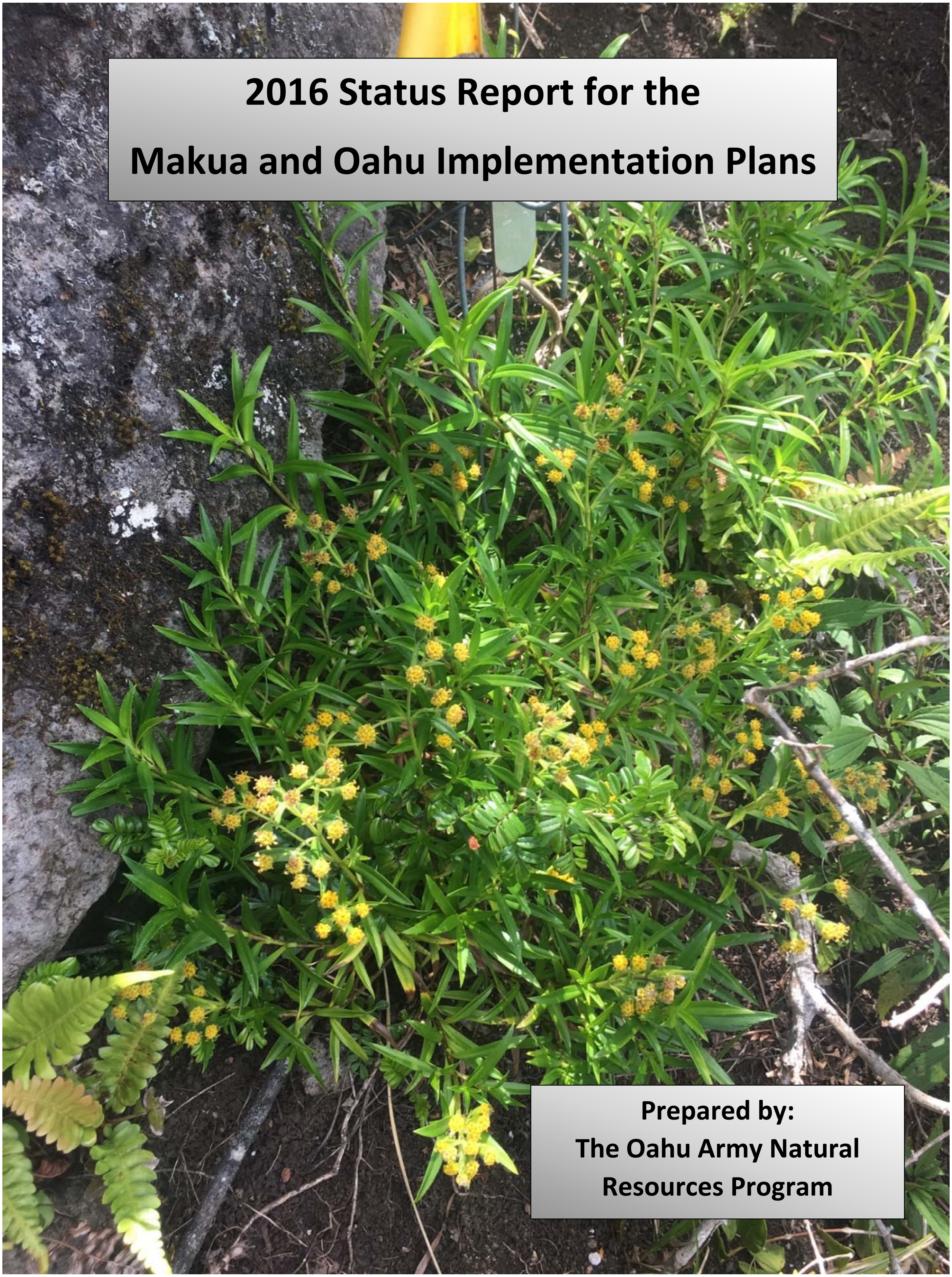
2016 Status Report for the Makua and Oahu Implementation Plans



Prepared by:
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*Cover photo: *Dubautia herbstobatae* reintroduction on the cliffs of Makaha Valley.

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EXECUTIVE SUMMARY

The Oahu Army Natural Resources Program (OANRP) has 60 personnel on staff, comprised of management and administrative support staff, an ecosystem restoration crew, an ungulate management crew, three resource management crews, and a nursery/seed bank crew. Most of these staff are employed via a Cooperative Agreement funded by the Army through the Pacific International Center for High Technology Research (PICHTR) and administered by the Research Corporation of the University of Hawaii-Pacific Cooperative Studies Unit (PCSU). Staff levels in Fiscal Year (FY) 2016 were slightly higher than those in FY 2015. For FY 2016, OANRP received a total of $6,210,148 to implement Makua Implementation Plan projects and Tier 1 projects from the Oahu Implementation Plan. This included funding for new and ongoing research initiatives, contracted fence construction projects, contracted bat survey work, and ongoing rat control services. As in FY 2015, for FY 2016, OANRP did not receive funding for OIP Tier 2 and Tier 3 projects as there was no training conducted that could impact the species at the Tier 2 and 3 levels, as specified in the 2003 Oahu Biological Opinion.

This status report (report) serves as the annual report for participating landowners, the U.S. Fish and Wildlife Service (USFWS), and the Implementation Team (IT) overseeing the Makua Implementation Plan (MIP) and Oahu Implementation Plan (OIP). The period covered in this report is July 1, 2015 to June 30, 2016. This report covers Year 12 of the MIP and Year 9 of the OIP.

Hawaiian diacriticals are not used in this document except in some appendices in order to simplify formatting. Please refer to Appendix ES-1, *Spelling of Hawaiian Names*.

OANRP completes thousands of actions each year to implement the MIP and OIP (IPs); the results of those myriad activities are summarized in this report. The report presents summary tables analyzing changes to population units of plants and snails over the last year and since the IPs were completed, as well as updates on new projects and technologies. More detailed information for all IP taxa is available via the program database supplied on CD (see Appendix ES-2 for a tutorial of how to use this database).

OANRP is reporting on the twelth year of the MIP Addendum (Addendum completed in 2005, original finalized in 2003) and the ninth year of the OIP (finalized in 2008). The MIP Addendum emphasized management for stability of three Population Units (PUs) per plant taxon in the most intact habitat and 300 individuals of *Achatinella mustelina* in each Evolutionarily Significant Unit (ESU). The original Makua Biological Opinion (BO) in 2007 and amended BO in 2008, both issued by the USFWS, require that the Army provide threat control for all Oahu Elepaio (*Chasiempis ibidis*) pairs in the Makua Action Area, stabilize 28 plant taxa and *Achatinella mustelina*, and take significant precautions to control the threat and spread of fire as a result of the 2007 Waialua fire that destroyed individuals and habitat of *Hibiscus brackenridgei* subsp. *mokuleianus*. The OIP outlines stabilization measures for 23 additional plant taxa, the Oahu Elepaio, and six extant Koolau *Achatinella* species. Since the OIP was finalized, two additional species were added requiring stabilization, *Drosophila montgomeryi* and *Drosophila substenoptera*. Of the OIP plants, management activities are conducted with eleven taxa that are present in the Schofield Barracks West Range Action Area and in the Kahuku Training Area. In 2016, OANRP did not receive funding to support the remaining 12 OIP plant taxa and the six Koolau *Achatinella* species because of the lack of Army training impacts to these taxa in the Kawailoa Training Area. The MIP and OIP also requires surveys of Army Landing Zones for weeds and the prevention and control of weeds on training areas.

The Army contracted the Center for Environmental Management of Military lands based at Colorado State University to prepare an updated biological assessment for the Army to enter into formal consultation for Oahu training ranges (including Makua Military Reservation). This document will include an analysis of the potential impacts from Army training (including weed spread) on the twenty plant taxa given federal status in August 2012. The decision was made recently to include Makua Military Reservation in this Biological Assesssment (BA), while in previous consultations, Oahu and Makua had been kept separate. This approach allows the Army to present a combined analysis of impacts to Oahu's endangered species. The draft BA is expected in December 2016 and a Biological Opinion from the USFWS is anticipated by the middle of 2017 calendar year. Management or stabilization requirements will be determined through the consultation process and outlined in the Biological Opinion to be issued upon completion of this process.

<u>Infrastructure</u>

The OANRP baseyard located on Schofield Barracks is complete. This baseyard includes three office buildings, one greenhouse, a seed storage facility, a workshop, an invasive species mitigation area (i.e., wash rack), pesticide storage, gear storage areas, and an interpretive garden. A generator was installed at the OANRP baseyard during this reporting period to serve as a backup power source for the seed storage equipment and nursery watering system. Nursery improvements also included partially covering shadehouses with plastic to improve fungal and pest control, automating the watering system, and increasing capacity for a common native growing area. OANRP was recently granted permission to utilize the former landfill site directly adjacent to Area X for a living collection orchard for some of endangered plant species. This site will be planted in FY 2017. Outreach staff continue to maintain the East Range baseyard because it is a convenient location to rendez-vous for volunteer trips. Also, with the assistance of a combat engineering unit, significant improvements were made to a landing zone and access road near the Kaluaa-Waieli Management Unit. Various field infrastructural improvements unrelated to fencing were also done including several new water catchments, a culvert repair and erosion control at Schofield Barracks North Firebreak Road, and erosion control improvements to two snail enclosures. Access to several areas in the Kahuku Training Area was also improved with the assistance of Army Explosive Ordnance Disposal units who blew up or removed old ordnance found in the course of field work.

<u>Landowner/Agency Cooperative Agreements and Partnerships</u>

OANRP could not meet stabilization goals without the cooperation of public and private landowners and agencies. OANRP continues to operate under a 20-year license agreement with Kamehameha Schools (KS) (expiring November 2030) and a license agreement with Hawaii Reserves, Inc. (expiring March 2017). The four-year license agreement with the Honolulu Board of Water Supply expired in November 2014; however; the Army and BWS real estate staff are actively working on a renewal. In addition, the Army did acquired a right of entry permit with the new landowners for *Hibiscus brackenridgei* subsp. *mokuleianus* surveys and monitoring in the Waialua area. The Army also continues to work cooperatively under an MOU with the U.S. Navy for work in Lualualei Naval Magazine. Lastly, the Army renewed its annual right of entry permit to protect Oahu Elepaio on Gill and Olson properties at Palehua.

In July 2011, an MOU was signed between the Army and the State of Hawaii (State), Department of Land and Natural Resources (DLNR). Currently, the Army holds six State of Hawaii permits, including a Natural Area Reserves Special Use Permit, a Threatened and Endangered Plant Species Permit, an Invertebrate Permit, a Forest Reserve Access Permit, a Conservation District Use Permit, and a Protected Wildlife Permit. The Army and the State are nearing finalization of a rental agreement for OANRP's use of the NIKE site mid-elevation greenhouse and associated facilities. A signed lease is expected before the end of the 2017 calendar year.

OANRP continues to provide and receive support from partner agencies including the Oahu Invasive Species Committee, Oahu Plant Extinction Prevention Program (OPEPP), Snail Extinction Prevention Program (SEPP) and the Koolau and Waianae Mountains Watershed Partnerships. The Army is also an official member of the Koolau Mountains Watershed Partnership, the Waianae Mountains Watershed Partnership, the Coordinating Group on Alien Pest Species, the Hawaii Rare Plant Restoration Group, the Pacific Island Climate Change Cooperative and the Hawaii Conservation Alliance. Highlights of our partnership work over the last fiscal year included massive fence gear lifts using Army heavy lift helicopters for State watershed fences in the Poamoho area, staff exchanges for high priority incipient invasive weed control in the Koolau Mountains, aerial spraying of a highly invasive fern in the new State of Hawaii Poamoho fence, cooperative predator removals in ungulate fences and rare snail enclosures, and numerous habitat improvements for endangered plant and invertebrate OPEPP and SEPP species.

Management Unit (MU) Protection

Management Unit protection continued on several fronts during this reporting period through 1) ungulate control/fencing efforts, 2) aggressive weed control including control of incipient invasives, 3) an expanded effort at active habitat restoration through outplanting of common natives, and 4) an expanded rodent control effort in several MUs.

During this reporting period, OANRP completed fence construction of the remaining section of fence around the perimeter of Makua Valley. This last section was located along the western edge of Kaluakauila Gulch and down to Farrington highway. OANRP also contracted the replacement of the last 1800 meter section of our existing Ohikililolo fence near the mouth of Makua Valley because of deterioration. Construction was completed in early summer of 2016. Pig removal efforts are now ongoing for the entirety of Makua Valley as the entire installation is now fenced. Fencing the entirety of MMR was listed as a requirement by the USFWS in the original MIP.

OANRP also contracted the replacement of 400 m of fence along the Opaeula/Helemano MU, about 2700 m of skirting, and replacement of the hypalon stream crossing barrier. Work was completed in the fall of 2015.

In addition to fence construction work, OANRP secured funding for two small fences at West Makaleha and Kaala MUs. The West Makaleha fence will be an expansion of our existing 3 Pts. enclosure to secure additional rare plant and snail habitat. The Kaala fence will also be an extension of an existing fenced area to better secure the plateau area from pig incursion via the headwaters of Waianae Kai Valley. Completion of those two small fences is anticipated in FY 2017 and work will be performed by subcontractors. For more details about OANRP ungulate control see Chapter 1.

As reported previously, OANRP transitioned our ecosystem management efforts to more intensive MU weed control and restoration.

In this reporting period, OANRP spent 8,447 hours controlling weeds across 540 ha. Incipient Control Area (ICA) efforts accounted for 388 ha of this total which is 72% of the total area over which weeds were controlled. Staff spent 2,452 hours on ICA management and conducted 539 visits to 175 ICAs. The ICA totals represent an increase from previous reporting periods. Some of this increase is due to aerial treatment of *Chromolaena odoratum* using helicopters. Weed Control Area (WCA) efforts covered 151 ha which is an increase from last year's effort. OANRP conducted control in WCAs for a total of 5,995 hours over 713 visits at 156 WCAs. See Chapter 3 for a comparison to last year's control figures.

OANRP conducted 90 road, landing zone, and weed transect surveys in order to detect and prevent the spread of any newly introduced invasive species. OANRP submitted 53 non-native plant samples to the Oahu Early Detection Program at Bishop Museum collected both during these surveys and during the course of regular work activities. Of these, one was a new state record, and two were new island records. Highlights are covered in Chapter 3.

OANRP has completed a total of 22 Ecosystem Restoration Management Unit Plans (ERMUPs) for the highest priority and largest MUs. Four ERMUPs (three updates and one new plan) are included in this year's report (see Appendices 3-1 to 3-4). Notably, the State Natural Areas Reserve System (NARS) program also completed a comprehensive draft management plan for the Pahole NAR which OANRP will also use to guide our weed control and habitat stabilization efforts in the Kapuna and Pahole MUs.

Native Habitat Restoration Program

Complementary to our other threat control programs, our additive restoration work expanded during this past reporting period. In seven MUs, and across nearly three acres, 1,743 common native plants were planted to supplement native recovery of weeded areas, provide additional host plants for rare snails, and rare *Drosphila* sp. flies, and help stabilize the habitat for rare plants. Four MUs received the bulk of common outplants, Ohikilolo Upper and Ohikilolo Lower, Palikea, and Kahanahaiki. Seed sows of other common native species (e.g *Bidens torta, Pipturus albidus)* also occurred at restoration work sites. See Chapter 3 for more information on habitat restoration efforts.

Rodent Control Program

OANRP directed rat and mice control across several levels of effort in our MUs: 1) Small trap grids were used for seasonal and year round localized rodent control around rare plant and snail populations, 2) Large trap grids were used for seasonal and year round rodent control across MUs for native habitat, rare plant, snail, and elepaio protection, and 3) MU wide dispersal of a hand broadcasted rodenticide was used for a pilot experimental project at one of our MUs. We partnered with the U.S. Department of Agriculture, National Wildlife Research Center for a large application of rodenticide to control rat population spikes at the Kahanahaiki MU in the fall of 2015 as our trap grid was not meeting our rodent control goals during periods of high food availability. We also conducted a smaller hand broadcast of rodenticide at our Ohikilolo MU in June of 2016. See Chapter 8 Rodent Control for details on these pilot projects.

We again expanded the use of the Goodnature® automatic traps to reduce labor costs of rebaiting traps. A large rodent control grid was established in the Makaha Unit 1 fence area during this reporting period. See Chapter 8 for details.

Lastly, OANRP continued to test new baits in all traps to maximize bait availability and lengthen rebaiting intervals. For more details about the OANRP rodent control program see Chapter 8 as well as Chapter 9 for a slug repellent/rat bait study using citric acid.

Monitoring Program

Our OANRP monitoring program consisted of a number of projects: baseline and follow-up vegetative community monitoring, weed control analysis, rare plant recruitment following *in situ* seed sowing and rodent control efforts, climate analyses of small snail enclosures, and seed viability analyses.

During this reporting period, OANRP monitored the Kaluaa and Waieli MU, the Manuwai MU, and Kamaili Mauka and Makai Subunits of this MU (Appendices 3-10, 3-11, 3-4A and 3-4B respectively).

Regarding remote sensing and weed control efforts, OANRP supported the final year of a University of Hawaii research project which compared satellite imagery, aerial imagery and gigapan robotic technology (Gigapan) for collecting vegetation monitoring data (Appendix ES-11). OANRP continues to use Gigapan to analyze fountain grass control efforts at MMR (Appendix 3-12), and has applied Gigapan technology in partnership with the State of Hawaii to monitor *Angiopteris evecta* control efforts. OANRP staff also conducted understory vegetation monitoring of a MU wide *Morella faya* tree control program at Palikea (Appendix 3-13).

Regarding native habitat and rare plant stabilization monitoring efforts, staff:

- Monitored ongoing vegetation changes at the Kahanahaiki chipper plot (Appendix 3-8)
- Conducted baseline monitoring for the proposed ESU-E snail enclosure at Palikea (Appendix 3-7)
- Conducted gigapan shrub cover analyses of the Lower Ohikilolo *Hibiscus brackenridgei* var. *mokuleianus and Euphorbia celastroides* var. *kaenana* patches at MMR (Appendix 3-2A)
- Took baseline gigapan images of the Kahanahaiki Subunit II area
- Monitored recruitment rates and the recovery of *Pritchardia kaalae* at the Ohikilolo MU given ongoing rodent control
- Monitored recruitment rates at a *Delissea waianaeensis* seed sowing trial in the Pahole MU
- Analysed microsite climate data at the two Ekahanui snail mini-enclosures (Appendix 5-1), and
- Conducted a follow-up laboratory trial of seed germination in senescing *Cyanea superba* subsp. *superba* fruit (Appendix 4-1)

<u>Fire Management</u>

During this reporting period, one large and several small fires occurred on Army training areas and adjacent to our MUs.

On October 29, 2015 a 5.78 acre fire burned unoccupied elepaio critical habitat in East Range, possibly started by a campfire. During the week of February 8th 2016, during Lightning Forge training exercises, four small fires totaling less than 10 acres burned in the Kahuku Training Area. The causes of the Kahuku fires were not fully determined. See Appendix ES-12 for further information regarding these fires.

In May of 2016, the Army conducted another successful, large prescribed burn at Schofield Barracks. The burn reduced fuel within the impact area as planned. No fires have occurred outside the Schofield Barracks firebreak road from training nor have any fires occurred at Makua Military Reservation.

During the week of March 14th, 2016 a huge fire burned about 70% of Nanakuli Valley. No OANRP helicopter support was provided and no MIP/OIP taxa were apparently affected although the fire came close to burning into the Palikea MU and two populations of MIP/OIP taxa.

Along the Kaukonahua Road leading to Waialua town, one of the landowners (Ameron) now voluntarily mows (albeit sporadically) the large swath of guinea grass on the western side of the road to prepare it for sale. In past years, OANRP contracted this mowing and spraying work to reduce the fuel load given the devasting fire of 2007 which burned nearly the entire wild population of *Hibiscus brackenridgei* subsp. *mokuleianus.*

<u>Outreach Program</u>

Our outreach program is focused on training military members on environmental requirements and natural resource management issues, as well as community outreach through volunteer work trips, educational displays at community events, internships, and the production of publications and other media materials.

In 2016, 331 military members were trained during the Environmental Compliance for Officers course on Natural Resource Issues and were educated on Natural Resource Issues at Makua during 15 minute video presentations.

During this reporting period, volunteers contributed 3,575 hours on 68 field work trips and 538 hours volunteering at our baseyard. See Chapter 2 for more details on our Outreach Program.

Rare Plant Program

The Executive Summary tables on the following pages for the MIP and OIP plant taxa include current status (with totals not including seedlings), last year's population numbers, and the number of plants in the original IPs for comparison for each population unit. Genetic storage and ungulate protection status is also summarized for each PU. The number of PUs that have reached numeric stabilization goals are included.

As of the end of this reporting period, 45 of 101 MIP PUs (45%) and 14 of 31 (45%) PUs for OIP Tier 1 plant species are at or above the stabilization goal for minimum number of reproducing plants. All data tables are included on the CDs distributed to IT members. During this reporting period, OANRP outplanted a grand total of 1,430 individuals of 17 species of MIP and OIP taxa. In the last year, OANRP made 784 observations at in situ and outplanting sites.

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 the "% Completed of Genetic Storage Requirement" listed in the tables is 10%. Genetic storage for reintroduced populations is not required because those populations originate from other populations with their own genetic storage requirement. PUs with population sizes of zero and a genetic storage requirement of "n/a (reintroduction)" denote reintroductions that are planned but have yet to be conducted. The number of seeds in genetic storage approximates the number of viable seeds initially received for stored collections. Viability rates for most collections were estimated or calculated at the time of storage. For untested collections, seed viability was averaged from other collections within the same PU or taxon.

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 2015	# Plant In Original Report	% Completed Genetic Storage Requirement	% of Plants Protected from Ungulates	PU Met Goal?	# PU Met Goal
Alectryon macrococcus var. macrococcus	50											
		Central Kaluaa to Central Waieli	8	3	5	0	8	53	0%	0%	No	
		Kahanahaiki to Keawapilau	2	1	1	0	2	8	0%	100%	No	
		Makaha	29	29	0	0	36	75	16%	100%	No	
		Makua	6	6	0	0	11	15	25%	100%	No	
		Alectryon macrococcus var. macrococcus Total:	45	39	6	0	57	151				0 of 4
Cenchrus agrimonioides var. agrimonioides	50											
		Central Ekahanui	319	183	136	54	257	20	70%	100%	Yes	
		Kahanahaiki and Pahole	292	210	82	22	380	276	28%	100%	Yes	
		Makaha and Waianae Kai	289	161	128	5	299	12	50%	97%	Yes	
		Cenchrus agrimonioides var. agrimonioides Total:	900	554	346	81	936	308				3 of 3
Cyanea grimesiana subsp. obatae	100											
		Kaluaa	141	124	17	0	150	0	75%	100%	Yes	
		North branch of South Ekahanui	147	82	65	0	149	5	100%	100%	No	
		Pahole to West Makaleha	111	75	36	0	111	46	52%	100%	No	
		Palikea (South Palawai)	139	120	19	1	144	63	63%	100%	Yes	
		Cyanea grimesiana subsp. obatae Total:	538	401	137	1	554	114				2 of 4
Cyanea longiflora	75											
		Kapuna to West Makaleha	259	63	196	2	272	66	45%	100%	No	
		Makaha and Waianae Kai	306	119	187	0	317	4	33%	100%	Yes	
		Pahole	78	60	18	2	162	114	96%	100%	No	
		Cyanea longiflora Total:	643	242	401	4	751	184				1 of 3
Cyanea superba subsp. superba	50											
		Kahanahaiki	226	48	178	1	257	152	100%	100%	No	
		Makaha	199	27	172	246	199	0	N/A	100%	No	
		Manuwai	108	0	108	0	142	0	N/A	100%	No	
		Pahole to Kapuna	166	95	71	4	166	170	N/A	100%	Yes	
		Cyanea superba subsp. superba Total:	699	170	529	251	764	322				1 of 4

Makua Implementation Plan - Executive Summary - Plants

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[shaded] = 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 2015	# Plant In Original Report	% Completed Genetic Storage Requirement	% of Plants Protected from Ungulates	PU Met Goal?	# PU Met Goal
Cyrtandra dentata	50											
		Kahanahaiki	175	33	142	9	113	97	58%	100%	No	
		Kawaiiki (Koolaus)	92	13	79	2	84	50	0%	0%	No	
		Opaeula (Koolaus)	196	35	161	2	130	26	2%	100%	No	
		Pahole to West Makaleha	1502	610	892	261	1273	300	100%	100%	Yes	
		Cyrtandra dentata Total:	1965	691	1274	274	1600	473				1 of 4
Delissea waianaeensis	100											
		Ekahanui	219	196	23	0	219	58	86%	100%	Yes	
		Kahanahaiki to Keawapilau	257	240	17	0	259	34	88%	100%	Yes	
		Kaluaa	661	598	63	0	739	44	80%	100%	Yes	
		Manuwai	132	88	44	0	132	0	N/A	100%	No	
		Delissea waianaeensis Total:	1269	1122	147	0	1349	136				3 of 4
Dubautia herbstobatae	50											
		Makaha	81	79	2	0	29	0	72%	0%	Yes	
		Ohikilolo Makai	91	89	2	0	91	700	0%	100%	Yes	
		Ohikilolo Mauka	424	415	9	0	424	1300	0%	100%	Yes	
		Dubautia herbstobatae Total:	596	583	13	0	544	2000				3 of 3
Euphorbia celastroides var. kaenana	25											
		East of Alau	22	20	2	66	23	26	75%	0%	No	
		Kaena	1154	880	274	0	1475	300	100%	0%	Yes	
		Makua	85	85	0	0	85	40	94%	100%	Yes	
		Puaakanoa	131	120	11	0	166	157	56%	0%	Yes	
		Euphorbia celastroides var. kaenana Total:	1392	1105	287	66	1749	523				3 of 4
Euphorbia herbstii	25											
		Kaluaa	0	0	0	0	0	0	N/A	100%	No	
		Kapuna to Pahole	98	54	44	1	108	170	34%	100%	Yes	
		Manuwai	0	0	0	0	0	0	N/A	100%	No	
		Euphorbia herbstii Total:	98	54	44	1	108	170				1 of 3

Makua Implementation Plan - Executive Summary - Plants

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(shaded) = 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 2015	# Plant in Original Report	% Completed Genetic Storage Requirement	% of Plants Protected from Ungulates	PU Met Goal?	# PU Met Goal
Flueggea neowawraea	50											
		Kahanahaiki to Kapuna	136	6	130	0	129	32	29%	100%	No	
		Makaha	64	9	55	0	65	4	27%	44%	No	
		Manuwai	45	0	45	0	35	0	N/A	100%	No	
		Ohikilolo	1	1	0	0	1	3	50%	100%	No	
		Flueggea neowawraea Total:	246	16	230	0	230	39				0 of 4
Gouania vitifolia	50											
		Keaau	51	51	0	0	55	0	66%	0%	Yes	
		Makaha (Future Introduction)	0	0	0	0	0	0	N/A	100%	No	
		Manuwai (Future Introduction)	0	0	0	0	0	0	N/A	100%	No	
		Gouania vitifolia Total:	51	51	0	0	55	0				1 of 3
Hesperomannia oahuensis	75											
		Haleauau	1	1	0	0	1	0	100%	100%	No	
		Makaha	46	11	35	0	46	13	29%	100%	No	
		Pahole NAR	34	2	32	0	42	8	N/A	100%	No	
		Puaili	68	16	52	0	73	0	N/A	100%	No	
		Hesperomannia oahuensis Total:	149	30	119	0	162	21				0 of 4
Hibiscus brackenridgei subsp. mokuleianus	50											
		Haili to Kawaiu	66	44	22	0	8	4	88%	0%	No	
		Keaau	58	20	38	0	16	0	50%	100%	No	
		Makua	144	124	20	0	88	7	73%	100%	Yes	
		Manuwai	151	145	6	0	170	0	N/A	100%	Yes	
		Hibiscus brackenridgei subsp. mokuleianus Total:	419	333	86	0	282	11				2 of 4
Kadua degeneri subsp. degeneri	50											
		Alaiheihe and Manuwai	145	81	64	28	148	60	60%	96%	Yes	
		Central Makaleha and West Branch of East Makaleha	32	24	8	19	36	47	62%	0%	No	
		Kahanahaiki to Pahole	202	102	100	150	278	161	100%	100%	Yes	
		Outplanting site to be determined	0	0	0	0	0	0	N/A		No	
		Kadua degeneri subsp. degeneri Total:	379	207	172	197	462	268				2 of 4

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 2015	# Plant In Original Report	% Completed Genetic Storage Requirement	% of Plants Protected from Ungulates	PU Met Goal?	# PU Met Goal
Kadua parvula	50											
		Ekahanui	45	6	39	0	0	0	N/A	100%	No	
		Halona	35	31	4	0	121	64	100%	0%	No	
		Ohikilolo	215	112	103	0	257	66	100%	100%	Yes	
		Kadua parvula Total:	295	149	146	0	378	130				1 of 3
Melanthera tenuifolia	50											
		Kamaileunu and Waianae Kai	1061	815	246	274	1061	880	0%	0%	Yes	
		Mt. Kaala NAR	155	131	24	0	125	250	0%	100%	Yes	
		Ohikilolo	1099	1088	11	0	1117	2009	12%	100%	Yes	
		Melanthera tenuifolia Total:	2315	2034	281	274	2303	3139				3 of 3
Neraudia angulata	100											
		Kaluakauila	124	100	24	1	134	0	N/A	100%	Yes	
		Makua	75	68	7	13	126	29	44%	100%	No	
		Manuwai	207	110	97	14	199	12	80%	100%	Yes	
		Waianae Kai Mauka	13	11	2	0	16	46	61%	100%	No	
		Neraudia angulata Total:	419	289	130	28	475	87				2 of 4
Nototrichium humile	25											
		Kaluakauila	208	160	48	0	208	200	2%	100%	Yes	
		Makua (south side)	53	50	3	0	53	138	0%	100%	Yes	
		Manuwai	112	112	0	0	115	0	N/A	100%	Yes	
		Waianae Kai	290	155	135	0	270	200	4%	84%	Yes	
		Nototrichium humile Total:	663	477	186	0	646	538				4 of 4
Phyllostegia kaalaensis	50											
		Keawapilau to Kapuna	0	0	0	0	0	0	100%	100%	No	
		Makaha	0	0	0	0	0	0	N/A	100%	No	
		Manuwai	0	0	0	0	0	0	N/A	100%	No	
		Pahole	0	0	0	0	0	10	100%	100%	No	
		Phyllostegia kaalaensis Total:	0	0	0	0	0	10				0 of 4
Plantago princeps var. princeps	50											
		Ekahanui	83	7	76	0	239	33	84%	100%	No	
		Halona	15	6	9	0	11	50	49%	0%	No	
		North Mohiakea	51	39	12	0	51	30	38%	100%	No	
		Ohikilolo	8	8	0	0	0	14	71%	100%	No	
		Plantago princeps var. princeps Total:	157	60	97	0	301	127				0 of 4

Makua Implementation Plan - Executive Summary - Plants

# of Stable IP Population Units: 45 of 101

(shaded) = 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 2015	# Plant In Original Report	% Completed Genetic Storage Requirement	% of Plants Protected from Ungulates	PU Met Goal?	# PU Met Goal
Pritchardia kaalae	25											
		Makaleha to Manuwai	134	123	11	0	135	141	2%	2%	Yes	
		Ohikilolo	1675	85	1590	0	1675	473	0%	100%	Yes	
		Ohikilolo East and West Makaleha	334	6	328	0	334	75	N/A	100%	No	
		Pritchardia kaalae Total:	2143	214	1929	0	2144	689				2 of 3
Sanicula mariversa	100											
		Kamaileunu	267	3	264	6	413	26	70%	100%	No	
		Keaau	13	0	13	16	43	141	18%	100%	No	
		Ohikilolo	160	2	158	180	216	162	34%	100%	No	
		Sanicula mariversa Total:	440	5	435	202	672	329				0 of 3
Schiedea kaalae	50											
		Kaluaa and Waieli	168	164	4	0	171	55	100%	100%	Yes	
		Maakua (Koolaus)	10	10	0	0	10	4	50%	0%	No	
		Pahole	125	58	67	7	228	3	100%	100%	Yes	
		South Ekahanui	297	149	148	0	428	85	79%	100%	Yes	
		Schiedea kaalae Total:	600	381	219	7	837	147				3 of 4
Schiedea nuttallii	50											
		Kahanahaiki to Pahole	123	88	35	317	220	65	87%	100%	Yes	
		Kapuna-Keawapilau Ridge	57	55	2	0	74	4	100%	100%	Yes	
		Makaha	96	91	5	0	111	0	N/A	100%	Yes	
		Schiedea nuttallii Total:	276	234	42	317	405	69				3 of 3
Schiedea obovata	100											
		Kahanahaiki to Pahole	448	232	216	182	1311	90	56%	100%	Yes	
		Keawapilau to West Makaleha	494	36	458	36	584	36	100%	92%	No	
		Makaha	90	76	14	0	198	0	N/A	100%	No	
		Schiedea obovata Total:	1032	344	688	218	2093	126				1 of 3
Tetramolopium filiforme	50											
		Kalena	117	24	93	0	117	0	16%	100%	No	
		Ohikilolo	3366	1902	1464	20	3858	2500	12%	100%	Yes	
		Puhawai	6	3	3	1	30	12	80%	0%	No	
		Waianae Kai	20	20	0	0	20	22	0%	0%	No	
		Tetramolopium filiforme Total:	3509	1949	1560	21	4025	2534				1 of 4

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 2015	# Plant in Original Report	% Completed Genetic Storage Requirement	% of Plants Protected from Ungulates	PU Met Goal?	# PU Met Goal
Viola chamissoniana subsp. chamissoniana	50											
		Halona	20	15	5	0	27	3	4%	0%	No	
		Makaha	79	68	11	0	79	50	0%	100%	Yes	
		Ohikilolo	263	208	55	0	411	0	0%	100%	Yes	
		Puu Kumakalii	44	44	0	0	44	20	16%	0%	No	
Viola chamissoniana subsp. chamissoniana Total:			406	335	71	0	561	73				2 of 4

Oahu Implementation Plan - Executive Summary - Plants

# of Stable IP Population Units: 14 of 31

(shaded) - 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 2015	# Plant in Original Report	% Completed Genetic Storage Requirement	% of Plants Protected from Ungulates	PU Met Goal?	# PU Met Goal
Abutilon sandwicense	50											
		Ekahanui and Huliwai	175	57	118	0	164	44	8%	100%	Yes	
		Kaawa to Puulu	79	30	49	1	91	124	2%	57%	No	
		Kahanahaiki	78	72	6	0	78	0	100%	100%	Yes	
		Makaha Makai	225	92	133	0	225	100	100%	75%	Yes	
		Abutilon sandwicense Total:	557	251	306	1	558	268				3 of 4
Cyanea acuminata	50											
		Helemano-Punaluu Summit Ridge to North Kaukonahua	272	130	142	0	272	72	8%	0%	Yes	
		Kaluanui and Maakua	249	123	126	50	249	0	0%	0%	Yes	
		Makaleha to Mohiakea	279	190	89	0	216	118	14%	98%	Yes	
		Cyanea acuminata Total:	800	443	357	50	737	190				3 of 3
Cyanea koolauensis	50											
		Kaipapau, Koloa and Kawainui	109	93	16	0	119	76	2%	82%	Yes	
		Opaeula to Helemano	24	22	2	0	27	13	0%	50%	No	
		Poamoho	39	20	19	0	39	12	3%	0%	No	
		Cyanea koolauensis Total:	172	135	37	0	185	101				1 of 3
Eugenia koolauensis	50											
		Kaunala	59	20	39	27	59	141	28%	95%	No	
		Oio	8	6	2	0	7	74	28%	83%	No	
		Pahipahialua	28	22	6	141	28	291	33%	100%	No	
		Eugenia koolauensis Total:	95	48	47	168	94	506				0 of 3
Gardenia mannii	50											
		Haleauau	77	77	0	0	69	2	63%	100%	Yes	
		Helemano and Poamoho	22	21	1	0	17	18	58%	0%	No	
		Lower Peahinaia	30	10	20	0	10	46	50%	60%	No	
		Gardenia mannii Total:	129	108	21	0	96	66				1 of 3
Hesperomannia swezeyi	25											
		Kamananui to Kaluanui	246	134	112	45	246	99	0%	4%	Yes	
		Kaukonahua	109	55	54	2	109	127	0%	0%	Yes	
		Lower Opaeula	38	15	23	0	39	24	0%	0%	No	
		Hesperomannia swezeyi Total:	393	204	189	47	394	250				2 of 3

Oahu Implementation Plan - Executive Summary - Plants

# of Stable IP Population Units: 14 of 31

(shaded) - 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 2015	# Plant in Original Report	% Completed Genetic Storage Requirement	% of Plants Protected from Ungulates	PU Met Goal?	# PU Met Goal
Labordia cyrtandrae	50											
		East Makaleha to North Mohiakea	349	298	51	0	335	100	20%	90%	Yes	
		Koloa	14	9	5	0	81	0	N/A	100%	No	
		Labordia cyrtandrae Total:	363	307	56	0	416	100				1 of 2
Phyllostegia hirsuta	100											
		Haleauau to Mohiakea	98	96	2	0	147	18	42%	100%	No	
		Koloa	153	114	39	1	220	0	55%	98%	Yes	
		Puu Palikea	142	87	55	0	241	0	N/A	100%	No	
		Phyllostegia hirsuta Total:	393	297	96	1	608	18				1 of 3
Phyllostegia mollis	100											
		Ekahanui	1	1	0	0	12	35	100%	100%	No	
		Kaluaa	137	74	63	0	130	49	100%	100%	No	
		Pualii	11	11	0	0	11	0	100%	100%	No	
		Phyllostegia mollis Total:	149	86	63	0	153	84				0 of 3
Schiedea trinervis	50											
		Kalena to East Makaleha	647	296	351	377	647	376	100%	89%	Yes	
		Schiedea trinervis Total:	647	296	351	377	647	376				1 of 1
Stenogyne kanehoana	100											
		Haleauau	281	281	0	0	129	1	100%	100%	Yes	
		Kaluaa	204	26	178	0	204	79	100%	100%	No	
		Makaha	60	0	60	0	130	0	N/A	100%	No	
		Stenogyne kanehoana Total:	545	307	238	0	463	80				1 of 3

Achatinella mustelina Management

During this reporting period, OANRP continued: 1) Monitoring wild snail populations, 2) Controlling rats around wild snail populations, 3) Improving rare snail habitat through weed control and host tree outplantings, 4) Maintaining existing snail enclosures, 5) Constructing two new small temporary snail enclosures, and 6) Securing funding for the construction of another larger snail enclosure at Palikea. The table below presents the status summary for the Waianae *A. mustelina* in the MIP. There is no OIP snail table as all Koolau snail taxa are Tier 2 or 3. Populations of *A. mustelina* in the MIP have been genetically assigned to one of six evolutionarily significant units (ESU). The MIP goal is to achieve 300 total snails across all age classes in each of eight managed populations within the six ESUs. Continuing from last year, six of the eight managed field populations have over 300 snails. See summary table below.

Summary of *A. mustelina* Management Table

ESU	Population	Number of Snails in MFS Pop. Reference Sites (PRS)	Number of Snails in No Mgmt. PRS	Number of Snails in PRS with Rat Control	Number of Snails in Enclosures (observed)	Planned Enclosure for Additional Snails Not Currently in Enclosures
A	Kahanahaiki	285	31	288	227 (Kahanahaiki) 61 (Pahole)	Kahanahaiki/Pahole
B1	Ohikilolo	330	19	330	0	3 Corners
B2	East Makaleha	340	194	371	0	3 Corners
C	Lower Kaala NAR & Schofield Barracks West Range	346	22	340	0	Kaala
D1	Central Kaluaa to Schofield Barraks South Range	689	8	689	689 (Hapapa)	Hapapa
D2	Makaha	298	0	213	0	
D*	South Range to Lihue	0	492	0	0	Kaala and Hapapa
E	Ekahanui	190	28	188	0	Palikea North
F	Puu Palikea	566	5	569	64 (Palikea)	Palikea

*Snails from this portion of the ESU are not managed for stability in the MIP

During this reporting period, OANRP continued to maintain the Kahanahaiki and Puu Hapapa predator exclosures and cooperated with SEPP to maintain the Puu Palikea exclosure. OANRP and partners continued to monitor population trends for *A. mustelina* within the Kahanahaiki, Puu Hapapa, and Palikea predator exclosures using timed-count monitoring. Snails from fragmented subpopulations at Palikea ESU-F continued to be translocated into the existing Palikea exclosure. Notably, the State began site clearing for a new Pahole snail exclosure to replace the existing dilapidated structure with a larger exclosure. Also, SEPP now exclusively maintains the Poamoho snail exclosure given the lack of OANRP funding for Tier 2 or 3 *Achatinella* species.

Two small snail enclosures were built in Ekahanui to serve as an experimental, temporary predator free site for snails in ESU-E given sharp population declines over the last several years. The intent was to move the bulk of the remaining snails in the ESU into the small enclosures until the larger permanent enclosure could be built at Palikea. This trial period is ongoing as mortality rates are unfortunately high despite improvements to microclimates in the small enclosures. Palikea was chosen as the preferred site given the infeasibility of building in Ekahanui itself and various other factors.Funding for its construction was secured for FY2017.

Sites for permanent snail enclosures were also selected at 3 Pts./West Makaleha and at Kaala for ESU-B2 and ESU-C respectively. Construction of those snail enclosures is pending future funding. For more information on rare snail management, see Chapter 5.

Rare Vertebrate Management

Currently, OANRP manages three species of rare vertebrates, the Oahu Elepaio (*Chasiempis ibidis*), Nene geese (*Branta sandvicensis*), and the Opeapea or Hawaiian Hoary Bat (*Lasiurus cinereus semotus*). Management consists of active predator control for the Elepaio, monitoring during Nene sightings at Schofield Barracks and Wheeler Army Airfield, and monitoring for Opeapea at Army installations across Oahu, as well as spot monitoring for bat roosting in trees to be removed at Schofield Barracks during the bat pupping season.

In 2016, OANRP controlled rats to protect 86 pairs of Oahu Elepaio at four management sites. The BO requires the protection of 75 pairs, therefore, OANRP met this requirement. Other highlights included:

- Completed a long-term species population growth analysis (see Appendix 6-1 for details).
- Completed the 4th survey since 2009 of the two drainages north of the Ekahanui MU. Since that time the Elepaio population north of Ekahanui has increased 303% with the number of breeding pairs increasing from 1 to 14.
- Two males were observed at the Makua Military Reservation, no birds were observed in 2015.
- The number of managed pairs and reproductive efforts in 2016 are summarized below.

Summary of Elepaio Management Table

Year	Managed Pairs	Success Active Nests	Family Groups	Fledglings	Fledglings/ Managed Pair
2016	86	21	36	68	0.79

The number of documented fledgings from managed pairs this year was 68 which is up from last year's number. Weather may be the cause of a less productive breeding season this year at one of our sites (Moanalua). The remaining three sites had fair (Palehua) to very productive breeding efforts (Ekahanui and Schofield Barracks West Range).

The total number of rats caught and the ratio of rats caught per trap decreased in 2016 across all four sites. Reasons for the lower catch rates might be attributed to higher rainfall (which washes off bait) or for other undetermined reasons. OANRP will continue to adapt rodent control approaches in order to maximize protection in a cost-effective manner. The total required access dates in Schofield Barracks West Range were met during the calendar year, but were not ideally distributed for Elepaio management. For more information, see the Rare Vertebrate Management Chapter 6.

Over the past year, Nene geese (*Branta sandvicensis*) were observed once at Wheeler Army Airfield. OANRP will continue to track nene visitation to Wheeler. Construction site staff and airfield operations staff provide timely observation data. For more information, see the Rare Vertebrate Management Chapter 6.

Acoustic monitoring for the Hawaiian hoary bat was completed at the majority of Army installations on Oahu. A total of 30 acoustic recorders were monitored for one year by U.S. Geological Survey staff and OANRP. Analysis of data is ongoing. In early September 2015, an official Garrison policy was signed that formalizes a tree cutting moratorium during the bat pupping season each year. OANRP was tasked to survey trees for roosting bats that required cutting, pruning or de-nutting because of safety issues. OANRP conducted six bat surveys to clear trees for removal or pruning, and 17 hours was spent by OANRP conducting these surveys (including travel time). Zero roosting bats were found. For more information, see the Rare Vertebrate Management Chapter 6.

Rare Insect Management

During this reporting period, OANRP focused efforts on regular monitoring of known *Drosophila* populations designated in last year's report as 'manage for stability' and continued host tree outplanting efforts. This monitoring allows OANRP to track fluctuations and attempt to determine abundance patterns. The number of *Drosophila* observed at baits differed dramatically by month and site, and results are summarized in Chapter 7. 110 *Urera glabra* were planted at each of four selected *Drosophila montgomeryi* sites. Additionally, about 150 *Urera kaalae* plants (50 at each site) were planted at Pualii, Palikea, and Central Kaluaa.

Surveys of suitable hosts continue at training ranges to obtain a thorough picture of endangered *Drosophila* distribution at Army training ranges for use in the upcoming Biological Assessment.

Alien Invertebrate Control Program

The Alien Invertebrate Control Program continues to focus on slug control, Coconut Rhinoceros Beetle (CRB) detection and invasive ant detection during this past reporting period. OANRP expanded its slug control program every year since 2010 for the protection of rare plants and rare plant habitat and this year was no exception. We now protect 32 PU's from slugs (up from 24). In 2015-2016, OANRP controlled slugs within nine Management Units (MUs) across an area equal to 7 acres, a 65% increase in area from the previous year (4.2 acres). OANRP is a cooperator in control and detection efforts for CRB and the little fire ant (LFA) on Oahu. There are no known breeding populations of CRB on Army controlled lands and the LFA has not been detected during OANRP surveillance of new plantings and Army plant holding facilities. The Army established an official Garrison policy for preventing the LFA from establishing at Army controlled lands in FY 2015. This policy requires that landscaping plants be sourced from LFA free nurseries and that the responsibility for eradication of LFA, if introduced, is with contractors.

Research Projects

During this reporting period, OANRP funded numerous research projects related to management of MIP and OIP taxa. Our in house research projects included research on decreasing rat bait palatability to slugs, pollination biology, seed viability, germination, and storage. As mentioned above regarding our rodent control program, OANRP also partnered with the U.S. Dept. of Agriculture, Wildlife Services to hand broadcast rodenticide in one of our MUs as an experimental pilot project. The funded projects are as follows. Details of the funded research projects are found in Appendices ES-3 through ES-11.

- **Studies on Hawaiian Tree Snails:** Brenden Holland, Hawaiian Tree Snails Conservation Lab (Appendix ES-3)

- **Molecular assessment of wild *Achatinella mustelina* diet:** Geoffrey Zahn and Anthony Amend, Dept. of Botany, University of Hawaii at Manoa (Appendix ES-4)

- **Adaptive Genetics of Hawaiian Tree Snails and Climate Change**: Dr. Michael Hadfield & Dr. Melissa Price (Appendix ES-5)

- **Assessment of Effects of Rodent Removal on Arthropods, and Development of Arthropod Monitoring Protocols on Conservation Lands Under U.S. Army Management:** Dr. Paul Krushelnycky (Appendix ES-6)

- **Assessment of the Effects of *Solenopsis papuana* on Arthropods in Oahu Forests:** Dr. Paul Krushelnycky, and Cassandra Ogura-Yamata, Dept. of Plant and Environmental Protection Sciences, University of Hawaii at Manoa (Appendix ES-7)

- **Measuring the Effects of Microbial Plant Symbionts On Native Plant Restoration:** Nicole A. Hynson, Assistant Professor, Dept. of Botany, University of Hawaii at Manoa (Appendix ES-8)

- **Role of Fungal Endophytes and Epiphytes in Endangered Species Conservation:** Geoffrey Zahn and Anthony Amend, Dept. of Botany, University of Hawaii at Manoa (Appendix ES-9)

- **Assessment of the Short and Long-Term Stability Goals for Endangered Hawaiian Flora Managed by the Oahu Army Natural Resources Program:** Orou Gaoue and Kasey Barton, Principal Investigators, Lalasia Bialic-Murphy, Graduate Assistant, Dept. of Botany, University of Hawaii at Manoa (Appendix ES-10)

- **Evaluation of Three Very High Resolution Remote Sensing Technologies for Vegetation Monitoring in Makaha and Kahanahaiki Valleys:** William Weaver, Graduate Assistant, Dr. Tomoaki Miura, Professor, Dept. of Natural Resources and Environmental Management, University of Hawaii at Manoa (Appendix ES-11)

Table of Contents

**Starred appendices are printed at the end of Chapter 9. All appendices are included in electronic format on a CD enclosed with this document. Also, they can be found online through the PCSU website at http://manoa.hawaii.edu/hpicesu/dpw_mit.htm.*

CHAPTER 1: UNGULATE MANAGEMENT

Notable projects from the 2015-2016 reporting year are discussed in the Project Highlights section of this chapter. This reporting year was from 1 July 2015 through 30 June 2016.

Threat control efforts are summarized for each Management Unit (MU) or non-MU land division. All totaled, about 3,260 meters of fencing was installed or replaced during the reporting year. Ungulate control data is presented with minimal discussion.

UNGULATE CONTROL PROGRAM

The Oahu Army Natural Resources Program (OANRP) ended the large scale fence construction phase of its management program and focused more on ecosystem management in the reporting period. OANRP transferred management of some Manage for Stability (MFS) plant populations in the MIP into these completed fences rather than building additional enclosures. Since Army training has not been shown to directly impact the Tier 2 or 3 species on Dillingham Military Reservation, Kahuku Training Area, Kawailoa Training Area or Schofield Barracks Military Reservation, the program focused work on the OIP Tier 1 species that are impacted by training. This significantly reduces the number of fences required for management from the 2003 Oahu Biological Opinion. The adjustment to the fence building schedule from the original MIP/OIP is in the table below.

Table 1: Ungulate fences no longer scheduled for OANRP construction

Makua Implementation Plan MU fences	Oahu Implementation Plan MU fences
East Makaleha	Kawaiiki I/II
Kamaileunu/ Waianae Kai	Kawailoa
Alaiheihe and Kaimuhole	Poamoho Lower
	Poamoho Upper
	Opaeula Lower II
	South Kaukonahua II
	Kaipapau
	Manana
	North Kaukonahua (*)
	Waiawa I (!)
	Waiawa II (!)
	Kahana
	Kaukonahua-Punaluu (*)

OANRP focused on working within partnerships to contract some of the above fence construction projects jointly [i.e. Native Ecosystem Protection and Management (NEPM) Program Partnerships] (*). These opportunistic partnerships will allow all parties to share the costs rather than one program absorbing all of it. Some of these fence projects may also be completed by other programs through other funding means (!).

In regards to staffing and funding, OANRP budgeted for two ungulate management technician positions for fence monitoring/maintenance and ungulate control work. One position was filled, but we continue to look for a qualified interested person to fill the second. Funding was also secured to construct three small fences at Kaala, West Makaleha and Palikea to better secure the Kaala summit area, provide for more rare plant habitat at

West Makaleha and extension to fence is planned to enclose new snail enclosure. These actions are scheduled for the 2017 report year.

Summary of Fencing Efforts

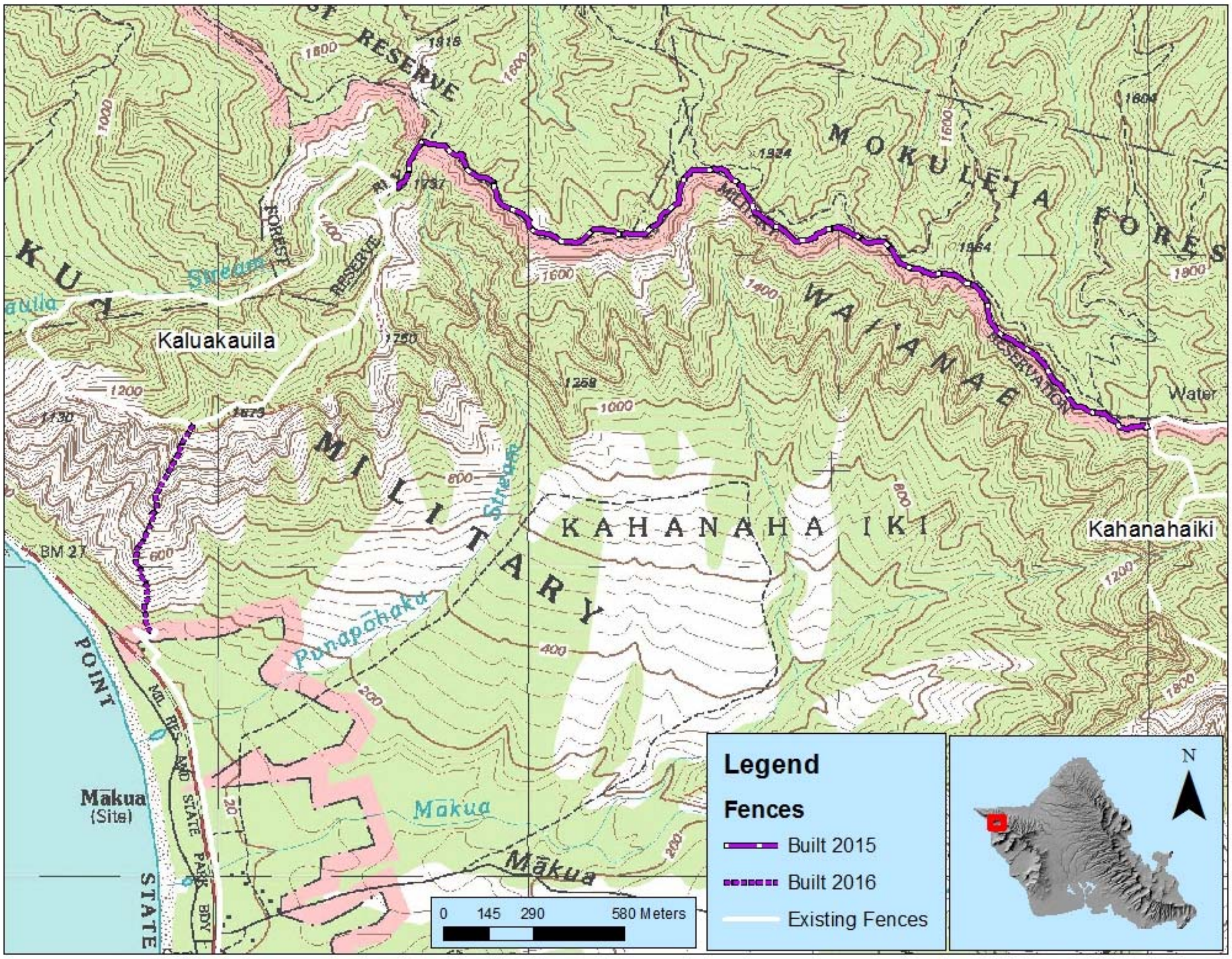


Figure 1: Map of fence construction on the Northern rim of MMR

- OANRP contracted the construction of the northern Makua rim fence (Figure 1). The contractor completed the final section of the fence from Kaluakauila to Farrington Highway (860 m) during this reporting period. With the completion of this final section of fencing, all of MMR is enclosed by a perimeter fence. This completes the terms and conditions laid out in the 2007 Makua Biological Opinion.

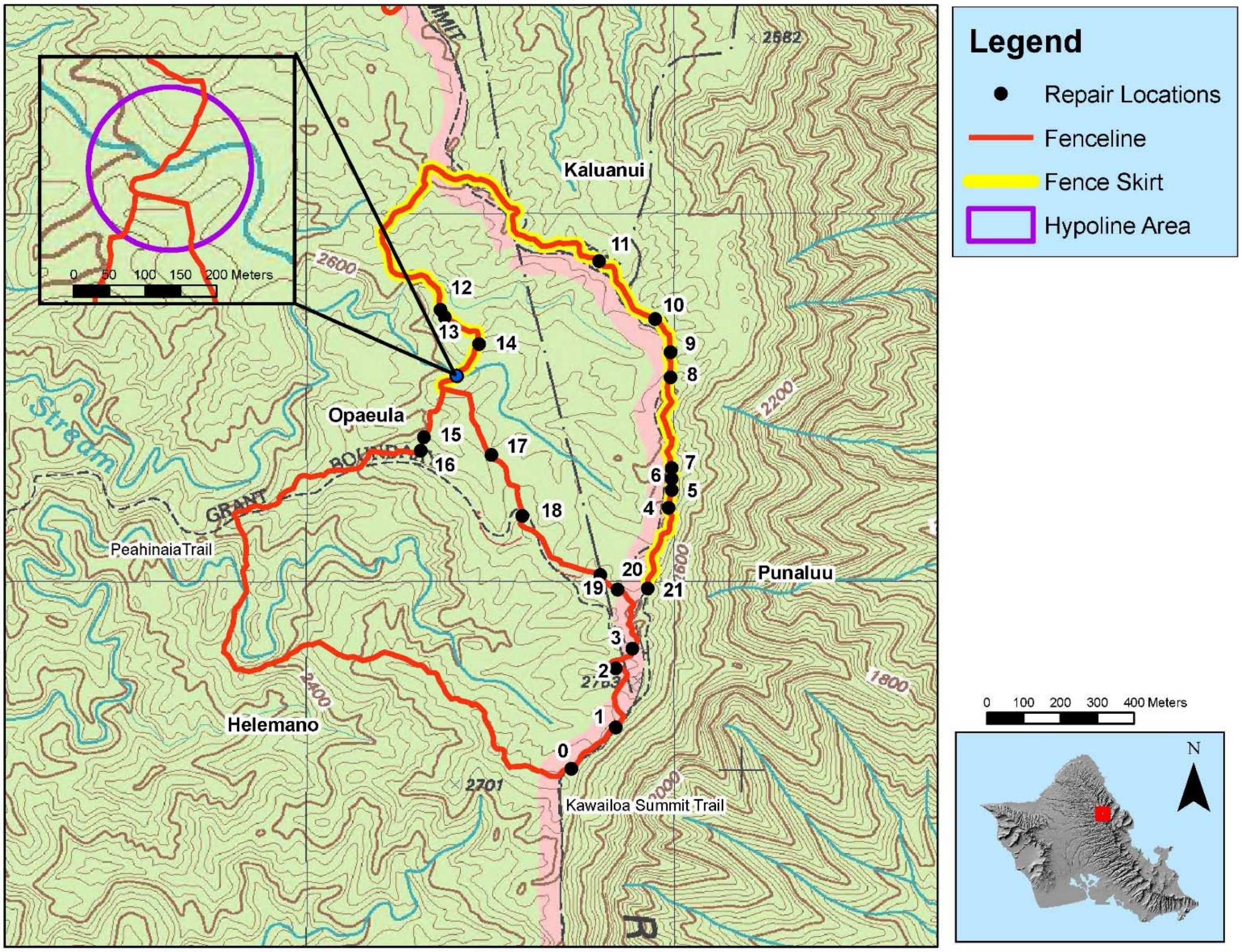


Figure 2: Map of fence repair and skirt replacement at Opaeula/Helemano MU

- OANRP contracted the replacement of 2000 m of skirting, 400 m (sections replaced are numbers above 1-21) of fencing and the stream barrier on the Opaeula/Helemano line (Figure 2). The wind and rain conditions at the Koolau summit deteriorated exposed sections of fence in a shorter period of time than OANRP observed elsewhere. The deteriorated sections were limited to the sections exposed to direct trade-winds. Sections of the fence on the leeward side and out of the wind remain in good condition and are expected to last another 15 -20 years. The original fencing was comprised of conventional hogwire and was replaced with the 16'x 52" combination panels. These panels are sturdier and expected to withstand the constant wind for a longer period of time. It is also easier to replace them when the time comes.

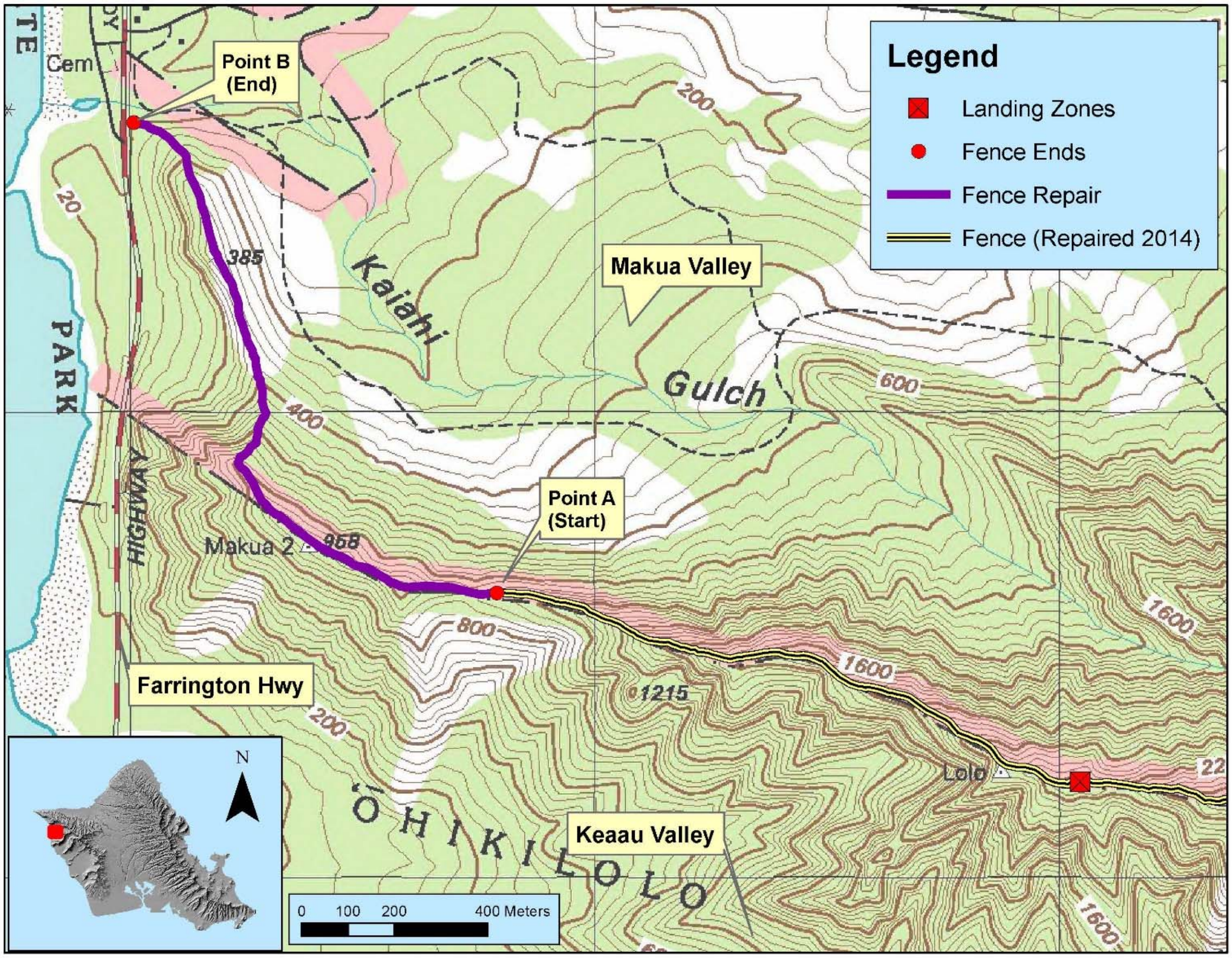


Figure 3: Map of fence replacement on Ohikilolo ridge at MMR

- OANRP contracted the replacement of the lowest 1800 m of fencing along the Ohikilolo ridge in Makua (Figure 3). This was the last section of the original hogwire fencing along the ridge. It had burned in sections in the past and likely deteriorated due to a combination of fire and salt winds. It was replaced with 16'x 52" combination panels.

<u>Summary of Ungulate Removal Efforts</u>

- Two pigs breached the Makaha Subunit II perimeter fences. Waianae Mountains Watershed Partnership (WMWP) staff removed the animals through hunting and OANRP is in the process of installing fickle fence around the whole unit to keep small piglets from squeezing in again. A couple of pigs also squeezed into Makaha Unit I. OANRP has been using live traps and encouraging the Honolulu Board of Water Supply to reinitiate their volunteer hunter program. Two animals were removed so far and OANRP continues to monitor for more. OANRP is also planning to install fickle fence on this unit.

- Pigs breached the fence at Ekahanui Unit I. Originally, it was reported by contractors that 12 pigs were observed. OANRP installed snares and was able to remove one pig initially. A hunt was conducted with Waianae Mountains Watershed Protection (WMWP) staff but no animals were observed or heard. Subsequent snaring operation have not yielded any pigs but there is sign of at least one animal left within the unit but not 11. OANRP continues to monitor, increase snare numbers and will survey in Unit II to scope for any sign.

- Pigs were also able to breach Kapuna Unit IV. OANRP has been working in conjunction with NAR staff to conduct snaring operations. So far, two animals were removed from Kapuna and monitoring continues.

- Pig eradication efforts continued in Lihue MU. To date, a total of 543 pigs were removed. Pig sign in all portions of the unit has been dramatically reduced but sign is still visible in a few areas. It seems as though the few remaining animals have become snare shy, making them difficult to capture. Efforts are focused on increasing coverage in areas with few snares, and making sure all snares are well set. OANRP is also running live traps and conibear traps along the firebreak road as an alternative to snaring exclusively. Access is limited so OANRP can only run those traps during the range maintenance week available each month.

- Goats were able to find a place to jump over the Keeau II Management Unit fence. One goat was removed through the use of snares and no other sign has been observed since.

- Occasionally, goats are able to breach the ridge fence on Ohikilolo and OANRP is stymied as to where. Two goats were removed from the Ohikilolo Management Unit fence area over the past reporting period.

OIP/MIP Management Unit Fence Status

The MU status table below shows the current status of all proposed and completed fence units, organized by MU. Shaded boxes identify where ungulate management or compliance documentations and authorizations are needed. The table identifies whether or not the fence is complete, whether it is ungulate free, identifies how many acres are actually protected versus acreage proposed in the Implementation plan, and lists the year the fence was completed or is expected to be completed. Fences which required a Conservation District Use Permit (CDUP), Cultural 106, MOU, ROE or RA, or a License agreement are checked in the appropriate box. The number of Manage for Stability Population Units (MFS) protected is also identified for each fence. For the sake of simplicity, this number also contains the number of Manage Reintroduction for Stability PUs. The MFS PUs are divided by taxa P (Plants), I (Invertebrates) and V (Vertebrates) The table also contains notes giving the highlights and status of each fence and lists the current threats to each fence unit.

MIP Management Unit Status

Management Unit	Management Unit Fence	Fenced	Ung Free	Acreage Current/ Proposed	Year Complete or Proposed	CDUP	106	MOU/ ROE/ RA	Lic. Agr.	# MFS PUs MIP P	MIP I	OIP P	OIP I	OIP V	Notes	Current Threats
ARMY LEASED AND OWNED LANDS																
Kahanahaiki	Kahanahaiki I	Yes	Yes	64/64	1998					9	1	1			Complete and ungulate free	None
	Kahanahaiki II	Yes	Yes	30/30	2013		X								Fence is complete and ungulate free	None
Kaluakauila	Kaluakauila	Yes	Yes	104/104	2002					5					Complete. Fence is in need of some repair but still pig-free.	None
Opaeula Lower	Opaeula Lower	Yes	Yes	26/26	2011	X	X		X	1		1	1		Fence is complete and ungulate free.	None
Ohikilolo	Ohikilolo	Yes	No	4000/574	2002 2016		X			14	1				The Northern Makua rim section is complete, ungulate eradication has been initiated. There are six PU fences within the larger unit which are ungulate free. Since July 2006, 22 goats have been able to breach the fence, a couple may still be inside but OANRP have not observed them since they were originally seen. Two goats removed in past reporting year.	Pig/Goat
Ohikilolo Lower	Ohikilolo Lower	Yes	No	70/70	2000					3					This strategic fence is complete.	None
Puu Kumakalii	Puu Kumakalii	No	-	-	-	-	-	-	-	3					None needed but is partially included within the Lihue fence. Any potential goat issues will be dealt with as they arise.	None
STATE OF HAWAII DEPARTMENT OF LAND AND NATURAL RESOURCES																
Ekahanui	Ekahanui I	Yes	Yes	44/44	2001	X				6	1	2		1	Completed by TNCH. Twelve piglets were reported from the Unit I enclosure this year. One has been caught so far in a snare and hunting has resulted in no catches.	Pigs
	Ekahanui II	Yes	Yes	165/159	2009	X	X								Complete and ungulate free. The completed fence is 3% larger than the original proposed MU fence	None
Haili to Kealia	Haili to Kealia	No	-	-	-	X	-	-	-	1					As per DOFAW staff 'no fence needed'	None
Kaena	Kaena	Partial	-	-	-	X	-	-	-	1					There is a predator proof fence installed by State but it only protects a few of the EupCelKae plants	None
Kaluaa/Waieli	Kaluaa/Waieli I	Yes	Yes	110/99	1999	X		X		6	1	2	1		Completed by TNCH. The completed fence is 9% larger than the original proposed MU fence.	None
	Kaluaa/Waieli II	Yes	Yes	25/17	2006	X		X							Completed by TNCH. The completed fence is 7% larger than the original proposed MU fence.	None
	Kaluaa/Waieli III	Yes	Yes	43/11	2010	X	X	X							Complete and ungulate free. The completed fence is 3% larger than the original proposed MU fence	None

Management Unit	Management Unit Fence	Fenced	Ung Free	Acreage Current/ Proposed	Year Complete or Proposed	CDUP	106	MOU/ ROE/ RA	Lic. Agr.	# MFS PUs					Notes	Current Threats
										MIP		OIP				
										P	I	P	I	V		
Keaau	Keaau II	Yes	Yes	8/33	2014	X	X	X		2					Complete and ungulate free. DLNR requested OANRP reduce the size of original proposed MU fence.	None
	Keaau III	Yes	Yes	4/33	2015	X	X	X							Fence was built by OPEP with assistance from WMWP and OANRP	None
Keaau/Makaha	Keaau/Makaha	Yes	Yes	1/3	2009	X	X			1					Complete and ungulate free. The completed fence is smaller than the original proposed due to the terrain limitations.	None
Manuwai	Manuwai I	Yes	Yes	166/166	2011	X	X	X		3	1		1		Complete and ungulate free. Closed strategic section out of concern for possible ungulate breach.	None
Napepeiaoolelo	Napepeiaoolelo	Yes	Yes	1/1	2009	X	X	X		0					Complete and ungulate free	None
Pahole	Pahole	Yes	Yes	215/215	1998	X				14	1				Complete and ungulate free	None
Palikea	Palikea I	Yes	Yes	23/21	2008	X		X		1	1	1	2		Complete and ungulate free. Extension to fence is planned to enclose new snail enclosure	None
Kapuna Upper	Kapuna I/II	Yes	Yes	32/182	2007	X		X		13	1				Complete and ungulate free.	None
	Kapuna III	Yes	Yes	56/182	2007	X		X							Complete and ungulate free.	None
	Kapuna IV	Yes	Yes	342/224	2007	X		X							Complete. Ongoing ungulate removal effort.	None
Waianae Kai	Slot Gulch	Yes	Yes	9/9	2010	X	X	X		1					Complete and ungulate free.	None
	Gouvit	Yes	Yes	1/1	2008	X		X		1					Complete and ungulate free	None
	NerAng Mauka	No	No	1/1	2011	X	X	X							Complete. All management actions have been transferred to Kamaili unit due to the continuous rock fall damage and threat to personnel.	Pigs/Goats
West Makaleha	West Makaleha	Yes	Yes	7/11	2001 2016	X	X	X		5					The *Schiedea obovata* and *Cyanea grimesiana* subsp. *obatae* PU fences are complete and pig free. OANRP will expand the existing *C. grimesiana* fence to include more *Cyrtandra dentata* MFS plants in FY 2017.	None
BOARD OF WATER SUPPLY																
Kamaileunu	Kamaileunu	Yes	Yes	5/2	2008	X	X		X	1			1		Both of the *Sanicula mariversa* PU fences at Kamaileunu and Kawiwi are completed and ungulate free.	None
Makaha	Makaha I	Yes	Yes	85/96	2007					8	1				Complete and ungulate free. Pigs breached the fence and were removed.	None
	Makaha II	Yes	Yes	66/66	2013	X	X		X	5		1			Complete and ungulate free. Pigs breached the fence and were removed.	None

OIP Management Unit Status

Management Unit	Management Unit Fence	Fenced	Ung Free	Acreage Current/ Proposed	Year Complete or Propose	CDUP	106	MOU/ ROE/ RA	Lic. Agr.	# MFS PUs MIP			OIP		Notes	Current Threats
										P	I	P	I	V		
ARMY LEASED AND MANAGED LANDS																
Kaala-Army	Kaala	Partial	No	183/183	2008		X					4	1		Strategic fences complete. Three pigs were caught in 2014, the first since 2010 and no sign since. A line has been scoped for the Waianae Kai side and 106 surveys complete. OANRP is pursuing construction of this fence in FY 2017.	Pig
Kaunala	Kaunala	Yes	Yes	5/5	2006		X					1			Complete and ungulate free.	None
Lihue	Lihue	Yes	No	1800/980	2012		X			3	1	6			Completed. Encompasses six PU fences and the original three proposed units. A total of 537 pigs have been removed. There are very few pigs left in unit.	Pig
Oio	Oio	Yes	Yes	4/4	2006	X						1			Complete and ungulate free.	None
Opaeula / Helemano	Opaeula / Helemano	Yes	Yes	273/273	2001/ 2007							1			Complete and ungulate free.	None
Pahipahialua	Pahipahialua	Yes	Yes	2/2	2006	X						1			Complete and ungulate free.	None
South Kaukonahua	South Kaukonahua I	No	No	0/95	TBD		X					1			Postponed pending completion of Section 7 consultation in 2017. The Tier 1 taxa *Hesperomannia swezeyi* occurs within this MU.	Pig
STATE OF HAWAII DEPARTMENT OF LAND AND NATURAL RESOURCES																
Huliwai	Huliwai	Yes	Yes	.3/1	2014	X		X				1			Complete and ungulate free.	None
Ekahanui	Ekahanui III	Yes	Yes	8/8	2010	X	X					1			Complete and ungulate free.	None
Manuwai	Manuwai II	Yes	Yes	138/138	2011	X	X			10	1	1	1		Complete and ungulate free. The Lihue and Manuwai II unit share a strategic boundary and the ungulate free status is subject to pig traffic from Lihue which is unlikely but possible.	Pig
North Kaukonahua	North Kaukonahua	No	No	0/31	Cancelled	X	X	X				1			Will included within the Larger Poamoho NAR fence. Fence is almost ¾ of the way completed.	Pig
Poamoho	Poamoho Lower II	Yes	Yes	5/5	2014	X	X	X				1			Included within the Larger Poamoho NAR fence.	Pig
	Poamoho Pond	Yes	Yes	18/18	2014	X	X	X							Included in the Poamoho NAR fence	Pig
Waimano	Waimano	Yes	Yes	4/4	2011	X	X								Complete and ungulate free. Transferred management of fence over to OPEP.	None
North Pualii	North Pualii	Yes	Yes	20/20	2006	X				1		1	1		Completed by TNCH and ungulate free.	None
	BOARD OF WATER SUPPLY															
Kamaili	Kamaili	Yes	Yes	9/7	2014	X	X		X	1		1			Complete and ungulate free.	None
	HAWAII RESERVES INC.															

