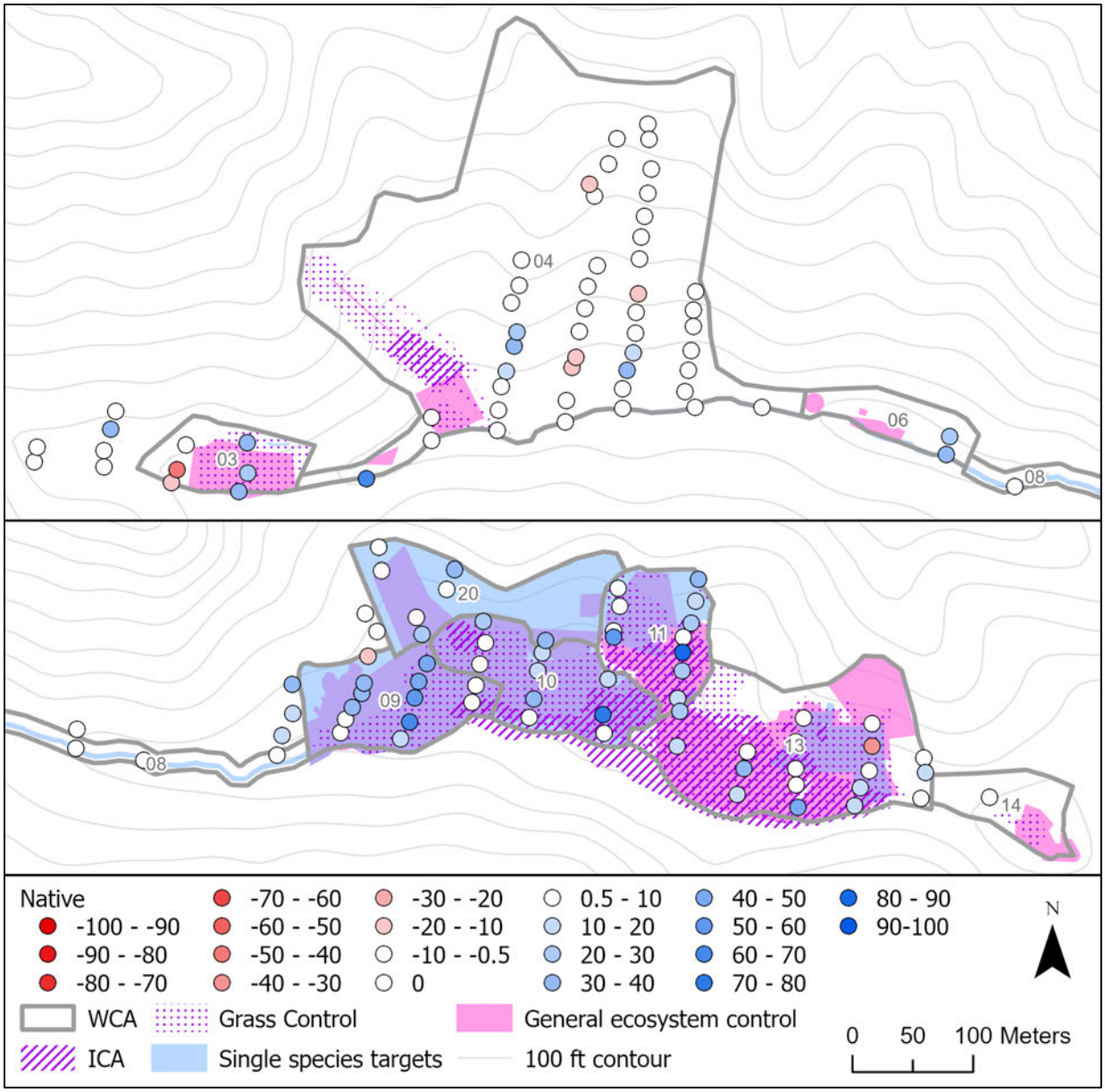


**Figure 15:** Locations of weed control efforts in relation to change in percent cover for native canopy vegetation in monitored plots between 2010 and 2022 in the west (top) and east (bottom) halves of ʻŌhikilolo Upper MU. Blue indicates beneficial change, and red depicts worsening conditions. Cover change of 0 indicates there was no change in percent cover. Cover change of 0 ± 10% remains uncolored, as absolute cover change of ≤ 10% is not recognized.

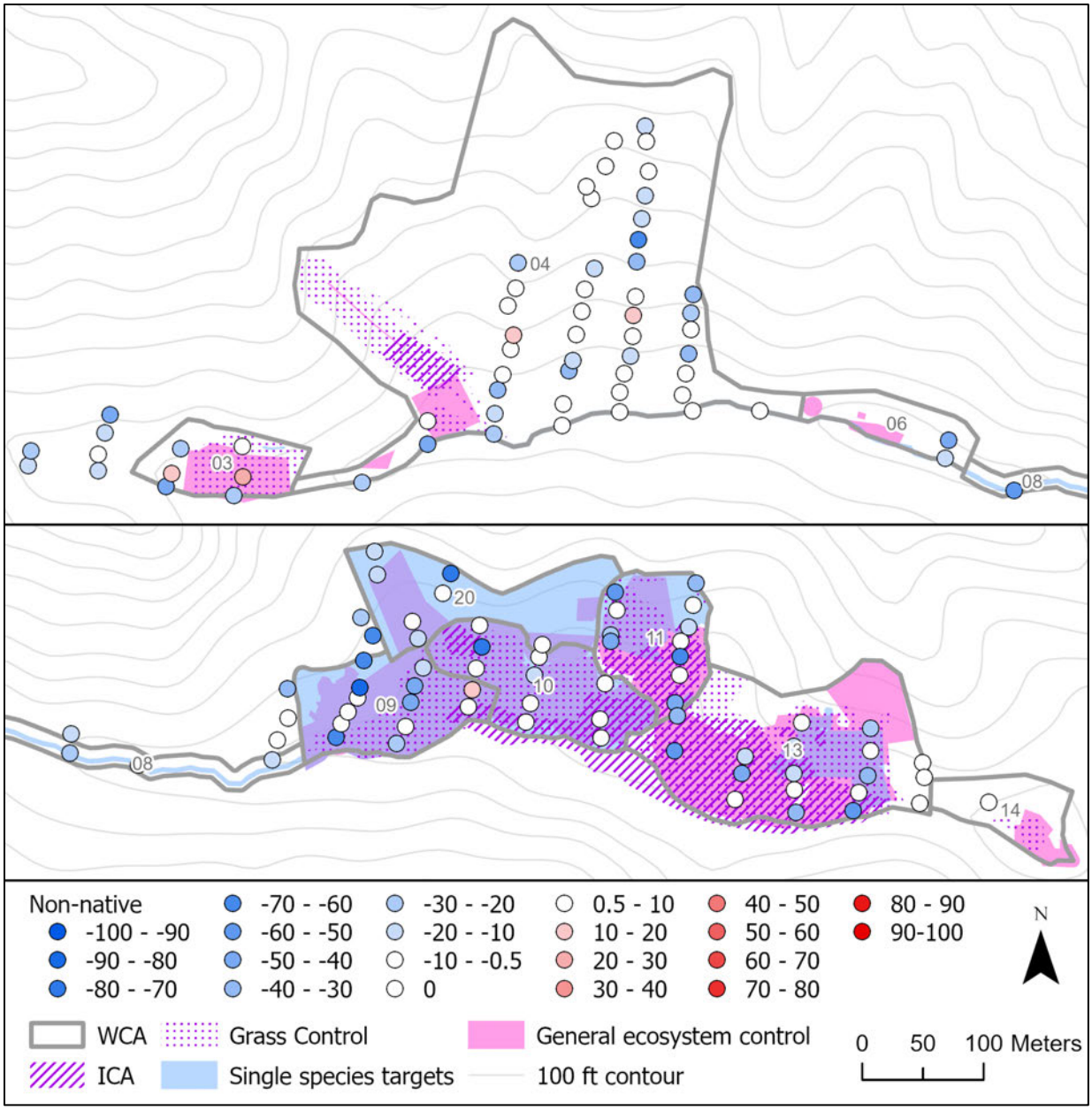


**Figure 16:** Locations of weed control efforts in relation to change in percent cover for non-native understory vegetation in monitored plots between 2010 and 2022 in the west (top) and east (bottom) halves of ʻŌhikilolo Upper MU. Blue indicates beneficial change, and red depicts worsening conditions. Cover change of 0 indicates there was no change in percent cover. Cover change of 0 ± 10% remains uncolored, as absolute cover change of ≤ 10% is not recognized.

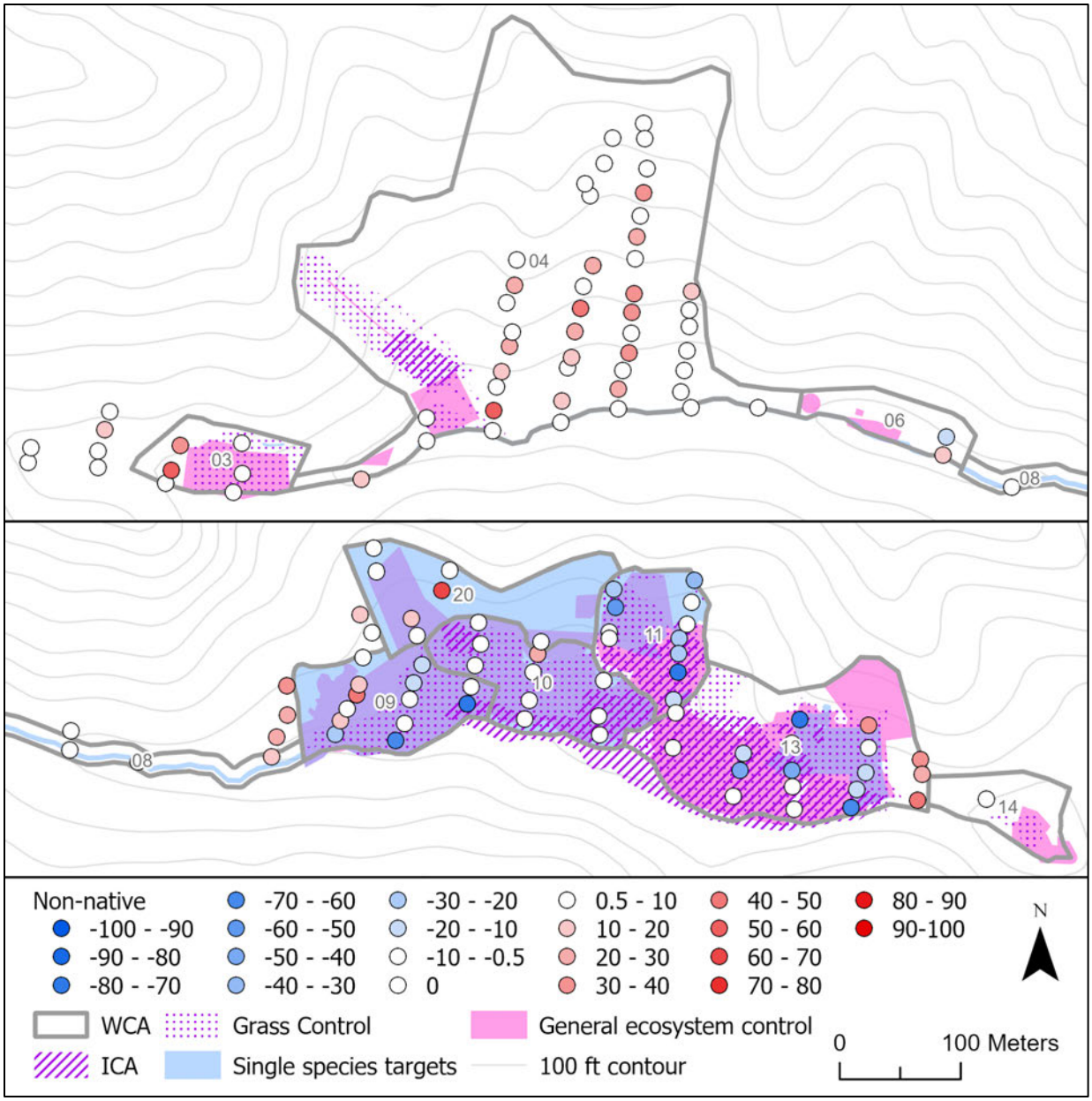


**Figure 17:** Locations of weed control efforts in relation to change in percent cover for non-native canopy vegetation in monitored plots between 2010 and 2022 in the west (top) and east (bottom) halves of ʻŌhikilolo Upper MU. Blue indicates beneficial change, and red depicts worsening conditions. Cover change of 0 indicates there was no change in percent cover. Cover change of 0 ± 10% remains uncolored, as absolute cover change of ≤ 10% is not recognized.

**Table 12:** Percent of plots that fell within weeded areas at ʻŌhikilolo Upper MU between 2010 and 2022.

| Weed control type | % plots weeded |
|---|---|
| WCA (all) | 53.8 |
| General ecosystem | 39.2 |
| Grass | 34.6 |
| Target species | 41.5 |
| ICA | 15.4 |

Native ecosystem restoration efforts began at ʻŌhikilolo Upper Priority Area 1 on a small scale between 2002 and 2013 with common native (5 taxa) outplantings (298 plants), experimental seed sows, and transplants. GIS and database tracking of restoration efforts did not occur during that time. More formal efforts (tracked in GIS and ANRPO database) began in 2016 and expanded over time to include chainsaw removal of non-native canopy along with the restoration of common native plants (20 taxa, 2,596 outplants) (Table 13). Restoration actions between 2016 and 2022 have occurred across 13% of Priority Area 1, and crossed through 20% of the monitoring plots in Priority Area 1 (Figure 18).

**Table 13:** Common native taxa outplanted at ʻŌhikilolo Upper MU prior to vegetation monitoring in 2022.

| Taxon | 2016-01-13 | 2017-12-27 | 2018-03-14 | 2019-03-12 | 2019-11-20 | 2020-08-12 | 2020-12-01 | 2021-12-15 | 2022-03-22 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| *Acacia koa* | | | 263 | 230 | 169 | | 49 | 98 | 73 | **882** |
| *Alyxia stellata* | 1 | | | | | | | 21 | | **22** |
| *Antidesma platyphyllum* | | | | | | | | 28 | 14 | **42** |
| *Carex wahuensis* | | | | | 98 | 49 | 30 | 14 | | **191** |
| *Coprosma foliosa* | | | | | | | 6 | | | **6** |
| *Deparia prolifera* | | | | | 21 | | | | | **21** |
| *Dianella sandwicensis* | | | | | 8 | | 25 | 49 | | **82** |
| *Dodonaea viscosa* | 35 | 30 | 63 | | 166 | | | 31 | | **325** |
| *Kadua affinis* | | | | | 54 | | | 21 | 11 | **86** |
| *Lysimachia hillebrandii* | | | | 31 | 17 | | 19 | | | **67** |
| *Metrosideros polymorpha* | 54 | 12 | | 20 | | | | 29 | 35 | **150** |
| *Metrosideros tremuloides* | | | | | | | | 4 | 63 | **67** |
| *Microlepia strigosa* | | | | | | | 64 | | | **64** |
| *Myoporum sandwicense* | | 28 | 6 | | | | | | | **34** |
| *Myrsine lessertiana* | 156 | | | | 56 | | | 8 | | **220** |
| *Sadleria cyatheoides* | | | | | | 42 | 40 | 8 | | **90** |
| *Sophora chrysophylla* | | | 25 | 93 | 13 | | 6 | | | **137** |
| *Vaccinium calycinum* | 4 | | | | | | 15 | | | **19** |
| *Vaccinium dentatum* | | 5 | | | | | | | | **5** |
| *Wikstroemia oahuensis* var. *oahuensis* | | | | 86 | | | | | | **86** |
| **Total** | **250** | **75** | **357** | **460** | **602** | **91** | **254** | **311** | **196** | **2596** |

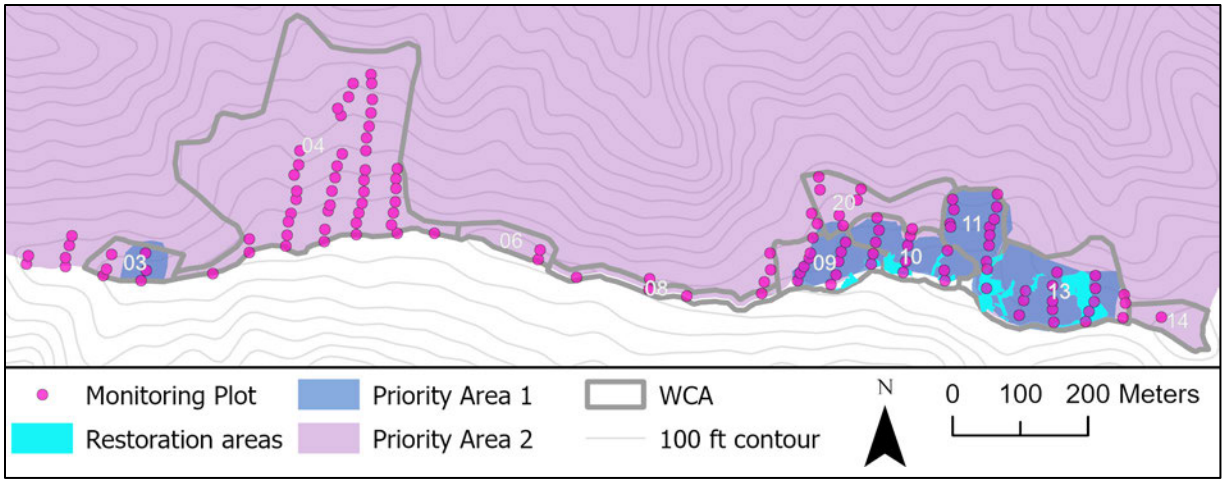


**Figure 18:** Locations of restoration actions at ʻŌhikilolo Upper MU between 2010 and 2022 in relation to monitored plots.

Comparison of vegetation change in plots that fell within vs. outside of weeded and restoration areas indicated that vegetation management had positive influences of vegetation change between 2010 and 2022. General ecosystem weeding had a significant influence on the native understory (GLM: $p = 0.008$; cover declined in unweeded areas, but did not decline in weeded areas), native canopy (GLM: $p < 0.001$; cover increased both inside and outside of weeded areas, but more so in weeded areas), and non-native canopy (GLM: $p < 0.001$; cover decreased in weeded areas, but increased in unweeded areas), but did not significantly influence the non-native understory (cover decreased similarly inside and outside of weeded areas) (Figure 19). Restoration had a significant influence on the native understory (GLM: $p = 0.007$; cover increased in restoration areas, but there was no change outside restoration areas) and non-native canopy (GLM: $p < 0.001$; cover decreased in restoration areas, and increased outside restoration areas), but did not significantly influence the non-native understory (cover decreased similarly inside and outside of restoration areas) or native canopy (cover increased similarly inside and outside of restoration areas) (Figure 20). These influences were in part a reflection of the effects of general ecosystem weeding, as among weeded plots, trends for native understory and non-native canopy did not differ significantly inside vs. outside of restoration areas. However, within general ecosystem weeded areas, restoration had a significant influence on native understory shrubs (GLM: $p = 0.009$; cover increased more in restoration areas than outside restoration areas), but did not significantly influence native understory ferns or grasses/sedges (trends in restoration areas were similar to declining trends outside restoration areas) (Figure 21). *Acacia koa* canopy frequency change was significantly influenced by restoration efforts in Priority Area 1 ($p = 0.004$; frequency increased more in restoration areas than outside restoration areas) (Figure 22). The decrease in *S. terebinthifolius* canopy cover in Priority Area 1, vs. the overall increase in cover for the MU, was presumed to be associated with weeding efforts. Indeed, the interaction of WCA weeding (all forms) with Priority Area had a significant influence on *S. terebinthifolius* canopy cover change (GLM: $p < 0.001$; cover decreased in weeded areas and Priority Area 1, but increased in unweeded areas and Priority Area 2), and was the best explanatory model for *S. terebinthifolius* canopy cover change, as canopy weeding for that taxon occurred with both general ecosystem and target weeding, and mostly occurred in Priority Area 1.

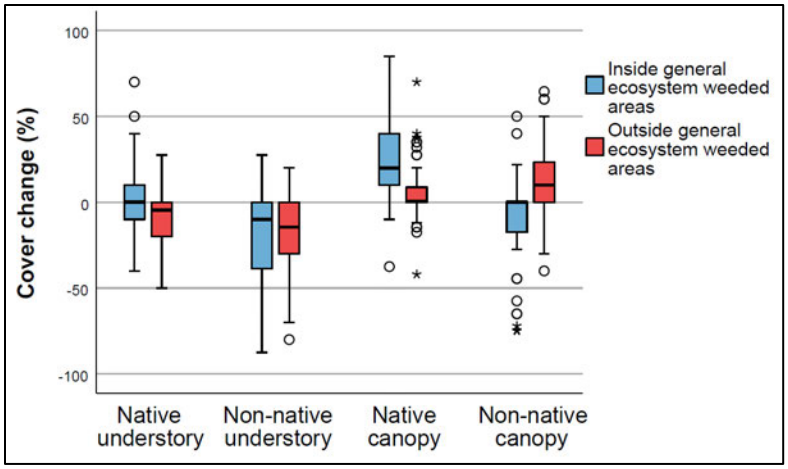


**Figure 19:** Boxplots of cover change between 2010 and 2022 inside and outside of general ecosystem weeded areas at ʻŌhikilolo Upper MU. Values > 0 represent increased cover in plots, while those < 0 represent decreased cover. Values equaling 0 represent no change.

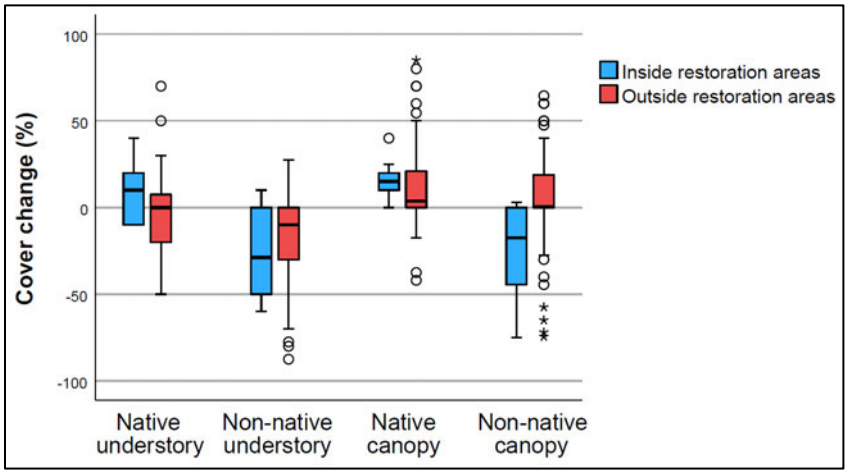


**Figure 20:** Boxplots of cover change between 2010 and 2022 inside and outside of restoration areas at ʻŌhikilolo Upper MU. Values > 0 represent increased cover in plots, while those < 0 represent decreased cover. Values equaling 0 represent no change.

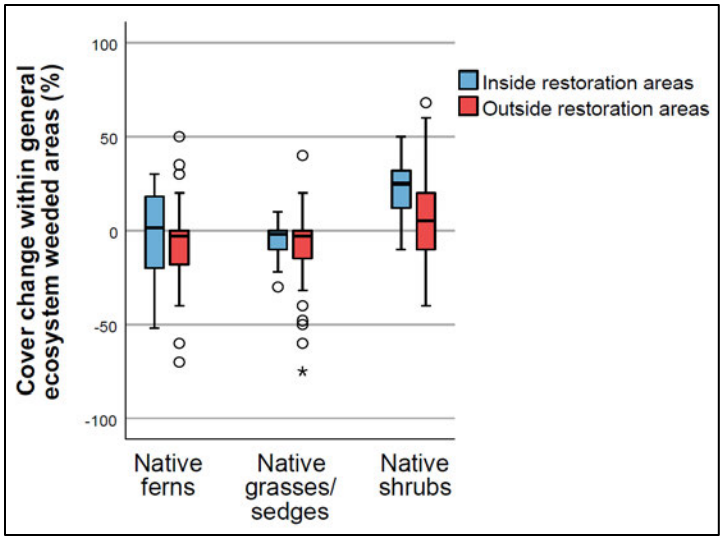


**Figure 21:** Boxplots of cover change within general ecosystem weeded areas for native understory categories between 2010 and 2022 inside and outside of restoration areas at ʻŌhikilolo Upper MU. Values > 0 represent increased cover in plots, while those < 0 represent decreased cover. Values equaling 0 represent no change.

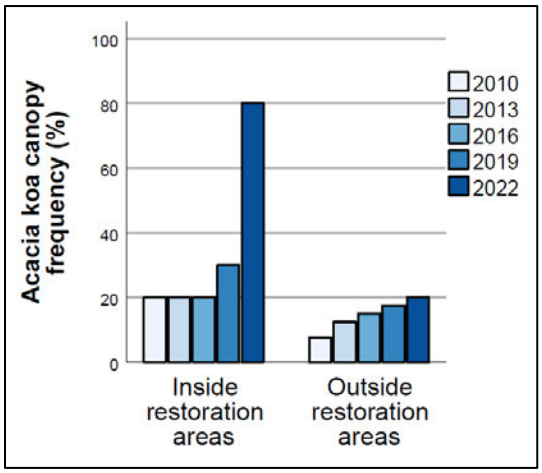


**Figure 22:** *Acacia koa* canopy frequencies over time at ʻŌhikilolo Upper Priority Area 1 between 2010 and 2022 inside and outside of restoration areas. Frequency values represent the proportion of plots in which species are present.

## SUMMARY AND DISCUSSION

At ʻŌhikilolo Upper MU, management goals were met for percent cover of non-native understory and canopy. Goals remained unmet for native understory and canopy cover. At ʻŌhikilolo Upper Priority Area 1, all goals were met for native and non-native understory and canopy. There were a number of significant differences in vegetation data over the years, many of which were relatively small. The most noteworthy changes are included in Table 14 below.

**Table 14:** Summary of notable changes since 2010 at ʻŌhikilolo Upper MU, and at Priority Area 1. Native taxa are in boldface. Arrows indicate increase (↑) or decrease (↓).

| | | |
|---|---|---|
| MU | | |
| Categorical cover | ↑ | Native canopy, total canopy |
| | ↓ | Native grasses/sedges, native understory, non- native shrubs, non-native understory |
| Richness | ↑ | Native canopy |
| Frequency | ↑ | Understory **CopFol, MetPol, WikOah,** CliHir, RubRos<br>Canopy **CopFol, DodVis, MetPol, MetTre, MyrLes** |
| | ↓ | Understory **BidTor, DorDec,** CenEry, FesBro, KalPin, LytMar, SetPar, SpoInd |
| Species cover | ↑ | Understory **FreArb**<br>Canopy **DodVis, MetPol, MetTre, MyrLes,** SchTer |
| | ↓ | Understory **CarMey, PteAqu,** AgeAde, AgeRip, BleApp, SchTer |
| General ecosystem weeding | Native understory cover declined in unweeded areas, but did not decline in weeded areas | |
| | Native canopy cover increased both inside and outside of weeded areas, but more so in weeded areas | |
| | Non-native canopy cover decreased in weeded areas, but increased in unweeded areas | |
| Restoration actions | Within general ecosystem weeded areas, native understory shrub cover increased more in restoration areas than outside restoration areas | |
| WCA weeding (all) and Priority Area | SchTer canopy cover change influenced by priority area (GLM: $p < 0.001$); cover decreased in weeded areas and Priority Area 1, but increased in unweeded areas and Priority Area 2 | |
| Priority Area 1 | | |
| Categorical cover | ↑ | Native shrubs, native canopy |
| | ↓ | Native ferns, native grasses/sedges, non-native understory, non-native canopy |
| Richness | ↑ | Native canopy |
| Frequency | ↑ | Understory **AcaKoa, CopFol, KadAff, PipAlb, PsyMar, WikOah**, CliHir, RubRos<br>Canopy **AcaKoa, AlySte, CibCha, CopFol, DodVis, MyrLes** |
| | ↓ | Understory **BidTor, MicStr,** AgeAde, FesBro, KalPin, LytMar, SchTer<br>Canopy SchTer |
| Species cover | ↑ | Understory **FreArb**<br>Canopy **AcaKoa, CibCha, DodVis, FesBro, MetPol, MyrLes** |
| | ↓ | Understory **CarMey,** BleApp, MelMin, Schter<br>Canopy SchTer |

The many notable changes in vegetation at ʻŌhikilolo Upper MU since 2010 include both beneficial and unfavorable ones. Vegetation change differed greatly in Priority Area 1, where the vast majority of vegetation management occurs, compared to Priority Area 2, where management has been largely limited to ungulate exclusion (Figures 23-25). Native understory declined in Priority Area 2, but was overall unchanged in Priority Area 1. Non-native understory declined in both areas, perhaps an artifact of drying conditions during monitoring in 2022. Native canopy cover increased in Priority Area 1 as well as Priority Area 2, but more so in Priority Area 1. Non-native canopy cover (*S. terebinthifolius*) declined in Priority Area 1, but increased in Priority Area 2.

Priority Area 1 is the first among all ANRPO managed areas undergoing long term belt plot monitoring to meet all management cover goals for native and non-native cover, which is particularly notable given that there have been periods of time when MU access was limited in association with UXO issues and COVID-19, during which vegetation management efforts fell behind. In Priority Area 2, the only management cover goal that was met was for non-native canopy, but given the trend of increasing cover, it will likely not be met during the next monitoring interval. In Priority area 2, post-fencing and in the absence of ungulates, the landscape continues undergoing change, with increased canopy cover for both non-native (predominantly *S. terebinthifolius*) and native (predominantly *M. polymorpha* and *M.*

*tremuloides*) trees, though the degree of increased native canopy was smaller than that of non-native canopy (Figures 25 and 26). Notwithstanding, both *M. polymorpha* and *M. tremuloides* had significant increases in the canopy cover in Priority Area 2 (Wilcoxon signed rank test: $p = 0.011$ and $p = 0.000$, respectively), which is an encouraging sign for passive native canopy recovery following ungulate exclusion. These cover changes may differ geographically from *S. terebinthifolius*, as staff observed *Metrosideros* spp. expanding in previously open/eroded sites, and *S. terebinthifolius* more so in gulches.

Vegetation management via weed control and restoration has had substantial impacts on vegetation. Weed management had beneficial impacts on native understory, native canopy, and non-native canopy. Though restoration efforts are still in the early stages, they have begun to have a discernable impact, as native understory shrub cover already benefited from these efforts (Figure 27). Similar benefits for native fern and grasses/sedges will be dependent on an increased emphasis on these taxon types during future restoration outplanting. Beneficial change in the native canopy in restoration areas is anticipated as outplants continue to grow.

Notably problematic weed taxa include *C. hirta* and *E. stipoides*. *Clidemia hirta* continued to spread, despite concerted efforts for control via targeted sweeps, though control measures are likely helping to slow the spread (Figure 28). Recent research found that *C. hirta* is the most prevalent taxon among seeds spread by both non-native and native birds (Vizentin-Bugoni *et al*. 2019), and *C. hirta* seed rain from bird dispersal is high even in areas of very low *C. hirta* presence (Hruska 2019). *Ehrharta stipoides* has continued to persist in three out of the four ICAs at ʻŌhikilolo, despite regular control for this taxon.

The limited recruitment of *E. bifidus* is of concern, given how prevalent it is in the canopy in Priority Area 1. The fruits take a long time to mature, and it is rare to see mature fruit at ʻŌhikilolo. This taxon has been challenging to propagate from seeds in the laboratory, with very limited germination only occurring upon excision of the seed from the fruit endocarp (ANRPO 2022b). Germination research is underway in the ANRPO Seed Lab, and it is hoped that the combination of seed excision and the use of gibberellic acid will prove successful for propagation.

There are some concerns about the monitoring transects regarding safety and potential negative impacts to native habitat. In the Priority Area 2 in particular, transects are steep with precarious footing, crumbling terrain, landslides, steep drop-offs, and very steep areas with insufficient hand or footholds adjacent large cliffs (Figure 29). A few plots were eliminated in 2022 due to staff safety concerns (two in Priority Area 2, and one in Priority Area 1), and staff suggested that several others, mainly in Priority Area 2, be considered for elimination. Staff also expressed concerns about disturbance to native vegetation in Priority Area 1 along monitoring transects from trampling as well as potential spread of weeds into those areas. Monitoring Priority Area 1 plots less frequently may allow time for any disturbance to recover, and provide fewer opportunities for weeds to be spread around. Likewise, monitoring Priority Area 2 less frequently, would reduce potential risks to staff safety.

**Figure 23:** Contrasting habitats of Priority Area 1 (top), with dense native dominated understory and canopy; and Priority Area 2 (bottom), dominated by *Schinus terebinthifolius* and non-native grass (bottom).

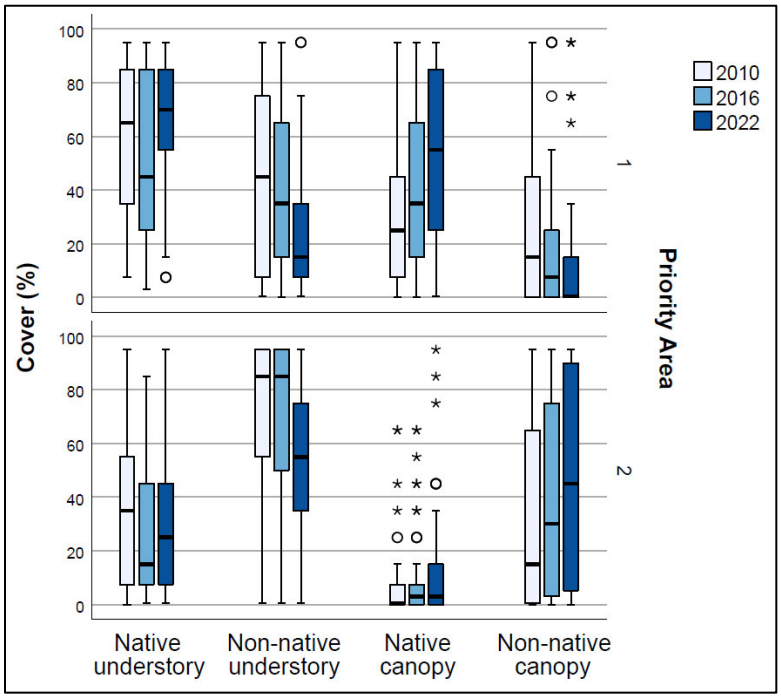


**Figure 24:** Boxplots for cover of native and non-native understory and canopy over time by Priority Area.

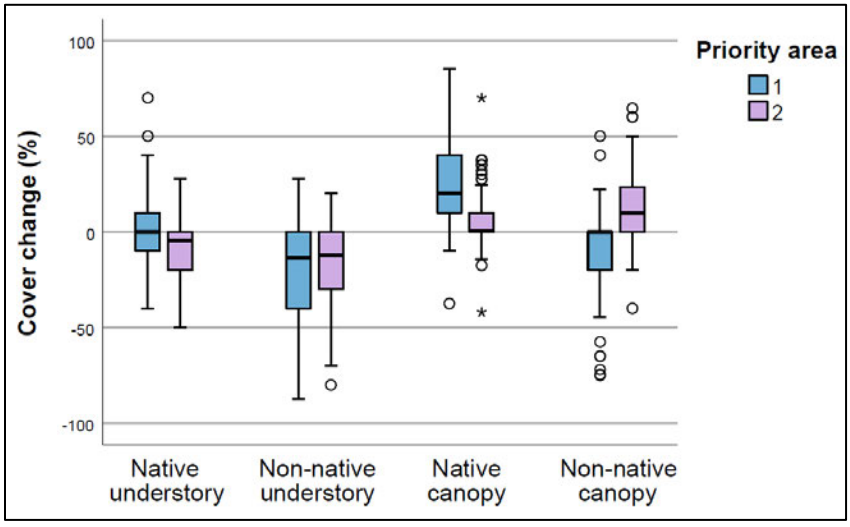


**Figure 25:** Boxplots for cover change between 2010 and 2022 for native and non-native understory and canopy over time by Priority Area.

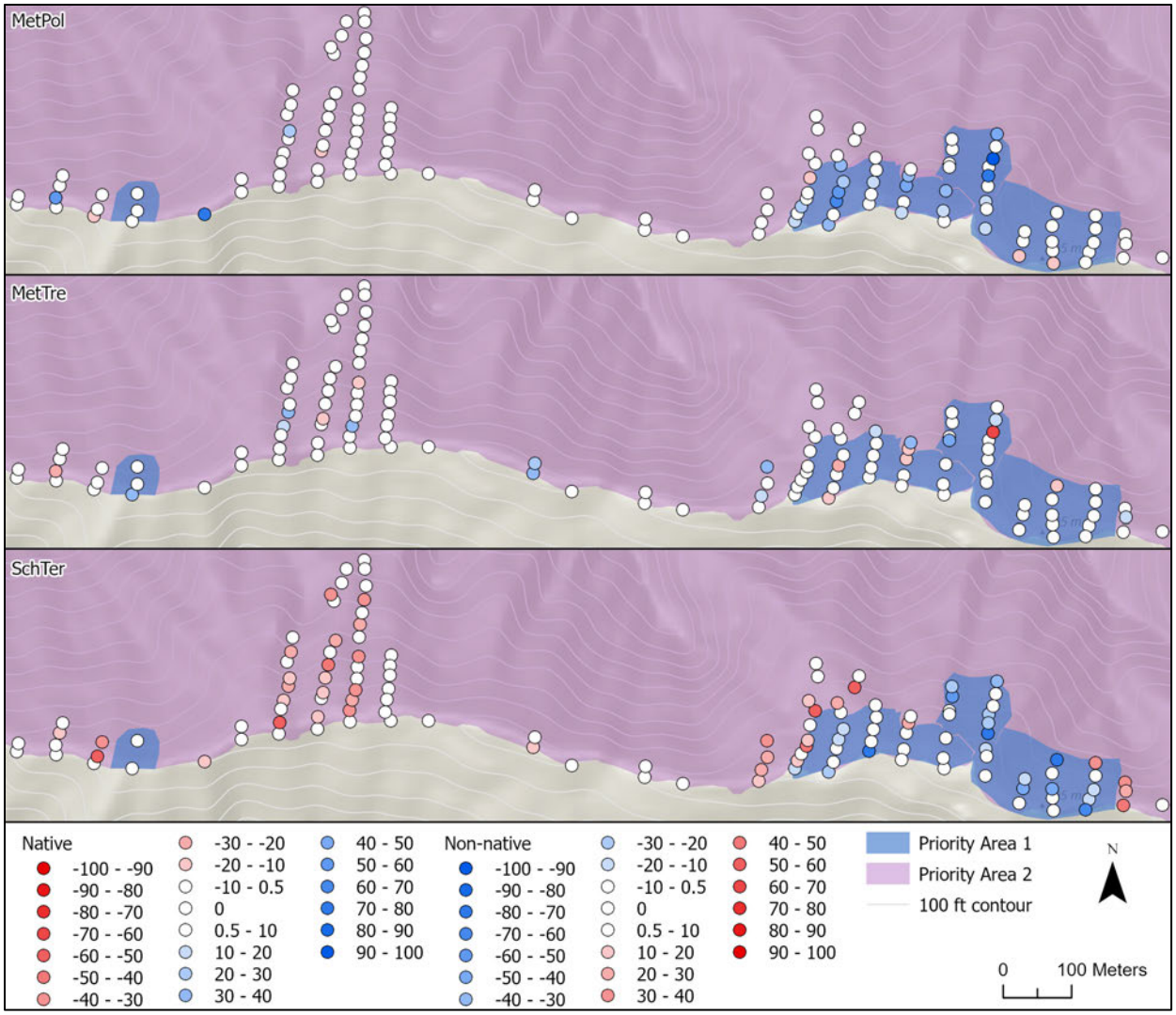


**Figure 26:** Locations of canopy cover change for *Metrosideros polymorpha*, *M. tremuloides*, and *Schinus terebinthifolius* at ʻŌhikilolo Upper MU between 2010 and 2022. Color gradients are inverted for native and non-native vegetation, such that blue indicates beneficial change, and red depicts worsening conditions. Cover change of 0 indicates there was no change in percent cover. Cover change of 0 ± 10% remains uncolored, as absolute cover change of ≤ 10% is not recognized.

**Figure 27:** Photographs of a monitoring plot within a restoration area in 2016 (top) prior to *Schinus terebinthifolius* clearing and common native outplanting, and in 2022 (bottom) showing rapid growth of *Acacia koa*.

**Figure 28:** Photograph of a monitoring plot with *Clidemia hirta* becoming well established at ʻŌhikilolo Upper MU.

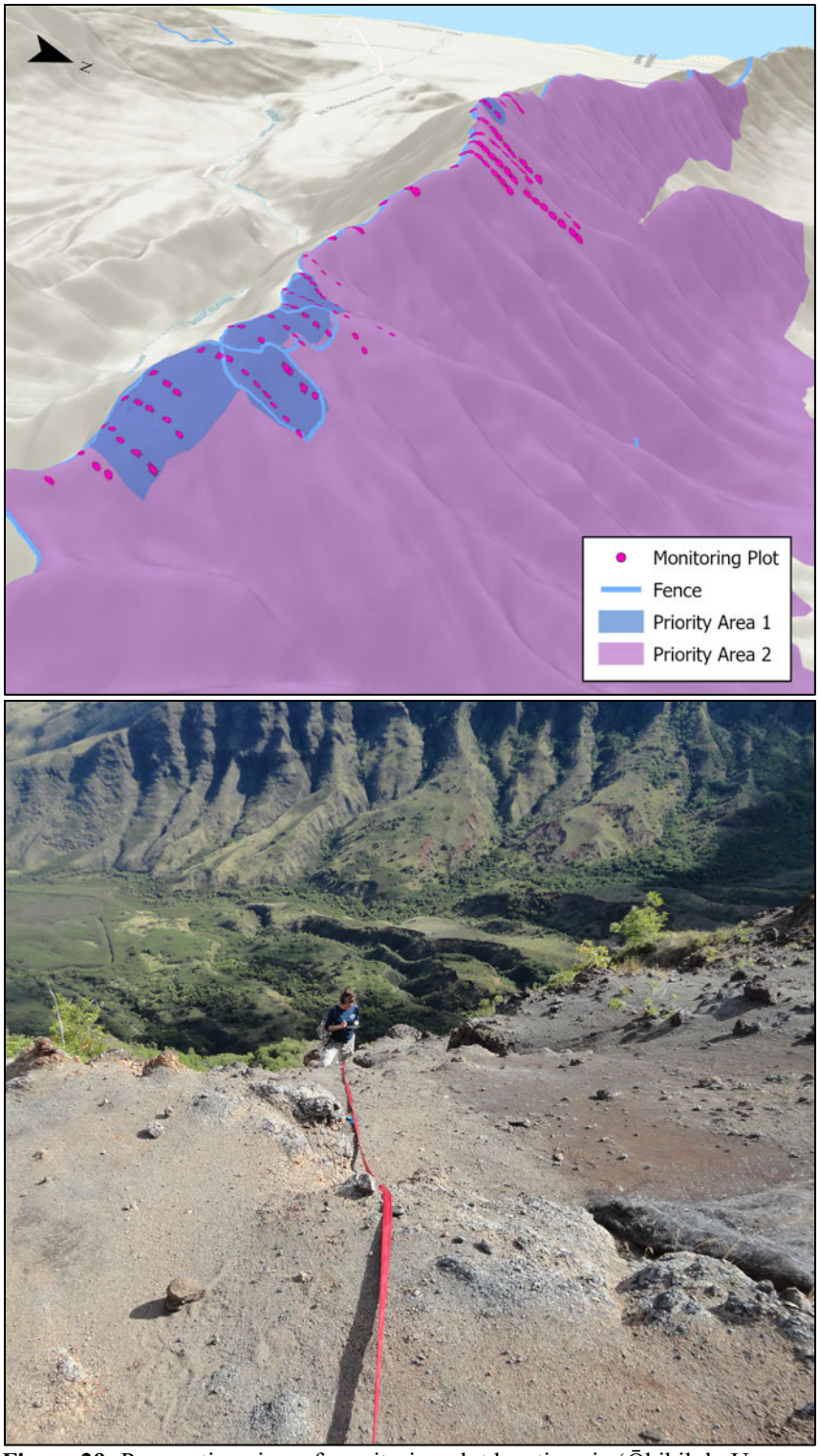


**Figure 29:** Perspective view of monitoring plot locations in ʻŌhikilolo Upper MU (top), and image showing a steep, crumbly, and eroded plot at the top of a monitoring transect in Priority Area 2, with staff member Brenna Keefe collecting data (bottom).

## RECOMMENDATIONS

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

- Continued planned general ecosystem weeding at rare taxa and restoration sites, grass control, and ICA control; discuss priorities and strategies for general ecosystem weeding outside of rare taxa and restoration sites.
- Consider strategies and timelines for continued and expanded native ecosystem restoration efforts where appropriate, to include greater representation of ferns, grasses, and sedges; consider restoration for the purposes of future rare plant reintroduction; consider use of jute mat seeded with common natives in eroded areas.
- Discuss what areas in Priority Area 2 may be good habitat in the future (utilizing L. Fortini climate change models for rare taxa) for rare plant reintroductions; consider that under the new consultation, management of *D. forbesii* in Priority Area 2 may be required.
- Continued assessment of germination techniques and embryo viability for *E. bifidus*. Research may also be needed to determine if plants are pollinator limited.
- Explore the potential for improved management strategies for *E. stipoides* and *C. hirta*.
    - Glyphosate is effective for *E. stipoides*, and seed longevity is short (one year), but frequent and thorough checks are required as plants are cryptic, recruitment is rapid, and seeds are easily spread. Per ANRPO Natural Resource Conservation Manager, eradication could be reached within 2-3 years with 6 ICA checks per year.
    - A more selective approach may be needed for *C. hirta*, prioritizing where to manage, and targeting hotspots. Biocontrols may be necessary. Consider releases of existing biocontrol if it is not already present, and support efforts to find new and more effective biocontrol.
- In Priority Area 1 WCAs, continue to implement species sweeps every 2-3 years for canopy and other target weeds that take years to mature, including *P. cattleianum*, *T. ciliata*, *S. campanulata*, *G. robusta*, *A. columnaris*, *Sideroxylon persimile*, and *C. burmannii* with a goal of controlling plants before they become reproductive. Consider target sweeps in Priority Area 2 areas that abut Priority Area 1.
- Discuss what if any management can/should happen for Priority Area 2, e.g. control of *S. terebinthifolius* near *Metrosideros* spp. in less steep places to prevent native trees from being overtaken by invasive ones. Consider to what extent this type of landscape level work is a priority, weighed against other actions at ʻŌhikilolo and other MU.
- Consider sweeps for emergent canopy *G. robusta* in Priority Area 2.
- Continue to target *Triumfetta semitriloba* on trails and fencelines, to reduce likelihood for staff to act as vectors.
- Target *Erigeron karvinskianus* to prevent its spread (requires foliar sprays).
- Consider aerial control of *T. ciliata.*
- Introduce *Tectococcus ovatus* biocontrol on *P. cattleianum* in surrounding areas, such as the Lower Mākua portion of ʻŌhikilolo MU, to reduce spread of *P. cattleianum* into ʻŌhikilolo Ridge region.
- Consider changing monitoring schedule to every 5 years for Priority Area 1, and every 10 years for the MU. Potential changes in monitoring frequencies of other ANRPO MU should be considered concurrently, to accommodate logistical considerations for yearly monitoring schedules. The boundaries of Priority Area 1 could also be reconsidered, if it no longer reflects current and future management plans, and plots monitored in association with Priority Area 1 could likewise be added or removed in accordance with any boundary changes.
- Consider the potential for supplementing plots with aerial imagery analysis.

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ARMY NATURAL RESOURCES PROGRAM ON O‘AHU
MONITORING PROGRAM

# SOIL STABILIZATION AND TREE STATUS IN ASSOCIATION WITH IPA CONTROL OF *MORELLA FAYA* SEVEN YEARS POST-TREATMENT AT PALIKEA

## INTRODUCTION

Incision Point Application (IPA) herbicide treatment of problematic non-native trees allows Army Natural Resources Program on O‘ahu (ANRPO) staff to effectively treat numerous individuals over a large area in a relatively short amount of time, with very small doses of pesticides. *Morella faya* is common throughout Palikea, and due to its ecosystem altering characteristics, is on the Hawai‘i Noxious Weed List, and considered a high risk weed species (Division of Plant Industry 2003; Hawai‘i-Pacific Weed Risk Assessment 2009). Vegetation monitoring of Palikea Management Unit (MU) in 2014 determined *M. faya* to be the second most frequently encountered non-native tree within the MU (45% frequency), after *Schinus terebinthifolius* (63% frequency) (ANRPO 2014). Recommendations were made for partial canopy thinning/removal of this species, as it is one of the more easily managed canopy weeds, and has infrequent recruitment. Large *M. faya* trees (197 total) were selectively treated using IPA in 2015 at Palikea. This was the first round of multiple selective treatments that may be conducted, pending further discussion of management strategies for this taxon at Palikea. Understory vegetation change in association with IPA treatment of *M. faya* was documented (baseline and Years 1 and 4 post-treatment) for a subset of treated trees at Palikea (ANRPO 2017, 2021a) (Figure 1). Results from this indicated that cover change below treated *M. faya* trees was a reflection of changes occurring similarly elsewhere in the MU (not in association with IPA control), as documented separately by MU-scale vegetation monitoring (ANRPO 2021b). The potential for destabilized soil on steep slopes following tree root degradation has been a concern, as this was observed during monitoring of one sampled tree in Year 4, which could not be safely accessed due to the potentially unstable nature of the slope beneath the tree at that time. There have been a few landslides at Palikea in recent years, one or more of which may have been at least partially attributable to IPA treatment of *M. faya.* Monitoring of the sampled trees was conducted in April 2023 (Year 7) to assess soil stabilization, and to document tree mortality and remaining structure.

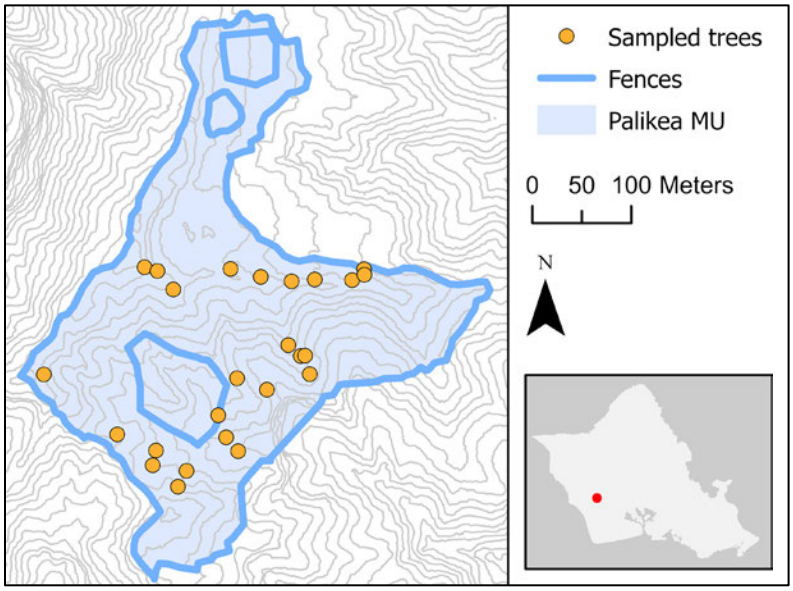


**Figure 1:** Locations of IPA controlled *Morella faya* trees sampled for monitoring at Palikea.

## METHODS

The overall health (noted as healthy, moderate, poor, or dead) of trees and defoliation ranking of 1 to 4 (1: 100%, 2: > 50%, 3: < 50%, and 4: 0% defoliation) as per Leary et al. (2013) was documented to assess treatment efficacy. Tree structure was assessed by documenting the remaining degree of branching. Soil stability was visually assessed, and measurements of slope inclination were made for each sampled tree.

## RESULTS

By Year 7, most sampled *M. faya* trees were dead (Figure 2), defoliated (Figure 3), and lost most branches (Figures 4 and 5). The few remaining live trees persisted via basal or side sprouts along the main trunk. Median slope inclination was 47° (+/- 3.0 SE) and ranged from 25° to 80°. Only one landslide was documented (this was the same tree that could not be safely accessed in Year 4), while 84% of treated trees had no apparent soil destabilization (Figure 6). The observed occurrence of soil destabilization was limited to trees on slopes with an inclination > 57°.

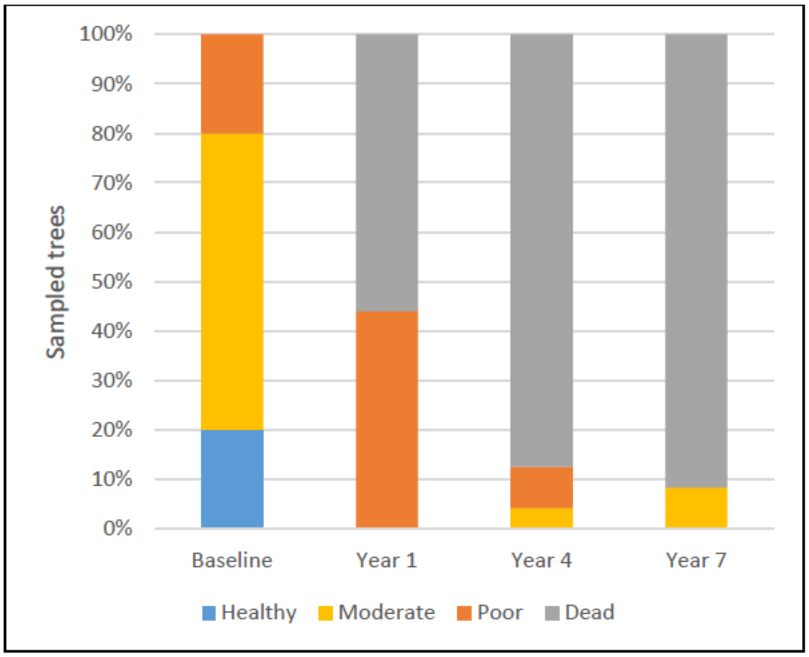


**Figure 2:** Health status of IPA treated trees over time. Baseline monitoring occurred 1-2 months after IPA application, and effects from herbicide were already apparent for several trees at that time.

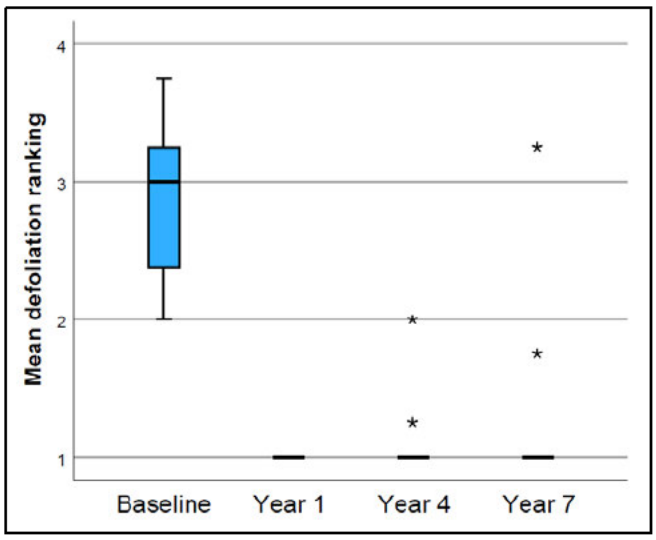


**Figure 3:** Boxplot of mean defoliation ranking among sampled trees (1: 100%, 2: > 50%, 3: < 50%, and 4: 0% defoliation) over time.

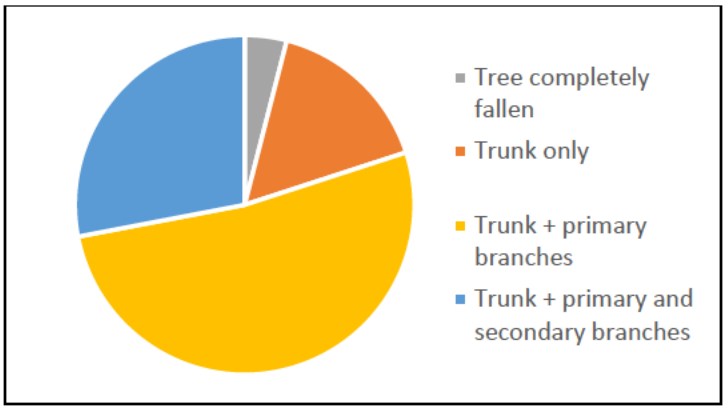


**Figure 4:** Remaining tree structure among sampled *Morella faya* trees by Year 7

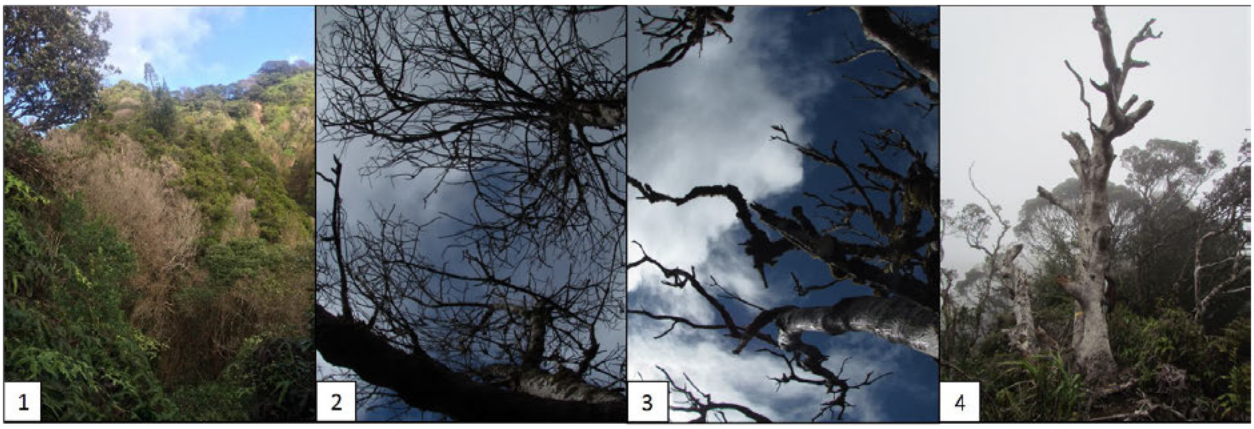


**Figure 5:** Photographs (from left to right) of various *Morella faya* trees in association with IPA treatment showing defoliation (1) of several trees amongst the surrounding vegetation and (2) within the canopy of a treated tree in Year 1; and (3) partial loss of limbs typical by Year 4, and (4) near total loss of limbs typical by Year 7.

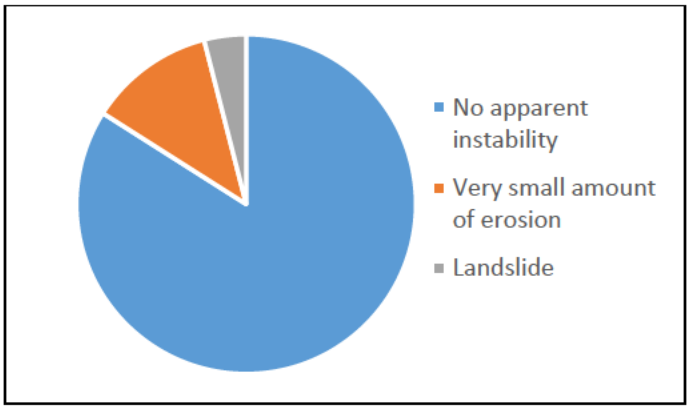

**Figure 6:** Soil stability of sampled *Morella faya* trees by Year 7.

## DISCUSSION

The documentation of gradual loss of limbs following IPA treatment of large *M. faya* trees has aided ANRPO's understanding of impacts following treatment of large trees, which could otherwise have a greater impact on vegetation below if loss of limbs occurred rapidly, or if the fully structured tree were to fall all at once. It was anecdotally observed that, compared with treated *M. faya* trees, fallen (untreated) *S. terebinthifolius* trees were more commonly observed, and resulted in more destruction and soil destabilization, as the entire tree tends to fall over, with tree roots and soil ripped from the ground, and vegetation crushed beneath.

There is potential for soil destabilization and landslides to occur on steeper slopes in association with IPA treated *M. faya* trees. Though destabilization and landslides may occur in association with other unrelated factors, efforts to mitigate the potential for landslides exacerbated by IPA treatment should be considered. Treatment of trees on steeper slopes should either be avoided altogether, or landslide mitigations should be attempted. This could include limb and trunk trimming one year post-treatment, when most small/tertiary branches have fallen off, but before trees become too weak to safely climb and trim with a chainsaw, so that the weight of the standing dead trees does not exacerbate soil destabilization. As tree-trimming is labor intensive, perhaps trimming could be prioritized for use only in select areas such as around/above restoration sites, rare plants, or other high value locations. Another option for trees on steep slopes is to fell them rather than using IPA. However, considerations would need to be made for potential large impacts on the surrounding vegetation. As soil below trimmed or felled trees on steep slopes may still become unstable following root degradation, future control of trees occurring on very steep slopes could be avoided altogether. Trees left untreated on steep slopes would not help with long term goals for target weed tree taxa, especially considering that much of Palikea consists of steep slope, so there may need to be considerations for how to address them at some point. Any resumption of IPA treatment (or other means of control) of trees should begin in areas with little risk of landslide, while considerations continue for how to manage trees on steep slopes. Considerations should also be made for common native tree restoration where needed to replace the canopy. Outplanting could most reasonably be done following limb and trunk trimming.

The extent to which further soil destabilization may occur with treated trees remains unknown. Additional monitoring could occur in Year 10 to document this along with remaining tree structure status.

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ARMY NATURAL RESOURCES PROGRAM ON OʻAHU
MONITORING PROGRAM

# POST-FIRE NATIVE WOODY VEGETATION MONITORING IN WEED CONTROL AREA LOWER ʻŌHIKILOLO-03, 2023

## INTRODUCTION

The Army Natural Resources Program on Oʻahu (ANRPO) conducts monitoring at ʻŌhikilolo Lower Management Unit (MU) within the Mākua Military Reservation (MMR) to assess cover change in native woody plant vegetation over time at the weed control areas (WCAs) surrounding the rare plant populations *Euphorbia celastroides* var. *kaenana* MMR-D (WCA Lower ʻŌhikilolo-01 and-02) and *Hibiscus brackenridgei* subsp. *mokuleianus* MMR-A and MMR-F (WCA Lower ʻŌhikilolo-03) using gigapixel panoramic imagery (www.gigapan.com) (Figure 1). These WCAs primarily consist of non-native grasses with scattered common and rare native shrubs. The surrounding habitat, dominated by invasive species *Leucaena leucocephala* and *Megathyrsus maximus*, is highly degraded and fire-prone. General ecosystem weeding within the WCAs has been ongoing since 2001, with intensive efforts to minimize fire fuel load from non-native grasses. Active restoration (outplanting) of common native plants within Lower ʻŌhikilolo-02 and Lower ʻŌhikilolo-03 began in 2016, and is ongoing (over 4200 total outplants). The majority of outplanted taxa consist of shrubs and trees. The intent of active restoration efforts is to improve and protect the habitat at these rare plant populations and to minimize the labor required for weed control. Replacing non-native grasses with native woody vegetation improves habitat, is presumed to reduce potential fire fuel around the rare plant populations, and potentially buffers the rare plant populations from fire. Weed control efforts controlling grass to mitigate potential fire fuel are extensive, and have required between 150 to 380 hours per year at the site over the last ten years. Expansive grass cutting/spraying is not conducive to native plant recruitment. While most ANRPO WCAs only have a small portion weeded within them annually, these ʻŌhikilolo Lower WCAs are weeded in their entirety every year, and usually several times during the year. Most of the efforts at ʻŌhikilolo Lower MU consist of controlling grasses and herbs. Woody invasives have relatively less recruitment here, and are controlled when seen. The objective of monitoring native woody vegetation cover at these locations is to document change in association with active restoration efforts along with natural recovery of *in situ* vegetation. Non-woody plants (grasses and herbs) were not monitored as cover of these plant types is much more variable than woody ones in association with rainfall levels, due to difficulties distinguishing native vs. non-native taxa in the imagery, and because the majority of outplants are woody taxa. Non-native cover was not monitored, as non-native shrub and tree cover is presumed to be minimal as a result of weeding efforts, and weedy non-woody cover may vary greatly in association the amount of time since the last weeding effort as well as rainfall levels, and may be difficult to distinguish from native non-woody cover.

In June 2022 a fire burned through a large portion of ʻŌhikilolo Lower MU, including WCA Lower ʻŌhikilolo-03 in its entirety (ANRPO 2022a). The majority of the vegetation at this WCA burned, though a patchy distribution of woody plants remained unburned or partially burned (ANRPO 2022b). To better document native woody vegetation survival post-fire at WCA Lower ʻŌhikilolo-03, monitoring was planned for the end of the following rainy season in 2023, as it was unknown to what extent plants impacted by the fire would recover.

# Image Redacted
# Sensitive Information
# Available Upon Request

**Figure 1:** Locations of weed control areas Lower ʻŌhikilolo-01, -02, and -03, showing GigaPan vantage points, areas with restoration actions prior to monitoring in 2023, and the extent of the June 2022 fire.

**METHODS**

Panoramic imagery was obtained for WCA Lower ʻŌhikilolo-03 in January 2016, March 2019, April 2022, June 2022, and March 2023 using a GigaPan Epic 100 robotic mount fitted with a Canon PowerShot SX30 IS digital camera in all years except for 2019, when a GigaPan Epic Pro with a Canon PowerShot SX60 was used. Imagery was taken from the same vantage point in all years. Because of the higher focal length of the camera used in 2019, a greater number of images was obtained that year. Panoramas were stitched using GigaPan Stitch Version 2.1.0161. Imagery was taken following WCA weeding and grass spraying as possible, such that WCA boundaries would be distinguishable, and any shrubs/trees (woody plants) identified within the WCA were presumed native, though in 2019 and 2023 weeding was less complete, and live grasses were still present. Imagery was taken during the same time of year (wet season), to mitigate seasonality influences, with the exception of the post-fire imagery in June 2022. In that panorama, vegetation cover may have been partially influenced by the dry summer conditions, though it is presumed that the fire was the predominant influence on cover change, given the magnitude of the burn which encompassed the entirety of the WCA.

Cover measurements were obtained from an arbitrary grid of sampled images within the panorama, encompassing approximately 56% of the WCA. Using Adobe Photoshop, a line drawing tool was used to estimate the proportion of woody plant cover in each sampled image. For Lower ʻŌhikilolo-03 post-fire images, measurements were made of the proportion of live foliated woody plant cover. Because some images partially included areas outside of WCA boundaries, only the portion of the image representing WCA area was used to obtain cover data. Cover measurements are from an oblique angle,

and do not represent horizontal ground cover. While cover data derived from an angled perspective likely differs from horizontal measurements, trends in cover change over time may be effectively tracked with imagery taken from the same vantage point.

Cover change was assessed using logistic regression. Data were weighted by the proportion of the image that fell within the WCA area. Cover and standard error estimates for each WCA were derived from logistic regression model predictions. Statistical analyses were performed using the software R, Version 4.2.2 (R Core Team 2022).

Re-monitoring of the three WCAs at ʻŌhikilolo Lower using GigaPan imagery occurs on a three-year interval. Re-monitoring should occur following weeding efforts as possible to ensure that shrubs in the imagery are native, and at the same time of year (wet season) to minimize seasonality influences. The next monitoring is planned for 2025.

## RESULTS

Immediately post-fire, 86% of the native woody cover was lost, as cover dropped from 46% in April 2022 to 6% in June 2022 (Figure 2). However, 14% of the burned vegetation recovered by March 2023, as cover rose significantly to 12% (GLM: $p < 0.001$). Ultimately, 26% of the native woody cover survived the fire. Expanded cover between 2016 and 2022 (pre-fire) is visible in the imagery for WCA Lower ʻŌhikilolo-03, while the devastating impacts from the fire are strikingly visible in the post-fire imagery (Figures 3) and in one example of a photopoint (Figure 4) from that WCA. Areas previously occupied by native woody vegetation were largely replaced with *M. maximus* and other weedy grasses (Figure 5). However, it is notable that approximately three-quarters of the larger *Erythrina sandiwicensis* trees survived.

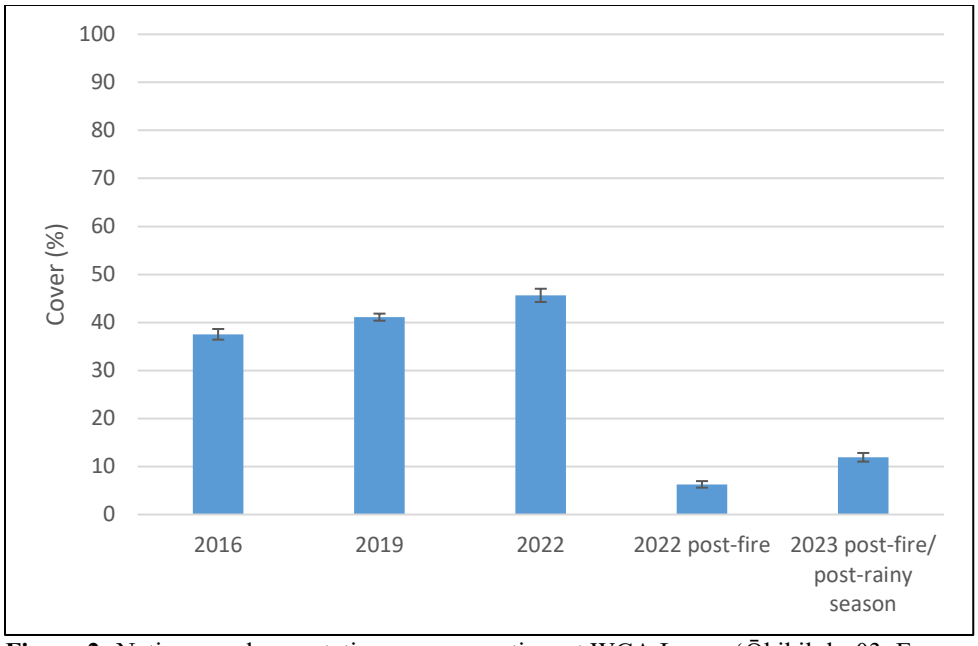


**Figure 2:** Native woody vegetation cover over time at WCA Lower ʻŌhikilolo-03. Error bars represent standard error. Cover and standard error estimates derived from logistic regression model predictions.

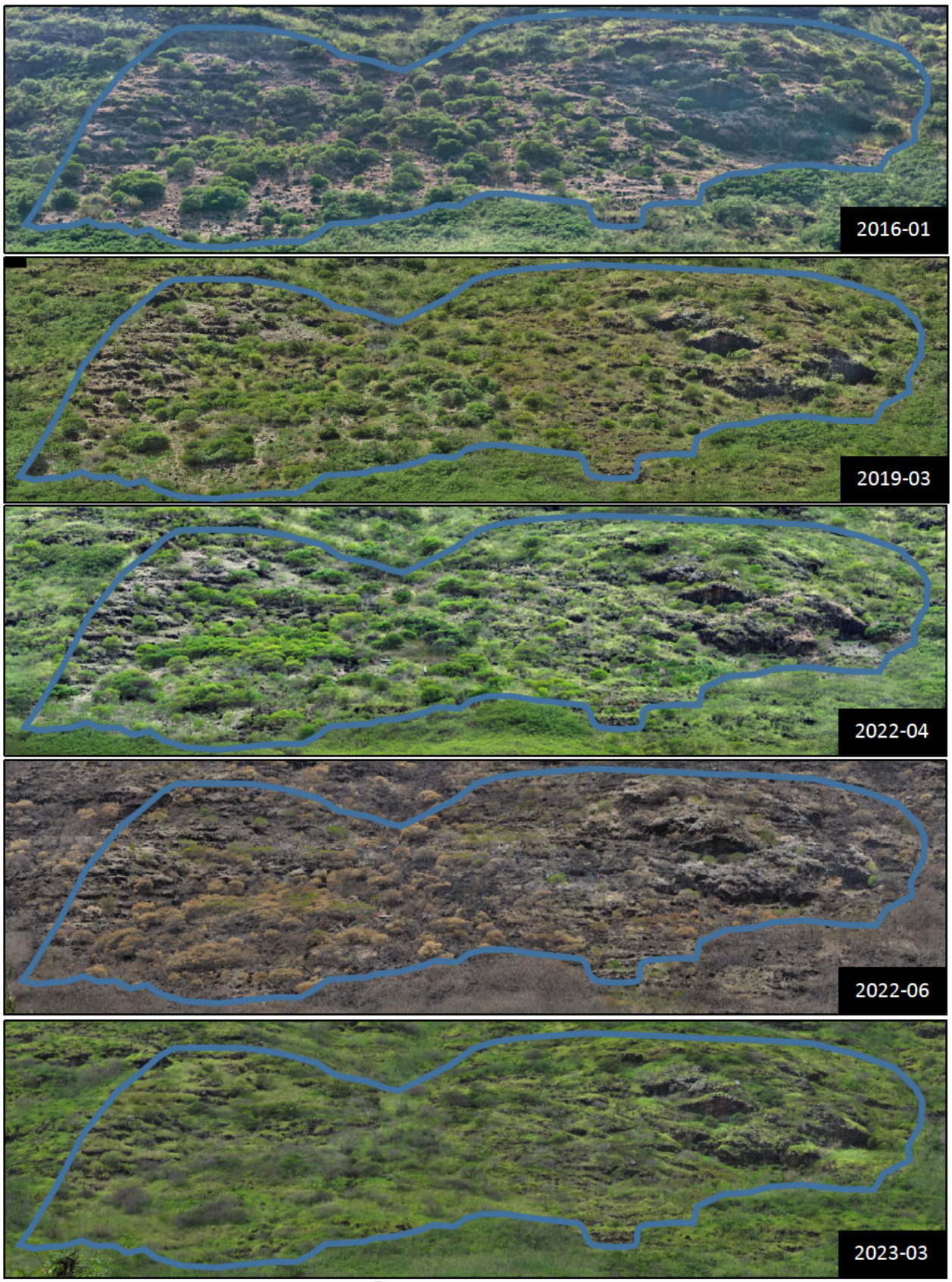


**Figure 3:** GigaPan imagery of WCA Lower ʻŌhikilolo-03 over time.

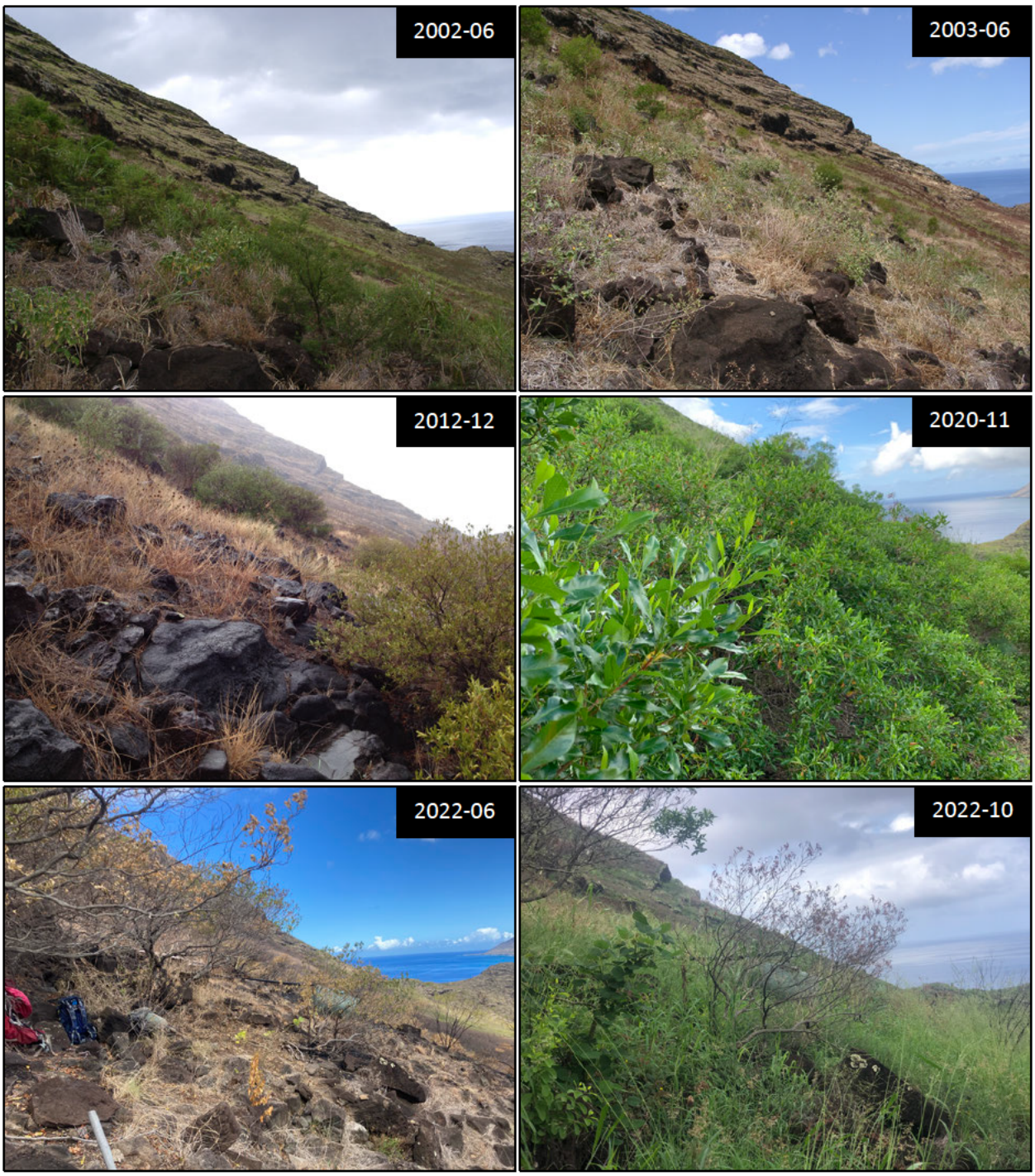


**Figure 4:** Example of a photopoint (Pole 8, at 270°) at Lower ʻŌhikilolo-03 showing change in vegetation over time (from left to right, and down): in 2002, during the initial stages of vegetation management, with some woody invasives still present; in 2003, after removal of woody invasives, and showing remnant native plants; in 2012, showing natural recovery of native woody plants; in 2020, showing substantial native vegetation infilling; in June of 2022, following the fire, with most of the plants burned; and in October of 2022, showing the return of weedy grasses, and modest recovery of native shrubs. Note that there are seasonality differences among the images.

**Figure 5:** GigaPan images from March 2023 showing roughly one-quarter surviving woody native shrubs (including *Hibiscus brackenridgei* subsp. *mokuleianus* in bloom) (top), and surviving larger *Erythrina sandiwicensis* trees (bottom). Invasive grasses dominate throughout the WCA.

## DISCUSSION

The dramatic increase in native woody cover at Lower ʻŌhikilolo-02 documented previously from GigaPan monitoring (ANRPO 2022b) is a testament to the value and efficacy of supplementing intensive weed management (removal of all woody weeds, regular grass control) with intensive active restoration efforts (outplanting in large numbers) in dryland habitat. However, substantial natural recovery of native woody vegetation can also occur solely with intensive weed management, as occurred at Lower ʻŌhikilolo-01, where common native outplanting has not occurred (ANRPO 2022b). GigaPan monitoring has only tracked native cover change since 2016, following the initiation of common native outplanting, but intensive weed control efforts have been going on for over 20 years. During that time, a considerable amount of natural recovery has occurred, as exemplified by sample photopoint images for Lower ʻŌhikilolo-03 from 2002 to 2022 (Figure 4, above). While this photopoint series also depicts the devastating impact from the most recent fire with the replacement of native woody vegetation by invasive grasses, it further demonstrates the potential for modest native shrub recovery in a relatively short period of time following the fire. It is anticipated that native cover will continue to increase gradually over time, as management continues in the form of weed control. During the course of weed management post-fire and after the start of the wet season, staff noted the presence of numerous *H. brackenridgei* subsp. *mokuleianus* and *Dodonaea viscosa* seedlings recruiting, though *M. maximus* and other grasses were quickly recolonizing (ANRPO 2023). The resumption of restoration efforts may accelerate the rate of recovery.

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# Population Unit Status - Makua Implementation Plan

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2021-09-07 | No plants remaining |
| **Makua** | Manage for stability | 15 | 0 | 0 | 4 | 0 | 0 | **4** | **0** | **0** | 4 | 0 | 0 | 0 | 0 | 0 | 2017-02-14 | No monitoring in the last year |
| **South Mohiakea** | Genetic Storage | 16 | 1 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2022-05-17 | No changes observed in the last year |
| **West Makaleha** | Genetic Storage | 40 | 4 | 0 | 1 | 0 | 0 | **1** | **0** | **0** | 1 | 0 | 0 | 0 | 0 | 0 | 2022-05-11 | No monitoring in the last year |
| | **In Total:** | 73 | 11 | 0 | 5 | 0 | 0 | **5** | **0** | **0** | 5 | 0 | 0 | 0 | 0 | 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 Kaluaa to Central Waieli** | Manage for stability | 50 | 3 | 0 | 2 | 0 | 0 | **2** | **0** | **0** | 2 | 0 | 0 | 0 | 0 | 0 | 2018-03-15 | No monitoring in the last year |
| **Makaha** | Manage for stability | 75 | 0 | 2 | 6 | 0 | 0 | **5** | **0** | **0** | 5 | 0 | 0 | 0 | 0 | 0 | 2023-05-30 | Thorough monitoring in the last year showed a decline |
| **Waianae Kai** | Genetic Storage | 16 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2016-06-13 | No plants present since 2015 |
| | **Out Total:** | 141 | 3 | 2 | 8 | 0 | 0 | **7** | **0** | **0** | 7 | 0 | 0 | 0 | 0 | 0 | | |
| | **Total for Taxon:** | 214 | 14 | 2 | 13 | 0 | 0 | **12** | **0** | **0** | 12 | 0 | 0 | 0 | 0 | 0 | | |

# Population Unit Status - Makua Implementation Plan

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 275 | 150 | 0 | **304** | **142** | **0** | 70 | 27 | 0 | 234 | 115 | 0 | 2023-05-30 | A thorough census has shown immature plants transition into mature plants |
| **Kuaokala** | Genetic Storage | | | | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2022-06-15 | No monitoring in the last year |
| | **In Total:** | 210 | 66 | 0 | 275 | 150 | 0 | **304** | **142** | **0** | 70 | 27 | 0 | 234 | 115 | 0 | | |

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 167 | 59 | 0 | **261** | **56** | **1** | 93 | 34 | 0 | 168 | 22 | 1 | 2022-09-08 | A thorough census led to more plants being discovered |
| **Makaha and Waianae Kai** | Manage for stability | 9 | 3 | 0 | 71 | 3 | 6 | **52** | **48** | **0** | 6 | 0 | 0 | 46 | 48 | 0 | 2023-06-15 | More plants were added to the outplanting site |
| **South Huliwai** | Genetic Storage | 27 | 0 | 0 | 32 | 5 | 0 | **34** | **29** | **11** | 34 | 29 | 11 | 0 | 0 | 0 | 2022-07-20 | A thorough census led to more plants being discovered |
| | **Out Total:** | 56 | 3 | 0 | 270 | 67 | 6 | **347** | **133** | **12** | 133 | 63 | 11 | 214 | 70 | 1 | | |
| | **Total for Taxon:** | 266 | 69 | 0 | 545 | 217 | 6 | **651** | **275** | **12** | 203 | 90 | 11 | 448 | 185 | 1 | | |

# Population Unit Status - Makua Implementation Plan

## Action Area: In

### TaxonName: Cyanea grimesiana subsp. obatae

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 63 | 62 | 0 | **71** | **40** | **0** | 4 | 0 | 0 | 67 | 40 | 0 | 2022-10-13 | A thorough census has shown immature plants transition into mature plants |
| | **In Total:** | 22 | 24 | 0 | 63 | 62 | 0 | **71** | **40** | **0** | 4 | 0 | 0 | 67 | 40 | 0 | | |

## Action Area: Out

### TaxonName: Cyanea grimesiana subsp. obatae

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 20 | 25 | 0 | **15** | **50** | **0** | 3 | 1 | 0 | 12 | 49 | 0 | 2023-05-09 | More plants were added to the outplanting site |
| **Makaha** | Genetic Storage | | | | 15 | 229 | 0 | **0** | **20** | **0** | 0 | 0 | 0 | 0 | 20 | 0 | 2023-06-15 | Thorough monitoring in the last year showed a decline |
| **North branch of South Ekahanui** | Manage reintroduction for stability | 5 | 0 | 0 | 60 | 38 | 0 | **53** | **77** | **0** | 0 | 0 | 0 | 53 | 77 | 0 | 2023-02-22 | More plants were added to the outplanting site |
| **Palikea (South Palawai)** | Manage for stability | 3 | 60 | 0 | 662 | 23 | 2 | **661** | **35** | **2** | 10 | 6 | 0 | 651 | 29 | 2 | 2022-10-11 | Small changes were noted during monitoring in the last year |
| | **Out Total:** | 8 | 60 | 0 | 757 | 315 | 2 | **729** | **182** | **2** | 13 | 7 | 0 | 716 | 175 | 2 | | |
| | **Total for Taxon:** | 30 | 84 | 0 | 820 | 377 | 2 | **800** | **222** | **2** | 17 | 7 | 0 | 783 | 215 | 2 | | |

# Population Unit Status - Makua Implementation Plan

## Action Area: In

### TaxonName: Cyanea longiflora

Target # of Matures: 75 # 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 56 | 31 | 0 | **41** | **18** | **0** | 12 | 1 | 0 | 29 | 17 | 0 | 2023-05-02 | Thorough monitoring in the last year showed a decline |
| **Pahole** | Manage for stability | 114 | 0 | 0 | 85 | 149 | 10 | **56** | **171** | **10** | 50 | 158 | 10 | 6 | 13 | 0 | 2023-05-17 | Thorough monitoring in the last year showed a decline in the maure age class |
| | **In Total:** | 180 | 0 | 0 | 141 | 180 | 10 | **97** | **189** | **10** | 62 | 159 | 10 | 35 | 30 | 0 | | |

## Action Area: Out

### TaxonName: Cyanea longiflora

Target # of Matures: 75 # 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 19 | 2 | 0 | **19** | **2** | **0** | 5 | 0 | 0 | 14 | 2 | 0 | 2022-09-20 | No changes observed in the last year |
| | **Out Total:** | 4 | 0 | 0 | 19 | 2 | 0 | **19** | **2** | **0** | 5 | 0 | 0 | 14 | 2 | 0 | | |
| | **Total for Taxon:** | 184 | 0 | 0 | 160 | 182 | 10 | **116** | **191** | **10** | 67 | 159 | 10 | 49 | 32 | 0 | | |

# Population Unit Status - Makua Implementation Plan

## Action Area: In

### TaxonName: Cyanea superba subsp. superba

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 18 | 135 | 0 | **17** | **76** | **0** | 0 | 0 | 0 | 17 | 76 | 0 | 2023-04-17 | A thorough census has shown a substantial decline in the immature age class |
| **Kaluaa** | Manage reintroduction for stability | | | | 0 | 85 | 0 | **0** | **64** | **0** | 0 | 0 | 0 | 0 | 64 | 0 | 2023-01-23 | A thorough census has shown a substantial decline in the immature age class |
| **Pahole to Kapuna** | Genetic Storage | 31 | 139 | 0 | 33 | 23 | 3 | **38** | **23** | **2** | 0 | 0 | 0 | 38 | 23 | 2 | 2022-10-12 | A thorough census has shown immature plants transition into mature plants |
| **Palikea** | Manage reintroduction for stability | | | | 19 | 277 | 0 | **19** | **186** | **0** | 0 | 0 | 0 | 19 | 186 | 0 | 2023-02-14 | A thorough census has shown a substantial decline in the immature age class |
| | **In Total:** | 34 | 288 | 0 | 70 | 520 | 3 | **74** | **349** | **2** | 0 | 0 | 0 | 74 | 349 | 2 | | |

## Action Area: Out

### TaxonName: Cyanea superba subsp. superba

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | | | | 58 | 13 | 0 | **34** | **5** | **0** | 0 | 0 | 0 | 34 | 5 | 0 | 2023-01-10 | Thorough monitoring in the last year showed a decline |
| | **Out Total:** | | | | 58 | 13 | 0 | **34** | **5** | **0** | 0 | 0 | 0 | 34 | 5 | 0 | | |
| | **Total for Taxon:** | 34 | 288 | 0 | 128 | 533 | 3 | **108** | **354** | **2** | 0 | 0 | 0 | 108 | 354 | 2 | | |

# Population Unit Status - Makua Implementation Plan

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 29 | 45 | 12 | **29** | **65** | **12** | 29 | 45 | 12 | 0 | 20 | 0 | 2022-12-12 | A new reintroduction was established |
| **Kawaiiki (Koolaus)** | Manage for stability | 50 | 0 | 0 | 2 | 19 | 1 | **2** | **19** | **1** | 2 | 19 | 1 | 0 | 0 | 0 | 2016-06-23 | No monitoring in the last year |
| **Opaeula (Koolaus)** | Manage for stability | 21 | 5 | 0 | 34 | 74 | 11 | **48** | **64** | **0** | 38 | 50 | 0 | 10 | 14 | 0 | 2023-06-14 | A new reintroduction was established |
| **Pahole to West Makaleha** | Manage for stability | 300 | 0 | 0 | 636 | 1786 | 73 | **820** | **1790** | **659** | 820 | 1713 | 659 | 0 | 77 | 0 | 2023-03-01 | A thorough census led to more plants being discovered |
| | **In Total:** | 423 | 50 | 0 | 701 | 1924 | 97 | **899** | **1938** | **672** | 889 | 1827 | 672 | 10 | 111 | 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 |
| | **Out Total:** | | | | 3 | 0 | 0 | **3** | **0** | **0** | 3 | 0 | 0 | 0 | 0 | 0 | | |
| | **Total for Taxon:** | 423 | 50 | 0 | 704 | 1924 | 97 | **902** | **1938** | **672** | 892 | 1827 | 672 | 10 | 111 | 0 | | |

# Population Unit Status - Makua Implementation Plan

## Action Area: In

### TaxonName: Delissea waianaeensis

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 109 | 34 | 0 | **135** | **45** | **0** | 4 | 0 | 0 | 131 | 45 | 0 | 2023-05-17 | More plants were added to the outplanting site |
| **Kaluakauila** | Manage reintroduction for storage | | | | 1 | 0 | 0 | **1** | **0** | **0** | 0 | 0 | 0 | 1 | 0 | 0 | 2023-06-07 | No changes observed in the last year |
| **Kapuna** | Manage reintroduction for storage | | | | 83 | 1 | 0 | **71** | **0** | **0** | 0 | 0 | 0 | 71 | 0 | 0 | 2023-04-25 | Thorough monitoring in the last year showed a decline |
| **Palikea 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 | 19 | 4 | 0 | **11** | **6** | **0** | 11 | 6 | 0 | 0 | 0 | 0 | 2023-06-13 | Thorough monitoring in the last year showed a decline |
| | **In Total:** | 37 | 1 | 0 | 213 | 39 | 0 | **219** | **51** | **0** | 16 | 6 | 0 | 203 | 45 | 0 | | |

## Action Area: Out

### TaxonName: Delissea waianaeensis

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 68 | 57 | 0 | **68** | **57** | **0** | 0 | 0 | 0 | 68 | 57 | 0 | 2022-04-11 | No monitoring in the last year |
| **Kaluaa** | Manage for stability | 44 | 0 | 0 | 165 | 127 | 0 | **201** | **104** | **10** | 1 | 0 | 0 | 200 | 104 | 10 | 2023-05-09 | More plants were added to the outplanting site |
| **Kealia** | Genetic Storage | 0 | 7 | 0 | 2 | 1 | 1 | **2** | **0** | **0** | 2 | 0 | 0 | 0 | 0 | 0 | 2022-07-25 | Small changes were noted during monitoring in the last year |
| **Manuwai** | Manage reintroduction for stability | | | | 36 | 4 | 0 | **29** | **86** | **0** | 0 | 0 | 0 | 29 | 86 | 0 | 2023-05-24 | More plants were added to the outplanting site |
| **Palawai** | Genetic Storage | 1 | 0 | 0 | 24 | 30 | 0 | **24** | **30** | **0** | 24 | 30 | 0 | 0 | 0 | 0 | 2016-06-22 | No monitoring in the last year |
| | **Out Total:** | 59 | 51 | 0 | 295 | 219 | 1 | **324** | **277** | **10** | 27 | 30 | 0 | 297 | 247 | 10 | | |
| | **Total for Taxon:** | 96 | 52 | 0 | 508 | 258 | 1 | **543** | **328** | **10** | 43 | 36 | 0 | 500 | 292 | 10 | | |

# Population Unit Status - Makua Implementation Plan

## Action Area: In

### TaxonName: Dubautia herbstobatae

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 in the last year |
| **Makaha/Ohikilolo** | Genetic Storage | | | | 225 | 4 | 0 | **225** | **4** | **0** | 225 | 4 | 0 | 0 | 0 | 0 | 2021-06-29 | No monitoring in the last year |
| **Ohikilolo Makai** | Manage for stability | 700 | 0 | 0 | 48 | 0 | 0 | **48** | **0** | **0** | 48 | 0 | 0 | 0 | 0 | 0 | 2021-07-01 | No monitoring in the last year |
| **Ohikilolo Mauka** | Manage for stability | 1300 | 0 | 0 | 125 | 14 | 0 | **125** | **14** | **0** | 125 | 14 | 0 | 0 | 0 | 0 | 2022-06-16 | No monitoring in the last year |
| | **In Total:** | 2070 | 0 | 0 | 468 | 18 | 0 | **468** | **18** | **0** | 468 | 18 | 0 | 0 | 0 | 0 | | |

## Action Area: Out

### TaxonName: Dubautia herbstobatae

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 plants observed at this site since 2001 |
| **Makaha** | Manage for stability | 0 | 0 | 0 | 21 | 194 | 0 | **3** | **77** | **0** | 3 | 9 | 0 | 0 | 68 | 0 | 2022-10-17 | Thorough monitoring in the last year showed a decline |
| **Waianae Kai** | Genetic Storage | 5 | 0 | 0 | 10 | 4 | 0 | **10** | **4** | **0** | 10 | 4 | 0 | 0 | 0 | 0 | 2005-06-22 | No monitoring in the last year |
| | **Out Total:** | 6 | 0 | 0 | 31 | 198 | 0 | **13** | **81** | **0** | 13 | 13 | 0 | 0 | 68 | 0 | | |
| | **Total for Taxon:** | 2076 | 0 | 0 | 499 | 216 | 0 | **481** | **99** | **0** | 481 | 31 | 0 | 0 | 68 | 0 | | |

# Population Unit Status - Makua Implementation Plan

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 1 | 0 | 0 | **1** | **0** | **0** | 1 | 0 | 0 | 0 | 0 | 0 | 2018-11-28 | 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 | 66 | 0 | 0 | **66** | **0** | **0** | 66 | 0 | 0 | 0 | 0 | 0 | 2022-07-28 | No changes observed in the last year |
| **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 | 133 | 0 | 0 | **132** | **5** | **0** | 132 | 5 | 0 | 0 | 0 | 0 | 2022-10-25 | Small changes were noted during monitoring in the last year |
| | **In Total:** | 420 | 15 | 0 | 326 | 39 | 0 | **325** | **44** | **0** | 325 | 44 | 0 | 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 1 | 0 | 0 | **1** | **0** | **0** | 1 | 0 | 0 | 0 | 0 | 0 | 2022-06-30 | No monitoring in the last year |
| **Kaena** | Manage for stability | 300 | 0 | 0 | 880 | 274 | 0 | **843** | **43** | **0** | 843 | 43 | 0 | 0 | 0 | 0 | 2022-07-13 | Thorough monitoring in the last year showed a decline |
| **Keawaula** | Genetic Storage | 69 | 6 | 0 | 36 | 2 | 3 | **30** | **2** | **0** | 30 | 2 | 0 | 0 | 0 | 0 | 2022-08-25 | Small changes were noted during 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 |
| | **Out Total:** | 438 | 11 | 0 | 951 | 276 | 3 | **908** | **45** | **0** | 908 | 45 | 0 | 0 | 0 | 0 | | |
| | **Total for Taxon:** | 858 | 26 | 0 | 1277 | 315 | 3 | **1233** | **89** | **0** | 1233 | 89 | 0 | 0 | 0 | 0 | | |

# Population Unit Status - Makua Implementation Plan

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 71 | 29 | 2 | **83** | **38** | **0** | 4 | 1 | 0 | 79 | 37 | 0 | 2022-10-17 | A thorough census has shown immature plants transition into mature plants |
| **Manuwai** | Manage reintroduction for stability | | | | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | | This outplanting has not started |
| | **In Total:** | 170 | 0 | 0 | 71 | 29 | 2 | **83** | **38** | **0** | 4 | 1 | 0 | 79 | 37 | 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | | | | 17 | 27 | 0 | **14** | **35** | **0** | 0 | 0 | 0 | 14 | 35 | 0 | 2023-02-23 | More plants were added to the outplanting site |
| **Makaha** | Manage reintroduction for storage | | | | 2 | 0 | 0 | **2** | **0** | **0** | 0 | 0 | 0 | 2 | 0 | 0 | 2022-10-06 | No changes observed in the last year |
| | **Out Total:** | | | | 19 | 27 | 0 | **16** | **35** | **0** | 0 | 0 | 0 | 16 | 35 | 0 | | |
| | **Total for Taxon:** | 170 | 0 | 0 | 90 | 56 | 2 | **99** | **73** | **0** | 4 | 1 | 0 | 95 | 72 | 0 | | |

# Population Unit Status - Makua Implementation Plan

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 9 | 50 | 0 | **10** | **63** | **0** | 5 | 0 | 0 | 5 | 63 | 0 | 2023-06-28 | 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 | 2016-03-02 | 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 |
| | **In Total:** | 12 | 26 | 0 | 16 | 50 | 0 | **17** | **63** | **0** | 12 | 0 | 0 | 5 | 63 | 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 4 | 0 | 0 | **4** | **0** | **0** | 4 | 0 | 0 | 0 | 0 | 0 | 2022-07-14 | No changes observed 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 | 12 | 11 | 0 | **12** | **11** | **0** | 7 | 0 | 0 | 5 | 11 | 0 | 2022-09-13 | No changes observed in the last year |
| **Manuwai** | Manage reintroduction for stability | 0 | 0 | 0 | 0 | 1 | 0 | **0** | **1** | **0** | 0 | 0 | 0 | 0 | 1 | 0 | 2022-05-04 | No monitoring in the last year |
| **Mt. Kaala NAR** | Genetic Storage | 4 | 0 | 0 | 2 | 0 | 0 | **2** | **0** | **0** | 2 | 0 | 0 | 0 | 0 | 0 | 2018-04-26 | No monitoring in the last year |
| **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 | 2022-06-29 | No monitoring in the last year |
| | **Out Total:** | 19 | 0 | 0 | 22 | 12 | 0 | **22** | **12** | **0** | 17 | 0 | 0 | 5 | 12 | 0 | | |
| | **Total for Taxon:** | 31 | 26 | 0 | 38 | 62 | 0 | **39** | **75** | **0** | 29 | 0 | 0 | 10 | 75 | 0 | | |

# Population Unit Status - Makua Implementation Plan

## Action Area: In

### TaxonName: Gouania vitifolia

Target # of Matures: 50 # MFS PU Met Goal: 0 of 1

| Population Unit Name | Management Designation | Total Mature Original IP | Total Imm Original IP | Total Seedling Original IP | Total Mature 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | | | | 5 | 50 | 0 | **5** | **50** | **0** | 4 | 3 | 0 | 1 | 47 | 0 | 2022-05-31 | No monitoring in the last year |
| | **In Total:** | | | | 5 | 50 | 0 | **5** | **50** | **0** | 4 | 3 | 0 | 1 | 47 | 0 | | |

## Action Area: Out

### TaxonName: Gouania vitifolia

Target # of Matures: 50 # MFS PU Met Goal: 0 of 1

| Population Unit Name | Management Designation | Total Mature Original IP | Total Imm Original IP | Total Seedling Original IP | Total Mature 2022 | Total Immature 2022 | Total Seedling 2022 | **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** | Genetic Storage | | | | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2022-04-06 | No plants alive at site |
| | **Out Total:** | | | | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | | |
| | **Total for Taxon:** | | | | 5 | 50 | 0 | **5** | **50** | **0** | 4 | 3 | 0 | 1 | 47 | 0 | | |

# Population Unit Status - Makua Implementation Plan

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | | | | 0 | 20 | 0 | **0** | **15** | **0** | 0 | 0 | 0 | 0 | 15 | 0 | 2023-04-20 | A thorough census has shown a decline in the immature age class |
| **Pahole NAR** | Manage reintroduction for stability | 8 | 0 | 0 | 1 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2022-10-31 | No plants alive at this site |
| | **In Total:** | 8 | 0 | 0 | 1 | 20 | 0 | **0** | **15** | **0** | 0 | 0 | 0 | 0 | 15 | 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 14 | 26 | 0 | **16** | **14** | **9** | 2 | 1 | 0 | 14 | 13 | 9 | 2023-06-15 | A thorough census has shown immature plants transition into mature plants |
| **Pualii** | Manage reintroduction for stability | | | | 23 | 9 | 0 | **17** | **1** | **5** | 0 | 0 | 0 | 17 | 1 | 5 | 2023-05-08 | Thorough monitoring in the last year showed a decline |
| **Waianae Kai** | Genetic Storage | 9 | 0 | 1 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2018-04-16 | No plants at this site since 2017 |
| | **Out Total:** | 22 | 0 | 1 | 37 | 35 | 0 | **33** | **15** | **14** | 2 | 1 | 0 | 31 | 14 | 14 | | |
| | **Total for Taxon:** | 30 | 0 | 1 | 38 | 55 | 0 | **33** | **30** | **14** | 2 | 1 | 0 | 31 | 29 | 14 | | |

# Population Unit Status - Makua Implementation Plan

## Action Area: In

### TaxonName: Hibiscus brackenridgei subsp. mokuleianus

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | | | | 59 | 73 | 9 | **57** | **81** | **11** | 12 | 14 | 2 | 45 | 67 | 9 | 2023-05-17 | More plants were added to the outplanting site |
| **Makua** | Manage for stability | 4 | 3 | 0 | 30 | 29 | 0 | **30** | **29** | **0** | 5 | 7 | 0 | 25 | 22 | 0 | 2022-06-21 | A new census was initiated but not yet completed |
| | **In Total:** | 4 | 3 | 0 | 89 | 102 | 9 | **87** | **110** | **11** | 17 | 21 | 2 | 70 | 89 | 9 | | |

## Action Area: Out

### TaxonName: Hibiscus brackenridgei subsp. mokuleianus

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 Kawaiu** | Manage for stability | 3 | 1 | 0 | 57 | 42 | 16 | **46** | **10** | **7** | 1 | 4 | 7 | 45 | 6 | 0 | 2023-04-10 | Thorough monitoring in the last year showed a decline |
| **Manuwai** | Manage reintroduction for stability | | | | 38 | 100 | 0 | **38** | **100** | **0** | 0 | 0 | 0 | 38 | 100 | 0 | 2022-06-21 | No monitoring in the last year |
| **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 |
| | **Out Total:** | 7 | 10 | 0 | 144 | 227 | 25 | **133** | **195** | **16** | 50 | 89 | 16 | 83 | 106 | 0 | | |
| | **Total for Taxon:** | 11 | 13 | 0 | 233 | 329 | 34 | **220** | **305** | **27** | 67 | 110 | 18 | 153 | 195 | 9 | | |

# Population Unit Status - Makua Implementation Plan

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 46 | 28 | 0 | **70** | **32** | **0** | 70 | 32 | 0 | 0 | 0 | 0 | 2022-08-23 | A thorough census led to more plants being discovered |
| **Makaha to Ohikilolo** | Manage reintroduction for stability | | | | 93 | 116 | 0 | **83** | **124** | **0** | 0 | 0 | 0 | 83 | 124 | 0 | 2023-04-13 | More plants were added to the outplanting site |
| | **In Total:** | 161 | 0 | 0 | 139 | 144 | 0 | **153** | **156** | **0** | 70 | 32 | 0 | 83 | 124 | 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Alaiheihe and Manuwai** | Manage for stability | 60 | 0 | 0 | 41 | 57 | 4 | **40** | **30** | **0** | 16 | 9 | 0 | 24 | 21 | 0 | 2023-05-23 | Thorough monitoring in the last year showed a decline |
| **Central Makaleha and West Branch of East Makaleha** | Manage for stability | 47 | 0 | 0 | 6 | 3 | 0 | **3** | **1** | **0** | 3 | 1 | 0 | 0 | 0 | 0 | 2022-09-21 | Thorough monitoring in the last year showed a decline |
| **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 plants at this site |
| | **Out Total:** | 117 | 0 | 0 | 47 | 60 | 4 | **43** | **31** | **0** | 19 | 10 | 0 | 24 | 21 | 0 | | |
| | **Total for Taxon:** | 278 | 0 | 0 | 186 | 204 | 4 | **196** | **187** | **0** | 89 | 42 | 0 | 107 | 145 | 0 | | |

# Population Unit Status - Makua Implementation Plan

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 79 | 18 | 0 | **71** | **19** | **0** | 43 | 13 | 0 | 28 | 6 | 0 | 2023-06-20 | Small changes were noted during monitoring in the last year |
| | **In Total:** | 66 | 0 | 0 | 79 | 18 | 0 | **71** | **19** | **0** | 43 | 13 | 0 | 28 | 6 | 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 reintroduction for stability | | | | 123 | 22 | 3 | **97** | **13** | **23** | 0 | 0 | 0 | 97 | 13 | 23 | 2023-05-15 | Thorough monitoring in the last year showed a decline |
| **Halona** | Manage for stability | 64 | 0 | 0 | 32 | 126 | 0 | **26** | **122** | **0** | 9 | 0 | 0 | 17 | 122 | 0 | 2022-09-07 | Small changes were noted during monitoring in the last year |
| | **Out Total:** | 64 | 0 | 0 | 155 | 148 | 3 | **123** | **135** | **23** | 9 | 0 | 0 | 114 | 135 | 23 | | |
| | **Total for Taxon:** | 130 | 0 | 0 | 234 | 166 | 3 | **194** | **154** | **23** | 52 | 13 | 0 | 142 | 141 | 23 | | |

# Population Unit Status - Makua Implementation Plan

## Action Area: In

### TaxonName: Neraudia angulata

Target # of Matures: 100 # 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | | | | 19 | 19 | 0 | **47** | **12** | **47** | 0 | 0 | 0 | 47 | 12 | 47 | 2023-05-16 | More plants were added to the outplanting site |
| **Kapuna** | Genetic Storage | 1 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2016-05-16 | No plants observed at this site since 2008 |
| **Makua** | Manage for stability | 29 | 0 | 22 | 44 | 80 | 0 | **44** | **80** | **0** | 20 | 4 | 0 | 24 | 76 | 0 | 2022-03-21 | No census taken in the last year |
| **Punapohaku** | Genetic Storage | | | | 2 | 0 | 0 | **2** | **0** | **0** | 2 | 0 | 0 | 0 | 0 | 0 | 2016-05-23 | No monitoring in the last year |
| | **In Total:** | 30 | 0 | 22 | 65 | 99 | 0 | **93** | **92** | **47** | 22 | 4 | 0 | 71 | 88 | 47 | | |

## Action Area: Out

### TaxonName: Neraudia angulata

Target # of Matures: 100 # 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 4 | 10 | 1 | **4** | **10** | **1** | 4 | 10 | 1 | 0 | 0 | 0 | 2016-08-15 | 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** | Manage for stability (backup site) | 56 | 14 | 0 | 29 | 25 | 0 | **17** | **44** | **0** | 3 | 8 | 0 | 14 | 36 | 0 | 2023-06-29 | More plants were added to the outplanting site |
| **Manuwai** | Manage for stability | 12 | 0 | 0 | 18 | 68 | 0 | **18** | **68** | **0** | 0 | 4 | 0 | 18 | 64 | 0 | 2022-06-21 | No census taken in the last year |
| **Waianae Kai Makai** | Genetic Storage | 4 | 0 | 0 | 13 | 0 | 0 | **13** | **0** | **0** | 13 | 0 | 0 | 0 | 0 | 0 | 2013-11-25 | No monitoring in the last year |
| **Waianae Kai Mauka** | Manage for stability | 21 | 25 | 0 | 11 | 2 | 0 | **11** | **2** | **0** | 7 | 2 | 0 | 4 | 0 | 0 | 2016-03-15 | A new census was initiated but not yet completed |
| | **Out Total:** | 111 | 39 | 0 | 84 | 105 | 1 | **72** | **124** | **1** | 36 | 24 | 1 | 36 | 100 | 0 | | |
| | **Total for Taxon:** | 141 | 39 | 22 | 149 | 204 | 1 | **165** | **216** | **48** | 58 | 28 | 1 | 107 | 188 | 47 | | |

# Population Unit Status - Makua Implementation Plan

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 28 | 1 | 0 | **28** | **1** | **0** | 28 | 1 | 0 | 0 | 0 | 0 | 2017-05-31 | No census taken in the last year |
| **Kaluakauila** | Manage for stability | 200 | 0 | 0 | 43 | 64 | 0 | **30** | **9** | **0** | 30 | 9 | 0 | 0 | 0 | 0 | 2023-05-17 | Thorough monitoring in the last year showed a decline |
| **Keaau** | Genetic Storage | 21 | 31 | 0 | 20 | 31 | 0 | **20** | **31** | **0** | 20 | 31 | 0 | 0 | 0 | 0 | 2016-09-07 | No monitoring in the last year |
| **Keawaula** | Genetic Storage | 200 | 30 | 0 | 109 | 22 | 0 | **109** | **22** | **0** | 109 | 22 | 0 | 0 | 0 | 0 | 2017-08-03 | No census taken 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 census taken 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 census taken in the last year |
| | **In Total:** | 834 | 93 | 0 | 429 | 198 | 0 | **416** | **143** | **0** | 409 | 143 | 0 | 7 | 0 | 0 | | |

# Population Unit Status - Makua Implementation Plan

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 census taken in the last year |
| **Kapuna and Keawapilau** | Genetic Storage | 9 | 1 | 0 | 4 | 0 | 0 | **4** | **0** | **0** | 4 | 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 | | | | 101 | 1 | 0 | **101** | **1** | **0** | 0 | 0 | 0 | 101 | 1 | 0 | 2022-06-21 | No census taken in the last year |
| **Nanakuli** | Genetic Storage | 5 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2016-03-29 | No plants at this site |
| **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 |
| **Waianae Kai** | Manage for stability | 200 | 0 | 0 | 53 | 135 | 0 | **53** | **135** | **0** | 53 | 135 | 0 | 0 | 0 | 0 | 2018-09-18 | A new census was initiated but not yet completed |
| | **Out Total:** | 446 | 7 | 0 | 223 | 142 | 0 | **223** | **142** | **0** | 122 | 141 | 0 | 101 | 1 | 0 | | |
| | **Total for Taxon:** | 1280 | 100 | 0 | 652 | 340 | 0 | **639** | **285** | **0** | 531 | 284 | 0 | 108 | 1 | 0 | | |

# Population Unit Status - Makua Implementation Plan

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 observed at this site since 2009 |
| **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 observed at this site since 2009 |
| **Palikea Gulch** | Genetic Storage | 10 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2004-09-01 | No plants at this site |
| | **In Total:** | 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2015-01-01 | No plants observed at this site since 2014 |
| **Manuwai** | Manage reintroduction for stability | 0 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2015-03-18 | No plants observed at this site since 2014 |
| **Waianae Kai** | Genetic Storage | 6 | 2 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2004-01-01 | No plants at this site |
| | **Out Total:** | 6 | 2 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | | |
| | **Total for Taxon:** | 26 | 2 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | | |

# Population Unit Status - Makua Implementation Plan

## Action Area: In

### TaxonName: Plantago princeps var. princeps

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 63 | 75 | 0 | **63** | **75** | **0** | 63 | 75 | 0 | 0 | 0 | 0 | 2021-11-17 | 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 | 2021-07-21 | No plants alive at site |
| **Pahole** | Genetic Storage | 12 | 0 | 0 | 0 | 3 | 0 | **0** | **3** | **0** | 0 | 3 | 0 | 0 | 0 | 0 | 2021-08-25 | No census taken in the last year |
| | **In Total:** | 46 | 10 | 0 | 63 | 78 | 0 | **63** | **78** | **0** | 63 | 78 | 0 | 0 | 0 | 0 | | |

## Action Area: Out

### TaxonName: Plantago princeps var. princeps

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 1 | 7 | 0 | **0** | **3** | **0** | 0 | 3 | 0 | 0 | 0 | 0 | 2023-06-28 | Thorough monitoring in the last year showed a decline |
| **Konahuanui** | Manage for stability | | | | 36 | 5 | 3 | **36** | **5** | **3** | 36 | 5 | 3 | 0 | 0 | 0 | 2021-09-21 | No monitoring in the last year |
| **North Palawai** | Genetic Storage | 32 | 0 | 0 | 1 | 0 | 0 | **1** | **0** | **0** | 1 | 0 | 0 | 0 | 0 | 0 | 2018-02-08 | No census taken in the last year |
| **Waieli** | Manage reintroduction for storage | | | | 0 | 2 | 0 | **0** | **1** | **0** | 0 | 0 | 0 | 0 | 1 | 0 | 2023-06-14 | Small changes were noted during monitoring in the last year |
| | **Out Total:** | 48 | 17 | 0 | 38 | 14 | 3 | **37** | **9** | **3** | 37 | 8 | 3 | 0 | 1 | 0 | | |
| | **Total for Taxon:** | 94 | 27 | 0 | 101 | 92 | 3 | **100** | **87** | **3** | 100 | 86 | 3 | 0 | 1 | 0 | | |

# Population Unit Status - Makua Implementation Plan

## Action Area: In

### TaxonName: Pritchardia kaalae

Target # of Matures: 25 # 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 161 | 941 | 477 | **178** | **925** | **483** | 76 | 617 | 477 | 102 | 308 | 6 | 2023-06-20 | A thorough census led to more plants being discovered |
| **Ohikilolo East and West Makaleha** | Manage reintroduction for stability | 0 | 75 | 0 | 45 | 222 | 13 | **45** | **222** | **13** | 0 | 0 | 0 | 45 | 222 | 13 | 2022-09-14 | No changes observed in the last year |
| | **In Total:** | 65 | 483 | 0 | 206 | 1163 | 490 | **223** | **1147** | **496** | 76 | 617 | 477 | 147 | 530 | 19 | | |

## Action Area: Out

### TaxonName: Pritchardia kaalae

Target # of Matures: 25 # 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 122 | 3 | 0 | **122** | **3** | **0** | 122 | 3 | 0 | 0 | 0 | 0 | 2023-03-09 | No changes observed in the last year |
| **Waianae Kai** | Genetic Storage | 7 | 2 | 0 | 4 | 5 | 0 | **6** | **11** | **0** | 6 | 11 | 0 | 0 | 0 | 0 | 2022-08-18 | A thorough census led to more plants being discovered |
| | **Out Total:** | 146 | 5 | 0 | 127 | 8 | 0 | **129** | **14** | **0** | 129 | 14 | 0 | 0 | 0 | 0 | | |
| | **Total for Taxon:** | 211 | 488 | 0 | 333 | 1171 | 490 | **352** | **1161** | **496** | 205 | 631 | 477 | 147 | 530 | 19 | | |

# Population Unit Status - Makua Implementation Plan

## Action Area: In

### TaxonName: Sanicula mariversa

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 14 | 2 | 0 | **14** | **2** | **0** | 14 | 2 | 0 | 0 | 0 | 0 | 2022-06-29 | No monitoring in the last year |
| **Ohikilolo** | Manage for stability | 34 | 128 | 0 | 12 | 115 | 0 | **12** | **117** | **0** | 12 | 96 | 0 | 0 | 21 | 0 | 2023-06-20 | Small changes were noted during monitoring in the last year |
| | **In Total:** | 50 | 253 | 0 | 26 | 117 | 0 | **26** | **119** | **0** | 26 | 98 | 0 | 0 | 21 | 0 | | |

## Action Area: Out

### TaxonName: Sanicula mariversa

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 31 | 182 | 1 | **31** | **182** | **1** | 31 | 182 | 1 | 0 | 0 | 0 | 2017-03-21 | No monitoring in the last year |
| **Puu Kawiwi** | Genetic Storage | 2 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2016-03-15 | No monitoring in the last year |
| | **Out Total:** | 28 | 0 | 0 | 31 | 182 | 1 | **31** | **182** | **1** | 31 | 182 | 1 | 0 | 0 | 0 | | |
| | **Total for Taxon:** | 78 | 253 | 0 | 57 | 299 | 1 | **57** | **301** | **1** | 57 | 280 | 1 | 0 | 21 | 0 | | |

# Population Unit Status - Makua Implementation Plan

## Action Area: In

### TaxonName: Schiedea kaalae

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Kaluanui** | Manage for stability | | | | 46 | 64 | 0 | **46** | **64** | **0** | 0 | 0 | 0 | 46 | 64 | 0 | 2022-03-14 | No census taken in the last year |
| **Pahole** | Manage for stability | 3 | 0 | 0 | 67 | 44 | 0 | **48** | **28** | **0** | 0 | 0 | 0 | 48 | 28 | 0 | 2023-01-04 | Thorough monitoring in the last year showed a decline |
| | **In Total:** | 3 | 0 | 0 | 113 | 108 | 0 | **94** | **92** | **0** | 0 | 0 | 0 | 94 | 92 | 0 | | |

## Action Area: Out

### TaxonName: Schiedea kaalae

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 123 | 11 | 20 | **120** | **7** | **0** | 0 | 0 | 0 | 120 | 7 | 0 | 2023-02-15 | Small changes were noted during monitoring in the last year |
| **Maakua (Koolaus)** | Genetic Storage | 4 | 0 | 0 | 3 | 0 | 0 | **3** | **0** | **0** | 3 | 0 | 0 | 0 | 0 | 0 | 2019-09-13 | No census taken 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 plants observed at this site since 2005 |
| **South Ekahanui** | Manage for stability | 10 | 75 | 0 | 151 | 32 | 60 | **151** | **32** | **60** | 8 | 0 | 0 | 143 | 32 | 60 | 2023-05-15 | No changes observed in the last year |
| | **Out Total:** | 19 | 128 | 0 | 370 | 43 | 82 | **367** | **39** | **62** | 17 | 0 | 1 | 350 | 39 | 61 | | |
| | **Total for Taxon:** | 22 | 128 | 0 | 483 | 151 | 82 | **461** | **131** | **62** | 17 | 0 | 1 | 444 | 131 | 61 | | |

# Population Unit Status - Makua Implementation Plan

## Action Area: In

### TaxonName: Schiedea nuttallii

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 186 | 14 | 0 | **168** | **49** | **5** | 8 | 3 | 5 | 160 | 46 | 0 | 2023-05-17 | More plants were added to the outplanting site |
| **Kapuna-Keawapilau Ridge** | Manage for stability | 3 | 1 | 0 | 67 | 12 | 15 | **24** | **20** | **0** | 0 | 0 | 0 | 24 | 20 | 0 | 2023-05-02 | Thorough monitoring in the last year showed a decline |
| | **In Total:** | 51 | 18 | 0 | 253 | 26 | 15 | **192** | **69** | **5** | 8 | 3 | 5 | 184 | 66 | 0 | | |

## Action Area: Out

### TaxonName: Schiedea nuttallii

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 174 | 0 | 0 | **140** | **0** | **0** | 0 | 0 | 0 | 140 | 0 | 0 | 2023-05-22 | Thorough monitoring in the last year showed a decline |
| | **Out Total:** | 0 | 0 | 0 | 174 | 0 | 0 | **140** | **0** | **0** | 0 | 0 | 0 | 140 | 0 | 0 | | |
| | **Total for Taxon:** | 51 | 18 | 0 | 427 | 26 | 15 | **332** | **69** | **5** | 8 | 3 | 5 | 324 | 66 | 0 | | |