Management Unit	Management Unit Fence	Fenced	Ung Free	Acreage Current/ Proposed	Year Complete or Propose	CDUP	106	MOU/ ROE/ RA	Lic. Agr.	# MFS PUs					Notes	Current Threats
										MIP		OIP				
										P	I	P	I	V		
Koloa	Koloa	Yes	Yes	177/160	2012	X	X		X			4			Complete and ungulate free.	None
	KAMEHAMEHA SCHOOLS															
Waiawa	Waiawa I	No	No	0/136	Cancelled	X			X						Army training does not impact these tier 1, 2 and 3 taxa. To be constructed by NEPM and KMWP.	Pig
	Waiawa II	No	No	0/136	Cancelled	X			X						Army training does not impact these tier 1, 2 and 3 taxa. To be constructed by NEPM and KMWP.	Pig
STATE OF HAWAII DEPARTMENT OF TRANSPORTATION																
North Halawa	North Halawa	Yes	Yes	.5/4	2010	X									Completed a small PU sized fence. Transferred management of fence over to OPEP.	Pig
KUALOA RANCH INC.																
Kahana	Kahana	Yes	No	1/23	2010	X									Small PU fences were built around individual *Schiedea kaalae* plants in gulch. Larger unit will not be built until the Army trains in a way that may impact Tier 2 and 3 taxa.	None
U. S. FISH AND WILDLIFE SERVICE																
Kipapa	Kipapa	Yes	Yes	120/4	2015	X									U.S. Fish and Wildlife Service constructed a 120 acre unit.	None

CHAPTER 2: ENVIRONMENTAL OUTREACH

The OANRP outreach program is tasked with:

- conducting outreach to the military (including troops, their families and civilian contractors);
- conducting outreach to local communities about natural resource management;
- educating local communities and students about Hawaii's natural resources and careers in natural resource management;
- managing an active volunteer program which assists staff in meeting IP goals, particularly by conducting field actions.

The following text highlights outreach activities from the 2016 reporting year.

Volunteers

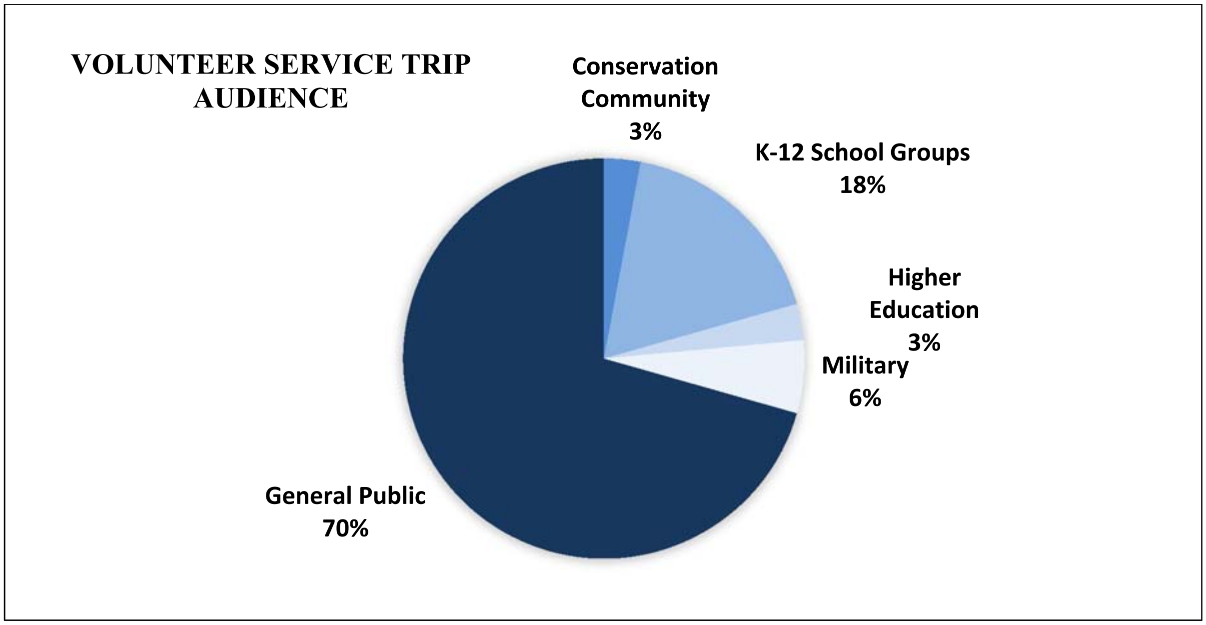
During the reporting period the outreach program continued to coordinate and lead an average of six volunteer trips each month and successfully met volunteer weeding goals. In addition to the ongoing generous support from a few of the program's most dedicated volunteers, baseyard hours increased this year due to the National Public Lands Day project to improve the Native Hawaiian Interpretive Garden. Additional information on this project is located in the last section of this chapter.

The table below compares volunteer participation with OANRP for this year with that of previous years, distinguishing between volunteer efforts spent in the field and around the OANRP baseyards.

Report Year	Total Volunteer Hours for Field Days*	Total Volunteer Hours at Work Site**	Total Volunteer Trips	Total Baseyard Volunteer Hours***
2016	3,575.5	974.5	68	537.75
2015+	3,013.5	824	52	333.25
2014	4,421.5	1,133.75	78	490.75
2013	3,767.5	957	69	569.5
2012	4,302.5	1,261.5	78	602.5
2011	4,194	1,231	76	618
2010	3,415	1,299	58	885

*****_Includes driving time to and from trailhead, safety briefing, hiking time to and from work site, and gear cleaning time at end of day_
**Includes actual time spent weeding, planting or monitoring
***Includes propagule processing, nursery maintenance, gear preparation, outreach support and maintenance of interpretive native gardens.
+_Shorter reporting year, spanning nine (9) months_

The general public are the primary participants in the volunteer program and include members of the community with no affiliation, but also special interest groups, such as hula halau. School groups also make up a large portion of the volunteer program audience. The figure below depicts the variety of audiences that participated in OANRP volunteer trips during this reporting year.



The majority of volunteer effort continues to focus on control of incipient and invasive weeds at the Kaala MU. A new volunteer project targeting invasive *Odontonema cuspidatum* has also contributed to the increased effort at Kaala. A large portion of volunteer time this reporting year has also been spent within the Kahanahaiki and Palikea MUs.

Coordinating with the Ecosystem Restoration Program, outreach staff led revegetation projects with volunteers in habitat restoration sites at Palikea and Kaala MUs. These additional projects provided volunteers with opportunities to plant common natives in areas they had also weeded in the past.

The table below summarizes volunteer service trips by location.

Volunteer service for reporting period 2016

Management Unit	Projects	Number of Visits
Kahanahaiki	Habitat weed control in WCAs	19
Kaala	Incipient weed control in *Sphagnum palustre* ICAs	5
	Incipient weed control in other ICAs	21
	Habitat weed control in WCAs	7
	Revegetation projects	2
Makaha I	Habitat weed control in WCAs	6
Palikea	Incipient weed control	5
	Habitat weed control in WCAs	4
	Revegetation projects	1
West Makaleha	Habitat weed control in WCAs	7
Kaluaa	Habitat weed control in WCAs	7
	Incipient weed control	1
Pualii	Habitat weed control in WCAs	3

The following list highlights additional volunteer coordination conducted by OANRP outreach staff.

- Maintained a volunteer database of 1,858 individuals and communicated regularly with active volunteers.
- Coordinated volunteer opportunities with OANRP field teams for individuals seeking careers in conservation.
- Facilitated an Eagle Scout Project with Troop 175, which included repair work along the Kaala boardwalk and the building of steps at the steep slope where boardwalk ends. The Scouts completed the project on May 28 and volunteered a collective total of 82 hours.

LEFT: Boy Scouts from Troop 175 assist in reparing the Kaala boardwalk to fulfill an Eagle Scout Project requirement.

Internships

Outreach staff coordinated internships at OANRP and with cooperating agencies. Outreach staff and field crew planned and implemented a four-day orientation for summer interns, consisting of new-hire training modules and hands-on field activities. Internship opportunities provided valuable natural resource management training for the next generation of conservationists. Participants experienced terrestrial field work in a variety of native ecosystems while working alongside experienced professionals. Bulleted points below highlight outreach staff efforts with the interns.

- Evaluated and scored 32 applicants, interviewed eight applicants and awarded four individuals with three-month, paid OANRP summer internships. Interns were placed with field and horticulture crews to gain valuable career skills and experience in the field of natural resource management.

- Evaluated, scored and interviewed two applicants, and awarded one individual with an 11-week, Pacific Internship Program for Exploring Science (PIPES) internship with OANRP. Intern was tasked with setting-up a common-native plant restoration trial, with guidance from field team staff, and presenting preliminary findings at the 2016 PIPES Student Symposium at the University of Hawaii, Hilo.
- Two interns from previous reporting years have since joined the OANRP staff in the following positions: Natural Resource Management Technician and Plant Propagation Assistant.

Educational Materials

Outreach staff developed new educational materials in various media focused on natural resource issues specific to MIP and OIP species and their habitats. These contributions are summarized by category in the bulleted list below.

- Outreach Exhibits and Activities:
    - Look what's happening in the Hawaiian forest activity
        - PURPOSE: Youth and families learn about monitoring in the forest through an engaging forest backdrop with "binoculars". A monitoring card designed for the activity guides participants through the monitoring tasks. Participants take home the monitoring card, which contains information on volunteering with OANRP.
    - Elepaio banner
        - PURPOSE: Provide overview of natural history, management and status of endangered Oahu elepaio to youth and families at outreach events. Segues into "Look whats happening in the Hawaiian forest" activity.
    - Natural resources pledge tree
        - PURPOSE: Visitors at the OANRP booth at community outreach events commit to a personal action to protect natural resources by writing a pledge on a wiliwili leaf and placing it on the large, metal tree.

TOP: Outreach specialist Kim Welch explains the "What's happening in the Hawaiian forest?" activity to a youth at Schofield Barracks Earth Day in front of the elepaio banner. RIGHT: A Mauka to Makai Earth Day attendee at the Waikiki Aquarium positions her pledge to protect natural resources on the metal wiliwili tree.

- Signs
  - Entering Critical Habitat
    - PURPOSE: Warn about fire policy and delineate critical habitat area for Oahu elepaio for Soldiers working in Schofield Barracks East Range.

Senior natural resource manager Joby Rohrer posts the "Entering Critical Habitat" sign for elepaio at Schofield Barracks East Range.

- Presentations:
  - Updated career day presentation
    - PURPOSE: Updated exisiting career day presentation to suit a new venue at Kalaheo High School for their career day.
- Other:
  - oanrp.com
    - Expanded content on OANRP volunteer site, www.oanrp.com, to provide prospective and current volunteers with information on how to get involved as a volunteer, upcoming volunteer opportunities and sign up process.
  - Bishop Museum Faces of Conservation
    - Supported Bishop Museum bird exhibit by providing a variety of captioned photos featuring OANRP staff. Photos were displayed in a running slideshow on a large screen within the exhibit hall and featured staff conducting management actions in support of endangered species.
  - Kupu Environmental Fair Job Board & Tablet Slideshow
    - Developed a mock job board for use at an environmental fair for youth interested in conservation. Board included current OANRP job and internship announcements. A Samsung Galaxy tablet displayed a slideshow of staff working on various management actions in the field.
  - NPLD 2015 Button
    - Created a button for particpants in the 2015 National Public Lands Day weeding and planting activities.

Troop Education

Outreach staff conducted presentations for Army troops, contractors and other active duty military personnel, highlighting the relationship between training activities and natural resources on Army training lands. In addition, a presentation covering natural resource concerns on Oahu Army training lands, is given by Schofield Range Control staff at bimonthly Officer-In-Charge/Range Safety Officer (OIC/RSO) Briefs held at Schofield Barracks. The brief provides rules and regulations pertaining to each Army training area on Oahu. Attendance is mandatory for representatives from each military Unit that schedules time on Oahu training ranges.

Event	Description	Number of presentations	Number of People Served
Environmental Compliance Officer (ECO) training presentation: "Protecting Natural Resources"	A one-hour presentation for the ECO training courses held at Schofield Barracks.	9	211
Training Area Presentation: "Protecting Natural Resources in Makua"	A 15-minute presentation on natural resource considerations at Makua Military Reservation (MMR).	3	120
Total number of people served:			**331**

Outreach Events

Outreach staff disseminated information on natural resources specific to Army training lands at local schools, community events and conferences. These activities are summarized in the table below. Total number of outreach activities = 15

- Total number of people served (approximated) = 7,887

Outreach activities for FY 2016

Event	Estimated # of People Served	Audience
Mauka to Makai Earth Day Event at Waikiki Aquarium	3000	General Public
Camp Mokuleia Staff Interpretive Hike at Kaala	9	
Mililani Waena Elementary School Teachers Interpretive Hike at Kaala	10	
Kula Kaiapuni O Waiau Hawaiian Immersion School Interpretive Hike at Kaala	25	
University of Hawaii Natural Resources and Environmental Management Class Presentation	30	Higher Education
Hawaii Pacific University Natural Resource Management Class Presentation	19	
Kupu Environmental Fair	200	
Leilehua High School Career Day Presentation	120	K-12
Kalaheo High School Career Day Presentation	60	
Hoala School Field Trip to OANRP Baseyard	12	
Hale Kula Field Trip to OANRP Baseyard*	102	Military
Helemano Spring Fling	500	
Schofield Fun Fest	2500	
Schofield Earth Day	800	
Fort Shafter Earth Day Festival	500	
Total Number of People Served	**7,887**	

**denotes K-12 audience, in addition to being military*

Contributions to Conferences/Workshops

OANRP staff contribute to outreach by presenting research findings at various conferences throughout the Pacific. This reporting year, five staff presented at the Ecology and Management of Alien Plant Invasions 13th International Conference and four staff presented at The 3rd Annual Oahu Weed Workshop. These and other presentations are listed in the table below.

Presentation Title	**Format**	**Author/leader name(s)**	**Venue**	**Date**
Restoring *Psidium cattleianum* dominated forest in the Waianae Mountains, Hawaii	Poster presentation	Beachy, Jane; Lee, Julia Gustine; Akamine, Michelle	Ecology and Management of Alien Plant Invasions	March 20-24, 2015
No Need for Devil Weed: Eradication Efforts and Challenges in Controlling *Chromolaena odorata*	Poster presentation	Marsh, Taylor; Beachy, Jane.	Ecology and Management of Alien Plant Invasions	March 20-24, 2015
Assessing the most effective weed control re-treatment interval for *Clidemia hirta* dominated areas at Opaeula Lower Management Unit, Oahu	Poster presentation	Akamine, Michelle; Beachy, Jane; Bialic-Murphy, Lalasia, Higashi, Michelle	Ecology and Management of Alien Plant Invasions	March 20-24, 2015
Efficacy of Undiluted Herbicide Injections on Tropical Woody Tree Species in Hawaii	Poster presentation	Lee, Julia Gustine; Beachy, Jane	Ecology and Management of Alien Plant Invasions	March 20-24, 2015
Targeted Surveys Provide Opportunities to Assess Threats to Managed Areas	Poster presentation	Lee, Julia Gustine; Beachy, Jane	Ecology and Management of Alien Plant Invasions	March 20-24, 2015
Assessing the most effective weed control re-treatment interval for *Clidemia hirta* dominated areas at Opaeula Lower Management Unit, Oahu	Oral presentation	Akamine, Michelle; Beachy, Jane; Bialic-Murphy, Lalasia, Higashi, Michelle	2016 Oahu Weed Workshop	February 24, 2016
Vegetation Monitoring Utilizing Gigpan Imagery	Oral presentation	Weaver, William; Akamine, Michelle	2016 Oahu Weed Workshop	February 24, 2016
Restoration case study: Psisum cattleianum dominated forest in the Waianae Mountains, Oahu	Oral presentation	Beachy, Jane	2016 Oahu Weed Workshop	February 24, 2016
Conserving native insect communities: Insights from management projects in the Waianae Mountains of Oahu, Hawaii*	Oral presentation	Krushelnycky, Paul D.	The Entomological Society of America Pacific Branch Meeting	April 3-6, 2016
Drosophila conservation on Oahu: Progress and priorities	Oral presentation	Magnacca, Karl	The Entomological Society of America Pacific Branch Meeting	April 3-6, 2016
Testing the attractiveness and efficacy of baits for the monitoring and control of the thief ant, *Solenopsis papuana**	Poster presentation	Ogura-Yamata, Cassandra S. and Paul D. Krushelnycky	The Entomological Society of America Pacific Branch Meeting	April 3-6, 2016

**Denotes OANRP-funded research from other organizations*

Public Relations and Publications

Wrote articles, press releases, bulletins and scholarly journal articles; provided coordination and accurate information to the local, state, regional, and national media and agencies. The table below is a summary of all media and publications relating to OANRP management in 2016.

Media coverage and publications in FY 2016

Title	Author	Publication	Date	Format
A Day on the Land at Honouliuli Forest Reserve	Hawaiian Electric Companies	YouTube (https://www.youtube.com/watch?v=reKTqeBqGHg&feature=youtu.be)	10-Sep-15	Online video
Volunteers sought for Sept. 26 Hawaiian Garden improvements	Hanley, Celeste	Hawaii Army Weekly (http://www.hawaiiarmyweekly.com/2015/09/21/volunteers-sought-for-sept-26-hawaiian-garden-improvements/)	21-Sep-15	News article
National Public Lands Day engages volunteers, aids SB Hawaiian Interpretive gardens	Hanley, Celeste	Hawaii Army Weekly (http://www.hawaiiarmyweekly.com/2015/10/01/national-public-lands-day-engages-volunteers-aids-sb-hawaiian-interpretive-gardens/)	01-Oct-15	News article
Episode 45: Featured Species | *Drosophila*	Magnacca, Karl	U.S. Fish and Wildlife Service Featured Species (https://www.fws.gov/endangered/about/ep_45_2015.html)	08-Oct-15	Online article
Army, State Take to the Skies, Summit to Protect Native Species	Gutierrez, Stefanie; Dennsion, Dan	State of Hawaii Newsroom (http://governor.hawaii.gov/newsroom/latest-news/u-s-army-dlnr-news-release-army-state-take-to-the-skies-summit-to-protect-native-species/)	25-Feb-16	Joint news release
Our State Flower is Endangered	Jade Moon	Midweek	Apr-16	News article
SB, IPC Earth Day celebrates wonders of the planet	Christine Cabalo	Hawaii Army Weekly (http://www.hawaiiarmyweekly.com/2016/04/29/sb-ipc-earth-day-celebrates-wonders-of-the-planet/)	29-Apr-16	News article

Ecosystem Management Program Bulletin

During this reporting period, the outreach staff edited, produced and distributed the Ecosystem Management Program (EMP) Bulletin, a newsletter highlighting achievements made by the Army Environmental Division's Conservation Branch on Oahu and Hawaii islands. While traditionally the bulletin had been published four times annually, staff have increased the number of articles per issue and reduced the overall number of issues annually to two.

- Volume 60, Issue 4 – Techniques
    - https://issuu.com/oanrp/docs/emp_bulletin_vol_60_issue_4_techniq

The EMP is posted online at http://manoa.hawaii.edu/hpicesu/dpw_emb.htm and at www.issuu.com/oanrp. It is also distributed to a comprehensive list of state, non-profit federal and educational institutions and OANRP volunteers. Articles from this publication are frequently picked up by other Army publications. A hard copy of the bulletin is also provided to the University of Hawaii at Manoa Hamilton Library.

Volunteer Recognition

Several volunteers will be eligible to receive the President's Volunteer Service Award for FY2016 at the end of September 2016, when outreach staff report their service hours to the Corporation for National and Community Service.

Four volunteers earned the President's Volunteer Service Award in FY2015. The table below summarizes these awards. Volunteers who contributed 40 or more hours in FY 2015, including the Presidential awardees, were honored with an interpretive hike and volunteer service opportunity within MMR on May 17.

2015 President's Volunteer Service Awardees

Award Level	Name	Hours of Service in FY2015
Silver	Elaine Mahoney	443.25
Silver	David Danzeiser	439.5
Silver	Roy Kikuta	280
Bronze	Kathy Altz	215

Grants

OANRP was selected as an awardee of the 2015 National Public Lands Day Department of Defense Legacy Award, receiving $6,500.00 in grant money towards the improvement of the Schofield Barracks Native Hawaiian Interpretive Garden. The majority of funds were utilized to purchase materials to construct a new shelter within the garden to protect visiting groups from rain and sun. Funding was also allotted for the replacement of aging interpretive signage and the purchase of tools tools for weeding and planting in the garden. The work project took place on two main days, September 26 and November 21, with four smaller workdays to complete the painting and assembly of the shelter.

Students from Hale Kula Elementary School enjoy a visit to the Schofield Barracks Native Hawaiian Interpretive Garden under the newly-constructed shelter, funded by the 2015 National Public Lands Day Department of Defense Legacy Award.

CHAPTER 3: ECOSYSTEM MANAGEMENT

Notable projects from the 2015-2016 reporting year are discussed in the Project Highlights section of this chapter. This reporting year covers twelve months, from July 1, 2015 through June 30, 2016. Last year's report covered only nine months, from October 1, 2014 through June 30, 2015.

Threat control efforts are summarized for each Management Unit (MU) or non-MU land division. Weed control and restoration data is presented with minimal discussion. For full explanations of project prioritization and field techniques, please refer to the 2007 Status Report for the Makua and Oahu Implementation Plans (MIP and OIP; http://manoa.hawaii.edu/hpicesu/DPW/2007_YER/default.htm).

Ecosystem Restoration Management Unit Plans (ERMUP) have been written for many MUs and are available online at http://manoa.hawaii.edu/hpicesu/dpw_ermp.htm. Each ERMUP details all relevant threat control and restoration actions in each MU for the five years immediately following its finalization. The ERMUPs are working documents; OANRP modifies them as needed and can provide the most current versions on request. This year, the Kaala and Ohikilolo (Lower and Upper) ERMUPs were revised, and the Kamaili ERMUP was completed; they are included as Appendices 3-1 to 3-4.

3.1 WEED CONTROL PROGRAM SUMMARY

MIP/OIP Goals

The stated MIP/OIP goals for weed control are:

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

Given the wide variety of habitat types, vegetation types, and weed levels encompassed in the MUs, these IP objectives should be treated as guidelines and adapted to each MU as management begins. Please see the 2010-2011 MIP and OIP Annual Report for a discussion of adaptive changes to these goals. The Ecosystem Restoration Management Unit Plans (ERMUPs) for each MU detail specific goals and monitoring expectations for each MU.

Weed Control Effort Summary

OANRP weed control efforts are divided into three primary categories: incipient control efforts, broad ecosystem control efforts, and early detection surveys. Weed control efforts are discussed for each category separately.

This year, OANRP spent 8,447 hours controlling weeds across 539.5 ha. These figures include both incipient and ecosystem control efforts by staff and volunteers but do not include survey efforts or travel time. The table below lists efforts for the previous six reporting cycles. Note that all reporting periods, including this year, were 12 months in length, except 2014-2015, which covered only nine months.

Report Year	Effort (hours)	Area (ha)
2015-2016	8,447	539.5
2014-2015 (9 months)	4,654	325.9
2013-2014	7,600	286.5
2012-2013	6,967.6	267.7
2011-2012	5,860	275.7
2010-2011	5,778	259

Complementing control efforts, OANRP staff conducted early detection surveys on all primary training range roads and military landing zones (LZs), some MU access roads, and all secondary training range roads in KTA, SBE, MMR, and SBW.

Keeping native forest from getting flushed down the drain.

Incipient Control Areas

Incipient control efforts are tracked in Incipient Control Areas (ICAs). Each ICA is drawn to include one incipient taxon; the goal of control is eradication of the taxon from the ICA. ICAs are primarily drawn in or near MUs. Those not located within or adjacent to an MU were selected for control either because they occur on an Army training range (for example, *Cenchrus setaceus* in MMR) or are particularly invasive (*Morella faya* in Kaluaa). Many ICAs are very small and can be checked in an hour or less, and in some MUs multiple small ICAs can be checked in one day. In contrast, a few ICAs, like those for *Sphagnum palustre* in Kaala or *Chromolaena odorata* in Kahuku, are quite large and require days to sweep completely. Typically, ICAs are swept repeatedly until eradication has been achieved and staff is reasonably confident there is no remaining seed bank. In the absence of data regarding seed longevity, staff does not consider a site eradicated until ten years after the last sighting. The goal of ICA efforts is to achieve local eradication of the target species. OANRP currently controls 61 taxa in 268 ICAs, and considers eradication to have been achieved at 18 ICAs.

Of the total 539.5 ha swept, ICA efforts covered 388.1 ha. Staff spent 2,452 hours on ICA management and conducted 539 visits to 175 ICAs. This is the greatest effort spent and area managed for incipient weeds in a reporting period to date; see table below. Additional staff time was directed towards incipient control this year, particularly surveys, sweeps, aerial sprays, and intensive hotspot treatment of several priority taxa, including *Chromolaena odorata*, *Schizachyrium condensatum*, *Cenchrus setaceus* and *Ehrharta stipoides*. This year, ICA work accounted for 72% of the total area controlled and 29% of total effort. This makes sense, as incipient control generally requires less time per acre than habitat restoration weed control.

Report Year	# ICAs	Visits	Effort (hours)	Area (ha)
2015-2016	175	539	2,452	388.1
2014-2015 (9 months)	147	333	1,537	245.6
2013-2014	157	389	1,753.6	196.41
2012-2013	152	311	1,369.2	184.34
2011-2012	115	260	1,661	219.27
2010-2011	130	281	665.5	164

While the goals for all ICAs are the same, the rate of visitation required to achieve local eradication varies widely. Some ICAs, such as those for *Ehrharta stipoides*, must be visited at least quarterly, as this cryptic grass grows and matures very quickly. In contrast, for *Angiopteris evecta*, once initial knockdown is complete, ICAs need only be swept once every year or two, as individuals are slow to mature. In general, ICA efforts are considered successful if visits are frequent enough to detect and control plants before they mature and there is a downward trend in total numbers of plants found per visit.

While the majority of ICAs require minimal amounts of effort to monitor, some require significant investment of resources. Volunteers contribute significantly to ICA control efforts at Kaala and Palikea, which enables OANRP to divert staff time to more challenging taxa and/or work sites. A good example of this are ICAs for *Sphagnum palustre, Juncus effusus*, and *Crocosmia crocosmiiflora* along the boardwalk at Kaala. All of these taxa are highly invasive, but none of these boardwalk ICAs are located in direct proximity to IP taxa. Volunteer effort here frees staff to focus on *Hedychium gardnerianum*, which directly threatens rare plants and their habitat, while maintaining pressure on the less immediate threats, posed by the boardwalk ICA taxa.

Although not included in this document, specific reports that identify dates of last mature and non-mature plants found, overall effort spent, and population trend graphs are available for each ICA. These reports may be generated in the OANRP database (supplied on CD) and are recommended for review by the IT.

The number of ICAs managed has increased steadily over the years. Part of this is due the difficulty of determining when a site has been extirpated; ten years is a long time to monitor. Each year, staff note new locations of known priority species, for example *Pterolepis glomerata* in the Waianae Mountains, or discover entirely new taxa, such as *Chelonanthes acutangulus*. While dispersal via Army training or OANRP management accounts for some of the new ICAs, some spread is likely due to public hikers, non-native animals, and wind events. Even with improved strategies and control techniques, the time required to address ICA work grows along with the number of ICA sites. Encouragingly, this year staff were able to confidently declare eradication at 12 ICAs, for a total of 18 eradications. Among these are two *Buddleja madagascariensis* sites (SBE), one *Cenchrus setaceus* site (SBE), one *Melochia umbellata* site (KTA), one *Rhodomyrtus tomentosa* site (KTA), and one *Senecio madagascariensis* site (SBS).

The eleven MUs where most ICA effort was spent this report year are highlighted in the table below. Note that effort hours do not include travel or trip preparation, or most time spent surveying outside of known ICA boundaries to define infestation areas. See the Invasive Species Update sections (3.7-3.8) for more detailed discussion of select priority targets.

2016 ICA Effort in MUs

MU	# of Taxa	Taxa List	# of Visits	Effort (hrs)	Comments
KTA No MU	6	*Acacia mangium* *Cenchrus setaceus* *Chromolaena odorata* *Melochia umbellata* *Miscanthus floridulus* *Rhodomyrtus tomentosa*	117	897.95	Almost 37% of ICA effort was spent at KTA this year. KTA hosts several ecosystem-altering weeds, including the largest population of *Chromolaena* in the State. As one of the most heavily used Ranges, KTA is a high priority incipient control area. *Chromolaena* control accounts for 89% of time spent at KTA. Hours recorded here do not include hours spent by OISC, which are included in Appendices 3-5 and 3-6. While all the other listed taxa require comparatively less effort, both *Melochia* and *A. mangium* infest large areas (35.6 ha and 82.7 ha, respectively) and have long-lived seeds.
Kaala Army	7	*Anthoxanthum odoratum* *Crocosmia* x *crocosmiiflora* *Diplazium esculentum* *Festuca arundinacea* *Juncus effusus* *Pterolepis glomerata* *Sphagnum palustre*	52	365.40	Staff work with volunteers to control most of the *Crocosmia, Juncus,* and *Sphagnum* ICAs. *Sphagnum* control efforts have been very successful, and the focus of control has shifted from drenches of large moss banks to detailed sweeps for small patches. Staff found one small new *Diplazium* site this year, and two new *Festuca* sites. All three sites are close to the FAA exclosure, in degraded areas, and likely had been around for years. *Festuca* in particular is very cryptic, especially when it is not fruiting. No *Pterolepis* were found at the transect trail or boardwalk sites this year.
SBE No MU	9	*Buddleja madagascariensis*	85	349.10	Located next to residential Wahiawa, heavily used for training, SBE is home to

MU	# of Taxa	Taxa List	# of Visits	Effort (hrs)	Comments
		Cenchrus setaceus *Chromolaena odorata* *Heterotheca grandiflora* *Rhodomyrtus tomentosa* *Schizachyrium condensatum* *Senecio madagascariensis* *Smilax bona-nox* *Vitex trifolia*			a diverse array of weeds not found on other Army lands. This year, 14% of all ICA effort was spent at SBE. Of this, 60% was spent on *Schizachyrium*. Staff surveyed most of the remaining appropriate habitat, installed 'no mowing' signage around hotspots, and instituted a new strategy of annual sweeps coupled with quarterly hotspot treatments. Two new ICAs were identified this year. This will continue to be a challenging species in future. Both *Buddleja* ICAs, one *Cenchrus* ICA, and the single *Senecio* ICA were declared eradicated this year. The remaining *Cenchrus* ICA will likely be declared eradicated in late 2016. No *Heterotheca* were seen at any of the three ICAs. Even more exciting, no plants have been seen at the *Chromolaena* ICA since 2015-02, suggesting the infestation was removed before creating a seed bank. *Rhodomyrtus* continues to persist across a large region.
Kaala NAR	5	*Crocosmia* x *crocosmiifolia* *Diplazium esculentum* *Juncus effusus* *Pterolepis glomerata* *Sphagnum palustre*	32	253.45	Staff assisted NEPM staff with treatment of *Sphagnum* both along the boardwalk, and in the core of the infestation; this accounts for about half the time spent in this MU this year. Most of the remaining time was spent on control of *Crocosmia* with volunteers. Volunteers also conducted most of the *Juncus* control. Several *Pterolepis* were found at the shelter this year.
SBW No MU	2	*Erythrina poepiggiana* *Chromolaena odorata*	38	213.00	During annual road surveys, an outlying *E. poepiggiana* was mapped more than 3km from known sites. This single tree was likely immature, despite its height, as it was not flowering during the annual flowering season. This species is wind dispersed. Aerial surveys of the area confirmed that it was a lone outlier. The largest mature tree along Kolekole Road was removed by DPW contractors, eliminating the largest remaining source of seed. Control of *Chromolaena* at SBW continues to be a high priority and accounts for 99% of the time spent at SBW No Mu. A combination of ground and aerial treatment was used to cover a large portion of the infestation. No new outlier sites were found this year.

MU	# of Taxa	Taxa List	# of Visits	Effort (hrs)	Comments
Ohikilolo Lower	1	*Cenchrus setaceus*	9	78.52	Both ground control and aerial sprays were conducted at the *Cenchrus* infestation. While progress at the core is encouraging, cliff-dwelling plants continue to be challenging to reach with spray gear, and better techniques are needed to sweep the entire infestation area. On the annual road survey, several outliers were found in the mowed zones bordering the firebreak road.
Kapuna Upper	2	*Angiopteris evecta* *Sphaeropteris cooperi*	13	48.91	*Angiopteris* ICAs cover 12.6 ha in Kapuna and Keawapilau gulches. This year, mature plants were found at only two of the eight ICAs. Staff will continue to conduct annual surveys of all ICAs, to prevent new plants from maturing. While abundant elsewhere, *Sphaeropteris* is known from a single site in this MU. Plants continue to be found at the site, although few matures have ever been seen; it is unknown how long spores or gametophytes persist.
Palikea	3	*Crocosmia* x *crocosmiiflora* *Dicliptera chinensis* *Setaria palmifolia*	13	39.25	The majority of time was spent on *Crocosmia* control and utilized volunteer labor. No *Dicliptera* were found at the gulch ICA this year; if no plants area seen by 2019, it will be declared eradicated. Small numbers of *Setaria* continue to pop up at all ICAs.
Manuwai	2	*Dietes iridioides* *Pterolepis glomerata*	12	33.21	Additional time and effort will be needed to effectively control *Pterolepis* in the coming year. This year, the largest ICA expanded along the fence/trail and downslope towards the gulch, while a new ICA was discovered during fence checks. Current efforts appear to be insufficient to either prevent spread or reduce the number of mature plants. Removing soil from directly around mature plants may help reduce the number of seeds on site, as well as increased use of pre-emergents. This area is not accessible to hikers, and improved staff sanitation may help reduce spread.
Pahole	6	*Angiopteris evecta* *Axonopus compressus* *Dicliptera chinensis*	35	21.65	Most of the ICAs at Pahole, with the exception of those for *Angiopteris* and *Dicliptera*, are found along the Makua/ Pahole fenceline. This year, increased effort was spent on *Ehrharta* ICAs, with 1-2x quarterly visits. Some of the ICAs are approaching eradication, although the

MU	# of Taxa	Taxa List	# of Visits	Effort (hrs)	Comments
		Ehrharta stipoides			Pahole Snail Enclosure site will require at least another year of monitoring. Likewise, sustained attention will be needed at the *Pterolepis* ICA, where staff continue to regularly find small numbers of plants. No mature *Angiopteris* were found at any ICA this year, and no *Dicliptera* were found.
		Pterolepis glomerata			
		Rhodomyrtus tomentosa			
Ohikilolo	4	*Cirsium vulgare*	19	20.96	Due to range closure issues at MMR last year, little time was spent at Ohikilolo. Once access was restored, staff were able to renew ICA work. Unfortunately, staff found several new locations of *Pterolepis*, including one on the LZ and two along the ridge fence. In addition, the *Ehrharta* infestation at the LZ and cabin has spread along the fence and management trails. Both taxa are cryptic, challenging to identify and remove. Hopefully the *Pterolepis* sites were discovered before creating seed banks. *Ehrharta* seeds are not-persistent, but frequent trips will be necessary in the future to bring this pest under control.
		Ehrharta stipoides			
		Pterolepis glomerata			
		Rubus argutus			

The table below highlights the taxa which required the most control effort in the past year. Effort from report year 2015 is presented for comparison. Note that report year 2016 covers twelve months, while 2015 covers only nine months.

2016 ICA Effort by Target Taxa

Taxa	2016 Effort (hours)	2015 Effort (hours)	Comments
Chromolaena odorata	1029.70	524.6	*Chromolaena* continues to be OANRP's top ICA priority. Staff efforts include treatments of hotspots, large sweeps, and aerial spraying; see discussion sections 3.4 and 3.6 below. OANRP continued to contract OISC to conduct work across half of the KTA infestation; see Appendices 3-5 and 3-6 for OISC's progress report.
Sphagnum palustre	331.35	186.4	Due to the success of previous control efforts, there is much less *S.palustre* on the Army side of the Kaala boardwalk than ever before. Volunteer efforts continued in a narrow, 3m buffer along the boardwalk. Staff swept the remainder of the Army infestation, beyond this 3m buffer. While small florets and occasional patches persist, the overall cover of *S. palustre* in the core is greatly reduced, as is shown by the reduction in moss killer used over the years. In 2012-2013, during initial treatment of the core, 1,177 L of moss killer were used. In contrast, only 457 L were used in the core this year. In addition to treating the core and outliers this year, staff also spent 76 hours (23% of total) conducting *S. palustre* control in the Kaala NAR under NEPM direction.

Taxa	2016 Effort (hours)	2015 Effort (hours)	Comments
Crocosmia x *crocosmiiflora*	229.00	115.75	Volunteers conduct the majority of *Crocosmia* control at both Kaala and Palikea. Most effort (78%) is spent at Kaala, where *Crocosmia* forms dense, localized banks. Corms are removed by hand. While this is effective on small populations, such as those at Palikea, it is not effective on the large patches at Kaala. A trial of chemical control methods was installed this year; results are pending.
Schizachyrium condensatum	210.80	190.95	SBE remains the only location on Oahu with *Schizachyrium*. Efforts to fully delimit the boundaries of the infestation continued this year, with only a few small areas remaining. Two new ICAs was identified in August 2015. Control efforts are ongoing, and are discussed in section 3.9.
Rhodomyrtus tomentosa	111.70	64.13	*Rhodomyrtus* is known from SBE, KTA, and Pahole. This year, a thorough survey was conducted at KTA, with no plants found; this site is considered eradicated. Only one plant was ever seen at Pahole, along the fence. Although short, the plant was mature and staff will monitor the site for several more years, as it may have set seed. The largest infestation is at SBE, where 96% of the total *Rhodomyrtus* effort was spent. Several new locations were found this year during *Schizachyrium* surveys. The size of the infestation is the greatest challenge; systematic sweeps must be implemented to make real progress towards eradication. Also, much of the infestation area is mowed periodically. While mowing doesn't kill the shrubs, it does make them difficult to locate, as the grass quickly grows tall, hiding the pruned *Rhodomyrtus*.
Cenchrus setaceus	90.27	75.05	ICAs for this fire-prone grass are located in DMR, KTA, SBE, and MMR. *Cenchrus* is a high priority taxon due to its association with fire and potential for negative impact to training ranges. Previous studies by the OANRP seed lab suggest seeds do not persist in the soil for longer than a year and half. Control efforts are discussed in section 3.8, below.
Pterolepis glomerata	77.4	34.45	This taxon is only a target in the Waianae Mountains, where it is a control priority in Kaala, Manuwai, Makaleha, Pahole, and Makaha. New sites were found this year at Manuwai, Ohikilolo, Makaleha West, and outside of Makaleha West. The tiny seeds of *Pterolepis* likely were tracked to these sites via staff, recreational hikers, hunters, and/or invasive animals. New tools and increased vigilance are needed to prevent further spread and suppress germination. It is thought *Pterolepis* forms a persistent seed bank. A biocontrol for a related species, *Tibouchina herbacea*, also attacks *P. glomerata* and may provide welcome assistance; the biocontrol has not yet been released.
Juncus effusus	68	33.9	Volunteers conduct the majority of control on this species, Since the seeds are long-lived, control will be required for years to come. This year, staff discovered *Juncus* on the upper portion of the Dupont Trail, about ten minutes hike from the Kaala road. It likely was tracked here by hikers from the Kaala boardwalk. Staff will begin control in the coming year.
Melochia umbellata	66.5	59.5	This species, incipient to KTA, has been controlled by OANRP since 2002. It likely forms a persistent seed bank. Of the eight ICAs, one has been eradicated, two have had no plants since 2011, and one has had no plants since 2013. The four remaining ICAs encompass the core of the infestation. Staff used aerial surveys to guide control efforts, and target control efforts around known hotspots and along roads. All known mature trees have been removed.

Taxa	2016 Effort (hours)	2015 Effort (hours)	Comments
Angiopteris evecta	58.41	20.67	This taxon is relatively widespread, but has been targeted for eradication in select MUs. Initial control is complete at all known sites, and the current strategy of annual maintenance checks appears to be effective. Staff continue to find large numbers of seedlings and immatures.
Ehrharta stipoides	49.15	24.3	Only one new *Ehrharta* location was found this year, on the contour trail at Huliwai. This is an improvement over last year, when new sites were found at four MUs. However, *Ehrharta* seems be established along large portions of the southern Lihue fence and in some non-MU areas of Makaleha. While difficult to identify, the lack of a persistent seed bank suggests this taxa is locally eradicable. Intensive monitoring of ICAs in Kahanahaiki and Pahole this year resulted in large reductions in numbers of plants found; several ICAs are expected to be declared eradicated in late 2016. The lone Makaha No MU ICA was declared eradicated, with no plants found for many years. At Kaluaa, no plants were found at the Hapapa site this year, although the access trail ICA was expanded to include new plants along the fence. Similarly, one of the Ekahanui ICAs was expanded; located in steep area bisected by a cliff, this is a challenging site to survey.

Weed Control Areas

Ecosystem control efforts are tracked in Weed Control Areas (WCAs). WCAs generally track all control efforts which are not single-species based. Note that WCAs are not necessarily drawn to encompass all of a MU, although in some MUs, like Makaha and Manuwai, the entire MU has been divided into WCAs. Each WCA is prioritized and goals are set based on a variety of factors including: presence of MIP/OIP rare taxa, potential for future rare taxa reintroductions, and integrity of native forest, invasive species presence, and fire threat. Different WCAs have different goals; some simply track trail and fenceline vegetation maintenance. The goals and priorities for weeding in a particular WCA are detailed in the appropriate ERMUP. For some low-priority WCAs, no control may be planned for many years. WCAs drawn outside of MUs typically provide a way of tracking weed control effort at genetic storage rare plant sites or along access trails and roads. OANRP does not necessarily plan to control 100% of the acreage in a WCA every year. Some WCAs are not intended to be visited annually, particularly those in sensitive habitats. Others, like the ones in Ohikilolo Lower which facilitate fuel break maintenance, are monitored quarterly and are swept in their entirety. Visitation rates and goals are further elucidated in the ERMUPs. Via the ERMUPs, staff hopes to more accurately show how priorities are set for different WCAs over a multi-year time period. See the 2009 Status Update for the MIP and OIP, Appendix 1-2, for information on control techniques.

Report Year	Effort	Visits	Area (ha)
2015-2016	5,995 hours	713	151.3
2014-2015 (9 months)	3,117 hours	352	80.4
2013-2014	5,846 hours	526	90
2012-2013	5,620 hours	532	83.4
2011-2012	4,199 hours	443	57
2010-2011	5,123 hours	409	
2009-2010	3,256 hours	353	
2008-2009	2,652 hours	267	

This year, WCA efforts covered 151.3 ha. Staff spent 5,995 hours over 713 visits at 156 WCAs. WCA work accounted for 28% of the total area controlled and 71% of total effort. Much WCA control involves intensively working in small areas around rare taxa locations, and thus requires higher inputs of time per acre than for ICA management. The table above compares this report year's efforts to previous report years. Note that last year's reporting period covered only nine months, but all other reporting periods, including 2015-2016, cover twelve months each. Area data from 2008 through 2011 was not collected as accurately as current practices and is not presented for comparison.

Increased use of new tools, the use of volunteers and interns, additional staff, the establishment of restoration projects, and an increased programmatic focus on weed control all contribute towards this year's high numbers. However, as MU vegetation monitoring results from the last several years show, many of the long-term (20 year), landscape level IP goals have not yet been met. Controlling alien plants and reestablishing native forest in Hawaii's unique ecosystems requires sustained effort and optimism. MU vegetation monitoring does not capture small-scale responses to weed control, for example, changes directly within a restoration site. In order to learn more about this type of change, this year staff installed plots and photopoints at a new Makaha restoration site and the new proposed Palikea North Snail enclosure (see Appendix 3-7); these trials will run for at least five years. Staff also monitored the Kahanahaiki Maile Flats restoration site this year, OANRP's oldest restoration project; results are detailed in Appendix 3-8.

Control efforts are summarized in the MU WCA Weed Control Summary table below. The table lists all MUs where WCA control was conducted in the past year. Data from the 2015 report is included for reference, although the two reporting periods cover different amounts of time, as described above. This year's data is shaded and in bold. For each year, the total actual area weeded is reported; for example, if one rare plant site of one acre was swept on three separate occasions, the area weeded is reported as one acre, not three acres. The number of separate weeding trips is recorded as number of visits, and the effort is recorded in person hours spent weeding (travel and set-up time is not included). While these statistics are not a replacement for vegetation monitoring, they detail the investment OANRP has made over the years.

In the OANRP database, specific reports can be generated which detail the amount of time spent in each WCA, the weeds controlled, the techniques used, and the rare taxa managed. These database reports, as well as the ERMUPs, provide a more detailed look into each MU and each WCA, and are recommended to the IT/USFWS for review. It can be difficult to compare effort spent between WCAs/MUs and to judge whether the effort spent was sufficient. Since goals for each site vary, estimating the effort needed for each WCA is very challenging. Staff continue to work towards creating meaningful estimates of effort needed per WCA for select sites in the coming year.

The top twenty MUs where the most effort was spent this reporting year are summarized in the table below. Most of these MUs are large, host multiple rare IP taxa, contain large swaths of native forest, and are easily accessible, but there are several exceptions. Ohikilolo Lower is home to two rare IP taxa and completely alien grass dominated. Maintaining the fuel reduction areas around the rare taxa is a high priority and requires consistent, large inputs of time in a normal year. Due to a safety incident, staff access was limited to most of MMR for many months. When staff regained access, alien grasses and herbs had colonized much of the fuel break and had to be re-cleared. While there was less invasive grass than prior to initial clearing in 2001, this is the most effort spent in the MU since then. Another exception is SBW No MU, which covers all weed control at OANRP's West Baseyard. While maintaining a weed-free baseyard is critical to minimizing the risk of accidental dispersal via management, most of this effort is due to volunteer weeding in the interpretive garden.

Volunteer weeding efforts contributed a large amount of time to the Kaluaa and Waieli, Makaha I, Kahanahaiki, Palikea, West Makaleha, and Pualii North MUs. At Kaluaa and Waieli, Makaha I and II, Kahanahaiki, Palikea, and Manuwai, staff conducted targeted sweeps for specific canopy weeds, treating them with low dose herbicide methods (i.e., incision point application) or conventional girdle/herbicide techniques. Understory weeds are not targeted on such sweeps, allowing staff to cover large acreages, and contributing to the high area/person hours spent at these MUs. Similarly, at Kaala Army staff conducted single-target sweeps for *Hedychium gardnerianum* in native-dominated forest. Much of the increase in effort at Kahanahaiki is due to new and on-going restoration projects. Since all alien canopy was removed at the sites, regular follow-up was conducted to prevent colonization by pioneer weeds and promote growth of native recruits. Likewise, increases in effort at Palikea are in part due to active restoration of *Drosophila* habitat sites, a volunteer site, and the new proposed snail enclosure.

Top Twenty MUs with Highest WCA Control Effort

IP Management Unit	Effort (person hours)	# Visits	Area Weeded (ha)	Targeted Canopy or Single Taxa Sweeps Conducted?	Volunteer Projects Present?
Kahanahaiki	1106.50	125	10.07	Yes (*Grevillea robusta*)	Yes
Palikea	939.40	103	6.13	Yes (*Morella faya, Cryptomeria japonica*)	Yes
Kaluaa and Waieli	550.50	56	15.11	Yes (*Grevillea robusta, Toona ciliata*)	Yes
Kaala Army	420.66	47	14.94	Yes (*Hedychium gardnerianum*)	Yes
Ohikilolo Lower	390.00	27	3.72	No	No
Makaha I	305.25	38	17.02	Yes (*Grevillea robusta, Toona ciliata*)	Yes
Manuwai	239.25	30	11.74	Yes (*Grevillea robusta, Schefflera actinophylla, Spathodea campanulata, Toona ciliata, Trema orientalis*)	No
Makaleha West	238.00	20	0.59	No	Yes
Lihue	227.75	35	12.14	No	No
SBW No MU	166.45	15	0.84	No	Yes
Pahole	160.00	29	2.67	No	No
Ohikilolo	152.15	19	0.99	No	Yes
Makaha II	146.00	23	6.64	Yes (*Grevillea robusta*)	No
Kapuna Upper	113.70	21	2.59	No	No
Opaeula Lower	101.75	8	0.90	No	No
Kamaili	72.00	12	0.71	No	No
Pualii North	63.50	10	0.66	No	Yes
Pahole No MU	57.25	11	6.61	No	No
Ekahanui	56.25	13	0.80	No	No
Makaha No MU	49.00	3	2.81	No	No

Native shrubs colonizing the Kahanahaiki ‘Shire’ restoration site.

MU WCA Weed Control Summary, 2015/07/01 through 2016/06/30

Management Unit	2016 Report Year					2015 Report Year			Comments
	MU area (ha)	Total WCA area (ha)	**Area weeded (ha)**	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Aimuu No MU	N/A	0.22	**0**	**0**	**0**	0.04 *(369 m²)*	1	2	Last year, staff controlled weeds around the remaining *Eugenia koolauensis* at this site. Weed control around *Eugenia* is currently a low priority, given the greater threat posed by *Puccinia* rust. No control occurred this year.
Alaiheihe No MU	N/A	9.99	**9.99**	**1**	**8.50**	9.22	1	9	This area includes the Lower Kaala NAR access road. Staff sprayed roadside weeds, focusing on *Urochloa maxima* and *Caesalpinia decapetala*. An *Ehrharta stipoides* site at the end of the road was monitored, with only 20 plants found.
Ekahanui	87.5	77.91	**0.80**	**13**	**56.25**	1.79	12	99.25	Control efforts focused around rare species sites, particularly reintroduction zones. Effort again declined this year, in part because resources were diverted to rare snail projects in the MU.
Haili to Kealia I	7.91	0.61	**0.05** *(518 m²)*	**3**	**21.00**	0	0	0	A new reintroduction of *Hibiscus brackenridgii* subsp *mokuleianus* was planted along the Kealia trail this year. Weed control targeted woody weeds and some grasses at the site.
Haili to Kealia No MU	N/A	3.37	**0.43**	**1**	**1.00**	0.03 *(296 m²)*	1	1	This area encompasses the Kuaokala access road. Staff controlled *Sphaeropteris cooperii* along the road, and will continue to do so opportunistically.
Helemano	60.63	61.86	**0.21**	**1**	**2.00**	0.91	2	2	Helemano is a low priority MU due to the small number of Tier 1 taxa, and is challenging to access due to weather. Staff targeted *Setaria palmifolia* along the fenceline.
Huliwai	0.12	0.20	**0**	**0**	**0**	0	0	0	This small MU is centered at an *Abutilon sandwicensis* population. No weed control was conducted this year. *Abutilon* appears to tolerate high weed cover.

Management Unit	2016 Report Year					2015 Report Year			Comments
	MU area (ha)	Total WCA area (ha)	**Area weeded (ha)**	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Huliwai No MU	N/A	9.44	**0.02** *(151 m²)*	**1**	**6.00**	0	0	0	While monitoring a *Cenchrus agrimonioides* var. *agrimonioides* site, staff also conducted weed control around it.
Kaala Army	49.02	51.18	**14.94**	**47**	**420.66**	5.43	22	280.5	*Hedychium gardnerianum* continues to be the primary weed target at Kaala. This year, staff targeted the WCAs closest to the boardwalk, portions of which had not been systematically swept for many years, as well as some of the steep slopes on the east side of the MU. Weeds also were treated at rare plant reintroduction sites
Kaala NAR	20.03	9.98	**0.70**	**3**	**4.00**	0	0	0	Staff assisted NEPM in sweeping across part of the bog, targeting *Hedychium gardnerianum* and *Psidium cattleianum*. A small amount of time was spent mowing the shelter/campsite area.
Kaena	10.06	3.28	**2.54**	**3**	**30**	0	0	0	Last year, reduced staffing on the Kaena crew contributed to the lack of weed control. This year, staff were able to renew weed control efforts, focusing on areas directly around *Euphorbia celastroides* var. *kaenana*. Since past control efforts were successful in controlling all woody weeds, staff expanded control to the westernmost *Euphorbia*.
Kaena East of Alau	14.51	0.89	**0.89**	**4**	**39**	0	0	0	Weed control efforts were renewed this year, and focused on reducing fuel loads around a small population of *E. celastroides* var. *kaenana*.
Kahanahaiki	37.7	41.47	**10.07**	**125**	**1,106.5**	2.71	38	302.67	An exceptionally large amount of area was swept and time was spent at Kahanahaiki this year. This is primarily due to work at restoration sites: 1. the Maile Flats chipper site, a volunteer project; 2. two gulch restoration sites (started last year); and 3. a third new gulch restoration site. In addition, staff weeded rare taxa sites and swept large areas to remove remaining *Grevillea robusta* canopy.

Management Unit	2016 Report Year					2015 Report Year			Comments
	MU area (ha)	Total WCA area (ha)	**Area weeded (ha)**	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Kaleleiki	0.12	0.80	**0**	**0**	**0**	0	0	0	The *E. koolauensis* population protected in this MU has been heavily impacted by the *Puccinia* rust. Weed control efforts are a low priority until a plan for *Eugenia* is developed.
Kaluaa and Waieli	80.97	82.96	**15.11**	**56**	**550.5**	14.63	48	603	This year, targeted canopy sweeps using IPA continued across the MU, and account for much of the area treated. Staff continued to focus other weed control efforts around rare taxa sites, reintroductions, and the Hapapa Snail Enclosure.
Kaluaa No MU	N/A	14.23	**2.26**	**5**	**30**	1.33	4	13	Limited effort is spent outside of the fenced enclosure. Staff maintained the access trail and road, and also controlled weeds within a small TNC exclosure home to several rare taxa.
Kaluakauila	42.73	10.56	**1.14**	**6**	**33**	2.24	3	31	Control efforts focused on grass control and shrub control around rare taxa sites. The ridgeline fuelbreak was maintained.
Kamaileunu No MU	N/A	0.96	**0.06** *(643 m²)*	**2**	**6**	0.10	3	19	All control was conducted at the LZ and campsite this year. Staff hope to install weed suppression of some kind to prevent weeds from obscuring the LZ between visits.
Kamaili	2.57	3.92	**0.71**	**12**	**72**	0.07 *(691 m²)*	2	11	This is the first year of significant weed control, as the fence was completed only last report year. Control efforts focused on rare taxa sites and along the fencelines. An experimental thinning of *Grevillea robusta* promoted growth of *A. sandwicensis*, which was very encouraging. Much of the MU is weed-dominated, and staff otherwise avoid creating large light gaps.
Kapuna Upper	172.35	179.20	**2.59**	**21**	**113.7**	1.29	22	104.84	Control efforts continue to focus around rare taxa and reintroduction sites. Additional time was spent clearing weeds from along the north-western fenceline, which was very overgrown.

Management Unit	2016 Report Year					2015 Report Year			Comments
	MU area (ha)	Total WCA area (ha)	**Area weeded (ha)**	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Kaunala	1.98	2.24	**0**	**0**	**0**	0.06 *(553 m^2)*	1	20	Until an effective strategy to combat *Puccinia* rust is created, OANRP is hesitant to commit resources to habitat restoration at any *E. koolauensis* sites.
Kawainui No MU	N/A	38.36	**0.08** *(823 m^2)*	**1**	**0.5**	0	0	0	While hiking on the summit trail, staff opportunistically controlled some outlying *Leptospermum scoparium*. There is a large infestation of *L. scoparium* in the northern Kooalu mountains, although it is not established in the Koloa MU.
Keaau and Makaha	1.19	0.18	**0**	**0**	**0**	0	0	0	Minimal effort is needed around this *Sanicula mariversa* site.
Keaau Hibiscus	3.64	3.23	**0.04** *(362 m^2)*	**1**	**20**	0	0	0	This is the first weed control in this newly fenced MU. Efforts focused on preparing a site for a *H. brackenridgii* outplanting.
Koko Crater No MU	N/A	0.28	**0.23**	**3**	**43.5**	0.23	2	15.5	Weed control was conducted around living collections of *H. brackenridgii* and *E. koolauensis* at Koko Crater Botanical Garden
Koloa	71.54	73.16	**0.12**	**1**	**9**	0.82	8	94.5	Located at the summit of the Koolau Mountains, weather poses a major challenge to conducting effective weed control. This year, staff controlled weeds around a reintroduction of *Phyllostegia hirsuta*. In future, control of the dominant weed *Psidium cattleianum* will resume.
KTA No MU	N/A	1.31	**0**	**0**	**0**	0.01 *(96 m^2)*	1	1	Last year, minimal weeding was conducted at an *E. koolauensis* site in conjunction with rare plant monitoring. This is a low priority action.
Lihue	711.92	714.91	**12.14**	**35**	**227.75**	3.02	12	93.5	The large increase in area weeded this year is primarily due to fenceline and roadside weeding, which accounts for 10.5 ha and 56 hours. The majority of remaining effort centered around rare taxa sites, including new reintroductions.

Management Unit	2016 Report Year					2015 Report Year			Comments
	MU area (ha)	Total WCA area (ha)	**Area weeded (ha)**	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Makaha I	34.2	34.32	**17.02**	**38**	**305.25**	5.8	34	271.75	Both effort and area treated increase dramatically this year. In part, this is due to targeted sweeps for *Grevillea robusta*. BWS granted OANRP permission to use Milestone herbicide for one year to control *G. robusta*. Aerial surveys were used to map large *G. robusta* and direct sweep efforts. Staff also targeted *Toona ciliata* in select areas. Other control efforts at Makaha I continue to focus around rare taxa sites and native forest patches in the mauka portion of the MU and select *Coffea arabica* patches. Volunteers contribute greatly to *Coffea* removal.
Makaha II	26.69	7.19	**6.64**	**23**	**146**	0.31	8	66	The entirety of Makaha II was swept for *G. robusta* this year; this accounts for much of the increase in area and effort. Staff also spent more time controlling weeds around rare taxa, as reintroduction sites expanded.
Makaha No MU	N/A	16.65	**2.81**	**3**	**49**	0	0	0	The BWS access road, already narrow in places, was overgrown with grass. Staff weedwhacked it for safety purposes.
Makaleha Central No MU	N/A	0.1	**0.01** *(144 m^2)*	**1**	**5**	0	0	0	Staff controlled weeds while monitoring a *Kadua degeneri* subsp. *degeneri* site.
Makaleha West	38.04	1.49	**0.59**	**20**	**238**	0.59	11	125.25	This MU has two widely separated WCAs. Staff weeded around rare taxa at the remote site, but the 99% of effort was spent at the 3-Points exclosure. At 3-Points, staff effort is targeted around rare taxa, while volunteers provide much of the labor to remove a large stand of *Psidium cattleianum* and assist with clearing weeds from the fence.
Makaleha West No MU	N/A	0.51	**0.17**	**2**	**1**	0.12	1	0.5	Control is conducted as needed to maintain the access trail.

Management Unit	2016 Report Year					2015 Report Year			Comments
	MU area (ha)	Total WCA area (ha)	**Area weeded (ha)**	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Manuwai	122.49	127.44	**11.74**	**30**	**239.25**	10.14	9	144	Effort at Manuwai was split fairly equally between large landscape sweeps for canopy weeds and focused control around rare taxa sites. Landscape sweeps account for most of the area treated. Staff noted particularly aggressive alien grass growth this year, likely due to the wet summer.
Manuwai No MU	N/A	3.4	**2.65**	**6**	**34.5**	0	0	0	All effort was spent controlling vegetation along access roads, particularly the road leading to the west side of the exclosure.
MMR No MU	N/A	18.22	**1.8**	**4**	**32.5**	0.35	1	5	Last year, fencing was completed along the Kuaokala road, connecting Kahanahaiki and Kaluakauila. This year, the majority of effort was spent controlling alien grasses along the fenceline. Minimal time was spent maintaining living collections at Makua Range Control.
Moanalua No MU	N/A	5.66	**0**	**0**	**0**	3.31	1	24	Last year, grass clearing was conducted along the four wheel drive Moanalua access road.
Nanakuli No MU	N/A	4.00	**0.49**	**2**	**2.5**	0.04 *(381 m^2)*	1	3	This is the Halona ridgeline, between the Palikea and Palikea IV MUs. Staff improved the LZ on this ridge, and swept the area for *Morella faya*.
Napepeiaoolelo	0.75	0.48	**0.07** *(724 m^2)*	**1**	**4**	0	0	0	The MU exclosure contains only 1 rare taxa, and historically has not been weeded much. This year, staff controlled weeds along the fenceline.
Ohikilolo	232.79	147.40	**0.99**	**19**	**152.15**	0.04 *(432 m^2)*	3	15.5	MMR was closed for part of the year due to a safety incident. In the Lower Makua portion of the MU, limited weed control was conducted, all around rare taxa sites. In the Ohikilolo Ridge portion of the MU, efforts were more extensive, but also centered around rare taxa and native forest sites, although some grass control was conducted. One volunteer trip was made to the cabin area.

Management Unit	2016 Report Year					2015 Report Year			Comments
	MU area (ha)	Total WCA area (ha)	**Area weeded (ha)**	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Ohikilolo Lower	28.75	4.52	**3.72**	**27**	**382**	3.66	13	148	Last year's range closure greatly set back fuel maintenance efforts. Multiple days of weedwhacking were needed to open the WCAs and allow them to be inspected for UXO. This accounts for the large bump in effort seen. Despite the closure, an experimental outplanting of *Scaevola taccada* survived the summer. New outplantings were installed at two WCAs in hopes of shading out fast-growing weeds. Monitoring of shrub cover was initiated during the past year (Appendix 3-2A)
Oio	1.33	1.39	**0**	**0**	**0**	0.09 *(908 m^2)*	1	16	Until an effective strategy to combat *Puccinia* rust is created, OANRP is hesitant to commit resources to habitat restoration at any *E. koolauensis* sites.
Opaeula Lower	10.15	6.80	**0.9**	**8**	**101.75**	0.27	3	6.5	This year, a trial examining the optimal interval between weeding events to minimize *C. hirta* recruitment was completed (Appendix 3-9). It was determined that follow-up weed control needed to be conducted at least once a year. With this information and increased staffing levels, *C. hirta* and other understory control efforts were expanded across central part of the MU and around rare taxa.
Pahipahialua	0.6	0.80	**0**	**0**	**0**	0.03 *(346 m^2)*	1	15	Until an effective strategy to combat *Puccinia* rust is created, OANRP is hesitant to commit resources to habitat restoration at any *E. koolauensis* sites.
Pahole	88.02	31.86	**2.67**	**29**	**160**	2.59	21	126	Weed control effort at Pahole is targeted primarily around rare taxa locations. Staff also sprayed alien grasses along the Pahole/ Kahanahaiki fenceline border.

Management Unit	2016 Report Year					2015 Report Year			Comments
	MU area (ha)	Total WCA area (ha)	**Area weeded (ha)**	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Pahole No MU	N/A	11.98	**6.61**	**11**	**57.25**	5.58	6	36.5	Staff continues to control weeds along the Pahole road, around the Nike greenhouse, and at the Nike LZ.
Palawai No MU	N/A	4.81	**0.48**	**4**	**13**	0.02 *(215 m^2)*	1	0.5	This area immediately abuts the Palikea MU. Control efforts targeted *Sphaeropteris cooperi*. There is a large source population here, and control efforts prevent ingress into the MU.
Palikea	9.95	11.39	**6.13**	**103**	**939.4**	1.29	33	281.3	Both effort and area controlled increased greatly this year. Much of the increase in area is due to sweeps targeting gradual removal of *Morella faya* and *Cryptomeria japonica*. No additional such canopy sweeps are planned, until OANRP is confident that further increasing light levels will not trigger an unmanageable increase in alien understory cover. Most effort was spent in three WCAs, which include active restoration sites, a volunteer project, and a potential new snail enclosure. Clearing for the new snail enclosure accounts for 271 hours.
Poamoho No MU	N/A	119.78	**1.38**	**3**	**41**	0	0	0	OANRP participated in a State-organized interagency road clearing effort at Poamoho.
Poamoho North	257.77	202.77	**6.32**	**1**	**15**	0	0	0	Staff spent one trip aerially spraying *Angiopteris evecta* with NEPM staff. This MU is of moderate priority, as it contains few MFS IP taxa and is actively managed by two other agencies. OANRP will continue to assist partner weed control efforts, as feasible.
Puaakanoa	10.7	1.07	**0**	**0**	**0**	0	0	0	Weed control efforts were hampered by the closure of MMR last year, and have not yet resumed. This MU was considered lower priority than Ohikilolo Lower, with regards to re-clearing grassy fuels.

Management Unit	2016 Report Year					2015 Report Year			Comments
	MU area (ha)	Total WCA area (ha)	**Area weeded (ha)**	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Pualii North	7.99	4.58	**0.66**	**10**	**63.5**	0.30	6	79.75	Staff control efforts focused around rare taxa sites and reintroductions. A volunteer project started in the gulch last year accounts for much of the effort spent.
Puu Kumakalii	4.83	6.12	**0**	**0**	**0**	0.27	1	1	No weed control was conducted around the cliff-side rare plant reintroductions this year. Control will be conducted as needed in this delicate habitat in future.
SBE No MU	N/A	4.16	**0.09** *(901 m^2)*	**3**	**3**	0.04 *(439 m^2)*	1	4	Weeds were cleared at the sediment disposal site, to keep it open for future use by DPW. A small amount of time was spent controlling weeds at the East Baseyard.
SBW No MU	N/A	2.08	**0.84**	**15**	**166.45**	1.28	9	20.75	The high number of hours is due to 142 hours of volunteer effort in the West Baseyard interpretive garden. The remaining staff effort focused on maintaining weeds at West Base to reduce the potential for staff to act as vectors.
Waianae Kai	3.66	1.14	**0**	**0**	**0**	0.15	2	5.5	Generally, control efforts focus around rare taxa locations and along the fenceline. No control was conducted this year due to scheduling issues.
Waianae Kai Neraudia Mauka	0.53	2.59	**0**	**0**	**0**	0.13	1	6	No control was conducted within this fence this year, as it will not be a MFS site for *Neraudia angulata* in future, and thus is low priority.
Waimanalo to Kaaikukai No MU	N/A	1.28	**0.83**	**1**	**3**	0.04 *(390 m^2)*	1	12.5	This area encompasses the Palikea access trail. Staff controlled alien grasses along the trail to reduce the potential for weed spread.
Waimea No MU	N/A	0.37	**0.34**	**4**	**40**	0	0	0	Weed control was conducted around living collections of *Nototrichium humile* at Waimea Valley botanical garden.
TOTAL	N/A	2,420.4	**151.3**	**713**	**5,995**	80.36	352	3,117	The previous reporting year covered only 9 months, while this year covers 12 months.

3.2 INTER-AGENCY INVASIVE PLANT COLLABORATION

Invasive species management can be incredibly daunting, as the number of weeds rarely diminishes and new species discoveries add to an ever-mounting list of challenges. Collaboration is critical in achieving progress. OANRP supports, and is supported, by a variety of partner agencies in addressing weed control issues. They include, but are not limited to:

- Oahu Invasive Species Committee (OISC). OANRP serves on the OISC steering committee. In the past year, joint projects have included *Cenchrus setaceus* and *Chromolaena odorata* control efforts. The OANRP Ecosystem Restoration Program Manager is currently serving as the OISC Chair, a two-year position.
- Bishop Museum and the Oahu Early Detection (OED) program of OISC. Plant samples submitted to the Bishop Museum Herbarium were identified by Museum and OED staff. Noteworthy finds are discussed in section 3.5.
- College of Tropical Agriculture and Human Resources (CTAHR). OANRP has worked with Dr. James Leary of CTAHR in research on novel weed control techniques, see section 3.9.
- State of Hawaii, Dept. of Land and Natural Resources (DLNR), Natural Area Reserve System (NARS), Forest Reserves (FS), and Native Ecosystems Protection and Management (NEPM). This year, OANRP staff collaborated with NEPM on one day of aerial spraying of *Angiopteris evecta* at Poamoho.
- Board of Water Supply (BWS)
- Koolau Mountains Watershed Partnership (KMWP)
- Puu Ohulehule Conservancy
- Waianae Mountains Watershed Partnership (WMWP)
- Waimea Valley

OANRP participated in Priority Oahu Native Ecosystems (ONE, formerly the Oahu Weed Working Group) meetings organized by NEPM. As part of a Priority ONE subcommittee, OANRP helped to plan the third Weed Workshop, hosted by Waimea Valley. OANRP staff also presented at the workshop. Both the workshop and Priority ONE meetings provide a valuable way to share information, data, and control techniques among local agencies conducting active weed control management work.

OANRP staff also attended the Ecology and Management of Alien Plant Invasions conference, held in Waikoloa, September 2015. Posters exhibited at the conference are included in Appendix 3-9.

3.3 VEGETATION MONITORING

Vegetation monitoring during the past year was conducted and analyzed for the Kaluaa and Waieli MU (Appendix 3-10), Manuwai MU (Appendix 3-11), and both subunits of Kamaili MU (Appendices 3-4A and 3-4B). The results of these studies are being incorporated into the latest draft of the ecosystem restoration plans and will be used to modify weed control plans for these MUs. Vegetation monitoring was also conducted across the Ohikilolo MU at the end of this report year. Results are being analyzed and will be presented next year. At the Ohikilolo Lower MU, a native shrub cover analysis using Gigapan was done as a pilot monitoring project (see Appendix 3-2A).

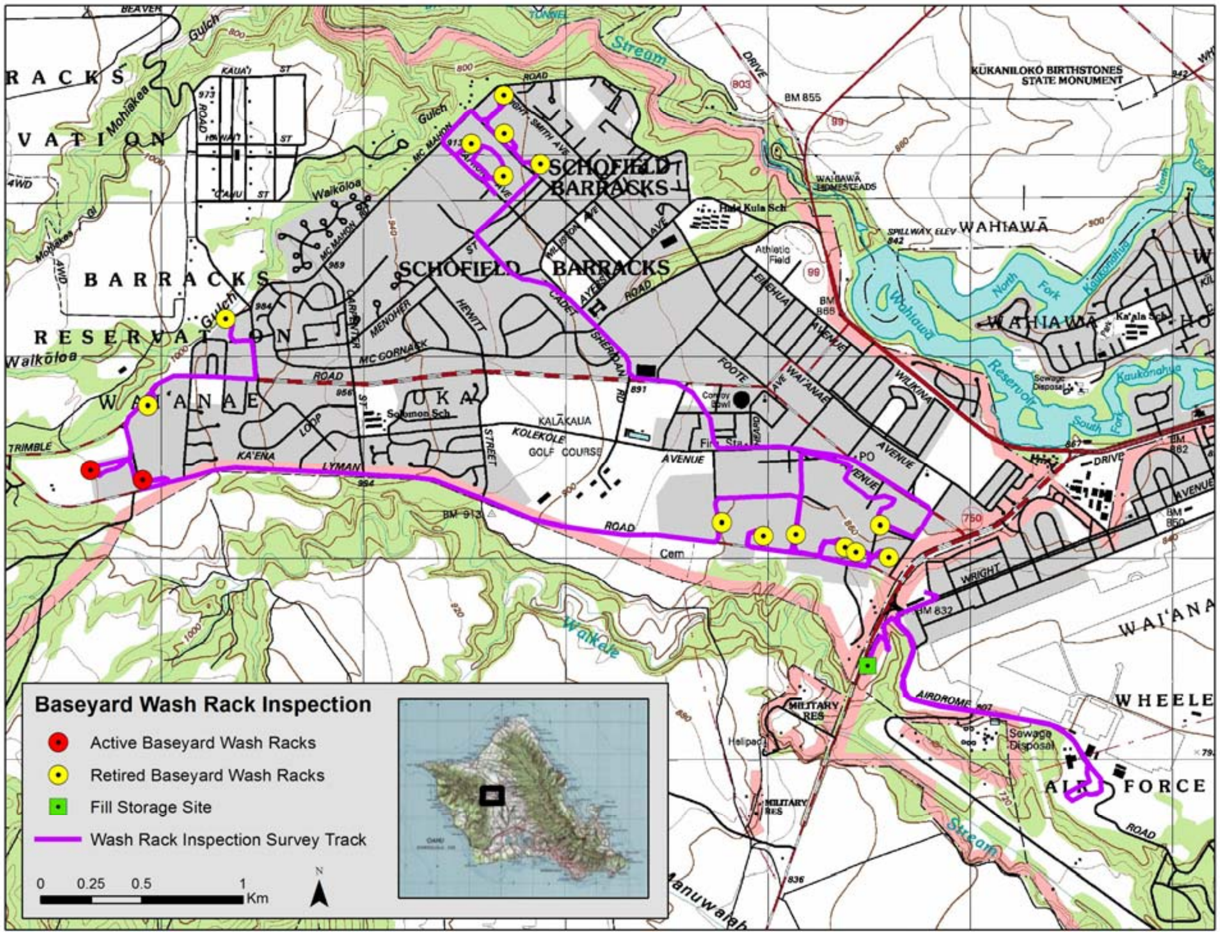
3.4 INVASIVE SPECIES SPREAD PREVENTION ON ARMY TRAINING RANGES

The Army's potential to move weeds from one training area to another has been amply demonstrated. This year, OANRP continued to coordinate with Range Division, DPW, and contractors to increase the Army's awareness of alien weed threats and improve sanitation-related protocols, practices, and policies.