# Population Unit Status - Makua Implementation Plan

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 303 | 223 | 8 | **186** | **568** | **26** | 0 | 0 | 0 | 186 | 568 | 26 | 2023-04-18 | Thorough monitoring in the last year showed a decline |
| **Keawapilau to West Makaleha** | Manage for stability | 24 | 12 | 0 | 38 | 50 | 20 | **19** | **79** | **52** | 17 | 6 | 52 | 2 | 73 | 0 | 2023-05-02 | A new reintroduction was established |
| | **In Total:** | 89 | 37 | 0 | 341 | 273 | 28 | **205** | **647** | **78** | 17 | 6 | 52 | 188 | 641 | 26 | | |

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 203 | 122 | 2 | **135** | **86** | **0** | 0 | 0 | 0 | 135 | 86 | 0 | 2023-05-30 | Thorough monitoring in the last year showed a decline |
| | **Out Total:** | 0 | 0 | 0 | 203 | 122 | 2 | **135** | **86** | **0** | 0 | 0 | 0 | 135 | 86 | 0 | | |
| | **Total for Taxon:** | 89 | 37 | 0 | 544 | 395 | 30 | **340** | **733** | **78** | 17 | 6 | 52 | 323 | 727 | 26 | | |

# Population Unit Status - Makua Implementation Plan

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | No monitoring in the last year |
| **Kalena** | Manage for stability | | | | 35 | 27 | 0 | **35** | **27** | **0** | 35 | 27 | 0 | 0 | 0 | 0 | 2021-11-17 | 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 | | | | 350 | 200 | 0 | **350** | **200** | **0** | 350 | 200 | 0 | 0 | 0 | 0 | 2016-06-21 | No monitoring in the last year |
| **Ohikilolo** | Manage for stability | 2500 | 0 | 0 | 2322 | 968 | 20 | **2808** | **741** | **20** | 2808 | 741 | 20 | 0 | 0 | 0 | 2022-11-23 | A thorough census led to more plants being discovered |
| **Puhawai** | Manage for stability | 6 | 6 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2021-11-18 | No plants observed at this site since 2017 |
| | **In Total:** | 2581 | 6 | 0 | 2777 | 1236 | 37 | **3263** | **1009** | **37** | 3263 | 1009 | 37 | 0 | 0 | 0 | | |

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 21 | 0 | 0 | **21** | **0** | **0** | 21 | 0 | 0 | 0 | 0 | 0 | 2018-09-18 | No monitoring in the last year |
| | **Out Total:** | 20 | 2 | 0 | 21 | 0 | 0 | **21** | **0** | **0** | 21 | 0 | 0 | 0 | 0 | 0 | | |
| | **Total for Taxon:** | 2601 | 8 | 0 | 2798 | 1236 | 37 | **3284** | **1009** | **37** | 3284 | 1009 | 37 | 0 | 0 | 0 | | |

# Population Unit Status - Makua Implementation Plan

## Action Area: In

### TaxonName: Viola chamissoniana subsp. chamissoniana

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2016-06-21 | No plants observed at the site since 2015 |
| **Ohikilolo** | Manage for stability | | | | 182 | 50 | 0 | **182** | **50** | **0** | 182 | 50 | 0 | 0 | 0 | 0 | 2021-06-29 | No monitoring in the last year |
| **Puu Kumakalii** | Manage for stability | 19 | 1 | 0 | 73 | 4 | 0 | **73** | **4** | **0** | 73 | 4 | 0 | 0 | 0 | 0 | 2021-09-23 | No monitoring in the last year |
| | **In Total:** | 309 | 11 | 0 | 295 | 64 | 0 | **295** | **64** | **0** | 295 | 64 | 0 | 0 | 0 | 0 | | |

## Action Area: Out

### TaxonName: Viola chamissoniana subsp. chamissoniana

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 54 | 0 | 0 | **51** | **0** | **0** | 13 | 0 | 0 | 38 | 0 | 0 | 2022-09-07 | Small changes were noted during 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 | 25 | 99 | 3 | **25** | **99** | **3** | 25 | 6 | 3 | 0 | 93 | 0 | 2022-01-27 | No census taken in the last year |
| **Makaleha** | Genetic Storage | | | | 19 | 9 | 1 | **19** | **9** | **1** | 19 | 9 | 1 | 0 | 0 | 0 | 2015-06-03 | No monitoring in the last year |
| **Puu Hapapa** | Genetic Storage | 10 | 3 | 0 | 6 | 1 | 0 | **6** | **1** | **0** | 6 | 1 | 0 | 0 | 0 | 0 | 2016-05-11 | No monitoring in the last year |
| | **Out Total:** | 101 | 3 | 0 | 139 | 109 | 4 | **136** | **109** | **4** | 98 | 16 | 4 | 38 | 93 | 0 | | |
| | **Total for Taxon:** | 410 | 14 | 0 | 434 | 173 | 4 | **431** | **173** | **4** | 393 | 80 | 4 | 38 | 93 | 0 | | |

# Population Unit Status - Makua Implementation Plan

## Action Area: In

### TaxonName: Wollastonia 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 1 | 0 | 0 | **1** | **0** | **0** | 1 | 0 | 0 | 0 | 0 | 0 | 2016-09-20 | 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 | 200 | 50 | 0 | **200** | **50** | **0** | 200 | 50 | 0 | 0 | 0 | 0 | 2016-03-30 | No monitoring in the last year |
| **Ohikilolo** | Manage for stability | 2008 | 1 | 0 | 570 | 11 | 0 | **570** | **11** | **0** | 570 | 11 | 0 | 0 | 0 | 0 | 2018-01-30 | No monitoring in the last year |
| | **In Total:** | 2441 | 21 | 0 | 775 | 141 | 0 | **775** | **141** | **0** | 775 | 141 | 0 | 0 | 0 | 0 | | |

## Action Area: Out

### TaxonName: Wollastonia 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 131 | 24 | 0 | **131** | **24** | **0** | 131 | 24 | 0 | 0 | 0 | 0 | 2015-09-22 | No monitoring in the last year |
| | **Out Total:** | 1130 | 0 | 0 | 946 | 270 | 274 | **946** | **270** | **274** | 946 | 270 | 274 | 0 | 0 | 0 | | |
| | **Total for Taxon:** | 3571 | 21 | 0 | 1721 | 411 | 274 | **1721** | **411** | **274** | 1721 | 411 | 274 | 0 | 0 | 0 | | |

# Population Unit Status - Oahu Implementation Plan

## Action Area: In

### TaxonName: Abutilon sandwicense

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 39 | 160 | 0 | **35** | **160** | **0** | 35 | 160 | 0 | 0 | 0 | 0 | 2022-09-15 | Small changes were noted during monitoring in the last year |
| **Kahanahaiki** | Manage reintroduction for stability | 0 | 0 | 0 | 73 | 30 | 1 | **71** | **25** | **0** | 0 | 0 | 0 | 71 | 25 | 0 | 2022-09-20 | Small changes were noted during monitoring in the last year |
| **Kaluakauila** | Manage reintroduction for storage | 0 | 4 | 0 | 0 | 3 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2023-05-17 | No plants remaining at site |
| **Keaau** | Genetic Storage | 1 | 0 | 10 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2016-09-07 | No plants present at site since 2016 |
| | **In Total:** | 37 | 92 | 16 | 112 | 193 | 1 | **106** | **185** | **0** | 35 | 160 | 0 | 71 | 25 | 0 | | |

# Population Unit Status - Oahu Implementation Plan

## Action Area: Out

### TaxonName: Abutilon sandwicense

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 plants since 2013 |
| **Ekahanui and Huliwai** | Manage for stability | 14 | 30 | 0 | 77 | 27 | 3 | **72** | **24** | **6** | 1 | 12 | 6 | 71 | 12 | 0 | 2022-08-08 | Small changes were noted during monitoring in the last year |
| **Halona** | Genetic Storage | 0 | 0 | 0 | 10 | 5 | 0 | **10** | **5** | **0** | 10 | 5 | 0 | 0 | 0 | 0 | 2016-08-15 | No monitoring in the last year |
| **Makaha Makai** | Manage for stability | 73 | 27 | 6 | 81 | 66 | 0 | **81** | **166** | **0** | 81 | 66 | 0 | 0 | 100 | 0 | 2023-04-18 | A new augmentation was planted |
| **Makaha Mauka** | Genetic Storage | 5 | 58 | 4 | 13 | 0 | 0 | **13** | **0** | **0** | 13 | 0 | 0 | 0 | 0 | 0 | 2018-07-16 | No monitoring in the last year |
| **Nanakuli** | Genetic Storage | 0 | 0 | 0 | 3 | 1 | 0 | **3** | **1** | **0** | 3 | 1 | 0 | 0 | 0 | 0 | 2019-06-08 | 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 data available |
| **Waianae Kai** | Genetic Storage | 2 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2015-07-09 | No plants present at this site since 2013 |
| **West Makaleha** | Genetic Storage | 0 | 2 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2012-09-17 | No plants at this site since 2010 |
| | **Out Total:** | 98 | 158 | 50 | 193 | 110 | 3 | **188** | **207** | **6** | 117 | 95 | 6 | 71 | 112 | 0 | | |
| | **Total for Taxon:** | 135 | 250 | 66 | 305 | 303 | 4 | **294** | **392** | **6** | 152 | 255 | 6 | 142 | 137 | 0 | | |

# Population Unit Status - Oahu Implementation Plan

## Action Area: In

### TaxonName: Cyanea acuminata

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 23 | 302 | 0 | **23** | **302** | **0** | 23 | 302 | 0 | 0 | 0 | 0 | 2019-05-28 | No monitoring in the last year |
| **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 data available |
| **Makaleha to Mohiakea** | Manage for stability | 85 | 33 | 0 | 210 | 93 | 0 | **210** | **93** | **0** | 210 | 93 | 0 | 0 | 0 | 0 | 2021-11-18 | No census taken in the last year |
| | **In Total:** | 147 | 46 | 7 | 235 | 395 | 0 | **235** | **395** | **0** | 235 | 395 | 0 | 0 | 0 | 0 | | |

## Action Area: Out

### TaxonName: Cyanea acuminata

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 |
| **Kaluanui and Maakua** | Manage for stability | 0 | 0 | 0 | 126 | 123 | 52 | **126** | **123** | **52** | 126 | 123 | 52 | 0 | 0 | 0 | 2021-04-13 | No monitoring in the last year |
| **Konahuanui** | Genetic Storage | 30 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | | No data available |
| **Pia** | Genetic Storage | 0 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | | No data available |
| **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 data available |
| | **Out Total:** | 39 | 0 | 0 | 210 | 156 | 52 | **210** | **156** | **52** | 210 | 156 | 52 | 0 | 0 | 0 | | |
| | **Total for Taxon:** | 186 | 46 | 7 | 445 | 551 | 52 | **445** | **551** | **52** | 445 | 551 | 52 | 0 | 0 | 0 | | |

# Population Unit Status - Oahu Implementation Plan

## Action Area: In

### TaxonName: Cyanea 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 40 | 24 | 0 | **40** | **24** | **0** | 40 | 24 | 0 | 0 | 0 | 0 | 2021-11-30 | No monitoring 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 | 8 | 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 Opaeula** | 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 |
| **Opaeula to Helemano** | Manage for stability | 10 | 3 | 0 | 22 | 7 | 0 | **22** | **7** | **0** | 22 | 7 | 0 | 0 | 0 | 0 | 2021-05-15 | No monitoring in the last year |
| **Poamoho** | Manage for stability | 12 | 0 | 0 | 20 | 19 | 0 | **20** | **19** | **0** | 20 | 19 | 0 | 0 | 0 | 0 | 2017-05-02 | No monitoring in the last year |
| | **In Total:** | 96 | 36 | 6 | 101 | 59 | 0 | **101** | **59** | **0** | 101 | 59 | 0 | 0 | 0 | 0 | | |

## Action Area: Out

### TaxonName: Cyanea 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 data available |
| **Lulumahu** | Genetic Storage | 10 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | | No data available |
| **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 data available |
| | **Out Total:** | 39 | 0 | 0 | 18 | 2 | 0 | **18** | **2** | **0** | 18 | 2 | 0 | 0 | 0 | 0 | | |

# Population Unit Status - Oahu Implementation Plan

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total for Taxon:** | 135 | 36 | 6 | 119 | 61 | 0 | **119** | **61** | **0** | 119 | 61 | 0 | 0 | 0 | 0 |

# Population Unit Status - Oahu Implementation Plan

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 8 | 10 | 0 | **8** | **10** | **0** | 8 | 10 | 0 | 0 | 0 | 0 | 2015-04-09 | No monitoring in the last year |
| **Kaiwikoele and Kamananui** | Genetic Storage | 16 | 16 | 15 | 17 | 26 | 1 | **17** | **26** | **1** | 17 | 26 | 1 | 0 | 0 | 0 | 2016-03-30 | No monitoring in the last year |
| **Kaleleiki** | Genetic Storage | 25 | 30 | 250 | 8 | 27 | 16 | **8** | **27** | **16** | 8 | 27 | 16 | 0 | 0 | 0 | 2022-03-09 | No monitoring in the last year |
| **Kaunala** | Manage for stability | 48 | 93 | 6 | 6 | 21 | 0 | **6** | **26** | **2** | 6 | 26 | 2 | 0 | 0 | 0 | 2022-06-01 | No monitoring in the last year |
| **Malaekahana** | Genetic Storage | | | | 0 | 4 | 0 | **0** | **4** | **0** | 0 | 4 | 0 | 0 | 0 | 0 | 2017-04-04 | No monitoring in the last year |
| **Ohiaai and East Oio** | Genetic Storage | 5 | 8 | 10 | 1 | 1 | 0 | **1** | **1** | **0** | 1 | 1 | 0 | 0 | 0 | 0 | 2015-03-18 | No monitoring in the last year |
| **Oio** | Manage for stability | 18 | 56 | 0 | 3 | 1 | 1 | **3** | **1** | **1** | 3 | 1 | 1 | 0 | 0 | 0 | 2022-06-01 | No monitoring in the last year |
| **Pahipahialua** | Manage for stability | 57 | 234 | 1 | 2 | 1 | 21 | **2** | **1** | **21** | 2 | 1 | 21 | 0 | 0 | 0 | 2022-03-29 | No monitoring in the last year |
| | **In Total:** | 169 | 437 | 282 | 45 | 91 | 39 | **45** | **96** | **41** | 45 | 96 | 41 | 0 | 0 | 0 | | |

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 1 | 0 | 0 | **1** | **0** | **0** | 1 | 0 | 0 | 0 | 0 | 0 | 2015-06-25 | No monitoring in the last year |
| **Palikea 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 data available |
| | **Out Total:** | 5 | 0 | 0 | 2 | 0 | 0 | **2** | **0** | **0** | 2 | 0 | 0 | 0 | 0 | 0 | | |
| | **Total for Taxon:** | 174 | 437 | 282 | 47 | 91 | 39 | **47** | **96** | **41** | 47 | 96 | 41 | 0 | 0 | 0 | | |

# Population Unit Status - Oahu Implementation Plan

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 37 | 84 | 0 | **58** | **117** | **0** | 1 | 0 | 0 | 57 | 117 | 0 | 2023-04-20 | More plants were added to the outplanting site |
| **Helemano and Poamoho** | Manage for stability | 18 | 0 | 0 | 23 | 0 | 0 | **23** | **0** | **0** | 23 | 0 | 0 | 0 | 0 | 0 | 2022-08-28 | No changes observed in the last year |
| **Kaiwikoele, Kamananui, and Kawainui** | Genetic Storage | 20 | 0 | 0 | 13 | 0 | 0 | **13** | **0** | **0** | 13 | 0 | 0 | 0 | 0 | 0 | 2015-06-17 | No monitoring in the last year |
| **Lower Peahinaia** | Manage for stability | 45 | 1 | 0 | 9 | 20 | 0 | **9** | **29** | **0** | 9 | 1 | 0 | 0 | 28 | 0 | 2023-06-14 | More plants were added to the outplanting site |
| **South Kaukonahua** | Genetic Storage | 2 | 0 | 0 | 2 | 0 | 0 | **2** | **0** | **0** | 2 | 0 | 0 | 0 | 0 | 0 | 2018-09-25 | No monitoring in the last year |
| **Upper Opaeula/Helemano** | Genetic Storage | 1 | 0 | 0 | 1 | 27 | 0 | **1** | **28** | **0** | 1 | 1 | 0 | 0 | 27 | 0 | 2022-09-27 | Small changes were noted during monitoring in the last year |
| | **In Total:** | 88 | 1 | 0 | 85 | 131 | 0 | **106** | **174** | **0** | 49 | 2 | 0 | 57 | 172 | 0 | | |

# Population Unit Status - Oahu Implementation Plan

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2016-03-09 | No plants at this site |
| **Kahana and Makaua** | Genetic Storage | 2 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | | No data available |
| **Kaipapau to Punaluu** | Genetic Storage | 4 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | | No data available |
| **Kalauao** | Genetic Storage | 4 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | | No data available |
| **Kaluaa and Maunauna** | Genetic Storage | 1 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2021-06-29 | No plants at this site |
| **Kamananui-Malaekahana Summit Ridge** | Genetic Storage | 13 | 0 | 0 | 3 | 0 | 0 | **3** | **0** | **0** | 3 | 0 | 0 | 0 | 0 | 0 | 2015-08-25 | No monitoring in the last year |
| **Kapakahi** | Genetic Storage | 4 | 0 | 0 | 2 | 0 | 0 | **2** | **0** | **0** | 2 | 0 | 0 | 0 | 0 | 0 | 2016-06-25 | 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 data available |
| **Pukele** | Genetic Storage | 1 | 0 | 0 | 1 | 0 | 0 | **1** | **0** | **0** | 1 | 0 | 0 | 0 | 0 | 0 | 1986-07-29 | No data available as of 1986 |
| **Waialae Nui** | Genetic Storage | 1 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | | No data available |
| | **Out Total:** | 36 | 0 | 0 | 6 | 0 | 0 | **6** | **0** | **0** | 6 | 0 | 0 | 0 | 0 | 0 | | |
| | **Total for Taxon:** | 124 | 1 | 0 | 91 | 131 | 0 | **112** | **174** | **0** | 55 | 2 | 0 | 57 | 172 | 0 | | |

# Population Unit Status - Oahu Implementation Plan

## Action Area: In

### TaxonName: Geniostoma 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 206 | 10 | 0 | **195** | **12** | **0** | 62 | 0 | 0 | 133 | 12 | 0 | 2023-04-05 | Thorough monitoring in the last year showed a decline |
| | **In Total:** | 84 | 16 | 2 | 206 | 10 | 0 | **195** | **12** | **0** | 62 | 0 | 0 | 133 | 12 | 0 | | |

## Action Area: Out

### TaxonName: Geniostoma 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | | | | 2 | 1 | 0 | **3** | **3** | **0** | 0 | 0 | 0 | 3 | 3 | 0 | 2023-05-04 | Small changes were noted during monitoring in the last year |
| | **Out Total:** | | | | 2 | 1 | 0 | **3** | **3** | **0** | 0 | 0 | 0 | 3 | 3 | 0 | | |
| | **Total for Taxon:** | 84 | 16 | 2 | 208 | 11 | 0 | **198** | **15** | **0** | 62 | 0 | 0 | 136 | 15 | 0 | | |

# Population Unit Status - Oahu Implementation Plan

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 2023-05-03 | No changes observed in the last year |
| **Kaukonahua** | Manage for stability | 76 | 51 | 122 | 55 | 54 | 2 | **55** | **54** | **2** | 55 | 54 | 2 | 0 | 0 | 0 | 2015-07-29 | No monitoring in the last year |
| **Lower Opaeula** | Manage for stability | 9 | 15 | 0 | 11 | 15 | 6 | **11** | **15** | **6** | 11 | 15 | 6 | 0 | 0 | 0 | 2017-05-03 | No monitoring in the last year |
| **Ohiaai ridge** | Genetic Storage | 5 | 1 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | | No plants at this site |
| **Poamoho** | Genetic Storage | 38 | 16 | 3 | 13 | 1 | 4 | **13** | **1** | **4** | 13 | 1 | 4 | 0 | 0 | 0 | 2017-05-03 | No monitoring in the last year |
| | **In Total:** | 182 | 128 | 139 | 213 | 182 | 57 | **213** | **182** | **57** | 213 | 182 | 57 | 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 plants at this site |
| **Kapakahi** | Genetic Storage | 1 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | | No plants at this site |
| **Niu-Waimanalo Summit Ridge** | Genetic Storage | 4 | 0 | 0 | 1 | 4 | 1 | **1** | **4** | **1** | 1 | 4 | 1 | 0 | 0 | 0 | 2015-05-29 | No monitoring in the last year |
| **Waimano** | Genetic Storage | 0 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | | No plants at this site |
| | **Out Total:** | 8 | 0 | 0 | 1 | 4 | 1 | **1** | **4** | **1** | 1 | 4 | 1 | 0 | 0 | 0 | | |
| | **Total for Taxon:** | 190 | 128 | 139 | 214 | 186 | 58 | **214** | **186** | **58** | 214 | 186 | 58 | 0 | 0 | 0 | | |

# Population Unit Status - Oahu Implementation Plan

## Action Area: In

### TaxonName: Phyllostegia hirsuta

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 12 | 4 | 0 | **11** | **4** | **0** | 9 | 4 | 0 | 2 | 0 | 0 | 2023-04-05 | Small changes were noted during monitoring in the last year |
| **Helemano and Opaeula** | 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 and Poamoho** | Genetic Storage | 1 | 0 | 0 | 2 | 0 | 0 | **2** | **0** | **0** | 2 | 0 | 0 | 0 | 0 | 0 | 2016-06-02 | No monitoring in the last year |
| **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 plants at this site |
| **Kawaiiki** | Genetic Storage | 0 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2008-10-09 | No plants at this site |
| **Koloa** | Manage for stability | 0 | 0 | 0 | 15 | 3 | 1 | **15** | **3** | **1** | 9 | 2 | 1 | 6 | 1 | 0 | 2022-05-11 | More plants were added to the outplanting site |
| | **In Total:** | 32 | 19 | 6 | 34 | 11 | 1 | **33** | **11** | **1** | 25 | 10 | 1 | 8 | 1 | 0 | | |

## Action Area: Out

### TaxonName: Phyllostegia hirsuta

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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 1 | 3 | 0 | **0** | **1** | **0** | 0 | 1 | 0 | 0 | 0 | 0 | 2023-02-13 | Thorough monitoring in the last year showed a decline |
| **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 | 2016-09-19 | 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 plants at this site |
| **Puu Palikea** | Manage reintroduction for stability | | | | 7 | 39 | 0 | **7** | **90** | **0** | 0 | 0 | 0 | 7 | 90 | 0 | 2023-04-10 | New reintroduction was established |
| **Waiamano** | Genetic Storage | | | | 1 | 0 | 0 | **1** | **0** | **0** | 1 | 0 | 0 | 0 | 0 | 0 | 2006-01-01 | No monitoring in the last year |
| | **Out Total:** | 18 | 10 | 7 | 15 | 45 | 0 | **14** | **94** | **0** | 7 | 4 | 0 | 7 | 90 | 0 | | |

# Population Unit Status - Oahu Implementation Plan

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total for Taxon:** | 50 | 29 | 13 | 49 | 56 | 1 | **47** | **105** | **1** | 32 | 14 | 1 | 15 | 91 | 0 |

# Population Unit Status - Oahu Implementation Plan

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 2020-09-21 | No plants observed at this site since 2020 |
| | **In Total:** | 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 2 | 4 | 0 | **2** | **4** | **0** | 0 | 0 | 0 | 2 | 4 | 0 | 2022-05-10 | No monitoring in the last year |
| **Kaluaa** | Manage for stability | 38 | 11 | 0 | 20 | 5 | 0 | **6** | **0** | **4** | 0 | 0 | 0 | 6 | 0 | 4 | 2023-05-31 | Thorough monitoring in the last year showed a decline |
| **Pualii** | Manage reintroduction for stability | 0 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2017-08-16 | No plants observed at this site since 2017 |
| **Waieli** | Genetic Storage | 0 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2018-04-12 | No plants observed at this site since 2017 |
| | **Out Total:** | 73 | 11 | 0 | 22 | 9 | 0 | **8** | **4** | **4** | 0 | 0 | 0 | 8 | 4 | 4 | | |
| | **Total for Taxon:** | 73 | 15 | 0 | 22 | 9 | 0 | **8** | **4** | **4** | 0 | 0 | 0 | 8 | 4 | 4 | | |

# Population Unit Status - Oahu Implementation Plan

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 418 | 745 | 377 | **402** | **767** | **377** | 280 | 373 | 377 | 122 | 394 | 0 | 2022-09-29 | Small changes were noted during monitoring in the last year |
| | **In Total:** | 180 | 196 | 318 | 418 | 745 | 377 | **402** | **767** | **377** | 280 | 373 | 377 | 122 | 394 | 0 | | |
| | **Total for Taxon:** | 180 | 196 | 318 | 418 | 745 | 377 | **402** | **767** | **377** | 280 | 373 | 377 | 122 | 394 | 0 | | |

# Population Unit Status - Oahu Implementation Plan

## 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 1 | 15 | 0 | **2** | **11** | **0** | 0 | 0 | 0 | 2 | 11 | 0 | 2023-04-20 | Small changes were noted during monitoring in the last year |
| | **In Total:** | 1 | 0 | 0 | 1 | 15 | 0 | **2** | **11** | **0** | 0 | 0 | 0 | 2 | 11 | 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 2022 | Total Immature 2022 | Total Seedling 2022 | **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 | 5 | 9 | 0 | **5** | **8** | **0** | 0 | 0 | 0 | 5 | 8 | 0 | 2023-04-13 | Small changes were noted during monitoring in the last year |
| **Makaha** | Manage reintroduction for stability | | | | 0 | 0 | 0 | **0** | **0** | **0** | 0 | 0 | 0 | 0 | 0 | 0 | 2019-06-03 | No plants observed at this site |
| | **Out Total:** | 0 | 79 | 0 | 5 | 9 | 0 | **5** | **8** | **0** | 0 | 0 | 0 | 5 | 8 | 0 | | |
| | **Total for Taxon:** | 1 | 79 | 0 | 6 | 24 | 0 | **7** | **19** | **0** | 0 | 0 | 0 | 7 | 19 | 0 | | |

# Threat Control Summary Makua Implementation Plan

## 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 | 0 | Yes | Partial | Partial | Partial | No |
| **Makua** | Manage for stability | 4 | Yes | Partial 25% | Partial 25% | No | No |
| **South Mohiakea** | Genetic Storage | 0 | Yes | No | No | No | No |
| **West Makaleha** | Genetic Storage | 1 | 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 Waieli** | Manage for stability | 2 | Partial 0% | Partial 0% | Partial 0% | Partial 0% | No |
| **Makaha** | Manage for stability | 5 | Partial 100% | Partial 80% | Partial 100% | No | No |
| **Waianae Kai** | Genetic Storage | 0 | Partial | 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 Makua Implementation Plan

## 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 | 304 | Partial 100% | Partial 100% | Partial 79% | No | No |
| **Kuaokala** | Genetic Storage | 0 | 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 | 261 | Yes | Partial 99% | Yes | No | No |
| **Makaha and Waianae Kai** | Manage for stability | 52 | Partial 88% | Partial 88% | Partial 100% | Partial 79% | No |
| **South Huliwai** | Genetic Storage | 34 | No | 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 Makua Implementation Plan

## 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 | 71 | Partial 96% | Partial 100% | Partial 99% | Partial 30% | 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 | 15 | Partial 100% | Partial 100% | Partial 80% | Partial 100% | No |
| **Makaha** | Genetic Storage | 0 | Partial | Partial | Yes | Partial | No |
| **North branch of South Ekahanui** | Manage reintroduction for stability | 53 | Yes | Partial 100% | Partial 100% | Partial 100% | No |
| **Palikea (South Palawai)** | Manage for stability | 661 | Partial 100% | 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 Makua Implementation Plan

## 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 | 41 | Partial 98% | Partial 100% | Partial 88% | Partial 98% | No |
| **Pahole** | Manage for stability | 56 | Yes | Partial 100% | No | Partial 100% | 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 | 19 | Partial 100% | 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 Makua Implementation Plan

## 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 | 17 | Yes | Partial 100% | Partial 100% | Partial 82% | No |
| **Kaluaa** | Manage reintroduction for stability | 0 | Partial | Partial | Partial | Partial | No |
| **Pahole to Kapuna** | Genetic Storage | 38 | Yes | Partial 95% | No | Partial 16% | No |
| **Palikea** | Manage reintroduction for stability | 19 | Partial 100% | Partial 100% | Partial 100% | Yes | Partial 100% |

## 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 | 34 | Partial 100% | Partial 100% | 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 Makua Implementation Plan

## Action Area: In

### TaxonName: Cyrtandra dentata

| PopulationUnitName | ManagementDesignation | # Mature Plants | Ungulates Managed | Weeds Managed | Rats Managed | Slugs Managed | Fire Managed |
|---|---|---|---|---|---|---|---|
| **Kahanahaiki** | Manage for stability | 29 | Yes | Partial 100% | Yes | No | No |
| **Kawaiiki (Koolaus)** | Manage for stability | 2 | No | No | No | No | No |
| **Opaeula (Koolaus)** | Manage for stability | 48 | Partial 98% | Partial 69% | Partial 69% | Partial 67% | No |
| **Pahole to West Makaleha** | Manage for stability | 820 | Partial 100% | Partial 75% | Partial 2% | Partial 27% | 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 Makua Implementation Plan

## Action Area: In

### TaxonName: Delissea waianaeensis

| PopulationUnitName | ManagementDesignation | # Mature Plants | Ungulates Managed | Weeds Managed | Rats Managed | Slugs Managed | Fire Managed |
|---|---|---|---|---|---|---|---|
| **Kahanahaiki to Keawapilau** | Manage for stability | 135 | Yes | Partial 99% | Partial 98% | Partial 98% | No |
| **Kaluakauila** | Manage reintroduction for storage | 1 | Yes | Partial 100% | No | No | No |
| **Kapuna** | Manage reintroduction for storage | 71 | Yes | Partial 100% | No | No | No |
| **Palikea Gulch** | Genetic Storage | 1 | No | No | No | No | Partial 100% |
| **South Mohiakea** | Genetic Storage | 11 | Yes | Partial 100% | Yes | No | No |

## Action Area: Out

### TaxonName: Delissea waianaeensis

| PopulationUnitName | ManagementDesignation | # Mature Plants | Ungulates Managed | Weeds Managed | Rats Managed | Slugs Managed | Fire Managed |
|---|---|---|---|---|---|---|---|
| **Ekahanui** | Manage for stability | 68 | Yes | Partial 100% | Partial 100% | Partial 100% | No |
| **Kaluaa** | Manage for stability | 201 | Yes | Partial 100% | Partial 87% | Partial 87% | No |
| **Kealia** | Genetic Storage | 2 | No | No | No | No | No |
| **Manuwai** | Manage reintroduction for stability | 29 | Yes | Partial 100% | Yes | Partial 100% | No |
| **Palawai** | Genetic Storage | 24 | Partial 96% | 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 Makua Implementation Plan

## 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 | 225 | No | No | No | No | No |
| **Ohikilolo Makai** | Manage for stability | 48 | Yes | Partial 56% | Partial 4% | No | No |
| **Ohikilolo Mauka** | Manage for stability | 125 | Yes | Partial 19% | Partial 9% | 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 | 3 | Yes | Partial 0% | Partial 100% | 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 Makua Implementation Plan

## 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 | 1 | Yes | No | No | No | No |
| **Kaluakauila** | Genetic Storage | 11 | No | No | No | No | No |
| **Makua** | Manage for stability | 66 | Yes | Partial 100% | No | No | Partial 100% |
| **North Kahanahaiki** | Genetic Storage | 115 | Yes | No | No | No | No |
| **Puaakanoa** | Manage for stability | 132 | No | Partial 44% | 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 | 1 | No | No | No | No | No |
| **Kaena** | Manage for stability | 843 | No | Partial 100% | Partial 100% | No | No |
| **Keawaula** | Genetic Storage | 30 | No | No | Partial 23% | 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 Makua Implementation Plan

## 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 | 83 | Yes | Partial 100% | No | Partial 98% | No |
| **Manuwai** | Manage reintroduction for stability | 0 | Yes | Partial | 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 | 14 | Yes | Partial 100% | Partial 100% | No | No |
| **Makaha** | Manage reintroduction for storage | 2 | Yes | Partial 100% | 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 Makua Implementation Plan

## 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 | 10 | Yes | Partial 90% | Partial 10% | Partial 0% | 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 | 4 | Partial 75% | No | Partial 25% | No | Partial 0% |
| **Halona** | Genetic Storage | 1 | No | No | No | No | No |
| **Kauhiuhi** | Genetic Storage | 1 | No | No | No | No | No |
| **Makaha** | Manage for stability | 12 | Partial 83% | Partial 92% | Partial 83% | No | No |
| **Manuwai** | Manage reintroduction for stability | 0 | Yes | Partial | No | No | No |
| **Mt. Kaala NAR** | Genetic Storage | 2 | 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 Makua Implementation Plan

## Action Area: In

### TaxonName: Gouania vitifolia

| PopulationUnitName | ManagementDesignation | # Mature Plants | Ungulates Managed | Weeds Managed | Rats Managed | Slugs Managed | Fire Managed |
|---|---|---|---|---|---|---|---|
| **Keaau** | Manage for stability | 5 | Yes | Partial 20% | No | No | No |

## Action Area: Out

### TaxonName: Gouania vitifolia

| PopulationUnitName | ManagementDesignation | # Mature Plants | Ungulates Managed | Weeds Managed | Rats Managed | Slugs Managed | Fire Managed |
|---|---|---|---|---|---|---|---|
| **Waianae Kai** | 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 Makua Implementation Plan

## Action Area: In

### TaxonName: Hesperomannia oahuensis

| PopulationUnitName | ManagementDesignation | # Mature Plants | Ungulates Managed | Weeds Managed | Rats Managed | Slugs Managed | Fire Managed |
|---|---|---|---|---|---|---|---|
| **Haleauau** | Manage for stability | 0 | Yes | Partial | Partial | No | No |
| **Pahole NAR** | Manage reintroduction for stability | 0 | Yes | Partial | 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 | 16 | Yes | Partial 88% | Yes | Partial 88% | No |
| **Pualii** | Manage reintroduction for stability | 17 | Yes | Partial 100% | Yes | 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 Makua Implementation Plan

## 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 | 57 | Yes | Partial 100% | No | No | No |
| **Makua** | Manage for stability | 30 | Yes | Partial 100% | 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 Kawaiu** | Manage for stability | 46 | No | Partial 98% | No | No | No |
| **Manuwai** | Manage reintroduction for stability | 38 | Yes | Partial 100% | No | No | No |
| **Waialua** | Genetic Storage | 49 | 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 Makua Implementation Plan

## 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 | 70 | Yes | Partial 100% | No | Partial 3% | No |
| **Makaha to Ohikilolo** | Manage reintroduction for stability | 83 | Partial 100% | Partial 100% | Yes | Partial 63% | 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 | 40 | Partial 95% | Partial 95% | No | No | No |
| **Central Makaleha and West Branch of East Makaleha** | Manage for stability | 3 | Partial 100% | Partial 100% | No | No | No |
| **East branch of East Makaleha** | Genetic Storage | 0 | Partial | No | Partial | 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 Makua Implementation Plan

## Action Area: In

### TaxonName: Kadua parvula

| PopulationUnitName | ManagementDesignation | # Mature Plants | Ungulates Managed | Weeds Managed | Rats Managed | Slugs Managed | Fire Managed |
|---|---|---|---|---|---|---|---|
| **Ohikilolo** | Manage for stability | 71 | Yes | Partial 39% | No | No | No |

## Action Area: Out

### TaxonName: Kadua parvula

| PopulationUnitName | ManagementDesignation | # Mature Plants | Ungulates Managed | Weeds Managed | Rats Managed | Slugs Managed | Fire Managed |
|---|---|---|---|---|---|---|---|
| **Ekahanui** | Manage reintroduction for stability | 97 | Yes | Partial 100% | Partial 100% | No | No |
| **Halona** | Manage for stability | 26 | Partial 65% | Partial 65% | Partial 65% | 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 Makua Implementation Plan

## 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 | 47 | Yes | Partial 100% | No | No | No |
| **Kapuna** | Genetic Storage | 0 | No | Partial | No | No | No |
| **Makua** | Manage for stability | 44 | Yes | Partial 55% | Partial 55% | No | No |
| **Punapohaku** | Genetic Storage | 2 | Yes | Partial 100% | 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 | 4 | No | No | No | No | No |
| **Leeward Puu Kaua** | Genetic Storage | 9 | No | No | No | No | No |
| **Makaha** | Manage for stability (backup site) | 17 | Partial 82% | Partial 82% | Partial 82% | No | No |
| **Manuwai** | Manage for stability | 18 | Yes | Partial 100% | No | No | No |
| **Waianae Kai Makai** | Genetic Storage | 13 | Yes | No | No | No | Partial 100% |
| **Waianae Kai Mauka** | Manage for stability | 11 | 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 Makua Implementation Plan

## Action Area: In

### TaxonName: Nototrichium humile

| PopulationUnitName | ManagementDesignation | # Mature Plants | Ungulates Managed | Weeds Managed | Rats Managed | Slugs Managed | Fire Managed |
|---|---|---|---|---|---|---|---|
| **Kahanahaiki** | Genetic Storage | 28 | Yes | Partial 25% | Partial 39% | No | No |
| **Kaluakauila** | Manage for stability | 30 | Yes | Partial 100% | No | No | No |
| **Keaau** | Genetic Storage | 20 | No | No | No | No | No |
| **Keawaula** | Genetic Storage | 109 | No | No | No | No | No |
| **Makua (East rim)** | Genetic Storage | 1 | Yes | No | No | No | No |
| **Makua (south side)** | Manage for stability | 50 | Yes | No | No | No | No |
| **Punapohaku** | Genetic Storage | 178 | Yes | 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% |
| **Kapuna and Keawapilau** | Genetic Storage | 4 | No | No | No | No | No |
| **Kolekole** | Genetic Storage | 12 | No | No | No | No | No |
| **Makaha** | Genetic Storage | 22 | Partial 64% | Partial 64% | No | No | No |
| **Manuwai** | Manage reintroduction for stability | 101 | Yes | Partial 100% | No | No | No |
| **Nanakuli** | Genetic Storage | 0 | No | No | No | No | No |
| **Puu Kaua (Leeward side)** | Genetic Storage | 2 | No | No | No | No | No |
| **Waianae Kai** | Manage for stability | 53 | Partial 92% | No | No | No | Partial 92% |

= 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 Makua Implementation Plan

## 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 | Partial | 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 | Partial | Yes | No | No |
| **Manuwai** | Manage reintroduction for stability | 0 | Yes | Partial | Yes | Yes | 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 Makua Implementation Plan

## 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 | 63 | Yes | No | No | No | No |
| **Ohikilolo** | Manage for stability | 0 | Yes | Partial | No | No | No |
| **Pahole** | Genetic Storage | 0 | Yes | Partial | 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 | 0 | Yes | Partial | Yes | No | No |
| **Konahuanui** | Manage for stability | 36 | No | No | No | No | No |
| **North Palawai** | Genetic Storage | 1 | No | No | No | No | No |
| **Waieli** | Manage reintroduction for storage | 0 | Yes | Partial | Partial | 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 Makua Implementation Plan

## Action Area: In

### TaxonName: Pritchardia kaalae

| PopulationUnitName | ManagementDesignation | # Mature Plants | Ungulates Managed | Weeds Managed | Rats Managed | Slugs Managed | Fire Managed |
|---|---|---|---|---|---|---|---|
| **Ohikilolo** | Manage for stability | 178 | Yes | Partial 94% | Partial 94% | No | No |
| **Ohikilolo East and West Makaleha** | Manage reintroduction for stability | 45 | Yes | Partial 100% | Yes | Partial 47% | 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 46% | No | Partial 30% | No | No |
| **Waianae Kai** | Genetic Storage | 6 | 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 Makua Implementation Plan

## Action Area: In

### TaxonName: Sanicula mariversa

| PopulationUnitName | ManagementDesignation | # Mature Plants | Ungulates Managed | Weeds Managed | Rats Managed | Slugs Managed | Fire Managed |
|---|---|---|---|---|---|---|---|
| **Keaau** | Manage for stability | 14 | Yes | No | No | No | No |
| **Ohikilolo** | Manage for stability | 12 | Yes | Partial 0% | Partial 0% | No | No |

## Action Area: Out

### TaxonName: Sanicula mariversa

| PopulationUnitName | ManagementDesignation | # Mature Plants | Ungulates Managed | Weeds Managed | Rats Managed | Slugs Managed | Fire Managed |
|---|---|---|---|---|---|---|---|
| **Kamaileunu** | Manage for stability | 31 | 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 Makua Implementation Plan

## Action Area: In

### TaxonName: Schiedea kaalae

| PopulationUnitName | ManagementDesignation | # Mature Plants | Ungulates Managed | Weeds Managed | Rats Managed | Slugs Managed | Fire Managed |
|---|---|---|---|---|---|---|---|
| **Kaluanui** | Manage for stability | 46 | No | No | No | No | No |
| **Pahole** | Manage for stability | 48 | Partial 100% | Partial 100% | Partial 0% | Partial 46% | 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 | No | No | No | No | No |
| **Kaluaa and Waieli** | Manage for stability | 120 | Yes | Partial 100% | Partial 100% | Partial 13% | No |
| **Maakua (Koolaus)** | Genetic Storage | 3 | No | No | No | No | No |
| **Makaua (Koolaus)** | Genetic Storage | 85 | No | No | No | No | No |
| **North Palawai** | Genetic Storage | 0 | Yes | No | No | No | No |
| **South Ekahanui** | Manage for stability | 151 | Yes | Partial 100% | Yes | Partial 95% | 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 Makua Implementation Plan

## 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 | 168 | Yes | Partial 100% | Partial 90% | Partial 10% | No |
| **Kapuna-Keawapilau Ridge** | Manage for stability | 24 | Yes | Partial 100% | Yes | Partial 100% | 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 | 140 | Yes | Partial 100% | 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 Makua Implementation Plan

## 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 | 186 | Partial 100% | Partial 100% | Partial 100% | Partial 99% | No |
| **Keawapilau to West Makaleha** | Manage for stability | 19 | Yes | Partial 68% | Partial 68% | Partial 63% | 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 | 135 | Yes | Partial 72% | Partial 33% | Partial 67% | 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 Makua Implementation Plan

## Action Area: In

### TaxonName: Tetramolopium filiforme

| PopulationUnitName | ManagementDesignation | # Mature Plants | Ungulates Managed | Weeds Managed | Rats Managed | Slugs Managed | Fire Managed |
|---|---|---|---|---|---|---|---|
| **Kahanahaiki** | Genetic Storage | 40 | Yes | No | No | No | No |
| **Kalena** | Manage for stability | 35 | Yes | No | No | No | No |
| **Keaau** | Genetic Storage | 30 | Yes | No | No | No | No |
| **Makaha/Ohikilolo Ridge** | Genetic Storage | 350 | No | No | No | No | No |
| **Ohikilolo** | Manage for stability | 2808 | Partial 100% | Partial 6% | No | No | No |
| **Puhawai** | Manage for stability | 0 | 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 | 21 | 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 Makua Implementation Plan

## 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 | 0 | No | No | No | No | No |
| **Ohikilolo** | Manage for stability | 182 | Yes | Partial 10% | Partial 7% | No | No |
| **Puu Kumakalii** | Manage for stability | 73 | 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 | 51 | Partial 75% | Partial 75% | Partial 75% | No | No |
| **Kamaileunu** | Genetic Storage | 35 | No | No | No | No | No |
| **Makaha** | Manage for stability | 25 | Partial 28% | Partial 0% | Partial 28% | No | No |
| **Makaleha** | Genetic Storage | 19 | Yes | No | No | No | No |
| **Puu Hapapa** | Genetic Storage | 6 | 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 Makua Implementation Plan

## Action Area: In

### TaxonName: Wollastonia tenuifolia

| PopulationUnitName | ManagementDesignation | # Mature Plants | Ungulates Managed | Weeds Managed | Rats Managed | Slugs Managed | Fire Managed |
|---|---|---|---|---|---|---|---|
| **Kahanahaiki** | Genetic Storage | 1 | Yes | No | No | No | No |
| **Kaluakauila** | Genetic Storage | 4 | Yes | No | No | No | No |
| **Keawaula** | Genetic Storage | 200 | No | No | No | No | No |
| **Ohikilolo** | Manage for stability | 570 | Partial 100% | Partial 3% | Partial 2% | No | Partial 9% |

## Action Area: Out

### TaxonName: Wollastonia tenuifolia

| PopulationUnitName | ManagementDesignation | # Mature Plants | Ungulates Managed | Weeds Managed | Rats Managed | Slugs Managed | Fire Managed |
|---|---|---|---|---|---|---|---|
| **Kamaileunu and Waianae Kai** | Manage for stability | 815 | Partial 21% | Partial 8% | Partial 10% | No | No |
| **Mt. Kaala NAR** | Manage for stability | 131 | 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 Oahu Implementation Plan

## 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 | 35 | Partial 63% | Partial 60% | Partial 6% | No | Partial 11% |
| **Kahanahaiki** | Manage reintroduction for stability | 71 | Yes | Partial 100% | No | No | No |
| **Kaluakauila** | Manage reintroduction for storage | 0 | Yes | Partial | No | No | No |
| **Keaau** | Genetic Storage | 0 | 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 | 72 | Partial 100% | Partial 100% | Partial 99% | No | No |
| **Halona** | Genetic Storage | 10 | No | No | No | No | No |
| **Makaha Makai** | Manage for stability | 81 | Partial 72% | Partial 72% | Partial 56% | No | No |
| **Makaha Mauka** | Genetic Storage | 13 | No | No | No | No | No |
| **Nanakuli** | Genetic Storage | 3 | No | No | No | No | No |
| **North Mikilua** | Genetic Storage | 9 | No | 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 Oahu Implementation Plan

## 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 | 23 | No | No | No | No | No |
| **Kahana and South Kaukonahua** | Genetic Storage | 2 | No | No | No | No | No |
| **Makaleha to Mohiakea** | Manage for stability | 210 | Partial 100% | Partial 7% | Partial 1% | 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 | 126 | 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 Oahu Implementation Plan

## Action Area: In

### TaxonName: Cyanea koolauensis

| PopulationUnitName | ManagementDesignation | # Mature Plants | Ungulates Managed | Weeds Managed | Rats Managed | Slugs Managed | Fire Managed |
|---|---|---|---|---|---|---|---|
| **Kaipapau, Koloa and Kawainui** | Manage for stability | 40 | Partial 53% | Partial 25% | Partial 25% | No | No |
| **Kamananui-Kawainui Ridge** | Genetic Storage | 6 | No | No | No | No | No |
| **Kaukonahua** | Genetic Storage | 8 | Partial 0% | No | No | No | No |
| **Kawaiiki** | Genetic Storage | 4 | No | No | No | No | No |
| **Lower Opaeula** | Genetic Storage | 1 | No | No | No | No | No |
| **Opaeula to Helemano** | Manage for stability | 22 | Partial 55% | No | No | No | No |
| **Poamoho** | Manage for stability | 20 | Partial 50% | 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 Oahu Implementation Plan

## 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 | 17 | No | Partial 0% | No | No | No |
| **Kaleleiki** | Genetic Storage | 8 | Partial 50% | Partial 50% | No | No | No |
| **Kaunala** | Manage for stability | 6 | Partial 83% | Partial 17% | No | No | No |
| **Malaekahana** | Genetic Storage | 0 | No | No | No | No | No |
| **Ohiaai and East Oio** | Genetic Storage | 1 | Yes | No | No | No | No |
| **Oio** | Manage for stability | 3 | Partial 67% | No | No | No | No |
| **Pahipahialua** | Manage for stability | 2 | Partial 100% | Partial 100% | 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 Oahu Implementation Plan

## Action Area: In

### TaxonName: Gardenia mannii

| PopulationUnitName | ManagementDesignation | # Mature Plants | Ungulates Managed | Weeds Managed | Rats Managed | Slugs Managed | Fire Managed |
|---|---|---|---|---|---|---|---|
| **Haleauau** | Manage for stability | 58 | Yes | Partial 98% | Partial 98% | No | No |
| **Helemano and Poamoho** | Manage for stability | 23 | Partial 48% | Partial 4% | No | No | No |
| **Kaiwikoele, Kamananui, and Kawainui** | Genetic Storage | 13 | No | No | No | No | No |
| **Lower Peahinaia** | Manage for stability | 9 | Partial 44% | Partial 78% | Partial 67% | Partial 0% | No |
| **South Kaukonahua** | Genetic Storage | 2 | No | No | No | No | No |
| **Upper Opaeula/Helemano** | Genetic Storage | 1 | Partial 100% | 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 | 0 | No | No | No | No | No |
| **Kaluaa and Maunauna** | Genetic Storage | 0 | 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 Oahu Implementation Plan

## Action Area: In

### TaxonName: Geniostoma cyrtandrae

| PopulationUnitName | ManagementDesignation | # Mature Plants | Ungulates Managed | Weeds Managed | Rats Managed | Slugs Managed | Fire Managed |
|---|---|---|---|---|---|---|---|
| **East Makaleha to North Mohiakea** | Manage for stability | 195 | Partial 93% | Partial 82% | Partial 67% | Partial 58% | No |

## Action Area: Out

### TaxonName: Geniostoma cyrtandrae

| PopulationUnitName | ManagementDesignation | # Mature Plants | Ungulates Managed | Weeds Managed | Rats Managed | Slugs Managed | Fire Managed |
|---|---|---|---|---|---|---|---|
| **Koloa** | Manage reintroduction for stability | 3 | Partial 100% | Partial 100% | Partial 0% | 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 Oahu Implementation Plan

## 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% | Partial 2% | No | No | No |
| **Kaukonahua** | Manage for stability | 55 | Partial 5% | No | No | No | No |
| **Lower Opaeula** | Manage for stability | 11 | No | No | No | No | No |
| **Poamoho** | Genetic Storage | 13 | Partial 54% | Partial 8% | 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 Ridge** | Genetic Storage | 1 | No | 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 Oahu Implementation Plan

## 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 | 11 | Yes | Partial 18% | Partial 18% | Partial 18% | No |
| **Helemano and Opaeula** | Genetic Storage | 1 | Partial 0% | Partial 0% | Partial 0% | No | No |
| **Helemano and Poamoho** | Genetic Storage | 2 | Yes | 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 | 15 | Partial 87% | Partial 87% | Partial 40% | 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 | 0 | Partial | 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 Palikea** | Manage reintroduction for stability | 7 | Yes | Partial 100% | Yes | Partial 100% | 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 Oahu Implementation Plan

## 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 | 2 | Yes | Partial 100% | Yes | Partial 100% | No |
| **Kaluaa** | Manage for stability | 6 | Yes | Partial 100% | Partial 100% | Partial 100% | No |
| **Pualii** | Manage reintroduction for stability | 0 | Yes | Partial | No | No | No |
| **Waieli** | Genetic Storage | 0 | Partial | 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 Oahu Implementation Plan

## 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 | 394 | Partial 99% | Partial 89% | Partial 6% | 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 Oahu Implementation Plan

## 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 | 2 | Yes | Partial 100% | Partial 0% | 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 | 5 | Yes | Partial 100% | Partial 0% | No | No |
| **Makaha** | Manage reintroduction for stability | 0 | Yes | Partial | 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