Wash Rack Status

- Use at the Central Vehicle Wash Facility (CVWF) continued this year with regular hours of operation: 0800-1600.
- The SBE Wash Rack has not been operational for much of this report year, from December 2015 through April 2016. It closed again in July 2016. Last year, it was closed from November 2014 through March 2015 and again in May 2015. Repairs are expected to occur from September 12 through October 30, 2016. Units are encouraged to use the CVWF as an alternative. Once the SBE Wash Rack reopens, it will be run by the CVWF contractor.
- This year OANRP and OISC staff continued to utilize the wash rack at KTA by checking out the facility key at Range Control, operating the machinery, and washing vehicles. On a few instances, the wash rack was not operational, but it was at least partially operational for much of the year.
- Throughout the year, staff noted several instances where the KTA wash rack was not used by departing troops, in direct contradiction to Range requirements. The Federal Biologist worked with Range Control and DPW to develop measures to improve compliance, which are currently going into effect (August 2016). In the coming year, the maintenance and scheduling of the wash rack will be done by the CVWF contractor; this should insure the facility is always functional. Units will be required to schedule the wash rack whenever reserving a KTA training range via the online Range Facility Management Support System (RFMSS). The contractor has requested that scheduling happen two weeks prior to washing. Contractors are expected to show up at the scheduled time, run the facility, and track actual usage via a sign-in log. Same-day usage requests will still be possible, but will require a Form 84; these also will be kept. Under the new system, OANRP staff will still be able use the wash rack without contractor oversight. OANRP will be able to use RFMSS to monitor whether or not the wash rack is scheduled, and the sign-in log to ensure scheduled washing actually occurred. It is hoped this increased oversight will lead to better compliance.
- OANRP facilitated discussions between contractors and Range personnel to ensure staffing of the KTA Wash Rack during Rim of the Pacific (RIMPAC) training when high numbers of troops were expected on the range.
- Prior to the construction of the CVWF, many units used small wash racks at their own baseyards. The CVWF has replaced these, and all but two on Schofield and one on Wheeler are no longer in use. All sites, except for the active Wheeler site, were surveyed for invasive weeds this year; see map below. Most of the decommissioned sites were converted to parking areas or covered by storage containers. The two active wash racks remaining on SBW are used primarily by tracked vehicles, which cannot be washed in the CVWF. The Wheeler site is for helicopter washing. All sites were manicured and pose little risk of invasive weed spread. During the survey, staff also inspected a DPW fill (sand, gravel, dirt) storage location on Wheeler. This site is part of the new Wheeler road survey and will be inspected annually.

Schofield Barracks Wash Rack Inspection Survey



Landing Zones

- The Range Scheduling office requested OANRP assistance in updating the list of LZs units can use and schedule. This involved removing any LZ either not on a training range or not on Army-leased land. The LZs which were removed include: Depression, Bryans, Hammer, Lychee, Non-Stop and Rose.
- Staff were notified that an LZ located on Dole land, Basilian LZ, is periodically leased by the Army for landing and possible bivouacking. OANRP will determine annual usage and will schedule surveys at this old airstrip at Opaeula, below Drum road starting in 2017.

Integrated Training Area Management (ITAM) and Contractors

- OANRP reviewed the Soldier Field Card at ITAM's request. These cards are meant to be a resource for soldiers, and a way of sharing information with them about proper range usage. The cards emphasize the importance of cleaning gear and vehicles, preventing range fires, altering vegetation and reporting alien invasive species, such as snakes.
- Staff drafted memos and maps detailing invasive species sites on SBE, SBW and KTA that ideally would be avoided by soldiers and maintenance personnel. While these sites will not be officially excluded from training, it was agreed that small sites could be marked with signs and cones, and that personnel would be briefed on avoiding them.

- Staff briefed new contract maintenance staff on invasive weed threats on the training ranges. The presentation provided images of *C. odorata*, *C. setaceus*, and *S. condensatum*, discussed newly established 'no mowing' sites, and detailed what the Natural Resource office's expectations are regarding work around these sites.
- Following the discovery of two new outlier *C. setaceus* sites in mowed areas in MMR, staff contacted the contract lead and provided her with a map and plant identification photos. She said that she would brief her staff regarding this new threat.

KTA and KLOA

- In response to concerns from Range Control about heavy impacts from motocross use to X-Strip LZ and the rampant trespassing by motocross riders onto KTA (beyond the boundaries of the designated motocross park), the State built a fence around X-Strip LZ.
- The Army plans to conduct rockfall mitigation work along Drum Road. Staff reviewed proposals for where to deposit material generated by this project; these included portions of KTA and KLOA. Staff provided maps of invasive species sites, and requested that the fill avoid these areas, particularly the newly discovered *Chelonanthes acutangulus* location near Puu Kapu LZ.

SBW

- DPW removed a large *Erythrina poeppiggiana* from along Kolekole Road this year, see photos below. This 20-30m tall tree was likely the source of most of the other *E. poeppigiana* found on range. OANRP staff will sweep the surrounding area for other plants.

- Staff identified a site for disposal of sediment from the CVWF.
- Staff provided advice to the Cultural Resources office and contractor GDIT on a proposed aerial spray of Schofield Barracks, following a controlled burn. Funding for the spray did not come through.
- Firing Points (FP) 303, 304, and 306, all located on McCarthy Flats, were surveyed prior to rehabilitation by ITAM. These FPs have not been used in years and were completely overgrown. This area is adjacent to the Mohiakea gulch *C. odorata* infestation, but no plants were found. Both aerial and ground surveys were conducted. Once work is complete, these FPs may provide

improved access to portions of the *C. odorata* infestation, which will assist with eradication efforts.

- The Explosive Hazard Training Lanes, aka the ‘mine detection area’ was surveyed prior to rehabilitation by ITAM. At one point this area had been fenced and maintained as open ground, but at the time of the survey, the fence was partially collapsed and the area was covered in alien grass. There are *C. odorata* less than 30m from the lanes. Re-locating the lanes would have required digging up training devices and re-burying them elsewhere; the risk of moving soil potentially containing *C. odorata* seed was deemed higher than the risk posed by renewing the lanes. Staff requested that the new fence entirely enclose the site, which would prevent anyone from accidentally wandering into the *C. odorata* infestation.

- Last year, signs were placed near the mine detection area to prevent soldiers from training within the *C. odorata* infestation. This year, additional signs were installed along Area X and FPs 212 and 213 for the same purpose. As *C. odorata* control efforts have expanded, areas formerly dominated by invasive grasses were sprayed and cleared to allow for access to the infestation and improve visibility. These cleared areas look like good places for soldiers to bivouac. The signs do not block areas previously open to training, but rather define the edge of the training area and ensure that control efforts don’t encourage additional traffic to *C. odorata* sites.

- Staff conducted a site visit with a unit planning to train at FP 213, which is on the edge of the *C. odorata* infestation. The area north of the FP is marked off-limits for training. Staff discussed the situation with the unit representatives and approved them to bivouac in stand of Eucalyptus just outside the FP, as the area was far from known *C. odorata*. The Range Scheduling office referred the unit to OANRP; this was encouraging, as it showed that Range staff understood the importance of the restrictions placed on the area by the Natural Resources office.

SBE

- The wash rack sediment disposal site at SBE was completely overgrown this year. The SBE wash rack was out of commission, so the site was not used. The sediment barrier fencing fell over under the weight of all the vegetation. Staff cleared the area and fixed the sediment barrier.
- OANRP continued working with ITAM and range maintenance contractor General Dynamics Information Technology (GDIT) to address the *S. condensatum* infestation. GDIT regulars mows the open grassy fields of SBE, which are preferred habitat for *S. condensatum*. OANRP placed cones and signs around known concentrations of plants. Contractors were directed to avoid these areas during maintenance work, which hopefully will reduce the potential for dispersal.

Poles, rope and signs installed around *S. condensatum* hotspots at SBE

3.5 WEED SURVEY UPDATES: NEW FINDS

This year OANRP conducted surveys along Roads and Landing Zones (LZs) used by both natural resource staff and the Army. A new survey was conducted this year across all the roads (paved and unpaved) on Wheeler Army Airfield (WAA). Three new OANRP LZs were surveyed for the first time this year. To help prompt staff to conduct OANRP LZ surveys each quarter, staff upgraded the helicopter plan form on the database, so that it now generates the date of the last completed LZ survey for each LZ listed on the form. This report should allow staff to easily determine if a survey needs to be done by looking on their helicopter plans, required for any operation.

Staff also surveyed locations of potential introduction such as OANRP camp sites, Army washrack sediment disposal sites and MU access trails. Unusual and noteworthy plants found during the course of other field work are referenced in the Summary of Alien Taxa on Surveys table below as incidental and are also discussed in that table. OANRP received continued support from the Oahu Early Detection (OED) program and Bishop Museum to identify unknown species and evaluate taxa invasiveness potential. This year a total of 53 submissions were sent to OED for identification.

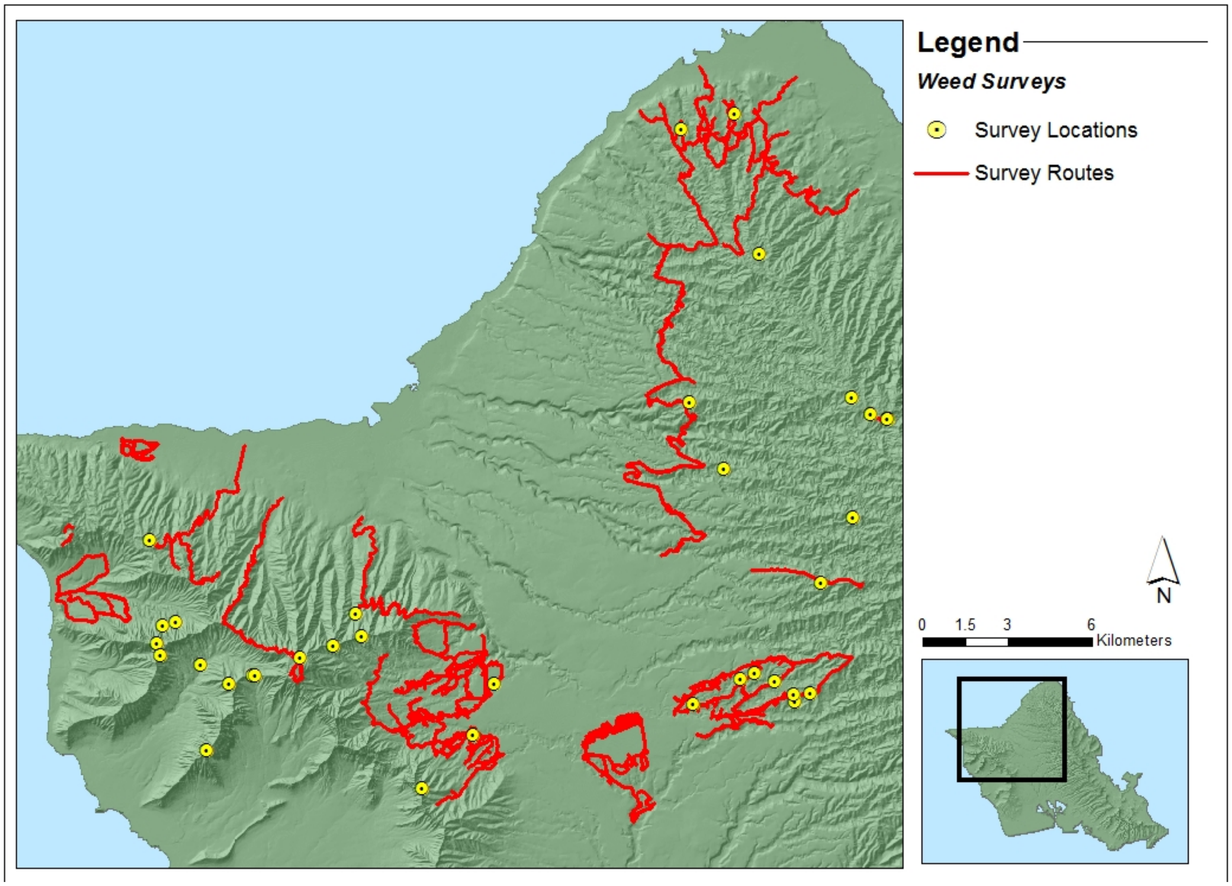
Access to roads throughout Schofield Barracks South Range has been difficult to schedule for the past 5 years, and only a partial survey was conducted the previous report year. OANRP gained access this year to all roads during a Range Maintenance week when no live-fire training was allowed. Continued access during these maintenance weeks is expected in the future.

Summary of Surveys Conducted

Survey Type	Description	# Surveys Conducted this Year
Road Survey	All drivable roads on Army Training Ranges were surveyed. Access roads to OANRP Management Units are surveyed annually or every other year; this year most were on the schedule.	18 road surveys
LZ Survey	Actively used Army LZs are surveyed once per year. This year two Army LZs were not surveyed due to landing restrictions: LZ Black and Elephant's Foot. Landing issues are now resolved and staff will survey this coming year. OANRP LZs were surveyed if used within a quarter.	44 surveys on 34 LZs
Transect Survey	Surveys are conducted annually along high use access trails to OANRP MUs, and along selected MU fencelines and transects inside MUs.	18 weed transect surveys
Camp/Other Survey	Surveys are conducted at OANRP campsites and other potential locations of introduction such as washrack sediment disposal sites. Survey frequency varies based on location and use.	10 surveys at 6 sites

Locations of LZ and camp/other survey sites surveyed this year are depicted in the map below as points. The line features are locations of roads and transects surveyed.

Map of Surveys Conducted in 2016



Survey data are tracked in the OANRP database and each year the list of new finds on each of those surveys is reviewed. The significant finds from those surveys, incidental observations during regular work, and noteworthy species submitted to Bishop Museum for identification are summarized below.

Summary of Alien Taxa on Surveys

Survey Type	Survey Code/ Description	Significant Alien Taxa Seen	Discussion
Road	**DMR-01** Roads throughout DMR	*Eragrostis leptostachya*	This grass was found to be locally common on most roads surveyed in DMR. Bishop Museum identified it as a new island record. It is unlikely to be highly invasive, and no control is planned.
Road	**KLOA-08** Drum Road	*Chelonanthus acutangulus*	New State Record (photos below). Found growing out of erosion matting along the road. An expert on the genus was required for final identification. No record of *C. acutangulus* as a weed elsewhere, but it is a common roadside plant in the tropical Americas. It thrives in disturbed areas and has tiny seeds. It was given a Hawaii Pacific Weed Risk Assessment score of 7, suggesting that control is warranted. Plants have been removed, and an ICA has been created for this species for quarterly monitoring/control at the site.

Survey Type	Survey Code/ Description	Significant Alien Taxa Seen	Discussion
		Digitaria abyssinica	*D. abyssinica w*as recorded as a New Island Record, however this mat-forming grass looks like a previously unidentified grass collected from this road, as well as a locally common unidentified grass at KTA. Distribution may be larger than previously thought. Will work to get mature samples from Drum Rd and KTA to document distribution. No control planned.
Road	**Pahole-01** Pahole Road	*Plantago debilis*	New distribution record for this species. Documented at only 3 other localities in the Bishop Museum records. No invasive threat record. No control planned.
Road	**SBS-01** Roads across Schofield South Range	*Mallotus phillippensis*	This species has a limited distribution. One individual found along a road in SBS this year. Scattered individuals in the nearby Kaluaa and Waieli MU are controlled during regular weed control sweeps. No control planned for this individual, as it is outside of a managed area, but staff will continue to document distribution as individuals are observed.
Road	**SBS-01 & SBW-04** Roads across Schofield South and West ranges	*Hypochaeris glabra*	Small aster with wide distribution across South and West Ranges. No invasive threat record. No control planned.
		Bothriospermum tenellum	Small herb with tiny white flowers. No invasive threat record. No control planned.
Road	**Wheeler-01** Roads throughout Wheeler Army Airfield (WAA)	*Anredera cordifolia*	This vine is highly invasive and spreads easily via aerial tubers. It was found in one location on the edge of a degraded gulch during this road survey. Staff will continue to monitor the spread of the plant during annual road surveys, but otherwise control is not planned.
		Cardiospermum grandiflorum	Found in a single location along a paved road near the airfield. This vine is known elsewhere from the island and is invasive. This location is not near a native area and is somewhat confined by roads. No control is planned, but any further spread on (WAA) will be documented.
		Cupaniopsis anacardioides	Planted as an ornamental street tree near the airfield, this taxon has some documented invasive behavior. No naturalized individuals noted. No control planned.
		Oldenlandia corymbosa	This small weed has a somewhat common distribution, and may be overlooked due to its small stature. No perceived invasive threat; no control planned.
		Triplaris weigeltiana	This species is potentially invasive and was found in a forested area surrounding the horse stables on WAA. OANRP have also documented it from Schofield Barracks. Staff will continue to document new locations, however, as it is far from native forest, no control is currently planned.

Survey Type	Survey Code/ Description	Significant Alien Taxa Seen	Discussion
	Wheeler-01 Roads throughout Wheeler Army Airfield (WAA)	*Manihot glaziovii*	*M. glaziovii* was found naturalizing in the immediate vicinity of mature trees in a wooded area near the stables on WAA. Bishop Museum Herbarium kept this specimen to document its distribution. As with other plants found on the Wheeler road survey, no control is planned for this species, but new locations will be documented.
LZ	**LZ-MOKFR-189** Nike Site LZ	*Eragrostis tenuifolia*	Found on the frequently used LZ at the Nike site, this taxon is not commonly documented on Oahu. No invasive threat record is known, however weeds on this LZ should be kept to a minimum. No control planned specifically for this grass.
LZ	**LZ-MMR-12** Ohikilolo LZ	*Pterolepis glomerata*	It is very worrisome to find *P. glomerata* on this LZ. At one point only known to from the Koolau Mountains, this weed is being observed at many new locations in the Waianae mountains. It is important to eradicate this new location at Ohikilolo LZ to prevent further spread into the MU. An ICA has been established at this site. Further discussion of this taxon can be found in section 3.1.
		Toona ciliata	It is not surprising that a small *T. ciliata,* a widespread invasive tree common in Makaha valley and becoming more prevalent in Makua valley, dispersed to the LZ, but it is important for staff to maintain a zero tolerance for it in the managed forest patches in Ohikilolo MU during weed control sweeps. No creation of an ICA is planned.
Incidental	Keaau	*Bromus diandrus*	One small sample was found on a trail at the back of Keaau Valley and was noted as a new island record. *B. diandrus* is an invasive grass with the potential to carry wildfire. Staff will continue to monitor the location found during the course of other work in the area, however no control is planned.
Incidental	Huliwai (contour trail)	*Ehrharta stipoides*	A small population of this invasive grass was found on either side of the contour trail as it runs through Huliwai gulch. It is being controlled quarterly in an ICA to prevent spread along the trail.
Incidental	Wheeler Army Airfield sediment deposition site	*Heliotropium amplexicaule*	An unknown species found during a survey of washrack sediment. No invasive threat record. No control planned.
Incidental	Makaleha East, Dupont Trail	*Juncus effusis*	A small number of *J. effusus* (1 mature, 2 immature) were found on either side of a radio transmitter along the Dupont Trail 10 minutes off the Kaala road. This invasive rush is controlled on the Army side of Kaala summit at several ICAs. An ICA has been created at this new location to prevent spread along the Dupont trail and in new locations at Kaala summit.
Incidental	SBE	*Lablab purpureus*	This bean crop was found on East Range, but has a wide distribution and no invasive threat record; therefore no control is planned.

Survey Type	Survey Code/ Description	Significant Alien Taxa Seen	Discussion
Incidental	Kaluakauila fenceline	*Linum trigynum*	This small plant is not well documented in the Bishop Herbarium, but has been noted by staff in several locations including the Ohikilolo and Kahanahaiki fencelines; it may be under reported. It does not appear to be particularly invasive or habitat altering. No control planned.
Incidental	Kaala summit near FAA fence	*Lolium multiflorum*	Several uncommon grasses occur at Kaala summit including *L. multiflorum*, submitted this year for identification. This grass has no invasive threat record and no control is planned.
Incidental	Multiple locations	*Pterolepis glomerata*	Found on the Ohikilolo LZ this year (see LZ write-up above), this invasive weed was additionally observed by staff at the following locations during the course of field work this year: Ohikilolo Ridge above the 'Ctenitis' fence (1 mature), at the junction where the Ohikilolo fence meets the West Makaleha fence (dozens of plants at all stages), and in West Makaleha Gulch below the fenced MU where a patch over 40m long and with over 600 plants. All of these locations have been designated as ICAs. Some of these locations are places traversed by both staff and recreational hikers. The population in West Makaleha Gulch (No MU) is unfenced with high levels of pig sign. Staff sanitation will continue to be stressed, and for now, populations occurring near high-value forest areas will be controlled, however this high rate of spread may at one point exceed OARNP staff ability to control this taxon in the Waianae Mountains. Additional discussion about this taxon can be found in section 3.1
Incidental	Kawaiki Gulch	*Saraca indica*	The Ashoka tree is prized for its flower display, and was found in a somewhat unusual location, in Kawaiki Gulch, in the Koolaus. This is a new adventive distribution for this species; it was possibly planted. It has no invasive threat record and no control planned.
Incidental	Makaha II fenceline (Kumaipo ridge)	*Setaria palmifolia*	Low numbers of the invasive grass *S. palmifolia,* have been observed in a small area and controlled (5 total) over a period of 8 months. An ICA has been established here with the hopes of quick eradication, and prevention of spread into the adjacent Makaha MU.
Incidental	Palehua, J/K/L Road	*Viola hederacea*	An isolated patch of *V. hederacea* was found along a side road off the main Palehua road. It was submitted to Bishop for identification and was noted as a new naturalized record. It is documented as cultivated on several islands and is known to produce seed, but has not been documented as naturalized before. No control planned.

Photos of New State Record, *Chelonanthus acutangulus*, found growing out of erosion control matting

3.6 INVASIVE SPECIES UPDATE: *CHROMOLAENA ODORATA*, DEVIL WEED

Control of *C. odorata* is a high priority for OANRP. Please see the 2011 Year End Report, Appendix 1-2 to view the draft management plan for *C. odorata* control.

This year, *C. odorata* control efforts alone accounted for 42% (1,030 hours) of the time spent on ICA work, and 12% of the total time spent conducting all weed control. Although high, these statistics under-represent the resources required to combat at *C. odorata*, as they do not include time spent conducting surveys outside of ICAs, such as motocross trail surveys in KTA, firing point surveys at SBW, and annual road surveys on all ranges. Also, they do not include time spent developing aerial spray equipment or improving power spray gear.

While the infestation at KTA was found to have expanded this year, no expansions were seen at either SBW or SBE. Encouragingly, no new sites were discovered off of Army land either. OISC continues to manage infestations at Kahana, Keamanea/Haleiwa, and Aiea/Camp Smith, see Appendices 3-5 and 3-6. However, no *C. odorata* surveys have been conducted in non-infested areas on Oahu, so it is possible that new infestations may be found in the future. To date, all discoveries on non-Army training ranges have been opportunistic. In order to better understand the scope of *C. odorata* invasion on Oahu and set realistic goals for control, island-wide surveys are needed.

Current resources are insufficient to conduct treatment in known infestations, much less survey potentially un-infested lands, and more aggressive tools are needed. Several biocontrol agents for *C. odorata* have been identified and released in other parts of the world, including Australia, Guam and Palau. At the Ecology and Management of Alien Plant Invasions (EMAPi) conference, September 2016, staff learned of a successful release of a gall fly, *Cecidochares connexa* in Papua New Guinea (Day, 2016). The presenter, Michael Day (Department of Agriculture, Fisheries and Forestry, Queensland, Australia), recommended that *C. connexa* would be a great fit for Oahu, as it has already been tested extensively for host specificity by a variety of other tropical countries, it disperses well and finds outlying patches of *C. odorata* on its own, and does not require large patches of its host to become established (pers. com). He thought that *C. connexa* would be an invaluable tool in a *C. odorata* eradication effort. This gall fly also was successful in reducing *C. odorata* cover in Guam (Reddy, 2011). OANRP has begun discussions with OISC and other members of the Chromolaena odorata Working Group (COWG) to figure out the steps necessary to release *C. connexa* on Oahu.

<u>Seed Longevity Trial Update</u>

In 2011, staff installed a five-year trial at KTA to determine how long *C. odorata* seeds persist in soil. Seed was collected and placed into packets of 1,250 seed, which were buried 6-8 inches underground at a site outside of, but adjacent to known *C. odorata* areas. Two bags each were removed from the site every three months for the first year of the trial, then once a year for the remaining four years. Staff analyzed trial results at the three-year mark (Appendix 3-9), and found germination declined from 73% at the start of the trial to 36% at three years, and that no seeds germinated in the dark. This suggests *C. odorata* forms a persistent, short-term seed bank. When the fourth year seed packets were opened, staff found only seven seeds, two of which went on to germinate. In contrast, 756 seeds were recovered from the second-year packets, and 356 seeds from the three-year packets. While it is possible that all other four-year seeds had simply decomposed or been predated, the extremely low number of seeds found is suspicious. The final, five-year packets were scheduled to be retrieved in July 2016, but could not be found. In the next months, the staff who installed the trial will visit the site again to locate the packets. Five-year results will be analyzed at that time. Thus far, staff are only confident in stating that *C. odorata* seeds persist at least three years, and possibly as long as five.

Left: germinating *C. odorata* seeds in the lab. Right: seed longevity trial at SBW; each packet is marked with a flag.

Given the peculiar results seen at the four year mark, staff decided to replicate the trial. A second buried seed trial was installed at SBW in May of 2016. Extra seed packets were buried, which means the trial can run as long as ten years, if needed. Sediment barriers or jute matting will be placed around the trial site to delineate it and prevent any packets from eroding out of the ground during heavy rain.

<u>Aerial Spray Equipment</u>

Aerial sprays are an efficient and effective way to control *C. odorata* in challenging terrain, over large areas. Over the past several years, staff worked with several different spray rigs and helicopter companies. Challenges with poorly maintained equipment, finicky parts, and occasionally poor spray coverage lead OANRP to build its own spray rig this year. This has greatly improved operational efficiency, minimizing time spent troubleshooting non-functional gear, improving re-filling time and overall sanitation. As a result, staff aerially sprayed a much larger area than ever before, 14.5 ha. The primary innovations of the system include: gravity fed spray ball (electric pump eliminated); high performance nozzles ($77 each); large filling port on tank; improved bottom drain allowing tank to empty completely; affordably priced irrigation solenoid ($25-35); large door on spray ball; appropriately placed filters; and increased hose diameter from tank to spray ball.

In the coming year, staff will draft a PCSU technical report detailing the design of the spray rig.

Above: the spray rig is attached to the helicopter via the belly hook and cushioning arms. The light colored tank allows staff to gauge how much spray mix is left. A large top port allows for easy filling.

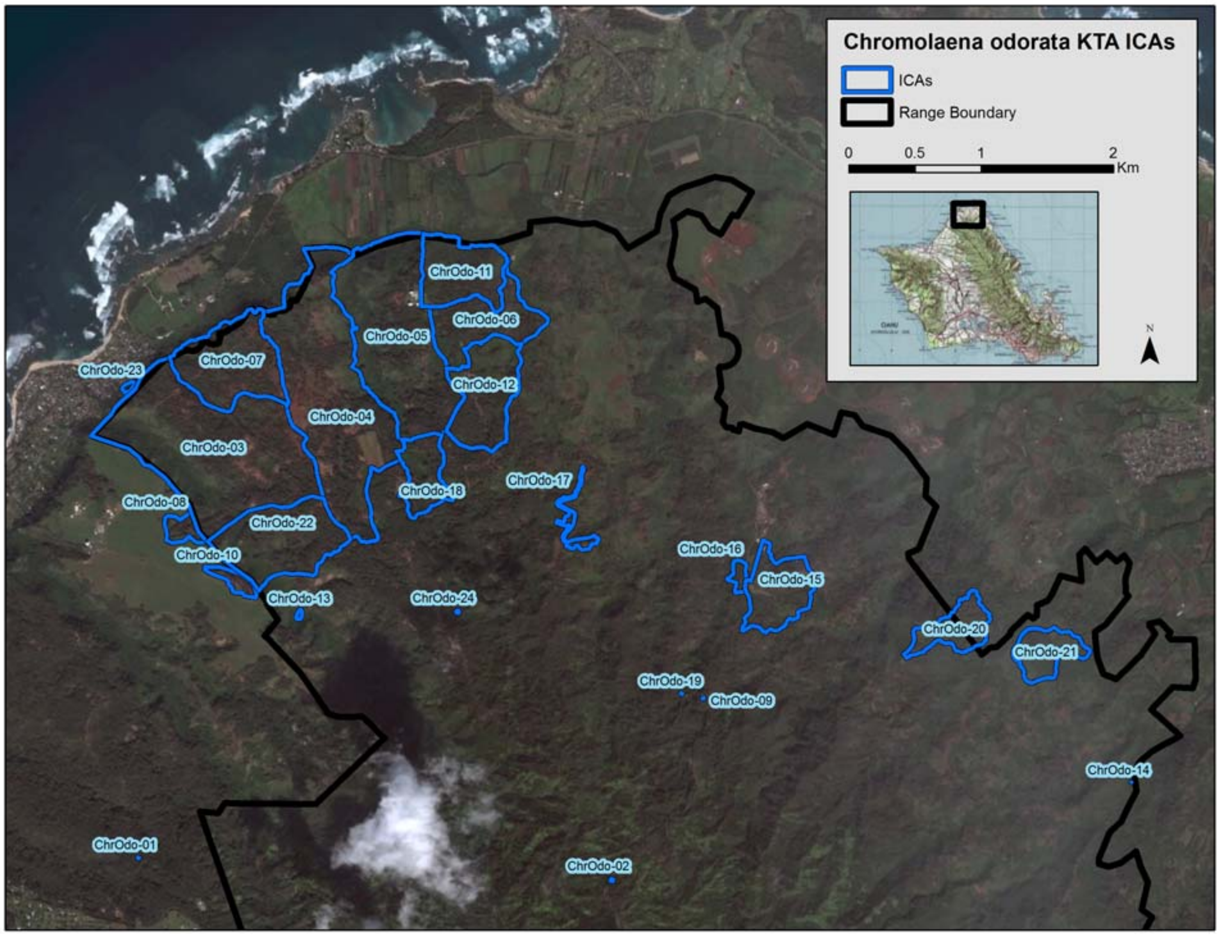
Below left: the sprayer is encased in a 1” thick PVC pipe. The large door allows for easy access to the spray nozzles, solenoid, and other parts. The nozzles are protected by a recycled cutting board.

Below right: High quality Accu-Flo™ nozzles create large droplets, reducing potential drift.

KTA Update

Control efforts at KTA account for 33% of all incipient control effort this report year. In addition, OANRP continues to contract OISC to conduct control across almost half of the primary infestation. See Appendices 3-5 and 3-6 for a summary of OISC's work, including maps of areas treated this year.

C. odorata Incipient Control Areas at KTA

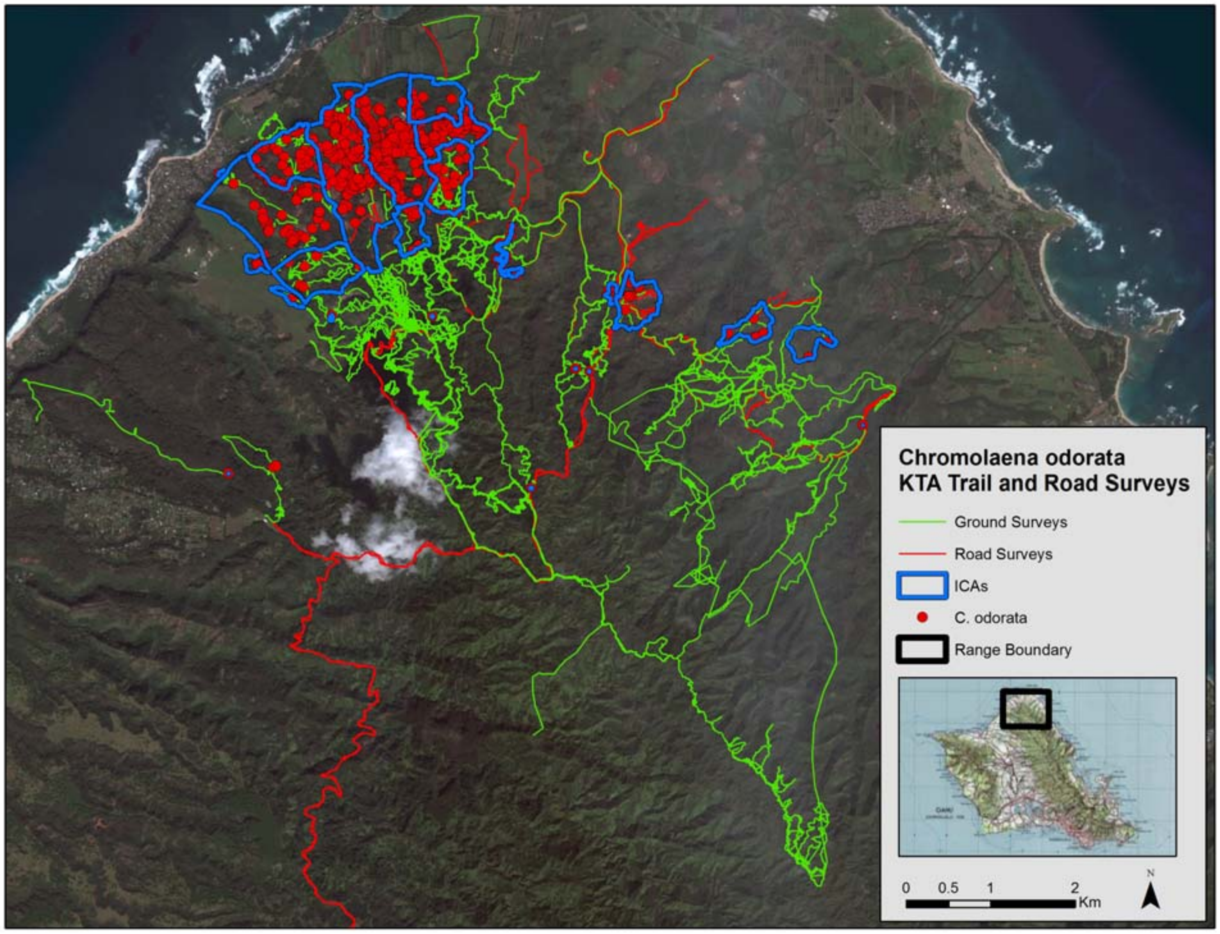


- Over the last few years, staff surveyed almost all of the trails (motocross, Army training, etc.) in KTA; see 'Trail and Road Surveys at KTA' map below. A systematic effort was made to check every loop and side-trail, no matter how convoluted. Since *C. odorata* is known to disperse easily along roads and trails, completing these surveys was a priority for mapping the infestation. From 2014 to June 2016, staff walked 675 km of trail. This effort was complemented by annual road surveys. Several new ICAs were found.
- The lands makai of KTA have *C. odorata*'s preferred open, disturbed habitat, are directly adjacent to the infestation, and have not yet been systematically surveyed. In 2011-2012, HDOA surveyed roads and agricultural fields bordering the highway, but the bluff between the fields and KTA plateau had not been surveyed. Staff completed two surveys in this bluff region this year; see 'Makai Surveys at Kahuku' map below. One was on Waialaee Agricultural Research Station, directly north of ICA #7. The only plants found were at the top of the bluff, near known hotspots; none were seen on the densely vegetated slopes. The other survey was a joint effort with OISC, and took place on private land north of ICA #3. One *C. odorata* location was found in the lower half of the property, but all other plants found were in previously known hotspots. Thick

vegetation limits visibility on ground surveys. In the coming year, staff hope to complete surveys at Waialee and conduct aerial surveys along the entire northern edge of the *C. odorata* infestation.

- Staff also surveyed several small fences installed by the Cultural Resources office around sensitive sites near the CACTF, as they are adjacent to ICAs #15 and 16. No plants were found.

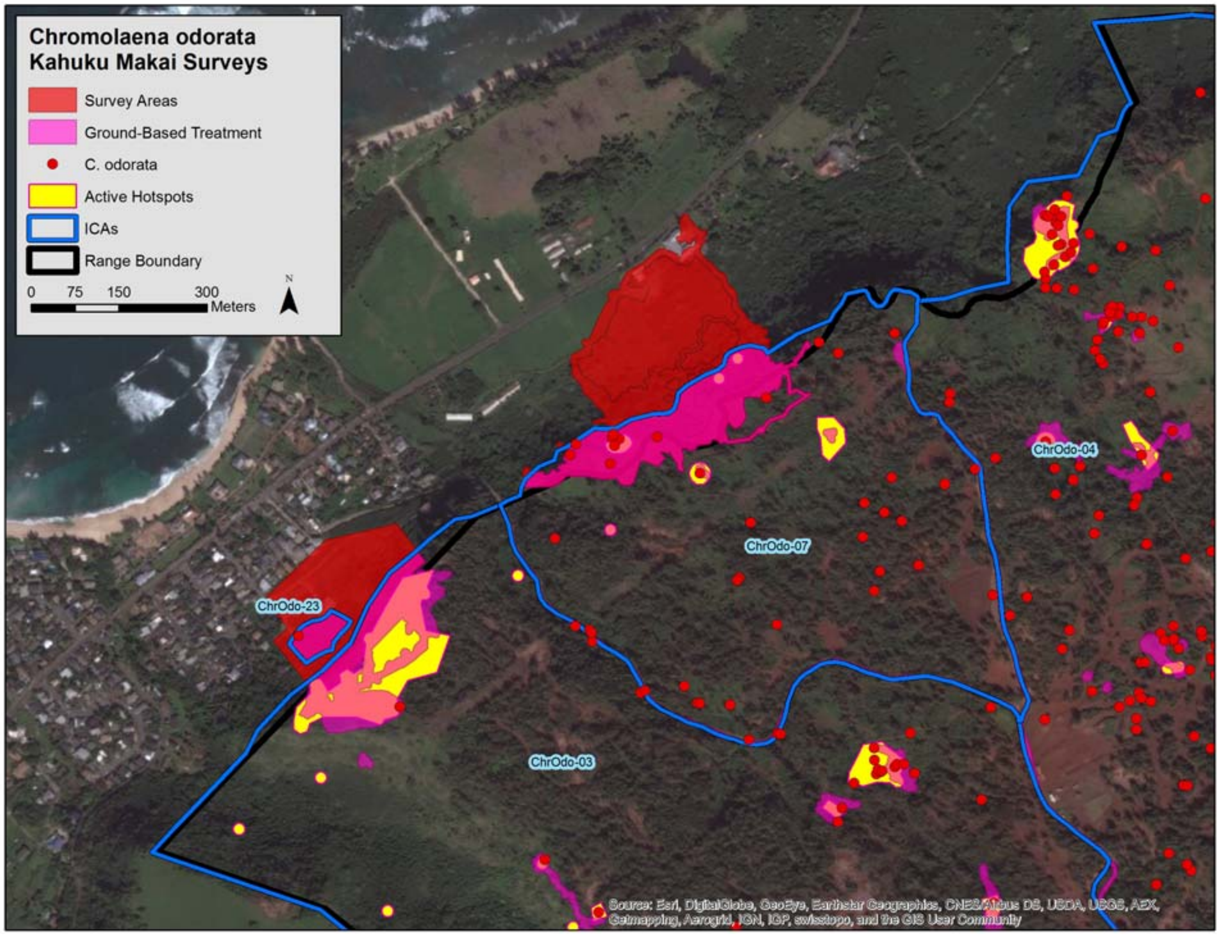
Trail and Road Surveys at KTA



- Four new ICAs were discovered this year, numbers 21-24.
    - ICA #21: Staff found this location during motocross trail surveys. Plants were found along an unsanctioned bulldozed road. Range Control was notified, but OANRP does not know if any investigation was completed. Most of the *C. odorata* were found in one location, with just a few plants located on an adjacent trail. Control efforts are underway.
    - ICA #22: Plants were found during motocross trail surveys at several locations in Kaunala gulch, just south of the official motocross park. The area is heavily used. Treatment has begun, and hotspots will be created at two sites.
    - ICA #23: OISC and OANRP conducted a joint survey of private land makai of the training range, in the Kaunala area. Only a couple plants were found on the makai end of the property; the rest were contiguous with a known hotspot already receiving treatment. OISC will conduct follow-up monitoring with the landowner.
    - ICA #24: A lone mature plant was discovered growing along the Pahipahialua *Eugenia koolauensis* fence. Unfortunately, it had set seed. Motocross trails in the surrounding area

had previously been surveyed, so this is likely a recent dispersal. Staff will scope the surrounding area for additional plants.

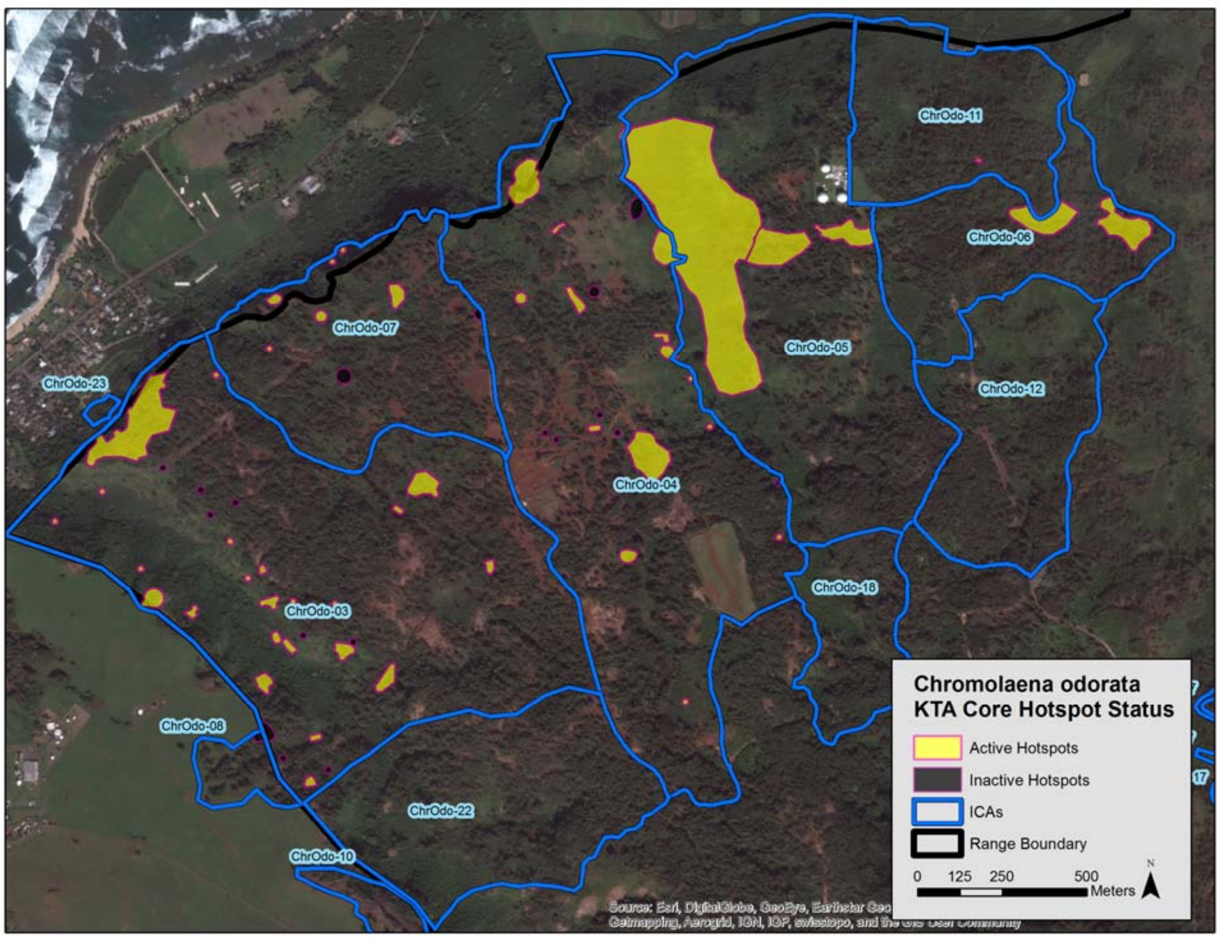
Makai Survey Areas at Kahuku



- The *C. odorata* infestation covers 580 ha in KTA. This is a huge area, and staff are unable to sweep every inch of it, despite contracting OISC to work in the priority motocross area. Instead, different strategies are employed in different ICAs. The core of the infestation is divided between ICAs # 3, 4, 5, and 7. The other ICAs are either on the fringes of the core, or represent distinct infestations, or are discrete outliers.
  - ICAs #3, 4, and 7 are swept twice a year by OISC. Hotspots are drawn around high densities of plants and OANRP sprays them with pre-emergent herbicides. OISC and OANRP share updates on these hotspots via a detailed google spreadsheet. This rigorous approach has resulted in several hotspots being deemed inactive (little to no recruitment seen for two years). See 'Active and Inactive Hotspots in Core ICAs' map, below.
  - ICA #5 contains the densest infestation of plants. Parts of it are treated aerially and parts are swept on the ground. The northern section of the ICA still needs to be surveyed.
  - ICA #6 is swept once a year, with hotspots treated once or twice a year, as needed.
  - ICA #11 has few plants. The northeastern section still needs to be swept. Once delineated, the boundary may be redrawn.

- ICA#12, 18 and 22 are large, but have low densities of plants. Staff monitor all trails and roads within them, but do not regularly conduct sweeps across them. This approach is somewhat effective, but record numbers of plants were found in ICA #12 this year. Next year, staff hope to complete aggressive sprays at new hotspots and conduct select sweeps.
- ICAs #15, 16 and 17 all have relatively small but persistent populations. Few plants were found this year. Staff check all roads and trails within these ICAs, but do not sweep them.
- ICAs #20 and 21 also have low densities of plants. Staff monitor known hotspots, trails and roads. Additional sweeps may be conducted as time becomes available.
- ICAs #1, 2, 9, 19, 14, 24, and 13 are small outlier sites. These are monitored regularly. ICA #13 has not received regular attention, due to its remote location.
- ICAs #8, 10 and 23 are on private land. OANRP will assist OISC with surveys and sprays in these areas as requested.

Active and Inactive Hotspots in Core ICAs



- All control efforts are summarized in the 'KTA Control Efforts' table below. Area, effort and number of visits are reported for the 2016 and 2015 report years. Note that the 2016 report year covers twelve months, while the 2015 report year only covers nine months. Numbers of plants controlled this report year are contrasted to the total number of plants removed to date. The number of immatures includes both immature and seedling plants. Note that during all aerial and some ground sprays, the number of plants treated is an estimate.

KTA Control Efforts

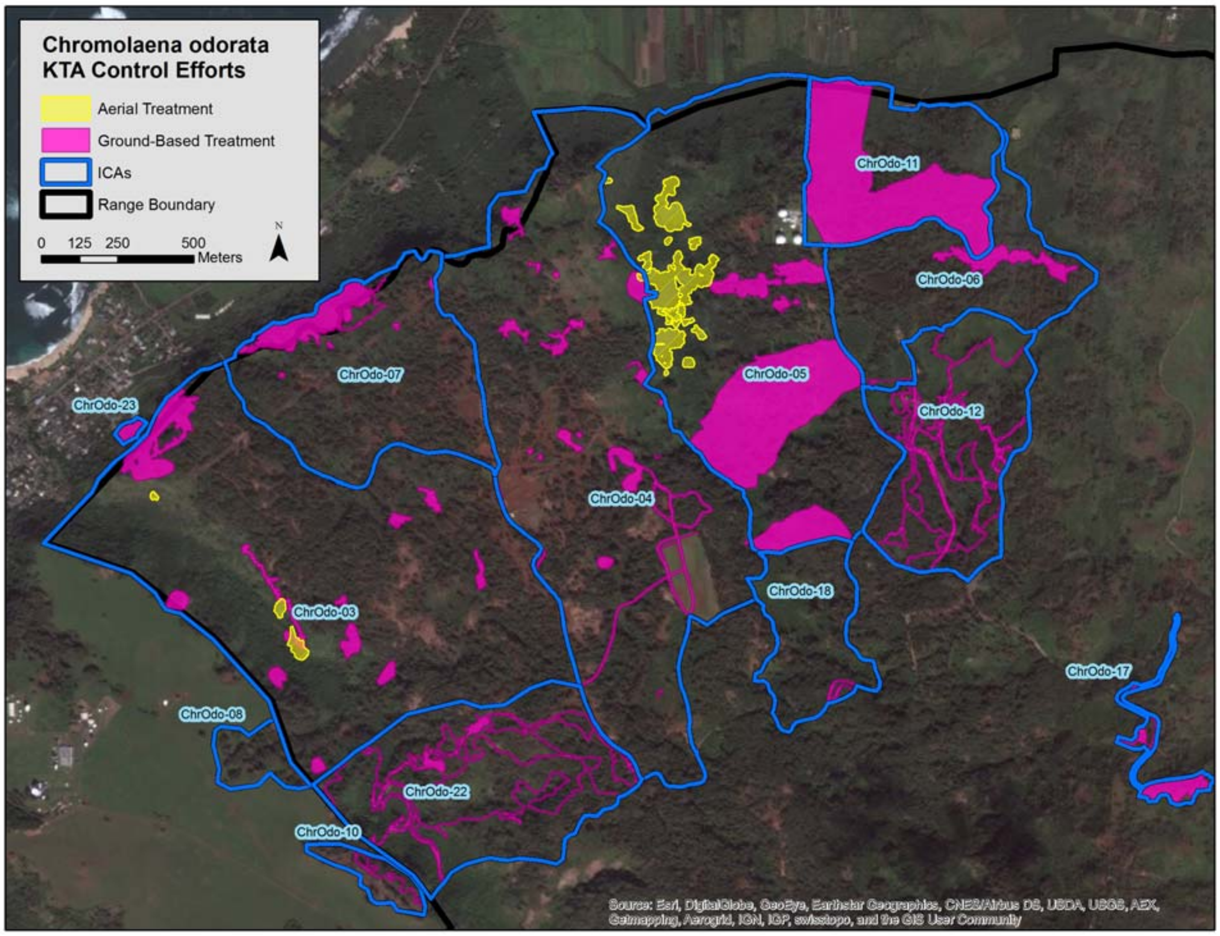
ICA Code	ICA Area (ha)	2016 Report Year			2015 Report Year			2016 # Plants Treated		Total # Plants Treated		Type and Strategy
		Area Weeded (ha)	Effort	# Visits	Area Weeded (ha)	Effort	# Visits	# Mat.	# Imm.	# Mat.	# Imm.	
WaimeaNoMU-ChrOdo-01	64 m²	63 m²	2.5	2	64 m²	1.5	2	0	0	0	1	Outlier
KTA-ChrOdo-02	328 m²	328 m²	0.5	1	328 m²	3	3	0	0	0	1	Outlier
KTA-ChrOdo-03	118.43	7.06	216.5	15	2.23	60.75	5	282	2,857	747	4,237	OISC Contract + OANRP hotspot
KTA-ChrOdo-04	111.63	6.77	107	12	4.56	66.7	6	50	751	864	4,150	OISC Contract + OANRP hotspot
KTA-ChrOdo-05	89.23	25.62	228	17	29.49	177	10	3,745	6,123	6,911	19,112	Sweep + Hotspot + Aerial spray
KTA-ChrOdo-06	29.73	1.9	32.5	2	27.14	92.75	7	37	478	2,292	12,887	Sweep + Hotspot
KTA-ChrOdo-07	41.26	4.72	59.35	6	0.73	13.5	2	55	129	205	273	OISC Contract + OANRP hotspot
AimuuNoMU-ChrOdo-08	4.59	0	0	0	0	0	0	N/A	N/A	N/A	N/A	Private Land. OISC.
KTA-ChrOdo-09	78 m²	78 m²	1.5	2	78 m²	2	2	0	0	1	1	Outlier
AimuuNoMU-ChrOdo-10	3.73	0.36	1	1	78 m²	1.5	1	0	8	0	8	Private Land. OISC.
KTA-ChrOdo-11	28.74	17.98	40	2	0	0	0	29	21	31	38	Sweep + Hotspot
KTA-ChrOdo-12	34.69	6.02	37	3	4.55	12.5	3	272	738	357	1,116	Trails + Roads + Hotspots + Sweep
KTA-ChrOdo-13	0.23	3 m²	0.25	1	0	0	0	1	0	1	0	Outlier/Hotspot
KTA-ChrOdo-14	6 m²	6 m²	1	2	6 m²	2.5	2	0	0	1	0	Outlier
KTA-ChrOdo-15	23.51	3.58	11.25	4	1.48	4	2	1	7	12	63	Trails + Roads + Hotspots
KTA-ChrOdo-16	2.2	0.79	0.75	1	0.13	1.5	2	0	0	1	5	Trails + Roads + Hotspots
KTA-ChrOdo-17	3.14	2.67	4.75	2	1.3	2	2	0	2	2	10	Trails + Roads + Hotspots
KTA-ChrOdo-18	16.43	0.23	2.5	2	275 m²	2.5	2	0	9	3	52	Trails + Roads + Hotspots
KTA-ChrOdo-19	78 m²	0	0	0	0	0	0	N/A	N/A	0	1	Outlier

ICA Code	ICA Area (ha)	2016 Report Year			2015 Report Year			2016 # Plants Treated		Total # Plants Treated		Type and Strategy
		Area Weeded (ha)	Effort	# Visits	Area Weeded (ha)	Effort	# Visits	# Mat.	# Imm.	# Mat.	# Imm.	
KTA-ChrOdo-20	14.72	3.07	10.25	4	N/A	N/A	N/A	3	64	3	64	Trails + Roads + Hotspots
KTA-ChrOdo-21	13.93	11.38	23	4	N/A	N/A	N/A	51	120	51	120	Trails + Roads + Hotspots
KTA-ChrOdo-22	43.8	4.8	24.5	4	N/A	N/A	N/A	15	164	15	164	Roads + Trails + Hotspots
KahukuLaie-ChrOdo-23	0.48	0.48	2.75	2	N/A	N/A	N/A	2	0	2	0	Private Land. OISC manage?
KTA-ChrOdo-24	63 m²	18 m²	0.1	1	N/A	N/A	N/A	1	0	1	0	Outlier
TOTALS	**580.57**	**98.1**	**807**	**90**	71.72	443.7	51	**4,544**	**11,471**	11,500	42,303	

Left: surveying dense *Schinus terebinthifolius* slopes with binoculars. Right: aerial spray in progress in Pahipahialua gulch.

- This year, 6.36 ha were sprayed aerially and 91.89 ha were treated on the ground, for a total of 98.24 ha of *C. odorata* controlled. The map below shows aerial and ground control efforts across the primary infestation. Last year, only 3.98 ha was aerially sprayed. Improved aerial spray equipment contributed to this increase, as less time was needed to troubleshoot gear. The new spray rig provided better herbicide coverage and thus better control. Staff were able to treat much of the core in ICA #5 more than once, and have effectively knocked it down. About 6.1 ha were aerially treated in ICA #5. Remote hotspots in ICA #3 were also aerially sprayed; about 0.3 ha were treated. These locations are very difficult to reach with spray equipment from the ground. In the coming year, staff plan to expand aerial treatment of remote hotspots and maintain pressure on the core. To facilitate this, staff and OISC will mark remote hotspots with orange flagging to make them easier to locate from the air.

Aerial and Ground Treatment in the KTA Core Infestation



- Control efforts at most of the outlier ICAs have been successful. No plants were found at ICAs #1, 2, 9, or 14 this year. All have been monitored regularly over the years, since discovery, with no additional plants found. At ICAs #1 and 2, one immature plant was found at each site in 2011. At ICA #9, one mature and one immature were found 2013 and at ICA #14 one mature was found in 2014. Staff will monitor these sites once year, for at least five to seven years after the last plant was seen, or until more information is known about seed longevity. More regular checks at ICAs #13 and 19 are needed.

Gray-brown dead *C. odorata* and alien grasses, treated via aerial spray. Patches of blue indicate freshly treated areas.

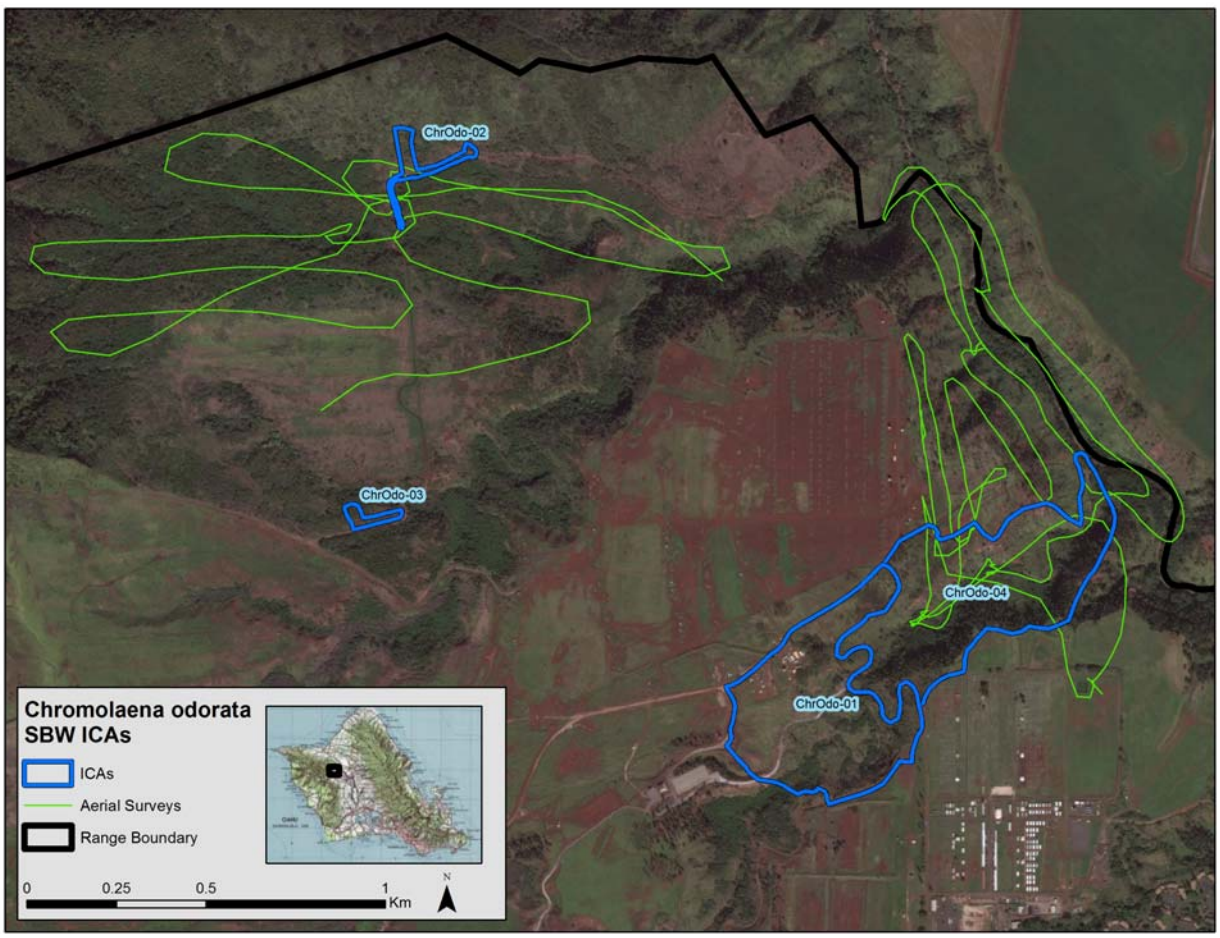
SBW Update

Control efforts at SBW are limited by range availability and the need for a UXO escort in the area. OANRP has been able to take advantage of regularly scheduled range maintenance 'cold' days, which have provided sufficient access. The table below summarizes control efforts at SBW in 2016 and the map below shows the locations of the ICAs.

SBW Control Efforts

ICA Code	2016 Report Year				2015 Report Year		
	ICA Area (ha)	Area Weeded (ha)	Effort (hours)	# Visits	Area Weeded (ha)	Effort (hours)	# Visits
SBWNoMU-ChrOdo-01	19.52	14.77	56	9	1.23	23	5
SBWNoMU-ChrOdo-02	1.10	0.73	7.5	4	0.70	5	3
SBWNoMU-ChrOdo-03	0.49	0.40	6.5	4	0.49	20	3
SBWNoMU-ChrOdo-04	23.34	11.66	140.5	19	3.66	24.5	5
TOTAL	**44.45**	**27.56**	**210.5**	**36**	6.1	72.5	16

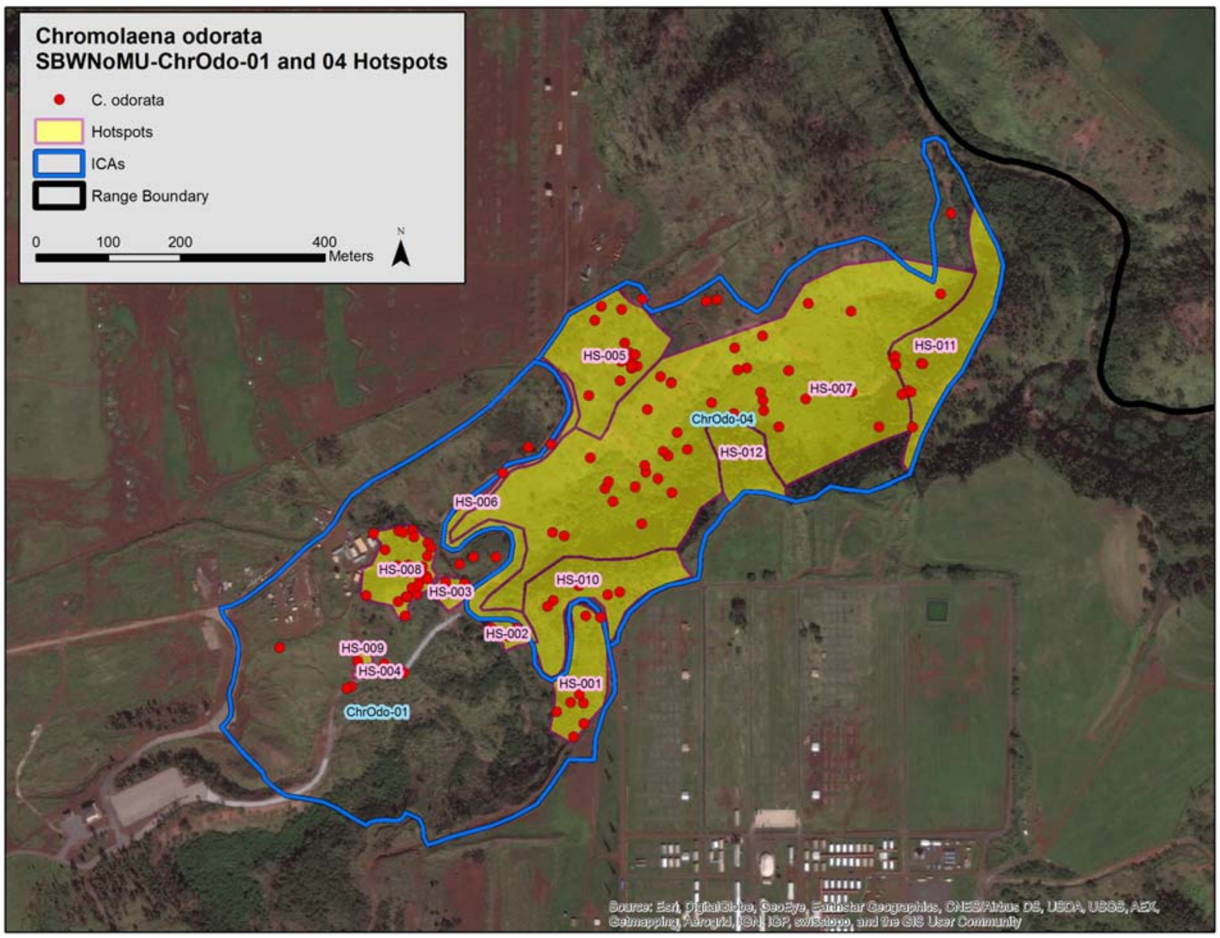
C. odorata Incipient Control Locations and Aerial Surveys at SBW



- No new *C. odorata* sites were found on SBW this year. All training roads were surveyed across SBW, SBS, and Wheeler. This is the first ever survey for Wheeler, and the first complete survey of SBS in over five years, and the most complete coverage of the greater Schofield Barracks area to date. One aerial survey was conducted; all plants seen were already in ICAs.

- As described in section 3.3, signage was installed in ICA #4 to prevent soldiers from entering infestation areas. Staff also maintained 'no mowing' signs and cones in ICA #1; these reduce the likelihood of *C. odorata* spread via road maintenance work.
- ICA #1 encompasses the western portion of the primary *C. odorata* infestation. Most of it is dominated by tall, dense stands of *Urochloa maxima*. This grass appears to be so thick in the area that *C. odorata* does not readily colonize it, unless some type of disturbance creates bare ground. Instead, most *C. odorata* is clustered along roads, around stands of *Eucalyptus* and *Casuarina*, or on open slopes. To facilitate control, geographic hotspots were designated around concentrations of plants, see maps below. These areas were surveyed and treated regularly and aggressively with pre-emergent herbicide. Staff scoped the remaining grass slopes via ground-based binocular surveys. This strategy appears to be effective, with 38 mature, and 452 immatures and seedlings removed this year. A total of 178 mature and 1,294 immature/seedling plants have been removed since discovery in 2013. The northernmost finger of the ICA was not treated this year; this is a priority for control next year, as incidental observations suggest plants are present.

Hotspots in SBW Core ICAs

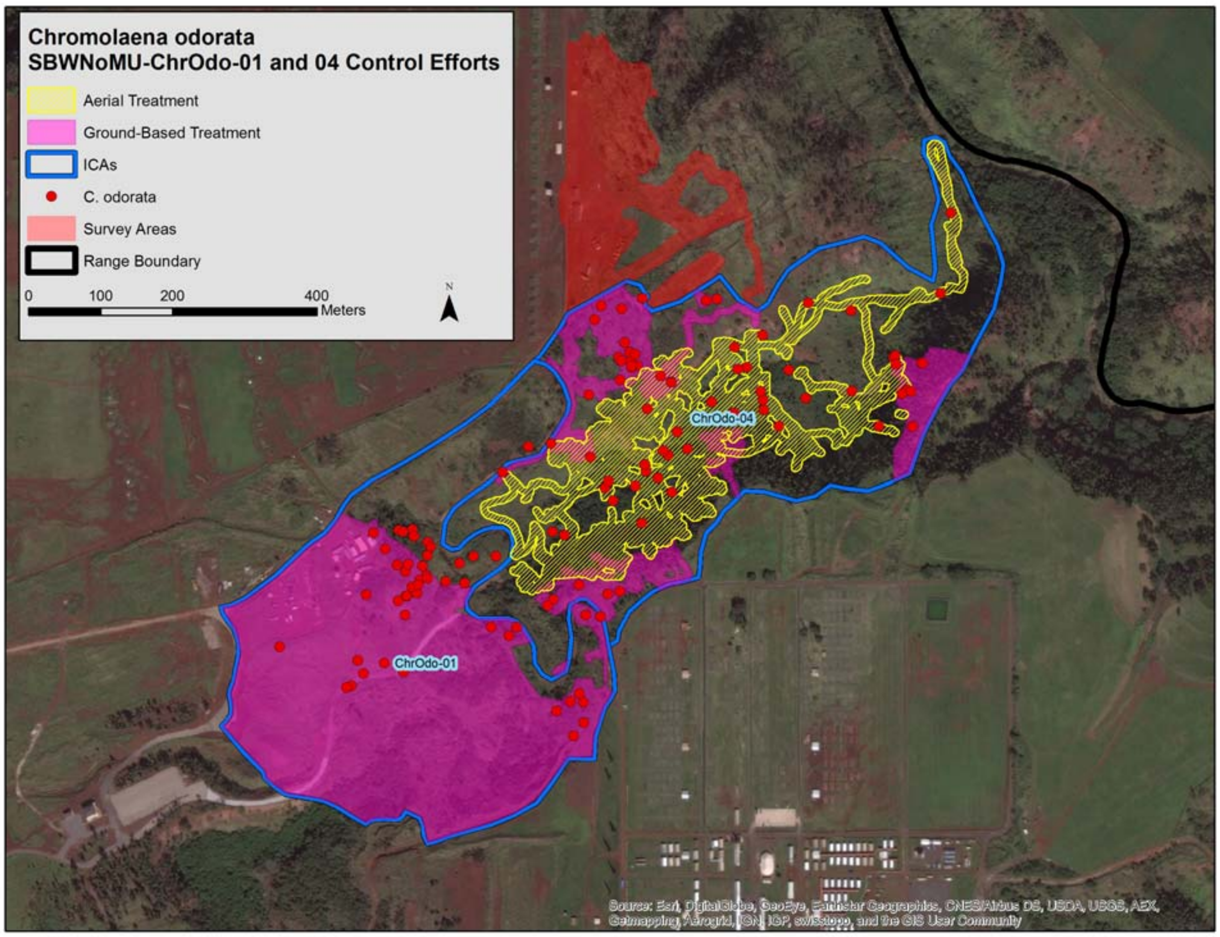


- ICA #2 is a discrete, outlier infestation. This site continues to have a small but persistent population, with 3 mature, 17 immature, and 8 seedling plants controlled this year. A total of 15 mature, 39 immature, and 11 seedlings have been removed since initial discovery in 2014. This suggests a seed bank formed at the site. Last year, two immature plants were found along the road, expanding this ICA. No plants were found along the road this year. Staff used pre-emergent herbicide twice a year from 2014-2016; more frequent application may be needed.

Also, more aggressive grass control may help by allowing staff to more easily survey the entire ICA and improve confidence that all plants present have been treated.

- ICA #3 is also a discrete, outlier infestation. When discovered in 2014, this site had tall *C. odorata* twining into the canopy. Despite this, relatively little recruitment has been seen. This year, 31 immature and 12 seedlings were controlled. A total of 7 mature, 42 immature, and 12 seedlings have been removed since 2014. The last mature was found in December 2014. Control efforts have been successful in suppressing maturation thus far. Additional grass control in the area will allow staff to more easily survey the area.

Aerial and Ground Treatment in SBW Core Infestation



- ICA #4 covers the eastern portion of the primary *C. odorata* infestation, including the core. The terrain here is difficult, as the area is a steep-sided gulch dominated by dense grass, with a high UXO hazard. As in ICA #1, hotspots were drawn around concentrations of plants. Some of the hotspots are treatable from the ground, but the largest, Hotspot 7 is best treated via aerial sprays. The strategy at ICA #4 was to treat all accessible areas from the ground, while aerially spraying and surveying the remainder of the area. This year, 8.14 ha were aerially sprayed, and 4.38 ha were treated on the ground. In contrast, only 4.1 ha were aerially sprayed last year. All known *C. odorata* were sprayed at least once this year; this is a big milestone. The map above shows both ground and aerial control for the past year. In the coming year, staff plan to continue aerial sprays and scout new routes into the ICA from the south.

Above: brown, aerially sprayed areas are sandwiched between *Casuarina* trees and green grass.

Below: dead *C. odorata* and grass on the slope seen in the photo above.

Above: dead, aerially sprayed grass is visible through a stand of *Eucalyptus*.

Below: dead *C. odorata* and other invasive shrubs on the slope in the photo above.

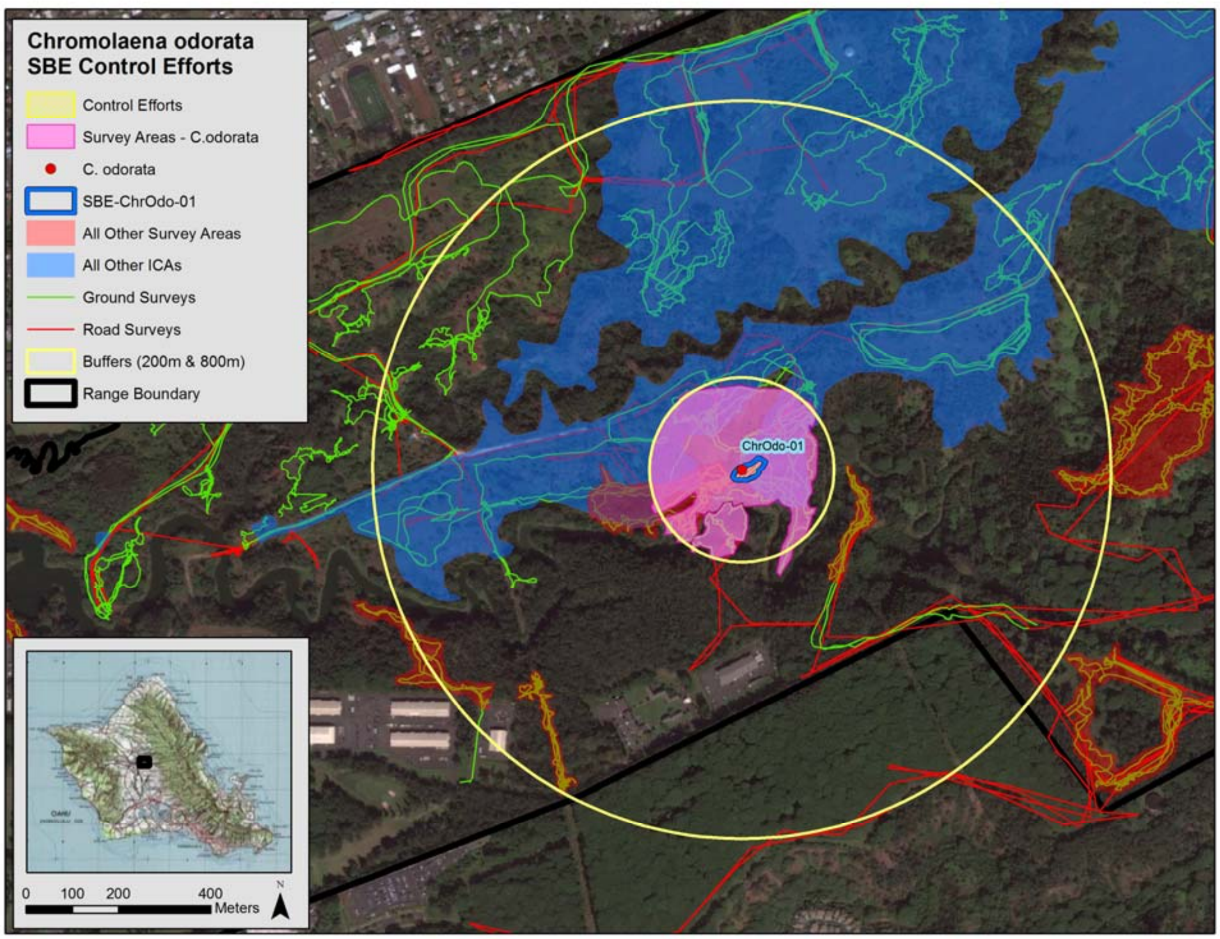
SBE Update

In October 2014, while conducting surveys for another incipient target at SBE, *Schizachyrium condensatum*, staff stumbled upon a small patch of immature *C. odorata*. This is the third Army Training Range with a *C. odorata* infestation. Control efforts are summarized in the table below.