2023-09-28



# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Alectryon macrococcus var. macrococcus** | | | | | | | | | | | | | | |
| Kahanahaiki to Keawapilau | Manage for stability | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Makua | Manage for stability | 4 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 2 | 33% |
| South Mohiakea | Genetic Storage | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0% |
| West Makaleha | Genetic Storage | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 50% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Alectryon macrococcus var. macrococcus** | | | | | | | | | | | | | | |
| Central Kaluaa to Central Waieli | Manage for stability | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Makaha | Manage for stability | 5 | 0 | 12 | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 10 | 10 | 59% |
| Waianae Kai | Genetic Storage | 0 | 0 | 0 | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 0 | 17 | 0 | 0 | 0 | 18 | 0 | 0 | 0 | 13 | 13 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Cenchrus agrimonioides var. agrimonioides** | | | | | | | | | | | | | | |
| Kahanahaiki and Pahole | Manage for stability | 70 | 27 | 82 | 91 | 77 | 0 | 0 | 67 | 41 | 0 | 0 | 50 | 100% |
| Kuaokala | Genetic Storage | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 100% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Cenchrus agrimonioides var. agrimonioides** | | | | | | | | | | | | | | |
| Central Ekahanui | Manage for stability | 93 | 34 | 53 | 90 | 66 | 0 | 51 | 57 | 22 | 0 | 32 | 42 | 84% |
| Makaha and Waianae Kai | Manage for stability | 6 | 0 | 8 | 12 | 10 | 0 | 9 | 7 | 2 | 0 | 8 | 8 | 57% |
| South Huliwai | Genetic Storage | 34 | 29 | 28 | 47 | 40 | 0 | 36 | 39 | 26 | 0 | 19 | 31 | 62% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 203 | 90 | 172 | 241 | 194 | 0 | 97 | 171 | 92 | 0 | 60 | 132 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Cyanea grimesiana subsp. obatae** | | | | | | | | | | | | | | |
| Pahole to West Makaleha | Manage for stability | 4 | 0 | 13 | 15 | 15 | 0 | 9 | 13 | 13 | 0 | 5 | 13 | 76% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Cyanea grimesiana subsp. obatae** | | | | | | | | | | | | | | |
| Kaluaa | Manage for stability | 3 | 1 | 1 | 3 | 3 | 0 | 3 | 3 | 3 | 0 | 3 | 3 | 75% |
| Makaha | Genetic Storage | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 100% |
| North branch of South Ekahanui | Manage reintroduction for stability | 0 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 100% |
| Palikea (South Palawai) | Manage for stability | 10 | 6 | 12 | 17 | 17 | 5 | 1 | 17 | 17 | 5 | 0 | 17 | 77% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | 7 | 29 | 38 | 38 | 7 | 15 | 36 | 36 | 7 | 10 | 36 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Cyanea longiflora** | | | | | | | | | | | | | | |
| Kapuna to West Makaleha | Manage for stability | 12 | 1 | 21 | 31 | 31 | 9 | 18 | 30 | 30 | 9 | 6 | 30 | 91% |
| Pahole | Manage for stability | 50 | 158 | 38 | 64 | 64 | 1 | 28 | 62 | 62 | 1 | 11 | 63 | 100% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Cyanea longiflora** | | | | | | | | | | | | | | |
| Makaha and Waianae Kai | Manage for stability | 5 | 0 | 4 | 6 | 6 | 1 | 3 | 6 | 6 | 1 | 2 | 6 | 67% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 67 | 159 | 63 | 101 | 101 | 11 | 49 | 98 | 98 | 11 | 19 | 99 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Cyanea superba subsp. superba** | | | | | | | | | | | | | | |
| Kahanahaiki | Manage reintroduction for stability | 0 | 0 | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 1 | 3 | 3 | 100% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 1 | 3 | 3 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Cyrtandra dentata** | | | | | | | | | | | | | | |
| Kahanahaiki | Manage for stability | 29 | 45 | 27 | 36 | 36 | 0 | 0 | 36 | 36 | 0 | 0 | 36 | 72% |
| Kawaiiki (Koolaus) | Manage for stability | 2 | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Opaeula (Koolaus) | Manage for stability | 38 | 50 | 6 | 12 | 12 | 0 | 1 | 12 | 12 | 0 | 1 | 12 | 27% |
| Pahole to West Makaleha | Manage for stability | 820 | 1713 | 45 | 159 | 159 | 0 | 5 | 159 | 159 | 0 | 1 | 159 | 100% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Cyrtandra dentata** | | | | | | | | | | | | | | |
| Central Makaleha | Genetic Storage | 3 | 0 | 0 | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 892 | 1827 | 78 | 207 | 207 | 0 | 6 | 207 | 207 | 0 | 2 | 207 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Delissea waianaeensis** | | | | | | | | | | | | | | |
| Kahanahaiki to Keawapilau | Manage for stability | 4 | 0 | 14 | 15 | 15 | 1 | 10 | 15 | 15 | 1 | 5 | 15 | 83% |
| Palikea Gulch | Genetic Storage | 1 | 0 | 6 | 7 | 7 | 3 | 4 | 7 | 7 | 3 | 0 | 7 | 100% |
| South Mohiakea | Genetic Storage | 11 | 6 | 11 | 21 | 21 | 0 | 4 | 20 | 20 | 0 | 4 | 20 | 91% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Delissea waianaeensis** | | | | | | | | | | | | | | |
| Ekahanui | Manage for stability | 0 | 0 | 6 | 6 | 6 | 0 | 5 | 6 | 6 | 0 | 5 | 6 | 100% |
| Kaluaa | Manage for stability | 1 | 0 | 7 | 9 | 9 | 0 | 7 | 8 | 8 | 0 | 7 | 9 | 100% |
| Kealia | Genetic Storage | 2 | 0 | 5 | 7 | 7 | 0 | 2 | 7 | 7 | 0 | 2 | 7 | 100% |
| Palawai | Genetic Storage | 24 | 30 | 8 | 30 | 30 | 0 | 0 | 28 | 28 | 0 | 0 | 28 | 88% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 43 | 36 | 57 | 95 | 95 | 4 | 32 | 91 | 91 | 4 | 23 | 92 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Dubautia herbstobatae** | | | | | | | | | | | | | | |
| Keaau | Genetic Storage | 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Makaha/Ohikilolo | Genetic Storage | 225 | 4 | 0 | 6 | 1 | 0 | 10 | 6 | 0 | 0 | 10 | 10 | 20% |
| Ohikilolo Makai | Manage for stability | 48 | 0 | 1 | 1 | 0 | 3 | 11 | 1 | 0 | 3 | 10 | 11 | 22% |
| Ohikilolo Mauka | Manage for stability | 125 | 14 | 0 | 7 | 1 | 11 | 34 | 6 | 0 | 10 | 31 | 31 | 62% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Dubautia herbstobatae** | | | | | | | | | | | | | | |
| Kamaileunu | Genetic Storage | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 100% |
| Makaha | Manage for stability | 3 | 9 | 29 | 23 | 1 | 12 | 22 | 19 | 1 | 12 | 20 | 22 | 69% |
| Waianae Kai | Genetic Storage | 10 | 4 | 0 | 5 | 0 | 2 | 2 | 4 | 0 | 2 | 2 | 2 | 20% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 481 | 31 | 31 | 43 | 3 | 29 | 80 | 37 | 1 | 28 | 74 | 77 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Euphorbia celastroides var. kaenana** | | | | | | | | | | | | | | |
| East Kahanahaiki | Genetic Storage | 1 | 0 | 1 | 1 | 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% |
| Makua | Manage for stability | 66 | 0 | 43 | 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 | 132 | 5 | 12 | 51 | 45 | 0 | 0 | 33 | 31 | 0 | 0 | 31 | 62% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Euphorbia celastroides var. kaenana** | | | | | | | | | | | | | | |
| East of Alau | Manage for stability | 1 | 0 | 25 | 26 | 26 | 0 | 0 | 24 | 21 | 0 | 0 | 21 | 81% |
| Kaena | Manage for stability | 843 | 43 | 13 | 106 | 87 | 0 | 0 | 71 | 60 | 0 | 0 | 60 | 100% |
| Keawaula | Genetic Storage | 30 | 2 | 19 | 34 | 29 | 0 | 0 | 19 | 10 | 0 | 0 | 10 | 20% |
| Waianae Kai | Genetic Storage | 34 | 0 | 0 | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1233 | 89 | 117 | 311 | 277 | 0 | 0 | 219 | 183 | 0 | 0 | 183 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Euphorbia herbstii** | | | | | | | | | | | | | | |
| Kapuna to Pahole | Manage for stability | 4 | 1 | 61 | 35 | 33 | 0 | 9 | 26 | 23 | 0 | 2 | 24 | 48% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 1 | 61 | 35 | 33 | 0 | 9 | 26 | 23 | 0 | 2 | 24 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Flueggea neowawraea** | | | | | | | | | | | | | | |
| Kahanahaiki to Kapuna | Manage for stability | 5 | 0 | 2 | 3 | 3 | 0 | 4 | 2 | 2 | 0 | 3 | 3 | 43% |
| Ohikilolo | Manage for stability | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 50% |
| West Makaleha | Genetic Storage | 6 | 0 | 1 | 1 | 1 | 0 | 5 | 1 | 1 | 0 | 4 | 4 | 57% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Flueggea neowawraea** | | | | | | | | | | | | | | |
| Central and East Makaleha | Genetic Storage | 4 | 0 | 3 | 1 | 1 | 0 | 5 | 1 | 1 | 0 | 4 | 4 | 57% |
| Halona | Genetic Storage | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 50% |
| Kauhiuhi | Genetic Storage | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 100% |
| Makaha | Manage for stability | 7 | 0 | 4 | 2 | 1 | 0 | 10 | 2 | 0 | 0 | 7 | 7 | 64% |
| Mt. Kaala NAR | Genetic Storage | 2 | 0 | 2 | 2 | 2 | 0 | 3 | 2 | 1 | 0 | 2 | 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 | 1 | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 29 | 0 | 14 | 10 | 9 | 0 | 32 | 9 | 6 | 0 | 24 | 24 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Gouania vitifolia** | | | | | | | | | | | | | | |
| Keaau | Manage for stability | 4 | 3 | 55 | 55 | 51 | 0 | 4 | 52 | 48 | 0 | 2 | 48 | 96% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Gouania vitifolia** | | | | | | | | | | | | | | |
| Waianae Kai | Genetic Storage | 0 | 0 | 0 | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 3 | 55 | 55 | 51 | 0 | 4 | 52 | 48 | 0 | 2 | 48 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Hesperomannia oahuensis** | | | | | | | | | | | | | | |
| Haleauau | Manage for stability | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 100% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Hesperomannia oahuensis** | | | | | | | | | | | | | | |
| Makaha | Manage for stability | 2 | 1 | 3 | 2 | 2 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 20% |
| Waianae Kai | Genetic Storage | 0 | 0 | 2 | 1 | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 1 | 6 | 4 | 3 | 0 | 1 | 2 | 2 | 0 | 1 | 2 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Hibiscus brackenridgei subsp. mokuleianus** | | | | | | | | | | | | | | |
| Keaau | Manage for stability | 12 | 14 | 21 | 17 | 17 | 0 | 30 | 15 | 15 | 0 | 23 | 32 | 97% |
| Makua | Manage for stability | 5 | 7 | 40 | 36 | 36 | 0 | 32 | 35 | 34 | 0 | 31 | 36 | 80% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Hibiscus brackenridgei subsp. mokuleianus** | | | | | | | | | | | | | | |
| Haili to Kawaiu | Manage for stability | 1 | 4 | 19 | 13 | 13 | 0 | 18 | 13 | 13 | 0 | 16 | 19 | 95% |
| Waialua | Genetic Storage | 49 | 85 | 30 | 43 | 38 | 0 | 55 | 31 | 18 | 0 | 50 | 58 | 100% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 67 | 110 | 110 | 109 | 104 | 0 | 135 | 94 | 80 | 0 | 120 | 145 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Kadua degeneri subsp. degeneri** | | | | | | | | | | | | | | |
| Kahanahaiki to Pahole | Manage for stability | 70 | 32 | 53 | 87 | 86 | 0 | 6 | 77 | 72 | 0 | 4 | 72 | 100% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Kadua degeneri subsp. degeneri** | | | | | | | | | | | | | | |
| Alaiheihe and Manuwai | Manage for stability | 16 | 9 | 28 | 40 | 39 | 1 | 0 | 38 | 36 | 1 | 0 | 37 | 84% |
| Central Makaleha and West Branch of East Makaleha | Manage for stability | 3 | 1 | 31 | 36 | 35 | 0 | 11 | 33 | 31 | 0 | 5 | 32 | 94% |
| East branch of East Makaleha | Genetic Storage | 0 | 0 | 0 | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 89 | 42 | 112 | 163 | 160 | 1 | 17 | 148 | 139 | 1 | 9 | 141 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Kadua parvula** | | | | | | | | | | | | | | |
| Ohikilolo | Manage for stability | 43 | 13 | 53 | 82 | 78 | 0 | 0 | 77 | 71 | 0 | 0 | 71 | 100% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Kadua parvula** | | | | | | | | | | | | | | |
| Halona | Manage for stability | 9 | 0 | 30 | 69 | 65 | 0 | 9 | 61 | 56 | 0 | 0 | 56 | 100% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 52 | 13 | 83 | 151 | 143 | 0 | 9 | 138 | 127 | 0 | 0 | 127 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Neraudia angulata** | | | | | | | | | | | | | | |
| Kapuna | Genetic Storage | 0 | 0 | 2 | 2 | 2 | 0 | 1 | 2 | 2 | 0 | 1 | 2 | 100% |
| Makua | Manage for stability | 20 | 4 | 37 | 18 | 18 | 0 | 22 | 17 | 16 | 0 | 15 | 20 | 40% |
| Punapohaku | Genetic Storage | 2 | 0 | 2 | 4 | 3 | 0 | 3 | 4 | 2 | 0 | 3 | 4 | 100% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Neraudia angulata** | | | | | | | | | | | | | | |
| Halona | Genetic Storage | 4 | 10 | 16 | 5 | 0 | 0 | 1 | 5 | 0 | 0 | 1 | 1 | 5% |
| 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 | 4 | 6 | 3 | 0 | 9 | 6 | 1 | 0 | 7 | 7 | 100% |
| Manuwai | Manage for stability | 0 | 4 | 6 | 2 | 2 | 0 | 6 | 1 | 0 | 0 | 6 | 6 | 100% |
| Waianae Kai Makai | Genetic Storage | 13 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0% |
| Waianae Kai Mauka | Manage for stability | 7 | 2 | 10 | 6 | 0 | 0 | 7 | 4 | 0 | 0 | 6 | 6 | 35% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 58 | 28 | 77 | 44 | 28 | 0 | 50 | 40 | 21 | 0 | 40 | 47 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Nototrichium humile** | | | | | | | | | | | | | | |
| Kahanahaiki | Genetic Storage | 28 | 1 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 3 | 3 | 11% |
| Kaluakauila | Manage for stability | 30 | 9 | 1 | 1 | 0 | 0 | 34 | 0 | 0 | 0 | 26 | 26 | 84% |
| Keaau | Genetic Storage | 20 | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Keawaula | Genetic Storage | 109 | 22 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 4 | 4 | 8% |
| 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 | 1 | 0 | 0 | 0 | 1 | 1 | 2% |
| Punapohaku | Genetic Storage | 178 | 77 | 0 | 0 | 0 | 0 | 40 | 0 | 0 | 0 | 35 | 35 | 70% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Nototrichium humile** | | | | | | | | | | | | | | |
| Kaimuhole and Palikea Gulch | Genetic Storage | 29 | 1 | 12 | 39 | 39 | 0 | 42 | 35 | 34 | 0 | 42 | 43 | 100% |
| Kapuna and Keawapilau | Genetic Storage | 4 | 0 | 4 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 8 | 8 | 100% |
| Kolekole | Genetic Storage | 12 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 6 | 6 | 50% |
| Makaha | Genetic Storage | 22 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Nanakuli | Genetic Storage | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Puu Kaua (Leeward side) | Genetic Storage | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Waianae Kai | Manage for stability | 53 | 135 | 2 | 0 | 0 | 0 | 16 | 0 | 0 | 0 | 16 | 16 | 32% |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| | | **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** | |
| | | 531 | 284 | 19 | 40 | 39 | 0 | 157 | 35 | 34 | 0 | 141 | 142 | |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Phyllostegia kaalaensis** | | | | | | | | | | | | | | |
| Keawapilau to Kapuna | Manage reintroduction for stability | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 100% |
| Pahole | Manage reintroduction for stability | 0 | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 2 | 100% |
| Palikea Gulch | Genetic Storage | 0 | 0 | 3 | 1 | 1 | 3 | 0 | 0 | 0 | 3 | 0 | 3 | 100% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Phyllostegia kaalaensis** | | | | | | | | | | | | | | |
| Waianae Kai | Genetic Storage | 0 | 0 | 2 | 1 | 0 | 2 | 1 | 0 | 0 | 2 | 0 | 2 | 100% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 8 | 3 | 2 | 8 | 1 | 0 | 0 | 8 | 0 | 8 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Plantago princeps var. princeps** | | | | | | | | | | | | | | |
| North Mohiakea | Manage for stability | 63 | 75 | 17 | 37 | 37 | 0 | 3 | 34 | 31 | 0 | 3 | 31 | 62% |
| Ohikilolo | Manage for stability | 0 | 0 | 16 | 18 | 18 | 0 | 3 | 14 | 13 | 0 | 0 | 13 | 81% |
| Pahole | Genetic Storage | 0 | 3 | 5 | 7 | 6 | 0 | 0 | 6 | 5 | 0 | 0 | 5 | 100% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Plantago princeps var. princeps** | | | | | | | | | | | | | | |
| Ekahanui | Manage for stability | 0 | 3 | 72 | 69 | 67 | 0 | 6 | 59 | 42 | 0 | 4 | 44 | 88% |
| Konahuanui | Manage for stability | 36 | 5 | 0 | 13 | 11 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0% |
| North Palawai | Genetic Storage | 1 | 0 | 2 | 2 | 2 | 0 | 0 | 2 | 2 | 0 | 0 | 2 | 67% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 86 | 112 | 146 | 141 | 0 | 12 | 117 | 93 | 0 | 7 | 95 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Pritchardia kaalae** | | | | | | | | | | | | | | |
| Ohikilolo | Manage for stability | 76 | 617 | 2 | 10 | 9 | 1 | 8 | 4 | 3 | 0 | 5 | 7 | 14% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Pritchardia kaalae** | | | | | | | | | | | | | | |
| Makaha | Genetic Storage | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Makaleha to Manuwai | Manage for stability | 122 | 3 | 0 | 2 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 2% |
| Waianae Kai | Genetic Storage | 6 | 11 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 17% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 205 | 631 | 2 | 12 | 10 | 2 | 8 | 5 | 4 | 1 | 5 | 9 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Sanicula mariversa** | | | | | | | | | | | | | | |
| Keaau | Manage for stability | 14 | 2 | 43 | 53 | 51 | 0 | 0 | 35 | 19 | 0 | 0 | 19 | 38% |
| Ohikilolo | Manage for stability | 12 | 96 | 51 | 57 | 42 | 0 | 1 | 23 | 17 | 0 | 0 | 17 | 34% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Sanicula mariversa** | | | | | | | | | | | | | | |
| Kamaileunu | Manage for stability | 31 | 182 | 37 | 87 | 87 | 0 | 1 | 72 | 60 | 0 | 0 | 60 | 100% |
| Puu Kawiwi | Genetic Storage | 0 | 0 | 2 | 3 | 3 | 0 | 0 | 3 | 2 | 0 | 0 | 2 | 100% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 57 | 280 | 133 | 200 | 183 | 0 | 2 | 133 | 98 | 0 | 0 | 98 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Schiedea kaalae** | | | | | | | | | | | | | | |
| Pahole | Manage for stability | 0 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 100% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Schiedea kaalae** | | | | | | | | | | | | | | |
| Kahana | Genetic Storage | 5 | 0 | 4 | 2 | 1 | 9 | 5 | 0 | 0 | 9 | 0 | 9 | 100% |
| Kaluaa and Waieli | Manage for stability | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 100% |
| Maakua (Koolaus) | Genetic Storage | 3 | 0 | 0 | 1 | 1 | 6 | 2 | 0 | 0 | 6 | 0 | 6 | 100% |
| 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 | 1 | 1 | 1 | 1 | 0 | 1 | 100% |
| South Ekahanui | Manage for stability | 8 | 0 | 12 | 17 | 16 | 14 | 12 | 16 | 10 | 14 | 6 | 19 | 95% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | 0 | 20 | 24 | 22 | 34 | 23 | 20 | 14 | 34 | 8 | 39 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Schiedea nuttallii** | | | | | | | | | | | | | | |
| Kahanahaiki to Pahole | Manage for stability | 8 | 3 | 50 | 45 | 41 | 23 | 32 | 38 | 23 | 19 | 20 | 41 | 82% |
| Kapuna-Keawapilau Ridge | Manage for stability | 0 | 0 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 100% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 3 | 52 | 47 | 43 | 24 | 34 | 40 | 25 | 20 | 22 | 43 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Schiedea obovata** | | | | | | | | | | | | | | |
| Kahanahaiki to Pahole | Manage for stability | 0 | 0 | 5 | 6 | 6 | 1 | 5 | 6 | 6 | 1 | 5 | 6 | 100% |
| Keawapilau to West Makaleha | Manage for stability | 17 | 6 | 88 | 95 | 94 | 0 | 20 | 93 | 90 | 0 | 9 | 90 | 100% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | 6 | 93 | 101 | 100 | 1 | 25 | 99 | 96 | 1 | 14 | 96 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Tetramolopium filiforme** | | | | | | | | | | | | | | |
| Kahanahaiki | Genetic Storage | 40 | 0 | 34 | 98 | 26 | 0 | 23 | 59 | 12 | 0 | 9 | 20 | 40% |
| Kalena | Manage for stability | 35 | 27 | 10 | 19 | 16 | 0 | 0 | 9 | 8 | 0 | 0 | 8 | 18% |
| Keaau | Genetic Storage | 30 | 41 | 0 | 17 | 15 | 0 | 0 | 2 | 1 | 0 | 0 | 1 | 3% |
| Makaha/Ohikilolo Ridge | Genetic Storage | 350 | 200 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Ohikilolo | Manage for stability | 2808 | 741 | 39 | 180 | 86 | 0 | 0 | 60 | 7 | 0 | 0 | 7 | 14% |
| Puhawai | Manage for stability | 0 | 0 | 5 | 4 | 4 | 0 | 0 | 4 | 4 | 0 | 0 | 4 | 80% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Tetramolopium filiforme** | | | | | | | | | | | | | | |
| Waianae Kai | Manage for stability | 21 | 0 | 0 | 1 | 1 | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3284 | 1009 | 88 | 319 | 148 | 0 | 23 | 134 | 32 | 0 | 9 | 40 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Viola chamissoniana subsp. chamissoniana** | | | | | | | | | | | | | | |
| Keaau | Genetic Storage | 40 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Makaha/Ohikilolo Ridge | Genetic Storage | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Ohikilolo | Manage for stability | 182 | 50 | 2 | 1 | 1 | 0 | 23 | 0 | 0 | 0 | 8 | 8 | 16% |
| Puu Kumakalii | Manage for stability | 73 | 4 | 0 | 12 | 10 | 5 | 17 | 3 | 1 | 4 | 10 | 12 | 24% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Viola chamissoniana subsp. chamissoniana** | | | | | | | | | | | | | | |
| Halona | Manage for stability | 13 | 0 | 6 | 4 | 3 | 3 | 6 | 1 | 1 | 3 | 5 | 5 | 26% |
| Kamaileunu | Genetic Storage | 35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Makaha | Manage for stability | 25 | 6 | 0 | 0 | 0 | 8 | 15 | 0 | 0 | 7 | 11 | 11 | 44% |
| Makaleha | Genetic Storage | 19 | 9 | 2 | 8 | 4 | 10 | 9 | 1 | 0 | 8 | 5 | 11 | 52% |
| Puu Hapapa | Genetic Storage | 6 | 1 | 7 | 7 | 5 | 5 | 4 | 4 | 3 | 2 | 1 | 4 | 31% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 393 | 80 | 17 | 32 | 23 | 31 | 74 | 9 | 5 | 24 | 40 | 51 |

# Genetic Storage Summary Makua Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Wollastonia tenuifolia** | | | | | | | | | | | | | | |
| Kahanahaiki | Genetic Storage | 1 | 0 | 16 | 11 | 0 | 0 | 2 | 5 | 0 | 0 | 2 | 2 | 12% |
| Kaluakauila | Genetic Storage | 4 | 80 | 0 | 9 | 0 | 0 | 4 | 1 | 0 | 0 | 3 | 3 | 75% |
| Keawaula | Genetic Storage | 200 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Ohikilolo | Manage for stability | 570 | 11 | 19 | 16 | 0 | 0 | 11 | 13 | 0 | 0 | 3 | 3 | 6% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Wollastonia tenuifolia** | | | | | | | | | | | | | | |
| Kamaileunu and Waianae Kai | Manage for stability | 815 | 246 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 1 | 2% |
| Mt. Kaala NAR | Manage for stability | 131 | 24 | 0 | 2 | 0 | 0 | 6 | 0 | 0 | 0 | 2 | 2 | 4% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1721 | 411 | 35 | 38 | 0 | 0 | 25 | 19 | 0 | 0 | 11 | 11 |

# Genetic Storage Summary Oahu Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Abutilon sandwicense** | | | | | | | | | | | | | | |
| Kaawa to Puulu | Manage for stability | 35 | 160 | 8 | 29 | 20 | 0 | 0 | 19 | 4 | 0 | 0 | 4 | 9% |
| Kahanahaiki | Manage reintroduction for stability | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 100% |
| Keaau | Genetic Storage | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Abutilon sandwicense** | | | | | | | | | | | | | | |
| East Makaleha | Genetic Storage | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Ekahanui and Huliwai | Manage for stability | 1 | 12 | 13 | 13 | 13 | 0 | 0 | 13 | 10 | 0 | 0 | 12 | 86% |
| Halona | Genetic Storage | 10 | 5 | 0 | 3 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0% |
| Makaha Makai | Manage for stability | 81 | 66 | 20 | 83 | 61 | 0 | 7 | 74 | 37 | 0 | 5 | 38 | 76% |
| Makaha Mauka | Genetic Storage | 13 | 0 | 8 | 25 | 16 | 0 | 3 | 22 | 3 | 0 | 1 | 3 | 14% |
| Nanakuli | Genetic Storage | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| 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% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 152 | 255 | 51 | 156 | 113 | 0 | 11 | 132 | 55 | 0 | 7 | 58 |

# Genetic Storage Summary Oahu Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Alectryon macrococcus var. macrococcus** | | | | | | | | | | | | | | |
| Kahanahaiki to Keawapilau | Manage for stability | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Makua | Manage for stability | 4 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 2 | 33% |
| South Mohiakea | Genetic Storage | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0% |
| West Makaleha | Genetic Storage | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 50% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Alectryon macrococcus var. macrococcus** | | | | | | | | | | | | | | |
| Central Kaluaa to Central Waieli | Manage for stability | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Makaha | Manage for stability | 5 | 0 | 12 | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 10 | 10 | 59% |
| Waianae Kai | Genetic Storage | 0 | 0 | 0 | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 0 | 17 | 0 | 0 | 0 | 18 | 0 | 0 | 0 | 13 | 13 |

# Genetic Storage Summary Oahu Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Cyanea acuminata** | | | | | | | | | | | | | | |
| Helemano-Punaluu Summit Ridge to North Kaukonahua | Manage for stability | 23 | 302 | 0 | 27 | 27 | 1 | 1 | 27 | 25 | 1 | 0 | 25 | 100% |
| 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 | 210 | 93 | 0 | 12 | 12 | 0 | 0 | 12 | 11 | 0 | 0 | 11 | 22% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Cyanea acuminata** | | | | | | | | | | | | | | |
| Kahana and Makaua | Genetic Storage | 11 | 3 | 0 | 1 | 1 | 0 | 0 | 0 | 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 | 126 | 123 | 0 | 2 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0% |
| Puukeahiakahoe | Genetic Storage | 3 | 0 | 0 | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 445 | 551 | 0 | 42 | 42 | 1 | 1 | 41 | 36 | 1 | 0 | 36 |

# Genetic Storage Summary Oahu Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Cyanea grimesiana subsp. obatae** | | | | | | | | | | | | | | |
| Pahole to West Makaleha | Manage for stability | 4 | 0 | 13 | 15 | 15 | 0 | 9 | 13 | 13 | 0 | 5 | 13 | 76% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Cyanea grimesiana subsp. obatae** | | | | | | | | | | | | | | |
| Kaluaa | Manage for stability | 3 | 1 | 1 | 3 | 3 | 0 | 3 | 3 | 3 | 0 | 3 | 3 | 75% |
| Makaha | Genetic Storage | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 100% |
| North branch of South Ekahanui | Manage reintroduction for stability | 0 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 100% |
| Palikea (South Palawai) | Manage for stability | 10 | 6 | 12 | 17 | 17 | 5 | 1 | 17 | 17 | 5 | 0 | 17 | 77% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | 7 | 29 | 38 | 38 | 7 | 15 | 36 | 36 | 7 | 10 | 36 |

# Genetic Storage Summary Oahu Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Cyanea koolauensis** | | | | | | | | | | | | | | |
| Kaipapau, Koloa and Kawainui | Manage for stability | 40 | 24 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 3% |
| 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% |
| Kawaiiki | Genetic Storage | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Lower Opaeula | Genetic Storage | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Opaeula to Helemano | Manage for stability | 22 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Poamoho | Manage for stability | 20 | 19 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 5% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Cyanea koolauensis** | | | | | | | | | | | | | | |
| 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% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 119 | 61 | 0 | 2 | 2 | 0 | 0 | 2 | 2 | 0 | 0 | 2 |

# Genetic Storage Summary Oahu Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Cyrtandra dentata** | | | | | | | | | | | | | | |
| Kahanahaiki | Manage for stability | 29 | 45 | 27 | 36 | 36 | 0 | 0 | 36 | 36 | 0 | 0 | 36 | 72% |
| Kawaiiki (Koolaus) | Manage for stability | 2 | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Opaeula (Koolaus) | Manage for stability | 38 | 50 | 6 | 12 | 12 | 0 | 1 | 12 | 12 | 0 | 1 | 12 | 27% |
| Pahole to West Makaleha | Manage for stability | 820 | 1713 | 45 | 159 | 159 | 0 | 5 | 159 | 159 | 0 | 1 | 159 | 100% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Cyrtandra dentata** | | | | | | | | | | | | | | |
| Central Makaleha | Genetic Storage | 3 | 0 | 0 | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 892 | 1827 | 78 | 207 | 207 | 0 | 6 | 207 | 207 | 0 | 2 | 207 |

# Genetic Storage Summary Oahu Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Delissea waianaeensis** | | | | | | | | | | | | | | |
| Kahanahaiki to Keawapilau | Manage for stability | 4 | 0 | 14 | 15 | 15 | 1 | 10 | 15 | 15 | 1 | 5 | 15 | 83% |
| Palikea Gulch | Genetic Storage | 1 | 0 | 6 | 7 | 7 | 3 | 4 | 7 | 7 | 3 | 0 | 7 | 100% |
| South Mohiakea | Genetic Storage | 11 | 6 | 11 | 21 | 21 | 0 | 4 | 20 | 20 | 0 | 4 | 20 | 91% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Delissea waianaeensis** | | | | | | | | | | | | | | |
| Ekahanui | Manage for stability | 0 | 0 | 6 | 6 | 6 | 0 | 5 | 6 | 6 | 0 | 5 | 6 | 100% |
| Kaluaa | Manage for stability | 1 | 0 | 7 | 9 | 9 | 0 | 7 | 8 | 8 | 0 | 7 | 9 | 100% |
| Kealia | Genetic Storage | 2 | 0 | 5 | 7 | 7 | 0 | 2 | 7 | 7 | 0 | 2 | 7 | 100% |
| Palawai | Genetic Storage | 24 | 30 | 8 | 30 | 30 | 0 | 0 | 28 | 28 | 0 | 0 | 28 | 88% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 43 | 36 | 57 | 95 | 95 | 4 | 32 | 91 | 91 | 4 | 23 | 92 |

# Genetic Storage Summary Oahu Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Eugenia koolauensis** | | | | | | | | | | | | | | |
| Aimuu | Genetic Storage | 8 | 10 | 2 | 0 | 0 | 1 | 11 | 0 | 0 | 0 | 11 | 11 | 100% |
| Kaiwikoele and Kamananui | Genetic Storage | 17 | 26 | 4 | 0 | 0 | 2 | 28 | 0 | 0 | 2 | 26 | 26 | 100% |
| Kaleleiki | Genetic Storage | 8 | 27 | 16 | 0 | 0 | 0 | 24 | 0 | 0 | 0 | 20 | 20 | 83% |
| Kaunala | Manage for stability | 6 | 26 | 27 | 0 | 0 | 1 | 40 | 0 | 0 | 0 | 29 | 29 | 88% |
| Malaekahana | Genetic Storage | 0 | 4 | 1 | 0 | 0 | 1 | 5 | 0 | 0 | 0 | 5 | 5 | 100% |
| Ohiaai and East Oio | Genetic Storage | 1 | 1 | 1 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 2 | 2 | 100% |
| Oio | Manage for stability | 3 | 1 | 10 | 0 | 0 | 1 | 13 | 0 | 0 | 0 | 10 | 10 | 77% |
| Pahipahialua | Manage for stability | 2 | 1 | 29 | 0 | 0 | 0 | 30 | 0 | 0 | 0 | 27 | 27 | 87% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Eugenia koolauensis** | | | | | | | | | | | | | | |
| Hanaimoa | Genetic Storage | 1 | 0 | 2 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 2 | 2 | 67% |
| Palikea and Kaimuhole | Genetic Storage | 1 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 1 | 50% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 47 | 96 | 93 | 0 | 0 | 7 | 159 | 0 | 0 | 2 | 133 | 133 |

# Genetic Storage Summary Oahu Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Flueggea neowawraea** | | | | | | | | | | | | | | |
| Kahanahaiki to Kapuna | Manage for stability | 5 | 0 | 2 | 3 | 3 | 0 | 4 | 2 | 2 | 0 | 3 | 3 | 43% |
| Ohikilolo | Manage for stability | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 50% |
| West Makaleha | Genetic Storage | 6 | 0 | 1 | 1 | 1 | 0 | 5 | 1 | 1 | 0 | 4 | 4 | 57% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Flueggea neowawraea** | | | | | | | | | | | | | | |
| Central and East Makaleha | Genetic Storage | 4 | 0 | 3 | 1 | 1 | 0 | 5 | 1 | 1 | 0 | 4 | 4 | 57% |
| Halona | Genetic Storage | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 50% |
| Kauhiuhi | Genetic Storage | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 100% |
| Makaha | Manage for stability | 7 | 0 | 4 | 2 | 1 | 0 | 10 | 2 | 0 | 0 | 7 | 7 | 64% |
| Mt. Kaala NAR | Genetic Storage | 2 | 0 | 2 | 2 | 2 | 0 | 3 | 2 | 1 | 0 | 2 | 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 | 1 | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 29 | 0 | 14 | 10 | 9 | 0 | 32 | 9 | 6 | 0 | 24 | 24 |

# Genetic Storage Summary Oahu Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Gardenia mannii** | | | | | | | | | | | | | | |
| Haleauau | Manage for stability | 1 | 0 | 8 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 4 | 4 | 44% |
| Helemano and Poamoho | Manage for stability | 23 | 0 | 2 | 2 | 1 | 0 | 13 | 1 | 1 | 0 | 12 | 12 | 48% |
| Kaiwikoele, Kamananui, and Kawainui | Genetic Storage | 13 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 8% |
| Lower Peahinaia | Manage for stability | 9 | 1 | 3 | 1 | 0 | 0 | 7 | 1 | 0 | 0 | 5 | 5 | 42% |
| South Kaukonahua | Genetic Storage | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 2 | 100% |
| Upper Opaeula/Helemano | Genetic Storage | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Gardenia mannii** | | | | | | | | | | | | | | |
| Ihiihi-Kawainui ridge | Genetic Storage | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Kaluaa and Maunauna | Genetic Storage | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 1 | 50% |
| Kamananui-Malaekahana Summit Ridge | Genetic Storage | 3 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 2 | 50% |
| 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% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 55 | 2 | 16 | 3 | 1 | 0 | 32 | 2 | 1 | 0 | 27 | 27 |

# Genetic Storage Summary Oahu Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Geniostoma cyrtandrae** | | | | | | | | | | | | | | |
| East Makaleha to North Mohiakea | Manage for stability | 62 | 0 | 1 | 9 | 9 | 0 | 2 | 9 | 8 | 0 | 0 | 8 | 16% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 62 | 0 | 1 | 9 | 9 | 0 | 2 | 9 | 8 | 0 | 0 | 8 |

# Genetic Storage Summary Oahu Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Hesperomannia swezeyi** | | | | | | | | | | | | | | |
| Kamananui to Kaluanui | Manage for stability | 134 | 112 | 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% |
| Lower Opaeula | Manage for stability | 11 | 15 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Poamoho | Genetic Storage | 13 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Hesperomannia swezeyi** | | | | | | | | | | | | | | |
| Niu-Waimanalo Summit Ridge | Genetic Storage | 1 | 4 | 0 | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 214 | 186 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

# Genetic Storage Summary Oahu Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Phyllostegia hirsuta** | | | | | | | | | | | | | | |
| Haleauau to Mohiakea | Manage for stability | 9 | 4 | 14 | 7 | 5 | 11 | 11 | 6 | 1 | 11 | 8 | 11 | 48% |
| Helemano and Opaeula | Genetic Storage | 1 | 4 | 4 | 1 | 1 | 2 | 3 | 1 | 0 | 2 | 1 | 2 | 40% |
| Helemano and Poamoho | Genetic Storage | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Kaipapau and Kawainui | Genetic Storage | 4 | 0 | 0 | 1 | 1 | 4 | 2 | 0 | 0 | 4 | 1 | 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 | 9 | 2 | 1 | 5 | 3 | 5 | 5 | 2 | 1 | 5 | 4 | 6 | 60% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Phyllostegia hirsuta** | | | | | | | | | | | | | | |
| Hapapa to Kaluaa | Genetic Storage | 0 | 1 | 13 | 8 | 7 | 10 | 13 | 6 | 4 | 9 | 10 | 12 | 92% |
| 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 | 0 | 0 | 0% |
| Palawai | Genetic Storage | 0 | 0 | 1 | 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% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 32 | 14 | 34 | 22 | 17 | 32 | 35 | 15 | 6 | 31 | 24 | 35 |

# Genetic Storage Summary Oahu Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Phyllostegia kaalaensis** | | | | | | | | | | | | | | |
| Keawapilau to Kapuna | Manage reintroduction for stability | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 100% |
| Pahole | Manage reintroduction for stability | 0 | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 2 | 100% |
| Palikea Gulch | Genetic Storage | 0 | 0 | 3 | 1 | 1 | 3 | 0 | 0 | 0 | 3 | 0 | 3 | 100% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Phyllostegia kaalaensis** | | | | | | | | | | | | | | |
| Waianae Kai | Genetic Storage | 0 | 0 | 2 | 1 | 0 | 2 | 1 | 0 | 0 | 2 | 0 | 2 | 100% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 8 | 3 | 2 | 8 | 1 | 0 | 0 | 8 | 0 | 8 |

# Genetic Storage Summary Oahu Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Phyllostegia mollis** | | | | | | | | | | | | | | |
| Mohiakea | Genetic Storage | 0 | 0 | 8 | 7 | 7 | 7 | 1 | 3 | 2 | 7 | 0 | 7 | 88% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Phyllostegia mollis** | | | | | | | | | | | | | | |
| Ekahanui | Manage for stability | 0 | 0 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 100% |
| Kaluaa | Manage for stability | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 100% |
| Pualii | Manage reintroduction for stability | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 100% |
| Waieli | Genetic Storage | 0 | 0 | 6 | 5 | 5 | 5 | 0 | 4 | 4 | 5 | 0 | 6 | 100% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 18 | 16 | 16 | 15 | 2 | 10 | 9 | 15 | 1 | 17 |

# Genetic Storage Summary Oahu Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Plantago princeps var. princeps** | | | | | | | | | | | | | | |
| North Mohiakea | Manage for stability | 63 | 75 | 17 | 37 | 37 | 0 | 3 | 34 | 31 | 0 | 3 | 31 | 62% |
| Ohikilolo | Manage for stability | 0 | 0 | 16 | 18 | 18 | 0 | 3 | 14 | 13 | 0 | 0 | 13 | 81% |
| Pahole | Genetic Storage | 0 | 3 | 5 | 7 | 6 | 0 | 0 | 6 | 5 | 0 | 0 | 5 | 100% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Plantago princeps var. princeps** | | | | | | | | | | | | | | |
| Ekahanui | Manage for stability | 0 | 3 | 72 | 69 | 67 | 0 | 6 | 59 | 42 | 0 | 4 | 44 | 88% |
| Konahuanui | Manage for stability | 36 | 5 | 0 | 13 | 11 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0% |
| North Palawai | Genetic Storage | 1 | 0 | 2 | 2 | 2 | 0 | 0 | 2 | 2 | 0 | 0 | 2 | 67% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 86 | 112 | 146 | 141 | 0 | 12 | 117 | 93 | 0 | 7 | 95 |

# Genetic Storage Summary Oahu Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Schiedea kaalae** | | | | | | | | | | | | | | |
| Pahole | Manage for stability | 0 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 100% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Schiedea kaalae** | | | | | | | | | | | | | | |
| Kahana | Genetic Storage | 5 | 0 | 4 | 2 | 1 | 9 | 5 | 0 | 0 | 9 | 0 | 9 | 100% |
| Kaluaa and Waieli | Manage for stability | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 100% |
| Maakua (Koolaus) | Genetic Storage | 3 | 0 | 0 | 1 | 1 | 6 | 2 | 0 | 0 | 6 | 0 | 6 | 100% |
| 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 | 1 | 1 | 1 | 1 | 0 | 1 | 100% |
| South Ekahanui | Manage for stability | 8 | 0 | 12 | 17 | 16 | 14 | 12 | 16 | 10 | 14 | 6 | 19 | 95% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | 0 | 20 | 24 | 22 | 34 | 23 | 20 | 14 | 34 | 8 | 39 |

# Genetic Storage Summary Oahu Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Schiedea trinervis** | | | | | | | | | | | | | | |
| Kalena to East Makaleha | Manage for stability | 280 | 373 | 14 | 92 | 91 | 1 | 1 | 91 | 89 | 1 | 0 | 89 | 100% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 280 | 373 | 14 | 92 | 91 | 1 | 1 | 91 | 89 | 1 | 0 | 89 |

# Genetic Storage Summary Oahu Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Stenogyne kanehoana** | | | | | | | | | | | | | | |
| Haleauau | Manage reintroduction for stability | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 100% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Stenogyne kanehoana** | | | | | | | | | | | | | | |
| Kaluaa | Manage reintroduction for stability | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 100% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 2 | 0 | 0 | 1 | 2 | 0 | 0 | 1 | 1 | 2 |

# Genetic Storage Summary Oahu Implementation Plan

| 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 |
| **Action Area: In** | | | | | | | | | | | | | | |
| **Viola chamissoniana subsp. chamissoniana** | | | | | | | | | | | | | | |
| Keaau | Genetic Storage | 40 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Makaha/Ohikilolo Ridge | Genetic Storage | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Ohikilolo | Manage for stability | 182 | 50 | 2 | 1 | 1 | 0 | 23 | 0 | 0 | 0 | 8 | 8 | 16% |
| Puu Kumakalii | Manage for stability | 73 | 4 | 0 | 12 | 10 | 5 | 17 | 3 | 1 | 4 | 10 | 12 | 24% |
| **Action Area: Out** | | | | | | | | | | | | | | |
| **Viola chamissoniana subsp. chamissoniana** | | | | | | | | | | | | | | |
| Halona | Manage for stability | 13 | 0 | 6 | 4 | 3 | 3 | 6 | 1 | 1 | 3 | 5 | 5 | 26% |
| Kamaileunu | Genetic Storage | 35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0% |
| Makaha | Manage for stability | 25 | 6 | 0 | 0 | 0 | 8 | 15 | 0 | 0 | 7 | 11 | 11 | 44% |
| Makaleha | Genetic Storage | 19 | 9 | 2 | 8 | 4 | 10 | 9 | 1 | 0 | 8 | 5 | 11 | 52% |
| Puu Hapapa | Genetic Storage | 6 | 1 | 7 | 7 | 5 | 5 | 4 | 4 | 3 | 2 | 1 | 4 | 31% |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 393 | 80 | 17 | 32 | 23 | 31 | 74 | 9 | 5 | 24 | 40 | 51 |

# Five Year Management Plan for *Phyllostegia kaalaensis*, 2023

# *Phyllostegia kaalaensis*

**Scientific name:** ***Phyllostegia kaalaensis***

**Hawaiian name:** Unknown

**Family:** Lamiaceae

**Federal status:** Listed Endangered October 10, 1996

**Requirements for MIP Stability**

- 4 Manage for Stability (MFS) Population Units (PUs)
- 50 reproducing individuals in each MFS PU (short-lived perennial, seems to be primarily a vegetatively reproducing taxon)
- Stable Population Structure
- Threats Controlled
- Complete genetic representation of all PUs in storage

## Description and Biology

*Phyllostegia kaalaensis* is a perennial herb with long stems extending out from the base of the plant. Its oppositely arranged leaves measure 5-13 cm (2.0-5.1 in) long. The inflorescences are borne at the stem tips. Each inflorescence consists of a single main stem with nodes each bearing 3-6 flowers. The flowers are tubular, white, and slightly fragrant. Each fruit consists of four segments connected at their bases. A segment consists of a single seed surrounded by a fleshy pulp. The fruits turn blackish upon ripening.

Flowering in *P. kaalaensis* has been reported from January to June (Nagata 1980). Insects, most likely moths, are presumed to pollinate the species' flowers. Little is known of the species' breeding system. The fleshy blackish fruits of the species are indicative of seed dispersal by fruit-eating birds.

The branches of *P. kaalaensis* often touch the ground and take root. A rooted stem becomes a separate plant when the stem connecting it to its maternal plant is severed. Reproduction in this species may be primarily through vegetative means, as most of the currently known plants are in dense patches far away from any other plants of the species. To date there have been no reports of seedlings or immature plants that obviously originated from a seed (Lau pers. comm. 2000). Given the species' tendency for vegetative reproduction, its clones have the potential for living indefinitely.

**Known Distribution and Habitat:** *Phyllostegia kaalaensis* is endemic to the Waiʻanae Mountains. The species has been found throughout the mountain range from 490-760 m (1,610-2,500 ft). This species is found in gulch bottoms and on gulch slopes in mesic to dry-mesic areas. It occurs most commonly in forests dominated by lama (*Diospyros sandwicensis*) and/or lonomea (*Sapindus oahuensis*), or in forests containing a mix of several tree species. The species grows either under the forest canopy, or in sunny openings.

**Taxonomic Background:** *Phyllostegia kaalaensis*' closest relative is the common *P. glabra*, whose range includes the Waiʻanae Mountains. *Phyllostegia kaalaensis* was accepted as representing a species distinct

from *P. glabra* only within the past decade (Wagner *et al*. 1990). The two are distinguished not only by various morphological differences, but by different habitat requirements as well. *Phyllostegia kaalaensis* occurs in habitats drier than those of *P. glabra*. The two species are not known to grow near one another.

**Table 1:** Historic collections of *P. kaalaensis* on O'ahu. Data compiled from Bishop Museum Herbarium Records provided by Bishop Museum, 2023.

| Area | Year | Collector |
|---|---|---|
| Pahole Gulch (central ridge) | 1976 | J.K. Obata |
| Palikea Gulch | 1977 | J.K Obata |
| Pahole Gulch (SE section) | 1978 | K.M. Nagata |
| Pahole Gulch (SW section) | 1978 | K.M. Nagata |
| ʻĒkahanui Gulch | 1987 | S. Perlman |
| Puʻu Kaua | 1987 | W.N. Takeuchi |

**Table 2:** Reproductive Biology Summary of *P. kaalaensis*.

| | Observed Phenology* | | | Reproductive Biology | | Seeds | |
|---|---|---|---|---|---|---|---|
| MFS Population Unit | Flower | Immature Fruit | Mature Fruit | Breeding System | Suspected Pollinator | Average # Per Fruit | Dormancy |
| All | Dec.-April | March-May | March-June | Hermaphroditic | Insect, likely Moth | 1.52 ± 1.29 | Non-Dormant (ND)** |

*Observed Phenology is based on field observations at each site. Actual duration of reproductive status is likely longer that those observed.
**Seed germination begins within 45 days, but complete germination takes between 63 and 263 days. This might suggest physiological dormancy (PD) (Baskin et. al. 2004).

## Plant Morphology and Habitat (Images)

**Figure 1:** Habit of *P. kaalaensis* outplant at Mākaha (left); Outplants at Kapuna (right)

**Figure 2:** Outplant at Mākaha with terminal inflorescence (left); Open flowers, showing asymmetrical corolla (right)

**Figure 3:** Open flower with pollinator (left); Immature fruit with powdery mildew (right)

**Figure 4:** Immature fruit (left); Maturing fruit (center); Mature fruit (right)

**Figure 5:** Powdery mildew on outplants (left and right)

**Figure 6:** Outplanting stock in the greenhouse (left); Clones in micropropagation (right)

**Table 3:** Habitat characteristics of *in situ* Population Reference Sites (PRSs). Average Annual Rainfall data is from the Rainfall Atlas of Hawai'i (Giambelluca et al. 2013 and 2014). All other data from ANRPO observations.

| PU | Pop. Ref. Code | Elev. (feet) | Slope | Canopy Cover | Topo. | Aspect | Average AnnualMax.Temp. (F) | Average Annual Rainfall (mm) |
|---|---|---|---|---|---|---|---|---|
| Keawapilau to Kapuna (MFS) | KAP-A *in situ* | 1,946-1,975 | Moderate | Int. | Lower Slope | N | 67.8 | 1,477 |
| Keawapilau to Kapuna (MFS) | PIL-A *in situ* | 1,621 | Flat | Int. | Gulch Bottom | N | 68.4 | 1,475 |
| Pahole (MFS) | PAH-A *in situ* | 1,969 | Flat | Open | Gulch Bottom | N | 67 | 1,420 |
| Palikea Gulch (GS) | ALI-A *In situ* | 1,686 | Moderate/ Steep | Int. | Mid Slope | NW | 68.3 | 1217 |
| Palikea Gulch (GS) | ALI-B *In situ* | 2,270 | Steep | Open | Upper Slope | N | 66.6 | 1211 |
| Wai'anae Kai (GS) | WAI-A *In situ* | 2,073-2,152 | NA | NA | NA | NA | 67 | 1733 |

**Int.= Intermediate**
**NA= Not available**

**Table 4:** List of Associated Species (six letter code = first three letters of genus, followed by first three letters of species), in alphabetical order, for each MFS Population Unit (PU) for both canopy and understory. Bold text indicates endemic and indigenous taxa.

| PU | PRS | Canopy | Understory |
|---|---|---|---|
| All | All | **AntPla, BobSan, CeoBru, DioHil, DioSan, FreArb, HibArnArn, KadAcu, MelPed, MetPol, NoteSan, PlaSan, PsyHat, PsyMar, PsyOdo,** AleMol, PsiGua, SchTer, TooCil | **AcaKoa, AlySte, CarWah, ChaTom, DioHil, DipSan, MicStr, PipAlb, PsyOdo, RocSan,** AdiRad, AgeAde, AgeRip, BleApp, BudAsi, Clihir, ConBon, DepPet, LanCam, OplHir, PasCon, PasEdu, PasSub, PsiGua, RubRos, SonOle |

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**Sensitive Information**
**Available Upon Request**

**Figure 7:** Map of current and historic *P. kaalaensis* populations.

## Current Status from 2003 MIP

"The total number of known *P. kaalaensis* individuals is 32-37. Of these, 14-19 are located in the Mākua action area. However, as mentioned above, the three largest population units each give the appearance of

representing a single clone. If these population units truly represent single clones, the species' known, genetically unique individuals number seven or less."

## Current Status

At the time the MIP was published in 2003, it was estimated that there were 32-37 extant wild founders, with four wild individuals in the Keawapilau to Kapuna PU, 10-15 in the Pahole PU, 10 in Palikea Gulch, and eight in Waiʻanae Kai. By the end of 2004, all wild plants were observed dead at the following *in situ* PRSs (KAP-A, PIL-A, PAH-A, ALI-A, ALI-B, WAI-A). Reintroductions were established in 2004 (PAH-B in the Pahole PU and PIL-B in the Keawapilau to Kapuna PU), 2007 (KAP-B in the Keawapilau to Kapuna PU),2008 (MAK-A) and 2013 (MAK-B in the Mākaha PU and ANU-A in the Manuwai PU). PAH-B was initially outplanted with 48 plants and in 2007 it was augmented with an additional 57 outplants, however, all plants were observed dead in 2010. Similarly, all plants were observed dead at PIL-B in 2006, at MAK-A in 2011, MAK-B in 2015, and ANU-A in 2015. Plant survivorship at all reintroduction sites was three years or less. *P. kaalaensis* is extirpated from the wild, however, ANPRO maintains 100% genetic storage with eight wild founders secured in micropropagation. These collections will serve as propagule sources to re-establish *P. kaalaensis* in the wild. Given that the majority of known threats (ungulates and invasive weeds) were largely controlled at MRFS PUs, the rapid loss of wild founders and reintroduction failures can likely be contributed to a changing climate and the severe impacts of powdery mildew (*Neoerysiphe galeopsidis*) on *P. kaalaensis*.

**Table 5:** Population Units for.*Phyllostegia kaalaensis*. MFS = Manage for Stability; MRFS= Manage Reintroduction for Stability; GS= Genetic Storage.

| Population Unit | Management Designation | PU Type | Action Area (In/Out) | Management Units for Threat Control |
|---|---|---|---|---|
| Keawapilau to Kapuna | MRFS | No plants surviving | In | Kapuna Upper |
| Pahole | MRFS | No plants surviving | In | Pahole |
| Palikea Gulch | GS | No plants surviving | In | Palikea Gulch No MU |
| Mākaha | MRFS | No plants surviving | Out | Mākaha 1 |
| Manuwai | MRFS | No plants surviving | Out | Manuwai |
| Waiʻanae Kai | GS | No plants surviving | Out | Waiʻanae Kai No MU |

**Table 6:** Stabilization Goal Status. Yes/No/Partial refers to if control is in place for each PU.

| | PU Stability Target | | MU Threat Control | | | | | Genetic Storage |
|---|---|---|---|---|---|---|---|---|
| Population Unit | 50 reproduc-ing plants | Stable Population Structure | Ungulate | Slugs | Rodent | Fire | Weeds | % Completed |
| Keawapilau to Kapuna | No | No | No extant plants | No extant plants | No | No | No | 100% |
| Pahole | No | No | No extant plants | No extant plants | No | No | No | 100% |
| Palikea Gulch | No | No | No extant plants | No extant plants | No | No | No | 100% |
| Mākaha | No | No | No extant plants | No extant plants | Yes | No | No | ---------- |
| Manuwai | No | No | No extant plants | No extant plants | Yes | No | No | ---------- |
| Wai‘anae Kai | No | No | No extant plants | No extant plants | No | No | No | 100% |

Shading=Threat to Taxon within Population Unit

No Shading= Absence of threat to Taxon within Population Unit

## Outplanting Considerations from 2003 MIP

*“Phyllostegia kaalaensis*' geographical and ecological ranges broadly overlap those of several other species of *Phyllostegia* in the Wai‘anae Mountains, including the endangered *P. mollis*, *P. parviflora*, and *P. hirsuta* (Lau pers. comm. 2000). Natural hybrid combinations have been identified among the Hawaiian *Phyllostegia*s (Wagner *et al*. 1990). Since hybridization seems to be a natural occurrence in *Phyllostegia*, the presence of the aforementioned endangered *Phyllostegia*s in a given gulch should not preclude the establishment of outplantings of *P. kaalaensis* in the gulch, as long as they are not conducted in the vicinity of any pre-existing wild populations of these endangered *Phyllostegia*s.

Given the ecological separation between *P. kaalaensis* and its close relative *P. glabra*, as long as outplanting sites for *P. kaalaensis* are established in the species' appropriate habitat, there should not be any *P. glabra* growing nearby.”

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# Sensitive Information
# Available Upon Request

**Figure 8:** Known locations and proposed reintroduction sites for *P. kaalaensis* (MIT 2003)

## Current Outplanting Considerations

*P. kaalaensis* is extremely vulnerable to the impacts of climate change with a vulnerability score of 0.946 (scale 0-1 (not vulnerable – extremely vulnerable)) (Fortini *et al.* 2013). When selecting future outplanting sites climate variables should be considered. Dr. Lucas Fortini (USGS) is developing climate range maps, examples of which were originally presented at the 2019 IT meeting, for the majority of ANRPO management taxa. ANRPO continues to work with Dr. Fortini to develop a reliable metric of habitat compatibility for rare plants in a changing climate. The climate range maps developed initially in 2019 were based on simple climate envelope models, resulting in maps that are binary, too general, and include no estimate of habitat preference. Recent efforts focused on creating Species Distribution Models (SDM) that work as a reliable measure of habitat compatibility for rare plant species. In total four habitat compatibility metrics/models were developed for *P. kaalaensis*. To identify which model provides the best fit for *P. kaalaensis,* monitoring data metrics from outplantings (vigor, survival, and reproductive phenology) were used to determine which model best matches site differences in outplanting performance. This was done comparing the strength and consistency of correlations across model values and outplanting metrics. The Climatch model under current climate conditions was identified as the best fit for *P. kaalaensis*. This model assumes no central tendency to the median climatic condition across wild occurrences, and better describes species with limited data sets. The resulting climate range maps are presented in Figure 9. The "Current" map indicates suitability under current climate conditions and the "Future" map projects suitable conditions for mid-century (2040-2059) based on mean habitat suitability projections across nine regionally adapted climate projections under the RCP 6.0 scenario (Berio Fortini et. al. in press). The Climatch model has an inverted scale with values closer to zero being more suitable. Although preliminary, these maps can be used as guides for future reintroduction and management site selection. While these maps provide us with more information regarding possible future range changes, they do not account for habitat quality in the landscape.

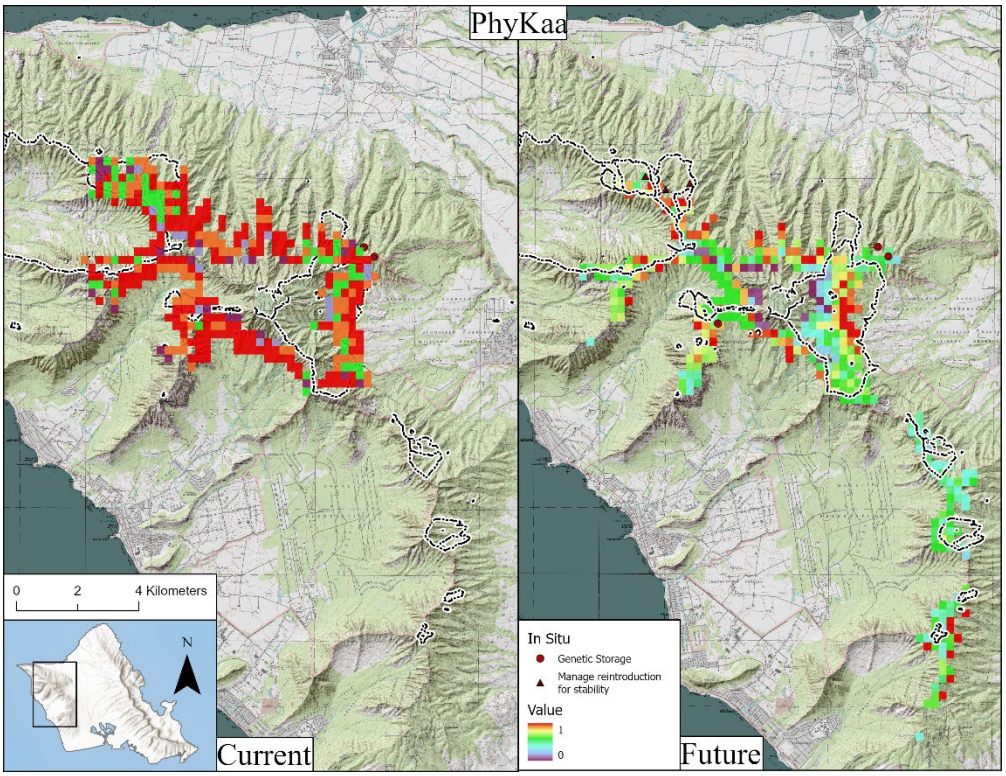


**Figure 9:** *P. kaalaensis* Climate Range Maps

## Reintroduction Plan

The proposed outplanting sites are designed to maintain population size to meet the stability goal for the number of reproducing individuals (Table 7). *P. kaalaensis* is currently extirpated in the wild, with no surviving reintroductions representing wild founders.

**Table 7:** Future proposed outplantings sites for *P. kaalaensis* to meet the stabilization goal of 50 reproducing individuals per Population Unit (PU). The propagule type for each planting will be plants grown from cuttings from a temporary greenhouse living collection established from clones held in micropropagation.

| Manage for Stability Population Units | Reintroduction Site(s) | Propagule Source | Total Number of Plants to be planted | 2024 | 2025 | 2026 | 2027 | 2028 |
|---|---|---|---|---|---|---|---|---|
| To be determined | Select new site | All Founders | 100 | | | 50 | 50 | |
| To be determined | Select new site | All founders | 100 | | | 50 | 50 | |
| To be determined | Select new site | All founders | 50 | | | | | 50 |
| To be determined | Select new site | All founders | 50 | | | | | 50 |

Since all initial reintroductions for this taxon failed by 2015, new reintroductions will be established in four MRFS PUs. Between 2024 and 2025 ANRPO will select new reintroduction sites in the currently designated MRFS PUs. If appropriate sites cannot be identified in the existing MRFS PUs, ANRPO will revisit the alternative reintroduction sites proposed in the 2003 MIP (Figure 8), West Makaleha, Kahanahāiki, Mt. Kaʻala NAR, and Kaluaʻā and Waʻieli. Climate range maps for *P. kaalaensis* should be considered when selecting new reintroduction sites. In addition, the ANRPO Horticulture and Seed Lab teams will continue to work with the micropropagation lab at Lyon Arboretum to pull clones of all eight founders in genetic storage to establish a temporary greenhouse living collection necessary to amass the quantity of propagules for outplanting in 2026 through 2028. Two reintroduction sites will be established in 2026 with 50 plants each and supplemented in 2027 with an addition 50 plants. These sites will be monitor frequently to assess the success of these reintroductions before establishing the third and fourth reintroductions. If the initial reintroductions fail or show significant declines in outplant survivorship, ANRPO may need to revise this reintroduction plan and associated management strategies. Given the relative few wild founders secured in micropropagation and the high risk of inbreeding depression in this taxa, each new reintroduction will include a mix of outplants representing all wild founders in storage. Through time outplanting numbers may need to increase if survival is poor, or if recruitment and development into mature plants is not observed, which may require outplanting beyond 2028.

## Monitoring Plan

New outplantings will be monitored twice a year for two years after outplanting to assess initial survivorship and site success, and then annually in subsequent years. All MRFS PUs will be monitored using the HRPRG Rare Plant Monitoring Form to record population structure and the age class, reproductive status and vigor of all known plants. The sites will also be surveyed for new seedlings and

juvenile plants. During monitoring actions, seeds from mature outplants will be collected to build a research collection to test seed storage behavior and longevity for this taxon.

## Threats

Major threats to *P. kaalaensis* include feral pigs and goats. These ungulates degrade the species' habitat, and harm the plants by feeding on them, trampling them, or uprooting them while rooting for food. Alien plants threaten the species by altering the species' habitat and competing with it for sunlight, moisture, nutrients, and growing space. Also, the spread of highly flammable alien grasses increases the incidence and destructiveness of wildfires. Alien slugs also pose a threat to this taxon by consuming seedlings and juvenile plants, however, few observations of slug damage on *P. kaalaensis* plants have been made in the field. Since the majority of these threats were controlled at previous reintroductions, management strategies need to consider mitigating the impacts of climate change and powdery mildew (*Neoerysiphe galeopsidis*) on *P. kaalaensis*.

## Genetic Storage Plan

*P. kaalaensis* seeds are desiccation tolerant and are considered "likely" orthodox in their seed storage behavior, however, seed viability testing has shown a 72% decrease in viability over a ten-year period when stored at -18°C and 20% RH (Chau *et al*. 2019). Based on available data, optimal seed storage conditions for this taxon are 5°C and 20% RH. Continued viability testing is needed to better understand *P. kaalaensis* storage at -18°C. The recollection interval for this taxon is set for 10 years. The ANPRO Seed Conservation Laboratory lacks access to enough seed for further viability and longevity testing. Once new reintroductions are established and a greenhouse living collection is re-established, efforts will be made to collect seed from greenhouse collections and outplants to build a robust research collection for continued seed storage research. Mid-term storage in micropropagation is the primary genetic storage strategy for this taxon. Genetic storage for this taxon is currently 100% representing eight wild founders. Research is currently underway at Lyon Arboretum to develop protocols for long-term storage of plant tissues in cyrostorage (-196°C).

**Table 8:** Action plan for maintaining genetic storage representation and providing propagules for reintroductions.

| What propagule type is used for meeting genetic storage goal? | What is the source for the propagules? | What is the Genetic Storage Method used to meet the goal? | What is the proposed re-collection interval for seed storage? | Is seed storage testing ongoing? | Plan for maintaining genetic storage.* |
|---|---|---|---|---|---|
| Cuttings | *In situ* and reintroduction sites | Primary: Micropropagation and living collection<br>Secondary: Seed Storage at 5C and 20% RH | 10 years | Research collection needed for further testing | Collect cuttings from reintroductions and living collection to refresh collections in micropropagation |

## Management Discussion

The primary goal for this taxon over the next five years will be to re-establish one reintroduction of *P kaalaensis* in the landscape at four MRFS PUs. Utilizing climate range maps developed by Dr. Lucas

Fortini, new reintroduction sites will be selected between 2024 and 2025. If appropriate reintroduction sites cannot be located in the current MRFS PUs, alternative sites will be investigated in the West Makaleha, Kahanahāiki, Kaʻala, and Kaluaʻā and Waiʻeli MUs. In the case that new reintroduction sites are selected in one or more of the alternative MUs, new MRFS PU will be designated. The goal is to outplant 100 plants, representing all eight founders secured in genetic storage, over two years at two MRFS PUs. These reintroductions will be monitored frequently after outplanting to assess survivorship and overall site success, before initiating two additional reintroductions in 2028. Depending on survivorship at each reintroduction, outplanting may need to continue beyond 2028. Before outplanting can take place, the ANRPO horticulture team will need to re-establish a greenhouse living collection. This collection will serve as the propagule source for outplanting efforts. The Seed Lab and Horticulture teams are currently working with the Lyon Arboretum Micropropagation Lab to withdraw three to four clones of each of the eight wild founders to serve as the basis of the greenhouse living collection. In addition, strategies to mitigate for the impact of powdery mildew (*Neoerysiphe galeopsidis*) need to be in place prior to outplanting. Research conducted in both the Amend and Hynson labs at the University of Hawaiʻi at Mānoa demonstrate that foliar endophytes modify plant disease and show potential as tool to manage disease. Both the application of a simple leaf slurry containing an uncultured fungal community sampled from either a related plant species or from the broader plant community and the cultured yeast isolate *Moesziomyces aphidis* reduced disease incidence of *Neoerysiphe galeopsidis* in *P. kaalaensis* in laboratory experiments (Egan et. al. 2021 and Zahn and Amend 2017). ANRPO is currently working with Dr. Hynson and Dr. Amend to develop a strategy utilizing the application of a community microbiome and a single yeast isolate to manage powdery mildew on *P. kaalaensis* both in the greenhouse and in the field. This strategy will inform application type and frequency necessary to manage powdery mildew.

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# Updated Five Year Management Plan for *Hibiscus brackenridgei* subsp. *mokuleianus*, 2010, 2023 *Hibiscus brackenridgei* subsp. *mokuleianus*

**Scientific name:** *Hibiscus brackenridgei* subsp. *mokuleianus*

**Hawaiian name:** *Maʻo hau hele*

**Family:** Malvaceae (Mallow family)

**Federal status:** Listed endangered November 10, 1994

**Requirements for Stability**

- 4 Manage for Stability (MFS) Population Units (PUs) (high fire risk)
- 50 reproducing individuals in each PU (short-lived perennial)
- Stable population structure
- Threats controlled
- Complete genetic representation of all PUs in storage

## Description and biology

*Hibiscus brackenridgei* is found at three separate areas on Oʻahu. Plants at each site differ from those of the other areas. The three areas are: 1) Waialua (152-366 m), (including the Kaimuhole and Palikea Gulch, Kihakapu and Pūʻulu, Kaumoku Nui PUs), 2) Keālia (107-213 m), (including the Haili to Kawaiū PU), and 3) the Mākua (98-146 m) and Keaʻau (195-293 m) PUs. *Hibiscus brackenridgei* plants from the southwestern tip of Molokaʻi at an elevation of about 60 m (*Hibiscus brackenridgei* var. *molokaiana*) are morphologically similar to the Mākua plants. The differences are evident in the plants' stature, branching pattern, and the morphology of the leaves, stems, and flowers. These differences are retained when plants from the three areas are grown together in a common garden (Lau pers. comm. 2000), showing that morphological differences among the plants of the three areas are attributable to underlying genetic differences. For the purpose of the Mākua Implementation Plan (MIP 2003), each grouping of plants is referred to as a type (Waialua, Keālia, Mākua). These types, however, likely represent parts of what originally was a morphological continuum, and the discovery of additional populations (e.g., Keaʻau) may blur the distinctions made here.