ICA Code	2016 Report Year				2015 Report Year		
	ICA Area (ha)	Area Weeded (ha)	Effort (hours)	# Visits	Area Weeded (ha)	Effort (hours)	# Visits
SBE-ChrOdo-01	0.18	0.18	12.25	7	0.14	8.4	3

No additional plants were found in the last year. Only 15 plants have been seen at the site: 14 immatures in October of 2014 and 1 mature in February 2015. A 200 meter buffer around the infestation site was completed last year. The map below details survey and control efforts at the site. Since no plants were found, additional surveys in the 800 meter buffer were not necessary. Much of SBE is surveyed or swept regularly. Road surveys are conducted once a year and include all drivable trails. Large areas are regularly surveyed in the course of ICA control work on *S. condensatum* and *R. tomentosa*. The map below shows areas swept and survey tracks completed following the discovery of *C. odorata* in 2014; while *C. odorata* was not the primary target of these efforts, it is likely any large patches of plants would have been discovered. Staff are confident that there currently are no other *C. odorata* sites at SBE.

***C. odorata* Control Efforts at SBE**



This ICA is located near powerline poles. Along with OISC, staff met with HECO representatives to discuss invasive species sanitation concerns. HECO indicated that their crews did wash vehicles after working in SBE. HECO is looking into making policy changes which will require their field crew and vegetation management contractors to follow sanitation guidelines, but indicated that this would take some time to institute.

This ICA will continue to be monitored regularly for at least five years after the date of the last mature plant found. Given no recruitment has been seen, it is possible the site was controlled before a seed bank was formed.

<u>References Cited</u>

Day MD, Winston RL (2016); Biological control of weeds in the 22 Pacific island countries and territories: current status and future prospects. In: Daehler CC, van Kleunen M, Pyšek P, Richardson DM (Eds), Proceedings of 13th International EMAPi conference, Waikoloa, Hawaii. NeoBiota 30: 167–192. doi: 10.3897/neobiota.30.7113

Reddy, G.; Kikuchi, R.; and Muniappan, R. The impact of *Cecidochares connexa* on *Chromolaena odorata* in Guam. Proceedings of the Eighth International Workshop on Biological Control and Management of *Chromolaena odorata* and other Eupatorieae, Nairobi, Kenya, 1-2 November 2010.

Managing *C. odorata* requires patience and optimism

3.7 INVASIVE SPECIES UPDATE: *CENCHRUS SETACEUS*, FOUNTAIN GRASS

Cenchrus setaceus is a priority for control whenever found on Army training lands, due to its invasive behavior, documented fire risk, and ability to thrive on steep rocky habitats where several IP taxa dwell. A buried seed trial conducted by OANRP staff found that it forms a transient seed bank (seeds viable for up to 1.5 years; see Appendix 3-9). The trial, installed at MMR, adjacent to the *C. setaceus* infestation, found that while initial germination of seeds was high (92%), after ten months germination had declined to 0%. A simultaneous lab trial showed that the seeds germinate in the absence of light, confirming that the seed bank is transient. This means that the taxon is eradicable, particularly from discrete infestations, and OANRP has indeed successfully eradicated it from three separate sites, one each at DMR, KTA, and now SBE. For this taxon, OANRP conservatively declares a site eradicated if consistent monitoring finds no plants at a site for twice the time of seed persistence, in this case, three years. If the site is difficult to survey and staff do not have high confidence in the detectability of *C. setaceus*, monitoring may be extended for several more years. The table below summarizes control efforts for this year. Not included in the table is ICA KeaauNoMU-CenSet-03, which is on private land and is managed by OISC. OANRP assists with control at this ICA as requested by OISC; no OANRP time was spent here this report year.

***C. setaceus* Control Efforts**

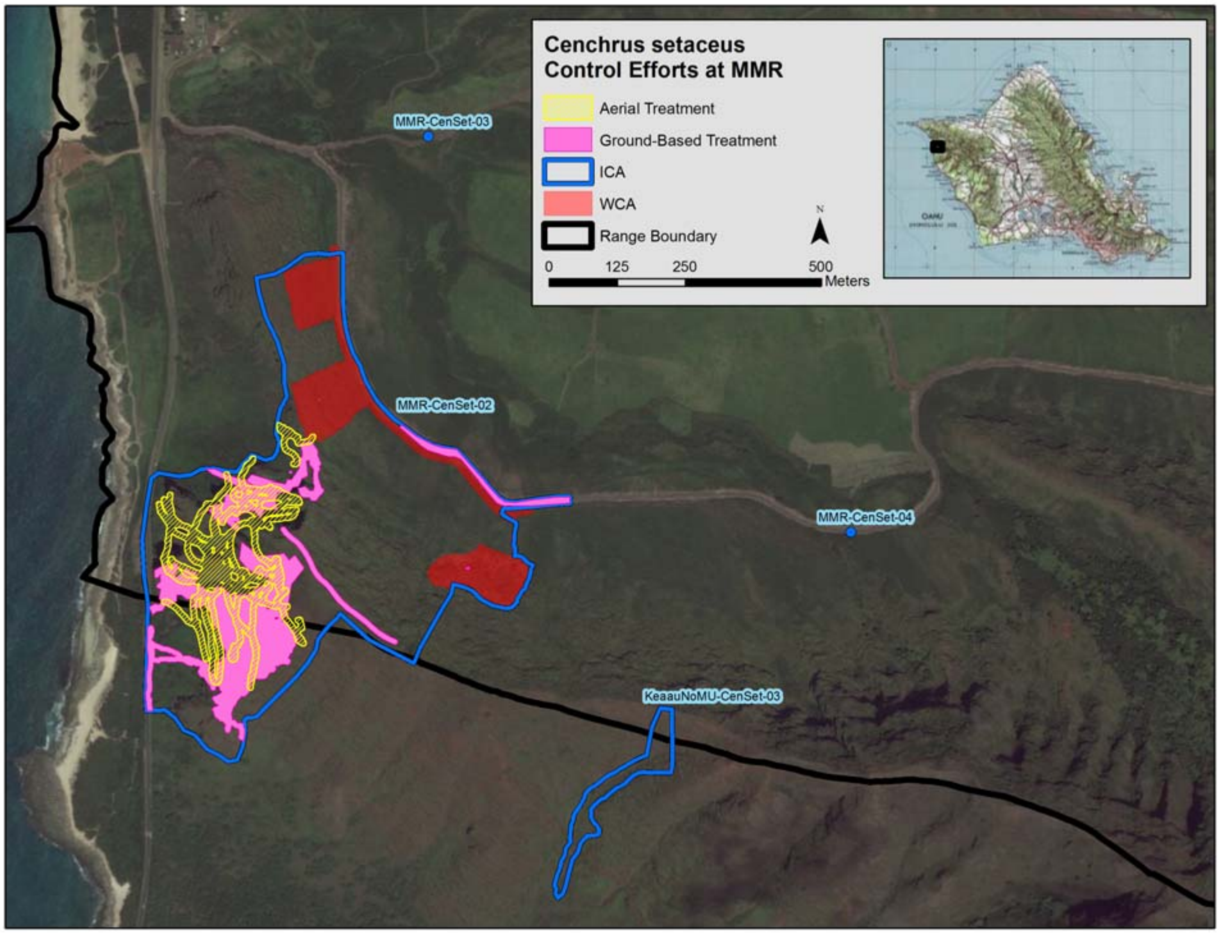
ICA	ICA Total Area (ha)	Area Weeded (ha)	Effort (hours)	# Visits	Comments
KTA-CenSet-02	0.1 (960**m²**)	0.1 (960**m²**)	4	2	Last plants were seen in 2013. This is a small site, with only small numbers found following initial discovery and control of 16 matures and 63 immatures. If no additional plants are found, this site will be declared eradicated in early 2017.
KTA-CenSet-03	0.77	0.38	3.75	2	Last plants were seen in February 2015. Quite a few plants were found here when it was first discovered: 84 mature and 42 immature. Fortunately, few plants were found on follow-up visits. The entire ICA needs to be swept thoroughly in the coming year.
MMR-CenSet-02	31.7	8.39	78.52	9	This is the largest infestation on Army land, and the largest in the Waianae Mountains.
MMR-CenSet-03	0.01 (78**m²**)	0.01 (78**m²**)	1.75	2	Three mature and nine immature plants were discovered and removed in January 2016. Plants may have been dispersed here by wind or vehicle.
MMR-CenSet-04	0.01 (78**m²**)	0.01 (78**m²**)	1	2	Discovered and removed in January 2016. Only 1 mature plant was seen, growing in the mowed area bordering the firebreak road. Plants may have been dispersed here by wind or vehicle.
SBE-CenSet-01	0.001 (15**m²**)	0.001 (15**m²**)	0.25	1	Eradicated. Staff monitored it this year anyway. This site is along a well-used training road. The likely dispersal source was a contaminated vehicle from PTA
SBE-CenSet-02	0.01 (98**m²**)	0.01 (98**m²**)	1	2	No plants have been found since 2012. Since monitoring intervals have not always been regular, one more check is needed before declaring this ICA eradicated. This site is along a well-used training road. The likely dispersal source was a contaminated vehicle from PTA.
TOTAL	**32.62**	**8.9**	**90.27**	**20**	

Of the remaining six active *C. setaceus* infestation sites, two are within six months of being declared eradicated (SBE-CenSet-02 and KTA-CenSet-02). The remaining KTA site, 03, is on track for eradication, with no plants found this report year. Given that *C. setaceus* is widespread at PTA, and well-established along at least two popular Oahu hiking trails on the southeastern part of the island, it is likely future infestations will be found. Sanitation measures are in place to clean military vehicles leaving PTA, but there is currently no effective way to sterilize recreational hikers.

MMR Status

The bulk of *C. setacus* management time and effort this year were spent at the MMR infestation.

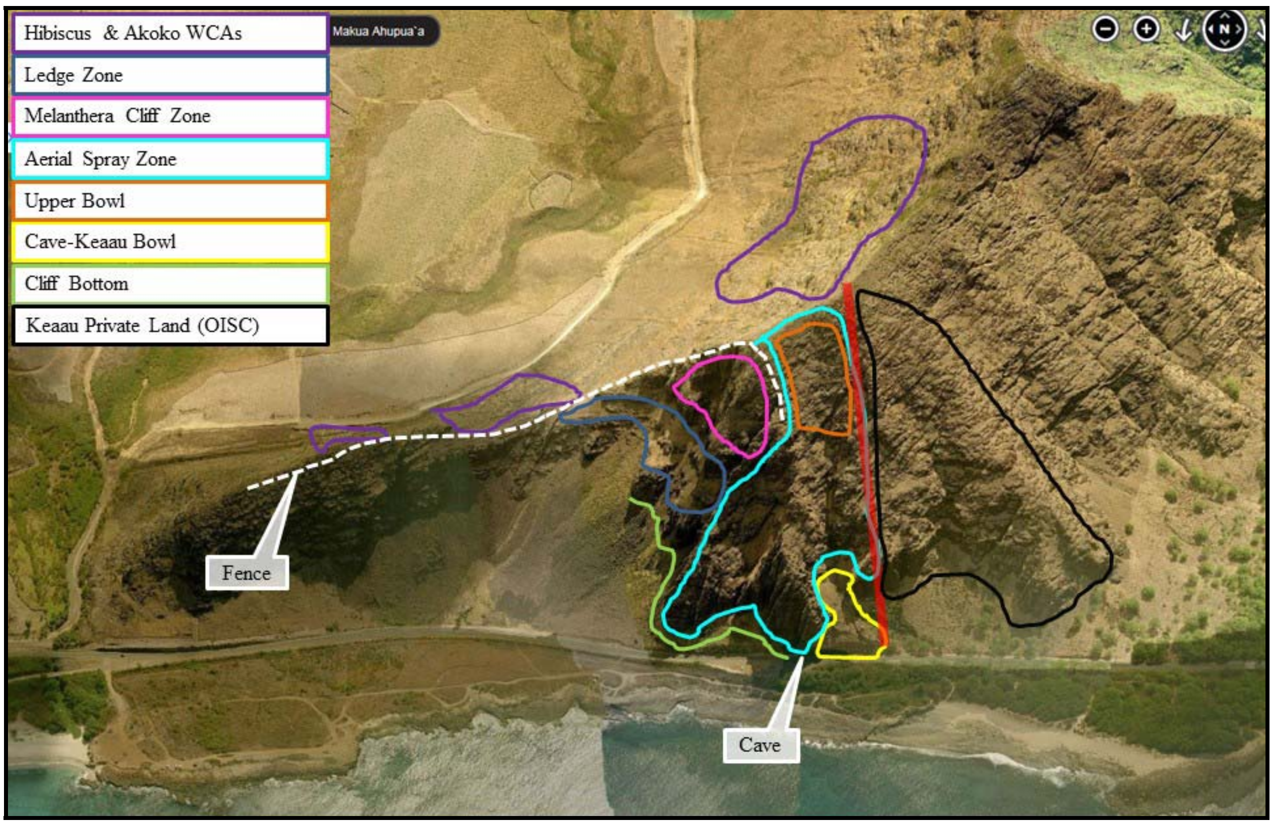
Incipient Control Area Locations and Aerial and Ground Control Treatment in MMR



- Unfortunately, two new outlier sites were discovered, ICAs #3 and 4, see map above. Both are located in areas along roads which are regularly mowed and sprayed to reduce fire risk. While discouraging, it is unsurprising that *C. setaceus* is taking advantage of open, disturbed areas. Staff have seen this before, with plants regularly found in the Ohikilolo Lower WCAs, where grass and other herbaceous weeds are managed around rare taxa. It is ironic that clearing creates areas readily colonized by *C. setaceus*, but fortunately open areas also are easier to survey and monitor. OANRP reached out to the contractors who do the mowing, and learned that their equipment stays on site, and also that the mowed areas are sprayed with herbicide. OANRP decided there was limited risk of further spread due to contractor work at the new ICAs, due to the aggressive control they perform and the potential for *C. setaceus* to germinate in any disturbed area. Photos of *C. setaceus* were sent to the contractor and OANRP requested they report any sightings.

- In the coming year, OANRP plans to conduct aerial and ground-based surveys across MMR, to ensure there are no additional *C. setaceus* outliers. It has been five years since similar surveys were completed following the discovery of *C. setaceus* at MMR in late 2011.
- The primary *C. setaceus* infestation is entirely within ICA #2. Due to its large size, challenging terrain, thick *Urocholoa maxima* cover, split ownership and the presence of UXO in MMR, multiple actions are needed to treat the entire site. The photo below details different Control Regions within ICA #2 which require different actions. The red line estimates the boundary between MMR and private land in Keaau. The control strategy at ICA #2 is as follows:
    - o Treat the core of the infestation, which is in the Aerial Spray Zone (light blue), focusing on the densest clusters of *C. setaceus* first to maximize total number of plants killed and pilot efficiency (top priority). Where feasible, follow-up with ground-based control, particularly in the Upper Bowl (orange). Once numbers have been reduced in the core, aerially treat plants throughout this zone. Spotters were not useful in initial knockdown, but will be useful during follow up control.

MMR-CenSet-02 Control Regions



- o From the ground, treat all walkable portions of the infestation. This includes the Ledge Zone (dark blue), Cave-Keaau Bowl (yellow), and Cliff Bottom (light green). Also, any plants seen along the fenceline.
- o During the course of WCA control work, treat any *C. setaceus* found in the Hibiscus and Akoko WCAs (purple).

  - Monitor the Melanthera Cliff for *Melanthera tenuifolia*, an IP taxon which dies back seasonally. Treat *C. setaceus* from the ground or aerially, ensuring minimal risk to *M. tenuifolia*.
  - Survey the grassy zones between the WCAs, between the fence and highway, and all other areas not in a Control Region once a year. Seek out vantage points and use binoculars to get thorough survey coverage.
  - Assist OISC, as requested, in the Keaau Private Land area (black). No herbicide may be used in this area, per landowner directive.
  - Develop alternative technologies to reach *C. setaceus* that cannot be treated either from the ground or with the aerial spray rig.

- Management was conducted in almost all of the Control Regions this year, with the exception of the Melanthera Cliff and Cliff Bottom. These regions were lower priority than other regions due to the comparatively fewer number of plants present in them. Also, the grassy area outside of the Control Regions was not surveyed, with the exception of the area between Farrington Highway and the fence, from the Melanthera Cliff in the south to the Akoko WCAs in the north. Binocular surveys of this roadside area revealed a couple plants growing along the illegal trail to the upper cave; these plants were removed. No other outliers were seen.
- Both ground-based control and aerial sprays were conducted at ICA #2 this year and are shown in the map above ('Incipient Control Area Locations and Aerial and Ground Control Treatment in MMR'). This year, 8.39 ha were treated in ICA #2. Of this, 4.11 ha were treated from the air and 5.89 ha were swept on the ground (ground and aerial treatments overlapped). Last year, 3.81 ha were swept, with 2.80 ha of aerial treatment and 2.42 ha of ground treatment (control areas overlapped). Note that WCA areas (in red on map) were swept multiple times during the course of ecosystem weed control work in both report years, but only time and area spent specifically controlling *C. setaceus* is counted in these totals. Aerial treatment centered over the steep infestation core in the Aerial Spray Zone last year, but expanded into outlying areas this year. The radiating extensions on the southern end of the aerial treatment shape represent surveys rather than sprays. Ground sweeps covered most Control Regions, including follow-up treatment in the core. Few plants were found in WCAs. The area covered in ground sweeps is particularly high this year, due to a survey across the Keaau Private Land region with OISC.


Aerial sprays at MMR

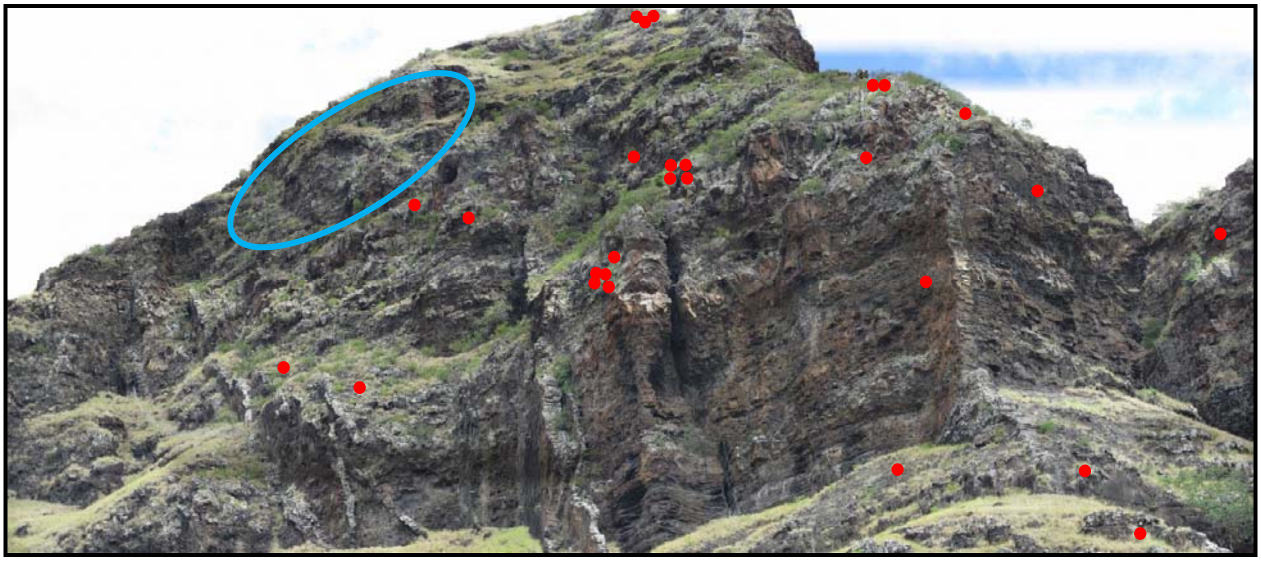
- One survey was conducted on private land on the southern end (Keaau Private Land) of the ICA, in conjunction with OISC. The landowner has prohibited the use of herbicides in this area, thus eliminating aerial sprays as a tool and limiting all control to hand-pulling. Prior to the survey, OANRP analyzed Gigapan® images of the Keaau area and used them to identify areas with suspected *C. setaceus*. Since this Keaau area is broken up by numerous ledges and cliffs, preventing systematic sweeps, the Gigapan analysis was helpful in directing ground work. OANRP will provide OISC with additional images as requested. In addition, OANRP will support OISC by providing rappel-trained staff to reach plants on cliffs, as OISC personnel do not currently have this training. Unfortunately, OISC faces challenges in securing funding for work on *C. setaceus* in the Waianae Mountains.

Taking a Gigapan of the *C. setaceus* infestation. The Gigapan unit must be close enough to the target area to zoom in and positively identify *C. setaceus*, but also far enough away to provide a landscape view.

- The efficacy of control in the core was analyzed using Gigapan® technology, and is discussed in Appendix 3-12. Overall, there has been a 78% reduction in *C. setaceus* cover in the core since control efforts began. The successful treatment of plants in the core has been an essential step towards controlling the population and reducing seed sources. However, in the monitored areas directly adjacent to the core, plant numbers did not decline significantly. While the monitored area represents only a small portion of the total infestation, these results jibe with staff observations, and make sense, given that the core has been the primary focus of aerial treatment efforts thus far.

- To achieve eradication, the entire ICA must be treated consistently. Now that the core is under control, in the coming year staff will continue to expand aerial control efforts across all steep zones. Spotters on the ground and in the helicopter will facilitate the identification and treatment of small and isolated plants. Multiple treatments of the same area will be necessary, as the detectability of isolated plants is low, even with spotters. After treated plants succumb to herbicide, aerial surveys and GigaPan imagery taken in conjunction with a GPS enabled rangefinder may provide helicopters and/or ground crews with GPS locations of any visible remaining living plants. While aerial sprays are an important tool, *C. setaceus* is much easier to detect on the ground than from the air. Wherever possible, ground-based surveys will be conducted to complement aerial efforts.

- In June 2016, GigaPan imagery (without GPS rangefinder) of the Melanthera Cliff region revealed dozens of *C. setaceus* scattered along the cliffs; see photo below. The imagery was reviewed by staff familiar with the *M. tenuifolia* population, and it was determined that no *C. setaceus* were in its immediate vicinity (circled in blue). Very little control has been performed in this region; some *C. setaceus* at the top of the cliffs were treated during initial surveys in 2011-2012. With assistance from a knowledgeable spotter, the pilot could spray the cliff areas adjacent to the wild plant population, with limited risk of unintended negative impacts. If left untreated, the population of widely scattered *C. setaceus* along the adjacent cliffs will likely grow and may expand into the *M. tenuifolia* population area.



GigaPan image showing the area containing *Melanthera tenuifolia* (in blue), and surrounding cliffs with scattered *Cenchrus setaceus* (red dots). No *C. setaceus* control has occurred on these cliffs.The three red dots on the bottom right of the image in the Ledge Zone, and are controlled from the ground.

- The most recent complete census (2009; seven years ago) of the *M. tenuifolia* population found only 1 remaining live plant, which was in poor condition. Staff plan to re-monitor the *M. tenuifolia* site via rappel in the coming year. If *M. tenuifolia* plants are found, any *C. setaceus* spotted in the wild plant population would have to be treated by hand, on rappel. If no *M.tenuifolia* are found, aerial sprays will be considered if *C. setaceus* is spotted in the wild plant population site.
- Of particular concern are cliff side plants which are either not reachable with the aerial spray rig, or too close to the road to spray without closing Farrington Highway. Staff hope to work with Dr. James Leary of CTAHR to use HBT to treat these plants; an appropriate herbicide must first be encapsulated in the HBT projectiles.
- Surveying the grassy areas between Control Regions in ICA #2 is a priority for the coming year. A combination of aerial surveys, GigaPan images, binocular surveys, and GPS enable rangefinders will be used to ensure that outlying *C. setaceus* are not being missed. These surveys may be done in conjunction with the MMR-wide surveys also planned for next year.
- The illegal trail running from Farrington Highway to the upper Makua cave continues to be popular with hikers, despite ‘No Trespassing’ signage. Hikers may spread *C. setaceus* from MMR to other regions, or re-introduce it to MMR from other regions.
- With aggressive treatment, *C. setaceus* may still prove eradicable at MMR, as other incipient populations of have been successfully extirpated by OANRP.

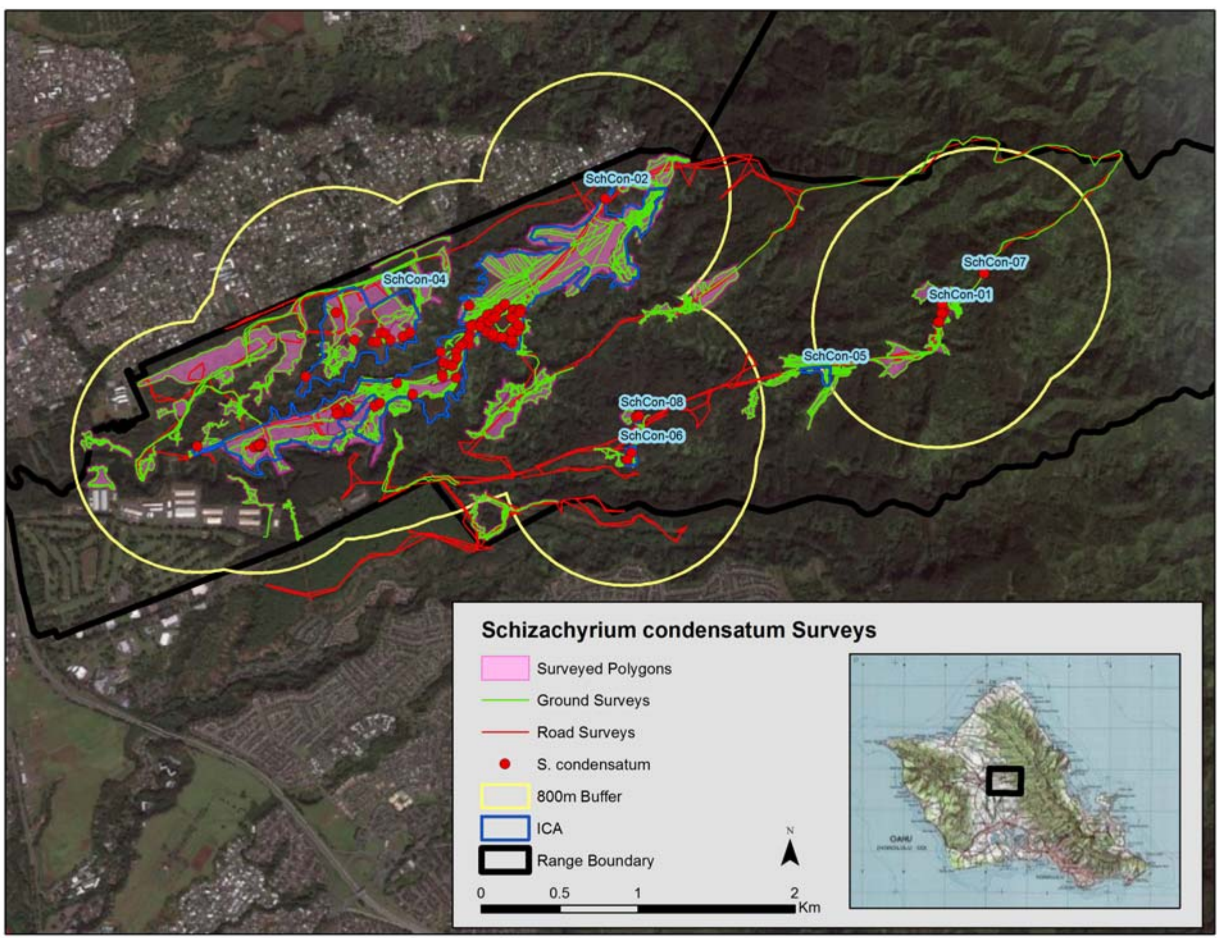
3.8 INVASIVE SPECIES UPDATE: *SCHIZACHYRIUM CONDENSATUM*, BUSH BEARDGRASS

The greatest challenges of managing *Schizachyrium condensatum* have been defining the size of the infestation, and preventing the taxon's spread via training and range maintenance activities.

Surveys

Defining the size of the *S. condensatum* was a priority this report year. Initially, 200m and 800m buffers were drawn around known plant points. These buffers covered much of SBE, and as additional plants were found, the buffers continued to grow. At the same time, staff conducting buffer surveys on the ground noted that *S. condensatum* was not observed growing in dense shade or banks of native fern *Dicranopteris linearis*. Rather, its preferred habitat was open and either grass-dominated or bare ground. Using digital imagery, this type of habitat was mapped across all of SBE, and these priority habitat zones were surveyed. This was more effective and time-efficient than trying to sweep across the entire 800m buffer. Surveys were documented using polygon and track shapefiles on ArcGIS. In addition, all SBE roads were driven as part of normal annual training road inspections. The map below depicts all surveys conducted and the current locations of *S. condensatum* ICAs. Four new ICAs were discovered during the surveys. Due to the high potential for *S. condensatum* to spread, even with on-going control, these surveys may be repeated in 3-5 years. In the meantime, staff will continue annual road and LZ surveys.

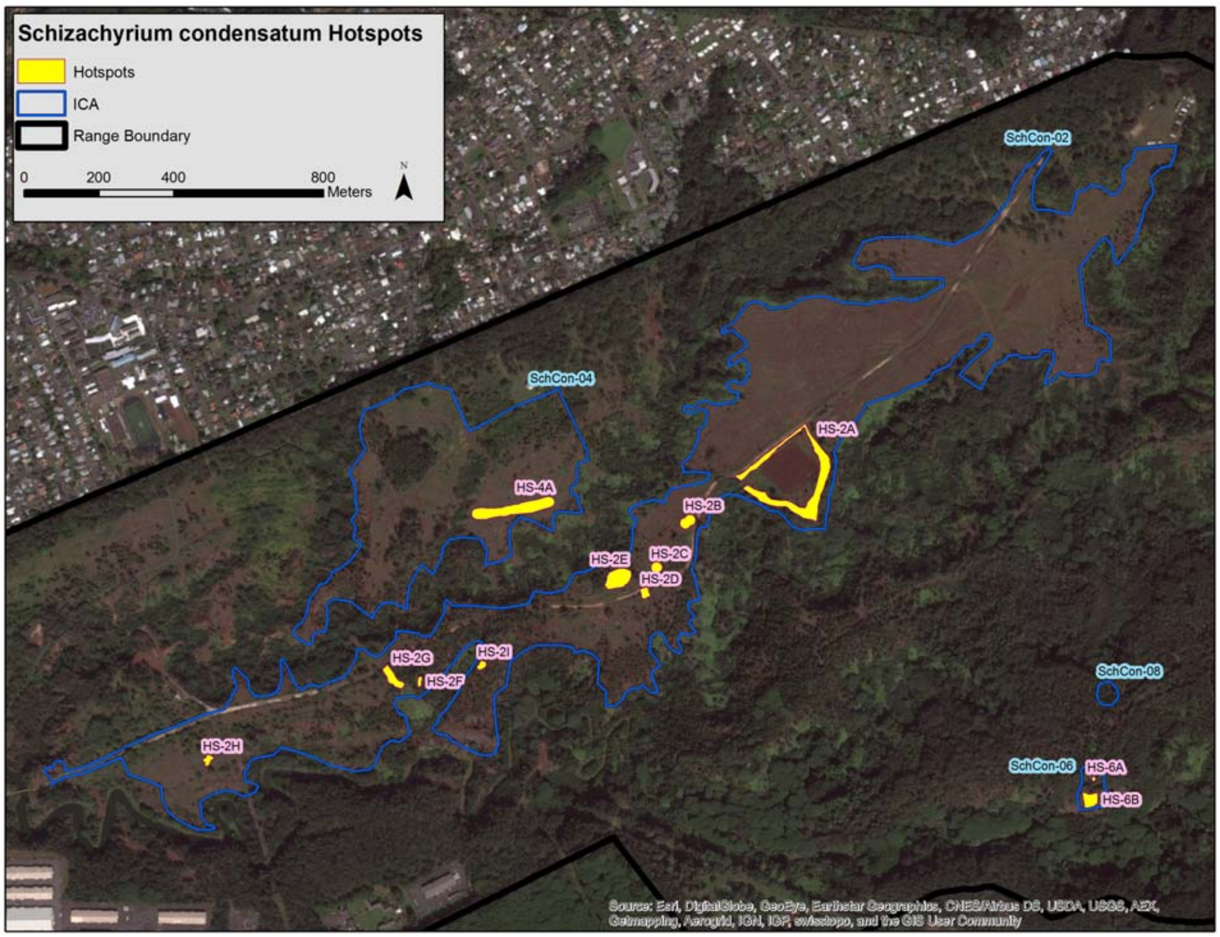
***S. condensatum* Surveys and Incipient Control Areas at SBE**



Control Efforts

A new strategy was implemented this year. Due to the large size of the ICAs and cryptic nature of *S. condensatum*, it was decided that complete sweeps of the largest two ICAs were not feasible. Instead, using field notes and plant location data, hotspots were drawn around concentrations of plants. These hotspots are comparatively small, quickly monitored and surveyed, and help staff to monitor and treat the areas most likely to see recruitment. Hotspots were drawn in most of the ICAs, even the small ones; the map below shows the hotspots in the largest ICAs. As discussed in section 3.4 above, a lot of progress was made in improving communication with ITAM and contract mowers this year. Signs and cones were installed around all hotspots in mowed areas. Contractors have been directed to avoid the cones; hopefully the cones will also discourage soldiers from walking through them.

Hotspots in Core ICAs



Control efforts are summarized in the table below. Note that the areas listed do not include surveyed areas found outside ICAs. Staff continue to find high numbers of plants. A seed sow trial was installed to determine whether *S. condensatum* forms a persistent seed bank; this is the second trial, as the first ended early due to seed packets eroding out the ground in heavy rain. Unfortunately, the new trial appears to have been run over by military vehicles, despite being tucked well off any roads. It will be monitored and all packets pulled if additional training disturbance is seen. More frequent visits may be needed to achieve eradication. Other options, such as increased use of pre-emergent herbicides or habitat modification, may also be considered.

S. condensatum Control Efforts

ICA	ICA Total Area (ha)	Area Weeded (ha)	Effort (hours)	# Visits	Comments
SBE-SchCon-01	0.23	0.23	13.5	6	First site discovered. Well-separated from the other ICAs and bordered by uluhe and thick forest, staff regularly find plants on the road margins.
SBE-SchCon-02	85.95	54.99	122	18	This is the largest ICA, and spans several large LZs and two zones used heavily by training engineers with large machinery. Staff continue to find high numbers of plants.
SBE-SchCon-04	25.84	14.98	43	7	This is the second largest ICA, and overlaps almost entirely with a *Rhodomyrtus tomentosa* ICA. There is one hotspot in this ICA.
SBE-SchCon-05	0.93	0.69	15	6	New this year. Outlier site. This ICA includes one patch of plants along the main road, and another on the edge of a frequently used military landing zone.
SBE-SchCon-06	0.79	0.79	10.55	5	New this year. Outlier site. There are several patches of plants along a navigation trail leading away from the road.
SBE-SchCon-07	0.01 (78m^2)	0.01 (78m^2)	1	1	New this year. Outlier site. Site is east of ICA-01, along a main road. It may be the result of a recent dispersal, as the road has been surveyed several times before.
SBE-SchCon-08	0.28	0.25	5.75	2	New this year. Outlier site. Site is adjacent to the heavily used Confidence Course.
TOTAL	**114**	**71.93**	**210.8**	**45**	

Brown, treated grass in Hotspot 2E, the densest concentration of *S. condensatum*.

3.9 NOVEL WEED CONTROL TECHNIQUE DEVELOPMENT: INCISION POINT APPLICATION

OANRP continues to collaborate with Dr. James Leary on various Incision Point Application (IPA) weed control projects. For a complete description of IPA, please see the 2009, 2010, 2011, 2012, 2013 and 2014 MIP and OIP Status Reports.

Work continued on development of IPA as an effective management tool this year. Staff completed monitoring of twenty-three efficacy trials. Installed by Dr. Leary and OANRP staff, the trials tested the efficacy of four different herbicide active ingredients on invasive trees. While most of the trials were conducted on Army lands, some were located on Forest Reserves, at Waimea Valley and at the Puu Ohulehule Conservancy. Partner assistance in hosting and reading trials is greatly appreciated. Due to the slow action of the herbicides tested, the trials ran for two years, or until the treated trees clearly died or recovered. The status of these trials is summarized in the "Status of IPA Efficacy Trials" table below. Also included in the table are the results of the earliest trials OANRP worked on with Dr. Leary. Some of these early trials tested only one product, Milestone© (aminopyralid); others included a product Dr. Leary was using under an Experimental Use Permit (aminocyclopyrachlor), and still others were joint projects with NARS staff. The active ingredient imazapyr was effective on the widest range of taxa, while triclopyr was the least effective. Some species, such as *Citharexylum caudatum* and *Syzygium cumini*, resisted all treatments. For these, higher dose rates, different application methods, or different chemistries may lead to effective control.

While an effective chemistry has been identified for *Grevillea robusta*, staff noted poor control of very large trees (diameter >150-200 cm) treated during weed sweeps across several MUs. Large trees may simply be protected by their size; it is likely these individuals did not receive enough herbicide to kill them. Trials will be installed to test additional chemistries and doses on large *G. robusta.* Last year, staff saw promising results from a technique similar to IPA, involving drilling holes around the trunk of a tree and filling the holes with undiluted glyphosphate. This technique may be tested on *S. cumini*, a priority target weed; large *S. cumini* have resisted all IPA control trials to date, despite doubling herbicide dosage. In the coming year, staff plan to collaborate with Dr. Leary to install several new trials, including one on *G. robusta*, update the table, and create a reference detailing which chemistries work on which taxa.

Over the past couple years, staff conducted sweeps across large areas of a few MUs, targeting select canopy weeds for control using IPA. The goal of the project was to expand the reach of the weed control program beyond the compact borders of restoration sites, rare taxa outplantings, and remnant native forest patches. However, there is concern that altering light levels across large acreages in this manner will lead to increased weed cover, without a corresponding increase in native plant cover. To address this concern, baseline monitoring was conducted at Palikea around treated *Morella faya* this year; this study is detailed in Appendix 3-13. In addition, areas treated with IPA are analyzed in the vegetation monitoring analyses of Manuwai MU (Appendix 3-11) and Kaluaa and Waieli MU (Appendix 3-10).

Status of IPA Efficacy Trials

Species; Family	Date Installed; Status	Average Time to Death	Comments	Recommended Treatment, Dose + Active Ingredient	
				Preferred	Alternatives
Acacia confusa; Fabaceae	2011-09-06; Complete	ACP: 100% (4) trees dead at 30 months. 50% dead at 6 months. AMP: Half (2) of trees 100% defoliated at 30 months.	Last reading at 30 months. Results poor for all chemistries but ACP (all trees dead) and AMP (no trees dead, 2 defoliated, 2 partially foliated). More trials needed.	1 cut/10cm, AMP	
Aleurites moluccana; Euphorbiaceae	2013-11-22; Complete	IMZ: major defoliation at 6 months; 40% dead at 10 months, 100% dead at 30 months. AMP: major defoliation at 6 months, 20% dead at 10 months, 80% dead at 30 months.	Last reading at 30 months. IMZ: 5 of 5 dead; this was the most effective treatment. AMP: 4 of 5 trees dead; largest tree had minor defoliation and recovered by 30 months. GLY: 1 of 5 dead (smallest tree), rest showed minimal defoliation, ineffective. TCP: none dead, some defoliation at 30 months, possibly due to other factors.	1 cut/15-25cm, IMZ	1 cut/15cm, AMP
Araucaria columnaris; Araucariaceae	2011-11-07; Complete	State	OANRP assisted NARS with installation of trial only. At last reading at 16 months, TCP was not effective, but AMP, GLY, and IMZ all showed some efficacy. Results were not definitive.		
	2013-11-07; Complete	AMP: 100% defoliation and 1 of 5 dead at 21 months. 2 more dead by 31 months. IMZ: 2 of 5 dead at 21 months.	Last reading at 31 months. No herbicide killed all trees. All dead trees were in smaller end of trunk size. AMP: 3 of 5 dead, largest tree had 1 dose/43cm and maintained 100% defoliation at 31 months. IMZ: 2 of 5 dead. GLY: 1 of 5 dead. TCP: completely ineffective.	1 cut/15-20cm, AMP	1 cut/10-15cm, IMZ
Ardesia elliptica; Myrsinaceae	2013-11-15; Complete	IMZ: 5 of 5 dead at 15 months, almost all defoliated by 6 months.	Last reading at 26 months. IMZ: 5 of 5 dead and partially rotted. AMP: 1 of 5 dead, results mixed, some recovering. GLY: results mixed, some trees recovering, TCP: ineffective, plants recovering.	1 cut/15-20cm, IMZ	
Callitris columellaris; Cupressaceae	2012-01-08; Complete	N/A	No effective control at 21 months.		
	2013-12-06; Complete	AMP: major defoliation at 6 months; 40% dead at 14 months; 60% dead at 27 months; largest trees recovering at 14 and 27 months. GLY: major defoliation at 6 months, 20-40% dead at 14 months, and recovery of 60% of plants at 27 months.	Last reading at 27 months. AMP: 3 of 5 dead, with 2 largest trees starting to recover; higher dose likely more effective. GLY: 1 of 5 dead, with some of remaining trees continuing to decline and some beginning to recover. IMZ and TCP: some initial defoliation, but all trees recovered by 27 months.	1 cut/10-15cm, AMP	cut/10-15cm, GLY

Species; Family	Date Installed; Status	Average Time to Death	Comments	Recommended Treatment, Dose + Active Ingredient	
				Preferred	Alternatives
Casuarina glauca; Casuarinaceae	2012-01-08; Complete	N/A	No effective control at 7 months. Trial disturbed before 21 months; results inconclusive.		
	2013-12-06; Complete	No trees died until 14 months, for any chemistry. Results inconsistent.	Last reading at 27 months. No clear winners. GLY: major defoliation at 6 months, continuing through 14 months, 2 of 5 trees dead at 27 months; oddly, largest trees died. TCP: major defoliation at 6 and 14 months, with 2 of 5 trees dead at 14 months. 3 trees recovered at 27 months. IMZ: defoliation at 6 months, with health declining for all plants through 27 months, and 1 of 5 dead. AMP: defoliation at 6 months, 1 of 5 dead at 27 months and 3 recovering. Not a good match with this application method, unless increase dose.		
Chrysophyllum oliveforme; Sapotaceae	2013-09-20; Reinstall	N/A	Last reading at 6 months; all trees alive. Difficult to read trial, due to thick canopy. Need to reinstall.		
Citharexylum caudatum; Verbenaceae	2013-10-25; Reinstall	N/A	Last reading at 11 months. TCP not effective. While others were somewhat effective, data suggest that no plants were going to die at dose give. Plan to reinstall at higher rate.		
Coffea arabica; Rubiaceae	2013-11-08; Complete	IMZ: 80% dead at 21 months.	Last reading at 31 months. IMZ the most effective killing all trees by trial end. Small to high levels of recovery seen among trees with all other herbicides.	1 cut/10cm, IMZ	
Cordia alliodora; Boraginacea	2013-08-30; On-going	IMZ: 1 dead at 22 months, major defoliation at 7 months.	Last reading at 22 months. Species is somewhat deciduous (per Waimea staff), so results inconclusive thus far. AMP: 0 of 5 dead, major defoliation seen at 22 months, but not earlier. IMZ: 1 of 5 dead, major defoliation seen at 7 months; this is most promising treatment thus far. GLY: none dead, plants defoliated, recovered, then defoliated again. TCP: none dead, major defoliation. Waiting for one more reading to conclude this trial	1 cut/15-20cm, IMZ	
Corymbia citriodora; Myrtaceae	2011-09-06; Complete	N/A	No effects seen by 11 months. Trees all very large. Conduct trial on smaller trees or use higher doses.		

Species; Family	Date Installed; Status	Average Time to Death	Comments	Recommended Treatment, Dose + Active Ingredient	
				Preferred	Alternatives
Cryptomeria japonica; Cupressaceae	2014-01-07; Complete	Some trees dead in 8-13 months, while rest showing defoliation. AMP: 5 of 5 dead at 19 months. GLY: 4 of 5 dead at 27 months.	Last reading at 27 months. AMP: 5 of 5 dead. GLY: 4 of 5 dead. IMZ: 2 of 5 dead, with larger size classes recovering. TCP: little effect, all trees healthy	1 cut/15-20cm, AMP	1 cut/15-20cm, GLY
Elaeocarpus grandis; Elaeocarpaceae	2013-12-13; Complete	IMZ: 3 of 5 dead, anywhere between 6-12 months or 2 years.	Last reading at 26 months. IMZ: 3 of 5 dead; largest trees were recovering. AMP: 2 of 5 in poor health, but all were flushing with new leaves. All TCP and GLY trees recovered.	1 cut/10-15cm, IMZ	
Fraxinus uhdei; Oleaceae	2013-11-08; Complete	IMZ: 100% defoliated at 7 months, 1 of 5 dead at 31 months. Highest levels of defoliation for all herbicides observed at 21 months.	Last reading at 31 months. IMZ: 1 of 5 dead, all 100% defoliated at 7 months, only largest 1 showed any recovery by 31 months. AMP and GLY: trees recovered at 31 months. TCP: mixed results, 1 of 5 died at 21 months, 2 100% defoliated and 2 fully recovered by 31 months.	1 cut/20cm, IMZ	
Grevillea robusta; Proteaceae	2010-11-16; Complete	AMP: 17% dead and 92% defoliated at 3 months. All dead when next checked at 29 months.	Trial only tested AMP, not other chemistries. Of 12 plants treated, 9 were relocated after 29 months, and all were dead. Dr. Leary conducted trials using all chemistries, and recommends AMP for this taxon. 2016 update: Staff using IPA to weed note that many larger trees are not dying. Additional trial will be conducted to determine best dose for larger trees.	1 cut/15cm, AMP	
Heliocarpus popayensis; Tiliaceae	2013-11-22; Complete	For IMZ: 100% defoliation and 20% mortality at 6 months; 80% dead at 10 months; 100% dead at 30 months.	Last reading at 30 months. IMZ: 5 of 5 dead; this is the most effective treatment. AMP: 2 of 5 dead; little difference between results at 10 months and 30 months. GLY: 1 of 5 dead; perhaps a higher dose would have been effective. TCP: 1 of 5 dead (smallest tree); ineffective.	1 cut/10-20cm, IMZ	1 cut/10-15cm, AMP
Leptospermum scoparium; Myrtaceae	2014-01-14; Complete	All chemistries: plants dead within 1 year.	Last reading at 26 months. IMZ: 5 of 5 dead. GLY: 5 of 5 dead. AMP: 1 of 5 dead. TCP: all trees alive.	1 cut/15-30cm, GLY or IMZ	
Leucaena leucocephala; Fabaceae	2010-11-16; Complete	AMP: 65% dead and 100% defoliated at 3 months.	Trial tested AMP only, not other chemistries. Trees 1-3 m tall were used. At 3 months, 13 of 20 trees were dead and all were 100% defoliated. At 29 months, 8 of 20 were relocated, and all were dead; others suspected to have fallen down	1 cut/10cm, AMP	

Species; Family	Date Installed; Status	Average Time to Death	Comments	Recommended Treatment, Dose + Active Ingredient	
				Preferred	Alternatives
	2011-11-07; Complete	State	OANRP assisted NARS with installation of trial only. Trial tested all chemistries. Short stature plants with trunk 'brains' were used. Last reading at 16 months. 5 of 5 AMP trees were dead. Other chemistries ineffective.	2 cuts/brain, AMP	
Melaleuca quinquenervia; Myrtaceae	2013-10-04; On-going	AMP: defoliation at 5 months, 3 dead at 13 months, 1 more at 20 months. AMP: major defoliation at 5 months, 3 dead at 13 months.	Last reading at 20 months. IMZ: 4 of 5 dead, major defoliation; this is most effective treatment. AMP: 3 of 5 dead, major defoliation, largest tree not affected, higher dose may be better. GLY: 2 of 5 dead, rest likely recovering, some defoliation; not effective. TCP: none dead, little defoliation; not effective.	1 cut/15-20cm, IMZ	1 cut/15-20cm, AMP
Morella faya; Myricaceae	2014-01-07; Complete	IMZ: 20% dead at 7 months, 80% dead at 13 months, 100% dead at 19 months. AMP: major defoliation evident at 7 months, 80% dead at 19 months.	Last full reading at 19 months. IMZ: 4 of 5 dead, 1 tree 100% defoliated. AMP: 4 of 5 dead, smallest 1 recovering. GLY: 2 of 5 dead, rest showing major defoliation. TCP: none dead, some defoliation on smallest tree but recovering. Final partial reading at 27 months; 11 trees were accidentally retreated with IMZ at 22 months. Data suggests IMZ still best, followed by AMP. GLY only partially effective on smaller sizes. TCP ineffective	1 cut/10-20cm, IMZ	1 cut/10-20cm, AMP
Pimenta dioica; Myrtaceae	2013-11-07; Complete	IMZ: all defoliated at 7 months; 4 of 5 dead and 1 tree 100% defoliated at 21 months. AMP: 2 dead at 21 months, major defoliation by 7 months.	Last reading at 31 months. IMZ: 4 of 5 dead at 21 months and the remaining tree stayed completely defoliated until the trial end. AMP: 2 of 5 dead, 1 tree 100% defoliated at 31 months. May be effective at a higher dose. GLY and TCP: ineffective, no trees died and most recovered.	1 cut/15-20cm, IMZ	1 cut/20cm, AMP
Psidium guajava; Myrtaceae	2013-09-27; Complete	IMZ: 100% defoliated and 20% dead at 10 months. 40% dead at 19 months. 60% dead at 30 months. GLY: 20% dead at 19 months, 40% dead at 30 months.	Last reading at 30 months. IMZ: 30 5 dead; most effective. Largest 2 trees re-sprouting; suspect too low of dose. GLY: 2 of 5 dead, 2 recovering; somewhat effective. Again, higher dose may be more effective. AMP: none dead, although all had major defoliation. TCP: 1 of 5 dead (smallest tree), rest partially defoliated, then recovered.	1 cut/15cm, IMZ	1 cut/15cm, GLY
Schefflera actinophylla; Araliaceae	2011-03-09; Complete	State	OANRP assisted NARS with installation of trial only. Last reading at 15 months. 4 of 4 trees dead for GLY, IMZ, and AMP. TCP not effective.	1 cut/15-20cm, GLY	1 cut/15-20cm, IMZ or AMP

Species; Family	Date Installed; Status	Average Time to Death	Comments	Recommended Treatment, Dose + Active Ingredient	
				Preferred	Alternatives
Spathodea campanulata; Bignoniaceae	2013-08-23; Complete	IMZ: 100% defoliation at 11 months and 3 apparently dead at 18 months, although 2 recovered by 37 months. 2 dead at 37 months, rest slowly recovering. GLY: some defoliation at 11 months.	Last reading at 37 months. IMZ: 2 of 5 dead, 2 very poor, largest recovering. AMP: none dead, major defoliation, but all recovering. GLY: none dead, major defoliation, all recovering. TCP: none dead, inconsistent defoliation, all recovered. Likely doses were too low. Puu Ohulehule Conservancy: GLY effective at very high doses.	1 cut/10-15cm, IMZ	1 cut/5cm, GLY
Syzygium cumini; Myrtaceae	2010-08-17; Complete	AMP: 0 of 6 dead, rest had varying defoliation at 6 months. 5 of 6 dead at 29 months.	Trial tested AMP only, not other chemistries. 2 doses were tested, 0.5mL per cut and 1mL per cut. 2 size classes of trees were used, small (11-15cm dbh) and large (30-55cm dbh), 6 trees of each size. Trial was compromised when several of large trees were bulldozed. No strong results on any of large trees. Stats are for small size classes only. At 6 months, 0 of 6 trees were dead, 2 of 6 were 100% defoliated, and 4 of 6 were more than 50% defoliated. At 32 months, 5 of 6 were dead, and 1 was poor. No major differences between high and low dose.	1cut/5-10cm, AMP (small size trees only)	
	2011-03-09; Complete	State	OANRP assisted NARS with installation of trial only. Last reading at 15 months. No treatment effective except experimental product, ACP.		
	2013-11-15; Complete	Some defoliation at 15 months.	Trial targeted large trees. Last reading at 26 months. IMZ: most promising, 3 of 5 in poor health (smallest trees) at 15 and 26 months; other 2 trees recovered. AMP: 4 of 5 recovered, smallest in poor health. TCP: 1 of 5 (smallest) dead, remainder recovered. GLY: 5 of 5 recovered. Recommend experimenting with higher doses or drilling with IMZ or GLY.		
Toona ciliata; Meliaceae	2011-09-06; Complete	IMZ: 25% dead at 3 months, 50% dead at 6 months, 100% defoliated at 11 months, 75% dead at 16 months, 100% dead at 30 months	Last reading at 30 months. IMZ: 4 of 4 dead. TCP: 3 of 4 dead. AMP: 1 of 4 dead, remainder re-sprouting.	1 cut/15cm, IMZ	1 cut/15cm, TCP or 1 cut/10cm, AMP
Trema orientalis; Cannabaceae	2013-12-18; Complete	IMZ: 2 dead at 8 months, rest at 15 months. AMP: 1 dead at 8 months (smallest), 3 more at 15 months.	Last reading at 15 months. AMP: 4 of 5 dead, largest still alive. IMZ: 4 of 5 dead, 1 recovered. GLY: 2 of 5 dead, rest recovered. TCP: 4 of 5 recovered, 1 died.	1 cut/20cm, IMZ or AMP	

ACP = Aminocyclopyrachlor, AMP = Aminopyralid, GLY = Glyphosate, IMZ = Imazapyr, TCP = Triclopyr

3.10 RESTORATION ACTIONS UPDATE

This year, restoration actions ramped up to target high priority Weed Control Areas. Restoration activities aim to compliment weed control efforts in areas with high weed recruitment, to restore connectivity and structure to native forest patches, and to replace vegetation following removal of dense patches of alien species.

The total area over which a given restoration action takes place is recorded in ArcMap, and restoration details including species used, propagule type and number, source populations, etc. are recorded in the OANRP access database.

The 'Restoration Action Summary' table below describes restoration efforts for this report year. Restoration actions are tracked within the WCAs because this existing subunit system, which is used to track weed control efforts, is conveniently already in place. Restoration actions are tracked as two types: outplantings, and seed sows/ divisions/ transplants (SDT). Outplantings require a higher level of staff input and planning, where SDT actions are sometimes opportunistic in the field, sometimes planned. SDT activities require low effort as compared to outplantings. 'Area' for each restoration type is calculated by merging all the overlapping efforts into a single geographic footprint within a given WCA for the year (overlapping efforts are not counted more than once). Total merged area of both types of restoration actions is also calculated and displayed at the bottom of the table.

Outplanting common native species accounted for the bulk of the restoration efforts. In some of the more active restoration sites, where complete removal of alien vegetation took place, seed sows were also frequently used. Both fresh and stored seed was used in these efforts.

In the past year, previously established vegetation monitoring methods were continued, and new techniques were initiated to track vegetation change within small restoration sites, which are often under 1 acre. In the past year, vegetation monitoring at restoration sites in Kahanahaiki was conducted at Maile Flats chipper site (results for five years post-initial clearing, Appendix 3-8), and at the "Shire" and "Schwepps" sites (photopoint monitoring). Monitoring of native shrub cover change at Ohikilolo Lower restoration areas was initiated using Gigapan imagery (Appendix 3-2A). Point-intercept vegetation monitoring was initiated to track vegetation change at the new snail enclosure site at Palikea (Appendix 3-7). There is also the anticipation that restoration actions including large scale canopy weed removal, outplantings, and SDTs will accelerate efforts towards reaching MU vegetation cover goals and be observed in the large-scale MU vegetation monitoring conducted across MUs.

In the coming year, restoration actions will continue at sites in the following Management Units: Ohikilolo Lower, Ohikilolo, Kahanahaiki, Palikea and Makaleha West. Additionally, new restoration actions are planned for Makaha. Outplantings will be conducted in select locations where weed control is ongoing weed control around rare plants, and also in a new restoration site on 'Camp Ridge' where a dense stand of *Psidium cattlianum* will be removed. Baseline point-intercept vegetation data will be established at this site, so more rigorous monitoring data will be available for this restoration project.

Restoration Action Summary Table

MU	WCA code	Restoration Action	# of plants	Area (m2)	Taxa	Comments
Kaala	Kaala-01	Outplanting	35	86	*Kadua centranthoides*	*K. centranthoides* was planted on the Army side of the boardwalk in an open area where *Juncus effusus* removal is ongoing. This location is particularly wet (isolated patches of standing water) and it is unclear how quickly plants will grow or fill in. No significant efforts will be conducted here in the coming year.
	Kaala-06	Outplanting	34	9	*K. centranthoides*	Planted in an open area where *J. effusus* removal is ongoing on the State managed side of the boardwalk.
		MU Outplanting Total:	**69**	**95**		
Kahanahaiki	Kahanahaiki-04	Outplanting	299	2427	*Acacia koa, Hibiscus arnottianus subsp. arnottianus, Pisonia spp., Planchonella sandwicensis*	A significant amount of time has been dedicated to the 'Shire' restoration site (~.75 acre site) in this WCA by staff. Three reintroductions with the same suite of species were conducted this year.
		SDT	n/a	2298	*Bidens torta, Dianella sandwicensis, Pipturus albidus*	Multiple seed sow and transplanting efforts were conducted at the 'Shire' restoration site. Impressive amounts of cover were established with *P. albidus* and *B. torta* seed sows and can be seen in the photopoints below.
	Kahanahaiki-16	Outplanting	59	1212	*A. koa, Bidens torta, H. arnottianus subsp. arnottianus Pisonia spp.*	A significant amount of time has been dedicated to the 'Schwepps' (~.5acre site) restoration site in this WCA by staff. Two outplanting efforts were conducted there this year.
		SDT	n/a	938	*B. torta, D. sandwicensis, P. albidus*	Native cover was also established at the 'Schwepps' restoration site with *P. albidus* and *B. torta* seed sows (photopoints below). *D. sandwicensis* transplants were scattered throughout the site.
		MU Outplanting Total:	**358**	**3,639**		
		MU SDT Total:	**n/a**	**3,236**		
Kaluaa and Waieli	KaluaaandWaieli-02	Outplanting	28	193	*Freycenetia arborea, Lobelia yuccoides*	Plants were outplanted inside the Hapapa snail enclosure. Staff observations suggest that native canopy cover inside the enclosure is sufficient, and future reintroductions will only be conducted as needed to increase diversity or to establish more important snail host species such as *Freycinetia arborea.*
	KaluaaandWaieli-02	SDT	n/a	138	*B. torta*	Seeds were sowed on the 'Hapapa Bench' area post weed control effort.
	KaluaaandWaieli-04	Outplanting	19	64	*Urera glabra*	All outplantings at this location are to establish higher levels of *Drosophila montgomeryi* host vegetation as a means towards

MU	WCA code	Restoration Action	# of plants	Area (m2)	Taxa	Comments
						stabilization. See Chapter 7 for additional *D. montgomeryi* stabilization details.
	KaluaaandWaieli-08	Outplanting	35	318	*Urera glabra*	All outplantings at this location are to establish higher levels of *Drosophila montgomeryi* host vegetation as a means towards stabilization. See section Chapter 7 for additional *D. montgomeryi* stabilization details.
	KaluaaandWaieli-09	SDT	n/a	46	*Pisonia spp.*	Opportunistic transplanting with volunteers during weed control rainout.
MU Outplanting Total:			**82**	**575**		
MU SDT Total:			**n/a**	**184**		
Ohikilolo Lower	LowerOhikilolo-02	Outplanting	546	2907	*Dodonea viscosa, Myoporum sandwicense, Erythrina sandwicensis*	Restoration was conducted around a managed population of *Euphorbia celestroides* var. *kaenana* to suppress weeds and fire-prone grasses, and improve habitat. *D. viscosa* was planted densely on a shelf above the wild *E. celestroides* (see photo below), *E. sandwicensis* was planted across the rocky center of the patch, and *M. sandwicensis* was planted at the bottom of the patch, near with *Scaevola taccada* outplanted last year. This coming year, similar outplantings will continue, especially in the flat, weed dominated areas, until native cover reaches a density that shades out weeds and ultimately reduces amount of herbicide and weed control necessary.
	LowerOhikilolo-03	Outplanting	32	447	*E. sandwicensis*	*E. sandwicensis* was planted on the top edge of a managed population of *Hibiscus brackenridgei*. This coming year additional species will be planted in areas with continual weed ingress.
MU Outplanting Total:			**578**	**3,354**		
Ohikilolo	Ohikilolo-10	Outplanting	138	909	*Metrosideros polymorpha, Myrsine lessertiana*	Outplantings were conducted to fill in canopy gaps in the Forest Patch Enclosure where they occur along the fence. Additional plantings here should not be necessary next year.
	Ohikilolo-13	Outplanting	112	377	*D. viscosa, M.s polymorpha, M. lessertiana*	Outplantings were conducted to fill in canopy gaps in the forest patch around the cabin, where significant alien canopy weed removal has occurred. In the future, restoration efforts will continue in this WCA, focusing on connecting native patches in the eastern region, and expanding native cover towards the western end of the WCA.
MU Outplanting Total:			**250**	**1,286**		
Palikea	Palikea-03	Outplanting	56	47	*Cheirodendron trigynum, D.*	Outplantings were conducted to shade out grasses on an open

MU	WCA code	Restoration Action	# of plants	Area (m2)	Taxa	Comments
					viscosa	slope along the crestline, adjacent to known snail populations.
	Palikea-03	SDT	n/a	46	*D. sandwicensis*	*D. sandwicensis* divisions were transplanted into the open area described in the comment above.
	Palikea-06	Outplanting	226	823	*C. trigynum, Coprosma longifolia, Kadua affinis, M. polymorpha, Pisonia spp., Psychotria hathewayi, Urera glabra*	Plantings were done in two locations where active weed control (canopy and understory) is taking place: shallow bowls and slopes just off the crestline (photo below), and a gulch where *Drosophila montgomeryi* was observed in the past. In the latter site, 23 *U. glabra* were planted along with *Pisonia umbellifera* and *P. brunoniana* to restore *Drosophila* habitat.
	Palikea-06	SDT	n/a	20	*D. sandwicensis*	*D. sandwicensis* divisions were planted around the outplanting site described above.
	Palikea-09	Outplanting	41	350	*D. viscosa*	*D. viscosa* was outplanted at a location where a monotypic stand of *Psidium cattleianum* had been removed in 2013 (photo below). *A. koa* recruitment is occurring on site, but supplemental plantings here will be necessary to prevent continued weed ingress.
MU Outplanting Total:			**323**	**1,220**		
MU SDT Total:			n/a	66		
Makaleha West	WestMakaleha-02	Outplanting	83	751	*Clermontia kakeana, Luzula hawaiiensis, Metrosideros polymorpha, Perrottetia sandwicensis*	These taxa were planted in locations where canopy weed control has taken place.
	WestMakaleha-02	SDT	n/a	238	*Alyxia stellata, Antidesma platyphyllum, Canavalia galeata, C. longifolia, K. acuminata, Melicope spp., M. polymorpha, Scaevola gaudichaudiana*	Staff worked with the Youth Conservation Core group to transplant a diversity of plants into open areas where *P. cattleianum* was removed.
MU Outplanting Total:			83	751		
SDT Total:			n/a	238		
OUTPLANTING YEAR END TOTAL:			1,743	10,920	2.7 acres	
SEEDSOW, DIVISIONS, TRANSPLANTS YEAR END TOTAL:			n/a	3,724	0.92 acres	
ALL RESTORATION EFFORTS YEAR END TOTAL:			n/a	11,750	2.9 acres: An overlap of SDT and outplanting efforts in some more intensive restoration areas accounts for the reduction of total area in this calculation.	

The photopoints below document change from July 31, 2014 (left) to June 14, 2016 (right) at the 'Shire' site in Kahanahaiki-04.

The photopoints below document change from July 31, 2014 (left) to June 14, 2016 (right) at the 'Schwepps' site in Kahanahaiki-16.

D. viscosa (circled) in Palikea-09, planted to supplement natural recruitment at a location where an isolated patch of *Psidum cattleianum* was removed.

Above: Over 400 *D. viscosa* (Aalii) were planted one meter apart in rows two meters apart across a grassy flat in Lower Ohikilolo-02 to shade grasses and re- establish native cover (x's approximate locations of plants in the foreground).

Below: Outplants in Palikea-06 were planted to connect patches of native vegetation.

CHAPTER 4: RARE PLANT MANAGEMENT

4.1 PROJECT HIGHLIGHTS

During this reporting period, OANRP outplanted a total of 1,430 individuals of 17 MIP and OIP taxa. In the last year, OANRP made 784 observations at *in situ* sites and outplanting sites of IP taxa. In this chapter, a summary of this year's highlights are included, along with the explanation for understanding the Taxon Status, Threat Control, and Genetic Storage Summaries. Lastly, our five year stabilization plan for *Plantago princeps* var. *princeps* and *Cyanea superba* subsp. *superba* are presented. Some of this year's highlights include:

Cyanea grimesiana subsp. *obatae* (MIP & OIP): This is a continuation of the update from the controlled breeding study in 2014. This project was initiated to conduct supplemental pollination experiments to compare the fitness of progeny from self-pollinated, intra-population and inter-population hand crosses. This project was designed to address concerns for difficulty of *ex situ* propagation and poor survival and lack of recruitment at outplantings and wild sites. This study will continue into the next fiscal year, as we will outplant this coming winter, and report on the progress of those outplantings in future reports. We did not observe differences in fruit set, seed set, seed weight, or germination due to source population or degree of mixing (selfed-pollinations, crosses within populations, crosses between populations). Fruit set, however, was higher than expected when the pollen used was collected on the same day. This suggests that our protocol for transporting and using pollen did not suffice for this species. It would be good to determine whether or not *C. grimesiana* subsp. *obatae* pollen can be dried and stored. Two outplantings of the progeny from this study will be planted this winter, one site at Palikea and another at Makaha. Locations and methods were approved by OANRP, NARS, and OPEPP staff.

Eugenia koolauensis (OIP): We have obtained material from the 150 maternal lines targeted for this species via salvaging seedlings and taking cuttings from trees in poor health at the *in situ* populations. Living collections now need to be cloned to meet genetic storage goals. A planting at Koko Crater Botanical Garden last winter was successful. Other than one initial rust treatment, plants appeared rust free for the last six months. Plants are growing, flowering, and fruiting. Due to this success, additional plants will be added this winter.

Cliff habitat and species (*Dubautia herbstobatae, Kadua parvula, Sanicula mariversa, Tetramolopium filiforme, Viola chamissoniana* subsp. *chamissoniana*): Declines in populations of cliff-dwelling IP taxa were observed this year. Of the 20 Population Units with the highest decline, cliff species comprise eight of the 20 PU, three of which experienced the highest declines this year. There has been a decline in all of the observed PU for these taxa except where outplantings occurred. There was such a decline in the *Kadua parvula* Ohikilolo PU that an overall decline still occurred despite the outplanting of 70 plants this year that yielded 20 matures. OANRP will strategize on ways to improve cliff habitats.

Dubautia herbstobatae (OIP): The first outplanting of this taxon was conducted this year. Over 50 plants were planted onto cliff habitat in Makaha via rappelling. The outplants are growing and little mortality has been observed. This is hopeful compared to the observations of *in situ* populations. Several days spent monitoring populations at Ohikilolo revealed a substantial decline in populations, along with decline in cliff habitat in general (see above). Surveys of Population Units are not complete and will be reported next year.

Pritchardia kaalae (MIP): Obtaining a bulk collection of fruits from this taxon to complete storage testing at the National Center for Genetic Resources Preservation (NCGRP) has been challenging. Restricted access to Makua Military Reservation last year allowed rat populations to increase in the absence of

OANRP control. Due to the long maturation time for fruit of *P. kaalae*, staff needed to wait for rat control to take effect and allow fruit to mature once again. In July 2016, the final shipment of seeds were mailed to NCGRP for one final test to confirm storage protocols for this taxon. Seeds will be subjected to various storage temperatures at various levels of processing (whole seed versus embryo removed) to determine the minimum amount of processing that will yield the longest re-collection interval.

Cyanea superba subsp. *superba* (MIP): A laboratory trial was conducted to examine seed germination reduction during *C. superba* subsp. *superba* fruit senescence (results are included in Appendix 4-1). Seed germination rates were relatively high among seeds sown from fresh fruit, however, viability from fruit that senesced for one to two weeks was less than half that of fresh material, followed by a total loss of viability after two weeks of fruit senescence. These results suggest a potential recruitment limitation in the event that fresh seeds are not dispersed by frugivores, as fruits tend to senesce on the plant for several days before falling to the ground.

4.2 TAXON STATUS SUMMARY

In the last year, there have been changes in the number of mature plants at 84/133 of the Manage for Stability Population Units managed by OANRP. Table 1 shows the Population Units where a change was observed in the last reporting period. The difference in the number of mature plants reported last year and this year is given (#Mat), with the percent change observed at each (%change). Most of the largest changes are due to fluctuations at outplanting sites when more plants are added, many plants in the same cohort mature at the same time, or are observed to have died at the same time. PU that are in **bold text** are wild *in situ* PUs that have not been augmented with outplants, so that the increase in the total number of plants is due to natural recruitment, the death of known plants OR better estimates from recent surveys. The largest increases occurred in PU that have been augmented with outplants, with a few exceptions. One exception was an increase in *in situ* populations of *Cyrtandra dentata* in the Koolau Mountains due to more thorough surveying in the past year. The next exception was in increase in the number of mature plants of *Euphorbia celastroides* var. *kaenana* at Kaena. This was due to a new population inside of the predator proof portion of the Natural Area Reserve. The last exception was for *Cyanea acuminata* at Kaala, which was also due to a more thorough survey, instead of an estimate, at one of the Population Reference Sites.

As mentioned in the Project highlights, many of the declines that were observed this year are due to thorough surveying of cliff dwelling species, particularly *Kadua parvula* (*in situ*), *Plantago princeps* var. *princeps* (*in situ* and an outplanting), and *Tetramolopium filiforme* (an outplanting). Other substantial declines occurred at outplantings that appear to have failed (not on cliffs). These include *Schiedea obovata* at Makaha, *Phyllostegia mollis* at Ekahanui, and *Labordia cyrtandrae* at Koloa. Declines for these three species cannot be attributed to any one cause.

Table 1: MFS PUs sorted by Decreasing and Increasing numbers of Mature Plants. **Bold** PUs have only wild plants. ΔMat = the change (negative or positive) to the number of mature plants from 2014. %change = percent observed (negative or positive).

IP	Species and MFS PU with DECREASES	Δ Mat	% Change
MIP	TetFil - Puhawai	-18	-600%
MIP	PlaPriPri - Ekahanui	-41	-586%
MIP	**KadPar - Halona**	-62	-200%
MIP	SchObo - Makaha	-70	-92%
OIP	PhyMol - Ekahanui	-10	-91%
MIP	**VioChaCha - Ohikilolo**	-178	-86%
MIP	**AleMacMac - Makua**	-5	-83%
MIP	NerAng - Makua	-52	-76%
OIP	LabCyr - Koloa	-24	-73%
MIP	**PlaPriPri - Halona**	-4	-67%
MIP	**SanMar - Kamaileunu**	-2	-67%
MIP	SchObo - Keawapilau to West Makaleha	-22	-61%
MIP	**VioChaCha - Halona**	-7	-47%
MIP	**KadDegDeg - Kahanahaiki to Pahole**	-45	-44%
MIP	SchKaa - Pahole	-25	-43%
MIP	**NotHum - Waianae Kai**	-61	-39%
MIP	SchNut - Kapuna-Keawapilau Ridge	-19	-35%
MIP	**TetFil - Ohikilolo**	-492	-26%
MIP	CenAgrAgr - Kahanahaiki and Pahole	-64	-25%
MIP	**EupCelKae - Puaakanoa**	-30	-25%
MIP	**AleMacMac - Makaha**	-7	-24%
OIP	PhyHir - Puu Palikea	-27	-24%
MIP	SchNut - Kahanahaiki to Pahole	-20	-23%
MIP	SchObo - Kahanahaiki to Pahole	-51	-22%
MIP	CyaSupSup - Kahanahaiki	-10	-21%
MIP	NerAng - Waianae Kai Mauka	-2	-18%
OIP	**HesSwe - Lower Opaeula**	-3	-17%
OIP	PhyMol - Kaluaa	-14	-16%
OIP	**CyaKoo - Kaipapau, Koloa & Kawainui**	-13	-12%
MIP	**CyrDen - Kahanahaiki**	-4	-12%
MIP	FluNeo - Makaha	-1	-11%
MIP	HibBraMok - Manuwai	-15	-10%
MIP	DelWai - Kaluaa	-52	-9%
MIP	**GouVit - Keaau**	-4	-8%
MIP	SchKaa - South Ekahanui	-11	-7%
OIP	**AbuSan - Kaawa to Puulu**	-2	-6%
MIP	CenAgrAgr - Makaha and Waianae Kai	-10	-6%
MIP	**EupCelKae - East of Alau**	-1	-5%
OIP	**CyaKoo - Poamoho**	-1	-5%
MIP	NerAng - Manuwai	-5	-5%
OIP	**CyaKoo - Opaeula to Helemano**	-1	-4%
MIP	KadPar – Ohikilolo	-4	-4%
MIP	EupHer - Kapuna to Pahole	-2	-4%
MIP	CyaGriOba - Kaluaa	-4	-3%
MIP	NotHum - Manuwai	-3	-3%
MIP	**MelTenf - Ohikilolo**	-21	-2%
MIP	CenAgrAgr - Central Ekahanui	-3	-2%

IP	Species and MFS PU with INCREASES	Δ Mat	% Change
OIP	HibBraMok - Keaau	20	100%
MIP	KadPar - Ekahanui	6	100%
MIP	PlaPriPri - Ohikilolo	4	100%
MIP	SanMar - Ohikilolo	2	100%
MIP	HibBraMok - Haili to Kawaiu	39	89%
MIP	HesOah - Makaha	8	73%
MIP	DubHer - Makaha	51	65%
MIP	NerAng - Makaha	90	63%
MIP	HesOah - Pualii	10	63%
MIP	**CyrDen - Kawaiiki (Koolaus)**	8	62%
MIP	CyaLong - Kapuna to West Makaleha	35	56%
MIP	HibBraMok - Makua	44	35%
MIP	PhyHir - Haleauau to Mohiakea	25	35%
OIP	NerAng - Kaluakauila	35	35%
MIP	**CyrDen - Opaeula (Koolaus)**	12	34%
MIP	**EupCelKae - Kaena**	301	34%
MIP	PriKaa – E. Ohikilolo East & W. Makaleha	2	33%
MIP	**CyaAcu - Makaleha to Mohiakea**	39	26%
OIP	SchNut - Makaha	23	25%
MIP	AbuSan - Ekahanui and Huliwai	11	24%
OIP	GarMan - Helemano and Poamoho	4	24%
OIP	**EugKoo - Oio**	1	20%
OIP	PhyHir - Koloa	17	18%
OIP	GarMan - Haleauau	8	12%
OIP	GarMan - Lower Peahinaia	1	11%
OIP	CyaGriOba - Palikea (South Palawai)	12	10%
MIP	**MelTenf - Mt. Kaala NAR**	10	8%
MIP	CyaLong - Makaha and Waianae Kai	9	8%
MIP	**KadDegDeg - Central Makaleha and West Branch of East Makaleha**	1	4%
MIP	**KadDegDeg - Alaiheihe and Manuwai**	3	4%
MIP	CyaLong - Pahole	2	3%
MIP	CyrDen - Pahole to West Makaleha	12	2%
MIP	LabCyr – E. Makaleha to North Mohiakea	3	1%
OIP	PriKaa - Makaleha to Manuwai	1	1%

The Taxon Status Summary for each IP taxon is included as Appendix 4-2. The example shown below (Table 2), displays the management designation, the original MIP or OIP population total, last year's reported total and the current status of the wild and outplanted plants for each PU. The PUs are grouped by those located inside the MIP or OIP AA (In) and PUs where all plants are outside of both AAs (Out). Definitions for each field are given below.

Table 2: Example of a Taxon Status Summary using *Cenchrus agrimonioides* var. *agrimonioides*

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Cenchrus agrimonioides var. agrimonioides Target # of Matures: 50 # MFS PU Met Goal: 3 of 3

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

Action Area: Out

TaxonName: Cenchrus agrimonioides var. agrimonioides Target # of Matures: 50 # MFS PU Met Goal: 3 of 3

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

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 their status will not be tracked or reported.

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 of numbers 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 2014: 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 for mature plants. These last three columns can be compared with the previous three columns to see the change observed over the last reporting period.

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

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

PU LastObs Date: Last Observation Date of the most recent Population Reference Site observed within a PU. Where thorough monitoring was done, the estimates were updated.

Population Trend Notes: Comments on the general population trend of each PU are 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, OANRP has monitored the PU and observed no change. When the PU has not been monitored, the same estimate from the previous year is repeated.

4.3 THREAT CONTROL SUMMARY

The Threat Control Summary for each IP taxon is included as Appendix 4-3. An example shown below (Table 3), includes the current status of fence construction and removal of pigs and goats from Management Units, invasive plant, rat and slug control and preventing wildfire.

Several changes in ungulate threat control were due to pigs found in fence units including Makaha I, Ekahanui II and III, and Kapuna Upper. Fences have been repaired and pigs have been removed but it is uncertain whether or not all pigs have been removed from any of the four units at this time. The threat control status for ungulates for these affected PU has been changed to ‘Partial’ until the last pigs are removed.

Weed control continues at most MU, and is a threat to all taxa in all PU. See Chapter 3 for more details. This year we reported the weed control status by overlaying weed control efforts with IP taxa population sites in GIS. To receive a ‘Yes’, the entirety of a 50m radial buffer around a PU needed to be weeded. There are only four population sites for four different taxa that meet this goal. All other weed control efforts are described as ‘Partial’ for this reporting year. Of the 133 MFS PU, 95 PU receive ‘Partial’ weed control status.

Rat control continued around many PU in the last year. Although rats are considered a potential threat to most IP taxa, they are mainly controlled around sites where significant damage has been observed. There are situations where occasional damage to a few plants is observed. In those cases, if the damage is not observed again, control is not immediately installed and the site is monitored more closely. Substantial damage has been seen this year at multiple PU of *Delissea waianaeensis,* as well as the outplanting of *Labordia cyrtandrae* at Kaala. New rat control grids were established at these sites. Rats are considered a threat to 20 of the 39 taxa in the MIP and OIP and are controlled at 83 population sites in 26 of the 63 MFS PU with those taxa. Last year we only conducted rat control at 15 MFS PU. A number of MFS PUs do receive year round or seasonal protection from rats where they are located within large rat control grids at Palikea, Kahanahaiki, Makaha, Ekahanui and Ohikilolo Ridge.

Slugs are a threat to seedlings and small immature plants of many native plants. They are noted as a threat to 25 of the 39 MIP and OIP taxa. Slugs are currently controlled at 21 of the 83 MFS PUs with those taxa, which is an increase from 10 MFS PU that received control last year. Decisions on where to initiate control are based on staff availability and can only occur at sites without native snails, thus meeting label restrictions. Future outplantings of IP taxa that may be dependent on slug control will be planned for areas that do not have those restrictions.

An example shown below (Table 3), summarizes the threat status at each Population Unit for every IP taxa. “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.

Table 3: Example of a Threat Control Summary using *Cenchrus agrimonioides* var. *agrimonioides*

Threat Control Summary

Action Area: In

TaxonName: Cenchrus agrimonioides var. agrimonioides

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki and Pahole	Manage for stability	319	Yes	Partial 2%	Partial 37%	No	No
Kuaokala	Genetic Storage	1	No	No	No	No	No

Action Area: Out

TaxonName: Cenchrus agrimonioides var. agrimonioides

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Central Ekahanui	Manage for stability	168	Yes	No	Yes	No	No
Makaha and Waianae Kai	Manage for stability	171	Partial 97%	Partial 96%	No	No	No
South Huliwai	Genetic Storage	15	No	No	No	No	No

= Threat to Taxon within Population Unit
No Shading = Absence of threat to Taxon within Population Unit
Ungulate Managed = Culmination of Cattle, Goats, and Pig threats
Yes=All PopRefSites within Population Unit have threat controlled
No=All PopRefSites within Population Unit have no threat control
Partial%=Percent of mature plants in Population Unit that have threat controlled
Partial 100%= All PopRefSites within Population Unit have threat partially controlled
Partial 0%= Threat partially controlled, but no mature plants

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), but may be a lower priority for other threat control.

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

Threat Columns: The 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.
Partial 0%= Threat partially controlled, but no mature plants are currently present in the PU.

Ungulates: This threat is indicated if pigs, goats or cattle have been observed at any sites within the PU. This threat is controlled (Yes) if a fence has been completed and all ungulates removed from the site. Most PUs are threatened by pigs, but others are threatened by goats and cattle as well. The same type of fence is used to control for all three types of ungulates on Oahu. Partial indicates that the threat is controlled for some but not all plants in the PU or only one of the ungulate threats has been controlled. If some of the mature plants in a MFS PU are outside of the fence, the threat is partially controlled for the percentage of mature plants inside the fence. If all plants are fenced, but only goats have been eliminated, the threat has been partially controlled for 100% of the mature plants.

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 to indicate what portion of the PU has had control.

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

Slugs: This threat is indicated for IP taxa as confirmed by OANRP staff. Currently, slug control is conducted under an Experimental Use Permit from Hawaii State Department of Agriculture, which permits the use of Sluggo®. Partial indicates that the threat is fully controlled over part of the PU.

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

4.4 Genetic Storage Summary

The Genetic Storage Summary for each IP taxon is included as Appendix 4-4. Every year, OANRP collects propagules from IP taxa for *ex situ* genetic storage. The amount of propagules to meet these goals were pre-determined in the MIP and OIP. In general, each wild plant (up to 50 plants from each PU) needs either 50 viable seeds (as estimated at the time of collection) or 3 explants/plants in tissue culture or nursery. This year we reported only the collections that have not expired, *i.e.* have not been stored for longer than the species re-collection interval.

This year there were 66 PU that reached their storage goal, representing 898 plants. This is a slight decline from last year, and attributed to the removal of expired collections from the seed bank inventory. There are an additional 1,351 plants that meet their storage goal in 217 other PU (where the PU genetic storage effort is not 100% complete. Sixty-nine new plants met their genetic storage goal this year.

In the example below (Table 4), estimates of seeds remaining in genetic storage 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.

Table 4: Example of a Genetic Storage Summary using *Cenchrus agrimonioides* var. *agrimonioides*

Genetic Storage Summary

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	80	42	40	74	56	0	2	34	10	0	1	11	22%
Kuaokala	Genetic Storage	1	3	0	0	0	0	1	0	0	0	1	1	100%
Action Area: Out														
Cenchrus agrimonioides var. agrimonioides														
Central Ekahanui	Manage for stability	47	72	18	36	19	0	40	12	1	0	38	38	76%
Makaha and Waianae Kai	Manage for stability	5	7	6	3	2	0	9	0	0	0	9	9	82%
South Huliwai	Genetic Storage	15	13	13	18	10	0	20	6	3	0	17	19	68%
		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	
		148	137	77	131	87	0	72	52	14	0	66	78	

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

Partial Storage Status: To meet the IP genetic storage goal for each PU for taxa with seed storage as the preferred genetic storage method, at least 50 seeds must be stored from 50 plants. This year, the number of seeds needed for each plant (50) accounts for the original viability (Estimate Viability) of seed collections. In order to show intermediate progress, this column displays the number individual plants that have collections of >10 seeds in storage. For taxa where vegetative collections will be used to meet storage goals, a minimum of three clones per plant in either the Lyon Micropropagation Lab, the Army nurseries or the State's Pahole Mid-elevation Nursery is required to meet stability goals. Plants with one or more representatives in either the Lyon Micropropagation Lab or a nursery are considered to partially meet storage goals. The number of plants that have met this goal at each location is displayed.

 # Plants that Met Goal: This column displays the total number of plants in each PU that have met the IP genetic storage goals. As discussed above, a plant is considered to meet the storage goal if it has 50 seeds in storage or three clones in micropropagation or three in a nursery. For some PUs, the number of founders has increased in the last year; therefore, it is feasible that NRS could be farther from reaching collection goals than last year. Also, as seeds age in storage, plants are outplanted, or explants contaminated, this number will drop. In other PUs where collections have been happening for many years, the number of founders represented in genetic storage may exceed the number of plants currently extant in each PU. In some cases, plants that are being grown for reintroductions are also being counted for genetic storage. These plants will eventually leave the greenhouse and the genetic storage goals will be met by retaining clones of all available founders or by securing seeds in storage. This column does not show the total number of seeds in storage; in some cases thousands of seeds have been collected from one plant. For the first time this year, collections that have expired in the seed bank, have been removed from the inventory and are not reflected here as represented. These collections have been flagged for *in situ* seed dispersal as collections have aged past adequate genetic representation of founder lines without high levels of artificial selection.

% 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%.

4.5 FIVE YEAR RARE PLANT PLANS

These plans are intended to include all pertinent species information for stabilization, serve as a planning document and as an updated educational reference for OANRP staff. In many cases, data or information is still being gathered and these plans will continue to be updated. A brief description of each section is given here:

- **Species Description:** The first section provides an overview of each taxon. The IP stability requirements are given, followed by a taxon description, biology, distribution, population trends, and habitat.
- **Reproductive Biology Table:** This information was summarized by OANRP based on best available data from the MIP, OIP, USFWS 5-year Status Updates, OANRP field observations and other published research. Phenology is primarily based on observations in the OANRP rare plant database. The suspected pollinator is based on casual observations, pollinator syndromes as reported in the MIP and OIP, or other published literature. The information on seeds is from data collected at the Army seed lab and from collaborative research with the Harold L. Lyon Arboretum.
- **Known Distribution & Historic Collections Table:** This information was selected from Bishop Museum specimen records and collections listed in published research, the Hawaii Biodiversity and Mapping Program and other collectors notes.
- **Species Occurrence Maps:** These maps display historic and current locations, MUs, landmarks and any other useful geographic data for each taxon. Other features may be used on public documents to obscure locations of rare elements.
- **Population Units:** A summary of the PUs for each taxon is provided with current management designations, action areas and management units.
- **Habitat Characteristics and Associated Species:** These tables summarize habitat data taken using the Hawaii Rare Plant Restoration Group's Rare Plant Monitoring Form. The data is meant to provide an assessment of the current habitat for the in situ and outplanting sites. Temperature and rainfall estimates are also included for each site when available.
- **Pictures:** These photos document habitat, habit, floral morphology and variation; and include many age classes and stages of maturing fruit and seed. This will serve as a reference for field staff making collections and searching for seedlings.
- **Taxonomic Background:** This section provides information pertaining to the history of the taxonomy of the species.
- **Population Structure & Trends:** Data from monitoring the population structure for each species is presented with a plan to establish or maintain population structure at levels that will sustain stability goals. A review of population estimates for each Population Unit (PU) is displayed in a table. Estimates come from the MIP, OIP, USFWS 5-year Status Updates and OANRP field observations. In most cases, these estimates cannot be used to represent a population trend.
- **Reintroduction Plan:** A standardized table is used to display the reintroduction plans for each PU. Every outplanting site in each PU is displayed showing the number of plants to be established, the PU stock and number of founders to be used and type and size of propagule (immature plants, seeds, etc.). Comments focus on details of propagation and planting strategies.
- **Threats & Stabilization Goals Update:** For each PU, the status of compliance with all stability goals is displayed in this table. All required MFS PUs are listed for each taxon. 'YES, NO or PARTIAL' are used to represent compliance with each stability goal. For population targets, whether or not each PU has enough mature plants is displayed, followed by an estimate on whether a stable population structure is present. The major threats are listed separately for each PU. The boxes are shaded to display whether each threat is present at each PU. A dark shade identifies PUs where the threat is present and the lighter boxes where the threat is not applicable. The corresponding status of threat control is listed as 'YES, NO or PARTIAL' for each PU. A summary of the status of genetic storage collections is displayed in the last column.

- **Genetic Storage Section:** This section provides an overview of propagation and genetic storage issues. A standardized table is used to display information recorded for each taxon or PUs where applicable. The plan for genetic storage is displayed and discussed. In most cases, 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. For taxa that do not produce enough mature seed for collection and testing storage conditions, micropropagation is considered the next best genetic storage technique. The maintenance of this storage method is continual, but requires much less resources and personnel than establishing a living collection in the nursery or a garden. For those taxa that do not produce storable seed and cannot be established in micropropagation, a living collection of plants in the nursery or an inter situ site is the last preferred genetic storage option. In most cases, current research is ongoing to determine the most applicable method. For species with substantial seed storage data, a schedule may be proposed for how frequently seed bank collections will need to be refreshed to maintain genetic storage goals. This schedule is based only on storage potential for the species; other factors such as threats and plant health must be factored into this schedule to create a revised collection plan. Therefore, the frequency of refresher collections will constantly be adjusted to reflect the most current storage data. The re-collection interval is set prior to the time period in storage where a decrease in viability is detected. For example, *Delissea waianaeensis* shows no decrease in viability after ten years. OANRP would not have to re-collect prior to ten years as the number of viable seeds in storage would not have yet begun to decrease. The re-collection interval will be 10 years or greater (10+ yrs). If its viability declines when stored collections are tested at year 15, the interval will be set between 10 and 15 years. Further research may then be conducted to determine what specific yearly interval is most appropriate. The status of seed storage research is also displayed and discussed. Collaborative research with the USDA National Center for Genetic Resources Preservation (NCGRP) and Lyon Arboretum Seedlab is ongoing.
- **Management Discussion & 5-Year Action Plan:** A summary of the management approach, overall strategy and important actions for each taxon. This section displays the schedule of actions for each PU. All management is planned by ‘MIP or OIP Year’ and the corresponding calendar dates are listed. This table can be used to schedule the actions proposed for each species into the OANRP scheduling database. Comments in this section focus on details of certain actions or explain the phasing or timeline in some PUs.

Plantago princeps var. *princeps*

Scientific name: *Plantago princeps* Cham. & Schlechtend. var. *princeps*
Hawaiian name: *Ale, laukahiu kauhiwi*
Family: Plantaginaceae (Plantain family)
Federal status: Listed Endangered

Requirements for Stability:

- **4 Populations (PU; found in two Action Areas)**
- **50 reproducing individuals in each population (short-lived perennial)**
- **Threats controlled**
- **Complete genetic representation in storage**

Description and biology: *Plantago princeps* var. *princeps* is a woody shrub, which is unusual for the genus. Most continental species in this genus are small herbs. The plant is either single stemmed or sparingly branched at the base, and attains a height range of around one foot to three feet, but is sometimes taller. The leaves are arranged in a cluster at the tip of each branch, are strap-shaped, and measure up to 20 cm (7.8 in) long. Each stem tip usually bears several erect, axillary inflorescences, each of which consists of a single stem bearing densely arranged flowers on its upper portion. The flowers and capsules are small and inconspicuous. The capsules each bear 1-3 black seeds measuring 1.5-2.1 mm (0.06-0.08 in) long.

Flowering and fruiting specimens have been collected throughout the year, and timing varies among different populations. The surface of the seed, once wet, is covered by a mucilaginous membrane (Wagner *et al.* 1990), which is theorized to cause the seeds to stick to animals (Carlquist 1974). It may also potentially aide in germination by maintaining imbibition and providing moisture. With the complete absence of ground mammals in Hawaii prior to the arrival of the Polynesians, birds, including the many now extinct flightless species, would have been the primary dispersal agents of Hawaiian *Plantago*s. Little is known about the breeding system and pollination. The longevity of individuals of this taxon is unknown, but since the plant is a small shrub, its longevity is presumed to be less than 10 years, and it is therefore a short-lived taxon for the purposes of the Makua and Oahu Implementation Plans.

Figure 1: Description and *ex situ* Conservation: Fruit, Seeds, Seedlings, Propagation. A) Infructescence with capsules, B) seedlings growing in growth chambers, C) plants growing in the nursery, D) a collection of seeds and capsules depicting mature seeds in the top half of ripe capsules, which are lovingly referred to as ‘party hats’.

Table 1: Reproductive Biology Summary of *Plantago princeps* var. *princeps*

	Observed Phenology			Reproductive Biology		Seeds*	
Population Unit	Flower	Immature Fruit	Mature Fruit	Breeding System	Suspected Pollinator	Seeds / Infructescence	Dormancy
Ekahanui	April**- May	March - May	May - June	Hermaphroditic	Wind?	69	Not Dormant
Halona	May	March – May	March – May			96	
North Mohiakea	Oct – Dec	Oct – Dec	Oct – Dec			88	
Ohikilolo	March - Oct	Apr – Oct	Apr - Oct			28	

*There are 1-3 seeds per fruit. Calculations are an average from all collections made in each Population Unit.
**Assumptions are that flowering occurs earlier, but observations have not been made every month so we are reporting based on what we have actually seen.

Known distribution: *Plantago princeps* var. *princeps* has been recorded from three general areas on the island of Oahu. Most of the currently known plants are scattered throughout cliffs on both the leeward and windward sides of the Waianae Mountains. There are also historical records of it from the southeastern Koolau Mountains in the valleys of Kalihi, Nuuanu, and Manoa. It had not been observed in that region for over half a century. The taxon was then discovered for the first time in the central Koolau Mountains in 2001, when plants were found at Waiawa. These plants are located a short distance to the lee of the Koolau summit ridge. Since then, a population was relocated in Nuuanu, and a large population was found near Konahuanui on the windward side of the summit. Recorded elevations for these plants in the Koolau Mountain range from 480-792 m (1,580-2,600 ft.).

Table 2: Selected Historic Collections of *P. princeps* var. *princeps*

Area	Year	Collector	Pop. Reference Code	Notes
Kalihi	unknown	J. Rock		
Manoa Cliff Trail	1931	H. St. John		Also 1915 J. Rock
Nuuanu Pali	1910	C.N. Forbes	NUU-A?	
Mt. Tantalus	1931	H. St. John		
Palawai	1987	J. Obata	PAL-B	Extirpated (recorded as from Napepeiauolelo)

Map removed to protect rare resources. Available upon request

Figure 2: Map 1. Populations of *P. princeps* var. *princeps* on Oahu.

Map removed to protect rare resources. Available upon request

Figure 3: Map 2. Populations of *P. princeps* var. *princeps* in the Northern Waianae Mountains.

Map removed to protect rare resources. Available upon request

Figure 4: Map 3. Populations of *P. princeps* var. *princeps* in the Southern Waianae Mountains.

Table 3: Population Units for *P. princeps* var. *princeps*. Includes Current and Proposed Management Designations for all populations. MFS = Manage for Stability; GS = Manage for Genetic Storage. MMR = Makua Military Reservation; SBW = Schofield Barracks West Range. See Population Structure and Management Discussion sections below for discussion on proposed changes. *Dependent on population surveys, these PU may swap designation over the next 5 years.

Population Unit	Current Management Designation	Proposed Management Designation	Action Area	Management Unit (MU)
Ekahanui	MFS	MFS	None	Ekahanui
Halona	MFS	MFS*	None	Palikea IV
North Mohiakea	MFS	MFS	SBW	Lihue
Ohikilolo	MFS	MFS	MMR	Ohikilolo
Konahuanui	No Management	GS*	None	Iolekaa to Kamooalii No MU
North Palawai	GS	GS	None	Palawai No MU
Nuuanu	No Management	GS	None	Honolulu No MU
Pahole	GS	GS	MMR	Pahole
Waiawa	No Management	GS	None	Waiawa No MU
Waieli (introduction)	GS	GS	None	Kaluaa and Waieli

Habitat: *Plantago princeps* var. *princeps* occurs in two extremely different types of habitat. In the Waianae Mountains the plants are found in the mesic vegetation on cliff faces, cliff ledges, and at the bases of cliffs. The majority of these plants are accessible only via rappelling. At one time, this cliff habitat was vegetated with native grasses, sedges, herbs, and shrubs, but is increasingly dominated by alien species. The southeastern Koolau Mountain Range plants grow in mesic to wet cliff habitats. The Konahuanui population, however, is mostly wet cliffs and wet forest. The Waiawa plants are situated in a wet forest area close to the Koolau summit ridge and were observed growing on a streamside embankment (Perlman pers. comm. 2000). These Koolau Mountain habitats are also becoming dominated by weeds.

Table 4: Habitat Characteristics by Population Unit. Commas separate information by Population Reference Site. An asterisk (*) indicates the Koolau Mountain Population Units. Average Annual Rainfall data is from the Rainfall Atlas of Hawaii (Giambelluca et al. 2013). All other data from OANRP observations.

Population Unit	Population Reference Codes	Elev. (ft.)	Slope	Canopy Cover	Topography	Aspect	Average Annual Rainfall (mm)
Manage for Stability Population Units							
Ekahanui	EKA-A, B, C, D (reintro¥)	2520, 2631¥	Steep – Vertical	Intermediate	Upper Slope	NE	1217
Halona	HAL-A	2408 - 2674	Steep – Vertical	Intermediate	Upper Slope	NW	1155
Mohiakea	SBW-A	3045-3050	Steep – Vertical	Intermediate – Open	Upper Slope	N	1460
Ohikilolo	MMR-A, B	2620, 2870	Vertical, Steep	Intermediate, Open	Upper Slope	N, N-NW	1700, 1527
Genetic Storage Population Units							
Konahuanui* (proposed)	NUU-A	1600	Steep - Vertical	Open	Mid-slope	N-NE	2258
North Palawai	PAL-A, B	2600, 2664	Moderate – Steep, Vertical	Intermediate	Mid Slope	NW, N	1158
Nuuanu*	NUU-B	1719	Moderate – Steep, Vertical	Intermediate	Mid Slope	N	3184
Pahole	PAH-A	2000	Steep – Vertical	Intermediate	Upper Slope	N	1425
Waiawa*	AWA-A	2060	Steep – Vertical	Partial – Full Sun	Gulch Bottom	N	4322
Waieli (introduction)	ELI-A	2726	Steep	Intermediate	Upper Slope	NE-E	1204

Table 5: List of Associated Species (six letter code = first three letters of genus, followed by first three letters of species) for each Population Unit for both canopy and understory. Some outplanting sites have yet to have the associated species recorded. Species observed by OANRP staff are listed in alphabetical order; introduced taxa precede native taxa and are underlined: AbuGra, CycPar

Population Unit	Population Reference Codes	Canopy	Understory
Ekahanui	EKA-A, B, C	PsiCat, PsiGua, SchTer, Antpla, ChrFor, CopFol, DioHil, DubLax, MetPol, Myrlan, Myrles, PsyMar, SopChr, Zankau	Ageade, AgeRip, BleApp, MelMin, NepBro, OplHir, PasSub, SchTer, SonOle, UnkSpp, AlySte, AspKau, AspUnis, BidTor, CarMey, CarWah, CocOrb, CypHilHil, DiaSan, EraGra, KadAcu, KadCor, LepThu, Lyshil, MicSpe, MicStr, PepTet, PlePar, RumAlb, VioChaTra
Halona	HAL-A	LanCam, MorFay, SchTer	AgeAde, AgeRip, MelMin, PasSub, CarMey, CarWah, EraGra, KadAcu, KadCor, PepTet, PlePar, RumAlb
Mohiakea	SBW-A	PsiCat, SchTer, UnkSpp, CopLon, DubLax, IleAno, LabTin, LepTam, MetPol, MetTre, PerSan, PipAlb, PitFlo, VacCal	AgeRip, BleApp, CliHir, CycPar, EriKar, KalPin, PasCon, RubArg, RubRos, VerLit, ArtAus, BidTor, BoeGra, CarMey, CarWah, DiaSan, DryUni, DubPla, EraGra, EraVar, LysHil, LytMar, MacAng, MetPol, MetRug, RumSpp, UnkSpp, VacCal,
Ohikilolo	MMR-A	GreRob, SchTer, MetPol, MetTre, MyrLes, PsyHat, SopChr	AgeAde, AgeRip, BleApp, CupCar, FesBro, KalPin, ThuEre, BidTor, CarMey, ElaPal, EupMul, KadAcu, KadCor, LysHil, MelTenf, PsyHat, PteAqu, SphChi,
Konahuanui	NUU-A	CitCau, MetPol, MetTre, PipAlb	AgeAde, CliHir, EriKar, MelMin, OplHir, HedGar, SpaCam, EraGra, MacAng, SetPar,
North Palawai	PAL-A, B	PasSub, PsiCat, SchTer DodVis, MetPol, PitCon, PitFlo, PsyHat,	AgeAde, AgeRip, BleApp, PasSub, SchTer, UnkSpp, AlySte, DubPla, EupCel, KadAff, Lyshil, RumAlb, VioChaTra
Nuuanu	NUU-B	No Data Available	
Pahole	PAH-A	SchTer, AlySte, BidTor, IleAno, MetPol, ScaGaua,	AgeRip, CocGra, SchTer, AlySte, BidTor, CarMey, CopFol, DicLin, Dodvis, KadAff, KadCor, KadDegDeg, LysHil, MetPol, MicStr, NepExaHaw, OdoChi, PsyMar, VacRet
Waiawa	AWA-A	CliHir, BroArg, CibCha, DicLin, DubPla, IsaDis, MetPol, PolOah, PriMar, PsySpp, SadSpp, ScaGaua, SyzSan, TreMac, UnkSpp, VacRet, WikOahOah	CliHir, SacInd, BidMac, MacAng, SelArb
Waieli	ELI-A (introduction)	SchTer, TooCil, CanGal, CibCha, CorFru, DioSan, FreArb, GreRob, IleAno, LabKaa, MetPol, MyrLes, PasEdu, PerSan, PipAlb, PisUmb, PitSpp, PlaSan, PsiCat, PsyMar,	BleApp, BudAsi, CliHir, ConBon, CraCre, CycPar, EriKar, KalPin, LanCam, MelMin, OplHir, PasCon, PasSub, CarMey, CarWah, CibCha, CopFol, CopLon, CorFru, DiaSan, EupMul, FreArb, KadAff, KadCor, LabSpp, LobYuc, MetPol, MicStr, MyrSpp, NepSpp, PhyDis, PipAlb,

Photographs by Population Unit
Waianae Mountains

Figure 5: Photographs from Ekahanui PU: A) Mature plant with fruit, B) Large, multi-headed plants (now mostly dead), C) Ripe infructescences, D) Immature, E) Habitat, F) *Achatinella mustelina* (kahuli tree snail) on *P. princeps*

Figure 6: Halona.
A) Mature plant and Habitat B) Mature plant and habitat; C) female stage flowers; D) reproducing plant and habitat

Figure 7: Pahole.
A) Mature plant,
B) Habitat

Figure 8: Palawai. Mature plant at Palawai, PAL-A.

Figure 9: Mohiakea (Puu Kalena). A) Mature plant with view, B) Mature Plant with infructescence, C) Flowering plants, D) Habitat and *Dubautia plantaginea* comparison.

<u>Koolau Population Units (Nuuanu and Konahuanui; no photographs from Waiawa)</u>

Figure 10: A) Nuuanu (NUU-B), B) Konahuanui (NUU-A) mature plants with ripe infructescences, C) immature plant at Konahuanui, D) habitat at Konahuanui.

Taxonomic background: *Plantago princeps* is endemic to the Hawaiian Islands. The species is divided into four varieties: var. *anomala* of Kauai; var. *laxiflora* of Molokai, Maui, and Hawaii; var. *longibracteata* of Kauai and the Koolau Mountains of Oahu; and var. *princeps* of both mountain ranges on Oahu. All of the varieties except var. *longibracteata* are sizable woody shrubs. In contrast, var. *longibracteata* is a small herb. When the Waianae Range plants were rediscovered in 1987, the specimens collected were identified as var. *anomala*. Only the southeastern Koolau Range plants were considered to represent var. *princeps* (Wagner *et al.* 1990). The Waianae Range plants were later reclassified as var. *princeps* (Wagner *et al.* 1999). There have been no subsequent vouchers taken from any Waianae Mountain populations. Due to this taxonomic history, vouchers would be useful from Population Units that have never been vouchered.

In 2008, a study of the molecular variation and adaptive radiation of the Hawaiian *Plantago* was published as part of a PhD dissertation at the University of Hawaii (Dunbar-Co 2008; Dunbar-Co, Wieczorek, Morden 2008). Only the Ekahanui and Waiawa populations were included in this study, which showed genetic separation from each other based on microsatellite data. While this variation is meaningful and could also suggest cryptic species, it is not enough to separate them into separate taxa, particularly in light of their morphological similarities. Phylogenetic analyses did not separate the Koolau and Waianae populations, and suggests a single dispersal event to Oahu for *P. princeps* (Stephanie Dunbar-Co, personal communication). It would however be useful to sample more populations to determine if indeed there is enough genetic separation to define into separate taxa. Additionally, there is taxonomic uncertainty regarding varieties of *P. princeps* on Oahu. However, at this time, both the Koolau and Waianae Mountain populations of *P. princeps* will be considered var. *princeps*.

Population Structure and Trends: During the finalization of the Makua Implementation Plan, population trend data was only available for the population in the North branch of North Palawai gulch (PAL-B). When this site was discovered in 1987 by John Obata, there were approximately 20 plants. By 2003 there were only 5 plants. This site lost its last plant by 2011. In this case, the rapid decline was attributed to competition from daisy fleabane (*Erigeron karvinskianus*), a highly invasive alien plant. Currently, all populations in the Waianae Mountains are in decline and all have *E. karvinskianus* is now present at all of the sites.

Population structure for this taxon is weak, but not non-existent (Fig.11). OANRP staff have observed seedlings at eight different Population Reference Sites, in seven Population Units (PU). There were seedlings at the Waieli introduction in 2012, and have since grown into immature plants, of which eight remain (2016). The current high number of immature plants in the Waianae Mountains is primarily due to the Ekahanui population, where 90% of the total plants are immature. At these sites, there has been a large decline in mature individuals (from 46 plants in 2014 to 7 plants in 2016), but the number of small immature plants has been greater than 50 for the last six years. Unfortunately, these small immature plants (around 2-4 leaves and a couple centimeters in height) fail to transition into large immatures. It is hypothesized that they succumb to downy mildew (Peronosporaceae) or possibly slugs (see Threats section below). Substantial declines in the number of mature plants at both the Halona and Ohikilolo PUs have also been observed over the last couple years.

Population Trends

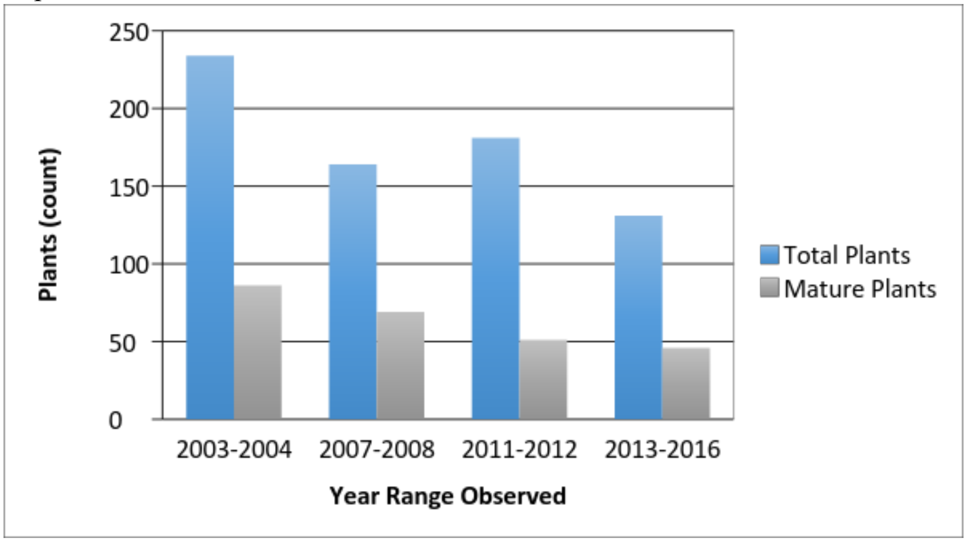


Figure 11: A) Overall counts of total plants and mature plants only for all monitored Waianae Mountain Population Units, excluding reintroductions.

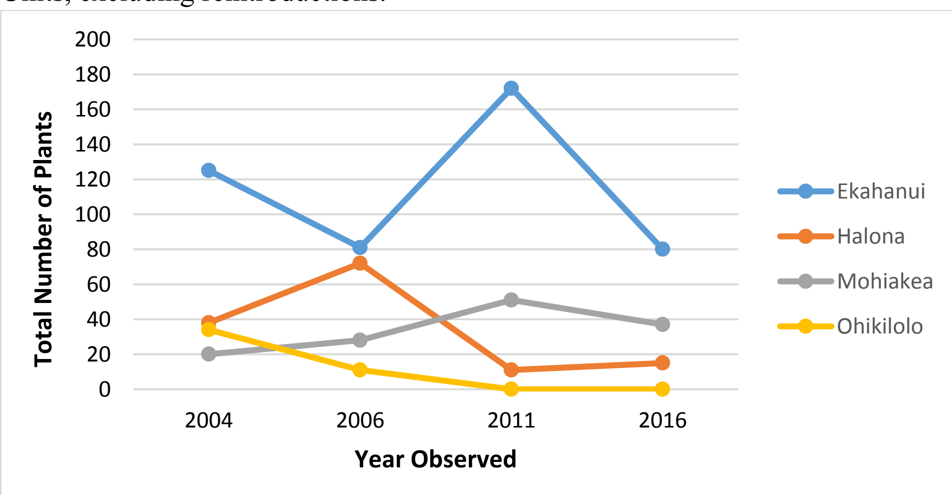


Figure 11: B) Counts for the total number of plants at the four current MFS PU (Waianae Mountains; excluding reintroductions).

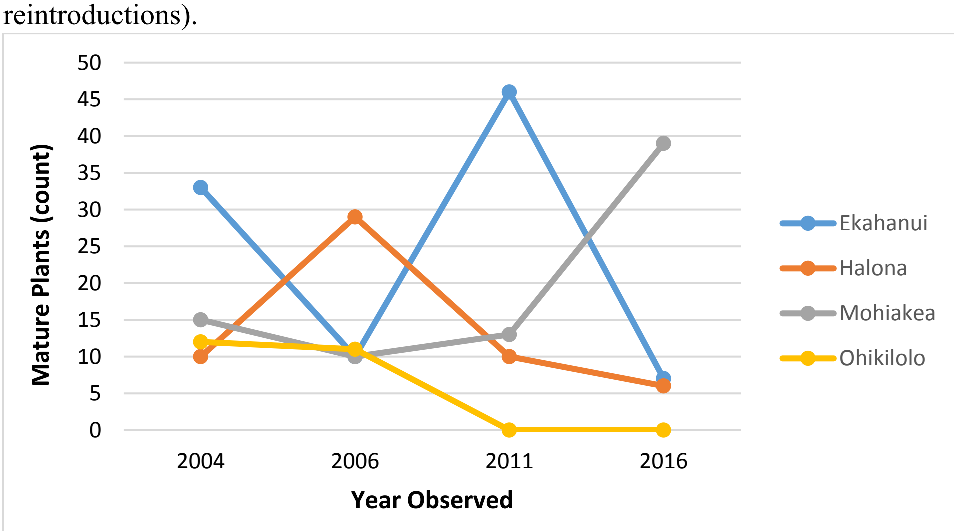


Figure 11: C) Counts of mature plants for the current four MFS PU (Waianae Mountains; excluding reintroductions).

The Koolau Mountain populations have only been monitored once by OANRP, and therefore no population trends are available for these sites. The last two seedlings at the Nuuanu (NUU-B) population were dug up and brought into cultivation to Lyon Arboretum by the Oahu Plant Extinction Prevention Program (OPEPP) since the last OANRP survey. They have since maintained representation of those two plants in cultivation, as well as have propagated and reintroduced several individuals into the Manoa Cliffs Trail Restoration Site from this collection. OPEPP also attempted to relocate the Waiawa population twice, but was unsuccessful at finding any plants. OANRP and OPEPP should conduct a thorough survey in this area one more time before establishing that this population no longer exists. The Konahuanui population needs to be re-monitored as it will be ten years since the last census, especially to verify that it is the largest population of this taxon.

Table 6: Summary of Population Structure of Koolau Populations of *P. princeps* var. *princeps*. Observations in 2016 conducted by OPEPP.

Population Reference Site	Year Observed	Total # of Plants	Mature Plants	Year Observed	Total # of Plants
Waiawa, AWA-A	2003	83	16	2016	0?
Konahuanui, NUU-A	2006	110	100	2016	No update
Nuuanu, NUU-B	2007	12	4	2016	0
ALL KOOLAU SITES		**205**	**120**		**?**

Current status: The known population units of *P. princeps* var. *princeps* in the Waianae Mountains total approximately 131 plants, consisting of mature and immature plants. All of the wild plants from Ohikilolo have died, and last year 57 individuals were reintroduced back into Ohikilolo at a new location. Four of these individuals matured quickly after they were planted. In 2003 there were about 35 mature plants in the Makua action area, and now, with the exception of the new Ohikilolo reintroduction, there are only nine (all located in the Pahole Natural Area Reserve). The population in the Schofield action area, however, is the only population in the Waianae Mountains not observed to be in decline. This is mostly due to the discovery of more plants in a new area adjacent to the original population site off of Puu Kalena.

<u>STABILIZATION EFFORTS</u>

The following section uses the above information, plus additional information we have learned about this taxon, to determine appropriate stabilization efforts for the next five years (July 2016 – June 2021). The following actions are requirements for stabilization:

- **4 Populations (PU)**
- **50 reproducing individuals in each population (short-lived perennial)**
- **Threats controlled**
- **Complete genetic representation in storage**

Population Units: Four Manage for Stability Population Units (MFS PU) are required for this taxon as it is in both the Makua and Schofield Action Areas. Due to the decline in this taxon, all other populations that are not MFS PU will become Manage for Genetic Storage Population Units. Representation of these populations will be maintained and depending on how taxonomic questions are addressed and future outplanting needs, these populations may be incorporated into mixed-source reintroductions.

We also propose to carefully monitor and survey the Konahuanui PU while securing collections. In the future, it might be necessary to change one of the existing Waianae Mountain MFS PUs to a Genetic Storage PU and begin to manage the Konahuanui PU as an MFS PU. The Waianae Mountain MFS PU that would be swapped is most likely be either Halona or Ohikilolo, depending on where the next reintroduction could be located for these source populations, the success of the Ohikilolo outplanting, and the population size of the current MFS PUs.

Outplanting considerations and plan: *Plantago princeps* var. *princeps* is the only native *Plantago* in the Waianae Mountains. The situation is more complex in the Koolau Mountains, where, in addition to var. *princeps*, there is another variety of *P. princeps* recorded, var. *longibracteata*. This variety is known from historical specimens collected on the windward side of the Koolau Mountains in the Kaluanui area between Punaluu Valley and Hauula. It has been recorded on wet cliffs and alongside waterfalls, but are currently known from Oahu. Additionally, there is a second native species in the Koolaus, *P. pachyphylla*, which is common in the Koolau summit areas. On Kauai, *P. princeps* var. *longibracteata* and *P. pachyphylla* form a hybrid population at the Waialeale summit (Bruegmann pers. comm. 2000). It is not yet known whether the ranges of *P. pachyphylla* or *P. princeps* var. *longibracteata* overlap that of *P. princeps* var. *princeps* in the Koolau Mountain forests, and whether any hybridization occurs or could potentially occur. No OANRP outplantings have occurred in the Koolaus, but if they are deemed necessary in the future, further study should be conducted on the distribution of *Plantago* taxa in the Koolau Mountain Range, and their potential for hybridization.

Given the extreme differences between the habitats of the Waianae and Koolau Mountain Range plants, it may not be prudent to mix the two stocks at a single outplanting site. However, depending on aspects such as the results of the molecular study, the decline of the Waianae Mountain populations, and the known and potential variation of impact of downy mildew on populations, this may need to be revisited in the future.

There have been three outplantings of *P. princeps* var. *princeps*: Waieli, above the Puu Hapapa shelf (introduction), Ekahanui (augmentation), and Ohikilolo (reintroduction). The Hapapa introduction is the oldest planting, initiated in 2007, with additional outplantings in 2009 and 2012. Survival at this site is 45%. The original plants from 2007 have mostly died, but very few of the plants from the 2009 planting have died, and now there are eight immature plants recruiting under one plant. The location of this cohort, as well as the site management (*i.e.* weed control and other threat control) could be helpful in determining suitable locations for planting in the future. Unfortunately, OANRP does not feel confident that there is more suitable habitat at Hapapa to expand this outplanting. The Ekahanui augmentation has completely failed. Eighty-nine plants were planted between 2014 and 2015. All outplants have succumbed to downy mildew, except for three plants observed in 2016; these three were all in poor health. The Ohikilolo reintroduction was initiated in 2016. Four of the 57 plants have matured. Several show signs and symptoms of downy mildew. However, in general, the plants look healthy and are growing. Propagule collections will be needed from these plants to produce additional outplants for this site and secure seeds for genetic storage.
Differences in the success of the reintroductions may not only be due to the location, but also the source population. The source population for the Waieli population is Mohiakea, which is the only wild population not in decline and anecdotally the stock least susceptible to downy mildew. On the other hand, the failed Ekahanui augmentation is from Ekahanui stock, which is the most susceptible to downy mildew in our nursery facilities. Downy mildew is one of the hypothesized leading causes of death at the Ekahanaui, and possibly Halona, populations. See the threats section for further discussion. Conducting a controlled breeding study in the nursery may be one approach to improving outplanting success. If the more downy mildew-susceptible maternal lines (source populations) are mixed with less downy mildew-susceptible maternal lines, more genetically diverse progeny may be available for reintroduction. Concerns for outbreeding depression would need to be addressed, as well as possible locations for mixed-source outplantings.

Hapapa Introduction

Figure 12: A) a flowering plant, B) a recruited immature plant, C) several recruiting immature plants.

Reintroduction Plan

The proposed outplanting sites for the Waianae Mountain Population Units are designed to meet the stability goal for the number of reproducing individuals, as currently none meet this goal. We plan to wait a year to see how the new Ohikilolo reintroduction performs before we finish planting into this site. We recognize that the Ekahanui augmentation will need to be replaced, but at this time we would like to discuss options and develop a plan to address downy mildew before we proceed with another planting of this stock (see Threats section below). Both the Halona and Mohiakea PUs will need outplantings to raise the number of reproducing plants to meet that stability goal. As the Mohiakea stock appears to be the healthiest, we should pursue site selection and proceed with a single source outplanting in this PU. However, this stock may also need to be incorporated into outplantings at other PUs (see Threats and Management Discussion below). Determination of how to proceed with outplantings in the Ekahanui and Halona PUs due to the impact of downy mildew will delay these plantings. The Mohiakea population is the highest in elevation (so potentially cooler), but in a similar rainfall range with the majority of sites. It will also be important to determine the impact of drought on the ability for a plant to survive downy mildew, and choose outplanting sites accordingly.

We have proposed an outplanting for all Koolau stock, but understand at the present time that surveys are needed to determine if outplanting is necessary. The most recent estimates of population size, though somewhat dated (2007), indicate that there may be enough reproducing individuals at Konahuanui to meet stabilization goals.

Table 7: Current and Proposed Outplantings of *P. princeps* var. *princeps* to meet stabilization goal of 50 reproducing individuals per Population Unit (PU). The propagule type for each planting will be immature plants grown from seeds collected from wild or outplanted plants. The estimate of the number of mature plants at Konahuanui is from 2007. An asterisk (*) indicates outplantings that have not yet been initiated. Note: We know how many mature plants are currently at population reference sites, but we recognize that the number of actively reproducing individuals (a requirement for stability) would likely be lower than the total number of mature plants.

<table>
<tr><th>Population Unit</th><th>Reintroduction Site(s)</th><th>Number of Plants to Outplant</th><th>Existing Mature Plants in PU</th><th>Propagule Population(s) Source</th><th>Number of Founders in Source Population.</th><th>Plant Size</th><th>Pot Size</th></tr>
<tr><td>Ekahanui</td><td>EKA-D
EKA-E*</td><td>89
200</td><td>9</td><td>EKA-A, B, C (SBW-A?)</td><td>42-50</td><td rowspan="5">~20-40 cm</td><td rowspan="5">4”-6” round</td></tr>
<tr><td>Halona</td><td>HAL-B*</td><td>200</td><td>6</td><td>HAL-A (SBW-A?)</td><td>18-25</td></tr>
<tr><td>North Mohiakea</td><td>ELI-A
SBW-B*</td><td>100
200</td><td>39</td><td>SBW-A
SBW-A</td><td>19-30
19-30</td></tr>
<tr><td>Ohikilolo</td><td>MMR-B</td><td>200</td><td>4</td><td>MMR-A</td><td>12</td></tr>
<tr><td>Konahuanui</td><td>Koolau*</td><td>TBD</td><td>TBD</td><td>ALL Koolau</td><td>ALL Koolau</td></tr>
</table>

Threats: The primary threats to *P. princeps* var. *princeps* that were known at the time the Makua Implementation Plan was finalized (2003) included feral pigs and goats (though few goats are known in the Koolau Mountains). Feral pigs are negatively impacting the habitat in Halona, by eroding and degrading the ridge above the cliffs that the plants are found on. This disturbance includes additional weeds, rock falls, and trampling. Fencing this area to protect this cliff habitat is necessary, but may not be feasible given the terrain. OANRP will visit to determine if fencing could reduce ungulate impact. The U.S. Navy may also pursue plans to fence Halona in its entirety. If these fencing plans do not come to fruition, OANRP will work with the State of Hawaii to determine other actions to reduce ungulate presence on these ridges, such as snaring.

Landslides are a secondary threat due to the nature of cliff habitat in higher rainfall areas. A large landslide occurred below the Halona population and small slumping events also impacted the Ekahanui population.

Various alien plant species threaten *P. princeps* var. *princeps* by altering its 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. There has been little weed control around these populations as they are primarily found on vertical slopes that require rappelling to access. A review of the weeding needs should be conducted to highlight where restoration work (weeding and common native seed sow) could improve these cliff habitats.

Predation of plants and fruits by rodents and slugs has been documented, and it can be assumed that they potentially have an influence on population stability. Rats have eaten plants in Ekahanui, and slugs have been seen on seedlings. We will continue to assess how these threats are impacting population stability as we monitor the populations.

There are additional threats to this taxon that were not described in the Makua Implementation Plan. These include climate change and downy mildew. Climate change has been anecdotally described as an impact to these cliff habitats, in conjunction with weeds, as populations have gotten drier and weedier over time in consecutive visits. This is despite a very low Climate Change Vulnerability Score of 0.28 (Fortini et al. 2013; 0 = not vulnerable to climate change, 1 = extremely vulnerable), which is likely due to the mid elevation wet forests location of the Koolau Mountain populations. Downy mildew, first observed when this taxon was propagated in the nursery, has since been seen at several wild populations and at outplantings. Downy mildew has been seen at all of the outplantings, and is assumed to be the leading cause of death in the Ekahanui augmentation. Downy mildew has also been seen at the wild populations in Ekahanui, Halona, and may have possibly been the cause of the extirpation of the Ohikilolo population. There appears to be variation among populations in susceptibility to downy mildew. In the nursery, the Ekahanui stock appears most susceptible, typically dying once infected. The Mohiakea stock is the least susceptible, and the Ohikilolo stock moderately susceptible. Both the Palawai and Halona stock has yet to be propagated *ex situ*. In the nursery, and typically during cooler rainy winter months, if plants show signs of downy mildew, they typically die within two weeks, depending on the stock. Treating them with fungicide after symptoms appear will typically only prevent a small percentage of them from dying. Plants kept on the mist bench have not shown symptoms, even without preventative fungicides. However, certain stocks have stayed off the mist bench and have not shown symptoms, again without preventative fungicides. More propagation is needed to determine best practices. However, preventative fungicides and leaving plants on the mist bench should be further explored as ways to prevent death by downy mildew in the nursery. It is uncertain at this time if and why misting of plants reduces the downy mildew symptoms, as this has also been observed to possible reduce symptoms of other mildews. This should be explored further. Currently, there are no techniques to treat plants that show signs of downy mildew in the field. It is believed that the mildew is always present, but it is only when it appears heavily on the leaves that it becomes virulent. OANRP will submit leaf samples to Dr. Anthony Amend at the University of Hawaii Botany Department in attempt to identify the downy mildew.

Progress on threat control efforts are summarized below (Table 8).

Figure 13: Downy mildew on wild plants at Ekahanui.

Table 8: Progress on threat control efforts for *P. princeps* var. *princeps*. * indicates OANRP uncertainty in reaching this goal due to the lack of current census data (based on population estimates from 2007).

Population Units	PU Stability Target		MU Threat Control						Genetic Storage
	Has the Stability Target for mature plants been met?	Does population structure support long-term population stability?	Ungulates	Weeds	Rodents	Fire	Slug	Downy Mildew	Are Genetic Storage goals met?
Manage for Stability Population Units									
Ekahanui	No	No	Yes	Partial (0%)	Yes	No	No	No	No
Halona	No	No	No	No	No	No	No	No	No
North Mohiakea	No	No	Yes	No	No	No	No	No	No
Ohikilolo	No	No	Yes	Yes	No	No	No	No	No
Konahuanui	Yes*	No	No	No	No	No	No	No	No
Genetic Storage Population Units (Waianae Mountains)									
North Palawai	No	No	No	No	No	No	No	No	No
Pahole	No	No	Yes	No	No	No	No	No	No
Waieli	No	No	Yes	Yes	No	No	No	No	No
Genetic Storage Population Units (Koolau Mountains)									
Nuuanu	No	No	No	No	No	No	No	No	No
Waiawa	No	No	No	No	No	No	No	No	No

Grey Shading = threat to taxon within Population Unit. No shading = absence of threat to taxon. Ungulate Managed = culmination of cattle, goats, and pig threats. Yes = All Population Reference Sites within Population Units have threat controlled. No = All Population Reference Sites within Population Units have no threat control. Partial% = percent of mature plants in Population Unit that have threat controlled. Partial 100% = all Population Reference Sites within Population Units have the threat partially controlled. Partial 0% = Threat partially controlled, but not around any mature plants.

Genetic Storage Plan

Table 9: Action plan for how to maintain genetic storage representation, and provide propagules for reintroduction, for *P. princeps* var. *princeps*.

What propagule type is used to meet genetic storage goals?	What is the source for the propagules?	What is the Genetic Storage Method used to meet the goal?	What is the proposed re-collection interval for seed storage?	Is seed storage testing ongoing?	Plan for maintaining genetic storage
Seeds	*in situ* & outplantings	Collecting infructescences	15 years	Yes	Collect seeds and maintain reintroductions for re-collecting

- It will be important to act quickly to collect from as many wild plants as possible while they persist given the rapid decline observed.
- Seeds need to be collected when they are dry. If it has been very wet weather just prior to a planned collection time, the collection should be reconsidered. Seeds that have been enclosed in their mucilaginous coat for several days may have imbibed enough water to initiate germination. Seeds that have begun to germinate cannot be stored in long term seed banking.

Management Highlights: The following key actions, in conjunction with the timeline below (Table 10), highlight the management direction for *P. princeps* var. *princeps* over the next five years:

- Pursue researchers to resolve taxonomic issues, including vouchers and molecular studies
- Pursue an *ex situ* controlled breeding study to determine if:
  - breeding plants from other populations with stock from Mohiakea produces offspring that are less susceptible to downy mildew
  - hybridization with other *Plantago* taxa is a concern (in conjunction with molecular studies)
  - Pursue researchers or staff to conduct studies
- Use results from the controlled breeding study and *in situ* monitoring to finalize timeline, stock, and locations for the next Waianae reintroductions
- Monitor and collect from Koolau Mountain populations, determine appropriate and feasible threat control needs and whether or not a reintroduction is needed
- Monitor and collect from Waieli and Ohikilolo reintroductions
- Revise Management Designations for populations as described above:
  - Change all No Management PUs to Manage for Genetic Storage
  - After 2017 surveys and monitoring, decide if to designate the Konahuanui PU as Manage for Stability and to change one (and which one) Waianae Manage for Stability PU to Manage for Genetic Storage.
- Evaluate the ungulate impact and threat control Halona PU
- Evaluate the need, technique, and capacity for restoration of the cliff habitats to combat weeds and the effects of climate change
- Submit samples of infected material to Dr. Anthony Amend at the University of Hawaii Botany Department to identify the downy mildew
- Coordinate with OPEPP and Lyon Arboretum regarding propagules of new Manage for Genetic Storage Populations
- Coordinate with OPEPP regarding management actions for Koolau Population Units, as they have worked on these in the past.

Table 10: Notes for key actions for Manage for Stability Population Units (MFS PU).

Proposed Actions for the following years:					
PU	**July 2016 – June 2017**	**July 2017 – June 2018**	**July 2018 – June 2019**	**July 2019 - June 2020**	**July 2020- June 2021**
Ekahanui	• Monitor • Collect • Breeding Study	• Monitor • Collect • Breeding Study	• Monitor • Collect • Threat Control	• Monitor • Collect • Outplant?	• Monitor • Collect • Outplant • Threat Control
Halona	• Assess threat control (fence?)	• Monitor • Collect • Implement additional threat control	• Monitor • Collect	• Outplant? • Monitor • Collect	• Monitor • Collect • Outplant?
North Mohiakea	• Monitor • Collect • Evaluate Threat Control Actions	• Monitor • Collect • Scope Outplanting site(s)	• Monitor • Collect • Implement additional threat control if needed	• Monitor • Collect • Outplant	• Monitor • Collect • Outplant
Ohikilolo	• Monitor • Collect • Determine Threat Control Actions	• Monitor • Collect • Implement Threat Control	• Monitor • Collect • Implement Threat Control • Outplant	• Monitor • Collect • Implement Threat Control	• Monitor • Collect • Implement Threat Control • Outplant
Konahuanui		• Monitor • Collect	• Determine Threat Control Actions	• Monitor • Collect	• Determine if need to scope an outplanting site
Palawai	• Monitor • Collect	• Monitor • Collect	• Monitor • Collect	• Monitor • Collect	• Monitor • Collect
Nuuanu	• Survey	• Monitor • Collect		• Monitor • Collect	
Waiawa	• Survey • Monitor • Collect		• Monitor • Collect		• Monitor • Collect

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Cyanea superba subsp. *superba*

- **Scientific name:** *Cyanea superba* (Cham.) A. Gray subsp. *superba*
- **Hawaiian name:** *Haha, ohawai*
- **Family:** Campanulaceae (Bellflower family)
- **Federal status:** Listed endangered September 11, 1991
- **MIP Requirements for Stability**
  - 4 Population Units (PU) (extirpated in the wild)
  - 50 reproducing individuals in each PU (long-lived perennial with a history of precipitous decline, extremely low genetic variability)
  - Stable population structure
  - Threats controlled
  - Complete genetic representation of all PUs in storage
- **Description and biology:** *Cyanea superba* subsp. *superba* (here after *C. superba*) is a tree 4-6 m tall with a single major stem, or occasionally two or more major stems arising from the base of the plant. Two of the basal-branching plants formerly growing at Kahanahaiki each had about 8-10 major stems (Lau pers. comm. 2000). The taxon's leaves measure 0.5-1.0 m long, and are clustered at the stem tips. The inflorescences hang below the leaves, and terminate in a cluster of 5-15 flowers. The corollas are whitish to cream, curved, and measure 5.5-8.8 cm long. The berries are yellow to orange, egg-shaped, and measure 16-22 mm long (excerpt from MIT 2003).

- This taxon flowers from September through October. It was probably originally pollinated by nectar-feeding birds, as is thought for *Cyanea* species in general, with their long tubular flowers. *C. superba* is capable of self-pollination and can be autogamous, as evidenced by the production of fertile seeds in the Kahanahaiki population unit in years when only a single plant had flowered (Pender et al. 2013). Fruit-eating birds presumably dispersed the seeds. Based on growth rates and the size of mature plants, *C. superba* may live for up to 20 years or more (Lau pers. comm. 2000).

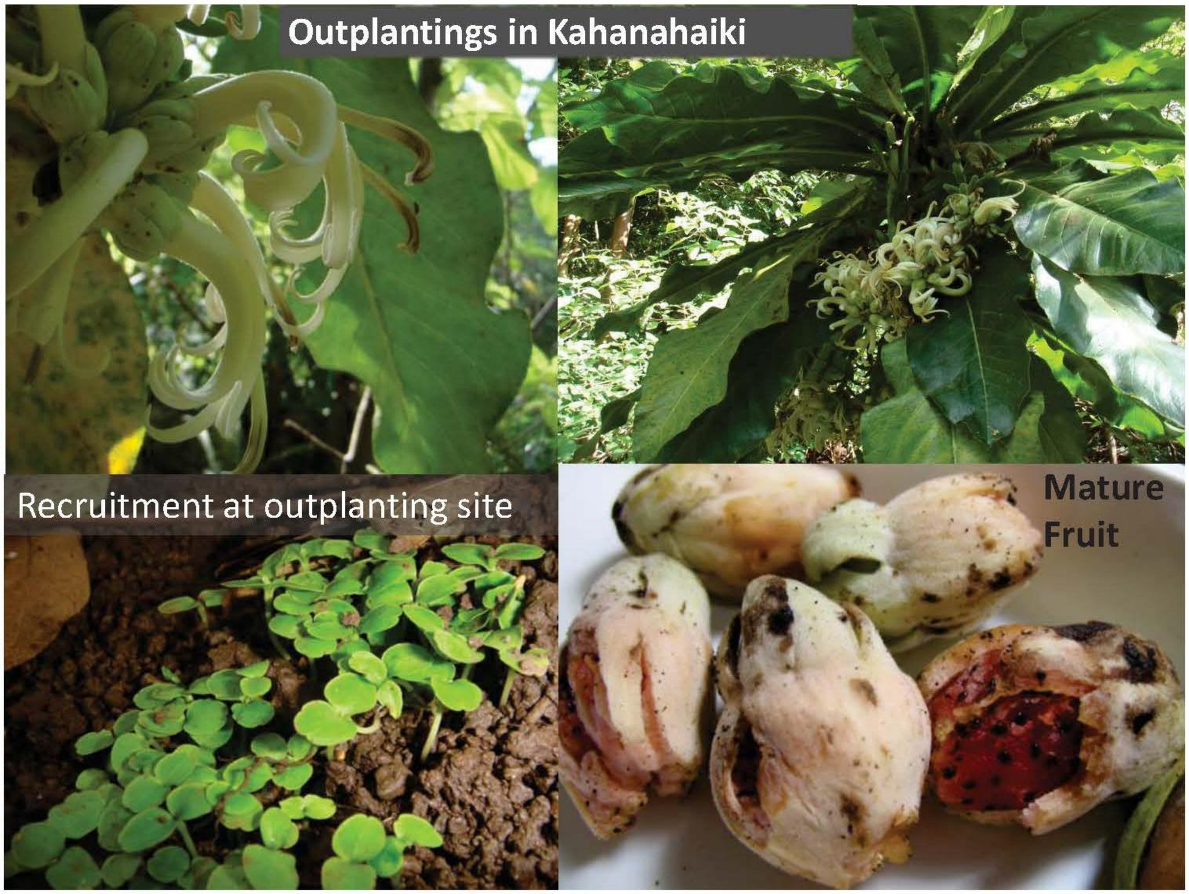
modified from: Makua Implementation Team (MIT). 2003.

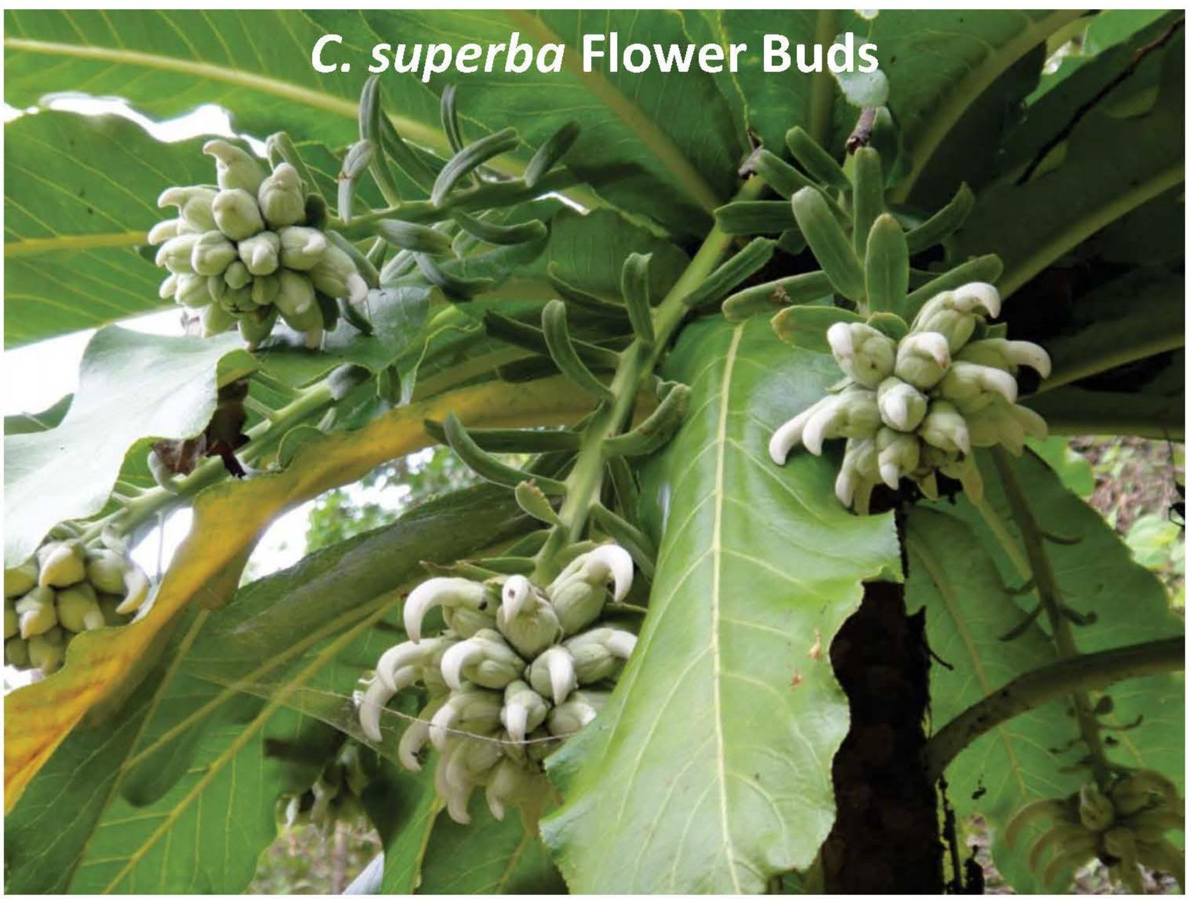
Reproductive Biology Table

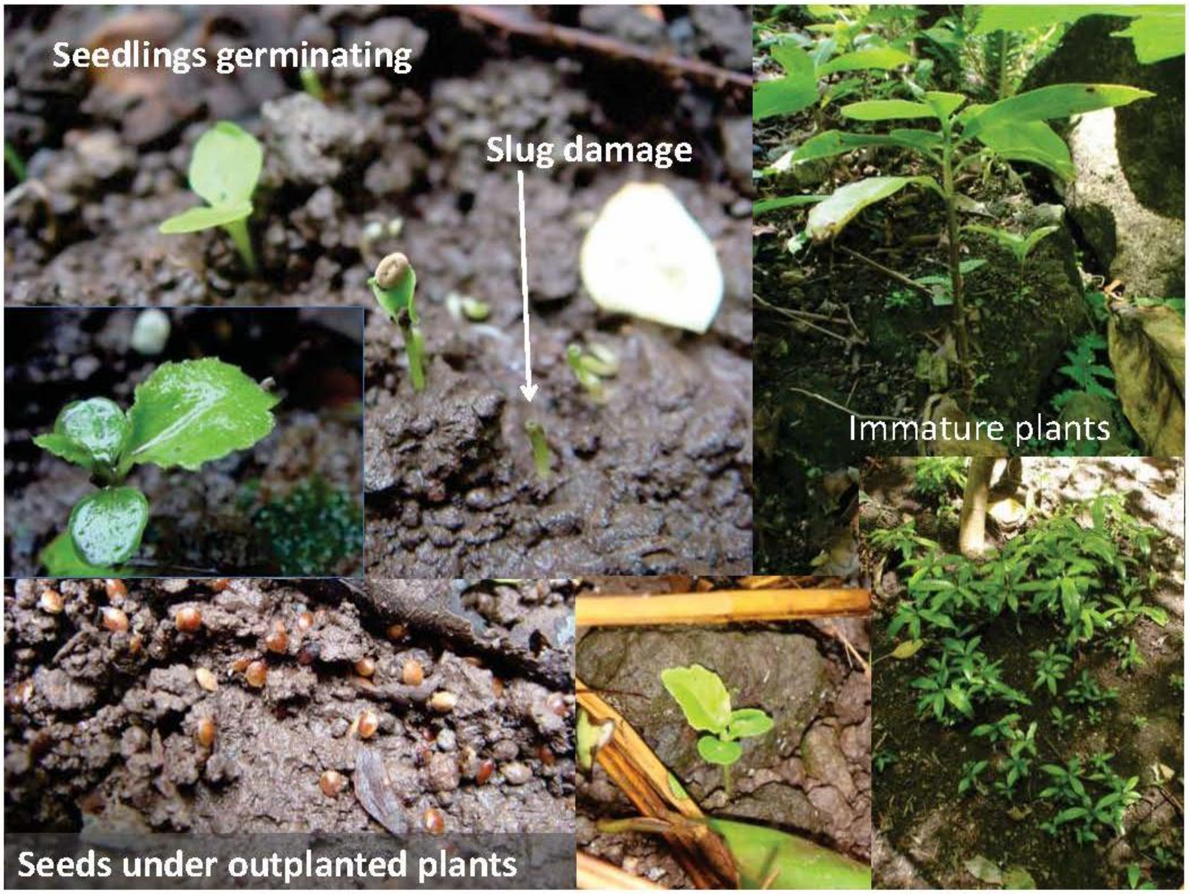
	Observed Phenology			Reproductive Biology		Seeds	
Population Unit	Flower	Immature Fruit	Mature Fruit	Breeding System	Suspected Pollinator	Average # Per Fruit	Dormancy
ALL	Sept-Oct	Oct-Jan	Oct-Jan	Hermaph-roditic	Bird*	112 ± 80	Not Dormant

*Smith, T.B. L.A. Freed, J.K. Lepson, J.H. Carothers. 1995.
Evolutionary Consequences of Extinctions in Populations of a Hawaiian Honeycreeper. Conservation Biology 9: 1, 107-113.

*Lammers, T.G. & C.E. Freeman. 1986. Ornithophily among the Hawaiian Lobelioideae (Campanulaceae): evidence from nectar sugar compositions. American Journal of Botany 73: 1613-1619.


Outplantings in Kahanahaiki
Recruitment at outplanting site
Mature Fruit


C. superba Flower Buds



Cyanea superba subsp. *superba*

- **Known distribution:** The few documented locations for *C. superba* are all in the northern Waianae Mountains. These locations are the eastern slope of Mt. Kaala, Makaleha Valley, Pahole Gulch, and Kahanahaiki Valley. After the original collections prior to 1870, no plants were known until its rediscovery in 1971 in Pahole. The Kahanahaiki site was discovered in 1987. By 1991, a total of less than 20 plants were known from Pahole and Kahanahaiki. The Pahole plants were gone by 1994 and the last Kahanahaiki plant died in 2002.
- **Habitat:** The historic sites in Kahanahaiki and Pahole, are on the lower to upper gulch slopes. These slopes are fairly steep. The vegetation at these sites consists of mesic forest comprised of a mix of various native and alien tree species.
- **Taxonomic background:** *Cyanea superba* is endemic to Oahu. It is comprised of two subspecies: subsp. *superba* of the northern Waianaes, and subsp. *regina* of the southeastern Koolau Mountains. *Cyanea superba* subsp. *regina* was last recorded in 1960. In 1913, Joseph Rock wrote in The Indigenous Trees of the Hawaiian Islands, "The queen of all is the lobeliaceous *Cyanea superba* var. *regina,* an exceedingly beautiful plant found only on Oahu, in the gulches of Wailupe and Niu, and in Makaleha of the Kaala range."
- **Population trends:** Populations of *C. superba* subsp. *superba* have plummeted over the last three decades. The decline of the Pahole population was especially steep. The population was discovered in the 1970's. In 1978, 36 mature plants, 10 saplings, and six seedlings were reported. By 1989 the number had declined to 10-12 plants. The site was then fenced to protect the plants from feral pigs. Despite of the protection offered by the fence, the last Pahole plant died in 1994. The last wild tree in Kahanahaiki died in 2002. It is possible that the last wild plants died of a fungal disease but we do not know this with any certainty, or if they died of another cause, including old age, and the fungal infection was secondary. We have noticed tip wilt and possible fungal infections in some of the outplanted plants to date but do not understand if it is the same cause of death. This tip wilt and consequent death has also been seen in *C. grimesiana* subsp. *obatae*.

modified from: **Makua Implementation Team (MIT). 2003.**

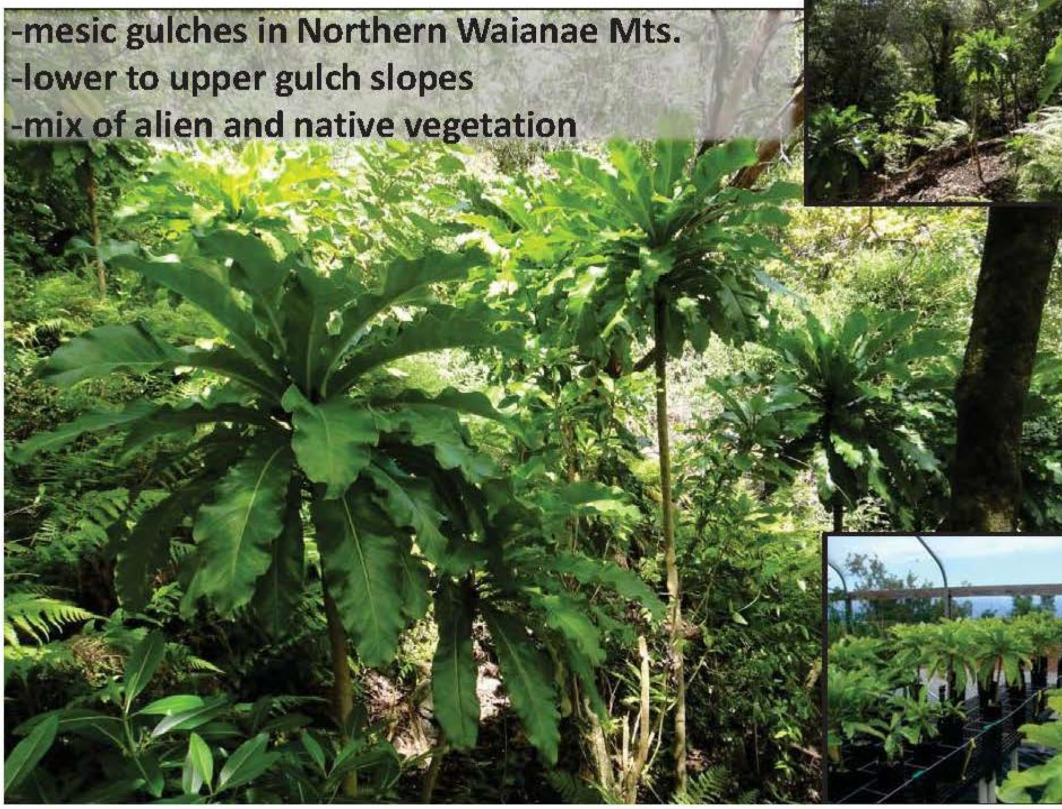
Selected Historic Collections of *C. superba* subsp. *superba*

Area	Year	Collector	Population Unit & Notes
Mt. Kaala	01 Mar 1870	Hillebrand, W.B.	"East Slope of Mt. Kaala" (Schofield)
Pahole Gulch	21 Mar 1971	Yamashita, G. Montgomery, S.L. Obata, J. Carson, H. Carson, Mrs. H.	Wild Pahole Gulch Site Found with 36 mature plants, 10 saplings, and six seedlings
Kahanahaiki	13 Sep 1987	Perlman, S.P. Obata, J.	Wild Kahanahaiki Site (MMR-A) Found with 12-15 plants

Data compiled from Bishop Museum Herbarium Records provided by Bishop Museum, 2015.