The plants of the Waialua population represent typical *H. brackenridgei* subsp. *mokuleianus* as described in the literature. The trees are usually single-trunked, commonly 4-7 m (13-23 ft) tall (Lau pers. comm. 2000), and reportedly reach up to 12 m (39 ft) in height (Roe 1961). The Keālia plants are shorter, and commonly measure 2-6 m (6.5-20 ft) tall. Most branch near ground level to form a small tree with multiple trunks. The main branches of both the Waialua and Keālia types grow upwards. The Mākua-Molokaʻi type is a rambling shrub whose main branches extend outwards to form a plant wider than tall.

The stems of the Waialua plants are densely armed with spines, each of which arises from a red pustule. Stems of the Keālia plants range from moderately spiny to completely spineless, and the stems of the Mākua-Molokaʻi plants are completely spineless. Leaves of all of the types are shaped like a maple leaf, with 5-7 lobes. The leaves of the Waialua and Keālia types measure 15-25 cm (5.9-9.8 in) across. Those of the Mākua-Molokaʻi type are smaller, measuring 10-15 cm (3.9-5.9 in) across. The flowers of all three types are borne in the leaf axils of the outermost stems, which often project beyond the crown of the plant. All types have five-petaled flowers measuring about 12-14 cm (4.7-5.5 in) in diameter. The flowers of the Waialua and Keālia types are yellow with streaks or blotches of dark red at the center, while the Mākua-Molokaʻi type's flowers are yellow with a solid dark red center.

Wild plants of all types go dormant and lose their leaves at the beginning of the summer dry season, usually by June. They remain dormant and leafless until new growth appears at the onset of the wet season, generally by October.

There are clear differences in growth rates between the types when they are grown in well-watered common gardens, with the Waialua plants being the fastest growing and the Keālia plants being the slowest. With all of the types, wild plants are invariably slower growing than plants of the same stock in cultivation (Lau pers. comm. 2000). The age at which cultivated plants flower also varies widely between the types. Waialua plants typically begin flowering when they are only half a year to two years old, while Keālia plants typically do not begin to flower until they are two to four years old. Several cultivated plants of Mākua stock were observed to flower before they were six months old (Lau pers. comm. 2000).

The taxon's seed dispersal agents are largely unknown, however, wind and gravity likely mechanisms for dispersal. The seeds of cultivated individuals have been observed to remain viable in garden soil for at least 15 years, and in the wild, seedlings are often found at locations where no mature plants have been seen in many years (Lau pers. comm. 2000).

**Habitat:** *Hibiscus brackenridgei* in the Waialua area occurs in dry gulches, in gulch bottoms and on lower to middle gulch slopes. The area is dominated by alien grasses, with scattered alien trees forming a very open canopy. In the few areas where native elements persist, these elements include native dry forest tree species such as wiliwili (*Erythrina sandwicensis*), lonomea (*Sapindus oahuensis*), and/or lama (*Diospyros sandwicensis*). The Keālia plants are situated on open ledges and bluffs with a mix of native and alien grasses, shrubs, and trees including alaheʻe (*Psydrax odorata*). The Mākua plants grow on rocky slopes in an area that is drier and more open than any of the other Oʻahu sites. This area has burned many times over in the past and most recently in June 2022. The vegetation there now consists of a mix of native and alien shrubs and grasses, a few trees, wiliwili (*Erythrina sandwicensis*) and naio (*Myoporum sandwicense*). The natural vegetation in this extremely dry area may have been a mix of grass and shrubs with scattered trees or groves of trees forming native shrubland or grassland. In Keaʻau, plants are located along dry rocky slopes dominated by alien grass (*Megathyrsus maximus*, including both short and tall forms). A portion of the population occurs on stepped rocks with soil pockets. Parts of the surrounding area contain large rock tallus and an open canopy primarily composed of native trees, including wiliwili (*Erythrina sandwicensis*) and alaheʻe (*Psydrax odorata*), ʻaʻaliʻi (*Dodonaea viscosa*), naio (*Myoporum sandwicense*) and ʻilieʻe (*Plumbago zeylanica*). The understory vegetation at this site contains mostly non-native grasses and shrubs. There are currently cattle grazing in the area on grasses and possibly native shrubs.

**Taxonomic background:** *Hibiscus brackenridgei* occurs only in the Hawaiian Islands. The species includes two named subspecies and an unnamed one (Wilson 1993). The plants of Maui, Lānaʻi, and Hawaiʻi are assigned to *H. brackenridgei* subsp. *brackenridgei*. The extinct Kauaʻi population of *H. brackenridgei*, was formerly assigned to *H. brackenridgei* subsp. *mokuleianus* (Bates 1990), has been reassessed as not belonging to any of the three currently named subspecies. It remains to be named (Wilson 1993).

The Mākua plants morphologically match *Hibiscus brackenridgei* var. *molokaiana*, which had been previously recorded only from West Molokaʻi. For the purposes of the IP, the target taxon consists of the various Oʻahu and Molokaʻi populations of typical *H. brackenridgei* subsp. *mokuleianus* and typical *H. brackenridgei* subsp. *molokaiana*, in addition to populations falling between these two morphological extremes. The target taxon is called *H. brackenridgei* subsp. *mokuleianus* in this plan, but the name is used in a sense wider than the original sense of the name. The name *H. brackenridgei* subsp. *mokuleianus* in the strict original sense applies only to the tall spiny-stemmed trees of the Waialua type.

The plants at the Keaʻau site do not appear to be an exact morphological match to the type of plants at the Mākua PU. These two sites are the only ones known from the leeward side of Oʻahu. The Keaʻau plants appear to be taller and have longer branches than the Mākua plants and may have a slightly different flowering period (J. Lau, pers. comm. 2010). Like the Mākua type, the stems do not have spines.

The flowers of the Mākua plants do not open until 2:00-7:00 pm and remain open until early morning to

about noon (Lau pers. comm. 2000). The flowers on the Kea'au plants may close earlier in the day than the Mākua plants (Lau pers. comm. 2010) as observed during a survey in February 2010. In a common garden, Sphinx moths or hawk moths (family Sphingidae) can be observed visiting the flowers of *H. brackenridgei* at dusk and into the evening (Lau pers. comm. 2000). These moths resemble hummingbirds as they hover in front of the flower while sipping the flowers' nectar with their long tongues. Presumably they pollinate the flowers when brushing up against the flower's anthers and stigmas as they feed. There are several native species of sphinx moths in addition to several introduced ones. In addition to observations of the flowers' being visited by sphinx moths, the light color of the flowers, their being borne conspicuously beyond the leaves of the plant, and particularly their opening in the afternoon, support the supposition that the primary pollinators of the target taxon are these moths (MIP 2003).

**Population trends (From 2010):** "In 1950 the target taxon was observed in gulches in the Waialua area as being "a large tree, occurring in pure stands or in association with *Erythrina*" (Hatheway 1952). During a survey of these same gulches in 2000, four mature trees and a few additional immature plants were found at five spots in three adjoining gulches. By 2006, additional surveys in the Waialua populations had found 11 mature plants, nearly 1300 immatures, and 65 seedlings. A massive fire in August 2007 burned an estimated 97% of these plants. Since that time, plants have come back at many sites, and currently have a total of 31 mature plants. Numbers of immature plants and seedlings have fluctuated exponentially since the fire, with nearly 1400 immatures and 13 seedlings in 2009, but only 137 immatures and 3 seedlings in 2010. When the Keālia plants were first found in 1986 there were 24 saplings, all one or two years old. There was no sign of mature plants at the site (Lau pers. comm. 2000), indicating that the colony had disappeared for a while, and had reappeared during a particularly good period for recruitment. Over the last five years, this population unit has remained fairly stable, with numbers fluctuating up and down between 3-8 matures, 1-5 immatures, and 0-9 seedlings. Parts of the Keālia PU have burned in the past, though the area around the extant plants does not appear to have burned in recent years. The Mākua population has also oscillated recently, with between 9-18 matures, 2-27 immatures, and 0-68 seedlings. This area has burned many times over in the past, but not since 1995. Due to its recent discovery, population trends for the Kea'au site are unknown, though it is noteworthy that this area has not burned in recent years. The Waialua fire was the most significant impact to this species ever witnessed. Aside from fire damage, it is likely that the size of a population is largely dependent on rainfall, with large numbers being found after a series of wet years, which would allow for the survival and rapid growth of seedlings and saplings. However, long-term population trends may be difficult to discern due to short-term fluctuations in the numbers of plants."

**Table 1:** Updated Reproductive Biology Summary of *H. brackenridgei* subsp. *mokuleianus*.

| | Observed Phenology | | | Reproductive Biology | | Seeds | |
|---|---|---|---|---|---|---|---|
| Population Unit | Flower | Immature Fruit | Mature Fruit | Breeding System | Suspected Pollinator | Average # Per Fruit | Dormancy |
| ALL | Jan- June | Feb-Nov | Feb-Dec | Hermaphroditic | Sphingid moths | 8.5 ± 4.5 | Physical Dormancy (PY) |

## Plant Morphology and Habitat (Images)

**Figure 1:** Flowering plant in Mākua (left); Flowering plant, Waialua Stock, in cultivation (right)

**Figure 2:** Flowering plant in Mākua (left); Reintroduction at Kaluakauila, planting on ridge in dry mesic forest (right)

**Figure 3:** Plant habit- Kea'au (left); Plant habit- Keālia (right)

**Figure 4:** Flower buds (left); Mature fruit (right)

**Figure 5:** Immature plants (left and center); Seedlings (right)

**Figure 6:** Surviving mature plants post fire June 2022 (left and right)

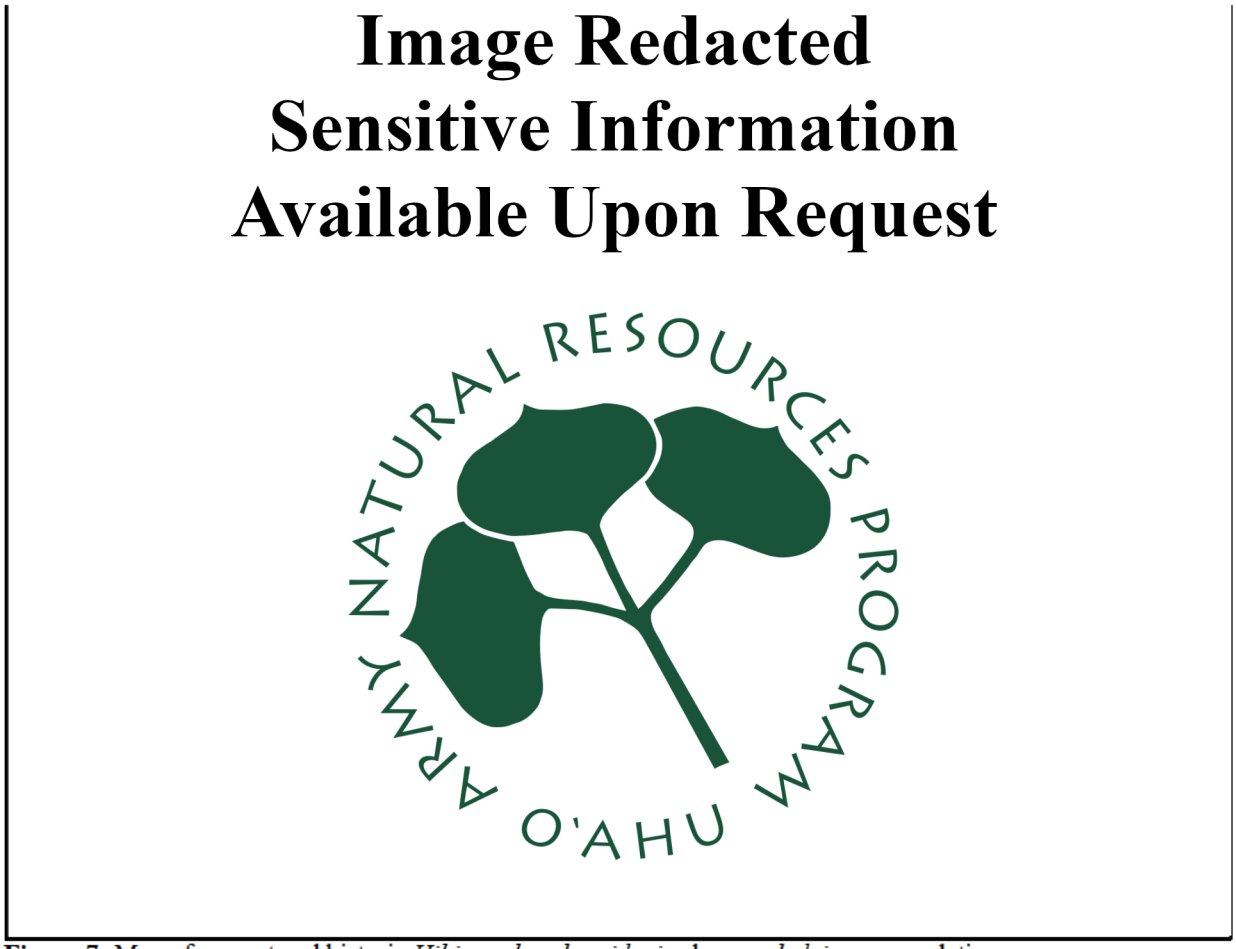


**Figure 7:** Map of current and historic *Hibiscus brackenridgei* subsp. *mokuleianus* populations

## Current Status

There are currently 552 known plants representing all age classes in the Wai‘anae Mountains, with 171 mature plants and 238 immature plants and seedlings at MFS PUs (Figure 8 and 9). Since 2005 numbers of *H. brackenridgei* subsp. *mokuleianus* have increased steadily, with some fluctuations, largely due to increased survey efforts and the establishment of reintroductions. Plant numbers peaked in 2017 with 474 mature plants. By 2020 mature plants declined sharply by 49% and have continued to decline slightly. There are a total of 4 MFS PUs: Kea‘au, Mākua, Haili to Kawaiū, and Manuwai. Manuwai is a Manage Reintroduction for Stability (MRFS) PU and Waialua is a Genetic Storage (GS) PU (Table 2). One Manage for Stability (MFS) PU, Kea‘au, currently meets stabilization goals for 50 reproducing plants, with 57 total mature plants. The Manuwai PU is currently the largest MRFS PU with 149 total plants (Figure 8). Recruitment has been observed at reintroduction sites in all MFS and MRFS PUs through time and Kea‘au, Mākua, and Haili to Kawaiū maintain F1 generation immature plants and/or seedlings. Fire remains a major threat for this taxon. Wildfires directly impacted the Waialua PU in 2007, the Kea‘au PU in 2018, and, most recently, the Mākua PU in June 2022. Post-fire monitoring at Mākua revealed a population decline of 34% and a 45% decrease in mature plants. None of the four MFS PUs meet stabilization goals for threats controlled, however, most threats are at least partially controlled at all PUs with the exception of ungulates at Haili to Kawaiū and fire at Manuwai and Haili to Kawaiū (Table 2).

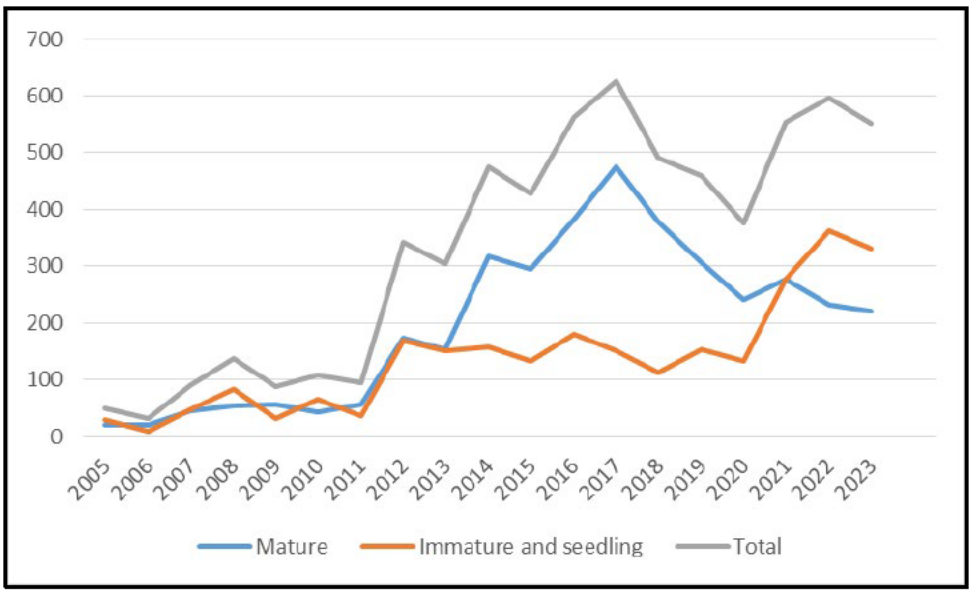


**Figure 8:** Total number of plants compared with total number of mature plants and total number of immature and seedlings for MFS PU over time.

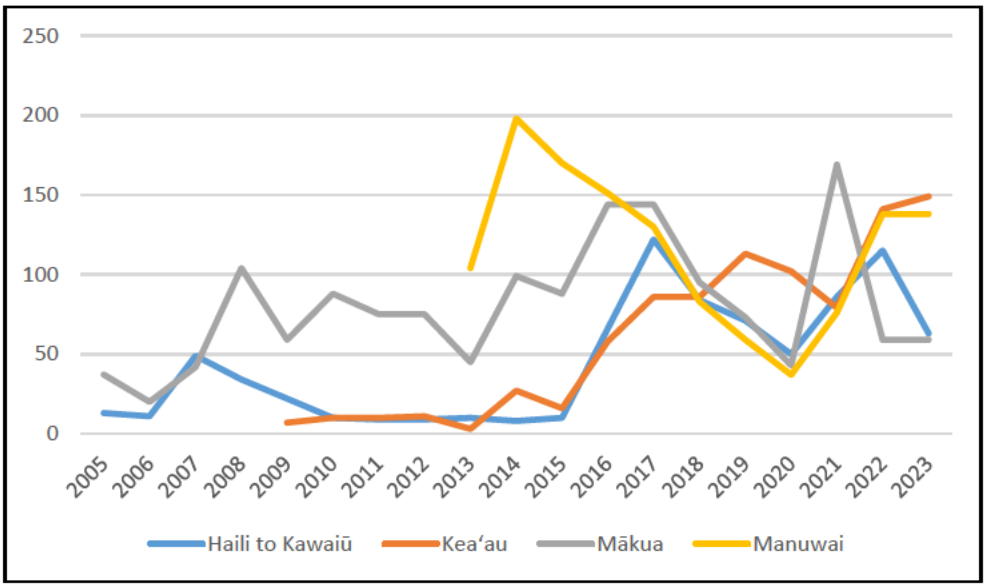


**Figure 9:** Total number of plants for each MFS PU over time.

**Table 2:** Population Units for *H. brackenridgei* subsp. *mokuleianus*. MFS = Manage for Stability; MRFS = Manage Reintroduction for Stability; GS = Manage for Genetic Storage.

| Population Unit | Management Designation | PU Type | Action Area (In/Out) | Management Units for Threat Control |
|---|---|---|---|---|
| Kea'au | MFS | *In situ*/Reintro | In | Kea'au |
| Mākua | MFS | *In situ*/Reintro | In | 'Ōhikilolo Lower |
| Haili to Kawaiū | MFS | *In situ*/Reintro | Out | Haili to Keālia 1 & 2 |
| Manuwai | MRFS | Reintro | Out | Manuwai |
| Waialua | GS | Reintro | Out | Waialua |

**Table 3:** Stabilization Goal Status. Yes/No/Partial refers to if control is in place for each PU.

| | PU Stability Target | | MU Threat Control | | | | | Genetic Storage |
|---|---|---|---|---|---|---|---|---|
| Population Unit | 50 Reproducing plants | Stable Population Structure | Ungulate | Slugs | Rodent | Fire | Weeds | % Completed |
| Kea'au | Yes | No | Yes | No | No | Partial | Partial 100% | 52% |
| Mākua | No | No | Yes | No | No | Partial 100% | Partial 100% | 78% |
| Haili to Kawaiū | No | No | No | No | No | No | Partial 98% | 85% |
| Manuwai | No | No | Yes | No | No | No | Partial 100% | ---------- |
| Waialua | --------- | ---------- | No | No | No | Partial 100% | No | 100% |

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

## Population Trends and Structure: Manage for Stability Population Units

The MIP assumed *H. brackenridgei* subsp. *mokuleianus* to live less than 10 years and treated it as short-lived taxa for purposes of the Implementation Plan. However, monitoring data revealed that some plants in reintroductions can survive for at least 10 years. More monitoring data for specific founder plants is needed to better understand longevity of *H. brackenridgei* subsp. *mokuleianus in situ.* See Table 4 for current plant numbers for each MFS PU. Specific population trend and structure information for each MFS PU is provided in the following sections.

**Table 4:** Current Plant Numbers.

| Population Unit | Current Matures | Current Immatures | Current Seedlings |
|---|---|---|---|
| Kea‘au | 57 | 81 | 11 |
| Mākua | 30 | 29 | 0 |
| Haili to Kawaiū | 46 | 10 | 7 |
| Manuwai | 38 | 100 | 0 |

## Kea‘au

This PU is located on the western Wai‘anae Mountains between ‘Ōhikilolo and Mākaha in the Kea‘au Hibiscus Management Unit (MU). There are two population reference sites (PRSs) in the PU, KEA-A and KEA-C. KEA-A is the *in situ* PRS, currently with 28 living plants (12 mature, 14 immatures, 2 seedlings). KEA-C is the reintroduction PRS, established in 2016. There have been five outplanting events at the KEA-C site with a total of 221 plants outplanted over the development of this PRS (Figure 10). The most recent ouplanting took place in January 2023 with an additional 50 plants added to this site. As of the last current complete census (07/19/2023), KEA-C currently supports 36 mature plants and 91 immature plants. Recruitment was observed at this site just one year after the initial outplanting in 2016. This site currently supports 25 F1 immature plants. Both the in situ site and reintroduction sites have rebounded well after the 2018 Kea‘au fire. The total number of plants at KEA-A has increased by 90% as compared to the last complete census conducted be for the 2018, whereas the total number of plants at KEA-C has increase by 40%. Natural Resource Staff continue to expand and maintain the firebreak in the Kea‘au MU with the goal of protecting both wild and reintroduced plants.

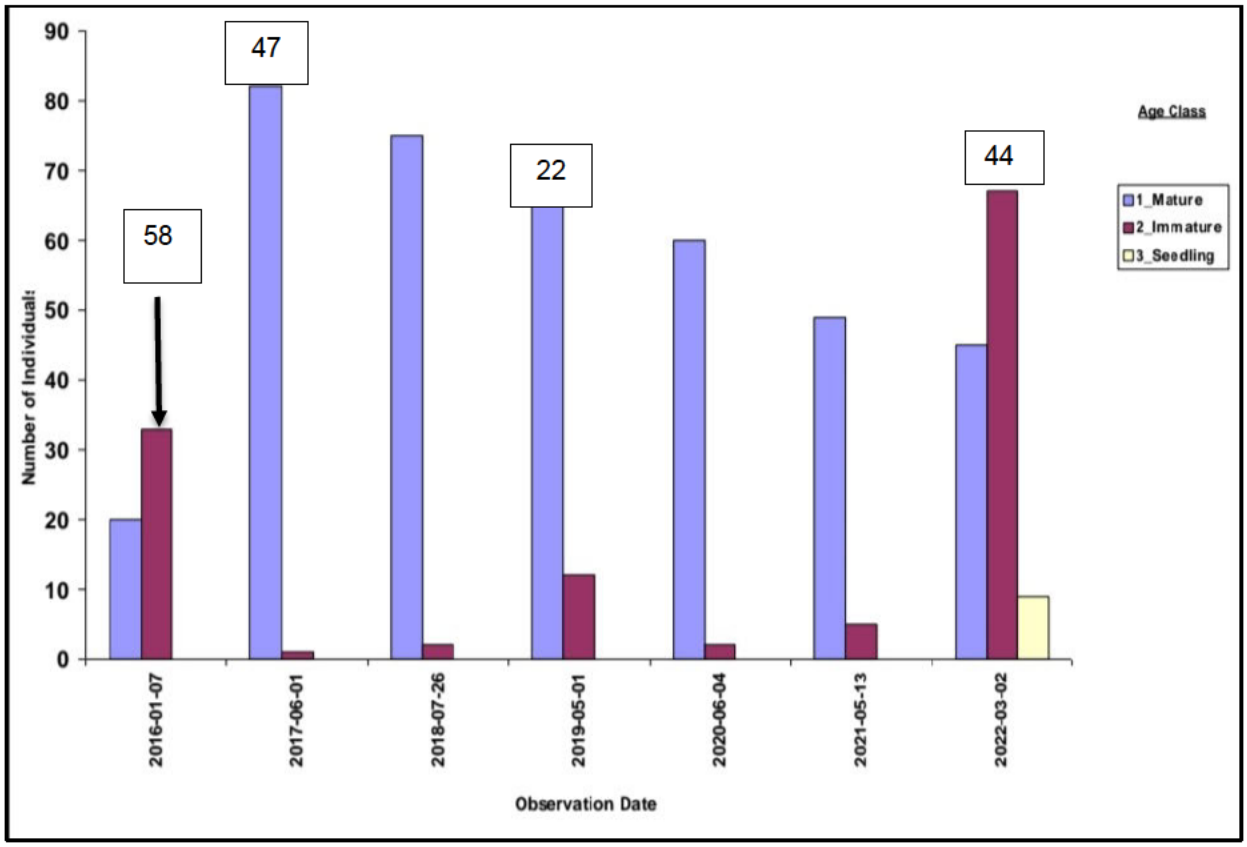


**Figure 10:** *Hibiscus brackenridgi* subsp. *mokuleianus* reintroduction KEA-C population structure for mature, immature plants, and seedlings. Number and arrow indicates when plants were added to the site.

## Mākua

This PU consists of just two PRSs in the ʻŌhikilolo Lower MU. MMR-A is the *in-situ* PRS and MMR-F, the reintroduction site, was established to augment the wild plants. The June 2022 fire in Mākua burned through both the MMR-A and MMR-F sites (ANRPO 2022). Ongoing weed control and efforts to reduce fuels on site through the maintenance of a 30-meter buffer around *H. brackenridgei* subsp. *mokuleianus* plants were essential in reducing the intensity of the fire around plants, allowing for some survivorship. Post fire monitoring revealed a population decline of 34% and a 45% decrease in the mature age class. A census initiated February 2023, but not completed, at MMR-A and F showed an 80% decline in mature plants since post fire monitoring in June 2022; however, the immature and seedling age classes increased by 36%. Based on the census complete in August of 2023, MMR-F currently supports seven mature plants and MMR-A still has one live mature plant and 142 F1 immature plants. There have been seven outplanting events at the MMR-F reintroduction with over 360 plants added over the course of its development (Figure 11).

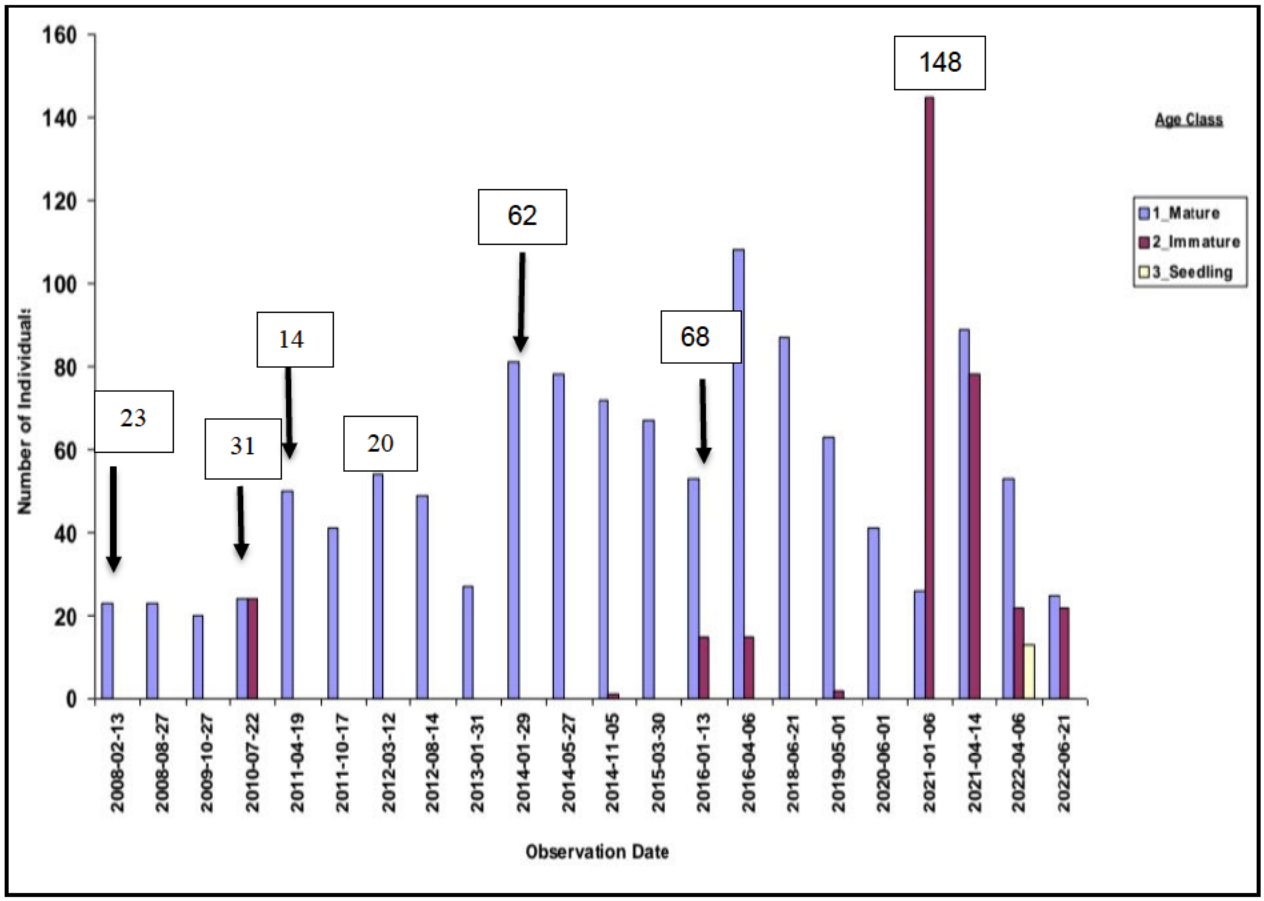


**Figure 11:** *Hibiscus brackenridgi* subsp. *mokuleianus* reintroduction MMR-F population structure for mature, immature plants, and seedlings. Numbers and arrows indicate when plants were added to the site.

## Haili to Kawaiū

This PU consists of five PRSs in the North Windward Wai‘anae Mountains. The two *in situ* PRSs are AIU-A and LIA-A, and DMR-A, LIA-B and LIA-C are reintroductions. AIU-A currently has one mature plant and three seedlings and LIA-A, four immature plants and four seedlings. The DMR-A reintroduction was established in 2005 with 21 plants. Additional plants were added in 2006 and 2008; however, all plants were observed dead in 2011. LIA-B was established by Thomas Gillespie (UCLA) for research. This PRS has not been monitored since establishment in 2017, but casual observations suggest there are a few surviving individuals. Natural Resources staff will monitor this PRS in the coming year to get an accurate census of surviving plants. LIA-C is the largest site in this PU and currently maintains 11 mature plants and six immature plants (Figure 12). Trends at LIA-C are reflective of overall population trends of *H. brackenridgi* subsp. *mokuleianus* at Haili to Kawaiū. Between March 2022 and February 2023 this PRS experienced a 53% and 87% decrease in mature and immature plants respectively due to the endemic, annual vine *Sicyos pachycarpus* aggressively smothering plants. In the future, Natural Resource staff will remove all *S. pachycarpus* plants from around or climbing *H. brackenridgei* subsp. *mokuleianus* outplants and recruits.

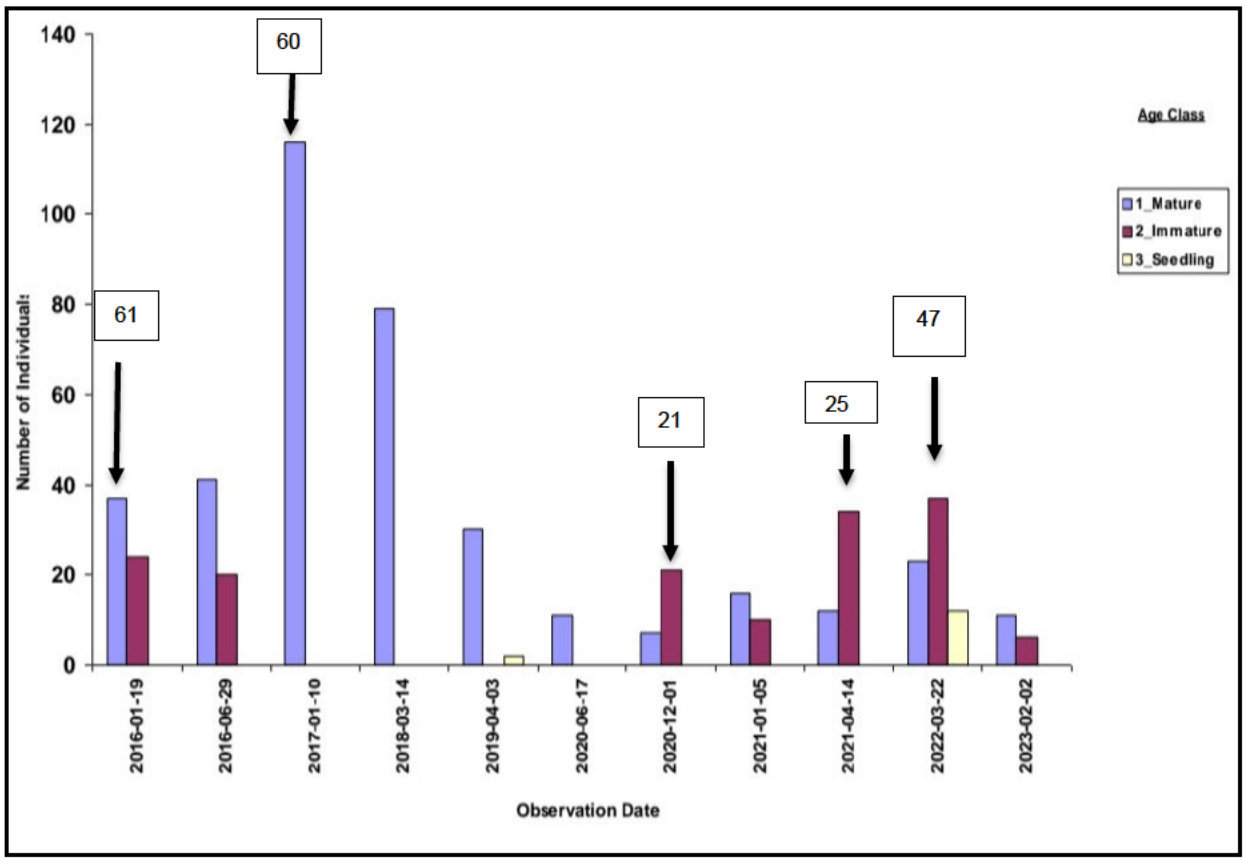


**Figure 12:** *Hibiscus brackenridgi* subsp. *mokuleianus* reintroduction LIA-C population structure for mature, immature plants, and seedlings. Numbers and arrows indicate when plants were added to the site.

## Manuwai

This is a Manage Reintroduction for Stability PU and consists of two reintroduction PRSs in the northern Wai‘anae Mountains within the Manuwai MU. ANU-A was established in 2013 with 104 plants and an additional 105 plants were added in 2014. Since establishment plant numbers at this site have been in steady decline. In 2017 seven immature and 20 F1 seedlings were observed; however, only one F1 immature was observed in June 2022. ANU-A currently supports 11 mature plants and one immature (Figure 13). Due to the decline in outplants, lack of recruitment at this site, difficult access, and changes to the habitat, including canopy closure and increased weed pressure, it was decided to establish an additional reintroduction in the Manuwai MU. ANU-B is on the eastern ridge in Manuwai at 1,760 feet. The reintroduction is located just off the ridge crest with an open canopy and is very accessible to carry out weed and other threat control. This site was established in March 2021 with 49 plants and since then an additional 155 plants have been added. Survivorship of outplants since establishment is over 91% and there are currently 27 mature plants and 175 immature plants (Figure 14)

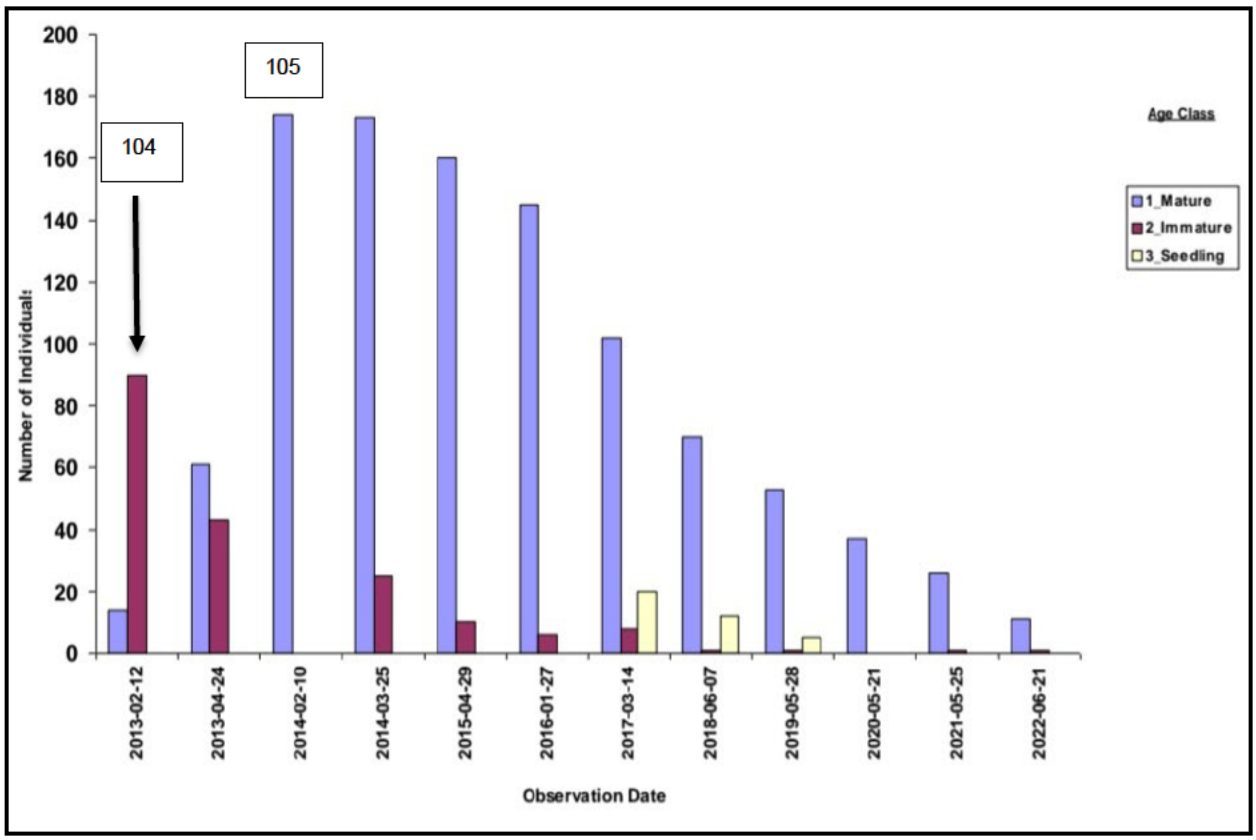


**Figure 13:** *H. brackenridgei* subsp. *mokuleianus in situ* ANU-A population structure for mature, immature plants, and seedlings. Numbers and arrows indicate when plants were added to the site.

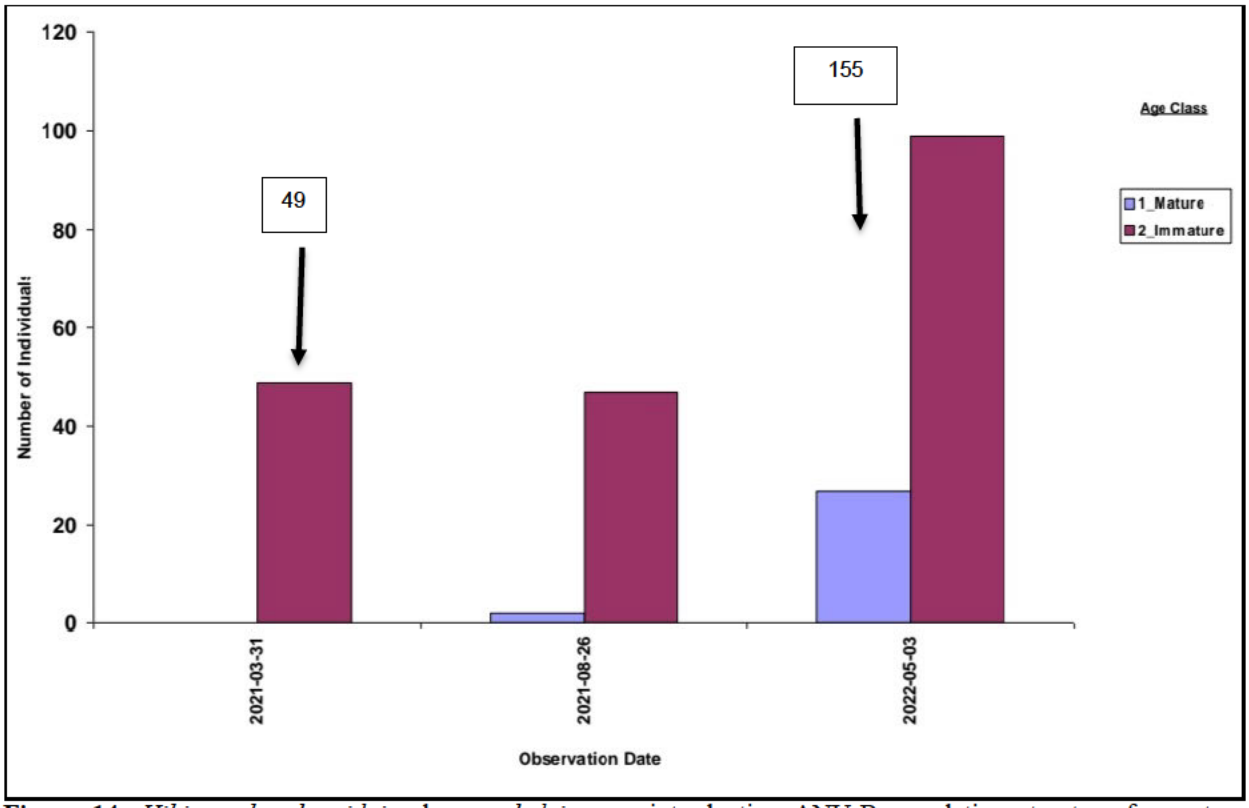


**Figure 14:** *Hibiscus brackenridgi* subsp. *mokuleianus* reintroduction ANU-B population structure for mature, immature plants, and seedlings. Number and arrow indicates when plants were added to the site.

## Current Outplanting Considerations

Vulnerability to climate change is defined as the relative inability of a species to exhibit any of the responses necessary for persistence under climate change. Using high resolution climate projections, Fortini et al. (2013) conducted a landscape-based assessment of Hawaiian native plants vulnerability to climate change. The assessment concluded that *H. brackenridgei* is vulnerable to the impacts of climate change with a vulnerability score of 0.382 (scale 0-1 (not vulnerable – extremely vulnerable)). This vulnerability score is relatively low compared to other endangered taxa in the state, however, additional management actions may be needed to protect this species into the future. *H. brackenridgei* subsp. *mokuleianus'* critical habitat is vulnerable to invasion by *Megathyrus maximus* and *Leucaena leucocephala* and other invasive plant species that increase fuel loads in the landscape around *H. brackenridgei* subsp. *mokuleianus* reintroductions and *in situ* sites, increasing risk for wild fire. Future efforts should focus on locating key microsites and microhabitats where the establishment of the aforementioned invasive species are less likely to establish or can be adequately controlled to reduce the potential for wild fire. This may include moving reintroduction sites higher in elevation, where heavy fuel producing invasive species are less likely to establish.

## Reintroduction Plan

The proposed outplanting sites are designed to maintain population size to meet the stability goal for the number of reproducing individuals (Table 5). Currently only the Kea‘au PU meets goals for 50 reproducing individuals.

**Table 5:** Future proposed outplantings sites for *H. brackenridgei* subsp. *mokuleianus* to meet the stabilization goal of 50 reproducing individuals per Population Unit (PU). The propagule type for each planting will be mature plants grown from cuttings taken from living collections, immature plants grown from seed collected from wild plants, or immature plants grown from seed collected from a living collection representing wild founders.

| Manage for Stability Population Unit(s) | Reintroduction Site | Propagule Source (PU) | Total Number of Plants to be planted | 2024 | 2025 | 2026 | 2027 | 2028 |
|---|---|---|---|---|---|---|---|---|
| Kea‘au | KEA-C | KEA-A | 50 | 25 | 25 | 0 | 0 | 0 |
| Mākua | MMR-F | MMR-A | 0 | 0 | 0 | 0 | 0 | 0 |
| Haili to Kawaiū | LIA-C | AIU-A, LIA-A | 50 | 50 | 0 | 0 | 0 | 0 |
| Haili to Kawaiū | LIA-D (New site, augmentation at LIA-A) | AIU-A, LIA-A | 75 | 0 | 50 | 25 | 0 | 0 |
| Manuwai | ANU-B | ALI, IMU, KAO, PUU, KIH | 25 | 25 | 0 | 0 | 0 | 0 |

Reintroductions will be prioritized to augment PUs that do not currently meet stabilization goals for the total number of mature plants or at sites where the number of mature plants are expected to fall below 50 in the near term. Outplanting numbers may need to increase if survival is poor, or if recruitment and development into mature plants is not observed. Outplanting will continue at three of the four MFS PUs to ensure robust outplantings at each MFS PUs. Outplanting will not take place at MMR-F in the Mākua PU over the next five years. Instead, Natural Resources staff will closely monitor post-fire population structure, and the transition of F1 seedlings and immature plants to maturity. If survivorship were to fall to zero at any of the sites listed in Table 5 over the next five years, new reintroduction sites may need to be selected and planted.

## Monitoring Plan

All PRSs within MFS PUs will be monitored annually using the HRPRG Rare Plant Monitoring Form to record population structure and the age class, reproductive status, and vigor of all known plants. Surveying for regeneration, new seedlings and juvenile plants, on site will be prioritized at all PRSs. For new founders and those for whom genetic storage is incomplete, seeds or cuttings will be collected during monitoring to increase genetic diversity for future outplanting populations, as well as to meet genetic storage goals. Monitoring data will serve to document population trends and structure, which will be used to guide *in situ* and reintroduction management strategies in the future. Observations of threats impacting plant resources should be clearly documented so that the appropriate control measures can be employed in a timely manner. New outplantings will be monitored twice a year after outplanting, and then annually in subsequent years.

## Threats

The major threats to *H. brackenridgei* subsp. *mokuleianus* include ungulates, alien plants, and fire. Pigs damage this species' habitat and directly harm plants through predation, trampling, and rooting for food sources. Alien plants negatively impact this species by altering habitat conditions and competing for moisture, nutrients, light, and space. Specifically, incursions of invasive plants can degrade or alter microhabitats necessary for recruitment of *H. brackenridgei* subsp. *mokuleianus*. Weeds are partially controlled in all PU, however, fire is only partially controlled in the Mākua and Kea'au PUs. Whereas, ungulates are controlled at Kea'au, Mākua, and Manuwai, Haili to Kawaiū receives no ungulate control due the difficulty of erecting a fence in this area. However, ungulate activity is closely monitored and there has been no ungulate damage to plants to date. Due to the high fire threat at MMR-A (*in situ*), a new reintroduction site was established in Kaluakauila (MMR-H) and more plants were added to the MMR-C reintroduction. These two reintroductions are intended to serve as back-up sites for MMR-A and MMR-F. Fuel reduction and fire break maintenance is critical in protecting this species and efforts to manage vegetation will continue at all PRSs with particular focus at KEA-A, KEA-C, MMR-A, and MMR-F.

## Genetic Storage Plan

*H. brackenridgei* subsp. *mokuleianus* seeds are orthodox. They tolerate desiccation and store well in conventional seed banking conditions, -18C and 20%RH. The recollection interval for this taxon is set for ≥ 20 years and is expected to increase following the results of the next viability test scheduled for 2024. The genetic storage strategy for *H. brackenridgei* subsp. *mokuleianus* has two phases. The first phase is to secure wild founders in a greenhouse living collection by propagating cuttings sampled from wild individuals. Once 50 founders or all accessible founders from each PU are secured, the second phase is to build in-ground living collections by PU including all available founders to serve as a source for seed collection. This shifts storage strategies from the more resource-intensive living collection to seed storage. The Waialua PU currently has 100% genetic storage complete, with 46 founders secured in living collection and 12 in seed storage. The horticulture team is managing a living collection representing Waialua stock at Koko Crater Botanical Garden for the purpose of increasing seed for storage. Similarly, the Kea'au PU, with 52% genetic storage complete, has 30 founders with at least one plant in living collection and 15 founders meeting genetic storage goals with ≥ 50 viable seeds in storage. A living collection representing wild founders from this PU is being managed for the purpose producing seed for storage at Kahua. The Mākua PU, with 78% genetic storage complete, has 34 of 45 founders secured in seed storage, and the Haili to Kawaiū PU, with 85% genetic storage complete, has 13 of 20 founders in seed storage. Living collections for the Mākua and Haili to Kawaiū PUs were established at Kahua in 2017 and 2019 respectively and have since been discontinued. Seed collections will be targeted at both *in situ* PRSs and reintroductions in these two PUs for founders currently not represented in seed storage.

**Table 6:** Action plan for maintaining genetic storage representation, and providing propagules for reintroductions.

| What propagule type is used for meeting genetic storage goal? | What is the source for the propagules? | What is the Genetic Storage Method used to meet the goal? | What is the proposed re-collection interval for seed storage? | Is seed storage testing ongoing? | Plan for maintaining genetic storage.* |
|---|---|---|---|---|---|
| Seeds and Living Collection | *In situ* and reintroductions | Seed Storage: -18C/ 20% RH and living collection | ≥20 years | Yes | Re-collect from *in situ* sites and reintroductions |

## Management Discussion

The primary goal for this taxon for the next five years will be to continue to augment established reintroductions with outplants in the Haili to Kawaiū, Kea‘au, and Manuwai PUs. Outplants have exhibited relatively high mortality rate at all sites. Continued outplantings will increase the number of plants at sites to meet stabilization goals, but more importantly will build population structure across all age classes by promoting regeneration or recruitment at reintroduction sites. Outplantings at the Mākua PU are not planned, however, efforts will focus on monitoring the large number of F1 seedling and immature plants that established after the June 2022 fire. In addition, Natural Resource Staff should consider conduction seed sows in rocky areas that would otherwise be difficult to plant. Establishing plants in and around rock outcroppings may provide protection from future fires. In response to the Mākua fire, a new reintroduction, MMR-H, was established in the Kaluakauila MU last outplanting season (2022/2023) and MMR-C, established in 2002, was augmented with more plants. These reintroductions were planted with MMR-A stock and are intended to serve as backup reintroductions for MMR-A and F in Mākua, considering the fire history at this MU. Regeneration has been observed in all PUs through time; however, mortality of recruits has been high, and few plants have been observed transitioning to the mature age class. Field staff will continue to employ strategies that promote natural recruitment at reintroduction sites. These strategies primarily include the control of known threats, including rodents, ungulates, weeds, and fire. ANRPO is currently managing vegetation and fuel loads in all MFS PUs, with large investments of effort in the Mākua and Kea‘au PUs to reduce fuels in a buffer around wild and reintroduced plants.

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# Updated Five Year Management Plan for *Delissea waianaeensis*, 2009, 2023

## *Delissea waianaeensis*

**Scientific name:** *Delissea waianaeensis* (Lammers)
**Hawaiian name:** None
**Family:** Campanulaceae (Bellflower family)
**Federal status:** Listed endangered October 10, 1996
**Requirements for Stability:**

- 4 Manage for Stability (MFS) Population Units (PUs)
- 100 reproducing individuals in each PU (short-lived perennial with population fluctuations and local declines)
- Threats controlled
- Complete genetic representation of all PUs in storage

## Description and biology

*Delissea waianaeensis* is a shrub 1-2.5 m tall, with a single stem; or it is occasionally branched, usually as the result of an injury. The stems are erect and topped by a cluster of leaves. The leaf blades measure 11-24 cm long, and their margins are toothed, lobed, or cut to various degrees. The inflorescences are 5-12 flowered racemes and are borne close to the stem among the leaves. The corollas are white to green, curved, and measure 45-62 mm long. The berries measure 7-16 mm long and are purple when ripe (Lammers 2005). Flowering and fruiting have been documented by ANRPO at various times of the year, with most flowering recorded from March through May, and fruiting from March through July. As with other species of *Delissea*, floral morphology of *D. waianaeensis* is indicative of bird pollination. It is capable of self-pollination, as evidenced by the production of viable seeds by isolated plants (Smith et. al. 1995, Lammers and Freeman 1986). The purple berries of *D. waianaeensis* are indicative of seed dispersal by fruit-eating birds. The longevity of individual plants is unknown. The species presumably lives for less than 10 years like other taxa of its size in the genus *Delissea* and in the closely related genus *Cyanea*. Therefore, *Delissea* is considered a short-lived species for the purposes of the Implementation Plan (MIP 2003).

**Known distribution:** *Delissea waianaeensis* is endemic to the Waiʻanae Mountains and has been documented from elevations of 245-760 m (Lammers 2005). It has been found primarily along the windward side of the range from Pālāwai in the south to Kawaihāpai in Mokulēʻia. The only recorded leeward site was in Kahanahāiki Valley on MMR.

**Habitat:** *Delissea waianaeensis* is usually found growing on north-facing gulch slopes, and sometimes in gulch bottoms. It occurs in mesic forests dominated by lama (*Diospyros sandwicensis*), ʻōhiʻa (*Metrosideros polymorpha*), and/or koa (*Acacia koa*). It can also occur in forests composed of a diverse mix of trees. It grows either under the forest canopy or in sunny openings in the forest (MIP 2003).

**Taxonomic background:** There are 15 species in the endemic Hawaiian genus *Delissea*. All species are endemic to a single island. Eleven are presumed extinct and the remaining four are listed endangered. In addition to *D. waianaeensis*, there are five species that have been recorded from Oʻahu but are now presumed to be extinct. *D. laciniata* and *D. lauliiana* have been documented only from the southeastern Koʻolau Mountains and last collected prior to 1872. *D. sinuate* has been documented only from the northern Waiʻanae Mountains and was last collected in 1937. *D. subcordata* is endemic to the Koʻolau Mountains and two sub-species are recognized. Neither has been collected since 1934. *D. takeuchii* is

endemic to the Wai‘anae Mountains and was last collected in 1987. It has leaves 3-4 times longer than wide compared to *D. waianaeensis* with leaves 1.3-2.7 times longer than wide. *D. takeuchii* differs further in having smaller and finer marginal teeth, wider corolla lobes and shorter anthers than *D. waianaeensis*.

**Population trends (from 2010):** Limited recruitment of seedlings has been observed at most *in situ* sites. Slugs are thought to depredate seedlings of *D. waianaeensis* and could limit regeneration at all sites. Seedlings have been observed to survive to be new mature founders at some *in situ* sites. However, at most *in situ* sites there have been very few (1-8) mature plants observed limiting the number of seeds that have been dispersed. At the much larger reintroduction sites, more seedlings and immature plants are becoming established as many of the planted individuals are now producing fruit. Although observations show a developing population structure, data on stage class transitions are still limited. Data collection on stage class distribution and survivorship will be collected and management adapted accordingly. If population structure will maintain the stabilization goal of 100 mature plants, no further planting may be needed. If monitoring shows that survivorship may not be sufficient to maintain the stability goal, the management strategy will be adapted.

**Table 1:** Updated Reproductive Biology Summary of *D. waianaeensis*

| | Observed Phenology | | | Reproductive Biology | | Seeds | |
|---|---|---|---|---|---|---|---|
| Population Unit | Flower | Immature Fruit | Mature Fruit | Breeding System | Suspected Pollinator | Average # Per Fruit | Dormancy |
| ALL | Feb-June | April-Aug | May- Sept | Hermaph-roditic | Bird | 132 ± 98 | Not Dormant or Conditional Morpho-physiological Dormancy (cMPD)* |

**Delissea rhytidoperma* exhibits cMPD (Baskin et. al. 2021)

## Plant Morphology and Habitat (Images)

**Figure 1:** Fully grown individual (left). *D. waianaeensis* seedlings (right)

**Figure 2:** Inflorescence with open flowers and buds(left); Flower showing reproductive structures (right)

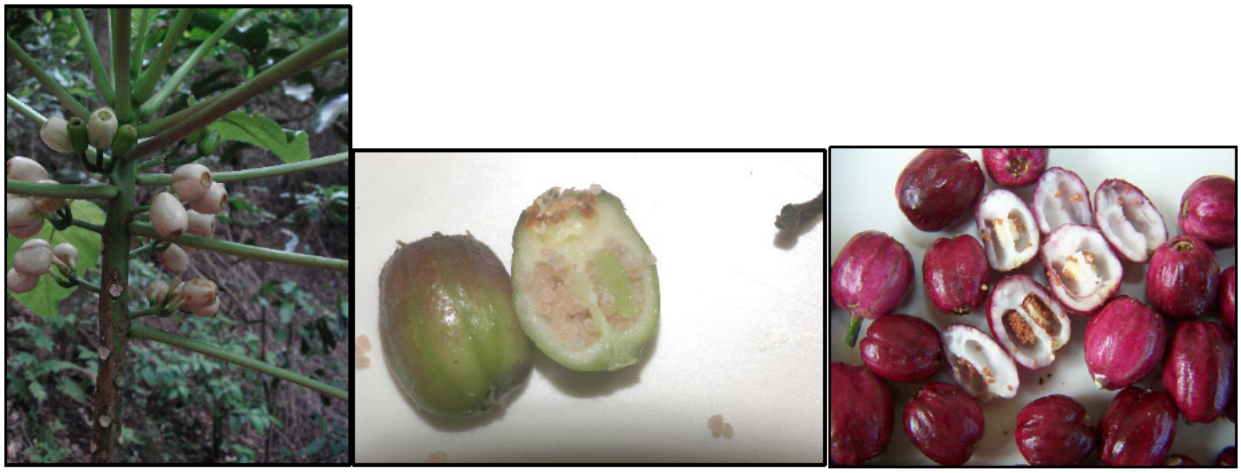

**Figure 3:** Immature fruit on plant (left); Immature fruit and seed (center); Mature fruit and seed (right)

**Figure 4:** Map of current and historic *D. waianaeensis* populations

## Current Status

Since the finalization of the MIP in 2003 the total number of plants of *D. waianaeensis* has increased through time largely due to outplanting efforts. The total population of *D. waianaeensis* peaked in 2013 with 2,056 plants, 1,148 mature plants and 908 immature plants and seedlings (Figure 5). However, since 2013 the population has continued to decline without additions of new outplants. This trend started to change with new outplanting efforts initiated in 2021. Recruitment has been observed at reintroductions in three Manage for Stability (MFS) Population Units (PUs): Kaluaʻā, ʻĒkahanui, and Kahanahāiki to Keawapilau. Kaluaʻā and ʻĒkahanui support 45 and 18 mature F1 plants respectively. Kaluaʻā is the largest PU for this taxon with 201 mature plants, 104 immature plants and 10 seedlings (Figure 6). PUs for *D. waianaeensis* include three MFS PUs, one Manage Reintroduction for Stability (MRFS) PU, four Genetic Storage (GS) PUs, and two Manage Reintroduction for Storage PUs (Table. 2). Two of the four MFS PUs currently meet stabilization goals for 100 reproducing individuals and four PUs have 100% genetic storage complete (Table 3). None of the four MFS PUs meet stabilization goals for threats controlled, however, all threats are at least partially controlled at all MFS PUs.