Possible Fungal Infections of Wild *C. superba*

C. superba Plantings

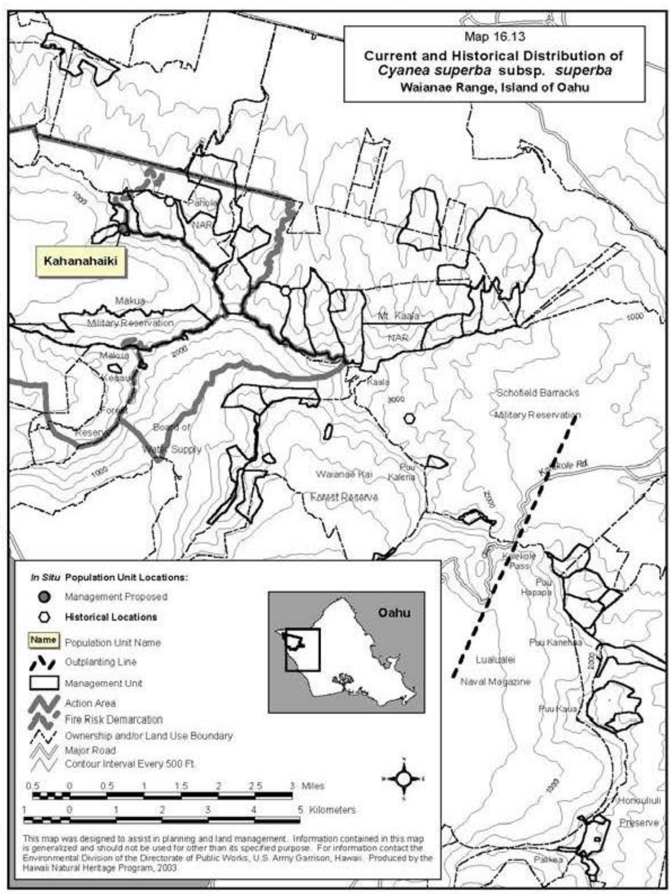


Outplanting considerations:

"Based on current and historical records of *C. superba* locations, under natural conditions it would be normal for the taxon to be growing with other species of *Cyanea* and with species of the related genera *Delissea* and *Clermontia*. It is common to find several *Cyanea* species and *Cyanea* relatives growing together, yet to date there is no evidence of hybridization occurring between species of *Cyanea* or between a *Cyanea* and a *Cyanea* relative. Consequently, concerns are minimal with respect to the possibility of inadvertently allowing unnatural hybridization to occur through the outplanting of *C. superba* subsp. *superba*. *Cyanea superba* subsp. *superba* has been documented only in the northern part of the Waianae Mountains, and not in the southern part. The southern Waianae Mountains are therefore not considered part of the taxon's natural range (MIP 2003)".

In the MIP, an outplanting line was drawn through the central Waianae Mountains limiting proposed reintroductions to the areas north of the line.

However, this restriction should be re-evaluated to allow for the possibility of managed translocations (assisted migration) of taxon to higher elevations or wetter habitats due to the impacts of climate change.



Species Occurrence

(# in circles = # mature plants)

Map removed to protect rare resources. Available upon request

Habitat Characteristics

Population Unit	Population Reference Codes	Elev. (m)	Slope	Canopy Cover	Topography	Aspect	Average Annual Rainfall (mm)
Kahanahaiki[1]	MMR-A MMR-E MMR-H	623 585-607 580-597	Moderate (10-45)	Intermediate Intermediate Closed	Upper Slope Mid Slope Gulch Bottom	North	1359.8 1347.0 1357.8
Makaha[2]	MAK-A	700	Moderate (10-45)	Intermediate	Mid Slope	North - Northeast	1748.5
Manuwai[2]	ANU-A	506	Moderate (10-45)	Intermediate	Gulch Bottom	Northeast	1406.0
Pahole to Kapuna[1]	PAH-A	543-561	Moderate (10-45)	Intermediate	Gulch Bottom	Northwest	1410.1 1457.7
Puu Palikea[2*]	PAK-A	853	Moderate (10-45)	Closed	Mid Slope	South East	1165

- Information was compiled from OANRP's HRPRG Rare Plant Monitoring forms & GIS data.
- Rainfall data complied from Rainfall Atlas of HI (Giambelluca et. al. 2013). Rainfall data is not precipitation and does NOT take into account cloud/mist "fog drip" moisture. Averages from 1977-2007.
- All Population Units are existing reintroductions[1] or introductions[2].
- *Not a current PU but 20 plants were planted here by The Nature Conservancy in 2005.

Associated Species

Population Unit	Population Code(s)	Canopy	Understory
Kahanahaiki	MMR-E MMR-H	AcaKoa, AleMol, AlySte, AntPla, BobBre, BudAsi, CarMey, CarWah, ChaTom, CibCha, CopFol, CorFru, CyrDen, DioHil, DioSan, EupCel, FreArb, GreRob, GynTri, KadAff, MetPol, MyrLes, NesSan, PipAlb, PisBru, PisSan, PisUmb, PlaSan, PsiCat, PsiGua	AcaKoa, AleMol, AlySte, AngEve, AspExc, AspKau, AspMac, BleApp, CarMey, CarWah, ChaTom, CibCha, CliHir, CocOrb, CopFol, CorFru, CycDen, CycPar, DiaSan, EupMul, FluNeo, KadAff, LanCam, MicStr, NepExaHaw, OdoChi, OplHir, PasCon, PipAlb, PlaSan, PsiCat
Makaha	MAK-A	AcaKoa, AleMol, AntPla, ClaSan, CofAra, DioHil, DioSan, ElaBif, GynTri, HibArnArn, MetPol, MyrLes, NesSan, PanBee, PipAlb, PisBru, PisSan, PisUmb, PlaSan, PsiCat, PsiGua, PsyOdo, SapOah, SchTer, StrPen, SyzCum, TooCil, UreGla, XylHaw	AlySte, AspNid, BidTor, BleApp, BudAsi, CarMey, CarWah, ChaObo, ChePla, CofAra, ConBon, CopFol, CorFru, CycPar, DooKun, DubPla, EraGra, EupMul, HibArnArn, KalPin, LanCam, LepTam, LysHil, MelMak, MicSpe, MicStr, NesSan, PasEdu, PipAlb, PolPelPel
Manuwai	ANU-A	No Monitoring Data	
Pahole to Kapuna	PAH-A	AcaKoa, AleMol, AntPla, ChaTom, CibSpp, DioHil, DioSan, DioSpp, FraUhd, HibArnArn, MetPol, MyrLes, NesSan, PipAlb, PisBru, PisUmb, PlaSan, PsiCat, PsiGua, PsyMar, SchTer, UreGla, XylHaw	AdiHis, AlySte, BleApp, BudAsi, CarWah, CliHir, ColOpp, CopFol, CycDen, CycPar, DelWai, DioSan, DooKun, DryFus, DrySan, FraUhd, MetPol, MicStr, NepBro, NepExaHaw, OplHir, PasCon, RubRos, SolAme
Puu Palikea*	PAK-A	AlySte, CibGla, CryJap, CyrGar, ElaBif, IleAno, KadAff, LabKaa, MetPol, MorFay, PipAlb, PitSpp, PlaSan, PsiGua, PsyHat, UreGla, XylHaw	AlySte, AspAcu, AspMac, BleApp, BudAsi, ChaTom, CibGla, CliHir, CycDen, CycPar, CyrWai, DipSan, EupMul, FreArb, KadAff, KadCor, MicStr, PepMem, PerSan, PipAlb, PisSpp, RubRos, SchTer, SelArb, TecGau, TouLat, WikOahOah

*Not a current PU but TNC planted 20 plants there in 2005.
Species are listed in alphabetical order as observed by OANRP; introduced taxa are underlined: AbuGra, CycPar

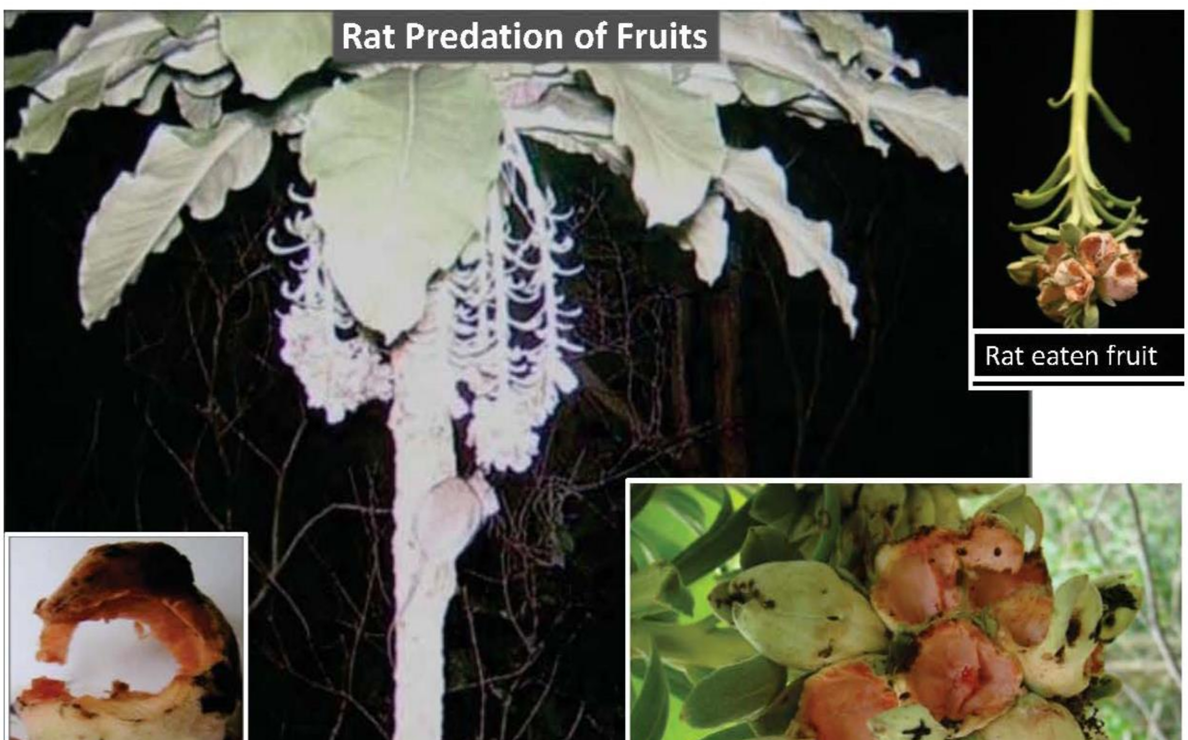
THREATS

- Major threats to *C. superba* include feral pigs, which degrade the taxon's habitat and harm the plants by feeding, trampling and/or uprooting them. Alien plants alter its 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. Rats predate plant parts and fruits and introduced slugs and snails threaten the taxon by feeding on its leaves, stems, and seedlings (Joe & Daehler 2008, OANRP pers. obs.). Fungal pathogens may also be a substantial threat to this taxon.
- Over the past 10 years, enormous progress has been made in refining and increasing the effectiveness and efficiency in threat control techniques. All plantings are contained in fences to control ungulates, have partial to full rodent control where reproducing plants are present, and receive slug control where rare native snails are absent.
- The long-billed, nectar-feeding native Hawaiian birds, which are the presumed pollinators of *C. superba*, have been almost totally eliminated from the taxon's historic range in Waianae Mountains. Studies at Kahanahaiki (Pender et al. 2013) found no native avian pollinators visiting flowers and non-native birds only nectar-robbing, making any cross-pollination unlikely. The loss of the taxon's normal pollinating vectors may lead to decreases in the level of outcrossing in this species, which is presumed to be bird-pollinated, despite the taxon's capability of autogamy. An increase in inbreeding could therefore potentially lead to an expression of inbreeding depression (IBD) in successive generations. Genetic analysis of all of the available wild and cultivated stocks of *C. superba,* which included, at most, representation from four wild plants from one, or possibly both, populations, has shown that the genetic variability within the taxon is already extremely low (Morden pers. comm. 2000). Over the past five years, OANRP has noticed a substantial portion of the fruit produced do not contain any seeds. These fruits are typically found at the bottom of an infructescence which flowers last, potentially indicating that it could be tied to resource allocation by the maternal plant. Additional reasons for low to no seed set likely stem from a lack of a pollinator (pollen limitation) and/or possibly IBD. The observation of fruit with no seeds on the same infructescence as fruit with dozens of seeds suggests the former may be more likely. Potential means of overcoming IBD include human-mediated outcrossing among maternal lines and potentially incorporating additional genetic material into *C. superba* subsp. *superba* by hybridizing it with closely related species of *Cyanea*, including *C. superba* subsp. *regina* of the Koolau Mountains, if the subspecies is ever rediscovered. The most morphologically-similar species, *Cyanea procera*, has only one remaining plant in the wild, and could also be a potential recipient of genetic rescue via hybridization with *C. superba*. This may be something to explore further down the road if IBD is identified and limits population stability. Prior to such extreme actions, OANRP would like to identify if there are other potentially suitable habitats outside of historic range that would have pollinators and fruit dispersers present to serve as new outplanting sites.

THREATS

- Recent studies by OANRP show seeds that remain in senesced fruits rapidly lose 50% of their viability. No avian dispersal was reported in studies of the Kahanahaiki plants or in monitoring by OANRP since 1997, meaning that at least half the seeds not predated by rats are lost as the fruit senesces on the plant. Due to these factors, recruitment and survival of new plants in restoration sites has been minimal and insufficient to meet MIP stabilization goals. OANRP would like to identify effective pollinators and dispersers and investigate whether or not there are other sites on Oahu where pollinators and fruit dispersers are more abundant. It is uncertain if there are any effective pollinators of *C. superba* on Oahu. We are currently uncertain of any sites on Oahu that have more avian dispersers as we do not know what species, native or alien, disperse *C. superba* fruit. Seedlings at Puu Palikea, however, have recruited throughout the Management Unit as opposed to only beneath the mature trees as in the other PUs. Therefore, some ambient (natural) dispersal is suspected, but the disperser is unknown. Recruitment has only been beneath the mature trees at the Kahanahaiki and Pahole to Kapuna PUs. There are a few seedlings that have recruited ~30m away from mature trees in Makaha PU.

- Climate change: Shifts in climatic conditions, including drought and increased temperatures, could potentially reduce recruitment for this taxon endemic to mesic forests. We are not sure if seedlings fail to establish and grow due to droughts, though we see the majority of seedlings in the spring as compared to later in the year. A trend of increasing lethal water stress has been observed on Maui for the Haleakala silversword (*Argyoxyiphium sandwicense* subsp. *macrocephalum*) and attributed to climate change (Krushelnycky et al. 2012). Conversely, it is possible that drier conditions may have fewer slugs, and we are uncertain if seedling-stage failure is due to a combination of slugs and drought. However, while we can control for slugs in sites (when no rare snails are present), we cannot combat climate change in existing sites. *C. superba* has a climate change vulnerability index of 0.936 (on a scale of 0-1, with 1 being the most vulnerable). It is the 4th highest value for IP taxa in the Waianae Mountains. 1st *K. parvula* (0.96); 2nd *P. kaalaensis* (0.946); 3rd *S. obovata* (0.944; Fortini et al. 2013).



Stabilization Goals Status (2016)

MIP Requirements for Stability

- 4 Population Units (PU)
- 50 reproducing individuals in each PU
- Stable population structure
- Threats controlled
- Complete genetic representation of all PUs in storage

MFS Population Units	PU Stability Target		MU Threat Control					Genetic Storage
	50 Repro-ducing Plants?	Does the PU have stable population structure?	Ungulates	Weeds	Rodents	Fire	Slugs	Are there enough propagules in Genetic Storage?
Kahanahaiki	YES	NO	YES	PARTIAL 78%	YES	NO	PARTIAL 45%**	YES
Manuwai	NO*	NO	YES	YES	NO*	NO	NO*	
Makaha	PARTIAL 54%	NO	YES	NO	YES	NO	NO**	
Pahole to Kapuna	YES	NO	YES	PARTIAL 71%	PARTIAL 60%	NO	NO***	

* No mature, reproducing plants currently at this site (142 immature outplants planted in 2013)
** Slug control is limited due to the presence of rare native snails
***Slug control had been monthly from Jan 2014 to April 2015

Genetic Storage Plan

What propagule type is used for meeting genetic storage goal?	What is the source for the propagules?	What is the Genetic Storage Method used to meet the goal?	What is the proposed re-collection interval for seed storage?	Is seed storage testing ongoing?	Plan for maintaining genetic storage.
Seeds	Reintroductions & Introductions	Seed banking (5C or -80C / 20% RH)	> 10 years	Yes	Collections will be made from outplantings as needed.

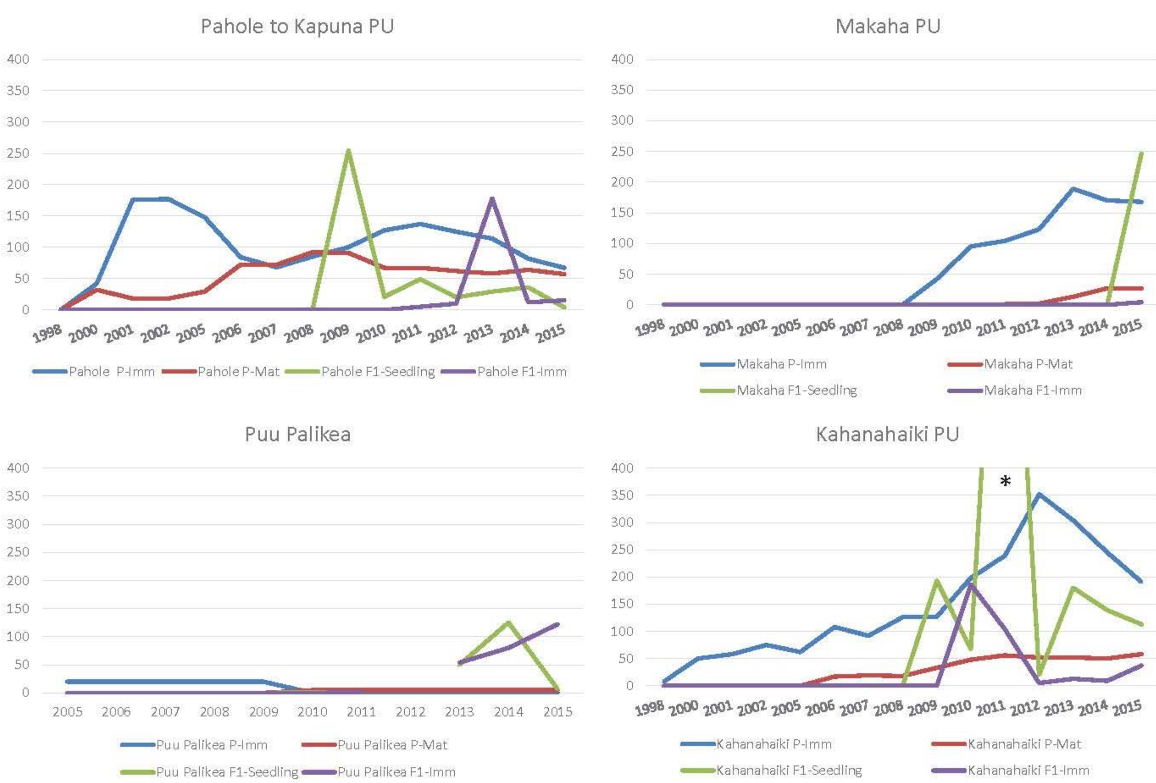
Genetic Storage Plan Comments:

- There were propagules from 3 founders from the wild Kahanahaiki population at the first outplanting, but seeds were never collected from one founder line before the outplanted progeny died. An additional "founder" was established via propagules of unknown provenance that we believed matriculated from the same Kahanahaiki population due to genetic analysis, but this remains uncertain. We currently track and maintain representation from these 3 founder lines.
- Collection procedures changed in December 2006 to harvest mature fruit directly from the trees to improve longevity of seeds in storage (as opposed to waiting for fruit to drop from the infructescence). Thorough storage testing began in January 2007 with seeds from this new harvest method. Five year results do not indicate a decline in viability.
- Seeds are currently banked at 5C, however, moving collections to -80C could significantly increase the longevity of these collections. Research conducted at the National Center for Genetic Resources Preservation suggests -80C storage slows the aging process (and therefore extends their storage life) more than 5C.
- As no wild plants remain, collections are made from outplantings, including reintroductions and introductions. Founders are tracked and collections made appropriately and currently refreshed every 10 years (at current 5C storage). The re-collection interval could be extended if seeds are stored at -80C. Collections were refreshed in Dec 2015.
- When new recruits become reproductive, collections will be made to represent these individuals as there are only 3 maternal lines, the recruits have undergone selective pressures at the seed, seedling, and immature stages and could contribute to maximizing the amount of genetic diversity in the taxon. Additional maternal lines could also greatly improve the efficiency of hand-pollination efforts to promote increased genetic diversity.

Population Structure

- There are currently 184 mature *C. superba*. Seedlings or immature plants were never observed at the Kahanahaiki wild site during the entire time they were monitored (1995-2002). Seedlings and immature plants were reported when the Pahole site was first discovered in 1971, but were gone by 1994. 1997-2002 was a well-recorded drought for much of the state and could have negatively impacted this population in mesic forest.
- In 2009, regeneration of seedlings under outplanted individuals was first observed. Over the 2009-2010 winter, over 500 seedlings were found under 8 separate plants in the Kahanahaiki PU. There were 21 mature trees at this time. An additional 300 seedlings were observed under two plants in the Pahole to Kapuna PU. Lastly, one immature plant was observed under a plant at Puu Palikea that had been planted by The Nature Conservancy. In total, seedlings were observed at 6 of the 12 outplanting sites (found within two PU and the Puu Palikea planting) with mature plants. Over the 2010-2011 winter season, there over 1,000 seedlings counted in the Kahanahaiki PU and 50 in the Pahole to Kapuna PU.
- In the years since 2011, there has been a decline in the number of seedlings (except for the newly established Makaha introduction which saw its first seedlings in 2015). New seedlings are observed each spring and several dozen have survived for more than six years as immature plants. None of these F1 plants have matured yet. Immature plants that naturally recruited are now present at 8 different outplanting sites in the Kahanahaiki PU (4 sites), Pahole to Kapuna PU (2 sites), Makaha PU, and Puu Palikea.
- Besides collections of fruit made for genetic storage and propagation, all other fruit has been left to mature on the plants. The fruit not eaten by rats was left to senesce and fall below the plants where new regeneration has been observed. Fruit at most PUs have been somewhat regularly dispersed by OANRP staff while conducting work in the area via smearing fruits across various substrates, and more thoroughly cleaning fruits to disperse seeds at Puu Palikea.
- The next slide graphically displays population trends at the three Manage Reintroduction for Stability PU that currently have reproducing plants (outplants have yet to flower at the most recent Manuwai PU), and the Puu Palikea outplanting. Please note that in the current absence of mature recruits, we are focused on quantifying the presence of naturally-occurring immature recruits (not planted) that have grown past the seedling stage. This refers to the purple line in the graphs. The other colors include immature outplants (blue), mature outplants (red), and recruits in the seedling stage (green). The lack of consistent monitoring at Puu Palikea is due to the fact that this is not a Manage for Stability Reintroduction at this time for OANRP.

Population Structure



*seedlings exceeded 1000

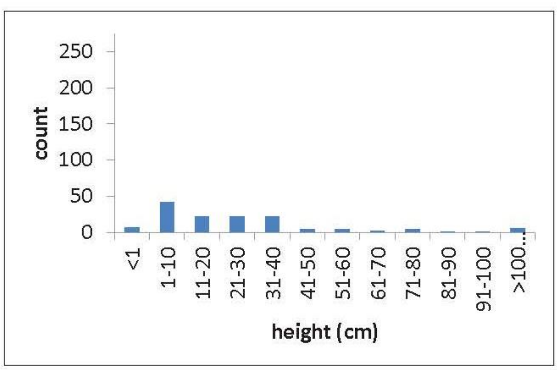
Counts of F1 plants in relation to numbers of outplants*

Population Unit	F1 total (2015)	height range (cm)	predominant F1 size class	outplant total (2014)	total mature outplants (2014)	Year of 1st planting	total outplants matured in last 10 years	ratio of F1s to mature outplants (2014)	ratio of F1s to outplants matured in last 10 years
Kahanahaiki	289	0.5-68	<1cm (88%)	295	50	1998	90	5.8	3.2
Manuwai	Outplants have yet to mature – recent reintroduction								
Pahole to Kapuna	19	0.5-ca. 20	>1cm (79%)	425	95	2001	175	0.2	0.1
Makaha	250	0.5-ca. 20	<1cm (98%)	215	27	2009	27	9.3	9.3
Palikea	129	0.5-93	>1cm (95%)	20	5	2005	ca. 10	25.8	ca. 12.9

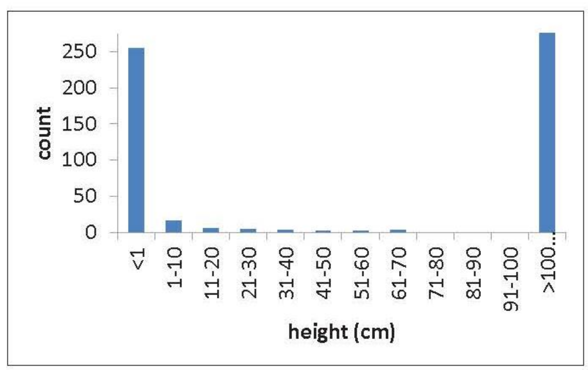
*Outplant data sourced from 2014 monitoring, as not all population reference sites were monitored in 2015. Anecdotally, seedlings at Makaha are now predominantly >1cm.

OANRP investigated variation in recruitment among PUs. To document the number of F1 plants and their heights, surveys at Kahanahaiki (MMR-D, MMR-E, MMR-F, MMR-H) and Puu Palikea (PAK-A) were conducted in April 2015. Kahanahaiki had more F1s in total, but Puu Palikea had a much higher ratio of F1s to mature outplants (see below). Most F1s at Kahanahaiki were <1 cm tall, while most at Palikea were >1 cm tall. While seeds may successfully germinate at Kahanahaiki, survival appears to be relatively poor. Recruitment at Kahanahaiki was primarily located below mature plants. Fruit that is not predated by rats is likely senescing, falling to the ground and having little to no recruitment. By comparison, at Palikea, recruitment often occurred distant from the few mature plants present. Given the results of the laboratory germination trial and F1 surveys at Kahanahaiki and Palikea, the relatively limited recruitment observed at Kahanahaiki (despite prolific production of viable seed), may be influenced by a lack of dispersers and/or habitat.

Comparison of Size Distributions of all Plants at Kahanahaiki and Puu Palikea



Size distribution of *Cyanea superba* subsp. *superba* at Palikea MU (n = 135), April 2015



Size distribution of *Cyanea superba* subsp. *superba* at Kahanahaiki MU (n = 539), April 2015

Plants measured from the ground to apical meristem. All plants <100 cm are F1s. All plants >100cm are outplants.

Note the small amount of recruits that are greater than 1cm at the Kahanahaiki PU. We consider plants less than 1cm to be that year's seedlings. There are more immature plants at Puu Palikea despite fewer mature outplants.

Cyanea superba subsp. *superba*
MIP Requirements for Stability

- [x] 4 Population Units (PU) (extirpated in the wild)
  - Kahanahaiki
  - Pahole to Kapuna
  - Makaha
  - Manuwai
- [x] * 50 reproducing individuals in each PU (long-lived perennial with a history of precipitous decline, extremely low genetic variability)
- [ ] Stable population structure
- [x] Threats controlled (more threat control will happen once plants at Manuwai begin to flower)
- [x] Complete genetic representation of all PUs in storage

* Only partially complete. Complete for Kahanahaiki and Pahole to Kapuna PUs, but Manuwai and Makaha PUs are too young & the majority of outplants have yet to mature

Management Discussion

- Outplantings of plants grown from the last remaining (only available) three founders from the wild Kahanahaiki site were established at Kahanahaiki in 1998 and at Pahole in 1999. Between 1997 and 2014, OANRP propagated nearly 1750 plants and outplanted over 1400 into 13 sites in the Kahanahaiki, Kapuna, Pahole, Makaha and Manuwai MUs. In addition, outplantings were conducted by NARS in Upper Kapuna and at Puu Palikea and Kaluaa by The Nature Conservancy. Survival across all sites is currently 54%. Currently there are 186 mature *C. superba* at eight different population sites across three PUs with recruitment (to the size class of small immature).
- Plants are outplanted as immature. Of the 303 plants to mature, plants took on average five years after outplanting to mature. Of the 117 outplants that have matured and died, they lived for an average of nine years total. The remaining 186 outplants that have matured are still alive.
- Despite observing recruitment, and a transition from seedlings to immature plants, none of these immature plants have grown very large or matured. Currently, the only obstacle to obtaining stability for this taxon is to establish stable population structure.

Management Discussion

In order to establish restoration sites that become stable, new efforts to incorporate the limiting factors identified in the threats section are needed. Restoration factors that could be addressed include the following:

1) **Habitat site selection** (large scale and micro-site locations): OANRP proposes selecting one or two new introduction sites and several seed sow sites to identify sites and micro-site conditions that promote recruitment and stage class transitions to immature and mature plants. New sites that would be considered as managed relocations should be considered to combat climate change.

2) **Overcoming inbreeding and lack of pollinators:** OANRP could conduct hand-pollinations to breed between different maternal lines within or among taxa, and use these progeny to establish new trial outplantings sites. We could also pollinate to increase seed set. OANRP could conduct pollinator observations to determine if certain sites have more visitation than others, or if areas have more potential pollinators than others.

3) **Fruit Dispersal**: OANRP could support ongoing fruit disperser research (identify species and quantify fruit dispersal). identify dispersers and quantify fruit dispersal among existing sites and propose new sites with more dispersers present. OANRP could conduct artificial (human-assisted) fruit dispersal.

4) **The number of outplants per population** site and unit. OANRP could consider increasing the number of outplants used to establish a new site or supplement an old site to promote recruitment.

5) **Threat Control**: OANRP to review all ongoing threat control efficacy to determine if increased efforts could have a positive effect on recruitment.

Current & Proposed Alternate Population Units

Manage For Stability Population Units	Fenced?	Easy Rodent Control?[1]	Easy slug control?[2]	Pollinators Present?	Dispersers Present?	Managed relocation?
Kahanahaiki	Yes	Ongoing	Ongoing (Partially)	No	No	No
Makaha	Yes	Ongoing	No	?	Yes?	No
Manuwai	Yes	Yes	Yes	?	?	No
Pahole to Kapuna	Yes	Yes	Yes	?	No	No
Proposed Alternate Population Units (to choose 1-2 for planting and 1-2 for trial seed sows)						
Central & East Makaleha	Maybe	To be considered in the future depending on fence construction (State of Hawaii DOFAW)				
Kaluaa	Yes	Yes	Maybe	?	?	No
Lihue (Haleauau)	Yes	Yes	Yes	?	?	Yes
Lower Opaeula	Yes	No	No	?	?	Yes
Puu Palikea	Yes	Ongoing	Ongoing	?	Yes?	Yes
Waianae Kai	No	hence removed from consideration				
West Makaleha	Yes?	Proposed OANRP fence will not include appropriate habitat				

[1] "Yes" means we can maintain rodent grid monthly. "No" means quarterly baiting.

[2] "Yes" indicates Sluggo can be applied monthly. "Maybe" indicates surveys for rare snails are needed. "Partially" indicates that some slug control cannot happen in that PU due to the presence of rare snails. For Makaha, "No" means there are native snails present and slug control cannot occur. For Lower Opaeula, "No" means that it is unlikely to maintain monthly applications of Sluggo.

1) Habitat Selection: Managed Relocation

- The outplanting line, which only permitted plantings north of Kolekole Pass, has been eliminated.
- Choosing reintroduction sites based on their Reintroduction Site Ranking Score from the 2003 Implementation Plan has been put on hold until a new scoring system can be devised that includes more threats to each species, especially climate change.
- Climate change: *C. superba* has a climate change vulnerability index of 0.936 (on a scale of 0-1, with 1 being the most vulnerable). It is the 6th highest value for IP taxa in the Waianae Mountains. 1st *D. herbstobatae* (0.986); 2nd *Sanicula mariversa* (0.968); 3rd *K. parvula* (0.96); 4th *P. kaalaensis* (0.946); 5th *S. obovata* (0.944; Fortini et al. 2013). OANRP should execute sound judgement in evaluating the need to choose introduction sites higher in elevation or wetter in climate for species with high vulnerability scores.

The Rare Plant Implementation Team has eliminated the MIT 2003 outplanting line and has chosen Palikea as a 5th Managed Reintroduction for Stability Population Unit (MRFS PU). Palikea will be considered a Managed Relocation. Five Manage for Stability PUs will remain until Palikea is established, at which point all management will stop for the Pahole MFS PU.

1) Habitat Selection: Microsite (Seed Sow Trials)

- *In situ* field seed sow trials could aide in identifying small-scale sites ideal for seedling recruitment and successful establishment of small to immature plants.
- Compare recruitment among existing and proposed PUs as well as among various microsite conditions within PU sites.
- Conduct seed sow trials along rainfall/precipitation gradients; consider purchasing data loggers & weather stations that track precipitation and humidity.
- There is a possibility that the seeds used in these trials could produce mature trees. The amount of seed sown, along with the average number of seeds produced per mature plant, will help address the number of outplants needed that could produce stable population structure at these sites.

OANRP proposes to initiate seed sow experiments at Lihue (upon permission from the Army) and Lower Opaeula to determine their potential as future introduction sites. OANRP will also conduct seed sow trials at Makaha and Palikea to investigate effects of environmental conditions on seedling establishment.

UPDATED Population Units

Site	OANRP Proposed Actions
Lihue (Haleauau)	Ask Army if we can plant/seed sow into Schofield as plants not present in this Action Area and look for potential sites; conduct seed sow if allowed
Kahanahaiki*	Continue as Manage Reintroduction for Stability PU (MRFS)
Makaha*	Continue as MRFS; conduct seed sow trial
Pahole to Kapuna*	Continue as MRFS (consider dropping status if/when a new PU established with completed outplanting)
Kaluaa	Look for sites to establish a trial planting, seed sow, or introduction further up the gulch from the current planting
Lower Opaeula	Conduct a seed sow (with minimal or no slug control)
Puu Palikea*	Augment existing introduction; make a new MRFS; conduct floral visitor & disperser observations (cameras); conduct seed sow trial
Manuwai*	Continue as MRFS; wait for plants to flower

*Current Manage Reintroduction for Stability Population Units

NOTE: The content on this slide and the following slides is based on discussions from the 2016 Rare Plant Implementation Team meeting.

2) Investigations into potential inbreeding depression

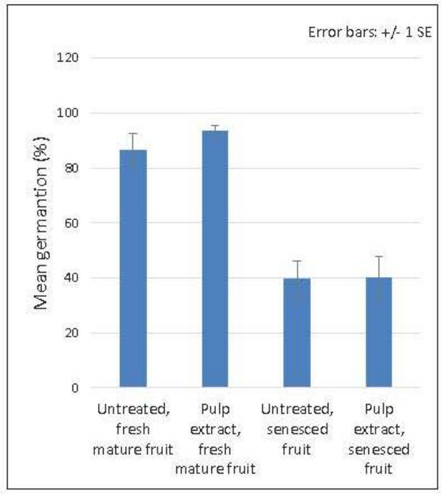
- As stated in the MIP, and with additional information gathered on this taxon and other species of *Cyanea*, inbreeding depression is a concern in this species due to:
  - Presumed bird-pollinated outcrossing species with no observations of pollination (except insect floral visitation); suggests high rates of selfing
  - Only three maternal lines from a single population available for outplantings
  - A rough approximate of half of the developing fruit do not contain any seeds; which could be a sign of pollen limitation or inbreeding depression (or resource allocation)
- Given the very limited amount of genetic variation among the remaining lines, it will likely take many generations of human-mediated outcrossing to increase genetic variation with little return.
- If inbreeding depression is limiting the taxon's ability to survive in the wild, it may be necessary to study strategies for increasing the genetic variability of the taxon.

The Rare Plant Implementation Team has decided that it is unreasonable to hand-pollinate tall trees and unlikely that birds will be observed effectively pollinating* C. superba. *Therefore, OANRP may only decide to place game cameras at Palikea during flowering to observe visitation.

3) Fruit Dispersal: *Cyanea superba* Germination Trial

Limited dispersal and recruitment of *Cyanea superba* subsp. *superba* occurs at reintroduced populations, with the majority of fruits either depredated by rats (seeds are destroyed), or rotting on the plant and falling to the ground with limited subsequent seed germination and seedling survival, despite having typically high seed germination rates in fresh mature fruit (Pender et al. 2013, OANRP 2015a, 2015b, M. Akamine pers. obs.). A laboratory trial was completed in 2015 that explored two questions to gain a preliminary understanding of recruitment limitations and factors affecting seed sow success. Do seeds from senesced *C. superba* subsp. *superba* fruit have reduced viability as compared with those from fresh mature fruit? If seed sowing is used to sustain populations, does total removal of fruit pulp promote higher germination rates? The trial examined: 1) *C. superba* subsp. *superba* seed germination rates of senesced fruit in comparison with fresh material as a means of exploring the ability of seeds from senesced fruit to germinate upon falling on the ground vs. those from fresh fruit; and 2) germination rates of *C. superba* subsp. *superba* seeds with and without pulp extract to examine the effects of fruit pulp on germination during seed sow efforts.

Results: Seeds were approximately 50% less viable from senesced vs. fresh *C. superba* subsp. *superba* fruit regardless of treatment (untreated seeds: $t = 6.659$, $p < 0.001$; seeds with pulp extract: $t = 5.077$, $p < 0.001$). The reduced germination in seeds from senesced fruit limits recruitment potential in the absence of dispersers, as fresh mature fruits that are not consumed by dispersers will senesce and fall to the ground, and subsequently have reduced potential for germination. Fruit extract had no effect on germination of seeds for either senesced ($t = 0.022$, $p = 0.982$) or fresh mature fruit ($t = 1.075$, $p = 0.296$).



Seed viability from senesced and fresh mature fruits, with and without fruit pulp extract. Fruits from 10 individuals were used for each of four treatments (with a minimum of 1 fruit per plant per treatment): untreated seeds of senesced fruits, seeds of senesced fruits with pulp extract, untreated seeds of fresh fruits, and seeds of fresh fruits with pulp extract. The degree of senescence was not quantified, but was estimated to be less than 1 week following peak maturation. Number of seeds sown per sample ranged from 22 to 200 (mean = 88.4, SD = 37.4, 3534 total seeds sown).

- A follow up trial began in Dec 2015 to explore two questions to gain a more precise understanding of recruitment limitations in association with fruit senescence. 1) What is the rate of decline in seed germination as *C. superba* subsp. *superba* fruits senesce, and 2) at what point are seeds no longer viable? This laboratory trial explores the ability of seeds from senesced fruit to germinate over time upon falling on the ground.
- Mature fruits were collected from infructescences (not from the ground) from at least 5 individuals, to include a total of 24 fruits. Fruits were cleaned and stored individually at ambient room temperature at the OANRP Seed Laboratory. Seeds from 4 randomly chosen fruits were sown twice a week for 3 weeks, beginning on the collection date, for a total of 6 viability assay dates. Seeds were sown on agar in Petri dishes, to include 50 seeds per fruit (fruits typically contain 100-200 seeds each). Petri dishes will be stored in a Percival Controlled Environment Chamber (with diurnal light and temperature settings matching average monthly temperatures for the Nike missile installation at Pahole, at approximately 2100 feet elevation), and examined weekly for germination for a total of 10 weeks.

Germination Trial

Photos: clockwise fresh fruit, removing seeds from fruit (top), seedlings germinating in the OANRP Seed Lab (bottom).

3) Quantifying *In Situ* Fruit Dispersal & Understanding Effects of Limited Dispersal

OANRP will continue to support research of M.S. student Sean McDonald who is documenting dispersers and quantifying presence and amount of fruit dispersal at most C. superba PUs, as well as testing different ways to increase dispersal. We will also report on our research for effects of senescing fruit on seed quality. Together, we will provide management recommendations for increasing fruit dispersal if it is possible.

4) Increasing # Mature Plants at Reintroductions

- It is possible that the number of reproducing plants required for stability will not yield a stable population, despite maximum feasible threat control efforts.
- To obtain stable populations, we need to see replacement of existing mature outplants with naturally recruiting mature trees.
- Increasing the number of mature outplants at a reintroduction site will result in a larger *in situ* seed bank and hopefully increase the number of plants recruiting and surviving through each size class and outcompete the present threats.
- Allee effects may also contribute to population stability by increasing the attractiveness of the population to pollinators and dispersers.

OANRP proposes to continue to establish outplantings with enough plants to reach 50 mature outplants for each PU, while site selection and fruit dispersal studies are ongoing. If seed sow trials are able to produce a mature tree, this information will be applied to adjust our outplanting goals (how many trees to plant) to maintain 50 mature naturally recruited trees and stable population structure. While there was excitement about planting more plants, OANRP will wait until they have more information to direct the effort.

5) Threat Control

- All plantings are contained in fences to control ungulates, have some weeding ongoing, partial to maximum rodent control where reproducing plants are present, and receive slug control when the absence of rare native snails is known.
- Current PUs with all threats mitigated to a feasible extent still have not produced enough recruitment to yield stable populations.
- This level of threat control alone (ungulates, rodents, slugs, weeds) is not likely to produce stable populations at existing sites with the current number of plants.
- Pursuing ways to mitigate for additional threats (lack of pollinators and dispersers and climate change) may help in establishing stable populations.

OANRP proposes to maintain and optimize existing threat mitigation and research and develop new efforts to deal with effects of climate change (PU and microsite selection) and lack of pollination and fruit dispersal.

Monitoring Plan

- These existing and any new outplanting sites in MFS PUs will be monitored annually in Quarter 2, using the Hawaii Rare Plant Restoration Group (HRPRG) Rare Plant Monitoring Form (RPMF):
  - Kahanahaiki- MMR-E, MMR-H
  - Makaha- MAK-A
  - Manuwai- ANU-A
  - Palikea – PAK-A
- All other existing sites will be monitored bi-annually. The RPMF will be used to record population structure, age class, reproductive status, and vigor of all accessible plants. If there is any threat to the health and safety of plants due to repeated monitoring and/or tagging, reductions in the number of tagged individuals will be made so that no harm is done to the plants. This monitoring data will serve to document the populations at the remaining sites to guide threat management and genetic storage needs.

- Seedlings will be monitored to track survivorship and growth.

- From most recent veg monitoring, MU native understory/canopy median % cover is 25/15 at Kiki, 7.5/25 at Makaha, 7.5/15 at Kapuna (no data for Pahole), 7.5/20 for Manuwai, 7.5/25 for Kaluaa, 35/25 for Palikea.

Reintroduction Plan

Population Unit	Reintroduction Site(s)	Number of Plants to be planted*	Propagule Type	Propagule Population(s) Source	Number of Founders in Source Population	Plant Size	Pot Size
Kahanahaiki	MMR-E	100 (166%)	Immature Plants	MMR-A	3 founders	25cm	.5-1 gallon
	MMR-H	100 (166%)					
	MMR- B, D, F, G	0					
Pahole to Kapuna	Pahole: PAH-A	100 (137%)					
Pahole to Kapuna	Pahole: PAH-B	0					
Pahole to Kapuna	Kapuna: KAP- A,B	0					
Makaha	MAK- A	150					
Manuwai	ANU-A	150					
Puu Palikea	PAK-A***	150					
Lihue	SBW-A		Seed Sow			TBD	
Lower Opaeula	OPA-A		Seed sow			TBD	

*Number of plants to be planted: The target number for each site is listed followed by a percentage for sites with existing plantings. The total number planted (adjusted for time to mature after planting) was divided by the number of these plants that are mature. The percentage displayed is the multiplier needed to compensate for the survivorship of mature plants calculated for each site. The target number is multiplied by this percentage to get the number of plants to be planted. For sites with no existing or recently planted plants, the baseline 150 plants (50 of each of the three founders) will be planted initially, and more will be added if needed.

Reintroduction Plan Comments

- The reintroduction of *C. superba* into Kahanahaiki was the first endangered species in the nation to be reintroduced onto Army managed lands.
- The MMR-B, D, F, G sites in Kahanahaiki are no longer supplemented due to poor performance when compared with MMR-E and MMR-H.
- The sites in the Pahole to Kapuna PU at KAP-A, KAP-B and PAH-B are Oahu NARS reintroductions planted from 1995 to 1999. They are monitored and collected from but not extensively managed.
- Reintroduction protocols for *C. superba* are well developed and will be followed for future reintroductions. The propagule type, plant and pot size are standardized.
- The average time that plants take to mature is five years after outplanting.
- The Palikea site had only 20 plants planted in 2005 but will receive ~150 new plants in 2017. All other MFS PU sites will be supplemented as needed.

5 Year Action Plan

Proposed Actions for the following years:					
Population Unit	**MIP YEAR 12 October 1, 2015 – September 31, 2016**	**MIP YEAR 13 October 1, 2016 – September 31, 2017**	**MIP YEAR 14 October 1, 2017 – September 31, 2018**	**MIP YEAR 15 October 1, 2018 – September 31, 2019**	**MIP YEAR 16 October 1, 2019 – September 31, 2020**
Kahanahaiki	•Monitor & Collect •Rat Control •Slug control (partial) •Weed Control	•Monitor & Collect •Rat Control •Slug control (partial) •Weed Control	•Monitor & Collect •Rat Control •Slug control (partial) •Weed Control	•Monitor & Collect •Rat Control •Slug control (partial) •Weed Control	•Monitor & Collect •Rat Control •Slug control (partial) •Weed Control
Manuwai	•Monitor	•Monitor •Rat Control •Slug Control •Weed Control	•Monitor & Collect •Rat Control •Slug control •Weed Control	•Monitor & Collect •Rat Control •Slug control •Weed Control	•Monitor & Collect •Rat Control •Slug control •Weed Control
Makaha	•Monitor & Collect •Rat Control •Weed Control	•Monitor & Collect •Rat Control •Weed Control •Seed Sow	•Monitor & Collect •Rat Control •Weed Control	•Monitor & Collect •Rat Control •Weed Control	•Monitor & Collect •Rat Control •Weed Control
Pahole to Kapuna	•Monitor	•Monitor	•Monitor	•Monitor	•Monitor
Kaluaa	•Find potential seed sow sites		•Seed Sow	•Monitor	•Monitor
Lower Opaeula	•Find potential seed sow sites	•Seed Sow	•Monitor	•Monitor	•Monitor
Lihue	•Find potential seed sow sites	•Seed Sow	•Monitor	•Monitor	•Monitor
Puu Palikea	•Find Outplanting Site	•Seed Sow •Rat Control •Slug Control	•Introduce •Rat Control •Slug Control •Weed Control	•Monitor •Rat Control •Slug control •Weed Control	•Monitor •Rat Control •Slug control •Weed Control

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Mahalo

Chapter 5: *ACHATINELLA MUSTELINA* MANAGEMENT

5.1 BACKGROUND

In this chapter, OANRP *Achatinella mustelina* management is outlined for the next three years: July 2016-June 2017, July 2017-June 2018, and July 2018-June 2019. Highlights of the past two years and progress toward the goals set for the Evolutionary Significant Units (ESUs) are also outlined. There are a total of 8 managed populations within the six ESUs (Figure 1). ESU-B and ESU-D have two managed populations each because of their large geographic spread. The Makua Implementation Plan (MIP) set a goal of 300 snails in each of the 8 managed populations. The snail populations within the ESUs are divided into Population Reference Sites (PRS). Each PRS is a discrete grouping of snails based on proximity to other snail groups. There are many PRS in each ESU given the fragmented status of the populations. Genetic analysis of the ESUs is ongoing and more information on possibilities for mixing or not mixing populations in light of climate change can be found in Appendix ES-5.

In addition to the goal of 300 snails, the predators of *A. mustelina*, (Black rats (*Rattus rattus*), the Rosy Wolf Snail (*Euglandina rosea*), and Jackson's chameleons (*Trioceros jacksonii xantholophus*)) are to be controlled at managed sites. OANRP has made significant progress toward these goals over the years. At six of the eight managed populations in the ESUs, the goal of 300 snails is met (Table 1). At three ESUs (ESU-A, D, and F) enclosures are used to protect PRS from all threats. Populations within all enclosures are stable or increasing. In many ESUs rat control is ongoing. See ESU tables in each section for the threat control status at individual PRS.

Construction plans are being developed for three additional enclosures. OANRP plan to complete construction of an enclosure at Palikea North for ESU-E in the summer of 2017. OANRP plan to construct enclosures at Kaala (ESU-C) and West Makaleha (ESU-B) by the summer of 2018. With the completion of these additional enclosures and a successful translocation effort, all six ESUs will be protected from predators.

Figure 1: Map of Six ESUs

Map removed to protect rare resources. Available upon request

Table 1: ESU population, rat control, and enclosure status

ESU	# Snails in MFS PRS	# Snails in No Mgmt. PRS	# Snails in PRS with Rat Control	# Snails in Enclosures	Current and Future Enclosure Location
A	285	28	288	227 (Kahanahaiki) 61 (Pahole)	Kahanahaiki/Pahole
B1	330	15	330	0	West Makaleha†
B2	340	198	371	0	West Makaleha†
C	345	23	340	0	Kaala†
D1	689	42	689	689 (Hapapa)	Hapapa
D2	298	0	213	0	
D*	0	492	0	0	Kaala† and Hapapa
E	190	28	188	0	Palikea North†
F	566	13	569	64 (Palikea)	Palikea

*Snails from this portion of the ESU are not managed for stability in the MIP

†Enclosure not yet constructed

5.2 ESU-A

ESU-A *Achatinella mustelina*

Figure 2: Map of ESU-A

Map removed to protect rare resources. Available upon request

5.2.1 Management History and Population Trends

Spanning parts of Kahanahaiki Gulch and Pahole Natural Area Reserve, there are 14 PRS at ESU-A (Table 2). The two enclosure sites are designated MFS (Manage for Stability) and the remaining are NM (No Management). The MFS PRS have 285 snails while the NM PRS snails have all been moved into one of the two snail enclosures. OANRP visit PRS at least three times to ensure any remaining snails are translocated. One additional new site was found last year (PAH-D) and additional survey work is needed along the Pahole rim area. There was a large effort to move and protect the NM PRS in either of the two enclosures. OANRP manages the enclosure at Kahanahaiki (MMR-A) and successful habitat restoration efforts are ongoing with increasing native habitat and cover throughout the enclosure and snails utilizing reintroduced plants for food and cover. SEPP manages the Pahole enclosure (PAH-B) and native cover is also increasing at that enclosure following restoration efforts. Clearing has begun around the Pahole enclosure to rebuild it in the near future to increase its size and level of predator protection. Rat control continues across the Kahanahaiki MU and includes protection around the enclosure at Pahole. *Euglandina rosea* are assumed to be ubiquitous across the habitat. *Trioceros jacksonii xantholophus* have not been seen in this area.

Table 2: ESU-A population structure and threat control summary

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes: Large	Medium	Small	Unk	Threat Control: Ungulate	Weed	Rat	Euglandina rosea	Jackson's Chameleon
Achatinella mustelina												
ESU: A Pahole to Kahanahaiki												
KAP-A **Just below Makua rim on trail above hunter's cabin.**	No Management	0	2015-10-14	0	0	0	0	Yes	No	No	No	No
KAP-B **Chaher weeding site**	No Management	0	2013-10-08	0	0	0	0	Yes	No	No	No	No
KAP-C **One Acre Site**	No Management	0	2015-10-28	0	0	0	0	Yes	No	No	No	No
LEH-F **West Makaleha off of Keawapilau ridge**	No Management	0	2016-03-30	0	0	0	0	Yes	No	No	No	No
MMR-A **Kahanahaiki Exclosure**	Manage for stability	224	2016-05-17	111	96	17	0	Yes	Partial	Yes	Yes	No
MMR-C **Maile Flats**	No Management	3 *	2016-05-17	2	1	0	0	Yes	Partial	Yes	No	No
MMR-D **Kahanahaiki Gulch**	No Management	0	2015-03-11	0	0	0	0	Yes	Partial	Yes	No	No
MMR-M **East Rim 2A ridge**	No Management	0 *	2016-03-30	0	0	0	0	Partial	No	No	No	No
MMR-N **Kahanahaiki gulch at Steph Joe's slug boxes**	No Management	0	2015-03-11	0	0	0	0	Yes	Partial	Yes	No	No
MMR-O **Giant Olopua**	No Management	0	2015-12-07	0	0	0	0	Yes	Partial	Yes	No	No
PAH-A **Cyasup Pahole gulch reintro lower site**	No Management	0	2011-07-15	0	0	0	0	Yes	No	No	No	No
PAH-B **Pahole Exclosure**	Manage for stability	61	2015-02-04	37	14	10	0	Yes	Partial	Yes	Yes	No
PAH-C **below Pahole snail exclosure**	No Management	0 *	2015-11-04	0	0	0	0	Yes	Partial	Yes	No	No
PAH-D **Along Makua Rim west of Kapuna fence**	No Management	28 *	2016-06-20	8	13	7	0	Yes	No	No	No	No
	ESU Total:	316		158	124	34	0					

*=Total Snails were Trans Located or Reintroduced

[shaded] = 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

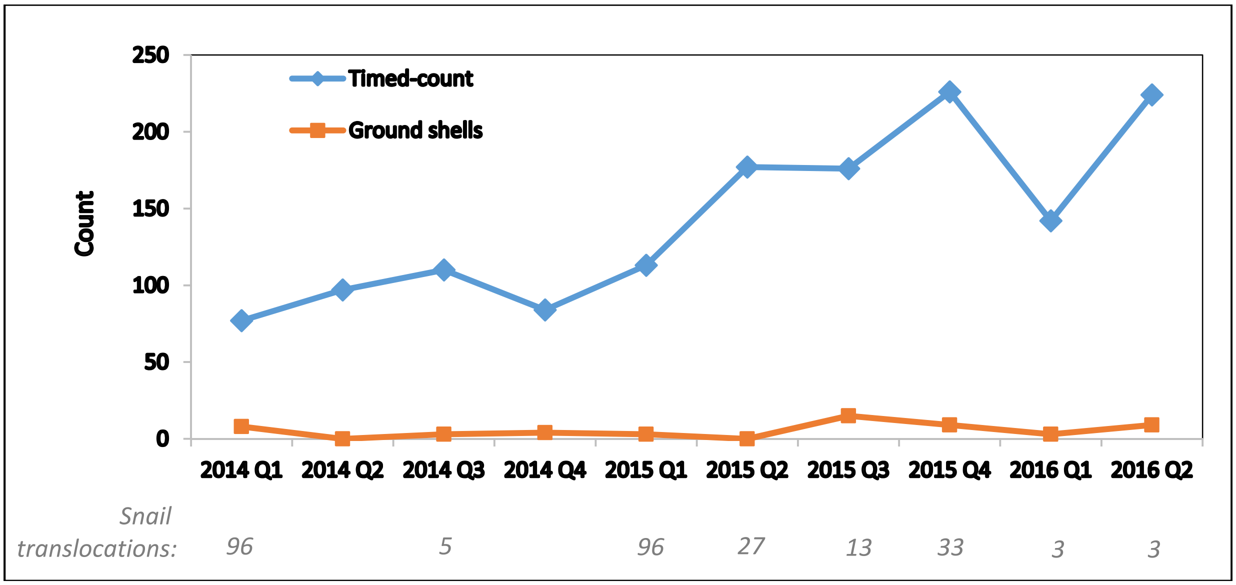
SizeClass	DefSizeClass
Large	>18 mm
Medium	8-18 mm
Small	< 8 mm

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.

5.2.1.1 MMR-A Kahanahaiki Enclosure PRS

The enclosure at Kahanahaiki is the focus of OANRP's management within ESU-A as all of the observed snails in Kahanahaiki have been translocated to the enclosure. Monitoring of the *A. mustelina* population within the enclosure has continued quarterly, including timed-counts and ground shell monitoring. There has been no evidence of predator incursion, and *A. mustelina* mortality has been very limited. A total of 276 snails have been translocated into the enclosure, including 52 from this year (July 1, 2015-June 30 2016). TCM (timed-count monitoring) records 224 snails during the most recent count. Only a fraction of existing snails are seen during TMC, thus there is a stable if not increasing trend within the enclosure (Figure 3). The lower numbers counted in Quarter 1 of 2016 were likely due to a combination of environmental conditions and less skilled observers. It was an unusually dry and windy night. In the future OANRP will consider repeating monitoring if conditions are not favorable and or if personnel skill is in question. Skill varies considerably among observers, and OANRP uses the most skilled observers available, when possible.

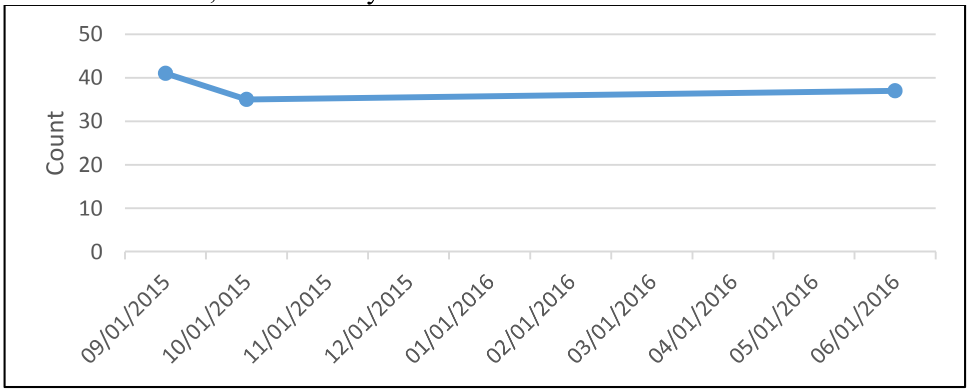
Figure 3: Quarterly timed-counts and ground shell counts for *A. mustelina* in the Kahanahiki snail enclosure from the first quarter of 2014 to the second quarter of 2016, with numbers of snails translocated into the enclosure over time.



5.2.1.2 PAH-B PRS

The enclosure at Pahole is the focus of SEPP's management in this area. Currently SEPP has secured funds to reconstruct the wall and increase the enclosure size. OANRP will assist in these efforts. Currently SEPP and OANRP are collaborating on enclosure designs and materials. TCM by SEPP in sampled areas in the enclosure suggest the population is relatively stable (Figure 4). There were once many more snails inside the enclosure but the habitat declined and snails disappeared. However through SEPP's weed control and outplanting efforts the habitat is improving, and with construction funded the future is optimistic.

Figure 4: Timed-counts of *Achatinella mustelina* in sampled areas of PAH-B, Pahole Enclosure, monitored by SEPP.



5.2.1.3 No Management (NM) PRS

All snails found at NM PRS within ESU-A have been translocated to the Kahanahaiki snail enclosure. OANRP visit sites at least three times to ensure any remaining snails are translocated. As time allows staff return for additional searches. Table 3 below summarizes the translocation efforts completed this year. A total of 52 snails were translocated.

Table 3: Translocations of *A. mustelina* into MMR-A Kahanahaiki Enclosure 2015-2016

Translocation Date	Population Reference Site	Small	Medium	Large	Total
2015-08-31	MMR-C Maile Flats	2	8	3	13
2015-11-04	PAH-C Below Snail Enclosure	3	5	12	20
2015-11-27	MMR-M East Rim	0	2	2	4
2015-12-07	MMR-C Maile Flats	2	3	4	9
2016-03-31	MMR-M East Rim	0	1	2	3
2016-05-17	MMR-C Maile Flats	0	1	2	3
Total		7	20	25	52

5.2.2 Future Management

OANRP will continue to work according to the monitoring plan (Table 4), and additional translocation efforts will be completed as outlined in the Three Year Action Plan below (Table 5). Threat control will continue around the existing enclosures, including tracking tunnels for *R. rattus*, and searches for *E. rosea*, and *T. jacksonii xantholophus*. Weed control and habitat improvements will continue cautiously to ensure there are no impacts to the snails. Installation of the remote monitoring system at Kahanahaiki has been delayed due to needed upgrades of the system by our vendor technicians. A new remote monitoring system will be installed in the near future. OANRP continues to investigate a debris alarm system. Once a suitable system is developed it will be deployed at Kahanahaiki and Pahole. OANRP will consider doing additional planting of snail host trees within the Kahanahaiki enclosure to enhance habitat in MIP Year 14.

Table 4: ESU-A Monitoring Plan for MFS PRS

PRS	Monitoring Type	Monitoring Interval	Survey Years	Comments
MMR-A Kahanahaiki Enclosure	TCM	quarterly to twice a year	all	Conduct night TCM with 2 personnel 2 hours each, for 4 person-hours total; quarterly until January 2018 to ensure stability, then twice a year thereafter.
	GSP	quarterly	all	GSP MMR-A.
PAH-B Pahole Enclosure	TCM/GSP	quarterly	all	Assist OSEPP as needed

Table 5: Three Year Action Plan for ESU-A

PRS	MIP YEAR 13 July 2016 – June 2017	MIP YEAR 14 July 2017 – June 2018	MIP YEAR 15 July 2018 – June 2019
MMR-A Kahanahaiki Enclosure	• Implement monitoring plan • Rat control • Install Remote Monitoring system • Install debris alarm • Maintain enclosure and monitor for predators • Improve habitat via weed control and restoration planting	• Implement monitoring plan • Rat control • Maintain enclosure and monitor for predators • Conduct additional outplanting if needed • Improve habitat via weed control and restoration planting	• Implement monitoring plan • Rat control • Maintain enclosure and monitor for predators • Improve habitat via weed control and restoration planting
PAH-B Pahole Enclosure	• Assist SEPP with instillation of remote monitoring system	• Assist SEPP with instillation of remote monitoring system	
MMR-M East Rim 2A Gulch	• Search for additional snails and translocate to Kahanahaiki enclosure		
PAH-D Along Makua Rim West of Kapuna Fence	• Assist SEPP with translocation to Pahole Enclosure		

5.3 ESU-B

ESU-B covers a large geographic area and is therefore divided into two units: ESU-B1 along the north-facing slopes of the southern Makua rim and ESU-B2 along the north-facing rim of the Mokuleia Forest Reserve. The subdivision of ESU-B has some genetic basis, see Makua Implementation Plan. Management of ESU-B1 is focused at Ohikilolo (Figure 5). ESU-B2 includes the gulches in Makaleha (Figure 7).

Figure 5: Map of ESU-B1

Map removed to protect rare resources. Available upon request

5.3.1 ESU-B1 Management History and Population Trends

There are two MFS PRS within ESU-B1, MMR-E (Ohikilolo Mauka) and MMR-F (Ohikilolo Makai) (Table 6). A combined total of 330 snails were observed during the most recent TCM at these PRS. There are seven NM PRS (not all are depicted in Figure 5). These sites had low numbers when last monitored more than ten years ago, and have not been monitored since. The designation for MMR-H (Koiahi) was changed from MFS to NM as numbers declined below the designated translocation trigger (see discussion below) and snails were moved from this location to MMR-F.

The Ohikilolo MU remains unique in that *E. rosea* have never been recorded in the area. *T. jacksonii xantholophus* have also never been seen. Rats are controlled across the sections with snails with an A24 and Victor snap trap grid. OANRP staff were excluded from the MU for six months this year due to a UXO incident. This impacted rodent numbers (see Rodent Management Chapter 8 for details). In addition, a rat bait hand broadcast was completed this year to use up bait remaining from the Kahanahaiki project (see Rodent Management Chapter 8 for details) and for a knockdown of rodents following the period of no access. Occasionally, goats breach the fenceline into the upper portions of the MU, therefore the ungulate control is designated as partial control.

Table 6: ESU-B1 population structure and threat control summary

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes: Large	Medium	Small	Unk	Threat Control: Ungulate	Weed	Rat	Euglandina rosea	Jackson's Chameleon
Achatinella mustelina												
ESU: B1 Ohikilolo												
MMR-E Ohikilolo Mauka	Manage for stability	78	2016-07-21	53	19	6	0	Yes	Partial	Yes	No	No
MMR-F Ohikilolo Makai	Manage for stability	252	2016-07-20	160	68	24	0	Yes	Partial	Yes	No	No
MMR-G Ohikilolo Alemac Site	No Management	0	2016-04-20	0	0	0	0	Yes	No	No	No	No
MMR-H Ohikilolo Koiahi Prikaa Reintro Site	No Management	0 *	2016-07-19	0	0	0	0	Yes	No	Yes	No	No
MMR-I Hedpar MMR-B	No Management	2	2002-06-03	2	0	0	0	Yes	No	No	No	No
MMR-J One ridge east of Lower Makua Camp	No Management	5	2000-11-27	0	0	0	5	Partial	No	No	No	No
MMR-K Ctesqu ridge	No Management	3	1998-03-02	0	0	0	3	Partial	No	No	No	No
MMR-L Myrsine along Ohikilolo fence from 3 pts	No Management	5	1998-03-03	5	0	0	0	Partial	No	No	No	No
	ESU Total:	345		220	87	30	8					

*=Total Snails were Trans Located or Reintroduced

[shaded] = 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

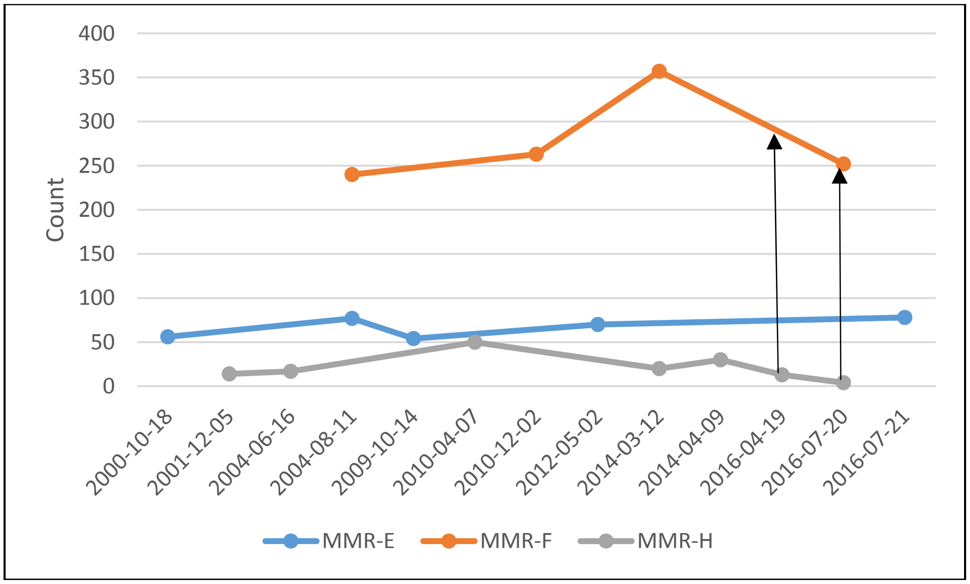
SizeClass	DefSizeClass
Large	>18 mm
Medium	8-18 mm
Small	< 8 mm

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.

5.3.1.1 MMR-E Ohikilolo Mauka PRS

OANRP conducted TCM on July 21, 2016 with protocols standardized in 2012. A total of 78 snails were counted compared to 70 snails in 2012. Thus the PRS appears to be stable (Figure 6). There are numerous *Myrsine lessertiana* recruiting in the area providing improved habitat for the snails. As with *Pritchardia kaalae* in the area, recruitment is likely due to rat control.

Figure 6: Population counts of *Achatinella mustelina* at MMR-E Ohikilolo Mauka PRS, MMR-F Ohikilolo Makai PRS, MMR-H Ohikilolo Koiahi Prikaa Reintro PRS. Arrows indicate translocations of all snails found at MMR-H to MMR-F.



5.3.1.2 MMR-F Ohikilolo Makai PRS

A TCM was conducted in 2014 and staff followed-up with another survey on July 20, 2016 with standardized protocols. During the later survey, a total of 252 snails were counted, including 24 small, 68 medium and 160 large snails. However, in 2014, a total of 357 snails were counted. The higher numbers observed in 2014 were likely due to the fact that the most experienced observers conducted this survey. This includes the OANRP Snail Specialist as well as SEPP staff. The counts in 2004 and 2010 were more similar to the 2016 numbers and conducted by only OANRP staff. With observer skill level taken into consideration and no other evidence of increasing predation, this PRS likely has stable numbers. OANRP will continue to train and calibrate staff on snail detection (including the consistent use of close focusing binoculars) for more reliable data results. A total of 17 snails were translocated from MMR-H to this PRS.

For the future, OANRP is proposing to only monitor the entire PRS every four years and monitor a smaller subset area with qualified staff every two years. This is proposed given the amount of staffing effort required to monitor the entire PRS, to lessen trampling impacts to habitat, and the apparently stable numbers. Monitoring a subset area every two years should still allow us to be able to detect population trends owing to increased or decreased predation or other factors. For rat control, OANRP will investigate the possibility of expanding the rat control grid to include snail areas that aren't currently managed for rats.

5.3.1.3 No Management PRS

MMR-H (Ohikilolo Koiahi Prikaa Reintro) was a MFS PRS until this year. OANRP and the IT discussed plans for the PRS in 2015 and 2016. It was agreed that if there was greater than 50% decline in numbers the snails would be translocated to the Ohikilolo Makai PRS. Monitoring of this PRS was conducted on April 9, 2015. Because a decline was observed from 32 snails to 13, the remaining snails were translocated to MMR-F, 700 meters further up the ridge into the forest patch where the majority of the Ohikilolo snails are found (MMR-F) (Table 7). No fresh ground shells have been observed at MMR-H during surveys and it is not clear what caused the decline in number counted nor the fate of the shells. The surrounding area was searched and expert observers were used. OANRP staff returned on July 19, 2016 and moved four additional snails to MMR-F. At least one additional trip will be conducted to translocate any remaining snails. Rat control has ceased at MMR-H. All other NM PRS are not a management priority as numbers are low and monitoring dates are old.

Table 7: Translocations of *A. mustelina* into MMR-F Ohikilolo Makai 2015-2016

Translocation Date	Population Reference eSite	Small	Medium	Large	Total
2016-4-09	MMR-H Koiahi	1	6	6	13
2016-7-19	MMR-H Koiahi	0	1	3	4
Total		1	7	9	17

5.3.2 ESU-B1 Future Management

OANRP will continue monitoring as indicated below (Table 8). Rat control and the use of tracking tunnels will continue across the MU (Table 9); however, rat control has ceased at MMR-H. OANRP will visit this site at least once more to translocate any remaining snails. Searches for *E. rosea*, and *T. jacksonii xantholophus* in the course of other work will also continue. A subset of snails from ESU-B1 may be moved into the future planned enclosure at 3 Points/West Makaleha along with the ESU-B2 snails pending further genetic work, risk analysis given climate change and threat levels, and success of the translocation of the ESU-B2 snails following enclosure completion.

Table 8: ESU-B1 monitoring plan for MFS PRS

PRS	Monitoring Type	Monitoring Interval	Survey Years	Comments
MMR-E Ohikilolo Mauka	TCM	Every 2 years	2018, 2020	Eight person-hour day survey with binoculars
	GSP	Annual	All	GSP MMR-E-1
MMR-F Ohikilolo Makai	TCM	Every 2 years	2018, 2022	TCM with binoculars. Effort to be determined based on chosen areas.
	TCM	Every 4 years	2020	46 person-hour day TCM with binoculars
	GSP	Annual	All	GSP MMR-F-4

Table 9: Three Year Action Plan for ESU-B1

PRS	MIP YEAR 13 July 2016 – June 2017	MIP YEAR 14 July 2017 – June 2018	MIP YEAR 15 July 2018 – June 2019
MMR-E Ohikilolo Mauka	• Implement monitoring plan • Rat control	• Implement monitoring plan • Rat control	• Implement monitoring plan • Rat control • Consider moving a sample of snails to 3 Points enclosure
MMR-F	• Implement monitoring plan • Rat control	• Implement monitoring plan • Rat control	• Implement monitoring plan • Rat control

Ohikilolo Makai			• Consider moving a sample of snails to 3 Points enclosure
MMR-H Ohikilolo Koiahi	• Translocate at least one more time to MMR-F		

ESU-B2

Figure 7: Map of ESU-B2

Map removed to protect rare resources. Available upon request

5.3.3 ESU-B2 Management History and Population Trends

There are two MFS PRSs within ESU-B2 below the Kaala Rd at: LEH-C (Culvert 69) and LEH-D (Culvert 73) (Table 10). Together these PRS have 340 observed snails. There are nine NM PRS, many of which have not been surveyed for many years. Numbers have likely declined at these sites. OANRP are working to construct an enclosure at West Makaleha by the summer of 2018 to manage the snails in this portion of ESU-B. Larger NM PRS will be visited to translocate snails once the enclosure is complete. Currently rats are controlled with A24s at LEH-C along the ridge crest and also at LEH-D. While *E. rosea* are assumed present throughout ESU-B2, *T. jacksonii xantholophus* have not been observed. The goat population and habitat damage has increased over the last several years. With the recent completion of the Kaala Road fence, and with additional strategic fencing planned for the upper Makaleha area, aggressive goat and pig control is needed to eliminate populations as their impacts will now be in a more concentrated area.

Table 10: ESU-B2 population structure and threat control 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: B2 East and Central Makaleha												
AAW-A Kaawa Gulch	No Management	20	2016-04-06	11	5	4	0	No	No	No	No	No
LEH-A Central Makaleha (culvert 39)	No Management	49	2011-05-18	29	15	5	0	No	No	No	No	No
LEH-B East Makaleha (culvert 45)	No Management	33	2011-04-19	11	12	10	0	No	No	No	No	No
LEH-C East Branch of East Makaleha (culvert 69)	Manage for stability	263	2014-07-24	201	56	6	0	No	No	Yes	No	No
LEH-D East Branch of East Makaleha (culvert 73)	Manage for stability	77	2016-07-13	45	31	1	0	No	No	Yes	No	No
LEH-E East Makaleha (culvert 56-57)	No Management	31	2011-04-20	16	7	8	0	No	No	Yes	No	No
LEH-G East Makaleha (culvert 59)	No Management	3	2006-04-17	3	0	0	0	No	No	No	No	No
LEH-H East Makaleha (culvert 54)	No Management	34	2000-03-23	0	0	0	34	No	No	No	No	No
LEH-I East Makaleha (culvert 67)	No Management	16	2000-03-23	16	0	0	0	No	No	No	No	No
LEH-J East Makaleha (culvert 69 - lower down	No Management	2	2006-11-16	2	0	0	0	No	No	No	No	No
LEH-K Culvert 43 Ridge	No Management	6	2009-08-04	3	3	0	0	No	No	No	No	No
LEH-L 3 Points	No Management	4	2014-04-07	3	0	1	0	Yes	No	No	No	No
	ESU Total:	538		340	129	35	34					

Size Class Definitions

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

*=Total Snails were Trans Located or Reintroduced

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

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

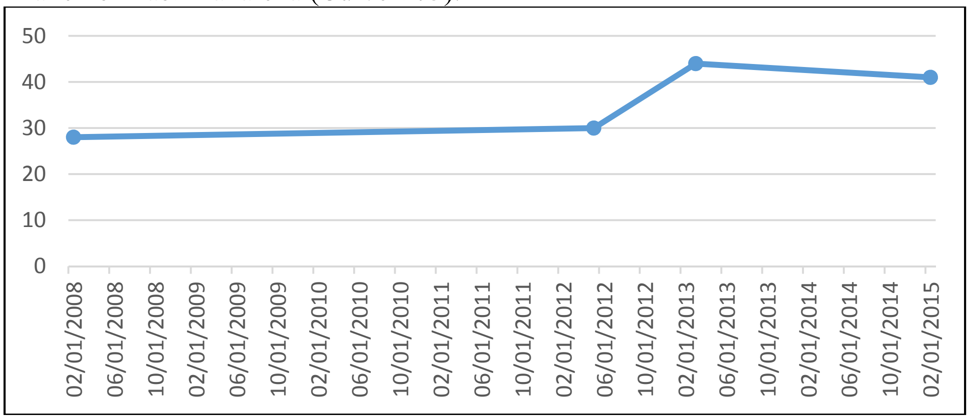
5.3.3.1 LEH-C East Branch of East Makaleha Culvert 69 PRS

OANRP will conduct TCM here in Quarter 4 of 2016. There is not a suitable site here for a GSP because most of the snails are found while on rappel and the area in general is very steep.

5.3.3.2 LEH-D East Branch of East Makaleha Culvert 73 PRS

A survey was conducted on July 13, 2016 with a total of 77 snails observed. This included an expanded search area, in which new areas inhabited by snails were found. Some of these snails could potentially be translocated into the planned snail enclosure at West Makaleha. Due to weather, a TCM for this year was cancelled and will be rescheduled soon. This area is also very steep with a predominant uluhe understory, determined to be inappropriate for GSP monitoring. In place of a GSP, the TCM is performed annually.

Figure 8: Timed Count Monitoring of *Achatinella mustelina* at LEH-D East Branch of East Makaleha (Culvert 73).



5.3.3.3 No Management PRS

The nine NM PRS are not a priority for OANRP. These sites will be visited opportunistically. Once the West Makaleha enclosure is completed, OANRP will translocate snails into it from at least the larger sites and opportunistically visit the smaller sites.

5.3.4 ESU-B2 Future Management

OANRP will conduct monitoring as outlined below (Table 11). Rat control will continue at LEH-C (Culvert 69) and LEH-D (Culvert 73) (Table 12). OANRP will pursue building a snail enclosure at West Makaleha/3 Points for ESU-B snails in Makaleha. Once the enclosure construction is underway, OANRP will finalize translocation plans with the IT (Implementation Team). OANRP will also likely be assisting State of Hawaii NARS staff with material transport of fencing materials for the strategic fences along sections of the Makaleha area and with future goat and pig control efforts.

Table 11: ESU-B2 Monitoring Plan for MFS PRS

PRS	Monitoring Type	Monitoring Interval	Survey Years	Comments
LEH-C East Culvert 69	TCM	every 2 years	2016, 2018	Conduct night TCM for 12 person-hours, and day TCM for 24 person-hours in steep areas of site (see prior notes to replicate search areas).
LEH-D East Culvert 73	TCM	annual	all	Conduct day TCM for 8 person-hours.

Table 12: Three Year Action Plan for ESU-B2

PRS	MIP YEAR 13 July 2016 – June 2017	MIP YEAR 14 July 2017 – June 2018	MIP YEAR 15 July 2018 – June 2019
LEH-C East Culvert 69	• Implement monitoring plan • Rat control • Pursue construction of enclosure at 3 Points	• Implement monitoring plan • Rat control • Pursue construction of enclosure at 3 Points	• Implement monitoring plan • Rat control • Translocate snails to 3 Points enclosure
LEH-D East Culvert 73	• Implement monitoring plan • Rat control • Pursue construction of enclosure at 3 Points	• Implement monitoring plan • Rat control • Pursue construction of enclosure at 3 Points	• Implement monitoring plan • Rat control • Translocate snails to 3 Points enclosure
NM PRS			• Translocate snails to 3 Points enclosure

5.4 ESU-C

Figure 9: Map of ESU-C

Map removed to protect rare resources. Available upon request

5.4.1 ESU-C Management History and Population Trends

There are two MFS PRS with 345 observed snails at ESU-C, SBW-A (North Haleauau Hame Ridge) and SBW-W (Skeet Pass) (Table 13). There are a number of NM PRS that have very few total observed snails and have not been monitored recently. OANRP conducts rat control at both MFS PRS. SBW-B (North Haleauau One Ridge North of Hame) was re-designated as a NM PRS (see discussion below). *Euglandina rosea* are present across the ESU. *Trioceros jacksonii xantholophus* was seen once in the lower elevational area of Lihue MU and do not seem to be common across the area. OANRP plan to construct an enclosure on the slopes of Kaala by the summer of 2018. A translocation plan will be developed with the IT once enclosure construction is underway. Ungulate control for pigs and goats is ongoing. Goats are occasionally observed along the ridgeline between Manuwai and Lihue Management Units in the vicinity of the historic snail populations and low numbers of pigs are still present in the Lihue fence area.

Table 13: ESU-C population structure and threat control summary

Number of Snails Counted

Achatinella mustelina

E SU: C Schofield Barracks West Range, Alaiheihe and Palikea Gulches

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes: Large	Medium	Small	Unk	Threat Control: Ungulate	Weed	Rat	Euglandina rosea	Jackson's Chameleon
ALI-A Palikea gulch	No Management	0	2009-06-02	0	0	0	0	No	No	No	No	No
ALI-B Palikea gulch west. Just east of Alaiheihe/Palikea dividing ridge.	No Management	0	2009-06-02	0	0	0	0	No	Partial	No	No	No
ANU-A Manuwai gulch	No Management	1	2004-06-02	0	1	0	0	Yes	No	No	No	No
IHE-A Alaiheihe Gulch Western Most Site	No Management	0	2005-03-22	0	0	0	0	No	No	No	No	No
IHE-B Alaiheihe middle site "Ptemac Site"	No Management	3	2009-06-02	1	2	0	0	No	No	No	No	No
IHE-C Alaiheihe below Nalu's LZ, TT's spot	No Management	0	2005-03-22	0	0	0	0	No	No	No	No	No
SBW-A North Haleauau Hame Ridge	Manage for stability	42	2015-12-16	24	18	0	0	Yes	Partial	Yes	No	No
SBW-B North Haleauau one ridge north of Hame	No Management	1	2013-11-11	1	0	0	0	Yes	Partial	Yes	No	No
SBW-C North Haleauau just above Pouteria pair territory	No Management	0	2009-09-06	0	0	0	0	Yes	No	No	No	No
SBW-P South Water gulch by Stenogyne kanehoana	No Management	0	2015-09-21	0	0	0	0	Yes	No	No	No	No
SBW-W Skeet Pass	Manage for stability	303	2014-08-27	190	89	24	0	Partial	Partial	Yes	No	No
SBW-X elepaio #4	No Management	1	2009-11-23	0	1	0	0	Yes	No	Partial	No	No
SBW-Y Elepaio #8	No Management	3	2009-11-23	0	3	0	0	Yes	No	Partial	No	No
SBW-Z Clair's Ridge	No Management	14	2010-06-03	10	4	0	0	Yes	No	No	No	No
	ESU Total:	368		226	118	24	0					

Size Class Definitions

Size Class	Def Size Class
Large	>18 mm
Medium	8-18 mm
Small	< 8 mm

*=Total Snails were Trans Located or Reintroduced

[shaded] = Threat to Taxon at Population Reference Site

No Shading = Absence of threat to Taxon at Population Reference Site

Yes=Threat is being controlled at PopRefSite

No=Threat is not being controlled at PopRefSite

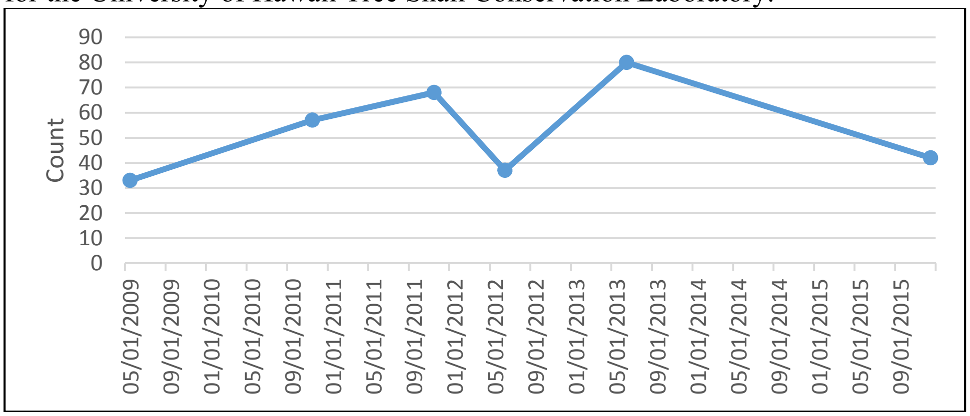
Partial=Threat is being partially controlled at PopRefSite

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

5.4.1.1 SBW-A North Haleauau-Hame Ridge PRS

This site was last surveyed on December 16, 2015 when a total of 42 snails were counted (Figure 10). It is difficult to get permission to camp here and perform night surveys as the site is located behind the live fire ranges. The majority of the snails live on non-native *Psidium cattleianum,* which is considered an inferior host tree for *A. mustelina*. This may help explain the lack of population growth in addition to the sometimes sporadic rat control due to range access issues.

Figure 10: Population counts of *Achatinella mustelina* at SBW-A, North Haleauau Hame Ridge. On the 2013 observation date, 10 snails were collected for the University of Hawaii Tree Snail Conservation Laboratory.



5.4.1.2 SBW-W Skeet Pass PRS

On August 27, 2014 a total of 303 snails were counted while surveying. In previous survey efforts, OANRP was exploring snail locations. It is very steep habitat and ropes have been used to access some areas. The monitoring plot for standardized TCM will be determined this year. Individuals in this PRS will be translocated once the enclosure at Kaala is complete.

5.4.1.3 No Management PRS

There are a total of 12 sites in this category and many of them have not been surveyed recently. Although most of them only had a few snails, as time allows OANRP will conduct surveys to ascertain whether or not there are any snails surviving. SBW-B (North Haleauau One Ridge North of Hame) was designated as NM this year. In 2009 seven snails were translocated to this area from SBW-C, however only one snail was seen here on November 11, 2013. As time allows OANRP will continue to survey for snails in the area.

5.4.2 ESU-C Future Management

OANRP will conduct monitoring of the MFS PRS (Table 14) and construction of the enclosure at Kaala will be pursued (Table 15) as outlined below. OANRP will work with the IT to develop a translocation plan for snails once construction of the enclosure is underway. Searches for *E. rosea*, and *T. jacksonii xantholophus* in the course of other work will also continue. Ungulate control will also be ongoing.

Table 14: ESU-C Monitoring Plan for MFS PRS

PRS	Monitoring Type	Monitoring Interval	Survey Years	Comments
SBW-A North Haleauau	TCM	annual	all	Conduct night TCM for 6 person-hours.
SBW-W Skeet Pass PRS	TCM	every 2 years	2016, 2018	Conduct night TCM for 9.25 person-hours

Table 15: Three Year Action Plan for ESU-C

PRS	MIP YEAR 13 July 2016 – June 2017	MIP YEAR 14 July 2017 – June 2018	MIP YEAR 15 July 2018 – June 2019
SBW-A North Haleauau	• Implement monitoring plan • Rat control • Pursue construction of enclosure at Kaala	• Implement monitoring plan • Rat control • Complete construction of enclosure at Kaala	• Implement monitoring plan • Rat control • Translocate snails to Kaala enclosure
SBW-W Skeet Pass PRS	• Implement monitoring plan • Rat control • Pursue construction of enclosure at Kaala	• Implement monitoring plan • Rat control • Complete construction of enclosure at Kaala	• Implement monitoring plan • Rat control • Translocate snails to Kaala enclosure
NM PRS			• Translocate snails to Kaala enclosure

5.5 ESU-D

ESU-D covers a large geographic area and is therefore divided into three units: ESU-D1 in the Kaluaa area (including Hapapa), ESU-D2 in Makaha Valley and ESU-D in the Lihue area. ESU D1 and D2 have MFS PRS, however ESU-D does not. The geographic extremes were picked for management by the IT so that the greatest genetic diversity could be represented. These three groups will be discussed below from South to North in the following order D1, D, and D2.

Figure 11: Map of ESU-D1

Map removed to protect rare resources. Available upon request

5.5.1 ESU-D1 Management History and Population Trends

There is one MFS PRS at KAL-G (Puu Hapapa Snail Enclosure) (Table 16). During TCM, 689 snails were observed and the population appears to be stable or increasing (Figure 12). There are 10 NM PRS with few to no snails as they have been translocated into the enclosure. Habitat restoration efforts in the Puu Hapapa Enclosure are largely complete with a nearly continuous sub-canopy of native host plants now established to facilitate genetic communication of snails across the enclosure. Improvements to the barrier alarm and electric deterrence and alarm system for *E. rosea* are ongoing. Staff will continue to opportunistically survey and translocate snails if found at the 10 NM PRS. Threats are abundant outside of the enclosure with *E. rosea* and *T. jacksonii xantholophus* commonly seen. Pigs occasionally disturb snail habitat in the unfenced area of PRS SBS-B.

Table 16: ESU-D1 Population Structure and Threat Control 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: D1 North Kaluaa, Waieli, Puu Hapapa, and Schofield Barracks South Range													
ELI-A South Waieli Gulch North Branch	No Management	34	*	2014-03-05	22	10	2	0	Yes	No	No	No	No
ELI-B South Waieli Gulch, North Side of Ridge	No Management	0		2016-06-15	0	0	0	0	Yes	No	No	No	No
KAL-A Land of 10,000 snails	No Management	0	*	2014-03-06	0	0	0	0	Yes	Partial	Yes	Partial	No
KAL-B Gulch 1 Kaluaa	No Management	0	*	2015-02-12	0	0	0	0	Yes	Partial	No	No	No
KAL-C North Kaluaa	No Management	0	*	2015-01-27	0	0	0	0	No	No	No	No	No
KAL-D Gulch 3	No Management	0	*	2015-01-14	0	0	0	0	Yes	Partial	No	No	No
KAL-E Gulch 2	No Management	8		2012-04-16	8	0	0	0	Yes	No	No	No	No
KAL-F Central Kaluaa South Branch	No Management	0	*	2016-06-06	0	0	0	0	Yes	No	No	No	No
KAL-G Puu Hapapa snail enclosure	Manage for stability	689		2016-02-17	309	332	48	0	Yes	Partial	Yes	Yes	Yes
MIK-A Mikilua Gulch	No Management	0		2012-10-04	0	0	0	0	No	No	No	No	No
SBS-A Moho Gulch Lamsan and Amamic exclosure	No Management	0		2012-12-19	0	0	0	0	Yes	No	No	No	No
SBS-B Puu Hapapa	No Management	0	*	2013-12-11	0	0	0	0	No	No	No	No	No
	ESU Total:	731			339	342	50	0					

*=Total Snails were Trans Located or Reintroduced

[shaded] = 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

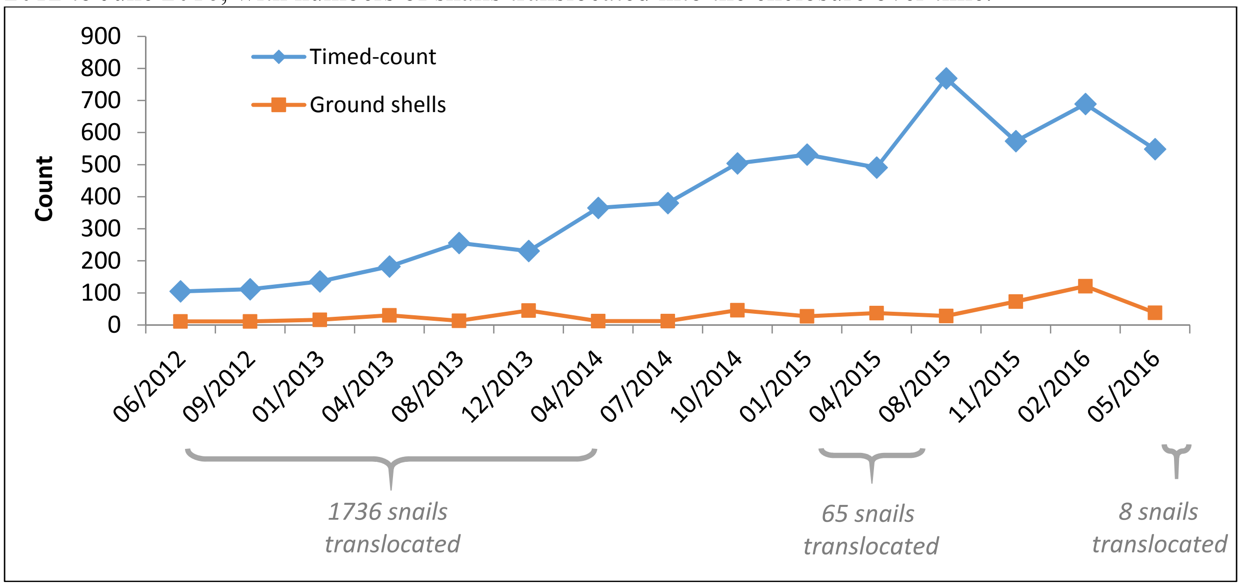
SizeClass	DefSizeClass
Large	>18 mm
Medium	8-18 mm
Small	< 8 mm

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.

5.5.1.1 KAL-G Puu Hapapa Snail Enclosure PRS

A total of 689 snails were observed during TCM on February 17, 2016 and most recently 548 snails on May 11, 2016 (Figure 12). Though TCM counts oscillate, the population appears to be stable if not increasing. This is most strongly supported by data since July of 2014. In July 2014 there were 308 snails counted. A total of 73 snails have been added since that time; however, TMC has recorded a high of 769 snails. Staff continue to conduct TCM here on a quarterly basis. The habitat continues to improve and the snails appear to be spreading out into new vegetation as outplanted trees grow larger. In the past year, no *T. jacksonii xantholophus* or *E. rosea* have been found inside the enclosure. Staff have been diligent in trimming the trees along the fence walls to prevent ingress of any *T. jacksonii xantholophus*. SEPP monitors other rare snail taxa which they have translocated into the enclosure, including *Amastra spirizona* from Makaha, *Laminella sanguinea* from the Waieli side of Puu Hapapa, *Amastra intermedia* from Mikilua and Daniel Chung's captive propagation project, *Cookeconcha sp.* from Puu Hapapa, and *Leptachatina sp.* from Mikilua.

Figure 12: Timed-counts and ground shell counts for *A. mustelina* in Hapapa snail enclosure from June 2012 to June 2016, with numbers of snails translocated into the enclosure over time.



5.5.1.2 No Management PRS

The ten NM PRS are not monitored regularly. With a high abundance of threats, these sites will likely continue to decline. OANRP staff opportunistically translocate the few snails remaining into the enclosure. Table 17 shows how the number of snails from which population that were translocated into the snail enclosure in the past year.

Table 17: Translocations of *A. mustelina* into KAL-G Hapapa Enclosure 2015-2016

Translocation Date	Population Reference Site	Small	Medium	Large	Total
2015-08-11	AchMus.KAL-C North Kaluaa	0	0	1	1
2016-06-07	AchMus.KAL-F Central Kaluaa South Branch	0	2	4	6
2016-06-15	AchMus.ELI-B South Waieli Gulch	0	1	1	2
Total		0	3	6	9

5.5.2 ESU-D1 Future Management

OANRP staff will continue monitoring KAL-G (Puu Hapapa Snail Enclosure) (Table 18) and management will continue (Table 19) as planned. Threat control will continue around the existing enclosure, including tracking tunnels for *R. rattus*, and searches for *E. rosea*, and *T. jacksonii xantholophus*. Weed control and habitat improvements will continue cautiously to ensure there are no impacts to the snails in the enclosure. Improvements to the barrier alarm system and electric deterrence system for *E. rosea* will also be installed in the coming year. Habitat improvements will also continue in the area surrounding the enclosure. Pig control at the SBS-B population will be done as needed as well as any further translocations from this PRS.

Table 18: ESU-D1 Monitoring Plan for MFS PRS

PRS	Monitoring Type	Monitoring Interval	Survey Years	Comments
KAL-G Puu Hapapa Snail Enclosure	TCM	quarterly	all	Conduct night TCM with 4 personnel for 7 person-hours total. Consider limiting TCM to twice a year.
	GSP	quarterly	all	GSP KAL-G-1

Table 19: Three Year Action Plan for ESU-D1

PRS	MIP YEAR 13 July 2016 – June 2017	MIP YEAR 14 July 2017 – June 2018	MIP YEAR 15 July 2018 – June 2019
KAL-G Puu Hapapa Snail Enclosure	• Implement monitoring plan • Rat control • Maintain enclosure and monitor for predators • Improve habitat via weed control and restoration planting	• Implement monitoring plan • Rat control • Maintain enclosure and monitor for predators	• Implement monitoring plan • Rat control • Maintain enclosure and monitor for predators

5.5.3 ESU-D No management PRS

Figure 13: Map of ESU-D

Map removed to protect rare resources. Available upon request

All of these populations are not being managed and have not been recently surveyed. OANRP recommends performing current surveys and moving some of these snails into the Puu Hapapa snail enclosure given the high level of predation. While this was not supported by the IT in previous years there is new genetic data to review and consider. OANRP looks forward to working with the IT to investigate this management recommendation.

Table 20: ESU-D Population Structure and Threat Control Summary

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes: Large	Medium	Small	Unk	Threat Control: Ungulate	Weed	Rat	Euglandina rosea	Jackson's Chameleon
Achatinella mustelina												
ESU: D No Management ESU Sites of Waianae Kai, Kaluaa, Puhawai, SBS, and SBW												
PHW-A Lualualei, Puhawai below Tetfil finger	No Management	11	2009-11-05	10	0	1	0	No	No	No	No	No
SBS-C Lower Moho Gulch - Jennifer Crummer's spot	No Management	0	2012-12-19	0	0	0	0	No	No	No	No	No
SBS-D Two gulches west of Moho gulch enclosure	No Management	11 *	2016-08-16	8	3	0	0	No	No	No	No	No
SBW-AA Mt Kaala below blue trail fence	No Management	12	2012-10-25	7	5	0	0	Yes	No	No	No	No
SBW-BB Below transect 790	No Management	15	2013-10-10	6	5	4	0	Yes	No	No	No	No
SBW-D Kaala-Kalena ridge on "M" in Military	No Management	1	2000-02-18	0	0	0	1	Yes	Partial	No	No	No
SBW-E Kaala-Kalena ridge between Military and Reservation	No Management	1	2000-02-18	1	0	0	0	Yes	No	No	No	No
SBW-F North Mohiakea Banana Gulch	No Management	4	2006-06-22	3	0	1	0	Yes	No	No	No	No
SBW-G South of Puu Kalena	No Management	0	2003-10-14	0	0	0	0	Yes	Partial	No	No	No
SBW-H North Branch of South Mohiakea	No Management	9	2015-06-23	5	2	2	0	Yes	No	No	No	No
SBW-I South Mohiakea Sicyos site	No Management	8	2016-06-21	6	1	1	0	Yes	No	No	No	No
SBW-J Zandip site along Kalena-Kumakalii Ridge	No Management	10	2000-05-17	10	0	0	0	Yes	Partial	No	No	No
SBW-K Kumakalii-Kalena ridge-"TR" gulch on the map by "Wahiawa District"	No Management	47	2009-11-05	30	9	8	0	Yes	No	No	No	No
SBW-L Kalena-Kumakalii Ridge-Dike rock gulch	No Management	43	2009-11-04	22	10	11	0	Yes	No	No	No	No
SBW-M Puu Kumakalii	No Management	23	2009-06-24	17	4	2	0	Yes	No	No	No	No
SBW-N 1st Peak North of Kolekole Pass	No Management	0	2009-06-24	0	0	0	0	No	No	No	No	No
SBW-O North of Puu Kalena Alstri Notch	No Management	0	2014-11-16	0	0	0	0	Yes	Partial	No	No	No

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes: Large	Medium	Small	Unk	Threat Control: Ungulate	Weed	Rat	Euglandina rosea	Jackson's Chameleon
SBW-Q North of Puu Kalena below Schtri Notch	No Management	81	2007-08-21	47	32	2	0	Yes	No	No	No	No
SBW-R Mt. Kaala southern end of Haleauau fencline	No Management	121	2014-09-11	92	25	4	0	Yes	Partial	No	No	No
SBW-S Upper Banana Gulch	No Management	4	2007-08-29	3	1	0	0	Yes	No	No	No	No
SBW-T Albizzia Gulch	No Management	33	2009-06-10	25	1	7	0	Yes	No	No	No	No
SBW-U Gulch #1/Tri Gulch Camp	No Management	17	2007-08-22	13	3	1	0	Yes	No	No	No	No
SBW-V Gulch #4/Tri Gulch Camp	No Management	31	2007-08-22	21	9	1	0	Yes	No	No	No	No
WAI-A Waianae Kai - Hesarb site	No Management	10	2000-06-26	0	0	0	10	No	No	No	No	No
	ESU Total:	492		326	110	45	11					

*=Total Snails were Trans Located or Reintroduced

[shaded] = 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.

5.5.4 ESU-D2

Figure 14: Map of ESU-D2

Map removed to protect rare resources. Available upon request

5.5.4.1 ESU-D2 Management History and Population Trends

There are seven MFS PRS in ESU-D2 with a total of 298 observed snails (Table 21). Rat control occurs at all PRS except MAK-F and MAK-G (see details below). *Euglandina rosea* are found across the MU, and while *T. jacksonii xantholophus* occur at the Kaneaki Heiau at the residential/forest boundary, they have not been seen in the upper elevations. As an example of the threat level, high numbers of *E. rosea* recently extirpated a population of *Amastra spirizona* snails in the Makaha Unit 1 Management Unit close to one of the *A. mustelina* sites (MAK-E). Overall, the *A. mustelina* snail population is quite fragmented with snails commonly occurring only in few numbers in a number of separate trees and shrubs, and staff have observed a retraction in the distribution of snails in the Makaha Unit 1 fence area. A significant decline of snails is likely to have occurred across this ESU over the last several years. A large grid of A-24 Goodnature traps was installed in the past year in the Makaha Unit 1 fence area with consistently high rates of activity in the rat tracking tunnels (see Ch. 8 Rodent Control).

Table 21: ESU-D2 Population Structure and Threat Control Summary

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes: Large	Medium	Small	Unk	Threat Control: Ungulate	Weed	Rat	Euglandina rosea	Jackson's Chameleon
Achatinella mustelina												
ESU: D2 Makaha												
MAK-A Isolau ridge	Manage for stability	11	2014-08-20	8	3	0	0	Yes	Partial	Yes	No	No
MAK-B Kumaipo ridge crest	Manage for stability	1	2015-06-17	1	0	0	0	Yes	Partial	Yes	No	No
MAK-C Near pinnacle rocks. Includes Hesarb ridge.	Manage for stability	14	2015-06-16	11	3	0	0	Yes	Partial	Yes	No	No
MAK-D On ledge below ridge crest above MAK-A site.	Manage for stability	127	2014-08-20	88	36	3	0	Yes	Partial	Yes	No	No
MAK-E Ridge east of Cyasup exclosure	Manage for stability	60	2015-06-18	47	10	3	0	Yes	Partial	Yes	No	No
MAK-F Waianae Kai trail to Kaala	Manage for stability	48	2015-06-17	36	11	1	0	No	Partial	No	No	No
MAK-G Upper Makaha 3850 ft.	Manage for stability	37	2016-04-05	28	5	4	0	No	No	No	No	No
	ESU Total:	298		219	68	11	0					

Size Class Definitions

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

*=Total Snails were Trans Located or Reintroduced

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

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

5.5.4.1.1 MAK-A Kumaipo Isolau Ridge PRS

This PRS was last surveyed in 2014 and will be surveyed this year to determine trends. Incidental observations indicate that there have been declines since the last TCM.

5.5.4.1.2 MAK-B Kumaipo Ridge Crest PRS

Many of the trees at this site that used to harbor snails have died and the snails have since declined. On the June 17, 2015 survey only one snail was observed here. OANRP will survey this site as time allows, and if numbers are low it will be re-designated as NM. This PRS is not a priority due to the low number of snails.

5.5.4.1.3 MAK-C Near Pinnacle Rocks PRS

Fourteen snails were seen in June of 2015. OANRP will survey this site in 2017 to update numbers.

5.5.4.1.4 MAK-D On Ledge Below Ridge Crest Above MAK-A Site PRS

This PRS was last surveyed in 2014 and will be surveyed this year to determine trends. Incidental observations indicate that there have been declines since the last TCM.

5.5.4.1.5 MAK-E Ridge East of Cyasup Exclosure PRS

This PRS has the second highest number of snails in the ESU. OANRP will monitor the site in 2017 to track trends.

5.5.4.1.6 MAK-F Waianae Kai Trail PRS

This site was last surveyed on June 17, 2015. Forty-eight snails were found. There is still more area that needs to be explored to understand the full extent of the PRS. It is a difficult and steep area with thick vegetation. OANRP staff will continue to explore the area in the next year to determine the extent of the PRS.

5.5.4.1.7 MAK-G Upper Makaha 3850 ft. PRS

This is a new site discovered by state staff while searching for rare plants in November 2015. OANRP staff surveyed on April 5, 2016 and found a total of 37 snails (4 small, 5 medium and 28 large). OANRP staff will return to the PRS this year to further explore the area and determine the extent of the PRS. These are currently the highest in elevation for *A. mustelina* on the entire island and they are located just 150 ft. lower than the summit bog.

5.5.4.2 ESU-D2 Future Management

OANRP plan to use the next year to update the status of the PRS within ESU-D2. The geographic extent of MAK-F and MAK-G PRSs needs to be determined. In addition, rat control options need to be explored at the MAK-F and G sites. They are both steep and predator control feasibility needs to be determined. Currently ESU-D2 is the only management area that OANRP has no plans for a future enclosure given the steep terrain and high threat of vandalism. In 2014 OANRP suggested these PRS be combined with the ESU-D1 snails at Hapapa but this was not supported by the IT. At present, there does not seem to be a good solution to address the fragmented population, high threat level and lack of a suitable site for an enclosure. Mixing of the population into another ESU may be the only long-term option and/or segmenting one of the proposed enclosures at Kaala or West Makaleha pending funding and habitat suitability. We look forward to working with the IT and further genetic and risk analyses to determine the best course of action for this ESU.

Table 22: ESU-D2 Monitoring Plan for MFS PRS

PRS	Monitoring Type	Monitoring Interval	Survey Years	Comments
MAK-A Isolau Ridge	TCM	every 2 years	2016, 2018	Conduct night TCM with 3 personnel 2 hours each, for 6 total person-hours.
MAK-C Near Pinnacle Rocks	TCM	every 2 years	2017, 2019	Conduct night TCM for 6 person-hours.
MAK-D On Ledge	TCM	every 2 years	2016, 2018	Conduct night TCM for 10 person-hours. Five hours in the lower area and 5 in the upper.
MAK-E Ridge East of Cyasup	TCM	every 2 years	2017, 2019	Conduct night TCM for 4 person-hours.
MAK-F Waianae Kai	TCM	every 2 years	2017, 2019	Conduct night TCM for 4 total person-hours. Conduct day TCM on rope for 4 person-hours.
MAK-G Upper Makaha	TCM	every 2 years	2017, 2019	Conduct night TCM for 4 total person-hours. Conduct day TCM on rope for 4 person-hours.

Table 23: Three Year Action Plan for ESU-D2

PRS	MIP YEAR 13 July 2016 – June 2017	MIP YEAR 14 July 2017 – June 2018	MIP YEAR 15 July 2018 – June 2019
MAK-A Isolau Ridge	• Resurvey • Implement monitoring plan	• Rat control	• Implement monitoring plan • Rat control
MAK-C Near Pinnacle Rocks	• Implement monitoring plan • Rat control	• Rat control	• Implement monitoring plan • Rat control
MAK-D On Ledge	• Implement monitoring plan • Rat control	• Rat control	• Implement monitoring plan • Rat control
MAK-E Ridge East of Cyasup	• Rat control	• Implement monitoring plan • Rat control	• Rat control
MAK-F Waianae Kai	• Determine PRS extent • Investigate rat control	• Implement monitoring plan • Rat control	• Rat control
MAK-G Upper Makaha	• Determine PRS extent • Investigate rat control	• Implement monitoring plan • Rat control	• Rat control

5.6 ESU-E

Figure 15: Map of ESU-E

Map removed to protect rare resources. Available upon request

5.6.1 ESU- E Management History and Population Trends

There are seven MFS PRS that include 190 observed snails and seven NM PRS with twenty-eight observed snails at ESU-E (Table 24). The larger PRS have not been surveyed since 2014 and OANRP will be conducting surveys in the near future. Overall OANRP suspects that the declines observed in 2014 have continued. Most of the PRS are included in the larger rat control grid in the Ekahanui MU. *Trioceros jacksonii xantholophus* have been seen once in Ekahanui but do not seem prevalent. *Euglandina rosea* are common and thought to be the major cause of decline. ESU-E is an area of considerable management focus given steep declines in snail numbers. Plans were made with the IT in 2015 to translocate snails to a permanent enclosure at Palikea. In order to temporarily maintain all remaining ESU-E snails in a highly protected location pending completion of a larger permanent enclosure at Palikea, two temporary enclosures were designed and built to house the snails in Ekahanui at the following new PRS: EKA-M, Mamane ridge and EKA-S, Spirizona. Unfortunately these efforts have not been successful given high mortality rates. Details on these efforts are included in the PRS section below (see section 5.6.1.6).

Table 24: ESU-E Population Structure and Threat Control 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: E Puu Kaua / Ekahanui												
EKA-A	Manage for stability	58	2014-08-27	38	15	5	0	Yes	No	Yes	No	No
Mamane Ridge and Near Piapripri EKA-A												
EKA-B	Manage for stability	0 *	2016-02-24	0	0	0	0	Yes	Partial	Yes	No	No
Below north population of Tetlep. Between Piapri EKA-A, EKA-B and EKA-C												
EKA-C	Manage for stability	88	2014-08-28	69	18	1	0	Yes	Partial	Yes	No	No
At Piapripri EKA-C site												
EKA-D	Manage for stability	11	2012-07-18	7	4	0	0	Yes	No	No	No	No
Puu Kaua												
EKA-E	No Management	8	2014-05-28	6	1	1	0	Yes	No	Yes	No	No
Amastra site												
EKA-F	No Management	1	2015-08-12	1	0	0	0	Yes	No	Yes	No	No
from Piapri-C head along blue trail under cliffs mauka												
EKA-G	No Management	0	2013-02-17	0	0	0	0	Yes	Partial	Yes	No	No
Cenagr												
EKA-H	Manage for stability	21	2013-05-16	12	6	3	0	Yes	No	Yes	No	No
South Ekahanui North Branch												
EKA-M	Manage for stability	8	2016-07-26	8	0	0	0	Yes	No	Yes	Yes	Yes
Mamane Ridge snail enclosure												
EKA-S	Manage for stability	4	2016-06-27	4	0	0	0	Yes	No	Yes	Yes	Yes
Spirizona snail enclosure												
HUL-A	No Management	3	2016-05-25	2	1	0	0	No	No	No	No	No
North Huliwai South Branch												
HUL-B	No Management	1	2007-06-18	1	0	0	0	No	No	No	No	No
South Huliwai Gulch												
HUL-C	No Management	7	2016-05-25	5	2	0	0	No	No	No	No	No
Off Ridge Crest South of Puu Kanehoa												
HUL-D	No Management	8	2016-06-01	6	1	1	0	No	No	No	No	No
Puu Kanehoa												
	ESU Total:	218		159	48	11	0					

*=Total Snails were Trans Located or Reintroduced

Size Class Definitions

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

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

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

5.6.1.1 EKA-A Mamane Ridge PRS

This site was surveyed on February 24, 2016 and a total of 20 snails were collected and translocated into the temporary enclosure at ESU-M Mamane ridge. Staff have collected *E. rosea* here and it appears that this predator is having a detrimental effect on the snails. OANRP staff will conduct a night survey in the near future to determine PRS numbers.

5.6.1.2 EKA-B Below Tetlep PRS

This site also appears to be showing a decline, likely due to *E. rosea.* As with EKA-A OANRP will conduct TCM in the near future. On February 24, 2016 a total of 11 (6 medium, and 5 large) *A. mustelina* were collected and translocated into the temporary enclosure at EKA-S.

5.6.1.3 EKA-C Plapri PRS

This is the primary site in the entire ESU. A total of 88 snails were counted here in August of 2014 but this site is also in danger of decline because staff have found and controlled *E. rosea* while surveying. On February 24, 2016 a total of 9 (2 small, 2 medium, and 5 large) *A. mustelina* were collected and translocated into the temporary enclosure at EKA-S.

5.6.1.4 EKA-D Puu Kaua PRS

Snails at this site have been in serious decline since a dieback affected most of the *M. lessertiana* trees in the area. *E. rosea* have also been a serious problem here. For example, *A. mustelina* was commly observed along the crestline near the summit and now only *E. rosea* are found. OANRP staff will visit the site in the next year to determine if it should be re-designated as NM PRS.

5.6.1.5 EKA-H South Ekahanui North Branch PRS

This site was last surveyed on April 29, 2015 when a total of 5 snails were counted. On this trip staff did not have ropes to search the steep habitat that had been searched in 2013. OANRP plan to return with ropes in the near future to survey and get an updated estimate for the area.

5.6.1.6 EKA-M Mamane ridge PRS and EKA-S Spirizona Temporary Snail Enclosures PRS

In recent years, populations of *A. mustelina* in ESU-E have been in decline (OANRP 2014). Plans were made to translocate snails to a permanent enclosure at Palikea. OANRP needed to temporarily maintain all remaining ESU-E snails in a highly protected location pending completion of a larger permanent enclosure at Palikea. To this end, two temporary enclosures were designed and built in February 2016 to house the snails in Ekahanui at two new PRSs, EKA-M Mamane ridge temporary enclosure and EKA-S Spirizona temporary enclosure.

Predator control at the enclosures is accomplished via structural exclusion, remote camera monitoring, supplemental rodent control, and *E. rosea* monitoring. Each enclosure is 10 ft tall, framed with untreated lumber, fully screened on all sides including the top with polyester-coated galvanized steel mesh, and has a wood-framed mesh door on the downslope wall. The mesh excludes *E. rosea*, rodents, and *T. jacksonii xantholophus*. A game camera installed near each enclosure is programmed to email photographs three times per day; these photos should show any major structural damage (see Figure 16). In addition to the existing grid of rat snap traps located across Ekahanui MU, two rat snap traps are placed along the wall inside each enclosure. The traps remain unbaited to avoid attracting rodents from the outside. Following completion of the enclosures, a total of 10 hours were spent searching for *E. rosea* over a span of 4 weeks to ensure that none were present. Enclosure integrity is monitored monthly in conjunction with *E. rosea* monitoring.

Figure 16: Photograph of temporary snail enclosure at Ekahanui taken by game camera and emailed to staff.

A preliminary translocation of twenty snails was made into each temporary enclosure (see Table 25) on February 25, 2016 (6 medium and 14 large snails from PRS EKA-A at Mamane; and 2 small, 6 medium, and 12 large snails from PRS EKA-B and EKA-C at Spirizona). Two additional large snails were already resident within the Mamane enclosure at that time. If snail numbers remained stable, staff planned to move all remaining snails into the enclosures. Monitoring of snails following translocation included timed-counts, capture-mark-recapture monitoring utilizing a HotSpotter© database to track individuals, and collection of ground shells within the enclosures. Hourly temperature and relative humidity inside and outside of both enclosures were recorded by data loggers to quantify any differences that may occur either inside vs. outside the enclosures, or between the enclosures. Prior to the initial translocation of snails, comparisons of conditions at the enclosures indicated there were a number of significant differences in mean temperature and median relative humidity inside vs. outside enclosures and between sites during the day and night. However, those differences were very small, and likely do not signify biologically meaningful differences with respect to environmental requirements for *A. mustelina* (see Appendix 5-1).

Following the preliminary translocation, higher than expected mortality occurred at both sites, with a marked decline in observed live snails (see Figure 17), and a total of 8 ground shells recovered at Mamane, and 12 at Spirizona, by the end of June 2016 (see Figure 18). Plans for subsequent translocations were halted. To date, no *E. rosea* have been found within the enclosure, and no apparent causes of the mortality are known. Suspected causes include environmental stress from the translocation, a lack of adequate food when the snails move onto the wooden beams or wire mesh structures of the enclosures, or perhaps a lack of suitable food when moved from one host tree to the enclosure with a similar but not identical set of host species.

In an attempt to improve the environment inside the enclosures by creating wetter and cooler conditions, automated sprinklers (set to run at 10:00 AM and 2:00 PM for five minutes each) and shade cloths were installed in May 2016. Data logger results indicate slightly cooler conditions, and humidity spikes following the running of the sprinklers on drier days, inside the enclosures compared with outside conditions, likely providing a beneficial cooling and humidifying effect for *A. mustelina* during higher environmental stress conditions. Detailed results of this analysis are included in Appendix 5-1. Sprinkler functionality was initially inconsistent resulting from a faulty solenoid and water catchment shortages. As of July 6, 2016, sprinkler run time at both sites was reduced from five minutes to three minutes and catchment tanks were refilled with hopes of having enough water for at least a few months. In the initial weeks following installation of the sprinklers and shade cloths the weekly number of snail deaths declined. However, higher than expected mortality resumed in late June through August, particularly at the Mamane enclosure. As of August 11, 2016, a total of 17 (3 small, 5 medium, and 9 large) ground shells were recovered from Mamane, and 13 (6 medium, and 7 large) from Spirizona. At least four births occurred at Mamane, of which three failed to survive. The two resident snails within the Mamane enclosure prior to the translocation event remain alive, and four additional live snails have been observed in a tree immediately outside the Mamane enclosure. Of the 20 translocated snails in each enclosure, 70% at Mamane, and 65% at Spirizona, were confirmed dead using Hotspotter© photo recognition software. The ultimate cause of mortality remains unknown.

Table 25: Translocations of *A. mustelina* into Ekahanui Temporary Snail Enclosures 2015-2016

Destination	Translocation Date	Population Reference Site	Small	Medium	Large	Total
EKA-M Mamane Ridge Snail Enclosure	2016-02-24	AchMus.EKA-A Mamane Ridge and Plapripri	0	6	14	20
EKA-S Spirizona Snail Enclosure	2016-02-24	AchMus.EKA-B Below north population of Tetlep	0	6	5	11
EKA-S Spirizona Snail Enclosure	2016-02-24	AchMus.EKA-C At Plapripri EKA-C site	2	2	5	9
Total			2	14	24	40

Figure 17: Timed-counts for *A. mustelina* at EKA-M Mamane ridge and EKA-S Spirizona temporary snail enclosures from March to June 2016.

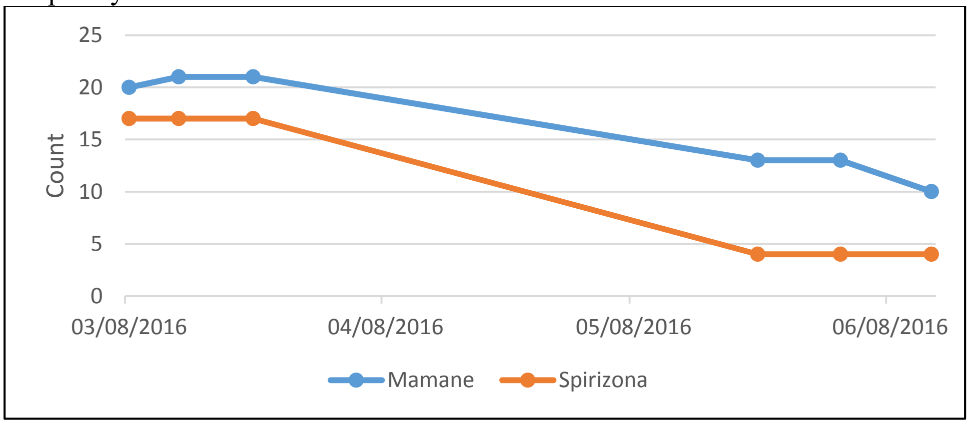
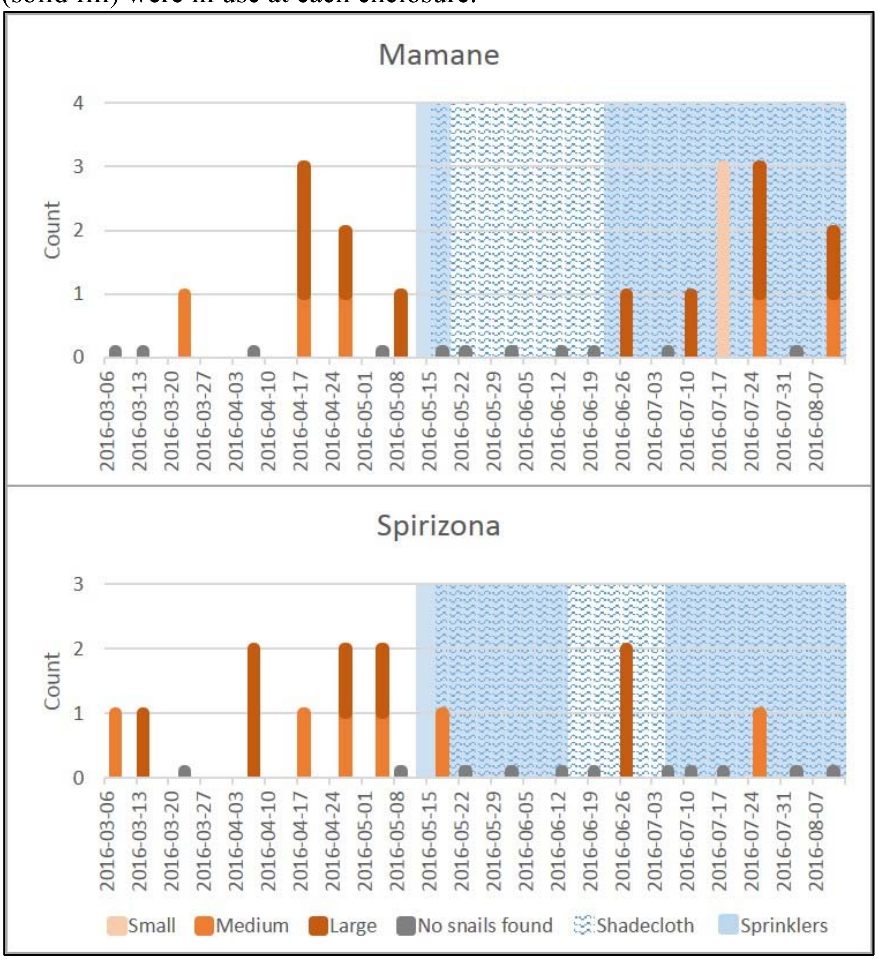


Figure 18: Counts of *Achatinella mustelina* ground shells recovered from the EKA-M Mamane and EKA-S Spirizona temporary snail enclosures between March 8 and August 11, 2016. Shell sizes are indicated by color for small (<8mm), medium (8-18mm) and large (>18mm) individuals. Background shading indicates date ranges in which shadecloth (patterned fill) and sprinklers (solid fill) were in use at each enclosure.



5.6.1.7 No Management PRS

Most of these sites have few snails and have not been visited recently. Once the enclosure at Palikea North is complete, OANRP staff will visit these sites to translocate all snails found.

5.6.1.8 HUL-D Puu Kanehoa PRS

A small population consisting of 8 snails was found here on June 1, 2016. This site is close to the study site used by Dr. Michael Hadfield in 1976. During his study he estimated the population to be approximately 200+ snails, but at the completion of his research in 1979, all of the snails had disappeared due to *E. rosea*. It always gives a feeling of hope to find snails in an area where they were thought to have been extirpated 40 years ago. This area will be included in translocation efforts.

5.6.2 ESU-E Future Management Plans

OANRP plans to complete the enclosure at Palikea North by the fall of 2017 to provide protected habitat for the remaining snails in ESU-E given the lack of an adequate location for a snail enclosure within the same ESU. Until the enclosure is built and has adequate habitat for snails, OANRP will conduct the monitoring and management actions outlined below (Tables 26 and 27). If the Palikea North Enclosure cannot be built due to lapsed funds OANRP will re-evaluate options given new monitoring data on the population status. Despite high mortality rates, incremental translocations to the Mamane and Spirizona mini-enclosures are not entirely ruled out for the future as habitat conditions will likely continue to improve with increased vegetative cover and predation outside the enclosures will also likely continue.

Table 26: ESU-E Monitoring Plan for MFS PRS

PRS	Monitoring Type	Monitoring Interval	Survey Years	Comments
EKA-A Mamane Ridge	TCM	every 2 years	2016, 2018	Night TCM 4.5 hours with binoculars.
	GSP	annual	all	GSP EKA-A1
EKA-B Below Tetlep	TCM	every 2 years	2016, 2018	Night TCM 6.0 hours with binoculars
EKA-C Plapri	TCM	every 2 years	2016, 2018	Day TCM 6 hours with binoculars
EKA-D Puu Kaua	TCM	every 2 years	2016	Day TCM 20 hours with binoculars requires rope access. Determine if MFS or NM PRS.
EKA-H South Ekahanui	TCM	every 2 years	2016	Conduct baseline survey, recording hours to use as standard. Day counts due to rope access. Determine if MFS or NM PRS.
EKA-M Mamane ridge	TCM/GSP	Monthly	2016, 2017, 2018	Conduct GSP and TCM monthly
EKA-S Spirizona	TCM/GSP	Monthly	2016, 2017, 2018	Conduct GSP and TCM monthly

Table 27: Three Year Action Plan for ESU-E

PRS	MIP YEAR 13 July 2016 – June 2017	MIP YEAR 14 July 2017 – June 2018	MIP YEAR 15 July 2018 – June 2019
EKA-A Mamane Ridge	• Implement monitoring plan • Rat Control • *E. rosea* searches	• Implement monitoring plan • Rat Control • *E. rosea* searches	• Implement monitoring plan • Rat Control • *E. rosea* searches • Translocation to Palikea North Enclosure
EKA-B Below Tetlep	• Implement monitoring plan • Rat Control • *E. rosea* searches	• Implement monitoring plan • Rat Control • *E. rosea* searches	• Implement monitoring plan • Rat Control • *E. rosea* searches • Translocation to Palikea North Enclosure
EKA-C Plapri	• Implement monitoring plan • Rat Control • *E. rosea* searches	• Implement monitoring plan • Rat Control *E. rosea* searches	• Implement monitoring plan • Rat Control • *E. rosea* searches • Translocation to Palikea North Enclosure
EKA-D Puu Kaua	• Implement monitoring plan • Determine if PRS should be designated NM	• Implement actions dependent on management designation	• Implement actions dependent on management designation
EKA-H South Ekahanui	• Implement monitoring plan • Determine if PRS should be designated NM	• Implement actions dependent on management designation	• Implement actions dependent on management designation
EKA-M Mamane ridge	• Implement monitoring plan • Rat Control • *E. rosea* searches	• Implement monitoring plan • Rat Control • *E. rosea* searches	• Implement monitoring plan • Rat Control • *E. rosea* searches • Translocation to Palikea North Enclosure
EKA-S Spirizona	• Implement monitoring plan • Rat Control • *E. rosea* searches	• Implement monitoring plan • Rat Control • *E. rosea* searches	• Implement monitoring plan • Rat Control • *E. rosea* searches • Translocation to Palikea North Enclosure

5.7 ESU-F

Figure 19: Map of ESU-F. *Note: PRS KAA-A located at Mauna Kapu was excluded from this map for purposes of clarity.*

Map removed to protect rare resources. Available upon request

5.7.1 Management History and Population Trends

A total of 566 snails have been detected by TCM in the five MFS PRS in ESU-F (Table 28). All the snails from the NM PRS in Palikea are listed as zero as snails from these PRS were moved into the enclosure, and no monitoring has been conducted since. The Palikea Snail Enclosure was funded by the USFWS and is jointly managed with the SEPP program. Snails were translocated into the enclosure given observed declines. As with other translocation efforts, these sites have been checked a total of three times to collect remaining snails. There are twelve snails in the NM PRS from Palawai which will likely be translocated to the existing enclosure in the near future. Small snail populations are still occasionally found in the Palikea Fence and those populations will be assessed for translocation based on their population sizes and risk of predation (e.g. if *E. rosea* are found nearby they will likely be moved). All PRS in the Palikea Fence are within the large rat control grid. SEPP maintains a rat grid around the NM PRS at PAL-B (Delsub Lama Fence). The other NM PRSs in Palawai have no rat control. *E. rosea* is present in PRSs outside of the enclosure and are routinely collected from under the angle barrier. There has only been one *T. jacksonii xantholophus* seen in the ESU. It was found in close proximately to the enclosure. However, there have not been any additional sightings in many hours of night surveying in the ESU and it is assumed they are in low densities.

Table 28: ESU-F Population Structure and Threat Control Summary

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes: Large	Medium	Small	Unk	Threat Control: Ungulate	Weed	Rat	Euglandina rosea	Jackson's Chameleon
Achatinella mustelina												
ESU: F **Puu Palikea**												
KAA-A Mauna Kapu (Palehua)	No Management	0 *	2016-01-25	0	0	0	0	No	No	Yes	No	No
PAK-A Puu Palikea-Ohia spot	No Management	0 *	2015-09-28	0	0	0	0	Yes	Partial	Yes	No	No
PAK-B Iele Patch	No Management	0 *	2016-04-13	0	0	0	0	Yes	Partial	Yes	No	No
PAK-C Steps spot	No Management	0 *	2015-09-28	0	0	0	0	Yes	Partial	Yes	No	No
PAK-D Joel Lau's site	No Management	0 *	2016-05-05	0	0	0	0	No	Partial	Yes	No	No
PAK-E Exogau site	No Management	0	2015-10-07	0	0	0	0	Yes	Partial	Yes	No	No
PAK-F Dodonaea site	No Management	0 *	2015-10-07	0	0	0	0	Yes	Partial	Yes	No	No
PAK-G Hame and Alani site just above Cyagri fence	No Management	0 *	2015-09-28	0	0	0	0	Yes	Partial	Yes	No	No
PAK-H Mike Hadfield's study site at Puu Palikea	Manage for stability	18	2016-01-06	13	2	3	0	Yes	Partial	Yes	No	No
PAK-I One ridge truck side of E and F	No Management	0 *	2015-10-07	0	0	0	0	No	Partial	Yes	No	No
PAK-K Pilo site	Manage for stability	92	2015-10-08	56	33	3	0	Yes	Partial	Yes	No	No
PAK-L Olapa site north of Puu Palikea	Manage for stability	76	2015-10-07	50	23	3	0	Yes	Partial	Yes	No	No
PAK-M Middle Site	Manage for stability	316	2016-06-07	205	82	29	0	Yes	Partial	Yes	No	No
PAK-N Campside of Lobelia Ridge	No Management	0 *	2015-10-07	0	0	0	0	No	Partial	No	No	No
PAK-O Below camp fence	No Management	1	2009-09-23	1	0	0	0	No	Partial	Yes	No	No
PAK-P Palikea snail exclosure	Manage for stability	64	2016-04-16	49	12	3	0	Yes	Partial	Yes	Yes	Yes
PAK-Q outside snail enclosure	No Management	0 *	2016-04-13	0	0	0	0	Yes	Partial	Yes	No	No

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails		Date of Survey	Size Classes: Large	Size Classes: Medium	Size Classes: Small	Size Classes: Unk	Threat Control: Ungulate	Threat Control: Weed	Threat Control: Rat	Threat Control: Euglandina rosea	Threat Control: Jackson's Chameleon
PAK-R 4 Trail Junction	No Management	0	*	2016-06-07	0	0	0	0	Partial	Partial	Yes	No	No
PAK-S Palikea North	No Management	0	*	2016-06-30	0	0	0	0	No	Partial	Yes	No	No
PAL-A Palawai next to Pri sp.	No Management	8		2014-05-14	6	1	1	0	No	No	No	No	No
PAL-B Delsub Lama Fence	No Management	2		2011-04-18	1	0	1	0	No	No	Yes	No	No
PAL-C Palawai Hesarb trail	No Management	2		2007-04-30	2	0	0	0	No	No	No	No	No
	ESU Total:	579			383	153	43	0					

*=Total Snails were Trans Located or Reintroduced

Size Class Definitions

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

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

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

5.7.1.1 PAK-H Hadfield's PRS

This site was surveyed on January 6, 2016 and a total of 18 snails were found. Staff decided that these snails did not need to be translocated into the snail enclosure as a trigger of 10 or less was set in 2014. OANRP will continue to monitor and translocate the snails in the future if numbers decline.

5.7.1.2 PAK-K Pilo PRS

OANRP staff conducted TCM on October 8, 2015 and a total of 92 snails were counted. This appears to be a healthy population and will not be translocated into the enclosure.

5.7.1.3 PAK-L Olapa PRS

This site had 76 snails when OANRP staff conducted TCM on October 7, 2015. The habitat is comprised of many native trees and there is no plan to translocate these snails.

5.7.1.4 PAK-M Middle Site PRS

This is the largest population in the ESU and on June 7, 2016 a total of 316 snails were counted during the TCM. This population appears stable and will not be translocated into the enclosure unless the level of predation increases and significant declines are detected. The area has many native trees and shrubs. Some habitat improvements may be made to control encroaching weed trees in the lower reaches of the area.

5.7.1.5 PAK-P Enclosure PRS

OANRP staff have translocated snails into the Palikea snail enclosure and have begun TCM on a quarterly basis. Snails outside the enclosure in small populations will continue to be brought inside for protection from predators. On April 13, 2016 TCM was performed during the day with 2-person hours spent in each of two separate plots within the enclosure for a total of 64 snails counted. Once a year, a night TCM will be performed for 4-person hours covering the entire enclosure . Future translocations from some of the other PRS (e.g. PAK-M) may occur if sharp declines are observed in population sizes.

5.7.1.6 PAK-S Palikea North Enclosure Site PRS

Two night surveys and numerous walk throughs during the day failed to detect any snails at this site. Site clearing began in the early summer of 2016 and was halted when snails where discovered in the work site area. The site largely consists of a dense thicket *of P. cattleleianum*. See Appendix 3-7 for more information on baseline vegetation monitoring at this site. 33 snails were translocated from this site to the existing Palikea Enclosure. *E. rosea* have also been found in the area near the location of the translocated snails (along with ground shells) indicating active predation.

5.7.1.7 No Management PRS

These sites have historically had very few snails and declining numbers. Translocations completed in 2015-2016 are outlined below (Table 29).

Table 29: Translocations of *A. mustelina* into PAK-P Palikea Snail Enclosure in 2015-2016

Translocation Date	Population Reference Site	Small	Medium	Large	Total
2015-08-25	AchMus PAK-Q	1	2	7	9
2015-09-28	AchMus PAK-A	2	2	5	9
2015-09-28	AchMus PAK-C	1	1	2	4
2015-09-28	AchMus PAK-R	2	3	15	20
2015-10-07	AchMus PAK-I	0	0	3	3
2015-10-07	AchMus PAK-R	1	3	1	5
2015-10-07	AchMus PAK-N	0	0	1	1
2015-10-07	AchMus PAK-Q	0	3	1	4
2015-10-17	AchMus PAK-F	0	2	7	9
2015-11-17	AchMus PAK-D	0	1	4	5
2016-01-25	AchMus KAA-A	0	2	1	2
2016-02-02	AchMus PAK-D	0	1	3	4
2016-02-03	AchMus PAK-Q	0	3	2	5
2016-02-04	AchMus PAK-R	0	1	2	3
2016-04-13	AchMus PAK-B	1	3	1	5
2016-04-13	AchMus PAK-R	0	1	2	3
2016-05-05	AchMus PAK-D	0	0	1	1
2016-06-07	AchMus PAK-R	2	2	5	9
2016-08-01	AchMus KAA-A	0	1	1	2
2016-6-14 thru 2016-06-30	AchMus PAK-S	3	8	21	33
Total		13	39	85	103

5.7.2 ESU-F Future Management

OANRP will continue monitoring and management as planned (Table 30 and 31). The majority of the translocations are complete from NM PRS. OANRP will continue to translocate snails from small declining NM PRS. Each of these sites will be visited a minimum of three times. The six PRS listed below (Table 31) require additional visits. Unlisted NM PRS have been visited three times.

As mentioned earlier, small snail populations are still occasionally found in the Palikea MU. They will be translocated based on numbers and risk of imminent predation. Threat control will continue in the MU, including quarterly tracking tunnels for *R. rattus*, and searches for *E. rosea*, and *T. jacksonii xantholophus*. Weed control and habitat improvements will continue cautiously to ensure there are no impacts to the snails. Habitat improvements across the MU will include gradual removal of non-native trees in snail areas and outplanting of natives to fill in light gaps and provide more host species.

In the Palikea Enclosure, at some point, a careful reduction of some ieie (*Freycenetia arborea*) cover will be needed for snail monitoring purposes as the ieie is becoming considerably dense in some areas of the enclosure. The barriers on the enclosure continue to function and prevent predator ingress. OANRP will make 1-2 trips in the next year to complete erosion control work around the enclosure wall. The debris alarm system will be installed once the system under development is finalized.

At the PAK-S Palikea North Enclosure Site, night surveys have not been completed for the work site area pending USFWS approval of revised search protocols. OANRP do not anticipate finding many more snails in the Palikea North Enclosure project area and it was fortunate that they were discovered. Surveys and site clearing will resume following USFWS approvals.

Table 30: ESU-F Monitoring Plan for MFS PRS

PRS	Monitoring Type	Monitoring Interval	Survey Years	Comments
PAK-H Hadfield's	TCM	every 2 years	2017, 2019	Conduct baseline day survey, recording hours to use as standard.
	GSP	annual	2016, 2017, 2018	
PAK-K Pilo	TCM	every 2 years	2017, 2019	Conduct day TCM for 4 person-hours.
PAK-L Olapa	TCM	every 2 years	2017, 2019	Conduct baseline survey, recording hours to use as standard. Determine night or day TCM based on terrain.
PAK-M Middle	TCM	every 2 years	2016, 2018	Conduct baseline night survey, recording hours to use as standard.
PAK-P Palikea Enclosure	TCM	Quarterly	2016, 2017,2018	Conduct day TCM for 4 person-hours.
PAK-P Palikea Enclosure	Survey	annual	2016, 2017, 2018	Conduct night survey to determine dispersal and perform *T. jacksonii xantholophus* search for a total of 4 person-hours.

Table 31: Three Year Action Plan for ESU-F

PRS	MIP YEAR 13 July 2016 – June 2017	MIP YEAR 14 July 2017 – June 2018	MIP YEAR 15 July 2018 – June 2019
KAA-A Mauna Kapu	• Translocate to enclosure		
PAK-G Hame	• Translocate to enclosure		
PAK-H Hadfield's	• Implement monitoring plan • Rat Control	• Implement monitoring plan • Rat Control	• Implement monitoring plan Rat Control
PAK-K Pilo	• Implement monitoring plan • Rat Control	• Implement monitoring plan • Rat Control	• Implement monitoring plan Rat Control
PAK-L Olapa	• Implement monitoring plan • Rat Control	• Implement monitoring plan • Rat Control	• Implement monitoring plan • Rat Control
PAK-M Middle	• Implement monitoring plan • Rat Control	• Implement monitoring plan • Rat Control	• Implement monitoring plan • Rat Control
PAK-P Palikea Enclosure	• Implement monitoring plan • Rat control • Maintain enclosure and monitor for predators • Improve habitat via weed control and restoration planting	• Implement monitoring plan • Rat control • Maintain enclosure and monitor for predators • Conduct additional outplanting if needed	• Implement monitoring plan • Rat control • Maintain enclosure and monitor for predators
PAK-I One Ridge Truck side of E and F	• Translocate to enclosure		
PAK-F Dodonea Site	• Translocate to enclosure		
PAK-S Palikea North	• Complete surveys • Translocate to enclosure		
PAK-B Ieie Patch	• Translocate to enclosure		

Chapter 6: Rare Vertebrate Management

OANRP manages or monitors three vertebrate species, Hawaiian Monarch Flycatcher (Oahu Elepaio), Hawaiian Goose (Nene), and the Hawaiian Hoary Bat (Opeapea). Results of our management and monitoring efforts are presented below.

6.1 OIP Elepaio Management 2016

6.1.1 Background

In 2000, the U.S. Fish and Wildlife Service (USFWS) granted the Oahu Elepaio (*Chasiempis ibidis*) endangered species status under the Federal Endangered Species Act and designated critical habitat on Oahu for the Elepaio in 2001. Under the terms of the Biological Opinion for Routine Military Training and Transformation dated 2003, Oahu Army Natural Resources Program (OANRP) is required to manage a minimum of 75 Oahu Elepaio pairs. Management of a pair includes monitoring and rodent control during the breeding season. The OANRP is required to conduct on-site management at Schofield Barracks West Range (SBW) for as many of the 75 pairs as possible, with the remaining number managed at off-site locations with cooperating landowners. The OANRP has conducted rodent control and Elepaio monitoring at Schofield Barracks Military Reservation (SBMR) (1998-present), Ekahanui Gulch in the Honouliuli Forest Reserve (2005-present), Moanalua Valley (2005-present), Palehua (2007-present), Makaha Valley (2005-2009), and Waikane Valley (2007-2008). This chapter summarizes Elepaio reproduction results at each of the sites currently being managed, and provides recommendations for improving the Elepaio stabilization program. This section also lists and discusses the terms and conditions for the implementation of reasonable and prudent measures outlined in the 2003 Biological Opinion. A population growth analysis study is also included in this report as Appendix 6-1.

6.1.2 Methods

Monitoring

Throughout the nesting season, from early January to late June, each managed Elepaio territory was visited at one or two-week intervals depending on breeding activity. Single male and paired territories where rodent control is not taking place are also monitored for breeding activity whenever possible, though their results are not included with that of managed pairs. The location and age of all birds observed and color band combination (explained below), if any, was noted on each visit. Nests were counted as successful if they fledged at least one chick. Nest success (successful nests/active nests) was calculated by the number of successful nests per the number of active nests. Active nests are nests known to have had eggs laid in them as determined by observations of incubation. Reproductive success (fledglings/managed pair) was measured as the average number of fledglings produced per managed pair. Some nests were abandoned for unknown reasons before eggs were laid. If a nest is abandoned after an egg is laid it is considered to have failed. To get a better sense of what happens at the nest during the night and why nests might be failing we installed motion sensor cameras at four nests in three management units that were built low to the ground. During the night, the black rat (*Rattus rattus*) is a serious threat to eggs, nestlings, and incubating female Elepaio. However, photographs taken from the cameras did not reveal any nest predation. This is the first year OANRP has conducted this type of monitoring. We hope to improve this monitoring technique and deploy more cameras into the field in future breeding seasons.

To facilitate demographic monitoring, Elepaio have been captured with mist-nets and marked with a standard aluminum bird band and a unique combination of three colored plastic bands. This is useful because it allows individual birds to be distinguished through binoculars and provides important information about the demography of the population, such as survival and movement of birds within and between years. It also makes it easier to distinguish birds from neighboring territories, yielding a more accurate population estimate. In most cases, Elepaio vocal recordings were used to lure birds into a mist-net. Each bird was weighed, measured, inspected for molt, fat, overall health, and then released unharmed at the site of capture within 30 minutes.

Figure 1: A small number of cameras were deployed at nests built low to the ground to monitor activity at night.

Rodent Control

This breeding season OANRP again used a combination of small and large-scale trapping grids containing only Victor® rat snap traps baited with peanut butter. Small-scale grids, deployed throughout the territory of an Elepaio pair at SBW and Moanalua Valley, consisted of 12-15 snap traps tied to trees or rocks to prevent scavengers from removing them. Territories labeled as single or vacant may have also contained snap traps baited throughout the breeding season. These territories once contained an Elepaio pair, but one or both birds have not recently been observed. These territories continue to be baited to help control rodents throughout the management area. Traps were counted as having caught a rodent if hair or tissue was found on the trap. Traps were cleaned with a wire brush after each capture so previous captures were not counted twice. Rodent control was conducted for the duration of the Elepaio nesting season. At Ekahanui, a large-scale rat trapping grid containing over 600 snap traps was deployed in 2011 for management of all Elepaio territories in the management unit. A second large-scale grid containing 170 snap traps was deployed in 2015 at Palehua to ensure rodent protection for all resident pairs. Another 22 traps were added this year at Palehua for a total of 192. Traps at all four sites were checked and re-baited every two weeks during the breeding season (December – June). Due to Army training at SBW we were allowed access only one week each month. Therefore, frequency of baiting was twice during that week of access to maximize the number of rodent kills. Pono Pacific was contracted to conduct rodent control at each of the four sites: Moanalua, SBW, Ekahanui and Palehua. OANRP conducted the monitoring of birds at each of these MUs.

Figure 2: Support Operations Office Associate, Kau'i Racette, with a molting adult Elepaio at Moanalua Valley.

6.1.3 Results

With 86 Elepaio pairs managed during the 2016 breeding season, the OANRP fulfilled the required 75 pairs for species management. The results of management conducted for each area during the 2016 breeding season are compiled below. The results from each area are presented in two ways. First, a map presents a compilation of all the known Elepaio territories within each Elepaio MU. The map denotes all of the territories that were baited. Second, the data is presented in tabular form with the number of territories that were single or contained pairs. The table also presents the number of paired territories in which rodent control was conducted, the number of active nests observed, total successful and failed nests, how many fledglings were observed, and the ratio of fledglings per pair. Rodent control data and a summary of results are also presented.

In the past we have reported numbers of rats captured for each of our 4 Elepaio MUs, however due to a number of reasons we will no longer be reporting that information. We have conducted several quality control checks of the contractor responsible for baiting the traps and have determined that the data is not accurate enough to analyze. Additionally, heavy rains and scavengers such as cats and mongoose are capable of removing any evidence of a rodent capture. Due to these factors we believe the capture data does not accurately reflect the relative abundance of rodents due to the under-recording of captures per year at each MU. Until we can more accurately record the total catches it is of little use to report this information. Instead, we propose the use of tracking tunnels as a monitoring tool to estimate percent rat activity and monitor our rat control efforts. Of the 4 Elepaio units managed we currently conduct quarterly tracking tunnel monitoring only at Ekahanui (see Chapter 8, Section 8.2 of this document). However, we have recently installed tracking tunnels at SBW and will be monitoring these every other month for the next 2 years as part of a pilot project involving an aerial broadcast of Diphacinone-50. Currently there are no plans to conduct tracking tunnel monitoring at Moanalua, but this is recommended to better monitor our control efforts. This type of monitoring method does have some limitations and cannot be used accurately at sites that are too small such as Palehua.

Figure 3: A banded Elepaio comes in to feed small nestlings. A bird is identified by its band combination, which is read top to bottom, left leg first then right leg. In this case, it would be yellow/green, white/aluminum or YGWA.

Schofield Barracks West Range

Schofield Barracks West Range Territory Occupancy Status and Rat Control 2016

Map removed to protect rare resources. Available upon request

Schofield Barracks West Range Site Demographic Data

SBW	2016	2015	2014	2013	2012	2011
Singles	16	16	17	18	16	15
Pairs	66	58	57	60	58	56
Pairs with Rat Control	28	26	22	29	28	31
Active Nests[1]	14	14	16	18	23	34
Successful Active Nests[2]	10/14=71%	8/14=57%	8/16=50%	9/18=50%	16/23=70%	22/34=65%
Unknown Nest Outcome[3]	2	2	3	0	0	0
Failed Active Nests	4	4	5	9	7	12
Family Groups Found[4]	7	5	8	15	11	11
Fledglings Observed[5]	21	14	20	28	28	46
Fledglings/Managed Pair[6]	0.75	0.54	0.91	0.97	1	1.48

[1] Nest containing eggs or nestlings.
[2]Percentage of successful active nests observed.
[3]Total number of active nests with unknown outcome (sufficient time gap between visits).
[4]Total number of occurrences where pairs were observed with fledglings in which no nests were found.
[5]Total number of fledglings observed from successful active nests and family groups.
[6]The ratio of fledglings per managed pair.

Reproductive Results

Of the active nests monitored in SBW, 71% (10/14) were successful in producing 14 fledglings, while 29% (4/14) of the active nests failed. Two nests had unknown outcomes (nests with sufficient time gap between visits in which a nest could have fledged with no subsequent detection of a fledgling). Another 7 fledglings were found with seven managed pairs where no nesting had been observed (family groups). A total of 21 fledglings were observed in territories benefiting from rodent control management. Another 6 fledglings were observed in territories not protected from rats.

Summary

Access in SBW was again limited to four or five days per month in 2016 due to weekly training by the Army. This allows for approximately one day per month of access for monitoring to each of the three managed gulches in SBW. This reduces the time available during the breeding season for the OANRP to detect active nests and fledglings. Despite the limited access, SBW recorded its highest number of resident pairs and 71% of active nests produced one or more fledglings. Twenty-one fledglings were observed in baited territories, making it the highest total since 2013. The resident population does include the South Haleauau drainage, which does not get monitored during the breeding season and was last surveyed in 2010. A follow-up survey to the one conducted six years ago is desperately needed to ensure an accurate population census of SBW.

Figure 4: “Elepaio have gigantic eyes. In fact, the only thing bigger than Elepaio’s eyes is his huge curiosity.” – Vince Mahoney, author

Honouliuli Forest Reserve – Ekahanui

Ekahanui Territory Occupancy Status and Rat Control 2016

Map removed to protect rare resources. Available upon request

Ekahanui Site Demographic Data

EKA	2016	2015	2014	2013	2012	2011
Singles	2	0	5	1	11	14
Pairs	40	39	30	39	31	30
Pairs with Rat Control	37	37	28	36	29	30
Active Nests[1]	12	23	14	26	21	15
Successful Active Nests[2]	8/12=67%	13/23=56%	7/14=50%	17/26=65%	9/21=43%	8/15=53%
Unknown Nest Outcome[3]	1	5	3	3	0	1
Failed Active Nests	4	6	6	9	12	6
Family Groups Found[4]	22	6	12	8	6	15
Fledglings Observed[5]	36	24	21	29	18	26
Fledglings/Managed Pair[6]	0.97	0.65	0.75	0.81	0.62	0.87

[1] Nest containing eggs or nestlings.
[2]Percentage of successful active nests observed.
[3]Total number of active nests with unknown outcome (time gap between visits).
[4]Total number of occurrences where pairs were observed with fledglings in which no nests were found.
[5]Total number of fledglings observed from successful active nests and family groups.
[6]The ratio of fledglings per managed pair.

Reproductive Results

Of the active nests monitored, 67% (8/12) were successful, producing eleven fledglings, and 33% (4/12) of active nests failed. One nest had an unknown outcome (nest with sufficient time gap between visits in which a nest could have fledged with no subsequent detection of a fledgling). Twenty-five fledglings were found in twenty managed pairs where no nesting had been observed (family groups). A total of 36 fledglings were observed in territories benefiting from rodent control management. Another three fledglings were observed in territories not protected from rats.

Summary

It was a very productive breeding season at Ekahanui this year. Thirty-six fledglings were found, most of them in family groups that were observed in late 2015. Seventeen pairs at Ekahanui produced twenty fledglings during the fall months of 2015, possibly due to favorable weather conditions in September-November. Breeding activity during these months is rare, especially involving such a significant number of pairs. Also, we continued with our biennial surveys of the two drainages north of the Ekahanui MU. After a 2-day survey it is encouraging to see that these populations have continued to remain stable since 2014, with just a slight increase in the number of birds and breeding pairs observed. It is our hope that successful rodent control at Ekahanui is helping to repopulate areas capable of sustaining breeding pairs of Elepaio.