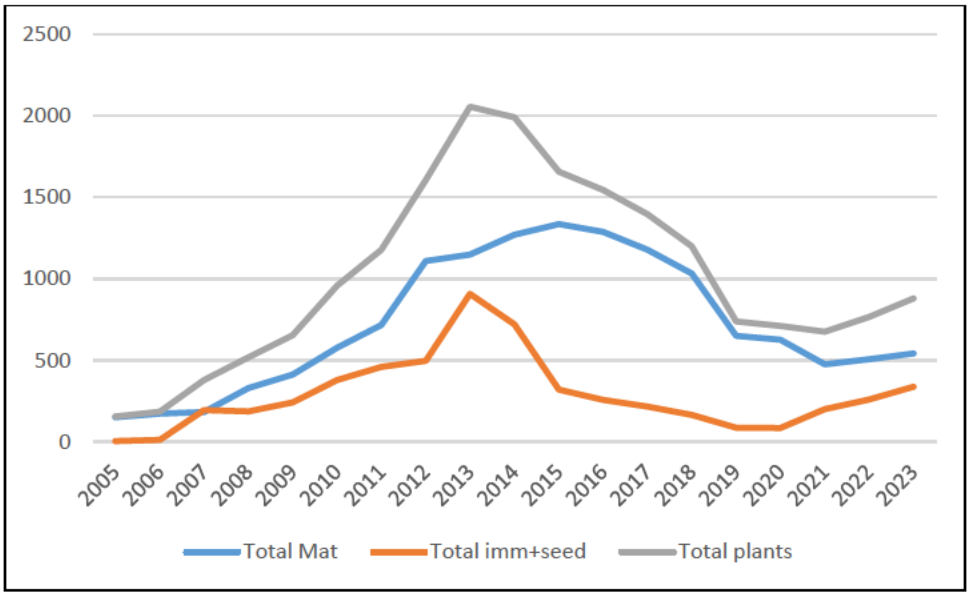


**Figure 5:** Number of total mature plants compared to total immature and seedling plants compared to the overall total of plants for all PUs over time.

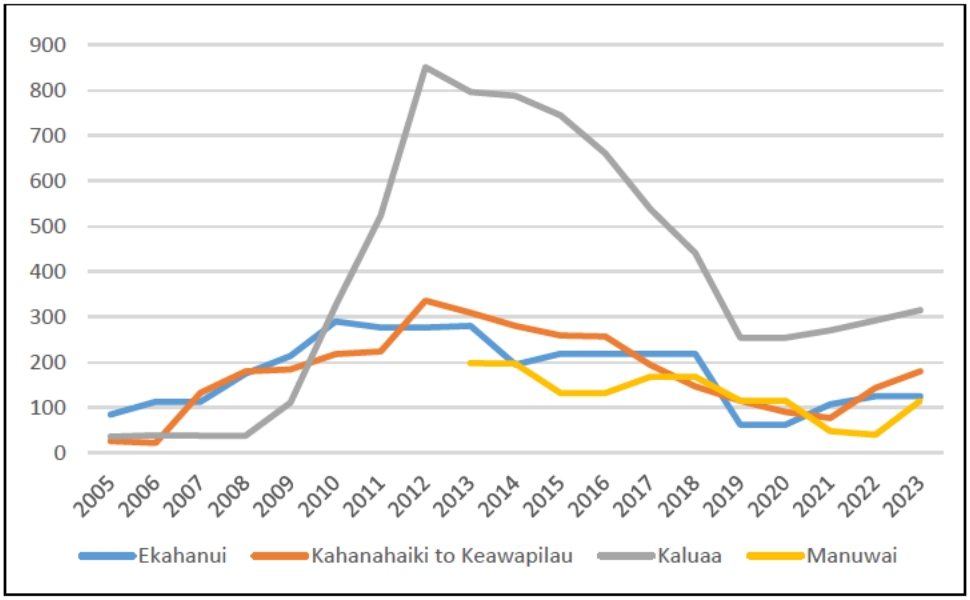


**Figure 6:** Total number of plants for each MFS PU over time

**Table 2:** Population Units for *D. waianaeensis.* MFS = Mange for Stability; MRFS= Manage Reintroduction for stability; GS = Genetic Storage

| Population Units | Management Designation | PU Type | Action Area (In/Out) | Management Units for Threat Control |
|---|---|---|---|---|
| Kahanahāiki to Keawapilau | MFS | *in situ*/Reintro | In | Kahanahāiki, Pahole, Kapuna Upper |
| Kaluakaulia | GS Manage Reintro for Storage | Reintro | In | Kaluakauila |

**Table 2** (continued).

| Population Units | Management Designation | PU Type | Action Area (In/Out) | Management Units for Threat Control |
|---|---|---|---|---|
| Kapuna | GS Manage Reintro for Storage | Reintro | In | Kapuna Upper |
| Palikea Gulch | GS | *in situ* | In | Palikea Gulch No MU |
| South Mohiākea | GS | *in situ* | In | Līhu‘e |
| Keālia | GS | *in situ* | Out | Haili to Keālia No MU |
| Manuwai | MRFS | Reintro | Out | Manuwai |
| ‘Ēkahanui | MFS | *in situ*/Reintro | Out | ‘Ēkahanui |
| Kalua‘ā | MFS | *in situ*/Reintro | Out | Kalua‘ā and Wai‘eli |
| Pālāwai | GS | *in situ* | Out | Pālāwai No MU |

**Table 3:** Stabilization Goal Status. Yes/No/Partial refers to if control is in place for each PU.

| | PU Stability Target | | MU Threat Control | | | | | Genetic Storage |
|---|---|---|---|---|---|---|---|---|
| Population Unit | 100 reproduc-ing plants | Stable Population Structure | Ungulate | Slugs | Rodent | Fire | Weeds | % Completed |
| Kahanahāiki to Keawapilau | Yes | No | Yes | Partial 98% | Partial 98% | No | Partial 99% | 83% |
| ‘Ēkahanui | No | No | Yes | Partial 100% | Partial 100% | No | Partial 100% | 100% |
| Kalua‘ā | Yes | No | Yes | Partial 87% | Partial 87% | No | Partial 100% | 100% |
| Manuwai | No | No | Yes | Partial 100% | Yes | No | Partial 100% | ---------- |

**Table 3** (continued).

| | PU Stability Target | | MU Threat Control | | | | | Genetic Storage |
|---|---|---|---|---|---|---|---|---|
| Population Unit | 100 reproduc-ing plants | Stable Population Structure | Ungulate | Slugs | Rodent | Fire | Weeds | % Completed |
| Palikea Gulch | ---------- | ---------- | No | No | No | Partial 100% | No | 100% |
| South Mohiākea | ---------- | ---------- | Yes | No | Yes | No | Partial 100% | 86% |
| Keālia | ---------- | ---------- | No | No | No | No | No | 100% |
| Pālāwai | ---------- | ---------- | Partial 96% | No | No | No | No | 88% |

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

## Population Trends and Structure: Manage for Stability Population Units

The MIP assumed *D. waianaeensis* to live less than 10 years and treated it as short-lived taxa for purposes of the Implementation Plan. However, monitoring data revealed that plants from reintroductions survive for up to 21 years. More monitoring data for specific founder plants is needed to better understand longevity of *D. waianaeensis in situ.* See Table 4 for current plant numbers for each MFS PU. Specific population trend and structure information for each MFS PU is provided in the following sections.

**Table 4:** Current Plant Numbers

| Population Unit | Current Matures | Current Immatures | Current Seedlings |
|---|---|---|---|
| ʻĒkahanui | 68 | 57 | 0 |
| Kahanahāiki to Keawapilau | 135 | 45 | 0 |
| Kaluaʻā | 201 | 104 | 10 |
| Manuwai | 29 | 86 | 0 |

## ʻĒkahanui

This PU is located in the southern Waiʻanae Mountain range and contains four Population Reference Sites (PRSs): EKA-A, EKA-B, EKA-C, and EKA-D. EKA-A, EKA-B, and EKA-C were *in situ* populations that have no remaining individuals left, with last plants confirmed dead in 2021, 2008, and 2004 respectively. EKA-D is a reintroduction site and is the last site of *D. waianaeensis* in the PU. This reintroduction was established in 2003 and was augmented with outplants multiple times, most recently with 82 plants added in 2021 (Figure 7). The site currently supports 68 matures and 57 immatures. Recruitment has been observed at this site since 2009 and currently 26% of all mature plants and 17% of immature plants on site represent the F1 generation.

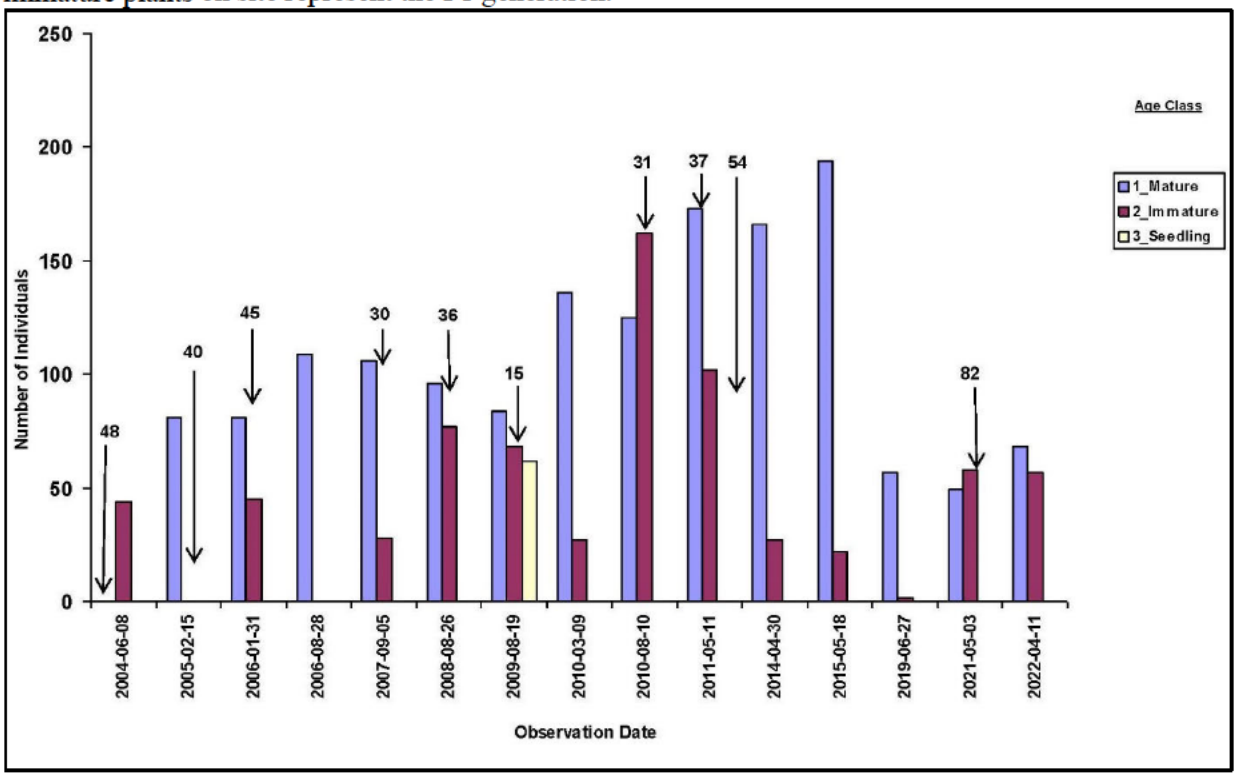


**Figure 7:** *D. waianaeensis* reintroduction EKA-D population structure for mature and immature plants, and seedlings. Numbers with arrows indicate when outplants were added to the site.

## Kahanahāiki to Keawapilau

The Kahanahāiki to Keawapilau PU is located in the northern Waiʻanae Mountains and consists of 14 PRSs, with five in the Kapuna Upper MU, three in the Kahanahāiki MU, and six in the Pahole MU. This PU supports nine *in situ* PRSs, however, only three sites have plants remaining. KAP-E and MMR-C have one mature plant remaining at each site and PAH-E has two remaining mature plants. Of the five reintroduction PRSs in this PU, only two sites, MMR-A and PAH-C, maintain a significant number of plants. MMR-A currently supports 27 mature plants and 20 immature plants. Two of the 27 mature plants represent the F1 generation. PAH-C is by far the largest reintroduction in this PU and has 103 mature plants and 24 immature plants, two of which represent the F1 generation. Established in 2007, this site has been supplemented with addition plants multiple times throughout its history and currently meets stabilization goals for 100 reproductive individuals (Figure 8).

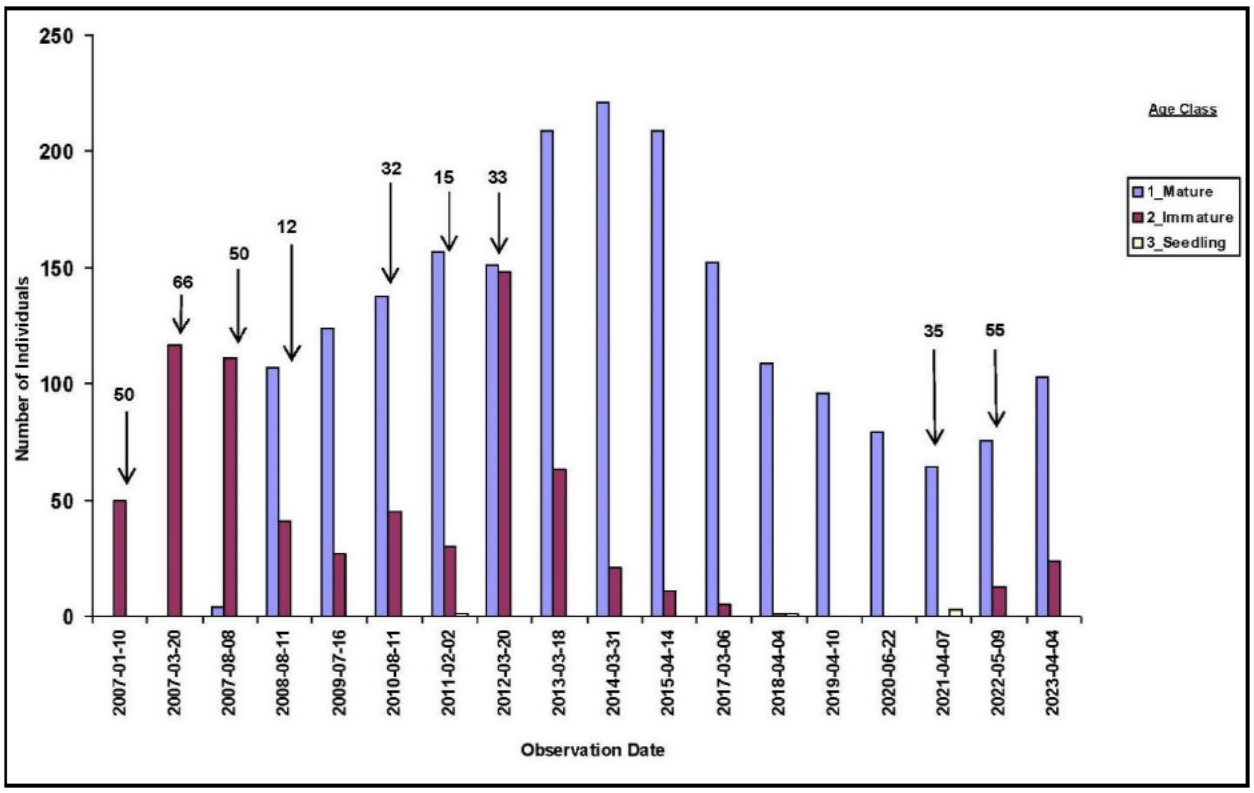


**Figure 8:** *D. waianaeensis* reintroduction PAH-C population structure for mature and immature plants, and seedlings. Numbers with arrows indicate when outplants were added to the site.

## Kalua‘ā

This PU is located in the southern Wai‘anae Mountains in the Kalua‘ā and Wai‘eli MU and it consists of four PRSs: ELI-A, KAL-B, KAL-C, and KAL-D. KAL-B is the only *in situ* site in the PU, and has one mature plant. KAL-C and KAL-D are both reintroduction sites with 153 (127 mature and 21 immature) and 130 (48 mature and 82 immature) plants respectively. The ELI-A reintroduction is the smallest, with 25 mature plants, one immature and 5 seedlings. KAL-C the largest site in this PU (Figure 9), has experienced a significant increase in plants since establishment in 2002, in part due to outplanting but also natural recruitment, followed by a sharp decline between 2018 and 2019. 35% of the mature plants at this site represent the F1 generation.

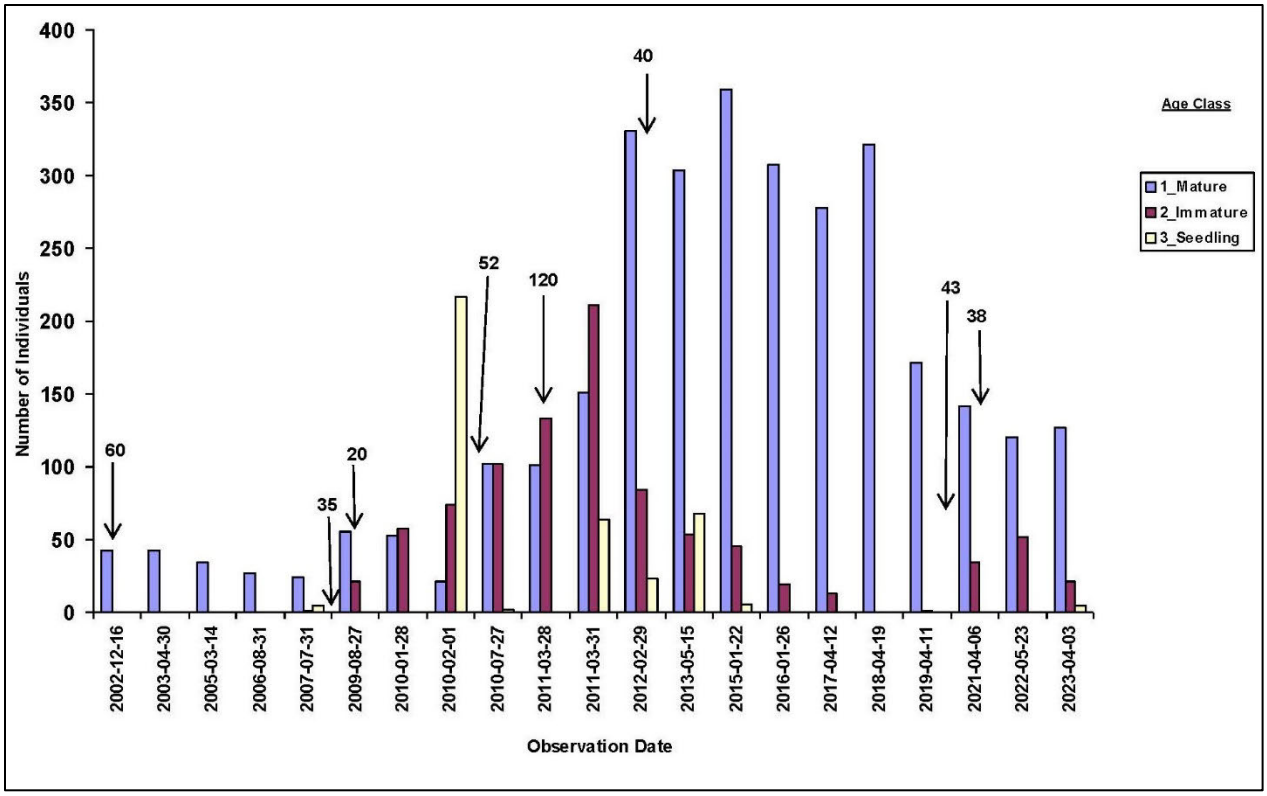


**Figure 9:** *D. waianaeensis* reintroduction KAL-C population structure for mature and immature plants, and seedlings. Numbers with arrows indicate when outplants were added to the site.

## Manuwai

This PU is located in the northern Wai‘anae Mountain range. Manuwai is a Manage Reintroduction for Stability PU and solely consists of reintroduction PRSs. ANU-A was established in 2013 with 200 plants and has experienced a consistent decline through time of both mature and immature plants, with minimal recruitment observed in over ten years (Figure 10). As the result of canopy closure at this site and continued decline of outplants, it was decided to establish an additional reintroduction in this MU. ANU-B was established in February 2023 on the east side of the MU near the DOFAW/PEPP *Mezoneuron kavaiense* outplanting. If successful, this site will replace ANU-A.

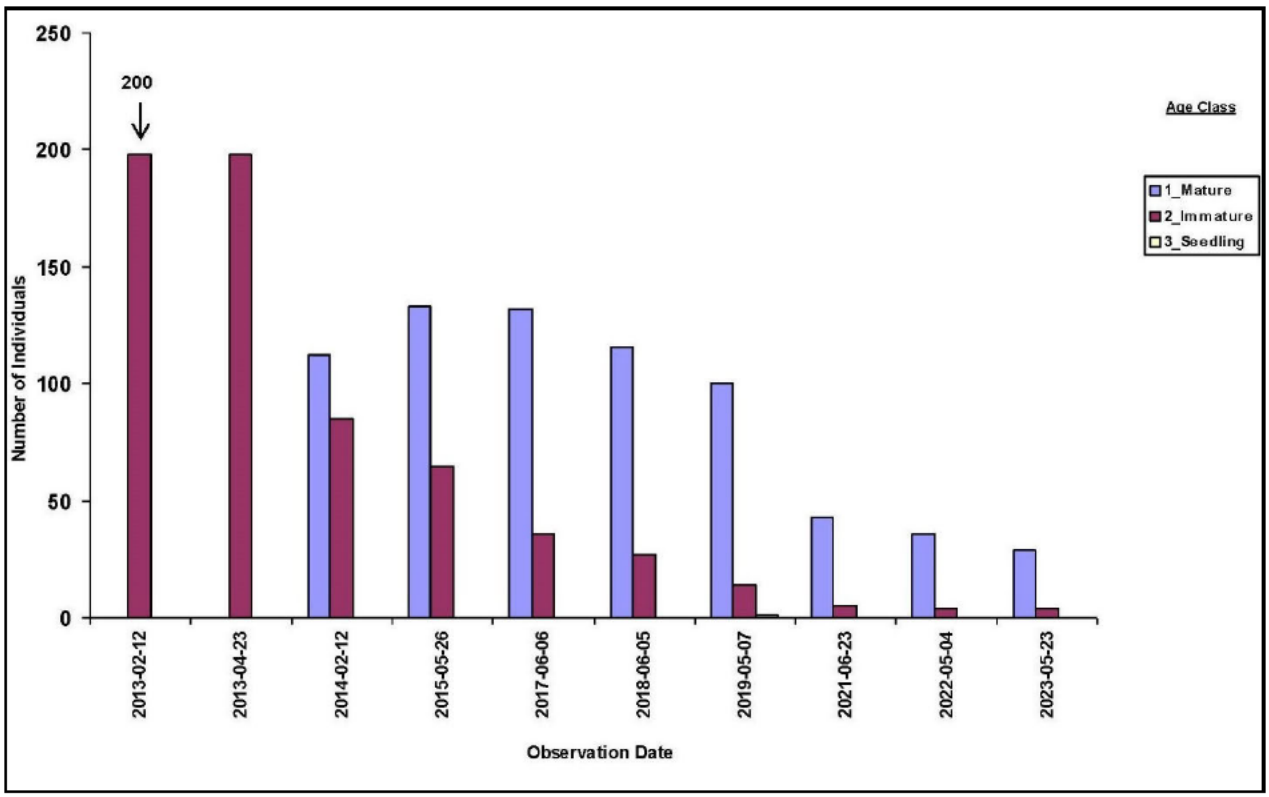


**Figure 10:** *D. waianaeensis* reintroduction ANU-A population structure for mature and immature plants, and seedlings. Numbers with arrows indicate when outplants were added to the site.

## Current Outplanting Considerations

*D. waianaeensis* is highly vulnerable to the impacts of climate change with a vulnerability score of 0.692 (scale 0-1 (not vulnerable – extremely vulnerable)) (Fortini *et al.* 2013). When selecting future outplanting sites climate variables should be considered. Dr. Lucas Fortini (USGS) is developing climate range maps, examples of which were originally presented at the 2019 IT meeting, for the majority of ANRPO management taxa. ANRPO continues to work with Dr. Fortini to develop a reliable metric of habitat compatibility for rare plants in a changing climate. The climate range maps developed initially in 2019 were based on simple climate envelope models, resulting in maps that are binary, too general, and include no estimate of habitat preference. Recent efforts focused on creating Species Distribution Models (SDM) that work as a reliable measure of habitat compatibility for rare plant species. In total four habitat compatibility metrics/models were developed for *D. waianaeensis*. To identify the model best fit to *D. waianaeensis,* outplanting monitoring data metrics (vigor, Survival, and reproductive phenology) were used to determine which model best match site differences in outplanting performance by comparing strength and consistency of correlations across model values and outplanting metrics. The Bioclim model under early 20$^{th}$ century climate conditions were identified as the best fit for *D. waianaeensis*. This model assumes a central tendency to the median climatic condition across wild occurrences, and considering past climate shifts, better describes habitat compatibility for long-lived species. The resulting climate range maps are presented in Figure 11. The "Current" map indicates suitability under current climate conditions and the "Future" map projects suitable conditions for mid-century (2040-2059) based on mean habitat suitability projections across nine regionally adapted climate projections under the RCP 6.0 scenario (Berio Fortini et. al. in press). Bioclim is a standard distribution model, with values closer to one

be more suitable. Final maps can be used as guides for future reintroduction and management site selection. While these maps provide us with more information regarding possible future range changes, they do not account for habitat quality in the landscape.

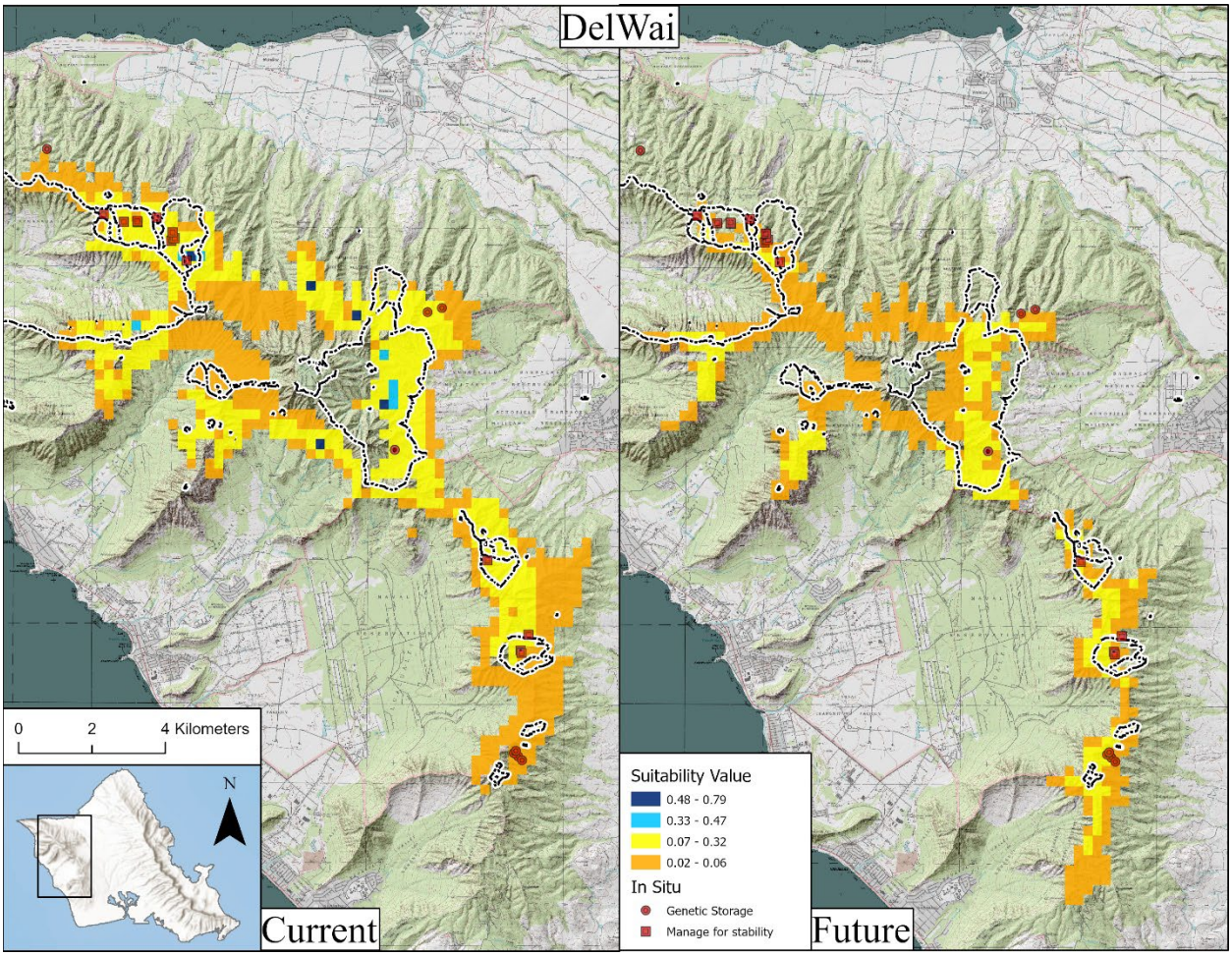


**Figure 11:** *D. waianaeensis* climate range maps.

## Reintroduction Plan

The proposed outplanting sites are designed to maintain population size to meet the stability goal for the number of reproducing individuals (Table 5) per PU. Currently Kahanahāiki to Keawapilau and Kalua‘ā PUs meet goals for 100 reproducing individuals.

**Table 5:** Future proposed outplantings sites for *D. waianaeensis* to meet the stabilization goal of 100 reproducing individuals per Population Unit (PU). The propagule type for each planting will be immature plants grown from seeds from wild plants or reintroductions.

| Manage for Stability Population Unit(s) | Reintroduction Site(s) | Propagule Source (PU) | Total Number of Plants to be planted 2023-2024 outplanting season | 2024 | 2025 | 2026 | 2027 | 2028 |
|---|---|---|---|---|---|---|---|---|
| Kahanahāiki to Keawapilau | MMR-A, PAH-C | KAP, PAH, MMR | 113 | 38 | 25 | 25 | 25 | 0 |
| ‘Ēkahanui | EKA-D | EKA | 85 | 35 | 25 | 25 | 0 | 0 |
| Kalua‘ā | KAL-D | KAL | 57 | 32 | 0 | 0 | 25 | 0 |
| Kalua‘ā | KAL-C | SBW-A | 55 | 55 | 0 | 0 | 0 | 0 |
| Manuwai | ANU-B | ALI | 150 | 0 | 100 | 50 | 0 | 0 |

Reintroductions will be prioritized to augment PUs that do not currently meet stabilization goals for the total number of mature plants or at sites where the number of mature plants are expected to fall below 50 in the near term. Outplanting numbers may need to increase if survival is poor, or if recruitment and development into mature plants is not observed. Outplanting will continue at all four MFS PUs to ensure robust population sizes, with well over 100 individuals at each MFS PU. If survivorship were to fall to zero at any of the sites listed in Table 5 over the next five years, new reintroduction sites will be selected and planted.

## Monitoring Plan

All PRSs within Manage for Stability PUs will be monitored annually using the HRPRG Rare Plant Monitoring Form to record population structure and the age class, reproductive status and vigor of all known plants. Surveying for regeneration, new seedlings, and juvenile plants on site will be prioritized at all PRSs. New founders and those without 50 viable seeds in genetic storage will be collected during monitoring to increase genetic diversity for future outplanting, as well as to meet genetic storage goals. Monitoring data will serve to document population trends and structure, which will be used to guide *in situ* management strategies in the future. Observations of threats impacting plant resources should be clearly documented so that the appropriate control measures can be employed in a timely manner.

## Threats

The major threats to *D. waianaeensis* include ungulates, rats, alien slugs, game birds (galliformes) and snails, and alien plants. Pigs damage this species' habitat and directly harm plants through predation, trampling, and rooting for food sources. Rats threaten this species through predation of its plant parts and fruits, while introduced slugs and snails threaten this species by feeding on its leaves, stems, and seedlings. Rats are unlikely to be effective dispersers. Seeds are small enough to pass through their guts intact, however, rats are likely depositing seeds in unfavorable locations. Kalij pheasant (*Lophura leucomelanos*) has been detected depredating fruits and in some cases damaging plants in the pursuit of fruit. Case et.al. 2022 found that seeds are destroyed in the guts of Kalij pheasants. It is likely that other galliformes, such as Erckel's Francolins (*Pternistis* erckelii) also pose a threat to this taxon. Alien plants negatively impact this species by altering habitat conditions and competing for moisture, nutrients, light, and space. More specifically, incursions of invasive plants can degrade or alter microhabitats necessary for recruitment of *D. waianaeensis* seedlings. All known threats to this taxon are currently partially or fully controlled at all MFS PUs. Slugs are expected to greatly reduce the potential for regeneration at both *in situ* and reintroduction sites and efforts are underway to expand slug control for this taxon. All new reintroduction sites for this taxon will be considered for slug control based on the presence or absence of native snail species of concern. The concern is to minimize non-target impacts of Ferroxx AQ, the molluscicide containing iron phosphate, used to control alien slugs and snails.

## Genetic Storage Plan

*D. waianaeensis* seeds tolerate desiccation but are freeze sensitive. Seeds are currently stored at 5°C and -80°C at 20% RH. Storage at -80°C is currently experimental and more viability data through time in storage is necessary to determine whether or not -80°C is an appropriate long-term storage method for this taxon and other freeze sensitive species. Seed storage is the preferred genetic storage technique; it is the most cost-effective method, requires the least amount of maintenance once established, and captures the largest amount of genetic variability. Seeds in storage have not shown a decline in viability and the recollection interval for this taxon is ≥ 25 years (Table 6). The 25-year viability test is scheduled for 2025-05-31. Re-collection intervals will continually be extended until a decline in viability is detected.

Average seed viability for *D. waianaeensis* collections in storage at ANRPO is 74.75%. Seeds from reintroductions and *in situ* sites will be collected and maintained in genetic storage to preserve representation from individual populations. New wild plants will be tracked closely as they reach maturity and seeds will be collected to bring new founders into the genetic storage collection. Seed collections from reintroductions will be used to maintain genetic storage goals of ≥ 50 viable seeds and to ensure propagules are available for reintroduction. Currently, four PUs, Palikea Gulch, ʻĒkahanui, Kaluaʻā, and Keālia, meet requirements with 100% genetic storage complete. Future seed collection efforts should be focused at the three PUs with incomplete genetic storage: Kahanahāiki to Keawapilau (83%), South Mohiākea (86%), and Pālāwai (88%).

**Table 6:** Action plan for maintaining genetic storage representation, and providing propagules for reintroductions.

| What propagule type is used for meeting genetic storage goal? | What is the source for the propagules? | What is the Genetic Storage Method used to meet the goal? | What is the proposed re-collection interval for seed storage? | Is seed storage testing ongoing? | Plan for maintaining genetic storage.* |
|---|---|---|---|---|---|
| Seeds | *In situ* and reintroductions | Seed Storage: 5C/ 20% RH | ≥25 years | Yes | Maintain reintroductions for recollection to refresh seed storage |

## Management Discussion

The primary goal for this taxon for the next five years will be to continue to augment established reintroductions with outplants in the Kahanahāiki to Keawapilau, ʻĒkahanui, Kaluaʻā, and Manuwai PUs. Outplants have exhibited significant mortality rates at all sites through time. Continued outplantings will increase the number of plants at sites to meet stabilization goals, but more importantly will build population structure across all age classes by promoting regeneration or recruitment at reintroduction sites. The aim of the outplantings outlined in Table 6 will be to establish large reintroductions, with 200+ outplants, that will be attractive to native and novel pollinators and dispersers. Regeneration has been observed in all PUs through time. Even though mortality of recruited seedlings and immature plants has been relatively high, F1 generation seedlings have been observed transitioning to the mature age class at Kahanahāiki to Keawapilau, ʻĒkahanui, and Kaluaʻā. Currently 22% of mature plants in the Kaluaʻā PU represent the F1 generation, and 26% at ʻĒkahanui. Field staff will continue to employ strategies that promote natural recruitment at reintroduction sites. These strategies primarily include the control of rodents, weeds, and slugs. ANRPO is currently expanding Ferroxx AQ use in all MFS PUs. Monitoring at all MFS PRSs will be conducted annually and developing population structure will be closely monitored. Data on age class distribution and survivorship will be collected and analyzed to inform management strategies. Efforts should be made to continue to develop strategies to promote seedling establishment. A seed sow trial resulted in modest germination and survival at a site with light gaps, native canopy, and fairly open understory, as opposed to a site with alien dominated canopy and dense understory, where no germination was observed (ANRPO 2021). Additional seed sow trials on varying substrates or habitat conditions across reintroduction sites should be considered to better understand seedling survivorship across various microhabitats and the rate of transition to the mature age class. Informally, field teams could also carry out seed sows and smears across sites to increase the likelihood of seedling establishment.

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# 2023 ANRPO Phytosanitation Protocols: Mollusc

ANRPO currently implements a streamlined approach to mollusc control in all ANRPO nursuries/greenhouses utilized for growing plants for outplanting. The approach employs chemical and physical and preventative measures, when required, to reduce the number of alien molluscs in plants grown for planting into natural areas. Regular applications of Ferroxx AQ and Deadline occur on a biweekly interval. Lettuce monitoring occurs on a monthly interval to detect changes in the size and distribution of the mollusc population. Nursery inspections have increased to once per quarter for all plants grown for planting. In addition, copper sulfate is applied once per quarter to reduce the growth of algae on greenhouse floors; this product is also known to repel molluscs.

**CHEMICAL:** The following chemicals will be applied at all greenhouses:

- Deadline
- FerroxxAQ
- Slugfest
- Copper Sulfate

Deadline and Ferroxx AQ are applied to greenhouse floors biweekly on a rotating basis. Slugfest will be applied as a spot treatment when lettuce monitoring reveals high levels of molluscs in specific groups of plants. Copper Sulfate is applied quarterly to the floors.

**PHYSICAL**

Lettuce monitoring occurs on a monthly basis to monitor the mollusc population in the greenhouses. Lettuce monitoring will serve the dual functions of removing molluscs from the greenhouse as well as giving staff insight as to where and how big mollusc populations are. Data from the lettuce baiting will be compiled and recorded to inform treatments in the greenhouse.

Plant cleaning will occur no sooner than three weeks prior (two weeks previously) to outplanting for both common and rare taxa. The three week window prior to outplanting will allow for at least one additional lettuce bait to occur and allow for at least 2 chemical applications prior to outplanting. During plant cleaning, ANRPO staff will employ a tiered system to determine whether or not to delay outplanting (see Table 1).

Living collection plants will not need to be cleaned or monitored since they will not be planted into wild sites and will only be planted at ex-situ areas (seed orchards and botanic gardens).

**Table 1:** Mollusc infestation levels and treatment options. Infestation level is determined at time of plant cleaning

| Infestation Level | Treatment |
|---|---|
| Light<br>(1-5 molluscs/tray) | 1. Remove visible pests.<br>2. Clean plants- remove top layer of soil, inspect for insect, weed and mollusc pests.<br>3. Re-inspect plants. Determine level of infestation. If pests are detected, the option exists to replace the infested plant with a plant that has been found to be clean.<br>4. Repeat as needed |
| Moderate<br>(6-15 molluscs/tray) | 1. Remove visible pests.<br>2. Clean plants.<br>3. Treat all infested plants w/ Slugfest. Drench or dunk plants in slugfest solution, drain and wait for re-entry interval to expire.<br>4. Re-inspect plants for signs of pests. Determine level of infestation.<br>5. Repeat as needed or move to light or heavy treatment. |
| Heavy<br>(16+ molluscs/tray) | 1. Remove pests.<br>2. Clean plants.<br>3. Treat w/ slugfest.<br>4. Bait w/ lettuce and remove pests.<br>5. Retreat w/ slugfest.<br>6. Re-inspect plants. Determine level of infestation. The decision to hold plants until clean or until classified as light will need to be made.<br>7. Repeat as necessary or move to light or moderate treatment. |

## PREVENTATIVE

Regular inspections for all pests are performed weekly by Horticulture staff. Inspections by individuals outside of the Horticulture staff occurs once per quarter to provide independent review of pest inventory. Independent inspections are performed for all pests across all plants being grown for outplanting into natural areas; living collections are excluded from the inspections since these plants will generally be excluded from outplantings. Increasing the number of inspections will improve the chances of detecting invasive molluscs as well as other pests in the greenhouse.

Salt will be utilized on an as needed basis for plants grown for outplanting at the Pahole Rare Plant Facility. While a majority of the space at Pahole will be used to hold living collections, certain species such as those in the genus *Cyanea* require cooler temperatures during the warmer periods of the year. These species will be moved to Pahole and will be placed on salt for the duration of their stay since the nursery structure has been modified to accommodate salt use. Salt use will be discontinued once the plants have been inspected and leave the facility for planting.

ARMY NATURAL RESOURCES PROGRAM ON O‘AHU
MONITORING PROGRAM

# VEGETATION MONITORING AT THE KAHANAHĀIKI SNAIL ENCLOSURE, APRIL 2023

## INTRODUCTION

Year 2 vegetation monitoring was conducted by the Army Natural Resources Program on O‘ahu (ANRPO) at the newly constructed snail enclosure at Kahanahāiki Management Unit (MU) in April 2023 in accordance with the restoration plan for the enclosure (ANRPO 2021a). The predator resistant enclosure was constructed to replace the small and aging adjacent enclosure in association with the management of *Achatinella mustelina* ESU-A snails (Figure 1). Prior to construction and weed removal, vegetation in this area included mixed native and non-native components in the understory and canopy. This area was previously a “hotspot” for *A. mustelina*, particularly within clusters of *Notelaea sandwicensis* (a preferred host tree for snails from this ESU) within the western portion of the enclosure. Clearing in association with the construction of the enclosure included removal of non-native vegetation (mainly *Psidium cattleianum*, *Schinus terebinthifolius*, and *Clidemia hirta*) in the canopy and understory within the enclosure area, as well as trimming and removal of both non-native and native trees as necessary along the corridor. The eastern portion of the enclosure, which had been dominated by *P. cattleianum*, was largely open following clearing. Baseline vegetation monitoring occurred in April 2021 (following construction completion and after the vast majority of the weed clearing was complete) (ANRPO 2021b), and Year 1 monitoring occurred in April 2022 (ANRPO 2022a). Common native taxa (542 outplants) were outplanted in 2021 (Table 1). Restoration strategies include filling canopy light gaps, and establishing a mid-story and connectivity across all vegetation layers, to include a diverse range of known *A. mustelina* hosts. Weed control within the enclosure occurs at least once per quarter, and clearing to maintain a vegetation gap along the enclosure wall will occur when necessary.

**Image Redacted**
**Sensitive Information**
**Available Upon Request**

**Figure 1:** Locations of snail enclosures at Kahanahāiki MU.

**Table 1:** Species outplanted in association with native vegetation restoration prior to Year 2 vegetation monitoring.

| Taxon | 2021-03 | 2021-10 | Total |
|---|---|---|---|
| *Antidesma platyphyllum* | 17 | 43 | **60** |
| *Ceodes brunoniana* | 4 | 28 | **32** |
| *Dianella sandwicensis* | | 98 | **98** |
| *Dodonaea viscosa* | | 35 | **35** |
| *Hibiscus arnottianus* subsp. *arnottianus* | | 21 | **21** |
| *Ilex anomala* | | 6 | **6** |
| *Kadua affinis* | 21 | 67 | **88** |
| *Metrosideros polymorpha* | 27 | 72 | **99** |
| *Microlepia strigosa* | | 64 | **64** |
| *Myrsine lessertiana* | 10 | 4 | **14** |
| *Planchonella sandwicensis* | | 6 | **6** |
| *Psychotria mariniana* | | 19 | **19** |
| **Total** | **79** | **463** | **542** |

The primary objective of monitoring is to assess if vegetation cover goals in the restoration plan are being met, or if progress is being made towards those goals in the interim, in conjunction with restoration efforts to achieve a native plant dominated community favorable for *A. mustelina*. Native vegetation cover goals by stratum include:

**0 – 2 m above ground level (AGL):** > 50% by 3 years after construction completion
**>2 m AGL:** > 50% by 5 years and > 75% by 8-10 years after construction completion
**Total AGL:** > 75% by 5 years and beyond after construction completion

A secondary objective is to assess if weed cover goals in the plan are being met. This includes maintaining low weed cover (< 10%), and having zero tolerance for specific taxa (*P. cattleianum*, *Macfadyena unguis-cati*, *Elephantopus mollis*, *Setaria palmifolia*, *Pterolepis glomerata*, *Casuarina glauca*, *Triumfetta semitriloba*, *Montanoa hibiscifolia*, *Nephrolepis brownii*, *Passiflora suberosa*, and non-native grasses).

## METHODS

**Canopy and understory cover:** Point intercept monitoring was used to document percent cover of native and non-native taxa in the understory and canopy. All species "hit" at points along transects were recorded for understory and canopy vegetation. A 5 millimeter diameter pole was used to determine "hits" in the understory (live vegetation that touches the pole, including leaves, branches and trunks) along an outstretched measuring tape at regular intervals. Vegetation "hits" in the understory were recorded from 0 – 2 m above ground level (AGL). A laser pointer held against the pole was used to determine laser "hits" in the canopy (above 2 m AGL) at these same intercept points, where the point fell within the perimeter of a tree's canopy. Locations where no vegetation was intercepted were recorded as non-vegetated. Point intercepts (Baseline: n = 422; Year 1: n = 427; Year 2: n = 468) were located every 0.5 m along seven (Baseline and Year 1) to eight (Year 2) transects spaced 3 m apart and oriented at a bearing of 60°. Locations of sampled points are not permanent. Approximations of percent cover were obtained from the proportion of "hits" among all intercepts.

**Canopy openness:** Hemispherical photography was used to document canopy openness (the amount of direct light passing through the canopy). Photographs were taken using a fish-eye lens at 2 m AGL, aimed 180° from the forest floor every 5 m along the point intercept transects (Baseline: n = 36; Year 1: n = 39; Year 2: n = 42).

**Supplemental data**: An Unmanned Aerial Vehicle (UAV) was used to acquire imagery of the enclosure in March 2021, April 2022, and June 2023. Permanent photopoints were established for visual documentation of change in each cardinal direction for each of 5 points in July 2021. During the course of vegetation monitoring, a supplemental species diversity list was created documenting all species that happened to be observed, but not intercepted, to help document change in the presence or absence of species that have low cover, or are uncommon, and therefore less likely to be documented during point intercept monitoring.

**Monitoring schedule**: The restoration plan recommended that vegetation monitoring occur annually for the first 5 years, after which the interval may be extended to every 2-3 years to track change in association with vegetation restoration. Once native vegetation fills in, the monitoring interval could be extended to every 5 years.

**Analysis:** Canopy openness was estimated from hemispheric photographs using Gap Light Analyzer (GLA), Version 2.0 (Frazer *et al*. 1999). Statistical analysis included Fisher's exact tests for the point intercept data, and logistic regression using generalized linear modeling (GLM) for canopy openness. Significance determinations were based on $\alpha = 0.05$, and only absolute cover changes $\geq 10\%$ were recognized. Species cover changes $< 10\%$ were not analyzed to mitigate the probability of detecting a change when none exists (Type I error). All analyses were performed using the software R, Version 4.2.2 (R Core Team 2022).

## RESULTS

By Year 2 there were substantial significant increases in both native and non-native understory and total cover (Table 2). Native canopy cover declined slightly, but did not meet the 10% standard for recognized change. Native vegetation continued to cover nearly one-quarter of the enclosure in the canopy (dominated by *N. sandwicensis, Metrosideros polymorpha*, *Diospyros sandwicensis*, and *Psydrax odorata* trees), and increased to nearly half of the enclosure in the understory (still primarily the sedge *Carex meyenii*, as well as naturally recruited *Scaevola gaudichaudiana*, which increased significantly), with total AGL cover increased to over 50% (Tables 3 and 4). Most of the increased native understory cover consisted of shrub and tree taxa. Non-native cover increased to encompass half of the enclosure in the understory (primarily *Conyza bonariensis*, which was absent initially but covered over a third of the enclosure in Year 2, along with other assorted Asteraceae), but remained absent in the canopy. The vast majority of the increased weed cover consisted of pioneer herbaceous taxa. Over three quarters of the canopy remained non-vegetated, while non-vegetated area was reduced to 20% in the understory. Canopy openness remained unchanged (GLM: $p = 0.910$), with median openness of 100% for all years. Sixty-nine taxa (41% native) were present in the enclosure (41 intercepted, 28 anecdotally observed) (Table 5). Most restoration outplant taxa were intercepted and/or anecdotally observed. Native vegetation remained most densely clustered along the western end of the enclosure, with most of the increased cover occurring in the central and eastern portion of the enclosure (Figure 2).

The native cover goal for the understory was nearly met, one year in advance of the target date. The non-native cover goal was far from being met, as there was a continued influx of weeds in the more open areas. Though zero-tolerance taxa (*C. glauca*, *Digitaria violascens*, *Eragrostis tenuifolia*, *Festuca bromoides*, *Melinis minutiflora*, *Oplismenus hirtellus*, *Paspalum conjugatum*, *P. suberosa*, and *P. cattleianum*) were present in the enclosure, their cover was low (3.2%).

The changes in native vegetation cover by Year 2 were readily visible in the UAV imagery (for total vegetation cover) (Figure 3) as well as in photopoint images (for visual representation of sub-canopy vegetation) (Figures 4-7).

**Table 2:** Vegetation percent cover by stratum over time. P-values obtained from Fisher's exact tests for Baseline and Year 2 data. Statistically significant results that meet the 10% standard for recognized change in cover are in boldface. Arrows indicate increase (↑) or decrease (↓) in cover.

| | Baseline | Year 1 | Year 2 | p |
|---|---|---|---|---|
| Understory | | | | |
| Native | 28.7 | 37.0 | 47.0 | **0.000↑** |
| Non-native | 4.0 | 21.3 | 50.2 | **0.000↑** |
| Non-vegetated | 69.2 | 46.6 | 20.7 | **0.000↓** |
| Canopy | | | | |
| Native | 27.5 | 25.1 | 20.9 | 0.023↓ |
| Non-native | 0.0 | 0.0 | 0.0 | NA |
| Non-vegetated | 72.5 | 74.9 | 79.1 | 0.023↑ |
| Total AGL* | | | | |
| Native | 38.6 | 48.5 | 53.8 | **0.000↑** |
| Non-native | 4.0 | 21.3 | 50.2 | **0.000↑** |
| Non-vegetated | 59.2 | 37.0 | 16.7 | **0.000↓** |

*Above ground level

**Table 3:** Species percent cover by stratum over time, listed in order of highest to lowest cover in Year 2. P-values obtained from Fisher's exact tests for Baseline and Year 2 data. Analysis was limited to taxa with > 10% change. Native taxa are in boldface. Arrows indicate increase (↑) or decrease (↓) in cover.

| Taxon | Baseline | Year 1 | Year 2 | p |
|---|---|---|---|---|
| Understory | | | | |
| *Conyza bonariensis* | 0.0 | 8.7 | 37.6 | 0.000↑ |
| ***Carex meyenii*** | 18.5 | 15.0 | 14.1 | |
| ***Scaevola gaudichaudiana*** | 0.0 | 6.1 | 11.3 | 0.000↑ |
| ***Alyxia stellata*** | 4.5 | 3.3 | 5.3 | |
| ***Notelaea sandwicensis*** | 3.6 | 4.0 | 4.3 | |
| *Youngia japonica* | 0.0 | 6.3 | 3.6 | |
| ***Psydrax odorata*** | 3.6 | 5.4 | 3.2 | |
| *Crassocephalum crepidioides* | 0.0 | 1.6 | 3.2 | |
| ***Cocculus orbiculatus*** | 0.2 | 1.2 | 3.2 | |
| ***Dodonaea viscosa***[1] | 0.0 | 0.9 | 3.2 | |
| ***Metrosideros polymorpha***[1] | 1.7 | 1.9 | 2.8 | |
| *Ageratum conyzoides* | 0.0 | 0.0 | 2.8 | |
| ***Microlepia strigosa***[1] | 0.9 | 2.8 | 2.6 | |
| *Gamochaeta pensylvanica* | 0.0 | 1.6 | 2.4 | |
| ***Diospyros sandwicensis*** | 2.4 | 1.2 | 2.6 | |
| ***Dianella sandwicensis***[1] | 0.0 | 0.0 | 2.6 | |
| ***Acacia koa*** | 0.0 | 0.9 | 1.7 | |
| *Digitaria violascens*[2] | 0.0 | 0.0 | 1.7 | |
| *Oxalis corniculata* | 0.0 | 3.5 | 1.5 | |
| *Sonchus oleraceus* | 0.5 | 0.5 | 1.5 | |
| ***Coprosma foliosa*** | 0.9 | 0.9 | 1.3 | |
| *Castilleja arvensis* | 0.0 | 0.0 | 1.3 | |
| *Clidemia hirta* | 0.0 | 0.2 | 0.9 | |
| *Passiflora suberosa*[2] | 0.2 | 0.0 | 0.9 | |
| ***Nephrolepis exaltata*** | 0.2 | 0.0 | 0.6 | |
| *Melinis minutiflora*[2] | 0.0 | 0.0 | 0.4 | |
| ***Kadua affinis***[1] | 0.0 | 0.5 | 0.2 | |
| ***Bidens torta*** | 0.0 | 0.2 | 0.2 | |
| *Psidium cattleianum*[2] | 1.2 | 0.0 | 0.2 | |
| ***Leptecophylla tameiameiae*** | 0.2 | 0.0 | 0.2 | |

**Table 3** (continued).

| Taxon | Baseline | Year 1 | Year 2 | p |
|---|---|---|---|---|
| Understory | | | | |
| ***Antidesma platyphyllum***[1] | 0.0 | 0.0 | 0.2 | |
| *Cheilanthes viridis* | 0.0 | 0.0 | 0.2 | |
| *Christella parasitica* | 0.0 | 0.0 | 0.2 | |
| *Conyza canadensis* var. *pusilla* | 0.0 | 0.0 | 0.2 | |
| ***Doodia kunthiana*** | 0.0 | 0.0 | 0.2 | |
| *Festuca bromoides*[2] | 0.0 | 0.0 | 0.2 | |
| *Gamochaeta argyrinea* | 0.0 | 0.0 | 0.2 | |
| *Mesosphaerum pectinatum* | 0.0 | 0.0 | 0.2 | |
| *Polygala paniculata* | 0.0 | 0.0 | 0.2 | |
| *Stachytarpheta australis* | 0.0 | 0.0 | 0.2 | |
| ***Wikstroemia oahuensis* var. *oahuensis*** | 0.0 | 0.0 | 0.2 | |
| ***Ceodes brunoniana***[1] | 0.0 | 0.5 | 0.0 | |
| ***Hibiscus arnottianus* subsp. *arnottianus***[1] | 0.0 | 0.5 | 0.0 | |
| ***Pipturus albidus*** | 0.0 | 0.5 | 0.0 | |
| *Oplismenus hirtellus*[2] | 1.2 | 0.2 | 0.0 | |
| ***Odontosoria chinensis*** | 0.2 | 0.2 | 0.0 | |
| ***Planchonella sandwicensis***[1] | 0.0 | 0.2 | 0.0 | |
| *Schinus terebinthifolius* | 0.5 | 0.0 | 0.0 | |
| *Ageratina riparia* | 0.2 | 0.0 | 0.0 | |
| ***Carex wahuensis*** | 0.2 | 0.0 | 0.0 | |
| *Cordyline fruticosa* | 0.2 | 0.0 | 0.0 | |
| Canopy | | | | |
| ***Notelaea sandwicensis*** | 10.2 | 8.7 | 9.2 | |
| ***Metrosideros polymorpha***[1] | 10.9 | 10.1 | 6.0 | |
| ***Diospyros sandwicensis*** | 3.8 | 5.9 | 4.1 | |
| ***Psydrax odorata*** | 7.8 | 6.1 | 3.6 | |
| ***Acacia koa*** | 0.0 | 0.0 | 0.6 | |
| ***Alyxia stellata*** | 3.3 | 1.9 | 0.2 | |
| ***Psychotria mariniana***[1] | 0.7 | 0.0 | 0.0 | |

[1]Taxon represented in restoration efforts. [2]Zero tolerance weed.

**Table 4:** Vegetation percent cover over time by growth form and stratum.

| | *Native* | | | *Non-native* | | |
|---|---|---|---|---|---|---|
| | Baseline | Year 1 | Year 2 | Baseline | Year 1 | Year 2 |
| Understory | | | | | | |
| Fern | 1.4 | 3.0 | 0.9 | 0.0 | 0.0 | 0.4 |
| Grass | 0.0 | 0.0 | 0.0 | 1.2 | 0.2 | 2.4 |
| Herb | 0.0 | 0.2 | 2.8 | 0.5 | 20.8 | 46.8 |
| Sedge | 18.7 | 15.0 | 14.1 | 0.0 | 0.0 | 0.0 |
| Shrub | 5.7 | 11.2 | 19.9 | 0.5 | 0.2 | 0.9 |
| Tree | 10.2 | 15.7 | 17.7 | 1.7 | 0.0 | 0.2 |
| Vine | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.9 |
| Canopy | | | | | | |
| Shrub | 3.3 | 1.9 | 0.2 | 0.0 | 0.0 | 0.0 |
| Tree | 27.5 | 24.8 | 20.7 | 0.0 | 0.0 | 0.0 |

**Table 5:** All species intercepted (I) or anecdotally observed (A) in the understory and/or canopy over time. Native taxa are in boldface.

| Taxa | Baseline | Year 1 | Year 2 | Taxa | Baseline | Year 1 | Year 2 |
|---|---|---|---|---|---|---|---|
| ***Acacia koa*** | | I | I | *Gamochaeta argyrinea* | | | I |
| *Ageratina riparia* | I | A | A | *Gamochaeta pensylvanica* | | I | I |
| *Ageratum conyzoides* | | A | I | *Gamochaeta* sp. | | | A |
| ***Alyxia stellata*** | I | I | I | ***Hibiscus arnottianus* subsp. *arnottianus*[1]** | | I | A |
| ***Antidesma platyphyllum*[1]** | A | A | I | ***Ilex anomala*[1]** | | A | |
| *Bidens alba* | | A | | ***Kadua affinis*[1]** | A | I | I |
| *Bidens pilosa* | | | A | *Lantana camara* | | | A |
| ***Bidens torta*** | A | I | I | ***Leptecophylla tameiameiae*** | I | | I |
| *Buddleja asiatica* | | A | | *Melinis minutiflora*[2] | A | A | I |
| *Casuarina glauca*[2] | | | A | *Mesosphaerum pectinatum* | | | I |
| ***Carex meyenii*** | I | I | I | ***Metrosideros polymorpha*[1]** | I | I | I |
| ***Carex wahuensis*** | I | A | A | ***Microlepia strigosa*[1]** | I | I | I |
| *Castilleja arvensis* | | | I | ***Myrsine lessertiana*[1]** | A | A | |
| ***Ceodes brunoniana*[1]** | A | I | A | ***Nephrolepis exaltata*** | I | A | I |
| *Chamaecrista nictitans* | A | | A | ***Notelaea sandwicensis*** | I | I | I |
| *Cheilanthes viridis* | | | I | ***Odontosoria chinensis*** | I | I | A |
| *Christella parasitica* | A | A | I | *Oplismenus hirtellus*[2] | I | I | A |
| *Clidemia hirta* | A | I | I | *Oxalis corniculata* | A | I | I |
| ***Cocculus orbiculatus*** | I | I | I | *Oxalis debilis* | A | | |
| *Conyza bonariensis* | | I | I | *Paspalum conjugatum*[2] | | A | A |
| *Conyza canadensis* var. *pusilla* | | A | I | *Passiflora suberosa*[2] | I | A | I |
| ***Coprosma foliosa*** | I | I | I | ***Pipturus albidus*** | | I | A |
| *Cordyline fruticosa* | I | | | *Pityrogramma austroamericana* | | | A |
| *Crassocephalum crepidioides* | A | I | I | ***Planchonella sandwicensis*[1]** | | I | A |
| *Cuphea carthagenesis* | | | A | *Plantago lanceolata* | | | A |
| ***Cyperus polystachyos*** | | | A | *Pluchea carolinensis* | | | A |
| *Desmodium incanum* | | | A | *Polygala paniculata* | | | I |
| ***Dianella sandwicensis*[1]** | | A | I | *Psidium cattleianum*[2] | I | A | I |
| *Digitaria violascens*[2] | | A | I | ***Psychotria mariniana*** | I | A | A |
| ***Diospyros sandwicensis*** | I | I | I | ***Psydrax odorata*** | I | I | I |
| ***Dodonaea viscosa*[1]** | | I | I | *Rubus rosifolius* | A | A | A |
| ***Doodia kunthiana*** | A | A | I | ***Scaevola gaudichaudiana*** | A | I | I |
| *Emilia fosbergii* | | A | A | *Schinus terebinthifolius* | I | A | A |
| *Emilia sonchifolia* | | | A | *Sonchus oleraceus* | I | I | I |
| *Eragrostis tenuifolia*[2] | | | A | *Stachytarpheta australis* | A | A | I |
| *Erechtites valerianifolia* | | | A | *Toona ciliata* | | | A |
| *Euphorbia hirta* | | A | | ***Wikstroemia oahuensis* var. *oahuensis*** | A | | I |
| *Festuca bromoides*[2] | | | I | *Youngia japonica* | A | I | I |

[1]Taxon represented in restoration efforts. [2]Zero tolerance weed.

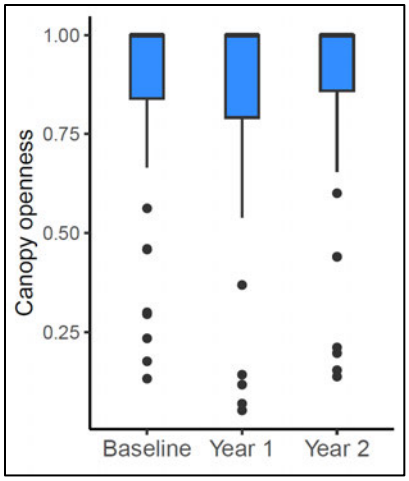


**Figure 2:** Boxplots for canopy openness over time. The openness scale ranges from 0 (completely closed canopy) to 1 (completely open canopy). *Note: Boxplots depict the range of values for variables. The box depicts the interquartile range (the middle 50% of the data values), and the horizontal line inside the box (appears as a bold line when it occurs at one end of the box) represents the median value. The lines extending from the box represent the range of the remaining data, excluding outliers, which are represented individually as dots.*

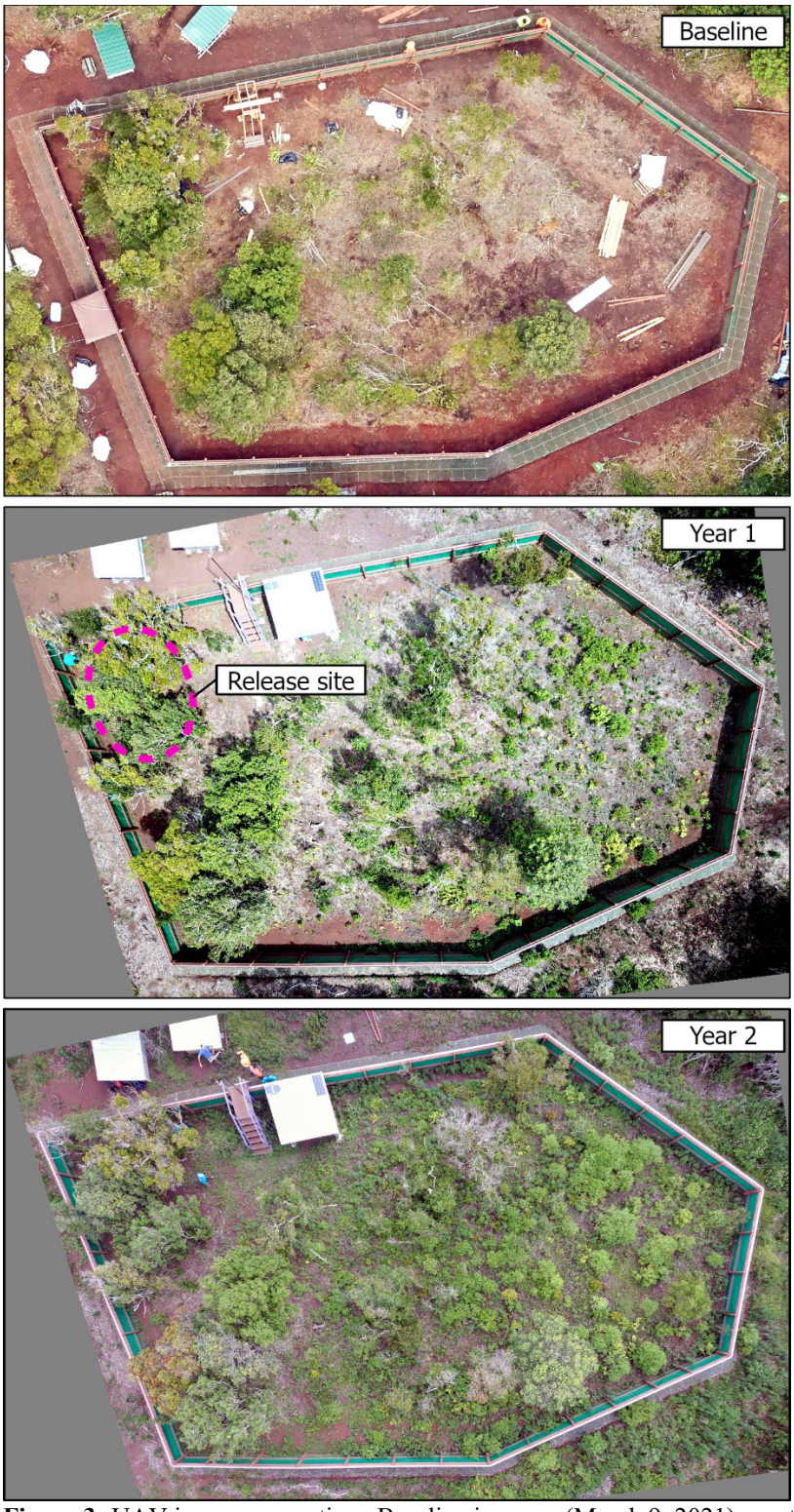


**Figure 3:** UAV imagery over time. Baseline imagery (March 9, 2021) was taken prior to restoration outplanting. Remnant native vegetation and extensive open areas are visible. Expansion of existing vegetation, natural recruitment, and outplants are visible in Year 1 (April 4, 2022) and Year 2 (June 19, 2023) imagery. The release site for translocated snails is indicated by the dashed circle. Expansion of weed cover is also visible in Year 2 imagery

**Figure 4:** Photopoint 1 images with views in each cardinal direction over time following the initiation of outplanting.

**Figure 5:** Photopoint 2 images with views in each cardinal direction over time following the initiation of outplanting.

**Figure 6:** Photopoint 3 images with views in each cardinal direction over time following the initiation of outplanting.

**Figure 7:** Photopoint 4 images with views in each cardinal direction over time following the initiation of outplanting.

## DISCUSSION

Better than expected progress was made towards the native understory goal (nearly met one year ahead of time) at the new Kahanahāiki snail enclosure. The lack of increased cover in the canopy was not unexpected, as cover expansion will take longer in that stratum. The slight decline in native canopy cover could have been an artifact of non-permanent sampling points, as canopy openness remained unchanged. Additional restoration is not planned for next season, as there has been extensive outplanting, and time is needed for plants to grow. Some mortality occurred among the outplanted tree taxa, perhaps as a result of dry and open conditions within the first few summers. Additional inputs of tree taxa may be more successful once the understory fills in more. Plans for additional outplanting will be re-evaluated in the coming years. To further enhance snail host tree diversity, outplants should include host tree taxa that are either absent (*Rockia sandwicensis*, perhaps grown from cuttings as fruit collections are challenging) or not well established yet (*Antidesma platyphyllum*, *Myrsine lessertiana*). *Notelaea sandwicensis*, an important host tree, has been challenging to propagate from seeds and cuttings, but should also be prioritized for outplanting pending improved propagation methods. Taxa with high calcium content (*Touchardia*, *Pipturus*) may be beneficial for snails (D. Sischo, pers. comm), and could be considered for future restoration efforts. As most of the outplants to date consisted of tree taxa, future restoration inputs could also include understory outplants (*Carex wahuensis*, *Coprosma foliosa*, *Eragrostis grandis*, etc.) and seed sows (*Bidens torta*). Though the non-native cover goal was not met yet, most of the weedy cover was comprised of herbaceous Asteraceae taxa that are not expected to pose major threats to restoration efforts, and will likely decline over time with the expansion of native vegetation and reduced light levels. The weedy influx appears to have happened during the wet winter months of 2023, as extensive weed cover is not visible in the photopoint images from September 2022. The zero-tolerance weeds present included taxa for which ingress was expected, and the minimal cover for those taxa is of limited concern. Spread should be mitigated by the ongoing quarterly weed control efforts. Of note is a sprawling patch of *D. violascens* in the southeastern portion of the enclosure that should be controlled before it becomes more widespread. Particular care should be taken to prevent an explosive grass invasion as occurred at the Palikea North snail enclosure in Years 3-5 (Appendix 5-3). Clearing of *C. bonariensis* and other pioneer Asteraceae is not recommended (so long as it is not overtopping native plants), as it does not appear to be hindering the growth of native plants, may be providing a degree of soil moisture retention, and may perhaps occupy space that could otherwise be invaded by weedy grasses.

Translocations of *A. mustelina* into the new enclosure were not planned to begin until it became more vegetated, however deteriorating conditions in the older enclosure led to rat and *Euglandina rosea* incursions, and prompted the decision to move snails into the new enclosure beginning in March 2022, as it was determined that they would be more successfully managed and protected at the new, predator-free enclosure (ANRPO 2022b). Snails were released into the northwest corner of the new enclosure with more intact canopy and understory cover (Figure 3). As of vegetation monitoring in April 2023, 238 snails were translocated into the new enclosure, and the population appeared to be generally stable (ANRPO 2023).

Though dense multi-layered host vegetation is presumed ideal, partially restored vegetation may be sufficient for releasing snails. Stable or increasing *A. mustelina* populations may also be used as a measure of vegetation rehabilitation success. Successful releases of *A. mustelina* in partially restored habitat have occurred at the Palikea North (Appendix 5-3) and 3 Points (Appendix 5-2) enclosures. The preliminary success of the snail releases at Kahanahāiki suggests habitat readiness, such as the early stages of vegetation restoration as characterized here, are similarly sufficient for snail releases. Kahanahāiki is the driest of our snail enclosure restoration sites, and growth of native vegetation may be relatively slower. However, the progress to date holds promise for achieving goals within the planned timelines.

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ARMY NATURAL RESOURCES PROGRAM ON O‘AHU
MONITORING PROGRAM

# VEGETATION MONITORING AT THE 3 POINTS SNAIL ENCLOSURE, JANUARY 2023

## INTRODUCTION

Vegetation monitoring is conducted by the Army Natural Resources Program on O‘ahu (ANRPO) at the 3 Points snail enclosure at Makaleha West Management Unit (MU) in accordance with the restoration plan for the enclosure (ANRPO 2018). The predator resistant enclosure was constructed in association with management of *Achatinella mustelina* ESU B1 and B2 snails (Figure 1). Prior to construction and weed removal in 2018, vegetation in this area was predominantly native in the canopy, and mixed native and non-native in the understory. The canopy was comprised mainly of *Metrosideros polymorpha*, while the understory had dense areas of *Dicranopteris linearis*, and expansive weedy cover dominated by *Rubus argutus*, *Clidemia hirta*, and invasive grasses. A rare plant reintroduction site for *Pritchardia kaalae* (LEH-D) is located partially within the footprint of the enclosure. Weed control occurred previously over the years in this general area, and common native species (*Antidesma platyphyllum*, *Clermontia kakeana*, *Clermontia persicifolia*, *Coprosma longifolia*, *M. polymorpha*, and *Perrotetia sandwicensis*) were outplanted in 2016 and 2017 within the footprint of the enclosure and adjacent areas. Clearing in association with the construction of the enclosure included removal of non-native vegetation in the canopy (mainly *Psidium cattleianum*) and understory, as well as trimming of both alien and native trees as necessary along the corridor. It also included extensive clearing of *D. linearis* to facilitate searches for *Euglandina rosea*, which had to be completely removed prior to releasing *A. mustelina* into the enclosure. Baseline vegetation monitoring was initiated in December 2018, after the majority of the weed and *D. linearis* clearing was complete (ANRPO 2019a). The enclosure was monitored again after one, two, and four years, in January 2020, January 2021, and January 2023, respectively (hereafter referred to as “Year 1,” “Year 2,” and “Year 4”) (ANRPO 2020 and 2021). Common native outplantings have been ongoing since April 2019, with a total of 862 outplants added to the site prior to the most recent monitoring in Year 4 (Table 1). Restoration strategies included filling canopy light gaps, and establishing a mid-story and connectivity across all vegetation layers (ANRPO 2018). Weed control occurs at least once per quarter, and clearing to maintain a vegetation gap along the fenceline occurs when necessary.

The primary objective of monitoring is to assess if vegetation cover goals in the plan are being met, or if progress is being made towards those goals in the interim, in conjunction with restoration efforts to achieve a native plant dominated community favorable for *A. mustelina*. Native vegetation cover goals by stratum include:

**0 – 2 m above ground level (AGL):** > 50% by 2 years after construction completion
**>2 m AGL:** > 90% by 5 years after construction completion
**Total AGL:** > 90% by 2 years and beyond after construction completion

A secondary objective is to assess if weed cover goals in the plan are being met. This includes maintaining low weed cover (< 10%), and having zero tolerance for specific taxa (*Angiopteris evecta*, *Blechnum appendiculatum*, *Nephrolepis brownii*, *R. argutus*, *Sphaeropteris cooperi*, and invasive grasses).

**Image Redacted**
**Sensitive Information**
**Available Upon Request**

**Figure 1:** Location of the 3 Points snail enclosure in relation to ESU B1 and B2 population reference sites.

**Table 1:** Species outplanted in association with native vegetation restoration prior to Year 4 vegetation monitoring.

| Species | 2019-04-10 | 2019-04-18 | 2019-11-20 | 2020-03-12 | 2020-05-11 | 2021-04-21 | 2022-10-25 | Total |
|---|---|---|---|---|---|---|---|---|
| *Acacia koa* | | | 20 | | | | | **20** |
| *Antidesma platyphyllum* | 20 | | | 1 | | | 14 | **35** |
| *Carex wahuensis* | | | 15 | 31 | | | 37 | **83** |
| *Cibotium chamissoi* | | | 31 | | | | | **31** |
| *Clermontia persicifolia* | | | | | | | 14 | **14** |
| *Coprosma foliosa* | | | 14 | | | | 2 | **16** |
| *Coprosma longifolia* | 95 | | 60 | | | 24 | 13 | **192** |
| *Dodonaea viscosa* | | | | | | | 7 | **7** |
| *Kadua affinis* | 113 | | 49 | 14 | | | 3 | **179** |
| *Metrosideros macropus* | | 36 | 9 | | | | | **45** |
| *Metrosideros polymorpha* | 40 | | 14 | 10 | | | | **64** |
| *Microlepia strigosa* | | | 29 | | 32 | | | **61** |
| *Polyscias sandwicensis* | | | | | | | 1 | **1** |
| *Perrottetia sandwicensis* | | | 30 | | | | | **30** |
| *Sadleria cyatheoides* | | | | 30 | 17 | | 14 | **61** |
| *Scaevola gaudichaudiana* | | | | 13 | | | | **13** |
| *Syzygium sandwicense* | 6 | | | | | | 4 | **10** |
| **Total** | **274** | **36** | **271** | **99** | **49** | **24** | **109** | **862** |

## METHODS

**Canopy and understory cover:** Point intercept monitoring was used to document percent cover of native and non-native taxa in the understory and canopy. All species "hit" at points along transects were recorded for understory and canopy vegetation. A 5 millimeter diameter pole was used to determine "hits" in the understory (live vegetation that touches the pole, including leaves, branches and trunks) along an outstretched measuring tape at regular intervals. Vegetation "hits" in the understory were recorded from 0 – 2 m above ground level (AGL). A laser pointer held against the pole was used to

determine laser "hits" in the canopy (above 2 m AGL) at these same intercept points, where the point fell within the perimeter of a tree's canopy. Locations where no vegetation was intercepted were recorded as non-vegetated. Point intercepts (Baseline: n = 606, Year 1: n = 583, Year 2: n = 588, Year 4: n = 591) were located every 0.5 m along eight transects spaced 6 m apart and oriented at a bearing of 155°. Locations of sampled points are not permanent. Approximations of percent cover were obtained from the proportion of "hits" among all intercepts.

**Canopy openness:** Hemispherical photography was used to document canopy openness (the amount of direct light passing through the canopy). Photographs were taken using a fish-eye lens at 2 m AGL, aimed 180° from the forest floor every 5 m along the point intercept transects (Baseline: n = 57, Year 1: n = 55, Year 2: n = 54, Year 4: n = 57).

**Supplemental data**: An Unmanned Aerial Vehicle (UAV) was used to acquire imagery of the enclosure. Baseline imagery was obtained in September 2018, Year 2 imagery in January 2021, and Year 3 imagery in April 2022. Imagery has not been obtained since Year 3. Permanent photopoints were established for visual documentation of change in each cardinal direction for each of 5 points. During construction and clearing, a list of taxa present within the enclosure was compiled (October 2018). During the course of vegetation monitoring, supplemental species diversity lists were created documenting all species that happened to be observed but not intercepted to help document change in the presence or absence of species that have low cover, or are uncommon, and therefore less likely to be documented during point intercept monitoring.

**Monitoring schedule**: The restoration plan recommended that vegetation monitoring occur annually for the first 5 years to track change in association with vegetation restoration. Once native vegetation filled in, the monitoring interval could be extended to every 2-3 years, and eventually to every 5 years. Because of the limited amount of change that occurred by Year 2, it was determined that annual monitoring was too frequent, and that monitoring in Year 3 was unnecessary.

**Analysis:** Canopy openness was estimated from hemispheric photographs using Gap Light Analyzer (GLA), Version 2.0 (Frazer *et al*. 1999). Statistical analysis included Fisher's exact tests for the point intercept data (Baseline and Year 4), and generalized linear modeling (GLM) (binomial family, logit link function, data determined as not overdispersed) for canopy openness (all years). Significance determinations were based on $\alpha = 0.05$, and only absolute cover changes ≥ 10% were recognized. Species cover changes < 10% were not analyzed to mitigate the probability of detecting a change when none exists (Type I error). All statistical analyses were performed using the software R, Version 4.2.2 (R Core Team 2022).

## RESULTS

By Year 4 there was a significant increase in native understory, and a slight decrease in native canopy, while total native cover AGL remained unchanged (Table 2). Native vegetation continued to cover the majority of the enclosure (84% total AGL) with canopy covering two-thirds of the enclosure (dominated by *M. polymorpha*), and understory covering just over half of the enclosure (primarily ferns and tree taxa, mainly *Cibotium chamissoi*, and *M. polymorpha*) (Tables 3 and 4). The reduction in native canopy cover occurred in association with the loss of a small number of trees. This included an *Acacia koa* along the western wall which died following construction (presumably resulting from root damage during trenching for the wall, see ANRPO 2019b for more discussion), as well as a few scattered small *M. polymorpha* (some of which fell over, presumably during high wind events, possibly exacerbated by ground surface destabilization associated with clearing, raking, and erosion; and some of which likely died as a result of drying conditions post-clearing of *D. linearis* and/or during summer droughts) (Figure 2). There was no evidence of Rapid Ohia Death, *Austropuccinia psidii*, or other pathogens. Canopy

openness remained unchanged, at roughly 50% (GLM: p = 0.908) (Figure 3). Nine native taxa not previously observed were found (either intercepted or anecdotally observed) in Year 4 including two new outplanted taxa and seven naturally recruiting ones (Table 5).

Non-native understory cover remained under 10%, though it had a small increase which did not meet the 10% standard for recognized change, and non-native canopy remained absent. Seven non-native taxa not previously found were anecdotally observed in Year 4 including one zero tolerance taxon, *N. brownii*. The observed *N. brownii* appeared to be creeping in under the wall from a large infestation outside the northeast corner of the enclosure.

The native understory goal was met by Year 4, the goal for native cover AGL remained unmet, and progress did not occur towards the native canopy goal. Non-native cover goals remained met. Though zero-tolerance taxa (*B. appendiculatum*, *N. brownii*, *R. argutus*, and invasive grasses) were present in the enclosure, their cover remained very low.

Extensive native canopy cover is apparent in the UAV imagery of the enclosure prior to Baseline monitoring through Year 3 (Figure 4). Increased native understory cover over time is evident in the photopoints (Figures 5 - 9).

**Table 2:** Vegetation percent cover by stratum over time. P-values obtained from Fisher's exact tests for Baseline and Year 4 data. Statistically significant results that meet the 10% standard for recognized change in cover are in boldface. Arrows indicate increase (↑) or decrease (↓) in cover.

| | Baseline | Year 1 | Year 2 | Year 4 | p | |
|---|---|---|---|---|---|---|
| Understory | | | | | | |
| Native | 25.9 | 25.0 | 30.4 | 52.5 | **0.000** | ↑ |
| Non-native | 4.8 | 1.0 | 7.0 | 8.6 | 0.010 | ↑ |
| Non-vegetated | 70.1 | 74.1 | 64.6 | 43.1 | **0.000** | ↓ |
| Canopy | | | | | | |
| Native | 76.7 | 72.2 | 74.1 | 66.3 | **0.000** | ↓ |
| Non-native | 0.0 | 0.0 | 0.0 | 0.0 | NA | |
| Non-vegetated | 23.3 | 27.8 | 25.9 | 33.7 | **0.000** | ↑ |
| Total AGL* | | | | | | |
| Native | 80.0 | 77.7 | 79.9 | 84.3 | 0.059 | |
| Non-native | 4.8 | 1.0 | 7.0 | 8.6 | 0.010 | ↑ |
| Non-vegetated | 18.8 | 22.1 | 19.0 | 14.0 | 0.029 | ↓ |

*Above ground level

**Table 3**: Species percent cover by stratum over time, listed in order of highest to lowest cover in Year 4. Fisher's Exact tests were used for cover change between Baseline and Year 4 for taxa with ≥ 10% absolute cover change. Native taxa are in boldface.

| Taxon | Baseline | Year 1 | Year 2 | Year 4 | p |
|---|---|---|---|---|---|
| Understory | | | | | |
| ***Cibotium chamissoi***[1] | 10.2 | 9.1 | 8.8 | 14.2 | |
| ***Metrosideros polymorpha***[1] | 4.3 | 5.5 | 7.7 | 6.6 | |
| ***Coprosma longifolia***[1] | 1.7 | 1.9 | 2.7 | 6.3 | |
| ***Lachnagrostis filiformis*** | 0.0 | 0.0 | 0.0 | 5.6 | |
| ***Kadua affinis***[1] | 0.7 | 1.0 | 2.7 | 4.2 | |
| ***Pritchardia kaalae***[3] | 2.3 | 2.1 | 1.5 | 4.1 | |
| ***Nephrolepis exaltata* subsp. *hawaiiensis*** | 1.7 | 2.4 | 1.4 | 3.9 | |
| ***Scaevola gaudichaudiana***[1] | 0.0 | 0.3 | 0.9 | 3.9 | |
| ***Odontosoria chinensis*** | 0.7 | 0.9 | 1.5 | 3.6 | |
| *Clidemia hirta* | 0.3 | 0.2 | 2.7 | 2.7 | |

**Table 3** (continued).

| Taxon | Baseline | Year 1 | Year 2 | Year 4 | p | |
|---|---|---|---|---|---|---|
| Understory | | | | | | |
| ***Antidesma platyphyllum***[1] | 1.7 | 0.9 | 1.0 | 2.7 | | |
| *Ageratum conyzoides* | 0.2 | 0.2 | 1.0 | 2.7 | | |
| ***Microlepia strigosa***[1] | 1.0 | 0.0 | 0.7 | 1.9 | | |
| ***Acacia koa***[1] | 0.5 | 0.0 | 0.9 | 1.7 | | |
| *Christella parasitica* | 0.2 | 0.0 | 0.0 | 1.4 | | |
| ***Alyxia stellata*** | 0.8 | 0.2 | 1.2 | 1.0 | | |
| ***Freycinetia arborea*** | 1.7 | 1.0 | 0.7 | 1.0 | | |
| ***Carex wahuensis***[1] | 0.0 | 0.3 | 0.7 | 0.8 | | |
| ***Coprosma foliosa***[1] | 1.8 | 1.2 | 0.3 | 0.8 | | |
| *Rubus argutus*[2] | 1.2 | 0.0 | 0.3 | 0.7 | | |
| ***Wikstroemia oahuensis* var. *oahuensis*** | 0.5 | 0.3 | 0.7 | 0.5 | | |
| *Blechnum appendiculatum*[2] | 2.0 | 0.3 | 0.5 | 0.3 | | |
| *Paspalum conjugatum*[2] | 0.0 | 0.2 | 0.5 | 0.3 | | |
| *Cyperus brevifolius* | 0.3 | 0.0 | 0.3 | 0.3 | | |
| *Cuphea carthagenesis* | 0.2 | 0.2 | 0.2 | 0.3 | | |
| ***Dicranopteris linearis*** | 0.0 | 0.0 | 0.0 | 0.3 | | |
| ***Elaphoglossum paleaceum*** | 0.2 | 0.0 | 0.5 | 0.2 | | |
| *Youngia japonica* | 0.0 | 0.0 | 0.2 | 0.2 | | |
| ***Perrottetia sandwicensis***[1] | 0.2 | 0.0 | 0.0 | 0.2 | | |
| ***Ceodes brunoniana*** | 0.0 | 0.0 | 0.0 | 0.2 | | |
| *Crassocephalum crepidioides* | 0.0 | 0.0 | 0.0 | 0.2 | | |
| ***Pipturus albidus*** | 0.0 | 0.0 | 0.0 | 0.2 | | |
| ***Psilotum nudum*** | 0.0 | 0.0 | 0.0 | 0.2 | | |
| *Festuca bromoides*[2] | 0.0 | 0.0 | 0.3 | 0.0 | | |
| *Rubus rosifolius* | 0.0 | 0.0 | 0.3 | 0.0 | | |
| ***Elaphoglossum crassifolium*** | 0.0 | 0.3 | 0.2 | 0.0 | | |
| *Ageratina adenophora* | 0.0 | 0.0 | 0.2 | 0.0 | | |
| *Deparia petersenii* | 0.0 | 0.0 | 0.2 | 0.0 | | |
| *Gamochaeta purpurea* | 0.0 | 0.0 | 0.2 | 0.0 | | |
| ***Melicope oahuensis*** | 0.0 | 0.0 | 0.2 | 0.0 | | |
| ***Sadleria cyatheoides***[1] | 0.0 | 0.0 | 0.2 | 0.0 | | |
| ***Dryopteris fusco-atra*** | 0.3 | 0.3 | 0.0 | 0.0 | | |
| ***Elaphoglossum aemulum*** | 0.3 | 0.2 | 0.0 | 0.0 | | |
| ***Doodia kunthiana*** | 0.0 | 0.2 | 0.0 | 0.0 | | |
| *Oxalis corniculata* | 0.5 | 0.0 | 0.0 | 0.0 | | |
| Canopy | | | | | | |
| ***Metrosideros polymorpha***[1] | 69.6 | 68.6 | 71.6 | 59.7 | 0.000 | ↓ |
| ***Cibotium chamissoi***[1] | 4.1 | 1.9 | 1.5 | 5.9 | | |
| ***Acacia koa***[1] | 7.9 | 2.4 | 3.9 | 5.4 | | |
| ***Antidesma platyphyllum*** | 3.1 | 1.9 | 2.0 | 2.0 | | |
| ***Alyxia stellata*** | 0.7 | 0.0 | 0.0 | 1.7 | | |
| ***Pritchardia kaalae***[3] | 0.2 | 0.0 | 0.0 | 0.3 | | |
| ***Freycinetia arborea*** | 0.5 | 0.7 | 0.5 | 0.2 | | |
| ***Coprosma longifolia***[1] | 0.8 | 0.9 | 0.2 | 0.2 | | |
| ***Coprosma foliosa***[1] | 0.7 | 0.5 | 0.0 | 0.2 | | |
| ***Kadua affinis***[1] | 0.0 | 0.3 | 0.0 | 0.2 | | |
| ***Melicope oahuensis*** | 0.0 | 0.0 | 0.5 | 0.0 | | |
| ***Lepisorus thunbergianus*** | 0.2 | 0.0 | 0.0 | 0.0 | | |

[1]Taxon represented in restoration efforts. [2]Zero tolerance weed. [3]Rare plant reintroduction.

**Table 4:** Vegetation percent cover over time by growth form within stratum.

| | *Native* | | | | *Non-native* | | | |
|---|---|---|---|---|---|---|---|---|
| | Baseline | Year 1 | Year 2 | Year 4 | Baseline | Year 1 | Year 2 | Year 4 |
| Understory | | | | | | | | |
| Fern | 13.9 | 12.3 | 12.4 | 22.2 | 2.1 | 0.3 | 0.7 | 1.7 |
| Grass | 0.0 | 0.0 | 0.0 | 5.6 | 0.0 | 0.2 | 0.9 | 0.3 |
| Herb | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.3 | 1.5 | 3.4 |
| Liana | 1.7 | 1.0 | 0.7 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Sedge | 0.0 | 0.3 | 0.7 | 0.8 | 0.3 | 0.0 | 0.3 | 0.3 |
| Shrub | 4.0 | 3.8 | 4.6 | 12.2 | 1.5 | 0.2 | 3.6 | 3.4 |
| Tree | 9.1 | 9.4 | 13.8 | 19.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Canopy | | | | | | | | |
| Fern | 4.3 | 1.9 | 1.5 | 5.9 | 0.0 | 0.0 | 0.0 | 0.0 |
| Liana | 0.5 | 0.7 | 0.5 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Shrub | 1.5 | 1.4 | 0.2 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tree | 74.9 | 71.4 | 74.0 | 64.5 | 0.0 | 0.0 | 0.0 | 0.0 |

**Figure 2:** UAV image showing a dead *Metrosideros polymorpha* by the enclosure crossover (April 11, 2022).

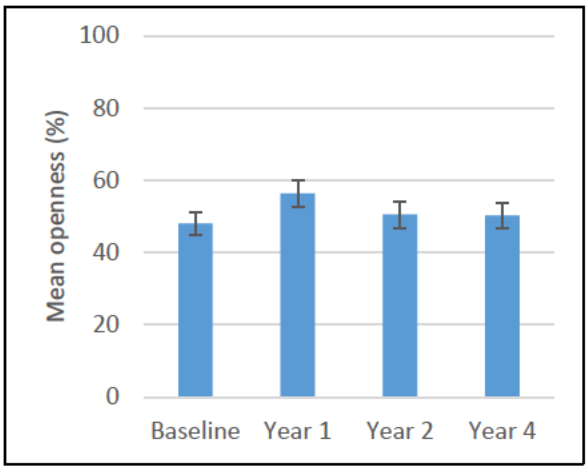


**Figure 3:** Mean canopy openness over time. Error bars show standard error.

**Table 5:** All species intercepted (I) or anecdotally observed (A) in the understory and/or canopy over time. Native taxa are in boldface. Pre-baseline taxa were documented during vegetation clearing. New taxon observations for Year 4 are highlighted in blue.

| Taxa | Pre-baseline | Baseline | Year 1 | Year 2 | Year 4 |
|---|---|---|---|---|---|
| ***Acacia koa***[1] | A | I | I | I | I |
| ***Adenophorus tenellus*** | A | A | | | |
| *Ageratina adenophora* | A | | | I | A |
| *Ageratina riparia* | | | A | | A |
| *Ageratum conyzoides* | | I | I | I | I |
| ***Alyxia stellata*** | A | I | I | I | I |
| *Andropogon virginicus*[2] | | | | | A |
| *Angiopteris evecta*[2] | A | | | | |
| ***Antidesma platyphyllum***[1] | A | I | I | I | I |
| ***Asplenium caudatum*** | A | A | A | | A |
| ***Asplenium contiguum*** | | A | A | A | |
| ***Asplenium polyodon*** | A | A | | | A |
| ***Athyrium microphyllum*** | A | A | A | A | A |
| ***Bidens torta*** | | | | | A |
| *Blechnum appendiculatum*[2] | A | I | I | I | I |
| *Buddleja asiatica* | A | | | A | A |
| ***Carex wahuensis***[1] | | | I | I | I |
| ***Ceodes brunoniana*** | | | | | I |
| ***Charpentiera obovata*** | | | | | A |
| *Cheilanthes viridis* | | | | | A |
| ***Cheirodendron trigynum*** | A | A | A | | A |
| *Christella parasitica* | A | I | A | A | I |
| ***Cibotium chamissoi***[1] | A | I | I | I | I |
| ***Clermontia persicifolia***[1] | A | A | | | A |
| *Clidemia hirta* | A | I | I | I | I |
| *Conyza bonariensis* | | | | | A |
| *Conyza canadensis* var. *pusilla* | | | | | A |
| ***Coprosma foliosa***[1] | A | I | I | I | I |
| ***Coprosma longifolia***[1] | A | I | I | I | I |
| *Cordyline fruticosa* | A | | | | A |
| *Crassocephalum crepidioides* | | | A | A | I |
| *Cuphea carthagenesis* | A | I | I | I | I |
| *Cyperus brevifolius* | | I | A | I | I |
| ***Cyperus polystachyos*** | | | | | A |
| *Deparia petersenii* | A | A | A | I | A |
| ***Dicranopteris linearis*** | A | A | A | A | I |
| ***Diplazium sandwichianum*** | | A | A | | |
| ***Dodonaea viscosa***[1] | | | | | A |
| ***Doodia kunthiana*** | A | A | I | A | A |
| ***Dryopteris fusco-atra*** | A | I | I | A | A |
| ***Dryopteris glabra*** | A | A | A | A | A |
| ***Elaphoglossum aemulum*** | A | I | I | A | A |
| ***Elaphoglossum alatum*** | A | A | A | A | A |
| ***Elaphoglossum crassifolium*** | A | A | I | I | A |
| ***Elaphoglossum paleaceum*** | A | I | A | I | I |
| *Erechtites valerianifolia* | | | | A | A |
| *Festuca bromoides*[2] | | | A | I | A |
| ***Freycinetia arborea*** | A | I | I | I | I |
| *Gamochaeta purpurea* | | | A | I | |
| *Grevillea robusta* | | | | A | |
| ***Kadua affinis***[1] | A | I | I | I | I |
| ***Korthalsella cylindrica*** | | | A | | |

**Table 5** (continued).

| Taxa | Pre-baseline | Baseline | Year 1 | Year 2 | Year 4 |
|---|---|---|---|---|---|
| ***Lachnagrostis filiformis*** | | | | | I |
| *Lantana camara* | | | A | | |
| ***Lepisorus thunbergianus*** | A | I | A | A | A |
| ***Machaerina mariscoides* subsp. *meyenii*** | A | A | | | |
| ***Melicope oahuensis*** | A | A | A | I | A |
| *Melinis minutiflora*[2] | A | | A | A | A |
| *Mesosphaerum pectinatum* | | | | | A |
| ***Metrosideros polymorpha***[1] | A | I | I | I | I |
| ***Microlepia strigosa***[1] | A | I | A | I | I |
| *Nephrolepis brownii*[2] | | | | | A |
| ***Nephrolepis exaltata* subsp. *hawaiiensis*** | A | I | I | I | I |
| ***Odontosoria chinensis*** | A | I | I | I | I |
| *Oxalis corniculata* | A | I | A | A | A |
| *Oxalis debilis* | A | A | A | A | A |
| *Paspalum conjugatum*[2] | A | A | I | I | I |
| *Passiflora suberosa* | | | | | A |
| ***Peperomia membranacea*** | A | A | | | |
| ***Perrottetia sandwicensis***[1] | A | I | A | A | I |
| ***Pipturus albidus*** | | | | | I |
| *Pityrogramma austroamericana* | | | | A | A |
| *Plantago major* | | A | | | |
| *Pluchea carolinensis* | | | | A | |
| *Polystachya concreta* | A | A | A | | A |
| ***Pritchardia kaalae***[3] | A | I | I | I | I |
| ***Pseudognaphalium sandwicensium* var. *molokaiense*** | | | | | A |
| *Psidium cattleianum* | A | | | A | A |
| ***Psilotum complanatum*** | | A | | | |
| ***Psilotum nudum*** | A | A | A | | I |
| *Rubus argutus*[2] | A | I | A | I | I |
| *Rubus rosifolius* | A | A | A | I | A |
| ***Sadleria cyatheoides***[1] | | | | I | A |
| ***Scaevola gaudichaudiana***[1] | A | A | I | I | I |
| *Schinus terebinthifolius* | A | | | A | A |
| *Setaria parviflora*[2] | A | A | | A | A |
| *Spathodea campanulata* | A | | | | |
| *Stachytarpheta australis* | A | A | A | A | A |
| ***Syzygium sandwicense***[1] | | | | | A |
| *Toona ciliata* | A | | | A | A |
| *Trema orientalis* | | A | | | |
| Unidentified orchid sp. | A | A | | | |
| ***Wikstroemia oahuensis* var. *oahuensis*** | A | I | I | I | I |
| *Youngia japonica* | | A | A | I | I |

[1]Taxon represented in restoration efforts. [2]Zero tolerance weed. [3]Rare plant reintroduction.

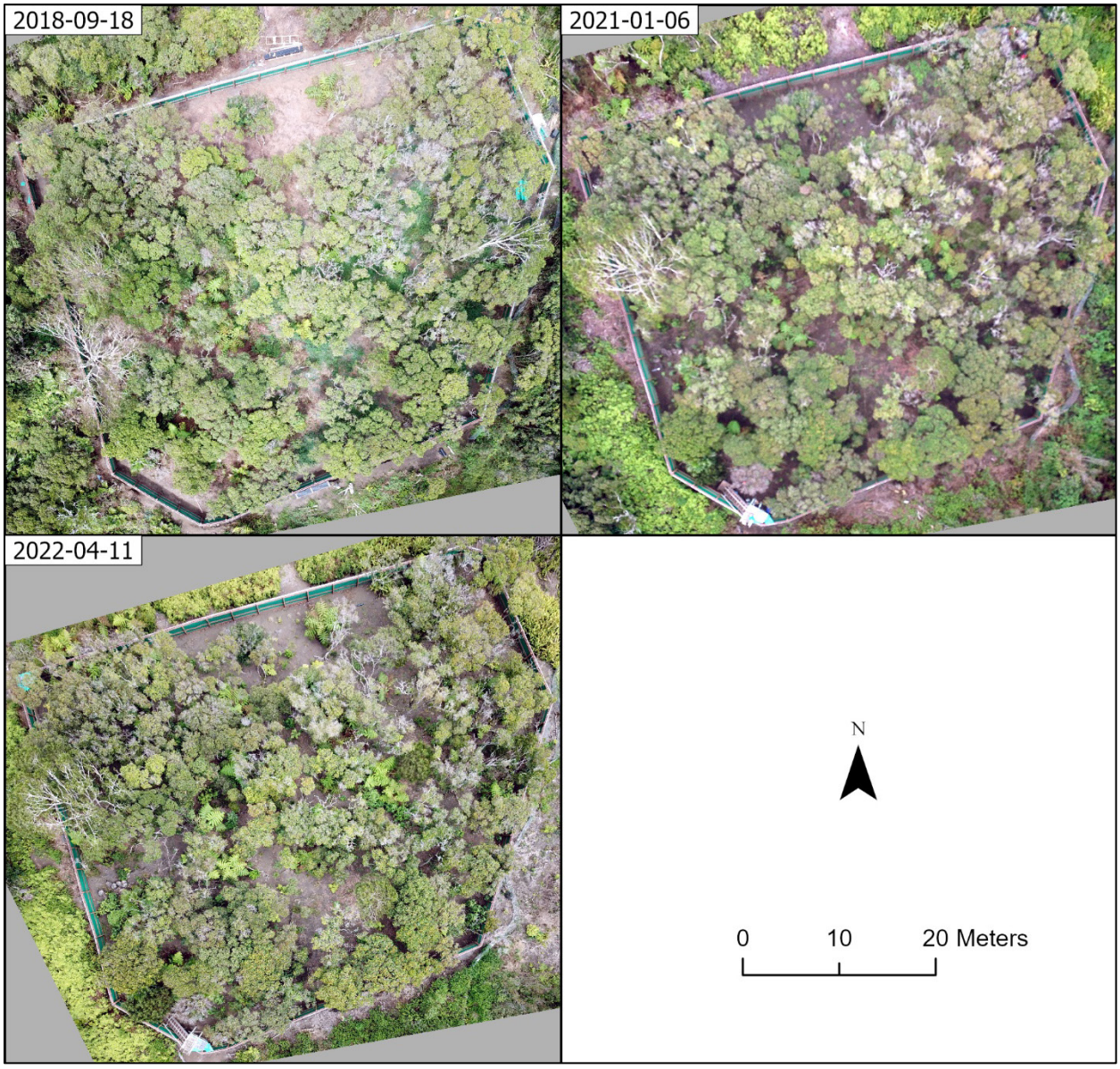


**Figure 4:** UAV imagery of the enclosure prior to Baseline monitoring (top left, September 18, 2018), when much of the understory clearing had been completed; during Year 2 monitoring (top right, January 6, 2021), showing less grass cover and small outplants visible in open areas; and during Year 3 (bottom left, April 4, 2022) showing expansion of some outplants in open areas. The large *Acacia koa* along the western wall which died following construction is visible (in poor health) in the top left image, and is being actively replaced by outplantings visible in the lower image.

**Figure 5:** Images from Photopoint 1 with views in each cardinal direction over time. Baseline images (December 2018) show a fairly open understory following weed clearing. Restoration outplants are visible in Year 2 (August 2020) images. Expanded understory cover is visible in Year 4 (September 2022).

**Figure 6:** Images from Photopoint 2 with views in each cardinal direction over time. Baseline images (December 2018) show a fairly open understory following weed clearing. Restoration outplants are visible in Year 2 (August 2020) images. Expanded understory cover is visible in Year 4 (September 2022).

**Figure 7:** Images from Photopoint 3 with views in each cardinal direction over time. Baseline images (December 2018) show a fairly open understory following weed clearing. Restoration outplants are visible in Year 2 (August 2020) images. Expanded understory cover is visible in Year 4 (September 2022).

**Figure 8:** Images from Photopoint 4 with views in each cardinal direction over time. Baseline images (December 2018) show a fairly open understory following weed clearing. Restoration outplants are visible in Year 2 (August 2020) images. Expanded understory cover is visible in Year 4 (September 2022).

**Figure 9:** Images from Photopoint 5 with views in each cardinal direction over time. Baseline images (December 2018) show a fairly open understory following weed clearing. Restoration outplants are visible in Year 2 (August 2020) images. Expanded understory cover is visible in Year 4 (September 2022).

## DISCUSSION

Though it took longer than anticipated, by Year 4 the native understory goal (> 50% cover) established in the restoration plan was met. Expansion of native understory was likely slowed by limited light availability resulting from extensive native canopy cover. Faster growth typically occurs in open areas. As native canopy cover decreased slightly, moving further away from the goal, it may take considerably longer than planned for the canopy goal (> 90%) to be met. However, this may foster additional understory growth and support meeting the total AGL goal more quickly. Expansion of existing canopy is likely to be slow, given the slow growth rate for *M. polymorpha*, which dominates the canopy. While canopy cover is not expected to increase substantially during the next few years, it is

hoped that outplants will continue to expand in the understory in the more open areas below canopy gaps, and eventually grow into the canopy layer.

Weedy ingress was anticipated, particularly in light gaps, but has and should continue to remain at low levels with regularly planned weeding intervals. Taxa problematic to control using standard weeding methods, *B. appendiculatum* and *R. argutus*, are anticipated to be eventually extirpated from the enclosure, following repeated control efforts tailored for those taxa.

## RECOMMENDATIONS AND MANAGEMENT RESPONSE

The impetus for making restoration goals was to trigger additional management actions if goals were not met. As progress towards the native canopy cover goals has not occurred, and new gaps formed with the loss of a few trees, considerations should be made for whether or not additional restoration inputs are needed, or if sufficient tree taxa outplants are in place that simply need additional time to grow into the canopy layer. Additional restoration is not planned for the next year, though discussions are warranted to facilitate planning for any future outplanting, given the time required for propagation. Any new outplanting efforts should continue to include fast-growing trees in open areas (e.g. *A. koa*, *Cheirodendron trigynum*, and *Kadua affinis*) as needed. Weed control efforts should continue to focus on eliminating zero tolerance taxa, including the newly encountered taxon *N. brownii*. Controlling the large *N. brownii* infestation outside the northeast corner of the enclosure may help mitigate ongoing incursions under the wall via spreading stolons. Foliar sprays of Polaris (2%) and Ranger Pro (2%) have been found effective in controlling the similarly stoloniferous fern *B. appendiculatum* (Priority O‘ahu Native Ecosystems 2013), and may be worth trying for control of *N. brownii* outside the enclosure wall. Basal bark applications of Garlon 4 (20%) have been found effective in controlling *Christella* spp. (not stoloniferous, but with creeping rhizomes) (Priority O‘ahu Native Ecosystems 2013), and would be a safer method to control *N. brownii* inside the enclosure, given the potential presence of *Achatinella*. Additional inputs of tree fern taxa (*Cibiotium* spp, *Sadleria* spp.) may help occupy space that could otherwise be occupied by zero-tolerance weeds, and recolonize areas once occupied by *D. linearis*. Additional tree fern cover and associated frond litter may have the added benefit of retaining moisture at the site. Though the weed cover goal has been successfully maintained through Year 4, extra care should be taken to prevent non-native grasses from taking over, as has happened at the Palikea North snail enclosure (Appendix 5-3), given that foliar sprays may be problematic in areas with rare snails.

While restoration actions are not new for the program, this restoration site is only the second (after Palikea North) to have specific aggressive goals within a narrow timeframe, given the need for suitable protected habitat for *A. mustelina* within a new enclosure. This site differs considerably from Palikea North given the extensive native canopy cover at the outset. As such it is an excellent learning opportunity for planning, execution, and practical timelines for fully restored habitat and habitat readiness for use by endangered animals. Qualifications for the level of restoration suitable for the release of *A. mustelina* have not been studied. Though dense multi-layered host vegetation is presumed ideal, partially restored vegetation may be sufficient for releasing snails. Stable or increasing *A. mustelina* populations may also be used as a measure of vegetation rehabilitation success.

The northwest corner of the enclosure contains known snail host plants including a large stand of *Freycinetia arborea* and a tall densely canopied *A. platyphyllum* deemed suitable for *A. mustelina*. Following completion of *E. rosea* removal, 462 *A. mustelina* from ESU B2 and 48 snails from ESU B1 wild populations were translocated into this area between November 2019 and July 2021 (ANRPO 2023). Since that time the population has remained relatively stable, mortality rates have remained low, and there has been evidence of reproduction (Chapter 5). The release area was initially bounded by a temporary barrier consisting of a low plywood wall with an internal electric barrier to prevent snails from traversing out into areas of more sparse vegetation where they may encounter environmental stress, and to facilitate

monitoring of survival and mortality within a confined area. Restricting snails to a smaller area also maximizes the opportunity for snails to encounter one another and to potentially reproduce. As snails have been observed migrating outwards from the release site, and native understory cover has expanded, the temporary barrier was removed in 2022. The success of the snail releases suggests habitat readiness, such as the early stages of vegetation restoration as characterized here, are sufficient for snail releases, and the need for such aggressive goals within a narrow timeframe as specified by the restoration plan may not be necessary or realistic.

Given the setback for canopy native cover, Year 10 may be a more realistic goal for achieving 90% cover. The goal of 90% cover by Year 5 was perhaps overly optimistic. This goal is more aggressive compared to enclosure canopy goals (> 75% by Year 10 at the new Kahanahāiki enclosure, and > 75% by Year 15 at Palikea North), largely because Baseline cover at the 3 Points enclosure (77%) was already relatively high (Baseline canopy cover of 39% at Kahanahāiki and 7% at Palikea North) (Appendix 5-1 and 5-3). As the native understory cover goal has been met, and a slow increase in native canopy cover increase is expected, the vegetation monitoring interval may be extended to every three years for the coming years (Years 7 and 10). The interval may then be extended to every five years if reasonable progress toward the canopy goal occurs by Year 10.

**REFERENCES**

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ARMY NATURAL RESOURCES PROGRAM ON O‘AHU
MONITORING PROGRAM

# VEGETATION MONITORING RESULTS FOR THE PALIKEA NORTH SNAIL ENCLOSURE, 2022

## INTRODUCTION

The Army Natural Resources Program on O‘ahu (ANRPO) documents vegetation cover change at the “Palikea North” *Achatinella mustelina* ESU-E predator resistant enclosure at Palikea Management Unit (MU) (Figure 1 and 2) as a measure of vegetation rehabilitation success in association with the enclosure’s restoration plan (ANRPO 2017). The goal of restoration was to achieve a native plant dominated community favorable for *A. mustelina* as well as *Drosophila substenoptera*, *Drosophila montgomeryi*, and *Chasiempis ibidis*. The primary objective of monitoring is to assess if native vegetation cover goals are met. Despite highly intensive and ongoing restoration efforts, by Year 3, native cover goals continued to fall short of the anticipated goal timeline established in the original restoration plan, and it was apparent that the goals were overly optimistic. Recommendations were made to revise the goals for strata that had not yet been met (ANRPO 2021a). Native vegetation cover goals in the restoration plan were revised in 2021 (ANRPO 2021b) to reflect a more realistically attainable outcome as follows:

> 50% for 0 – 1 m above ground level (AGL) by Year 1
> 50% for 1 – 2 m AGL by Years 5 – 6*
> 50% for > 2 m AGL by Year 10*, > 75% by Year 15*
> 75% for total AGL cover by Year 2

*revised goals (ANRPO 2021b)

A secondary objective is to assess if weed cover goals in the plan are met. Goals include maintaining < 10% weed cover, and having zero tolerance for a number of species (*Blechnum appendiculatum*, *Ehrharta stipoides*, *Nephrolepis brownii*, *Paspalum conjugatum*, and *Drymaria cordata*). Other taxa are specified as control targets (*Christella dentata*, *Christella parasitica*, *Clidemia hirta*, *Passiflora edulis*, *Passiflora suberosa*, *Phytolacca octandra*, *Psidium cattleianum*, *Rubus rosifolius*, and *Schinus terebinthifolius*, as well as non-native grasses and Asteraceae).

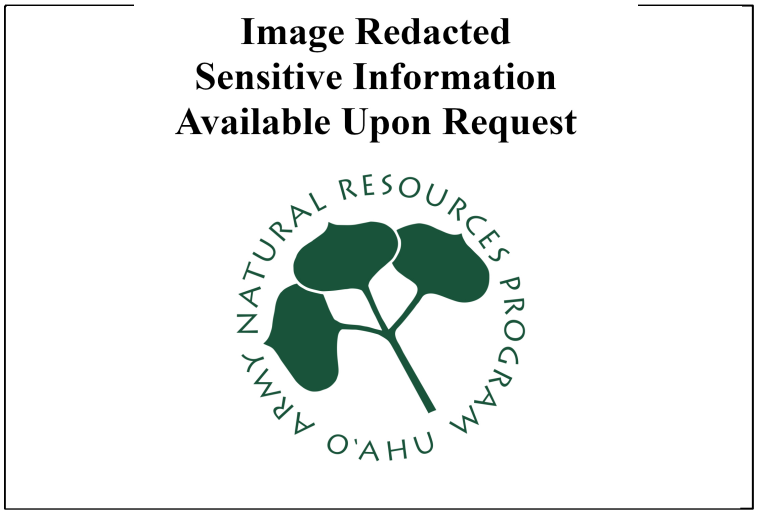


**Figure 1:** Location of the Palikea North snail enclosure at Palikea MU.

**Figure 2:** View of the Palikea North snail enclosure (September 2022).

Vegetation monitoring occurred in April 2016 prior to non-native vegetation removal and enclosure wall construction, in September 2017 following completion of the enclosure wall, and annually thereafter in September/October 2018 - 2022 (referred to in this report as pre-clearing, baseline, and Years 1 through 5). Prior to initial non-native vegetation clearing, in 2016 the enclosure area contained dense vegetation with nearly continuous non-native cover and a smaller amount of scattered native vegetation. Non-native vegetation primarily consisted of *P. cattleianum*, *S. terebinthifolius*, and *C. hirta*. Native vegetation was mainly *Metrosideros polymorpha*, *Freycinetia arborea*, and *Nephrolepis exaltata*. After removal of non-native vegetation and enclosure wall completion in 2017, canopy openness increased dramatically, and native cover was somewhat reduced, primarily consisting of the remaining *M. polymorpha* trees. Considerable vegetation cover change occurred in the first four years after the completion of enclosure construction, following the expansion of native vegetation from natural regrowth and recruitment, as well as the addition of large numbers of outplants, sown seeds, and transplants. The native cover goal for the 0 – 1 m AGL stratum was met by Year 2, and by Year 4 the goal of > 75% total AGL native cover was met. Weed cover goals were maintained in the first year, but not thereafter, following aggressive colonization by weeds, particularly by grasses in Years 3 and 4, as well as shrubs by Year 4. Four zero tolerance taxa were present within the first four years, with *E. stipoides* and *P. conjugatum* presenting the greatest challenges for control. A number of new control targets were present in conjunction with an increase in non-native species diversity. Canopy openness remained high through Year 4. Results were described and discussed in more detail in prior ANRPO Implementation Plan status reports (ANRPO 2016, 2019, 2020, 2021a, and 2022a), and are reiterated in tables and figures presented in this report.

## METHODS

**Percent cover:** Point intercept monitoring was used to assess changes in percent cover of native and non-native taxa in the understory and canopy. All species "hit" at points along transects were recorded for understory and canopy vegetation. A 5 millimeter diameter pole was used to determine "hits" in the understory (live vegetation that touches the pole, including leaves, branches and trunks) along an outstretched measuring tape at regular intervals. Vegetation "hits" in the understory were recorded from 0 – 1 m AGL and 1 – 2 m AGL. A laser pointer was used to determine laser "hits" in the canopy (above 2 m AGL) at these same intercept points, where the point fell within the perimeter of a tree's canopy. Locations where no vegetation was intercepted were recorded as non-vegetated. Locations of the sampled points are not permanent. Points were along 11 transects pre-clearing, and along 10 transects thereafter. Transects were spaced 5 m apart and oriented east/west, with point intercepts located every 1 m along transects (pre-clearing: n = 542, baseline: n = 501, Year 1: n = 492, Year 2: n = 494, Year 3: n = 490, Year 4: n = 491, and Year 5: n = 504). Approximations of percent cover were obtained from the proportion of "hits" among all intercepts.

**Canopy openness:** Hemispherical photography was used to monitor changes in canopy openness. Fish-eye photographs were taken at 2 m AGL, aimed 180° from the forest floor every 10 m on alternating transects during pre-clearing monitoring, and every 5 m along all transects during baseline and Years 1 - 5 monitoring (pre-clearing: n = 22, baseline: n = 86, Year 1: n = 92, Year 2: n = 93, Year 3: n = 95, Year 4: n = 97, and Year 5: n = 95).

**Supplemental data**: Unmanned aerial vehicle (UAV) imagery was taken during the course of non-native vegetation clearing and in conjunction with vegetation monitoring following completion of the enclosure construction. Five permanent photopoints were established (marked with permanent galvanized pipe) for visual documentation of sub-canopy change in each cardinal direction at each point. During the course of vegetation monitoring, a species diversity list was created documenting all species that happened to be observed, but not intercepted. The list will help document change in the presence or absence of species that have low cover, or are uncommon, and therefore less likely to be documented during point intercept monitoring.

**Analysis:** Analysis included Fisher's Exact tests for cover data, and generalized linear model (GLM) binomial regression for canopy openness data. Only absolute cover changes > 10% were analyzed to mitigate the probability of detecting a change when none exists (Type I error), and $\alpha = 0.05$ was used for significance determinations. Additional point intercepts were obtained during the 2016 monitoring (prior to wall construction) and were excluded from the analysis as they were located outside the enclosure wall. Exact wall placement had not been determined at that time. Canopy openness was estimated from hemispheric photographs using Gap Light Analyzer (GLA), Version 2.0 (Frazer *et al*. 1999). All statistical analyses were performed using the software R, Version 4.2.2 (R Core Team 2022).

**Monitoring schedule:** Monitoring will continue in Years 7, 10, and 15. The monitoring interval will be re-evaluated after Year 15.

## RESULTS

Upon further expansion of native vegetation (naturally occurring and restored, including over 3,300 outplants) (Table 1), in Year 5 there was a continued increase in native vegetation cover for the 1 - 2 m and > 2 m strata (Table 2 and Figure 3). However, there was a notable decline from Year 4 in native cover in the 0 – 1 m and total AGL strata, largely as a result of decreased cover of the native sedge *Cyperus polystachyos* in Year 5 in the 0 - 1 m AGL stratum (Table 3). *Cyperus polystachyos* had been the most prevalent native taxon in that stratum since Year 2, when large numbers of seeds were sown.

Nonetheless, cover remained high in the 0 – 1 m stratum, and fern, tree, and shrub taxa became the most predominant native growth forms (Table 4). *Nephrolepis exaltata* (largely regeneration from *in situ* plants) had the highest cover, with a significant increase from baseline cover, and surpassing pre-clearing levels. Most prevalent in the 0 – 1 stratum following *N. exaltata* were *Kadua affinis* and *Coprosma longifolia*, (the two taxon with the greatest number of outplants), as well as *C. polystachyos*. The increased native cover in the 1 – 2 m stratum was largely attributable to the vertical growth of *C. longifolia* and other shrub taxa into this stratum. *Metrosideros polymorpha* and *C. trigynum* remained the dominant canopy species. Canopy openness decreased over time since baseline measures (GLM: $p = 0.023$) (Figure 4). Most outplanted, sown, and transplanted taxa were either intercepted during monitoring or otherwise anecdotally observed in Year 5 (Table 5). Fates of unobserved taxa used for restoration were undetermined, as they are not individually tracked, and the density of the vegetation greatly hampered visibility and limited the ability to observe small plants and infrequent taxa and to make comprehensive lists of all species present.

The goal of > 50% native cover was maintained for the 0 – 1 m stratum, and nearly met for the 1 – 2 m stratum in Year 5. The goal of > 75% cover was nearly met for total AGL native vegetation. Progress was made towards meeting the native cover goal in the > 2 m stratum. The goal of maintaining weed cover of < 10% continued to not be met. This was primarily due to the persistence of grasses (mainly *P. conjugatum* and *E. stipoides*) and *C. hirta*. However, weed cover did not change significantly since Year 4. All five zero tolerance species were present, with *P. conjugatum* and *E. stipoides* continuing to be most problematic. Weed diversity in Year 5 was similar to that of the prior two years. It was notable that *Phytolacca octandra* was not intercepted or anecdotally observed in Year 5, as this taxon recruited prolifically following clearing, and maintained a presence through Year 4.

The dramatic changes in vegetation cover following removal of non-native vegetation, and notable changes in the first five years following construction completion and initiation of both active (outplantings, seed sows, and transplants) and passive (growth of in situ vegetation as well as natural recruitment) native plant restoration, are quite apparent in the UAV imagery (for total vegetation cover) (Figure 5) as well as in photopoint images (for visual representation of sub-canopy vegetation) (Figures 6-10).

**Table 1:** Species outplanted, sown, and/or transplanted in association with native vegetation restoration during the first five years following enclosure construction (Fall 2017 to Fall 2018 = Year 1, etc.). Total number of outplants, seeds, and transplants are listed by year post-construction. Seed and transplant numbers were not tracked for every restoration effort; these are listed as undetermined, or U. **Achatinella mustelina* host plant.

| Species | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | **Total** |
|---|---|---|---|---|---|---|
| Outplants | | | | | | |
| *Acacia koa* | 24 | | | | | **24** |
| *Alyxia stellata* | 3 | | 4 | | | **7** |
| *Antidesma platyphyllum** | | 15 | 4 | | 2 | **21** |
| *Bidens torta* | 146 | 1 | | | | **147** |
| *Carex wahuensis* | | | 62 | | | **62** |
| *Ceodes brunoniana** | 160 | | | 49 | | **209** |
| *Cheirodendron trigynum* | 168 | 12 | 66 | 31 | 17 | **294** |
| *Clermontia oblongifolia* | | 14 | | 21 | | **35** |
| *Coprosma longifolia** | 290 | 19 | 13 | 117 | | **439** |
| *Cyrtandra waianaeensis* | | | | 1 | | **1** |
| *Dianella sandwicense* | | | 40 | 28 | | **68** |
| *Dodonaea viscosa* | | | 12 | | | **12** |
| *Freycinetia arborea** | 3 | 20 | 10 | 11 | 49 | **93** |
| *Geniostoma kaalae** | | 98 | 25 | | | **123** |
| *Ilex anomala* | 12 | 13 | | 1 | | **26** |

**Table 1** (continued).

| Species | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | **Total** |
|---|---|---|---|---|---|---|
| Outplants | | | | | | |
| *Kadua affinis** | 412 | 20 | 57 | | | **489** |
| *Luzula hawaiiensis* | | 4 | | | | **4** |
| *Metrosideros polymorpha** | | 84 | 103 | 8 | 4 | **199** |
| *Microlepia speluncae* | | 3 | | 50 | | **53** |
| *Microlepia strigosa* | | 3 | | 33 | | **36** |
| *Myrsine lessertiana** | | | 35 | 4 | 5 | **44** |
| *Perrottetia sandwicensis** | 26 | 35 | 54 | 56 | | **171** |
| *Pipturus albidus* | 12 | | | 27 | | **39** |
| *Pittosporum confertiflorum* | | 11 | | | | **11** |
| *Psychotria hathewayi** | | 16 | 7 | 1 | 20 | **44** |
| *Psychotria mariniana** | 38 | 7 | 20 | 48 | 35 | **148** |
| *Pteris excelsa* | | | | 64 | | **64** |
| *Rumex albescens* | | | | 30 | | **30** |
| *Sadleria cyatheoides* | | | | | 20 | **20** |
| *Santalum freycinetianum* var. *freycinetianum* | 4 | | | | | **4** |
| *Scaevola gaudichaudiana* | 9 | | 5 | 1 | | **15** |
| *Touchardia oahuensis* | 131 | 100 | 57 | 68 | | **356** |
| *Wikstroemia oahuensis* var. *oahuensis* | 33 | | | | | **33** |
| **Total outplants** | **1471** | **475** | **574** | **649** | **152** | **3321** |
| Seed sows | | | | | | **24** |
| *Bidens torta* | ca. 10,000 | 19,000 | | | | **>29,000** |
| *Cyperus polystachyos* | | >10,000 | | | | **>10,000** |
| *Pipturus albidus* | U | U | | | | **U** |
| *Scaevola gaudichaudiana* | 24 | 24 | | | | **>48** |
| **Total seeds sown** | **>10,024** | **>29,024** | | | | **>39,048** |
| Transplants | | | | | | |
| *Cibotium chamissoi* | 65 | | | | | **65** |
| *Dianella sandwicense* | | U | | | | **U** |
| **Total transplants** | **65** | **U** | | | | **65** |

**Table 2:** Vegetation cover by stratum during pre-clearing (2016), baseline (2017), and Years 1 - 5 (2018 - 2022) monitoring. Fisher's Exact tests were used for cover change between baseline and Year 5, and between Years 4 and 5. Statistically significant results are in boldface. Arrows indicate increase (↑) or decrease (↓) in cover. Cover values meeting management goals are highlighted in blue.

| | Pre-clearing | Baseline | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | p | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Baseline-Year 5 | Year 4-Year 5 |
| 0-1 m | | | | | | | | | |
| Native | 18.1 | 2.8 | 24.4 | 53.0 | 63.7 | 71.9 | 56.9 | **0.000↑** | **0.000↓** |
| Non-native | 37.3 | 0.0 | 6.1 | 18.8 | 27.6 | 50.1 | 48.8 | **0.000↑** | 0.704 |
| Non-vegetated | 49.8 | 97.2 | 71.1 | 37.9 | 25.7 | 9.8 | 20.2 | **0.000↓** | **0.000↑** |
| 1-2 m | | | | | | | | | |
| Native | 6.1 | 1.4 | 2.2 | 9.3 | 25.7 | 36.5 | 47.0 | **0.000↑** | **0.000↑** |
| Non-native | 36.3 | 0.0 | 0.0 | 0.2 | 2.4 | 4.3 | 6.9 | **0.000↑** | 0.074 |
| Non-vegetated | 59.6 | 98.6 | 97.8 | 90.5 | 73.1 | 62.3 | 50.6 | **0.000↓** | **0.000↓** |
| >2 m | | | | | | | | | |
| Native | 16.8 | 6.8 | 6.9 | 7.1 | 10.8 | 16.1 | 19.8 | **0.000↑** | 0.137 |
| Non-native | 94.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.2 | 1.000 | 0.368 |
| Non-vegetated | 2.0 | 93.2 | 93.1 | 92.9 | 89.2 | 83.7 | 80.2 | **0.000↓** | 0.162 |
| Total vegetation AGL | | | | | | | | | |
| Native | 32.1 | 9.0 | 28.9 | 57.7 | 72.4 | 81.7 | 72.8 | **0.000↑** | **0.000↓** |
| Non-native | 98.2 | 0.0 | 6.1 | 18.8 | 28.8 | 51.1 | 50.4 | **0.000↑** | 0.849 |

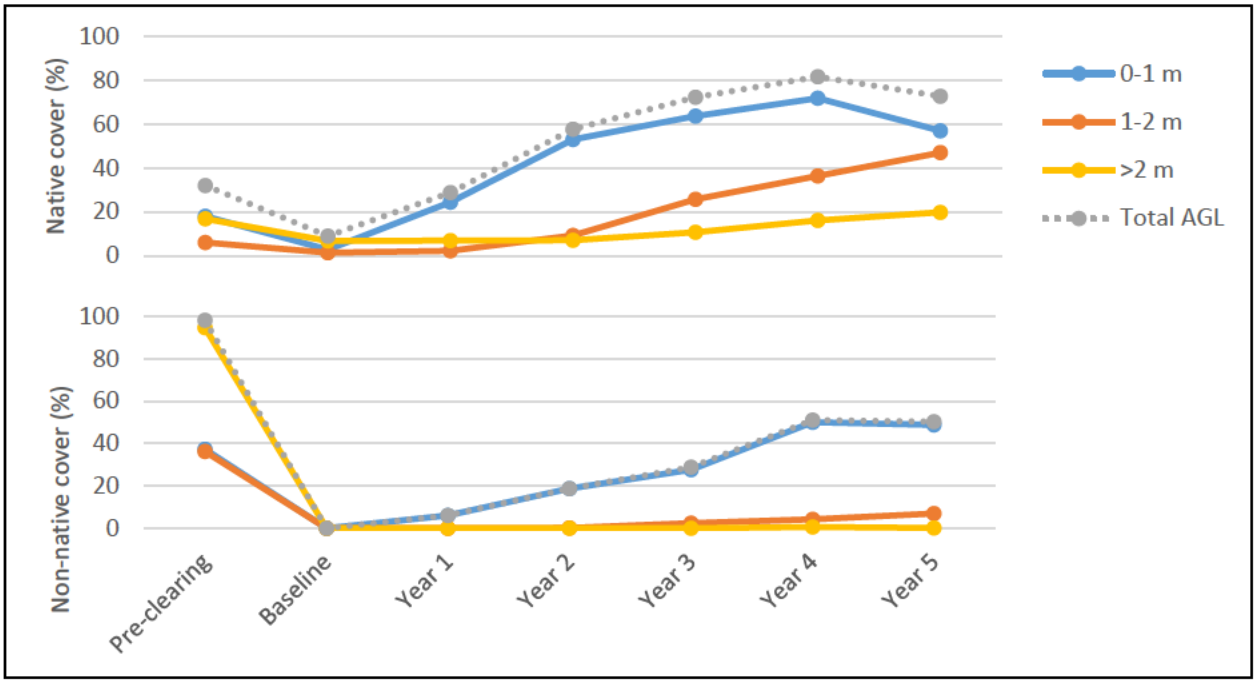


**Figure 3:** Native and non-native cover by stratum, and total cover above ground level (AGL), over time.

**Table 3:** Species percent cover by stratum and year: pre-clearing (2016), baseline (2017), and Years 1 – 5 (2018 - 2022). Fisher's Exact tests were used for cover change between baseline and Year 5, and between Years 4 and 5, for taxa with > 10% absolute cover change (years compared highlighted in blue). Native taxa are in boldface. Arrows indicate increase (↑) or decrease (↓) in cover.

| Species | Pre-clearing | Baseline | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | p |
|---|---|---|---|---|---|---|---|---|
| 0-1 m | | | | | | | | |
| ***Acacia koa*** | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.2 | |
| *Ageratum conyzoides* | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 1.0 | 0.6 | |
| ***Alyxia stellata*** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | |
| *Andropogon virginicus* | 0.0 | 0.0 | 0.0 | 0.2 | 0.4 | 2.6 | 2.0 | |
| ***Asplenium contiguum*** | 0.9 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.2 | |
| ***Bidens torta*** | 0.0 | 0.0 | 2.2 | 1.2 | 0.8 | 0.6 | 0.6 | |
| *Blechnum appendiculatum*[1] | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | |
| *Buddleja asiatica* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | |
| ***Carex wahuensis*** | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 1.0 | 1.6 | |
| ***Ceodes brunoniana*** | 0.0 | 0.0 | 0.6 | 0.4 | 0.4 | 0.2 | 0.0 | |
| ***Cheirodendron trigynum*** | 0.0 | 0.2 | 0.8 | 1.8 | 0.4 | 1.6 | 1.4 | |
| *Christella parasitica* | 0.2 | 0.0 | 0.0 | 0.2 | 0.2 | 0.8 | 0.6 | |
| ***Cibotium chamissoi*** | 0.0 | 0.0 | 0.2 | 1.6 | 1.2 | 1.0 | 1.2 | |
| ***Clermontia oblongifolia*** | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | |
| *Clidemia hirta* | 13.1 | 0.0 | 0.6 | 2.4 | 4.9 | 12.2 | 12.1 | 0.000↑ |
| *Conyza bonariensis* | 0.0 | 0.0 | 0.0 | 0.6 | 0.6 | 0.4 | 0.0 | |
| *Conyza canadensis* var. *pusilla* | 0.0 | 0.0 | 0.0 | 0.6 | 1.2 | 1.0 | 0.0 | |
| ***Coprosma foliosa*** | 0.0 | 0.2 | 0.0 | 0.6 | 0.0 | 0.8 | 0.2 | |
| ***Coprosma longifolia*** | 0.0 | 0.2 | 3.3 | 7.9 | 11.8 | 9.2 | 9.5 | |
| *Crassocephalum crepidioides* | 0.0 | 0.0 | 0.0 | 5.9 | 0.4 | 0.0 | 0.0 | |
| ***Cyperus hypochlorus* var. *hypochlorus*** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | |
| ***Cyperus polystachyos*** | 0.0 | 0.0 | 1.6 | 22.3 | 21.4 | 32.2 | 8.1 | 0.000↓ |
| ***Dianella sandwicensis*** | 0.0 | 0.0 | 0.0 | 0.4 | 1.2 | 2.9 | 4.4 | |
| ***Dodonaea viscosa*** | 0.0 | 0.0 | 0.0 | 0.2 | 2.0 | 1.4 | 1.8 | |
| *Drymaria cordata* var. *pacifica*[1] | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.2 | 0.0 | |

**Table 3** (continued).

| Species | Pre-clearing | Baseline | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | p |
|---|---|---|---|---|---|---|---|---|
| 0-1 m | | | | | | | | |
| *Ehrharta stipoides*[1] | 0.9 | 0.0 | 0.2 | 1.0 | 4.9 | 5.7 | 10.7 | 0.000↑ |
| *Emilia sonchifolia* | 0.0 | 0.0 | 0.0 | 0.4 | 0.4 | 0.0 | 0.0 | |
| *Erechtites valerianifolia* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | |
| ***Freycinetia arborea*** | 0.6 | 1.0 | 1.8 | 2.4 | 3.3 | 3.7 | 5.0 | |
| ***Geniostoma kaalae*** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | |
| ***Kadua affinis*** | 0.0 | 0.0 | 2.2 | 7.7 | 10.0 | 11.0 | 9.9 | |
| *Melinis minutiflora* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.2 | 1.0 | |
| ***Metrosideros polymorpha*** | 0.4 | 0.2 | 0.0 | 0.2 | 1.2 | 1.0 | 2.0 | |
| ***Microlepia speluncae*** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | |
| ***Microlepia strigosa*** | 2.8 | 0.0 | 0.2 | 0.8 | 1.6 | 2.2 | 2.6 | |
| *Nephrolepis brownii*[1] | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.4 | 0.8 | |
| ***Nephrolepis exaltata*** | 14.0 | 1.0 | 3.9 | 5.1 | 10.8 | 12.0 | 14.7 | 0.000↑ |
| *Oxalis corniculata* | 0.0 | 0.0 | 0.4 | 3.0 | 0.0 | 0.2 | 0.4 | |
| *Paspalum conjugatum*[1] | 4.4 | 0.0 | 4.1 | 4.0 | 15.9 | 30.3 | 27.0 | 0.000↑ |
| *Passiflora edulis* | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | |
| *Passiflora suberosa* | 0.2 | 0.0 | 0.0 | 0.0 | 0.2 | 0.8 | 0.0 | |
| ***Peperomia membranacea*** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | |
| ***Perrottetia sandwicensis*** | 0.0 | 0.0 | 0.6 | 0.2 | 0.0 | 0.0 | 0.0 | |
| *Phlebodium aureum* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | |
| *Phytolacca octandra* | 0.0 | 0.0 | 0.6 | 0.4 | 0.2 | 0.4 | 0.0 | |
| *Physalis peruviana* | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | |
| ***Pipturus albidus*** | 0.0 | 0.0 | 6.5 | 2.0 | 1.8 | 0.8 | 0.0 | |
| *Pluchea carolinensis* | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | |
| *Psidium cattleianum* | 20.3 | 0.0 | 0.4 | 0.6 | 0.8 | 0.2 | 0.6 | |
| ***Psychotria mariniana*** | 0.0 | 0.0 | 0.2 | 0.0 | 0.6 | 0.2 | 0.4 | |
| *Rubus rosifolius* | 2.4 | 0.0 | 0.2 | 0.2 | 0.4 | 0.0 | 0.2 | |
| ***Scaevola gaudichaudiana*** | 0.0 | 0.0 | 2.2 | 6.7 | 7.1 | 4.9 | 4.2 | |
| *Schinus terebinthifolius* | 0.4 | 0.0 | 0.0 | 0.2 | 0.0 | 0.8 | 0.6 | |
| *Setaria parviflora* | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.4 | 0.0 | |
| ***Smilax melastomifolia*** | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | |
| ***Solanum americanum*** | 0.0 | 0.0 | 0.0 | 0.2 | 0.8 | 1.0 | 0.0 | |
| ***Touchardia oahuensis*** | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 0.0 | |
| ***Wikstroemia oahuensis* var. *oahuensis*** | 0.0 | 0.0 | 0.2 | 0.4 | 1.2 | 0.8 | 1.6 | |
| *Youngia japonica* | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.2 | 0.0 | |
| 1-2 m | | | | | | | | |
| ***Acacia koa*** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | |
| *Ageratina adenophora* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | |
| *Andropogon virginicus* | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.2 | 0.8 | |
| ***Antidesma platyphyllum*** | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| ***Bidens torta*** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | |
| ***Ceodes brunoniana*** | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | |
| ***Cheirodendron trigynum*** | 0.2 | 0.2 | 0.0 | 1.8 | 2.2 | 7.3 | 5.4 | |
| ***Cibotium chamissoi*** | 0.4 | 0.2 | 0.6 | 1.2 | 3.3 | 4.7 | 4.2 | |
| ***Clermontia persicifolia*** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | |
| *Clidemia hirta* | 19.9 | 0.0 | 0.0 | 0.0 | 0.4 | 1.2 | 3.2 | |
| *Conyza bonariensis* | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | |
| *Conyza canadensis var. pusilla* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | |
| ***Coprosma foliosa*** | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.4 | 0.6 | |
| ***Coprosma longifolia*** | 0.0 | 0.6 | 0.2 | 0.2 | 4.9 | 6.9 | 12.9 | 0.000↑ |
| *Crassocephalum crepidioides* | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | |
| ***Dianella sandwicensis*** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | |
| ***Dodonaea viscosa*** | 0.0 | 0.0 | 0.0 | 0.0 | 1.2 | 2.6 | 3.6 | |

**Table 3** (continued).

| Species | Pre-clearing | Baseline | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | p |
|---|---|---|---|---|---|---|---|---|
| 1-2 m | | | | | | | | |
| ***Freycinetia arborea*** | 2.0 | 0.0 | 0.0 | 0.8 | 0.8 | 2.0 | 5.0 | |
| ***Geniostoma kaalae*** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | |
| ***Kadua affinis*** | 0.6 | 0.2 | 0.4 | 0.6 | 4.7 | 7.7 | 8.1 | |
| *Melinis minutiflora* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | |
| ***Metrosideros polymorpha*** | 0.9 | 0.2 | 0.0 | 0.2 | 0.4 | 0.0 | 0.4 | |
| ***Microlepia speluncae*** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | |
| ***Microlepia strigosa*** | 0.6 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.4 | |
| *Morella faya* | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| ***Nephrolepis exaltata* subsp. *hawaiiensis*** | 1.1 | 0.0 | 0.0 | 0.0 | 0.4 | 0.4 | 0.6 | |
| *Paspalum conjugatum*[1] | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.8 | 1.8 | |
| *Passiflora edulis* | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | |
| *Passiflora suberosa* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | |
| ***Pipturus albidus*** | 0.0 | 0.0 | 1.0 | 3.2 | 3.1 | 3.3 | 2.8 | |
| *Psidium cattleianum* | 15.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.4 | |
| ***Psychotria mariniana*** | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | |
| *Rubus rosifolius* | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | |
| ***Scaevola gaudichaudiana*** | 0.0 | 0.0 | 0.0 | 1.2 | 5.1 | 4.5 | 7.3 | |
| *Schinus terebinthifolius* | 1.1 | 0.0 | 0.0 | 0.0 | 0.2 | 0.6 | 0.4 | |
| ***Smilax melastomifolia*** | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | |
| ***Wikstroemia oahuensis* var. *oahuensis*** | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | |
| >2 m | | | | | | | | |
| ***Acacia koa*** | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.6 | |
| ***Cheirodendron trigynum*** | 1.1 | 0.2 | 0.2 | 0.4 | 1.2 | 4.3 | 5.6 | |
| ***Cibotium chamissoi*** | 0.4 | 0.0 | 0.0 | 0.2 | 0.4 | 0.2 | 0.4 | |
| *Clidemia hirta* | 4.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | |
| ***Coprosma foliosa*** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | |
| ***Coprosma longifolia*** | 0.2 | 1.0 | 0.4 | 0.0 | 0.2 | 0.0 | 0.8 | |
| ***Dodonaea viscosa*** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 2.6 | |
| ***Freycinetia arborea*** | 5.4 | 0.2 | 0.0 | 0.0 | 0.6 | 0.2 | 1.2 | |
| *Grevillea robusta* | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| ***Kadua affinis*** | 0.6 | 0.0 | 0.4 | 0.0 | 0.0 | 0.6 | 0.0 | |
| ***Metrosideros polymorpha*** | 9.6 | 5.4 | 5.9 | 4.7 | 5.1 | 5.7 | 5.6 | |
| *Morella faya* | 4.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| *Passiflora edulis* | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| *Passiflora suberosa* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | |
| ***Pipturus albidus*** | 0.0 | 0.0 | 0.0 | 1.6 | 3.7 | 4.3 | 3.8 | |
| *Psidium cattleianum* | 77.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| ***Psychotria mariniana*** | 0.4 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | |
| ***Scaevola gaudichaudiana*** | 0.4 | 0.0 | 0.0 | 0.0 | 0.2 | 1.6 | 1.4 | |
| *Schinus terebinthifolius* | 39.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | |
| ***Smilax melastomifolia*** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | |

[1]Zero tolerance weed

**Table 4:** Vegetation percent cover by growth form within stratum by year: pre-clearing (2016), baseline (2017), and Years 1 - 5 (2018 - 2022).

| | *Native* | | | | | | | *Non-native* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pre-clearing | Base-line | Year 1 | 2 | 3 | 4 | 5 | Pre-clearing | Base-line | Year 1 | 2 | 3 | 4 | 5 |
| 0-1 m | | | | | | | | | | | | | | |
| Fern | 17.7 | 2.0 | 5.7 | 9.1 | 14.9 | 17.7 | 20.2 | 0.7 | 0.0 | 0.0 | 0.2 | 0.4 | 1.2 | 1.8 |
| Grass | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.4 | 0.0 | 4.3 | 5.3 | 21.0 | 38.1 | 38.5 |
| Herb | 0.0 | 0.0 | 2.2 | 1.6 | 2.0 | 3.5 | 5.2 | 0.0 | 0.0 | 0.4 | 10.5 | 2.7 | 3.1 | 1.2 |
| Sedge | 0.0 | 0.0 | 1.6 | 22.3 | 22.0 | 33.0 | 9.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Shrub | 0.0 | 0.4 | 5.7 | 16.0 | 21.0 | 17.3 | 15.5 | 15.1 | 0.0 | 1.6 | 3.0 | 5.3 | 12.8 | 12.3 |
| Tree | 0.4 | 0.4 | 11.0 | 12.6 | 16.5 | 15.9 | 15.9 | 20.7 | 0.0 | 0.4 | 0.8 | 0.8 | 1.0 | 1.2 |
| Vine | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.2 | 0.8 | 0.0 |
| 1-2 m | | | | | | | | | | | | | | |
| Fern | 4.1 | 0.2 | 0.6 | 2.0 | 4.7 | 6.9 | 9.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Grass | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 1.2 | 2.8 |
| Herb | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.4 | 0.0 |
| Shrub | 0.2 | 0.6 | 0.2 | 1.4 | 10.4 | 12.0 | 21.0 | 20.1 | 0.0 | 0.0 | 0.0 | 0.4 | 1.6 | 3.2 |
| Tree | 2.0 | 0.6 | 1.4 | 5.9 | 11.6 | 19.8 | 20.4 | 16.6 | 0.0 | 0.0 | 0.0 | 0.2 | 0.8 | 0.8 |
| Vine | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.2 | 0.2 |
| >2 m | | | | | | | | | | | | | | |
| Fern | 5.7 | 0.2 | 0.0 | 0.2 | 1.0 | 0.4 | 1.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Shrub | 0.6 | 1.0 | 0.4 | 0.0 | 0.4 | 1.6 | 2.6 | 4.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 |
| Tree | 11.6 | 5.6 | 6.5 | 6.9 | 10.0 | 14.7 | 17.3 | 94.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 |
| Vine | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 |

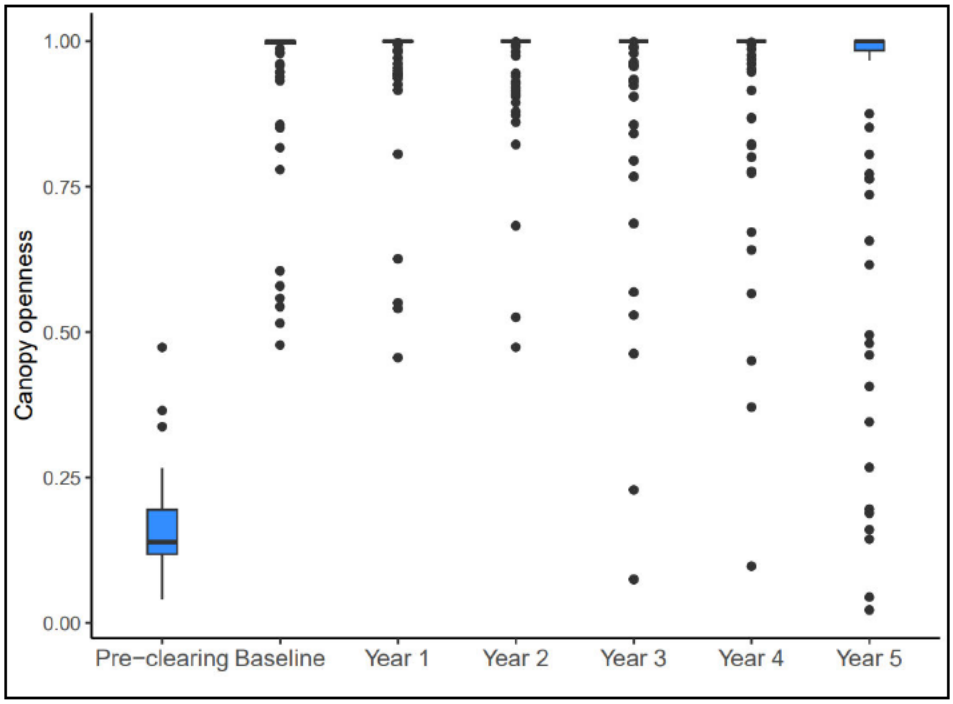


**Figure 4:** Canopy openness over time. Openness expressed as a proportion, between 0 (completely closed) and 1 (completely open). *Note: Boxplots illustrate the range of values of variables. The boxes depict the middle 50% of the data values, and the horizontal line inside the box represents the median value. The range in values for all remaining data are indicated by the vertical lines, and the circles, which represent outliers.*

**Table 5:** All taxa intercepted (I) or anecdotally (A) observed by year in any strata from 0 - 1 m, 1 -2 m, or >2 m above ground level. Note: The anecdotally observed area in 2016 (pre-clearing, prior to wall construction and final wall placement determination) included area outside the enclosure wall, and may include taxa not present within the bounds of the enclosure. New taxon observations for 2022 are highlighted in blue. [1]Taxon represented in restoration efforts (outplant, seed sow, and/or transplant). [2]Zero tolerance weed.

| Species | Pre-clearing | Base-line | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
|---|---|---|---|---|---|---|---|
| Native | | | | | | | |
| *Acacia koa*[1] | | | I | A | I | A | I |
| *Alyxia stellata*[1] | | | A | A | A | I | A |
| *Antidesma platyphyllum*[1] | I | | | A | A | A | A |
| *Asplenium caudatum* | A | | | | | | |
| *Asplenium contiguum* | I | A | A | A | I | I | I |
| *Athyrium microphyllum* | A | | | | | | |
| *Bidens torta*[1] | | | I | I | I | I | I |
| *Carex wahuensis*[1] | | | | | I | I | I |
| *Ceodes brunoniana*[1] | | | I | I | I | I | A |
| *Cheirodendron trigynum*[1] | I | I | I | I | I | I | I |
| *Cibotium chamissoi*[1] | I | I | I | I | I | I | I |
| *Clermontia oblongifolia*[1] | | | | A | I | I | A |
| *Coprosma foliosa* | A | I | | I | I | I | I |
| *Coprosma longifolia*[1] | I | I | I | I | I | I | I |
| *Cyperus hypochlorus* var. *hypochlorus* | | | | | | | I |
| *Cyperus polystachyos*[1] | | | I | I | I | I | I |
| *Dianella sandwicensis*[1] | A | A | A | I | I | I | I |
| *Dodonaea viscosa*[1] | | | A | I | I | I | I |
| *Dryopteris fusco-atra* | | A | A | | | | |
| *Dryopteris glabra* | A | | | | | | |
| *Freycinetia arborea*[1] | I | I | I | I | I | I | I |
| *Geniostoma kaalae*[1] | A | A | | A | A | | I |
| *Hydrangea arguta* | A | A | | | | | |
| *Ilex anomala*[1] | A | | A | | | | |
| *Kadua affinis*[1] | I | I | I | I | I | I | I |
| *Lepisorus thunbergianus* | A | A | A | A | A | A | A |
| *Metrosideros polymorpha*[1] | I | I | I | I | I | I | I |
| *Microlepia speluncae*[1] | | | | | | | I |
| *Microlepia strigosa*[1] | I | A | I | I | I | I | I |
| *Myrsine lessertiana*[1] | A | | | | A | | A |
| *Nephrolepis exaltata* subsp. *hawaiiensis* | I | I | I | I | I | I | I |
| *Odontosoria chinensis* | | | | A | A | | |
| *Peperomia membranacea* | | A | A | A | | | I |
| *Peperomia tetraphylla* | A | A | A | | | | |
| *Perrottetia sandwicensis*[1] | | | I | I | A | | |
| *Pipturus albidus*[1] | | | I | I | I | I | I |
| *Pittosporum confertiflorum*[1] | | | | A | A | A | A |
| *Psilotum nudum* | A | A | | | | | |
| *Psychotria hathewayi*[1] | A | A | | A | | A | A |
| *Psychotria mariniana*[1] | I | A | I | I | I | I | I |
| *Pteris excelsa*[1] | | | | | | | A |
| *Pteridium aquilinum* | | | A | A | A | | |
| *Rumex albescens*[1] | | | | | | | A |
| *Sadleria cyatheoides*[1] | | | | A | A | A | A |
| *Scaevola gaudichaudiana*[1] | I | A | I | I | I | I | I |
| *Sicyos pachycarpus* | | | | A | | | |
| *Solanum americanum* | | | | I | I | I | A |

**Table 5** (continued).

| Species | Pre-clearing | Base-line | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
|---|---|---|---|---|---|---|---|
| Native | | | | | | | |
| *Smilax melastomifolia* | A | A | A | I | I | I | I |
| *Streblus pendulinus* | A | A | A | | | | |
| *Touchardia oahuensis*[1] | | | A | I | I | A | A |
| *Vandenboschia davallioides* | A | | | | | | |
| *Waltheria indica* | | A | | | | | |
| *Wikstroemia oahuensis* var. *oahuensis*[1] | I | A | I | I | I | I | I |
| Total native diversity | 29 | 25 | 30 | 36 | 35 | 31 | 38 |
| Non-native | | | | | | | |
| *Acacia confusa* | | | | | | A | |
| *Ageratina adenophora* | | | | | A | I | A |
| *Ageratina riparia* | | | | | A | | |
| *Ageratum conyzoides* | | | A | I | I | I | I |
| *Andropogon virginicus* | | | A | I | I | I | I |
| *Blechnum appendiculatum*[2] | I | | | | | | I |
| *Buddleja asiatica* | | | A | A | | I | A |
| *Castilleja arvensis* | | | | | | | A |
| *Casuarina equisetifolia* | | | A | | | | |
| *Cheilanthes viridis* | | | | | A | A | A |
| *Christella parasitica* | I | A | A | I | I | I | I |
| *Clidemia hirta* | I | A | I | I | I | I | I |
| *Conyza bonariensis* | | | A | I | I | I | A |
| *Conyza canadensis* var. *pusilla* | | | | I | I | I | A |
| *Crassocephalum crepidioides* | | | A | I | I | | A |
| *Cuphea carthagenensis* | | | | | A | A | A |
| *Cyperus meyenianus* | | | | | A | | |
| *Drymaria cordata* var. *pacifica*[2] | | | | I | A | I | A |
| *Epidendrum x obrienianum* | A | | | | | | |
| *Ehrharta stipoides*[2] | I | A | I | I | I | I | I |
| *Emilia sonchifolia* | | | A | I | I | A | A |
| *Erechtites valerianifolia* | | | | | | A | I |
| *Gamochaeta purpurea* | | | A | A | A | | A |
| *Grevillea robusta* | I | | | | | A | |
| *Lantana camara* | | | | | | A | |
| *Leucaena leucocephala* | | | A | | | | |
| *Macrothelypteris torresiana* | | | | A | A | | |
| *Melinis minutiflora* | | | A | | A | I | I |
| *Mesosphaerum pectinatum* | | | | | A | | A |
| *Morella faya* | I | | A | | | | |
| *Nephrolepis brownii*[2] | | | | | I | I | I |
| *Oxalis corniculata* | | | I | I | A | I | I |
| *Paspalum conjugatum*[2] | I | A | I | I | I | I | I |
| *Passiflora edulis* | I | | | | I | | |
| *Passiflora suberosa* | I | A | | A | I | I | I |
| *Phlebodium aureum* | | | A | | | A | I |
| *Physalis peruviana* | | | | I | | A | |
| *Phytolacca octandra* | | A | I | I | I | I | |
| *Pityrogramma austroamericana* | | | A | | | | A |
| *Pluchea carolinensis* | | | I | | A | A | |
| *Polystachia concreta* | | A | | | | | |
| *Psidium cattleianum* | I | A | I | I | I | I | I |
| *Rubus rosifolius* | I | | I | I | I | I | I |
| *Schinus terebinthifolius* | I | A | A | I | I | I | I |

**Table 5** (continued).

| Species | Pre-clearing | Base-line | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
|---|---|---|---|---|---|---|---|
| Non-native | | | | | | | |
| *Setaria parviflora* | | | | | I | I | |
| Unknown* | | | A | | | | |
| *Youngia japonica* | A | | A | I | | I | |
| Total non-native diversity | 14 | 9 | 25 | 22 | 30 | 31 | 29 |

*Unidentified herbaceous dicot, presumed non-native.

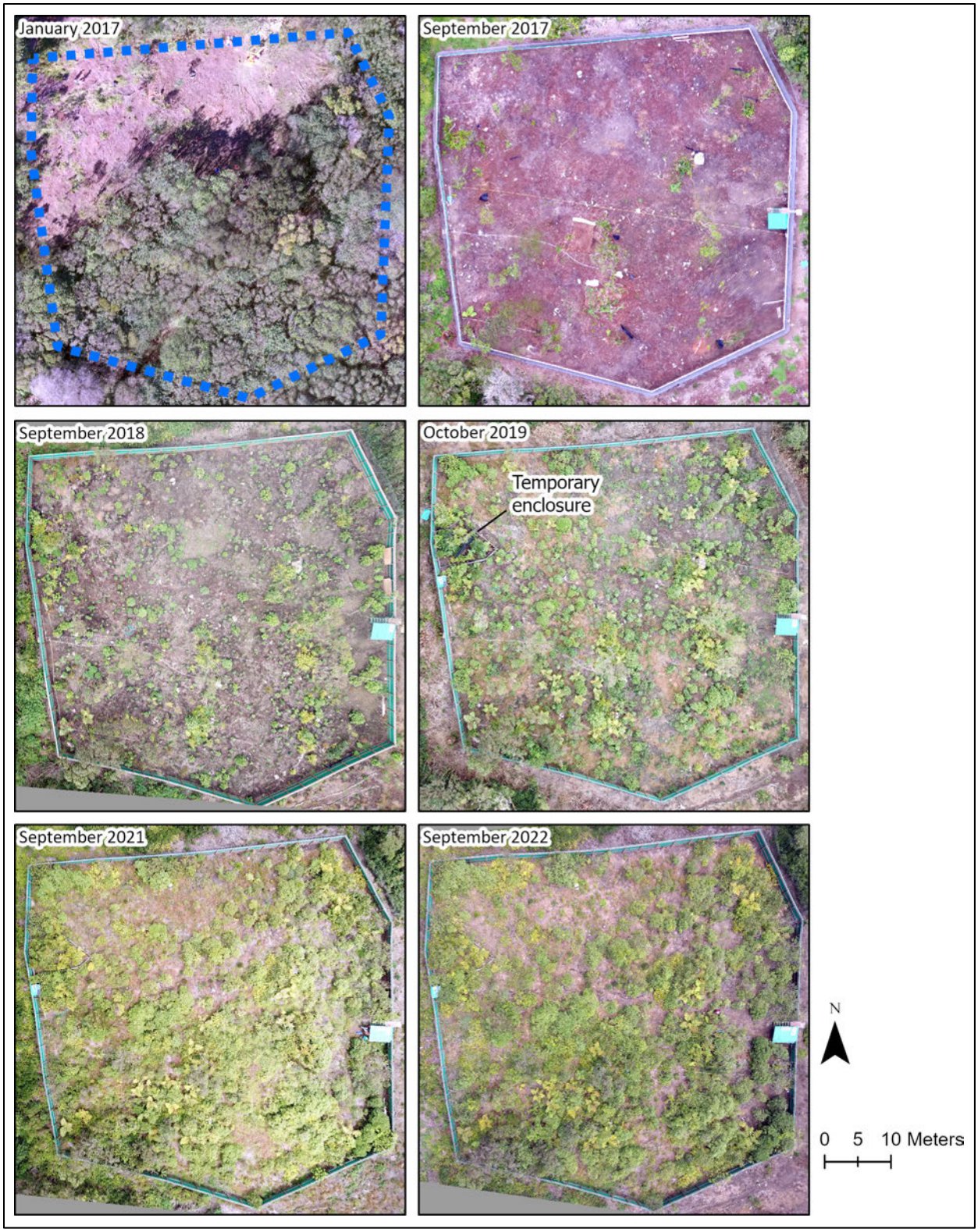


**Figure 5:** UAV imagery of the enclosure over time (left to right, and top to bottom): during clearing (January 2017), post-completion (baseline, September 2017), and in Years 1, 2, 4 and 5 (September 2018, October 2019, September 2021, and September 2022) monitoring. The temporary enclosure is indicated when it first appeared in the imagery.

**Figure 6:** Photopoint 1 images over time with views in each cardinal direction pre-clearing (June 2016); post-clearing and after the initial outplantings (January 2018); and at five years (September 2022) post-completion of the wall. Full-sized images may be viewed upon request.

**Figure 7:** Photopoint 2 images over time with views in each cardinal direction pre-clearing (June 2016); post-clearing and after the initial outplantings (January 2018); and at five years (September 2022) post-completion of the wall. Full-sized images may be viewed upon request.

**Figure 8:** Photopoint 3 images over time with views in each cardinal direction pre-clearing (June 2016); post-clearing and after the initial outplantings (January 2018); and at five years (September 2022) post-completion of the wall. Full-sized images may be viewed upon request.

**Figure 9:** Photopoint 4 images over time with views in each cardinal direction pre-clearing (June 2016); post-clearing and after the initial outplantings (January 2018); and at five years (September 2022) post-completion of the wall. Full-sized images may be viewed upon request.

**Figure 10:** Photopoint 5 images over time with views in each cardinal direction pre-clearing (June 2016); post-clearing and after the initial outplantings (January 2018); and at five years (September 2022) post-completion of the wall. Full-sized images may be viewed upon request.

## DISCUSSION AND RECOMMENDATIONS

### *Weed cover goals and management considerations*

The weed cover goal of < 10% continued to not be met in Year 5, though the trend of increasing weed cover, particularly weedy grasses and a resurgence of *C. hirta*, stabilized during the year. The enclosure has been scheduled for weeding at least once per quarter, to address the continual influx and spread of weeds, with particular emphasis on controlling target and zero tolerance taxa (ANRPO 2022b). However, weeding efforts have not always been consistent or covered the entirety of the enclosure, in part due to the COVID-19 pandemic, as well as concerns about foliar sprays near the snail release site. Alien

grass has become increasingly challenging to control, and control efforts in recent years included the use of Ranger Pro, and were limited to more open areas to avoid negative impacts to native vegetation.

It was anticipated that weed cover would be most challenging to maintain in the first few years following clearing, with invasive pioneer species flushing out in the newly opened habitat. It was further anticipated that as native vegetation filled in, weed management would be less challenging. However, weed management was easiest to maintain in the first year, and became increasingly difficult in Years 2-4. This pattern has also been observed in recent years at other restoration sites, where the "middle" years are the most challenging for weed management, as weeds come in because it is still fairly open, but natives are also filling in, limiting the use of some tools like foliar sprays. The earliest invaders were primarily Asteraceae, *P. octandra*, and grasses, which were readily controlled using herbicide and/or hand pulling (ANRPO 2022b), as native cover in the 0 – 1 m stratum was very low, and individual native plants were isolated and easily avoided. As native cover expanded, the early invading Asteraceae and *P. octandra* fell out, but cover expanded for shade tolerant taxa *P. conjugatum*, *E. stipoides*, and *C. hirta*. Weedy grass cover in particular became increasingly difficult to manage. In Year 5, weed cover stabilized in the 0 – 1 m stratum, though control efforts were similar to prior years. This may have occurred as there was less room for expansion because of extensive native vegetation infilling.

Continuing efforts to manage weed cover will be necessary in the coming years. The goal of having < 10% weed cover is not feasible at this point, given how widespread grasses became by Years 4 and 5. Ongoing refinement of the methods, the timing of, and the extent to which grass control should occur is warranted. Challenging issues for grass control include 1) the limited capacity for grass specific herbicides such as Fusilade to control *P. conjugatum* and *E. stipoides*, 2) non-target impacts using broad spectrum herbicides such as Ranger Pro on grass that is tightly intermixed with native vegetation, 3) hand pulling is not ideal for such widescale grass infestation, and, most concerning, 4) the potential threat to snails from foliar sprays, as snails primarily occur in the understory, given the limited amount of canopy present. Given these challenges, and because snails are becoming increasingly widespread as they continue to migrate away from the original release site, foliar grass sprays are no longer appropriate.. Considerations should be made regarding if and where hand clearing should occur, e.g., if there are any outplants that appear to be negatively impacted by grass, and methods for clearing grass by hand should be explored. More aggressive forms of grass control may eventually be resumed once the canopy forms, native shrubs are not so intermixed with the grasses, and snails migrate to strata well above the grass layer. If the Snail Extinction Prevention Program (SEPP) releases ground dwelling snails into the enclosure, that should also be a consideration with respect to grass control. Perhaps the release of ground dwelling snails should not occur until grasses are better controlled. Further discussion is recommended regarding additional restoration inputs, such as *C. polystachyos* seed sows, to create more ground cover in place of weedy grasses, and/or to fill any remaining open areas that could be colonized by weedy grasses. General ecosystem weeding should continue to be prioritized to be thoroughly conducted across the entire enclosure, perhaps only twice a year, to minimize trampling of native vegetation. These efforts should focus on specified control targets *C. hirta*, *P. suberosa*, *P. cattleianum*, *R. rosifolius*, and *S. terebinthifolius*. Zero target taxa *B. appendiculatum*, *N. brownii* and *D. cordata* var. *pacifica* should also be comprehensively controlled before they become more widespread.

***Native cover goals and management considerations***

Substantial increase in native vegetation cover occurred in the first five years as a successful result of both active and passive restoration. In Year 5, the native cover goal for the 0 – 1m stratum continued to be surpassed, and the goals for the 1 – 2 m stratum and total AGL were nearly met. Cover in the > 2 m stratum appears to be on track for meeting its goal in the coming years. The decline in *C. polystachyos* is not particularly concerning, as it was largely intended to function as a ground cover during the early stages of restoration. This taxon favors open sunny areas, and possibly dropped off as

native vegetation filled in and/or is perhaps short-lived. Though useful and acceptable as a temporary ground cover, it is not an ideal long term component in snail enclosures. Sedge cover presents challenges to snail enclosure maintenance, as dense sedge cover is difficult to inspect during quarterly *E. rosea* sweeps.

Specific goals for native vegetation cover were constructed to guide restoration efforts and to trigger additional restoration actions if those goals were not met. This was particularly important in the early years of restoration as intensive efforts were needed to rapidly establish sufficient habitat for the release of *A. mustelina*. As the native cover goals are either met or on track towards being met, additional restoration actions are not triggered. No additional restoration inputs are planned at this time, though deliberations may continue, e.g., regarding *C. polystachyos* seed sows.

Restoration actions are not new for the program, however, this restoration site is the first to have specific aggressive goals within a narrow timeframe, given the pressing need for suitable protected habitat for *A. mustelina*. As such it continues to be an excellent learning opportunity for planning, execution, and practical timelines for fully restored habitat and habitat readiness for use by endangered animals. Qualifications for the level of restoration suitable for the release of *A. mustelina* have not been studied. Though dense multi-layered host vegetation is presumed ideal, partially restored vegetation may be sufficient for releasing snails. Stable or increasing *A. mustelina* populations may also be used as a measure of vegetation rehabilitation success. Prior to vegetation monitoring in 2022, a total of 347 ESU-E snails (including wild snails from ʻĒkahanui and snails from the SEPP captive rearing facility) had been released in the enclosure since December 2018, and the population at the release site has remained stable (ANRPO 2022c). The release area (approximately 40 $m^2$) was initially bounded by a low plywood wall with an internal electric barrier to prevent snails from traversing out into areas of sparse vegetation where they may encounter environmental stress, and to facilitate monitoring of survival and mortality within a confined area. Restricting snails to a smaller area also maximized the opportunity for snails to encounter one another and potentially reproduce. The electronic barrier further ensured that snails did not escape over the wall of the larger enclosure, where they would not be protected from predators, and could potentially intermix with ESU-F *A. mustelina*. Shade cloth and a drip irrigation system were installed to enhance shade and moisture levels. By Year 3, because the vegetation in the release site had become so dense, the shade cloth and irrigation were discontinued. As vegetation within and adjacent to the release area continued to expand towards and over the plywood wall, small numbers of snails began to make their way into the larger enclosure. Through Year 3, those found outside the plywood wall were moved back inside for added protection and to enhance fecundity. Following Year 3, there was less concern regarding snails encountering environmental stress in the larger enclosure, given the continued expansion of vegetation cover in the surrounding area; the temporary wall ceased to be maintained, vegetation growing over the wall was no longer trimmed, and staff stopped moving escaped snails back inside the temporary release site. In Year 5, the temporary barrier was removed, allowing snails to more freely migrate into the surrounding vegetation. Given the expanded presence of *A. mustelina* beyond the original release site, staff walking around or applying herbicide in the areas adjacent to the release site should be careful and cognizant that snails are present (though not necessarily observed) in these areas, and foliar herbicide sprays should be limited or avoided altogether. The ongoing success of snail releases at the Palikea North snail enclosure continues to indicate an unexpected level of *A. mustelina* resilience within small confined islands of dense, short stature host vegetation, and persistence as the surrounding vegetation gradually fills in, such that the early stages of vegetation restoration as characterized here are sufficient for snail releases. It also suggests that protection against predators is a more pressing concern for snail persistence than habitat quality.

While the Palikea North snail enclosure was constructed to house and protect *A. mustelina*, the goal of restoration efforts at the enclosure was to achieve a native dominated plant community favorable for *A. mustelina* as well as *D. substenoptera*, *D. montgomeryi*, and *C. ibidis*. An emphasis was placed on

outplanting suitable host taxa for *A. mustelina* (60% of outplants) (Table 1). By Year 5, *A. mustelina* host taxa covered 39% total AGL. *Cheirodendron trigynum* and *Touchardia oahuensis*, host plants for *D. substenoptera* and *D. montgomeryi*, respectively, were extensively outplanted. By Years 4 and 5, *C. trigynum* were growing into the canopy; *T. oahuensis*, though not as fast growing, is anticipated to expand in the coming years. Arthropod richness and abundance, including estimated *C. ibidis* prey, has been found to be positively associated with higher native plant cover, and negatively associated with higher non-native plant cover (Krushelnycky 2013). The transformation of the snail enclosure area from non-native to native dominated forest is presumed to benefit *C. ibidis* by enhancing prey abundance and diversity. Measures of vegetation rehabilitation success were specified to include increasing native vegetation as well as utilization of the enclosure by *A. mustelina*, *D. substenoptera*, *D. montgomeryi*, and *C. ibidis*. With the substantially increased native vegetation cover in the higher strata and ongoing successful use of the enclosure by *A. mustelina* through Year 5, the early stages of vegetation rehabilitation continue to have positive results, with the restoration goal in essence being met for achieving a native dominated community favorable for *A. mustelina*. Additional headway is anticipated as restoration progresses, with further improved habitat for *A. mustelina*, and eventual establishment of habitat suitable for *D. substenoptera*, *D. montgomeryi*, and *C. ibidis*.

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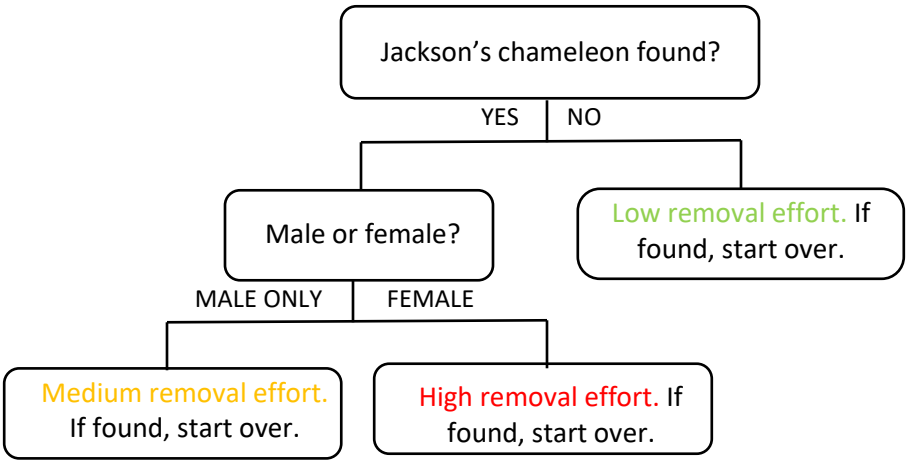
**Jackson's Chameleons Search Protocol**

Highremoval effort = once chameleon(s) found, full search of enclosure to be scheduled ASAP. Full search includes staff searching on foot as well as tree climbers searching in trees* until all areas/trees have been searched. After this initial search, full searches will continue quarterly for a year. Searches may be conducted during quarterly snail TCM, however, observers should be dedicated to a single target.
Medium removal effort = once chameleon(s) found, full search of enclosure to be scheduled ASAP. Full search includes staff searching on foot as well as tree climbers searching in trees until all areas/trees have been searched. After this initial search, on-foot searches only (no tree climbers) will continue during the course of quarterly snail TCM; these searches should cover the entirety of the enclosure.
Low removal effort = on an annual basis: for 3 of the 4 quarterly TCM trips to each enclosure, on-foot searches to occur during the course of quarterly TCM, in the areas where snails are being counted. For one of the quarterly TCM trips to each enclosure, a full search will be conducted.

*Tree climbers are only searching for Jackson's Chameleons
This protocol differs from EugRos in that there is no initial search when enclosure is built. May discuss in future, but this is intended for existing enclosures.



**Protocol for Rosy wolfsnail *(Euglandina rosea* s.l.*)* removal, control and maintenance within rare tree snail enclosures**

**Goal:** Eradicate any resident rosy wolf snails (RWSs) from new predator proof fences (enclosures) prior to rare snail introduction/reintroduction. Following rare snail (*Achatinella*) establishment, ensure any RWS incursions are caught early and extirpated before reproduction can occur and grow the population.

**Approach**:

1. Conduct adequate surveys to have confidence RWSs are absent from the enclosure prior to *Achatinella* introduction.
2. Conduct regular surveys for RWSs to ensure no ingress has taken place.
3. Be alert for signs of RWS presence within the enclosure (*e.g.* live snails, fresh shells or eggs) and, if found, promptly initiate surveys. If the RWS is of reproductive size any offspring will be extremely difficult to find until they have grown to at least 20 mm in size (S. Joe *unpub. data*).
4. Survey frequency and duration should be maximized for efficiency. Improvements to barrier design, better understanding of the probabilities surrounding RWS detection and other relevant research will lead to more targeted surveys with less labor.

**RWS reproductive biology**: The following data are all taken from Jerlach (1994). Under optimal laboratory conditions (between 77 and 86º F and full feeding) RWS takes 263 days reach reproductive size (>31 mm). Eggs were more commonly laid after 386 days when RWS surpassed 40 mm in size. Nine eggs on average were produced per clutch and snails emerged after one month.

| Life stage | Description | Size | Age |
|---|---|---|---|
| Hatchling | prior to shell thickening | <10 mm | 0-41 days |
| Juvenile | thickened shell, immature | 10-30mm | 42-311 days |
| Subadult | sexually mature, not full grown | 31-40mm | 312-460 days |
| Adult | full grown | >40mm | 460-550 days |

The majority of RWSs collected by staff inside and outside enclosures are reproductive adults or subadults. Detection and removal of their offspring (eggs, hatchlings and juveniles) has been comparatively rare. Measurements of RWSs collected by staff opportunistically in 2021 were, on average 41 mm (N = 30). Assuming RWS wild populations are not comprised of 99% mature snails but instead contain sizable proportions of hatchlings and juveniles, it is clear their small size makes them very difficult to find.

**RWS feeding behavior**: Jerlach (1994) found adults preferentially consumed 100% of prey offered at the smallest size class (<15 mm). They consumed 80% of prey between 16-20 mm and 40% of prey between 21-30 mm. This preference was found to be flexible (Meyer & Cowie 2010). Prey that was formerly rejected when paired with smaller prey was later consumed when paired with even larger prey. When presented prey between 1 and 30 mm, RWSs have been observed to consume up to three snails per day (Meyer & Cowie 2010). *Achatinella* are approx. 4.50 mm at birth and grow to a maximum size of 20 mm (Severns 1981) meaning they are at risk of consumption by RWSs throughout their lifetime.

**RWS surveys:** Searches take place during the day by staff trained to recognize RWSs as well as eggs. Fresh, marked, RWS shells may be intentionally hidden for staff to find during surveys. This not only provides data on overall detectability of RWS at different age classes and under different vegetative

conditions, but it also allows searchers to remain both focused and motivated when no RWSs are found for long periods (see ANRPO Annual Report 2021, Chapter 9, Section 9.1).

RWSs are cryptic and hard to find. Data on searcher detection rates of marked shells is only available for four surveys so far (see table below). On average, searchers recovered 88% of shells, however, in no instance were 100% of shells found during the survey. It appears detection rates improve with more search effort (more person-hours per survey) however, given there are only two replicates for each enclosure, data has not been standardized by area, and the many differences between the enclosures (vegetative cover or canopy height) this is presented tentatively. Because of the cryptic natural coloration of RWS, even the person responsible for hiding the shell sometimes had difficulty recovering it after the end of the survey.

| Survey effort (combined staff time on single day) | Enclosure | Proportion of RWSs detected (N = 12-24 per survey) |
|---|---|---|
| 15 person-hours | South Kahanahāiki | 75 % |
| 24 person-hours | Ka‘ala | 83 % |
| 40 person-hours | South Kahanahāiki | 96 % |
| 42 person-hours | Ka‘ala | 98 % |

1. Prior to enclosure completion, any leaves, twigs, or branches which provide habitat for RWSs should be raked and removed. A leaf blower is useful for this purpose. Care should be taken not to pile debris in proximity to the enclosure as this only attracts more RWSs from the surrounding area, and increases the likelihood of an incursion should one of the barriers fail. All obscuring grasses, sedges, ferns or other understory vegetation should be removed as necessary to facilitate searching for RWSs.
2. Following enclosure completion, any accumulated debris that may harbor RWSs should again be removed. Removal of understory vegetation may be required following *Achatinella* introduction and establishment if RWSs persist across multiple surveys.
3. Following enclosure completion and removal of debris, RWS searches are conducted according to the schedule outlined below in Figure 1.

RWS survey time is apportioned as follows. Approximately 60% is spent searching for RWSs on the ground, 30% searching the understory, and 10% searching the canopy with binoculars. A complete survey is defined as one where on a single day, staff has searched for RWSs on the ground, understory, and canopy roughly according to the time ratio specified above. This differs from our previous method described in Appendix 3-4 for the Puu Hapapa enclosure (ANRPO 2012) wherein a minimum number of hours of search time defined a complete survey. However, given that enclosures vary greatly in size, canopy height, and ground cover, it is more important to emphasize all visible areas within the enclosures be searched thoroughly. Large enclosures with heavy vegetation and a high canopy require more time to search. In such enclosures no amount of time will reveal a RWS hidden in the canopy or too small to be viewed by searchers on the ground. As surveys are repeated at intervals over time however, RWSs will grow making them more easily detected. A RWS missed due to its location in the canopy, or buried under soil may move to an area where it would be visible.

We have set minimum survey intervals in an attempt to balance the risk of RWS establishment against practical limitations on staff resources. We also wanted to standardize the process by which we cleared RWSs from all of the enclosures. While it reflects the best information we have to date, it is nonetheless subjective and may be updated based on new data.

If RWSs are discovered at any point in the surveys the highest level of RWS removal is triggered for another four surveys regardless of when the find occurred. Though labor intensive, exhaustive surveys are the only

means we have to control RWSs. Investigations into all aspects of RWS ecology, including basic knowledge of habitat utilization (time spent on the ground vs. in the canopy for example), will greatly aid efforts to conserve *Achatinella* into the future.

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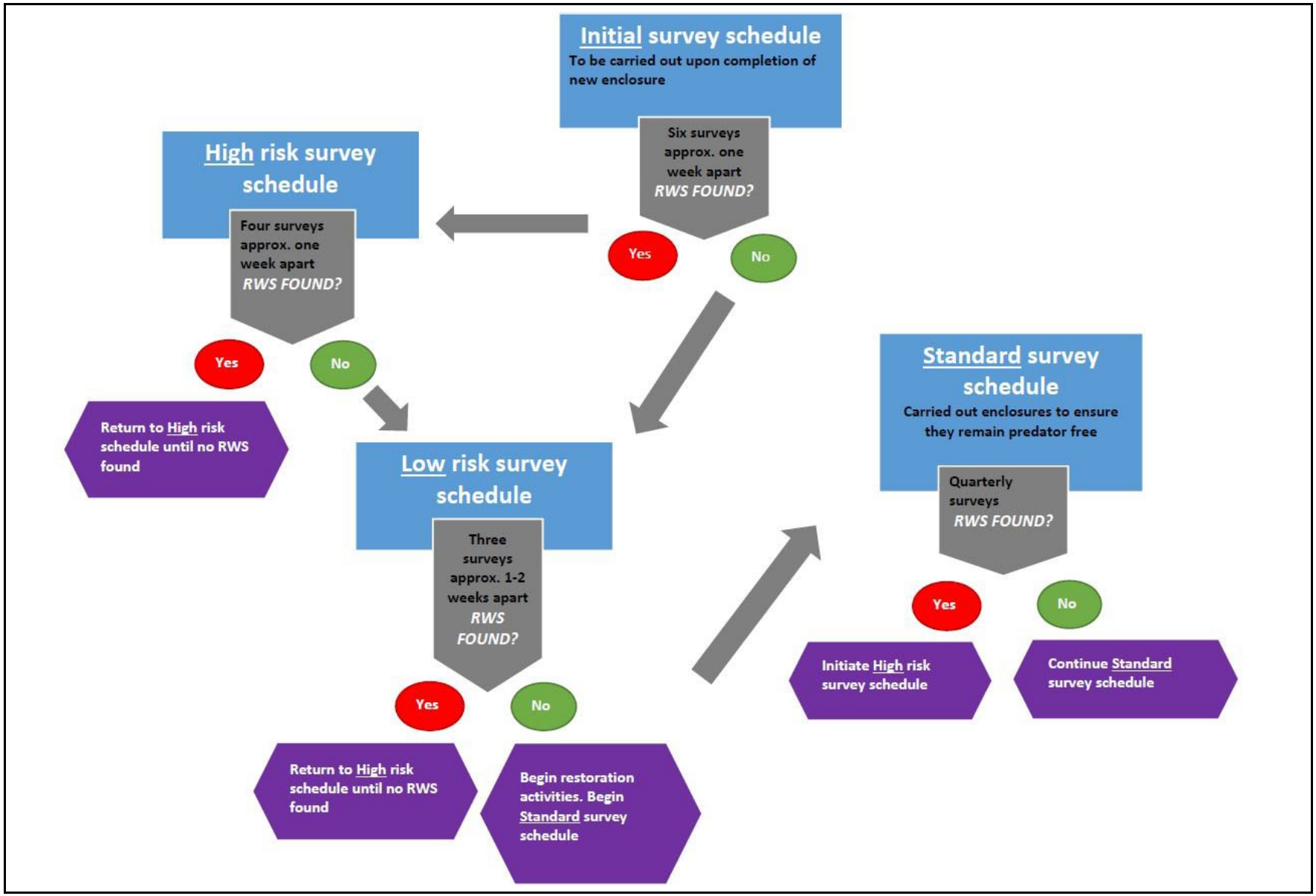
**Figure 1:** Flowchart of *Euglandina rosea* survey protocol for tree snail enclosures

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