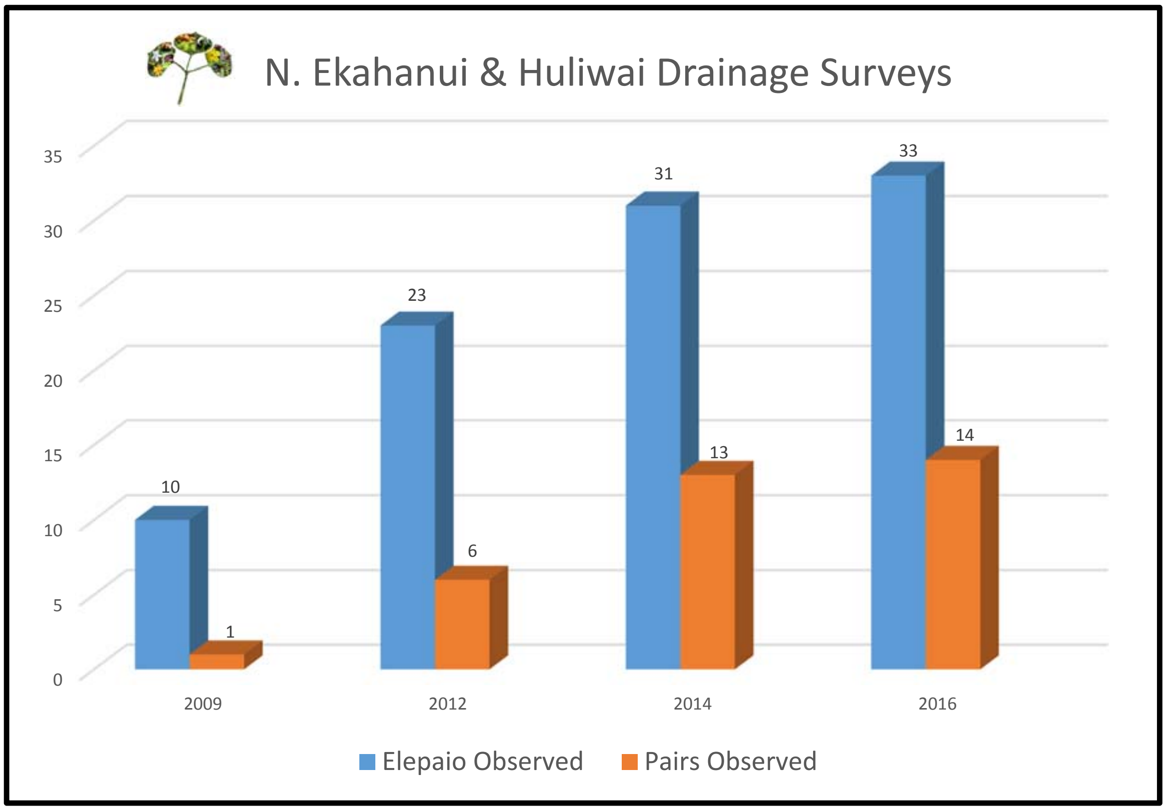


Figure 5: Results of surveys conducted in non-managed drainages north of Ekahanui.

Palehua

Palehua Territory Occupancy Status and Rat Control 2016

Map removed to protect rare resources. Available upon request

Palehua Site Demographic Data

HUA	2016	2015	2014	2013	2012	2011
Singles	2	1	2	0	0	0
Pairs	11	15	11	17	16	17
Pairs with Rat Control	11	15	10	17	16	17
Active Nests[1]	6	6	8	16	8	13
Successful Active Nests[2]	2/6=33%	3/6=50%	4/8=50%	11/16=69%	3/8=38%	10/13=76%
Unknown Nest Outcome[3]	0	0	0	0	0	2
Failed Active Nests	4	3	4	5	5	1
Family Groups Found[4]	5	1	4	5	3	5
Fledglings Observed[5]	8	5	10	21	6	16
Fledglings/Managed Pair[6]	0.72	0.33	1	1.24	0.38	0.94

[1] Nest containing eggs or nestlings.
[2] Percentage of successful active nests observed.
[3] Total number of active nests with unknown outcome (time gap between visits).
[4] Total number of occurrences where pairs were observed with fledglings in which no nests were found.
[5] Total number of fledglings observed from successful active nests and family groups.
[6] The ratio of fledglings per managed pair.

Reproductive Results

Of the active nests monitored, 33% (2/6) were successful in producing three fledglings, while 67% (4/6) of the nests failed. Five fledglings were found with four managed pairs where no nesting had been observed (family groups). A total of eight fledglings were observed in territories benefiting from rodent control management.

Summary

Our smallest Elepaio population had another modest breeding season at Palehua. Number of pairs dropped back down to eleven, equaling the total for 2014. It's unclear if the drop in pairs is due to the death of one or both birds in a pair or if the birds decided to move to more attractive breeding areas. Fledglings are up from the previous year, though successful active nests was at its lowest since 2010. Five pairs began nesting early in September-October of 2015. They likely took advantage of favorable weather conditions in the fall. Five fledglings were found before the end of November, which is an unusual occurrence at our management units.

Figure 6: Processing an Elepaio includes collecting biometrics data such as tail and wing measurements.

Moanalua Valley

Moanalua Territory Occupancy Status and Rat Control 2016

Map removed to protect rare resources. Available upon request

Moanalua Site Demographic Data

MOA	2016	2015	2014	2013	2012	2011
Singles	6	6	7	14	19	10
Pairs	34	33	32	33	32	21
Pairs with Rat Control	12	19	22	23	24	16
Active Nests[1]	3	7	16	17	15	13
Successful Active Nests[2]	1/3=33%	3/7=43%	5/16=31%	14/17=82%	10/15=67%	5/13=38%
Unknown Nest Outcome[3]	2	1	7	6	2	5
Failed Active Nests	2	3	6	3	5	3
Family Groups Found[4]	2	4	4	2	2	3
Fledglings Observed[5]	3	7	11	17	13	9
Fledglings/Managed Pair[6]	0.25	0.37	0.5	0.74	0.54	0.56

[1] Nest containing eggs or nestlings.
[2]Percentage of successful active nests observed.
[3]Total number of active nests with unknown outcome (time gap between visits).
[4]Total number of occurrences where pairs were observed with fledglings in which no nests were found.
[5]Total number of fledglings observed from successful active nests and family groups.
[6]The ratio of fledglings per managed pair.

Reproductive Results

Of the active nests monitored, 33% (1/3) were successful in producing one fledgling, and 67% (2/3) failed. Two nests had unknown outcomes (nests with sufficient time gap between visits in which a nest could have fledged with no subsequent detection of a fledgling). Two fledglings were found in four managed pairs where no nesting had been observed (family groups). A total of three fledglings were observed in territories benefiting from rodent control management. Another three fledglings were observed in territories not protected from rats.

Summary

The breeding season in Moanalua Valley this year produced few active nests and a small number of fledglings. The resident population remains high, though just one nest was successful from only three that were active at 12 managed pairs. Unfavorable weather conditions with above average rainfall during the spring and summer months, especially April-July, likely played a role in the lack of breeding success at this MU. Monitoring also proved to be challenging this season due to the poor weather conditions and a deteriorating road that provides access to Elepaio territories scattered throughout this 1,300 acre management unit.

Figure 7: A very inquisitive juvenile Elepaio at Moanalua Valley.

6.1.4 OIP Summary

Management Action Highlights 2016

- Conducted rodent control in a total of 88 territories with pairs at four management sites.
- Completed a long-term species population growth analysis. See Appendix 6-1 for details.
- Completed the 4th survey since 2009 of the two drainages north of the Ekahanui MU. Since that time the Elepaio population north of Ekahanui has increased 303% with the number of breeding pairs increasing from 1 to 14.
- The table below summarizes the number of managed pairs and reproductive output since 2006.

Summary of Elepaio Management Table

Year	Managed Pairs	Success Active Nests	Family Groups	Fledglings	Fledglings/ Managed Pair
2016[1]	88	21	36	68	0.77
2015[1]	97	27	20	50	0.52
2014[1]	81	24	28	62	0.77
2013[1]	105	51	38	95	0.90
2012[1]	97	38	22	65	0.67
2011[1]	94	47	34	96	1.02
2010[1]	87	18	15	39	0.45
2009[2]	81	29	24	60	0.74
2008[3]	74	25	20	56	0.76
2007[3]	78	18	26	46	0.59
2006[4]	69	11	17	33	0.48

[1]SBW, Ekahanui, Moanalua, Palehua
[2]SBW, Ekahanui, Makaha, Moanalua, Palehua
[3]SBW, Ekahanui, Makaha, Moanalua, Waikane, Palehua
[4]SBW, Ekahanui, Makaha, Moanalua

Management Actions 2017

- Continue to mist-net and band all adult and juvenile Elepaio within the MUs to improve yearly demographic monitoring. In the process, recording songs and calls in order to expand our collection of Oahu Elepaio vocalizations at all MUs.
- Conduct surveys within and beyond MUs to monitor bird movements and population growth of the species. This includes a follow-up survey of South Haleauau gulch in SBW to update the original survey that was conducted in 2010.
- Increase the use of motion sensor cameras to monitor nesting activity at night and document Elepaio nest predation.
- Conduct rodent control and Elepaio monitoring at Ekahanui, SBW, Palehua and Moanalua to meet required 75 managed pairs.

6.1.5 Terms and Conditions for Implementation

Minimize direct impacts of military activities on survival and reproduction of Oahu Elepaio within the action area at Schofield Barracks Military Reserve (SBMR).

1. *The Army will report to the Service in writing at least semiannually (twice per year) the number of high explosive rounds that land above the fire break road, the locations where such rounds land, and whether these locations are within any known Elepaio territories.*

   [No high explosive rounds landed above the firebreak road]

2. *The Army will notify the Service within 24 hours of any fires that burn any portion of a known Elepaio territory and the number of Elepaio territories affected*.

   [No fires affected any known Elepaio territories during the 2015 breeding season]

3. *The Army will limit training actions in the forest above the fire break road at SBMR in the Elepaio nesting season (January to May) to small numbers of troops (platoon or less) that remain in one location for short periods of time (one hour or less), to limit possible nest disturbance*.

   [No training actions have occurred above the firebreak road]

4. *The depository designated to receive specimens of any Oahu Elepaio that are killed is the B.P. Bishop Museum, 1525 Bernice Street, Honolulu, Hawaii, 96817 (telephone: 808/547-3511). If the B.P Bishop Museum does not wish to accession the specimens, the permittee should contact the Service's Division of Law Enforcement in Honolulu, Hawaii (telephone: 808/541-2681; fax: 808/541- 3062) for instructions on disposition*.

   [No specimens were collected by OANRP staff]

Minimize loss of Oahu Elepaio habitat at SBMR, Schofield Barracks East Range (SBER), and Kawailoa Training Area (KLOA).

1. *The Army will report to the Service in writing on a semi-annual (twice per year) the number of fires above the fire break road, the area burned by each fire above the fire break road, including the amount of critical habitat burned, and how each fire was ignited or crossed the fire break road.*

   [On October 29, 2015 a fire burned 5.78 acres of Elepaio critical habitat at SBER. Surveys conducted before and after the fire revealed no resident Elepaio.]

2. *The Army will notify the Service within 24 hours of any instance in which training was not conducted in accordance with the Wildland Fire Management Plan (WFMP)*.

   [All training was conducted in accordance with the WFMP]

Manage threats to Oahu Elepaio and Oahu Elepaio habitat at SBMR, SBER, and KLOA.

1. *The Army will report to the Service in writing annually the number of Elepaio territories in which rats were controlled, the location of each territory in which rats were controlled, the methods by which rats were controlled in each territory, the dates on which rat control activities were conducted in each territory, and the status of Elepaio in each territory from the previous year.*

   [This report documents all of the above requirements]

2. *The Army, Service, and ornithological experts will formally reassess all impacts to Oahu Elepaio and Elepaio critical habitat that have occurred during the first five years following completion of this*

biological opinion. This formal review will occur before the end of calendar year 2008 and its purpose will be to reassess impacts from training exercises and, if necessary, correct any outstanding issues that are still impacting Elepaio and resulting in the loss suitable Elepaio habitat at SBMR. The feasibility of restoring critical habitat areas that have been lost also will be reassessed during this formal review.

[Completed]

Figure 8: Adult feeding its young at a nest in native *Pisonia umbellifera*. This year, only 5% of Elepaio nests were built in native trees.

6.2 MIP ELEPAIO MANAGEMENT 2016

Background

The initial Biological Opinion (BO) that triggered the development of the Makua Implementation Plan (MIP) was issued in 1999. At that time, the Oahu Elepaio (*Chasiempis ibidis*) was not listed as an endangered species, but the 1999 BO did include recommendations related to Elepaio. These included conducting complete surveys of the Makua Action Area (AA) for Elepaio presence, monitoring of all known Elepaio within Makua Military Reservation (MMR) and installing and maintaining predator control grids around nesting pairs within MMR. In 2000, the U.S. Fish and Wildlife Service (USFWS) granted the Oahu Elepaio endangered species status under the Federal Endangered Species Act and in 2001 designated critical habitat on Oahu for the Elepaio. In the *Supplement to the Biological Opinion and Conference Opinion for Proposed Critical Habitat for Routine Military Training at Makua Military Reservation* issued in 2001, the recommendations from the 1999 BO became requirements. In September 2004, the USFWS issued another BO that covered newly designated critical habitat within the Makua AA for plants and Elepaio. This BO outlined additional requirements related to this critical habitat. The most recent BO issued in 2007 required the protection of all Elepaio pairs within the Makua AA. A term and condition in this 2007 BO was to construct ungulate-proof fencing around Makua Military Reservation and control rodents using aerially broadcast rodenticide when authorized.

Methods/Results

The methods section and the presentation of the results are in the same format as in the OIP Elepaio management section of this year-end report.

Figure 9: Elepaio molt all their feathers at the end of each breeding season. This bird must manage without a tail before growing back a new one.

Makua Territory Occupancy Status and Rat Control 2016

Map removed to protect rare resources. Available upon request

Makua Site Demographic Data

Makua	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006
Single Males	2	N/A	0	2	2	2	2	1	1	2	4
Single Females	0	N/A	0	0	0	0	0	0	1	1	1
Pairs	0	N/A	0	0	0	0	0	2	2	2	1
Pairs with Rat Control	0	N/A	0	0	0	0	0	2	2	2	1
Active Nests[1]	0	N/A	0	0	0	0	0	1	1	0	0
Successful Active Nests[2]	0	N/A	0	0	0	0	0	0	0	0	0
Unknown Active Nests[3]	0	N/A	0	0	0	0	0	1	0	0	0
Failed Active Nests	0	N/A	0	0	0	0	0	0	1	0	0
Family Groups Found[4]	0	N/A	0	0	0	0	0	0	0	0	0
Fledglings Found[5]	0	N/A	0	0	0	0	0	0	0	0	0
Fledglings/Pair[6]	0	N/A	0	0	0	0	0	0	0	0	0

[1] Nest containing eggs or nestlings.
[2]Total number of successful active nests observed.
[3]Total number of active nests with unknown outcome (time gap between visits).
[4]Total number of occurrences where pairs were observed with fledglings in which no nests were found.
[5]Total number of fledglings observed from successful active nests and family groups.
[6]The ratio of fledglings per managed pair.

Reproductive Results

In 2016, one survey of the valley was conducted at the end of June. Previous occupied territories and other areas containing suitable breeding habitat were surveyed with the help of digital recordings of Elepaio songs and calls specific to Makua Valley. During the 3-day camping trip two adult males were found, both defending separate territories in gulches deep within the valley. Another survey will hopefully take place in the fall to see if either male finds a mate. A breeding pair of Elepaio has not been observed in Makua Valley since 2009.

MIP Summary

Management Actions 2016

- There were no Elepaio territories monitored for breeding activity in Makua Valley.

Management Actions 2017

- Conduct yearly territory occupancy surveys at all territories and surrounding gulches within the Makua AA, monitoring and banding, and data entry and organization.

Figure 10: As the sun rises, OANRP staff look out over beautiful Makua Valley.

6.3 Nene Management 2016

Background

A family of four Nene geese (*Branta sandvicensis*) were observed using a construction site at the eastern end of the Wheeler Army Airfield runway for foraging activities during the summer and early fall of 2014, but only sporadically since. The Nene were observed once during the reporting period in December 2015. The table and aerial photo below summarize observations through 30 June 2016

Summary of Nene observations through 30 June 2016

Date	Time (hrs)	Observed	Location
8/14/14	0745-1000	4 birds: K59, K60, 001 and 002	New planted and watered grass
9/23/14	1813	4 birds: K59, K60, 001 and 002	Southeast corner of airfield next to Medevac helicopter park, evaporation pond being built.
10/3/14	0830-0900	4 birds, bands not observed	North west edge of construction site, adjacent to pooling water and green new grass
10/4/14	1100	4 birds, bands not observed; could see transmitter on one bird.	North west edge of construction site, adjacent to pooling water and green new grass. Northern pintail duck also observed using same pool.
10/6/14	0715-0845 And 1000-1435	4 birds: K59, K60, 001 and 002	North west edge of construction site, adjacent to pooling water and green new grass
7/16/15	0915	3 birds	Area E Central, resting in planted grass area.
12/17/15	Not recorded	2 birds	Not recorded

Figure 11: Aerial photo of the WAAF construction site.

The parent birds were Kauai Island individuals, translocated to Hawaii Island in an effort to reduce the number of Nene near the Lihue airport. These birds left Hawaii Island and nested at the James Campbell National Wildlife Refuge (NWR) in Kahuku, Oahu in 2014. They successfully fledged two chicks, aided by the ongoing predator control program at the NWR. The male parent bird died during the past year (Aaron Nadig, USFWS, pers. comm.) so only three birds are known to remain on Oahu.

Figure 12: Nene geese at Wheeler Army Airfield.

Nene Management Summary

In order to avoid any harm to the geese, the USFWS recommended all activity cease within 150 feet of the birds. In addition, OANRP outreach staff conducted an educational campaign. An article was published in the Hawaii Army Weekly that included information on how to report and avoid negatively impacting the Nene. In addition, outreach staff produced posters with the same information for sites around Wheeler where the Nene would most likely be observed including; the Wheeler Tower, Wheeler Airfield operations and the construction site offices. Additionally, the Leilehua golf course staff was notified to report any Nene appearances. OANRP are coordinating closely with USFWS to modify practices at the construction site to reduce the site’s attractiveness and are including Nene in the Biological Assessment being prepared for Oahu training. OANRP developed a Nene observation form on which construction workers and airfield employees can record data and to ensure consistency. This form is included on the next page.

NĒNĒ GOOSE OBSERVATION FORM

Date:________________ Observer Name/Contact:_______________________

Time:______________________ #Birds present:_________________________

Banded Y/N Band Number(s):____

(*Only obtain band numbers using binoculars. Maintain safe distance (at least 10 meters) from nēnē at all times*)

Observations:

What are the geese doing? (Feeding, resting, preening, bathing, etc).

What areas? (Water retaining area, planted grass area, etc)).

____

____

____

Please call or text DPW Environmental, Natural Resource Section, immediately when nēnē are observed.

Kapua Kawelo, Chief **864-1014** Phil Taylor, Avian Conser. Spec. **916-412-9215**

Please scan and email Nēnē Observation Form to: **Hilary.k.kawelo.civ@mail.mil**

6.4 OPEAPEA MANAGEMENT 2016

6.4.1 Background

OANRP originally conducted acoustic monitoring for the Hawaiian Hoary bat (*Lasiurus cinereus semotus*) or Opeapea from 2010 to 2013 on all Oahu Army Training Areas: Dillingham Military Reservation (DMR), Kahuku Training Area (KTA), Kawailoa Training Area (KLOA), Makua Military Reservation (MMR) and Schofield Barracks Military Reservation (SBMR). These surveys were conducted for over 301 nights in order to establish bat presence or absence and document potential seasonal use of habitats by the Opeapea. OANRP found Opeapea present at all Oahu Training Areas (Figure 13). Specific foraging behavior was documented from KTA, DMR and Schofield Barracks West Range (SBW). In general, bat detections on Oahu are much lower than from data collected on Hawaii, Maui and Kauai islands (C. Pinzai pers. comm.).

Map removed to protect rare resources. Available upon request

Figure 13: OANRP bat survey sites on Army Training lands.

6.4.2 Opeapea Management Summary

OANRP secured funding in FY 15 to conduct more intensive acoustic monitoring surveys across a majority of the Army installations on Oahu, including cantonment areas. The survey period was originally from January 2015 to January 2016 but due to range scheduling conflicts the recorders were left out until March 2016. Figure 14 displays all of the locations that the bat acoustic recorders were placed throughout the duration of the study. A total of 30 monitoring stations were run nightly for this study. Final results are forthcoming and these data will be used to inform the upcoming consultation with the USFWS.

Map removed to protect rare resources. Available upon request

Figure 14: Current survey sites for Opeapea on Army controlled lands.

In the interim, the USFWS provided restrictions to minimize impacts to bats through an informal consultation. Consequently, the Army has ceased felling trees which are greater than 15 feet tall during the bat pupping season, June 1st through Sept 15th each year. During the 2016 pupping season, permission was given to remove trees that were safety hazards or necessary for ongoing construction projects. The Army's expert arborist provided guidance on the necessity of trimming or removal in regards to the safety issues. In each case, OANRP employed a combination of acoustical monitoring and thermal imager surveys or to determine if bats were utilizing the trees for roosting and if pups were present. OANRP also recorded whether any other wildlife was observed during the surveys. Results of all the surveys are listed in Appendix 6-2 to 6-7. Table 6.1 shows that a total of six surveys were conducted by OANRP before the end of this reporting period. All totaled, about 17 hours (this includes travel time) were spent conducting these surveys in 174 trees (17 different species). Zero roosting or flying bats were detected during the course of these surveys. These procedures will be formalized in the upcoming Section 7 consultation. Also, tree removal contracts are now being designed to include bat pupping season restrictions and the summer cutting limitations are being built into landscape maintenance timelines. In early September 2015 an official Garrison policy was signed placing a moratorium on tree cutting during the bat pupping season. This policy is included as Appendix 6-8.

OANRP purchased two thermal imagers, on Fluke 400T and one IR Hunter Mark II, to use for detecting possible roosting bat pups. OANRP continues to work closely with the biologist for HECO to formulate a bat survey program and find alternative methods for determining the presence of a roost tree with pups.

Table 6.1 2016 Opeapea Acoustic/Thermal Surveys

DATE	2016-06-16	2016-06-18	2016-06-25	2016-06-27	2016-07-05	2016-08-18
INSPECTOR	K. Kawelo	M. Burt	M. Burt	M. Burt	K. Kawelo	M. Burt
THERMAL OR ACOUSTIC SURVEY	Thermal	Both	Both	Both	Thermal	Thermal
START TIME	5:30	5:00	4:40	4:40	05:00	06:00
END TIME	6:30	6:30	6:30	7:30	06:30	06:20
TOTAL TIME	1 Hr	1.5 Hr	1.8 Hr	2.8 Hr	1.5 hrs	20 min
BAT DETECTED (T/A)?	No	No	No	No	No	No
WILDLIFE DETECTED?	Yes	Yes	Yes	Yes	Yes	Yes
WEATHER	Clear, Light wind	Clear, Light wind	Clear, Light wind and rain	Clear, Light wind	Clear, Light wind and rain	Clear, Light wind
Army Installation	SBMI	FSAB	WAAF	SBMI (LGC)	SBER	FSAB
AFRICAN TULIP	8			11		
EUCALYPTUS SPP.	19		15	18	10	
MONKEY POD		8				
BANYAN		3		3		
ALBIZIA SPP.	12				3	
CINNAMON	4					
PRIDE OF INDIA	1				5	
JAVA PLUM	2					
SHOWER TREE		2				1
EAR POD		5				
GUN POWDER	1				3	
TROPICAL ASH				1		
PHILIPPINE NARRA				2		
CHRISTMASBERRY					5	
IRONWOOD					2	
MACARANGA					6	
SILK OAK					2	

CHAPTER 7: *DROSOPHILA* SPECIES MANAGEMENT

7.1 BACKGROUND

Fourteen species of Hawaiian picture wing *Drosophila* flies are currently listed as threatened or endangered, and many more are equally rare. Six listed species are endemic to Oahu, and three – *D. montgomeryi*, *D. obatai*, and *D. substenoptera* – are currently known to occur on Army lands. OANRP work on *Drosophila* began in March 2013, focusing on monitoring known populations, surveying for new ones, and restoring habitat.

This year's surveys were significantly reduced compared to previous years due to unforeseen personnel issues, and were mostly limited to monitoring of existing sites. In addition, the El Nino weather pattern beginning in the summer of 2015, with a wet summer in leeward areas followed by a dry winter, has resulted in severely reduced *Drosophila* populations among both common and rare species.

7.2 SURVEY METHODS

Many species of Hawaiian *Drosophila*, including the picture wing group to which all of the endangered species belong, are readily attracted to baits of fermented banana and mushrooms. Both baits are spread on a cellulose sponge which is hung from a tree in a cool, shaded, sheltered site, and checked for flies after about one hour. Depending on the quality of the site (number and size of host plants, and microclimate) and the density of baiting spots, surveys typically consist of setting out 16-24 sponges, in groups of 4 or 8 with groups separated by 20-100 m. Baits are checked at least every hour, as flies do not necessarily stay at baits for long periods; number and species of all picture wings on each sponge are recorded at each check. The greatest activity is typically during the cooler hours before 10 AM and after 2 PM, but flies may appear at any time. Direct quantification of *Drosophila* populations is difficult, since populations may fluctuate not only seasonally but from day to day. However, repeated surveys can yield useful data on long-term trends. Abundance numbers are reported as the maximum number of individuals observed on a survey day (compiled by adding the maximum observed at each discrete group of bait sponges at any one time, assuming that the same individual flies may move between sponges within a group but are unlikely to be seen at two different groups), since numbers fluctuate through the day.

Known, significant populations of *D. montgomeryi* at Kaluaa MU and *D. substenoptera* at Palikea MU, where flies occur relatively consistently, are monitored monthly in order to determine approximate population trends through the year. For *D. montgomeryi*, Pualii (designated as a management site for *D. montgomeryi*) and Waianae Kai (not a managed population, but the largest known population) are monitored quarterly. Other known populations (Kaala and Lower Opaeula for *D. substenoptera*, Lihue and Manuwai for *D. obatai*) are visited periodically through the year, typically quarterly or less. New populations of endangered *Drosophila* were searched for by looking in similar habitat both in areas suggested by other staff as having host plants, at historic collecting localities, and in new sites where surveys have been minimal. Numbers of *Vespula pensylvanica* (western yellowjacket), a potentially serious invasive predator, are monitored at Palikea and Puu Hapapa with 10 heptyl butyrate baited traps at each site checked monthly.

7.3 RESULTS

7.3.1 *Drosophila montgomeryi*

Drosophila montgomeryi is a small yellow-brown species which breeds in rotting bark of *Urera kaalae* (endangered, very few wild trees left) and *Urera glabra* (opuhe, uncommon but found at many sites). It

Map removed to protect rare resources. Available upon request

Figure 1: Distribution of *Drosophila montgomeryi* observations in the 2015-16 reporting year and earlier records from 2009-15, with known *Urera* spp. sites and all survey points in the Waianae range.

is currently known from ten sites that are regarded as five population units (PUs), effectively covering nearly its entire historic range in the Waianae mountains (Figure 1). Field work this year has focused on monitoring known populations rather than searching for new sites (Table 1). The Lihue PU was not surveyed due to access issues. While *Urera glabra* occurs widely across the Waianae range, it often occurs as scattered clumps of a few or only one individual, unsuited for survival of *D. montgomeryi* and probably not viable for long-term survival of this dioecious, wind-pollinated tree.

Kaluaa & Waieli MU

Three sites in this MU – Puu Hapapa, North Kaluaa, and Central Kaluaa gulch 1 – have been monitored monthly since June 2013 (though not every site was visited each month) over a total of 54 survey days. In past years abundance of *D. montgomeryi* has followed a distinct seasonal pattern, increasing dramatically over the winter months to a peak between January and May (Figure 2), more or less in synchrony with several common *Drosophila* species. This is most likely due to increased rain and treefalls from storms that cause death or branch breakage of *Urera* near monitoring sites. During the 2015-16 sampling season, there was no such winter pulse in *D. montgomeryi*, with only relatively few scattered individuals. More appeared in the late spring and early summer before dropping out again. The common species *D. inedita* and *D. ambochila* did both have similar winter seasons as in previous years, although they did not reach as high abundance as usual.

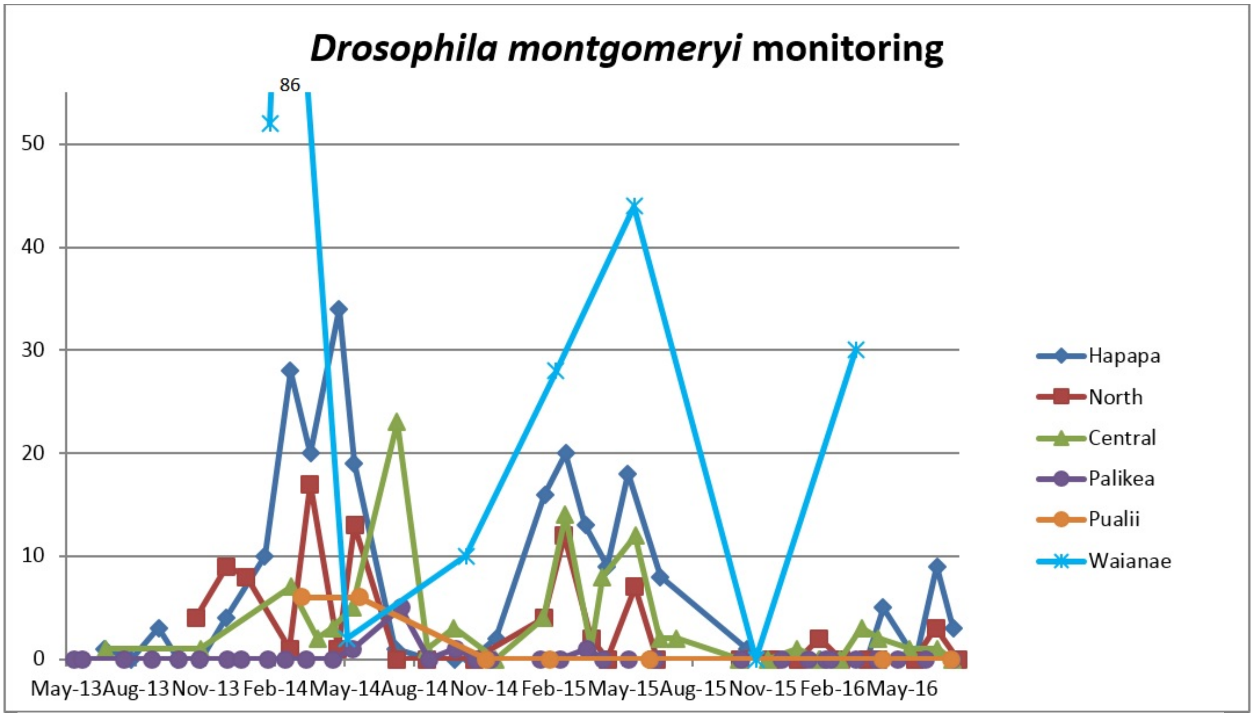


Figure 2: *Drosophila montgomeryi* numbers during monthly monitoring at three sites in Kaluaa PU (Puu Hapapa, North Kaluaa, and Central Kaluaa) and Palikea, and quarterly monitoring at Waianae and Pualii. Y axis is the maximum number observed across the entire site on the survey day (see Survey Methods, section 5.2).

Pualii

This site was visited for the first time in 2014, and quarterly monitoring began in 2015. At the time of the first visit, the last wild *Urera kaalae* tree in North Pualii Gulch had recently fallen and the decaying trunk was supporting a large number of *D. montgomeryi*. Unfortunately, the species has not been seen since the second visit there, and the survival of this population is uncertain. Only one of the original *U. kaalae* outplants remains, but at least 10 natural offspring of these plants have grown up, and several have now reached substantial height. This appears to be the only site where outplanted trees of this species are successfully reproducing. There are no *U. glabra* aside from recent outplants, which have not grown as much as those at other sites. Nevertheless, it is an area of high-quality native habitat, both in the immediate vicinity and further downslope in the gulch. It may be a potential reintroduction site after additional host plant restoration.

Palikea

Despite continuous monitoring here since May 2013 (targeting *D. substenoptera*, which is consistently found in the area), *D. montgomeryi* was not detected until May 2014. Three of the four records of *D. montgomeryi* here have been of single individuals, indicating that the population remains low. After a year of occasional sightings, it has not been seen here since March 2015. However, there are other patches of *Urera* around the Palikea MU that may also harbor populations of *D. montgomeryi*. The area where they were found is already a target for weed management and restoration, and has high potential for management to benefit *D. montgomeryi*. *Urera kaalae* was absent (many have been planted in the past year), but *U. glabra*

Site	Days	Max No.
Kaluaa - Central	10	3
Kaluaa - North	9	3
Puu Hapapa	9	9
Pualii	3	0
Palikea	9	0
Waianae	2	30
Ekahanui	1	0

Table 1: Survey effort for *D. montgomeryi* across all potential sites in 2015-16 reporting period, in survey days. "Max No." is the highest number of flies observed in a single day.

had already begun to increase naturally as weed control reduced alien cover, and outplanting has significantly boosted the population. Outplanted *U. glabra* here has done exceptionally well – many of them are 6–8 feet tall after only 18 months.

Waianae Kai

The largest known population of *D. montgomeryi* occurs in the northeastern subgulches of Kumaipo stream, Waianae Valley. Three sites have been discovered so far, all at the base of Mt. Kaala and consisting of small patches (~0.5 ha) of diverse native forest constrained by alien-dominated vegetation above and below. All are located on or just below steep slopes that are vulnerable to landslides, which may preclude fencing as a matter of practicality. A fourth was discovered this year, but it has been surveyed only once under unfavorable conditions and it is uncertain whether *D. montgomeryi* occurs there. However, being on a ridge it may be more amenable to fencing and protection of the habitat from pig damage which is severely impacting the other sites. Gulches to the west of the known sites were surveyed and found to contain no *Urera*; however, the area to the east in Hiu Gulch has yet to be checked, and there may be additional sites in the area.

Habitat restoration

This was the second year of active habitat management for *Drosophila montgomeryi*. Last year, approximately 50 *U. glabra* grown from cuttings were planted at each of North Kaluaa, Pualii, and

Figure 3: Habitat restoration for *D. montgomeryi* at Palikea. The photos in each column were taken from the same viewpoint on opposite ends of a clearing where invasive plants had been removed (October 2014) and *Urera glabra* and other natives planted in February 2015.

Palikea, and 35 at Central Kaluaa, between November 2014 and April 2015. In December 2015, an additional 35 *U. glabra* were planted at Central Kaluaa, and 25 *U. glabra* and 50 *U. kaalae* at North Kaluaa (see Restoration section for details). Approximately 50 *U. kaalae* each were also planted at Palikea, Central Kaluaa, and Pualii by the OPEPP program. All sites are exhibiting high survivorship (87–100%) and good growth, especially Kaluaa and Palikea (Figure 3). Observations of some individuals suggests that pruning of tip shoots of *U. glabra* may promote extremely vigorous growth of side branches and ultimately larger, more robust trees that will be better habitat for flies in a few years.

In May 2016, the alien fungal pathogen mamaki rust (*Pucciniastrum boehmeriae*) was first noticed and on *Urera kaalae* (Figure 4), and positively identified by HDOA. Although it manifests differently than in mamaki (*Pipturus albidus*), without any scorching or wilting of the leaves, the leaves are much more heavily covered in fungal spores and may fall off easily. The full effect of the rust is as yet unknown. Although present at all sites, the burden as determined by visible spores is highly variable: North Kaluaa and Pualii have very little, Central Kaluaa and Palikea a moderate amount, and Puu Hapapa is severely affected. Most of the large *U. kaalae* at Puu Hapapa died or had heavy branch dieback over the winter of uncertain causes; while it was quite dry, it is possible that rust infection contributed to the losses.

Figure 4: Underside of a *Urera kaalae* leaf at Puu Hapapa, showing a dense covering of yellow urediniospores characteristic of heavy mamaki rust (*Pucciniastrum boehmeriae*) infection.

7.3.2 *Drosophila substenoptera*

Surveys for this species have focused on finding new populations. Based on collection records, it requires moderately tall, non-boggy wet forest with its host plants, *Cheirodendron* sp. (olapa) and *Polyscias*

Map removed to protect rare resources. Available upon request

Figure 5: Distribution of *Drosophila substenoptera* observations in the 2015-16 reporting year and earlier records from 2013-15.

(=*Tetraplasandra*) *oahuensis* (ohe mauka), a habitat which is relatively uncommon since these trees tend to occur most abundantly in short-stature forest near summit crestlines. Currently, there are three known PUs for *D. substenoptera* – Palikea, Kaala-Kalena, and Opaeula (Figure 5). PU trends are only graphed for Palikea as the other two PUs have insufficient numbers of survey days. At other sites *D. substenoptera* is highly sporadic, typically occurring as single individuals observed only once during a day. This rarity has undoubtedly hampered our ability to detect it at new sites.

Waianae Range

Monthly monitoring in the northern portion of Palikea MU has been ongoing since May 2013 (33 survey days total, 9 in the current reporting period; Table 2). Aside from a large flush in late May 2013, numbers of *D. substenoptera* and another endangered species, *D. hemipeza*, have been consistently low, but they have always been present. In contrast to *D. montgomeryi*, abundance of *D. substenoptera* tends to increase in the summer rather than winter, somewhat correlated with *D. hemipeza* and the common *D. crucigera* but not *D. punalua* (Figure 6). At the Kaala-Kalena PU, three new sites were surveyed (Kalena summit ridge, Kaala transect, and Kaala northeast face). No flies were found, but the Kaala sites are promising and will be revisited.

Site	Days	Max No.
Palikea	9	5
Kaala	5	0
Lihue	1	0
Koloa	2	0

Table 2: Survey effort for *D. substenoptera* across all potential sites in 2015-16 reporting period, in survey days.

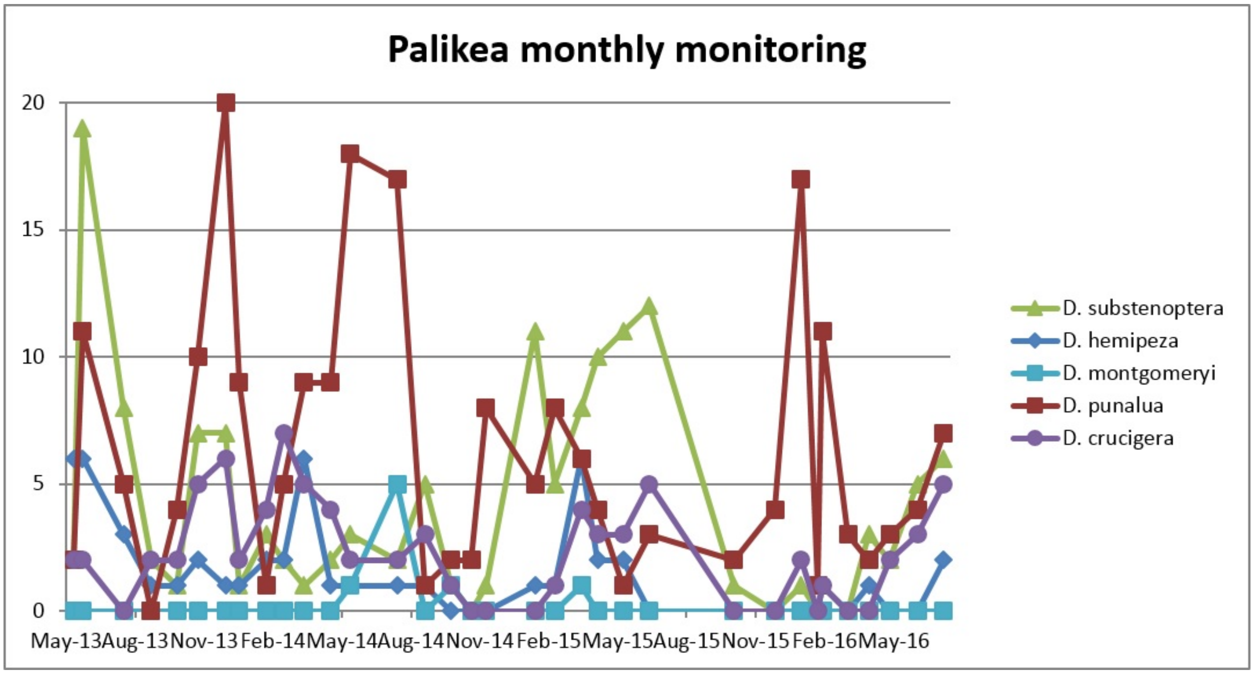


Figure 6: Monthly monitoring results for all species at Palikea, from May 2013 to July 2015.

Koolau Range

In December 2013, a single *D. substenoptera* was observed at Lower Opaeula MU, the first record of the species in the Koolau range since 1972. In early 2015, it was sighted again in the same area. Historically, *D. substenoptera* was more widespread and abundant on this side than in the Waianae range. However, collection effort has been limited due to the difficulty in accessing areas of intact habitat for this species. OANRP surveys in the Koolaus for *D. substenoptera* have been relatively few due to higher priorities elsewhere, and concentrated in only a few sites. Surveys this year at Koloa did not find any of this species. Finding additional Koolau populations is a high priority for this species; Helemano, Poamoho, and Kaukonahua have yet to be surveyed. Lower Opaeula and Koloa will continue to be checked given the extremely high quality of habitat there and low observation rate at sites where *D. substenoptera* is known to be present. Appropriate breeding habitat, of taller non-boggy forest, is surprisingly limited given the wide distribution of *Cheirodendron* on other islands under similar climatic conditions, and often occurs only on steep slopes or in the bottom of drainages that are weedy and difficult to access.

7.3.3 *Drosophila obatai*

Drosophila obatai was rediscovered in Manuwai Gulch MU in 2011, 40 years after the previous record in 1971. It breeds in rotting stems of *Chrysodracon* (=*Pleomele*) spp. (halapepe), which suffers from very low reproduction rates but remains widespread in the northern Waianae range thanks to its longevity. It is currently known from seven sites in four potential PUs (Makaleha, Manuwai, Palikea Gulch, and Pulee), although three of these are within 1,200 m of each other and could potentially form one contiguous population. While it almost certainly was contiguous until recently, native forest in general and *Chrysodracon* in particular is now much more fragmented, and moving between patches of host trees more difficult for the flies.

Site	Days	Max No.
Manuwai	1	0
Lihue - Mohiakea	1	0

Table 3: Survey effort for *D. obatai* across all potential sites in 2015-16 reporting period, in survey days.

Surveys for *D. obatai* in 2015-16 were few due to the limited survey time available and a focus on monitoring *D. montgomeryi* (Table 3). Only Manuwai and South Mohiakea were visited, and no

Map removed to protect rare resources. Available upon request

Figure 7: Distribution of *Drosophila obatai* observations from 2013-15, with known *Chrysodracon* spp. sites and all survey points in the Waianae range.

D. obatai were found. Given the lack of records even at Manuwai, where it has recently been most common, and the already-perilous state of this species, the upcoming year will focus more heavily on finding new sites and establishing its continued presence at previous ones.

7.3.4 Other Rare *Drosophila*

During the course of surveys, four additional rare *Drosophila* were found in management units where *D. montgomeryi* and *D. substenoptera* occur (Table 4). A fifth, *D. craddockae*, was found at Makua. Most of the rare species that had been found in previous years were not seen this year, due to the generally poor conditions (dry winter and wet summer) and reduced survey effort.

Table 4: Non-target rare *Drosophila* observed during surveys, July 2015–June 2016.

Species	Sites	Total Obs.	Max. No.
D. craddockae	Ohikilolo	2	2
D. divaricata	Kaluaa, Hapapa	25	5
D. hemipeza	Palikea, Hapapa	2	1
D. nigribasis	Kaala	10	5
D. oahuensis	Kaala, Koloa	12	4

Drosophila craddockae is closely related to *D. pullipes* of Hawaii and *D. grimshawi* of Maui Nui. Like the former, it is a specialist on *Wikstroemia* spp., an unusual host. While its host is abundant, *D. craddockae* is rarely observed, and has been found only sporadically at widely separated localities in recent years. Only two were seen, at the same time at Ohikilolo. This is a new site record for the species, the sixth in our surveys.

Drosophila divaricata is closely related to the more common *D. inedita*, but can be easily distinguished by its much larger size and slightly different wing pattern. The host plant is unknown. It has generally been rare, but was observed regularly in North Kaluaa, and occasionally at Central Kaluaa and Puu Hapapa in 2015–16.

Drosophila hemipeza is the only listed endangered species on Oahu that is known to be extant but does not occur on Army lands or OIP/MIP action areas, although it historically occurred at Kahuku Training Area and West Makaleha Gulch adjacent to Makua. It has been consistently found at Palikea MU but always in low numbers for several years; occasional individuals have shown up at Puu Hapapa as well. Only two were seen this year, both at Palikea.

Drosophila nigribasis breeds in *Cheirodendron*; it is related to *D. substenoptera* but appears to favor wetter habitats. In our surveys, it is restricted to Koloa and the vicinity of Kaala summit.

Drosophila oahuensis is also a *Cheirodendron* breeder, and appears to span the habitat range of *D. nigribasis* and *D. substenoptera*, including both the near-summit area of Kaala and wet-mesic sites such as North Haleauau Gulch in Lihue. The majority of both *D. nigribasis* and *D. oahuensis* came from one site on the west side of Kaala.

Drosophila craddockae, widespread but extremely rare and sporadic.

Drosophila divaricata, restricted to Honouliuli in the southern Waianae range.

Drosophila hemipeza, very similar to *D. substenoptera* and also often seen waving its wings.

7.3.5 *Vespula pensylvanica*

This highly invasive social predatory wasp is considered a major factor in the decline of picture wing *Drosophila* on Maui and Hawaii. Little is known of its impacts on Oahu, where it is present but much less conspicuous. The typical life cycle of a yellowjacket colony consists of an individual fertilized queen starting a nest in the spring, building up numbers of workers slowly at first but with exponential growth, peaking in the fall when new reproductives (males and the next generation of queens) are produced. After the reproductives leave the colony it typically declines and the workers die off, but in warm climates such as Hawaii they may persist through the winter and grow to an exceptionally large size during a second summer, with tens or hundreds of thousands of workers.

Numbers at the two sites sampled are relatively modest compared to upper elevations of Hawaii or Maui. Still, they show a significant number of *Vespula* present at both during the summer, coinciding with the low period of *Drosophila* numbers. It is unclear if there is any causal relationship; *Vespula* numbers so far in 2016 have gone higher earlier at Palikea but remain zero at Hapapa, which is similar to the numbers of *Drosophila* seen (and thus unexpected since the relationship would be inverse if *Vespula* are limiting *Drosophila* numbers).

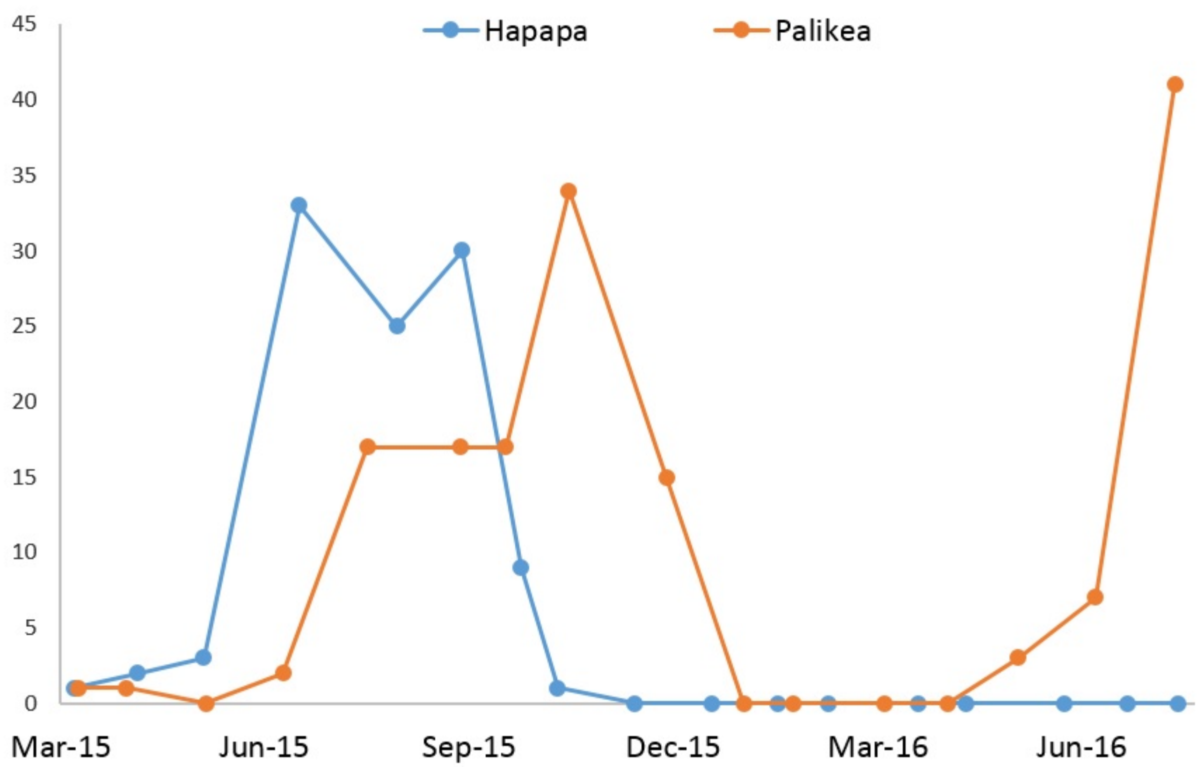


Figure 8: *Vespula pensylvanica* numbers at Palikea and Puu Hapapa (monthly total across 10 traps at each site).

We plan to continue monitoring at Palikea and Hapapa, since the current regime of maintaining 10 traps at each site can be done in conjunction with the monthly fly monitoring without additional effort. No other sites have both significant *Drosophila* populations and relatively open canopy suited to *Vespula* monitoring. At present, there are no plans to conduct control of *Vespula*, but this may be considered if populations increase in the future.

CHAPTER 8: RODENT MANAGEMENT

OANRP has managed MIP and OIP species that are subject to rodent predation with various strategies since 1997. This chapter discusses rodent control methods utilized over the past reporting year and highlights recent changes. Specifically, this chapter has seven main sections: Section 8.1 provides an overview of the current rodent control program and discusses recent changes; Section 8.2 discusses the Diphacinone-50 (D-50) hand broadcast at Kahanahaiki; Section 8.3 a citric acid bait trial; Section 8.4 discusses current techniques for protecting rare plants; Section 8.5 describes Standard Operating Procedures (SOPs) that OANRP uses; Section 8.6 discusses operations conducted at Ohikilolo; and Section 8.7 lays out future plans for rat control.

8.1 OANRP RODENT CONTROL PROGRAM SUMMARY

OANRP manages rats seasonally or year-round, depending on whether the rare taxa require protection seasonally or year-round. For example, *Chasiempis ibidis* (or Oahu Elepaio) are only protected during the seasonal nest season, while *Achatinella* mustelina are protected from predation year round. The methods of rodent control that OANRP currently utilizes are limited to kill-traps (Victor snap traps, Woodstream Corporation Lititz, PA; Ka Mate Ltd. traps Nelson, New Zealand; and Goodnature Ltd. A24 traps Wellington, New Zealand), Diphacinone bait used for trials, and predator-proof fences.

Rat control in 2016 consisted of deploying small Victor snap trap and Goodnature A24 trap grids around select resources, installing and maintaining large-scale trapping grids consisting of Victor, Ka Mate, and/or Goodnature A24 traps in some MUS, and an experimental broadcast of Diphacinone-50 to minimize seasonal fluctuations of rat populations at Kahanahaiki.

In October 2015 a new predator control contract was awarded to Pono Pacific for a five year period. Most sites had an increase in the number of traps and size of grids. A new large-scale rat grid was established at the Makaha I Unit fence this past reporting period using A24s. Pono Pacific is now responsible for checking tracking traps and tunnels at Palikea, Ekahanui, Kahanahaiki, and Makaha. Prior to this contract the OANRP field teams were conducting this control, and now they will be able to focus efforts on other units and management actions.

Table 1: Rat control strategies to be utilized by OANRP in 2016-2017.

MU/Area	Primary Spp. Protected	Description	Deployment	Check Interval	Trap Type	# Traps
East Makaleha	*A. mustelina*	Two small grids	Year-round	6 weeks	Victors	40
					A24s	20
Ekahanui	*A. mustelina*	Many small grids	Year-round	2 weeks	Victors	47
					A24s	30
Ekahanui	*C. ibidis*	Large-scale grid	In Season: Dec-June	2 weeks	Victors	674
Ekahanui	*A. mustelina, Cyanea grimesiana, Schiedea kaalae, Delissea waianaeensis*	Large-scale grid	Off Season: July-Nov	2 weeks	Victors	200
Kaala	*Labordia cyrtandrae*	One small grid	Rapid Response	6 per year	Victors	35
					Kamates	35
Kahanahaiki	*A. mustelina, Cyanea superba*	Large-scale grid	Year-round	4 weeks	A24s	170

MU/Area	Primary Spp. Protected	Description	Deployment	Check Interval	Trap Type	# Traps
Kaluaa	*D. waianaeensis, C. grimesiana*	One small grid	Rapid Response	6 per year	Victors	37
					Kamates	38
Kamaohanui	*A. mustelina*	One small grid	Year-round	6 weeks	Ka Mates	47
					A24s	10
Kapuna/ Keawapilau	*Hesperomannia oahuensis*	One small grid	Rapid Response	6 per year	Victors	23
					A24s	5
Kapuna/ Keawapilau	*Schiedea nuttallii*	One small grid	Rapid Response	6 per year	Victors	13
					A24s	4
Makaha Unit I	*A. mustelina, H. oahuensis, C. superba*	Large-scale grid	Year-round	4 weeks	A24s	111
Makaha Unit I	*H. oahuensis*	One small grid	Rapid Response	6 per year	Victors	14
					A24s	6
Makaha Unit II	*C. grimesiana, Cyanea longiflora, H. oahuensis, S. nuttallii*	Many small grids	Year-round	6 weeks	A24s	47
Makaha Unit II	*C. grimesiana*	One small grid	Rapid Response	6 per year	Victors	12
Makaha Unit II	*H. oahuensis*	One small grid	Rapid Response	6 per year	Victors	12
Manuwai	*D. waianaeensis*	One small grid	Rapid Response	6 per year	Victors	14
					Ka Mate	12
					A24s	8
Moanalua	*C. ibidis*	Many small grids*	Annual: Dec-June	2 weeks	Victors	180
Ohikilolo	*A. mustelina, Pritchardia kaalae*	Many small grids	Year-round	6 weeks	Victors	133
					A24s	53
Opaeula Lower	*Cyrtandra dentata*	One small grid	Year-round	6 weeks	Victors	24
Palehua	*C. ibidis*	Large-scale grid	Annual: Dec-June	2 weeks	Victors	200
Palikea	*A. mustelina*	Large-scale grid	Year-round	2 weeks	Ka Mate	250
Pualii	*H. oahuensis*	One small grid	Rapid Response	6 per year	Victors	24
					A24s	4
Lihue (Banana)	*C. ibidis*	Many small grids*	Annual: Dec-June	4 weeks†	Victors	111
Lihue (Haleauau)	*C. ibidis*	Many small grids*	Annual: Dec-June	4 weeks†	Victors	166
Lihue (Haleauau)	*A. mustelina*	Two small grids	Year-round	6 weeks	Victors	24
Lihue (Haleauau)	*H. oahuensis*	One small grid	Rapid Response	6 per year	Victors	12
					A24s	3

MU/Area	Primary Spp. Protected	Description	Deployment	Check Interval	Trap Type	# Traps
Lihue (Mohiakea)	*C. ibidis*	Many small grids*	Annual: Dec-June	4 weeks†	Victors	165
Lihue (Mohiakea)	*D. waianaeensis*	One small grid	Rapid Response	6 per year	Victors	7
Makaleha West	*C. grimesiana*	One small grid	Year-round	6 weeks	Victors	29
Kaluaa and Waieli	*A. mustelina*	One small grid	Year-round	6 weeks	Victors	25
Kahanahaiki	*A. mustelina*	Predator-proof fence	Constructed 1998			
Waieli-Hapapa	*A. mustelina*	Predator-proof fence	Constructed 2011			
Palikea	*A. mustelina*	Predator-proof fence	Constructed 2012			

* *Each managed Elepaio (C. ibidis) territory has 12-15 traps installed ~12 m apart.*

† *Due to limited range access traps are baited twice during one week once a month.*

8.2 Tracking Tunnel Results from Large-Scale Grids

For this report and future reports a graph of tracking tunnel results will be provided for all of our large-scale grids (Kahanahaiki, Ekahanui, Makaha, Ohikilolo, and Palikea) (see figures 1 and 2). Kahanahaiki and Ohikilolo results are provided in sections 8.3 and 8.7 of this report as they were used to monitor results from Diphacinone bait trials. In general these graphs should be used to look at the big differences between years or between control and treatment sites. Small changes of ~20% or less cannot accurately be assessed.

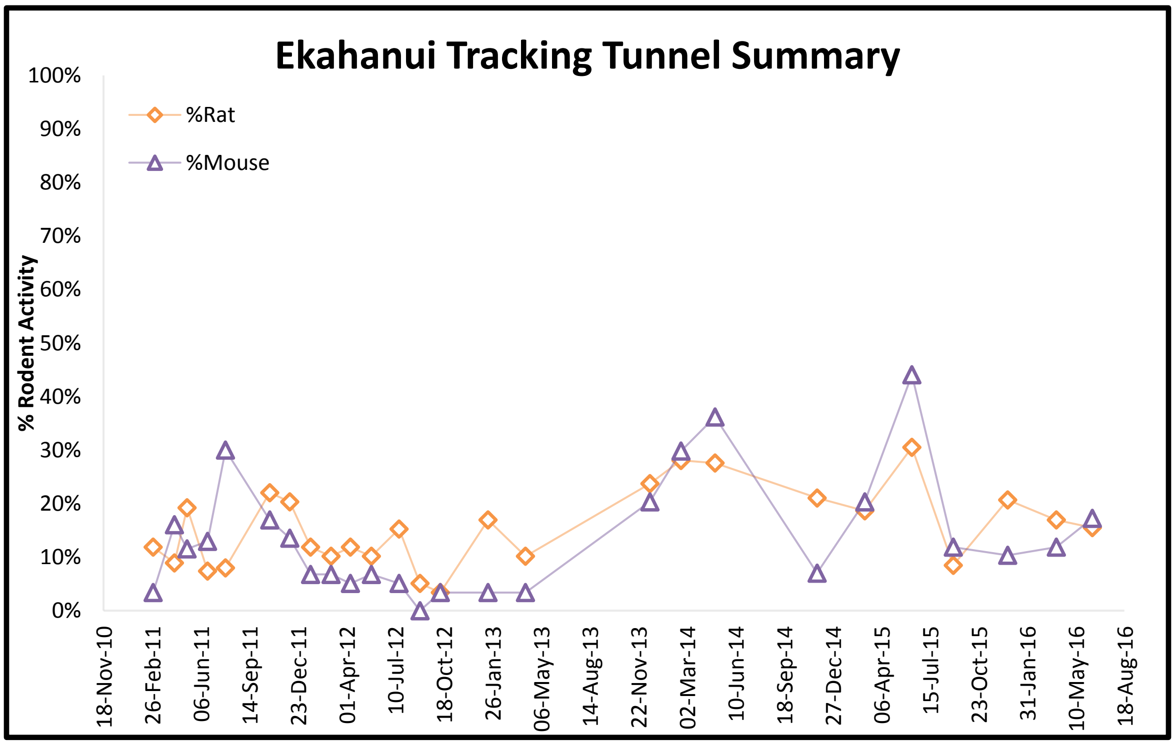


Figure 1: Percent of rodent activity at Ekahanui.

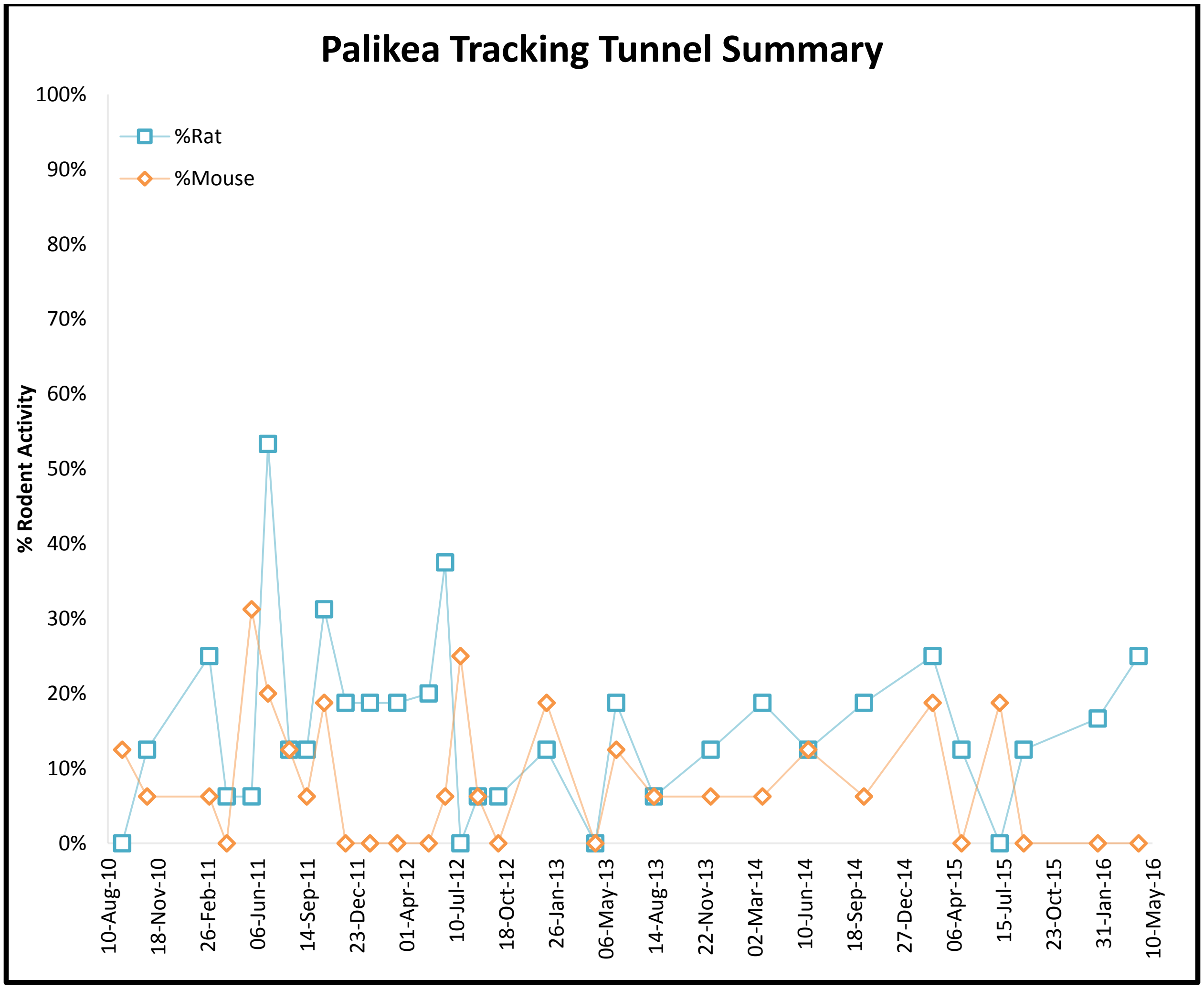


Figure 2: Percent of rodent activity at Palikea.

In December of 2014 a grid of A24s was installed at Makaha unit I to protect several rare plant out planting locations as well as multiple populations of A. mustelina. The grid consists of 111 A24s at a 100x25m spacing. Traps and tunnels are checked every month by Pono Pacific. No control site was installed to compare tracking, however it is believed that there is very high rodent activity in this area as evidenced by the high initial tracking of approximately 90% before the traps were baited (see figure 3). Currently at this site the grid of A24s has not been an acceptable method of reducing the percent tracking to target levels of 10% or less.

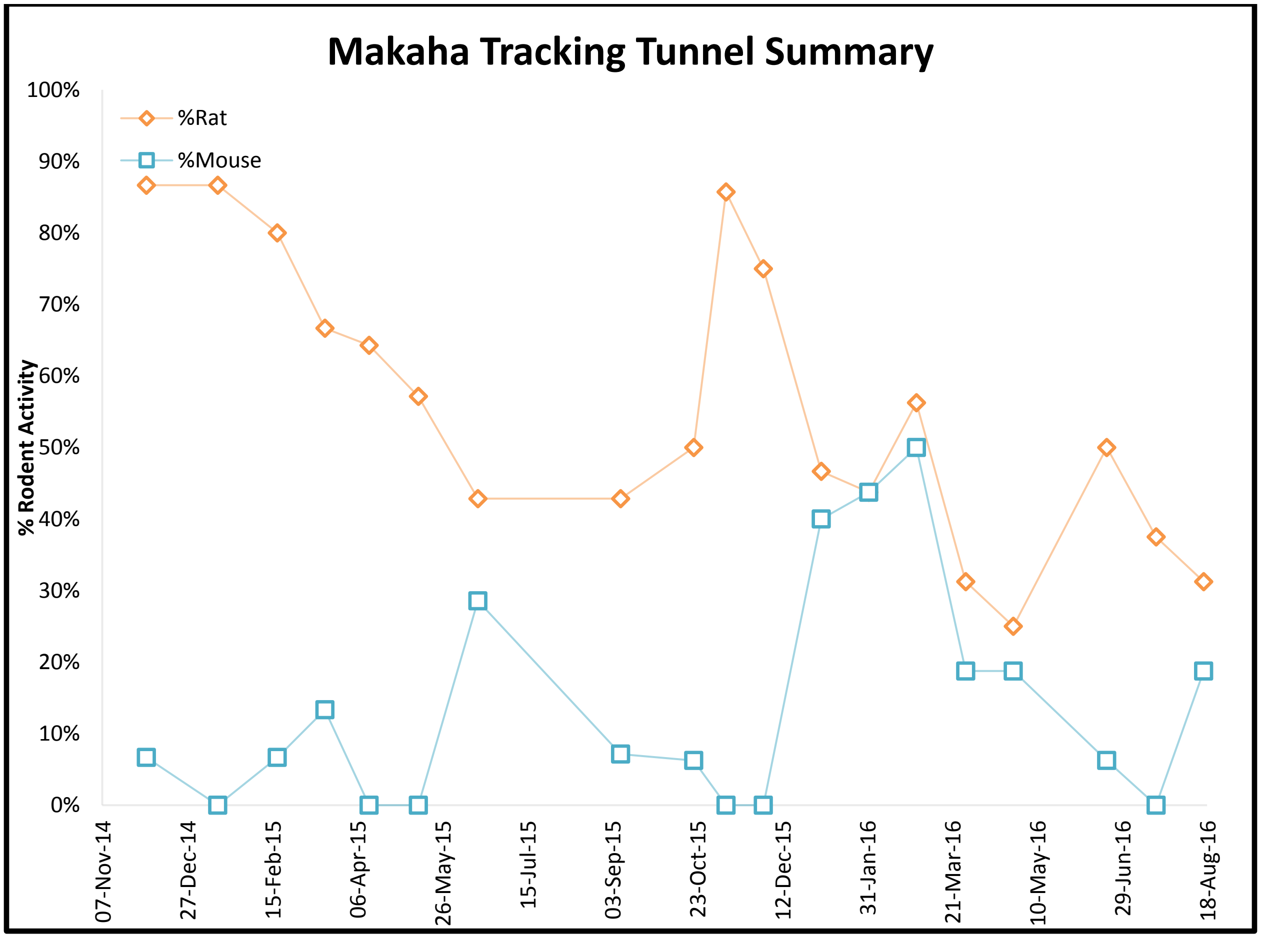


Figure 3: Percent of rodent activity at Makaha.

8.3 Kahanahaiki Diphacinone-50 Hand Broadcast Trial

In 2012, OANRP halted rodenticide use because of a change in the Special Local Needs (SLN) label that makes bait-station application unfeasible in the steep, rugged terrain where threat management is needed. Relying solely on traps has not been effective in keeping populations below the targeted 10% tracking level in monitoring tunnels, particularly during the period of peak rat abundance (typically Fall/Winter). In an attempt to combat this problem in Hawaiian habitats, OANRP in collaboration with USDA National Wildlife Research Center (NWRC), made an effort to determine the effectiveness of a single broadcast treatment of Diphacinone-50 in Kahanahaiki, involving two hand-broadcast applications spaced approximately 5-7 days apart and one canopy baiting during a period of high rat abundance, November 2015. The hand broadcast application involved OANRP staff walking a grid of trails while evenly distributing rodenticide bait; canopy baiting involved placing bait, held in small cloth bags, into trees within the grid. These application methods comply within the Diphacinone-50 label (EPA Registration No. 56228-35). The hand broadcast method of rat control was assessed in the Programmatic Environmental Assessment for the Final Implementation Plan for Oahu Training Areas, March 2010, FNSI June 2010. NWRC provided the monitoring associated with this study (e.g. confirming bait application was completed according to label, showing efficacy of this rat-reduction method, and documenting non-target impacts).

Figure 4: Field staff and researchers on the day of the first broadcast.

The hand-broadcasts were conducted on November 2nd and November 9th, 2015. The original plan was to conduct the trial in October, however due to the large amounts of ripe strawberry guava fruit still on the trees and on the ground the decision was made to postpone until November. The operational side of the broadcast was highly successful and conducted efficiently. Staff were able to overcome many logistical problems with scheduling and effectively manage the large amount of people needed to conduct the trial.

One of the goals of the project was to determine if a hand broadcast and canopy baiting application of Diphacinone-50 in combination with a grid of mechanical traps (already in operation) has a seasonal knockdown effect on the rat population at Kahanahaiki (ideally <10% tracking activity through the winter). The results of the tracking tunnel monitoring show that the percent activity was reduced to an all-time low of 2.6% for two weeks following the broadcast. Unfortunately the tracking increased to 18.4% one month post broadcast in December, increased to pre-broadcast levels of 36.8% two months post-broadcast in January, and ultimately reached 54% during the winter season peak in (month) (see Figure 5). The entire Kahanahaiki study site was ~36 ha, but the broadcast covered approximately 20 ha. This method may produce longer lasting results if done on a larger scale, ~200ha or larger.

Currently, data is being analyzed and a detailed report of results will be available shortly and will be attached to the Year End Report next year. See Appendix 8-1 for the OANRP Diphacinone-50 Hand Broadcast Study Plan.

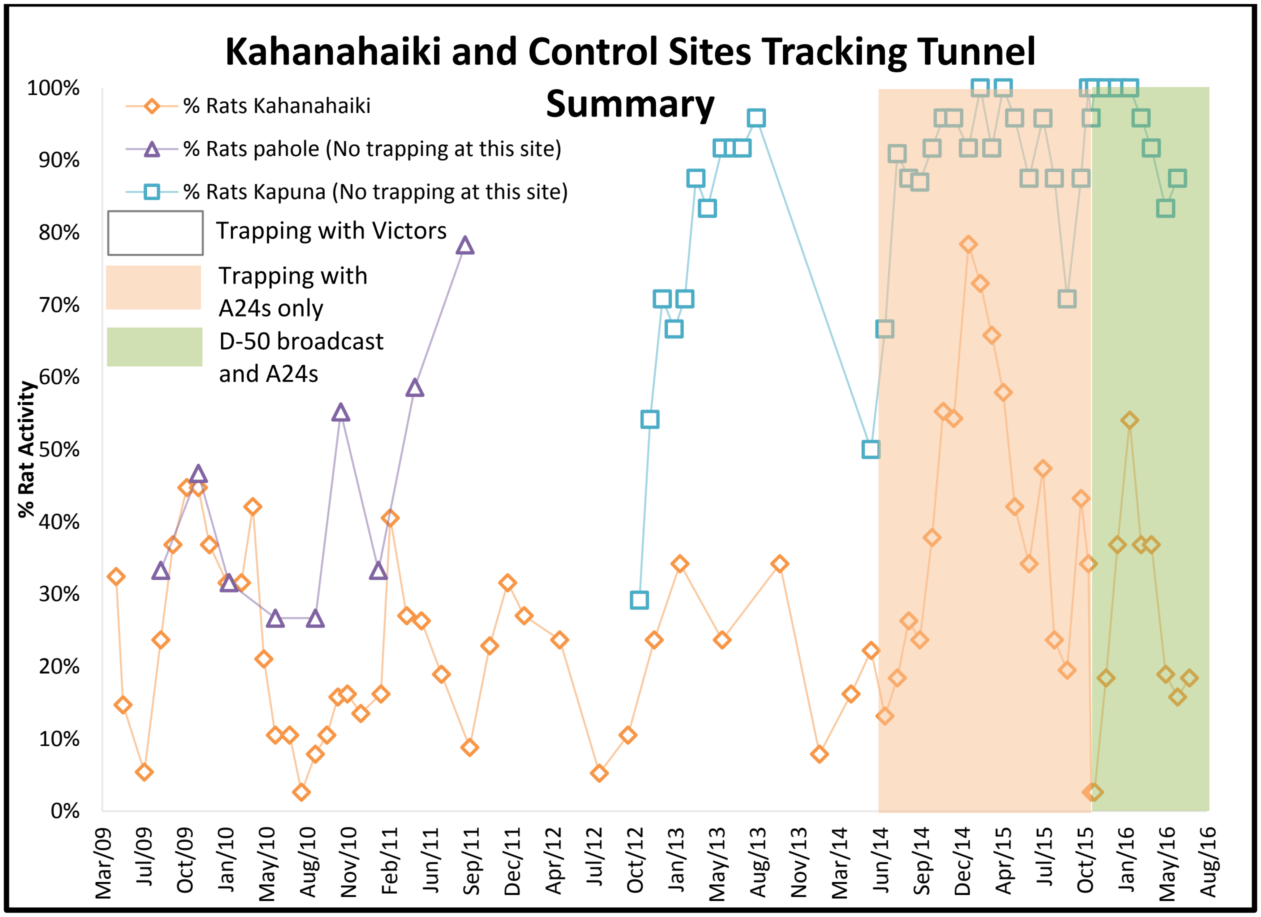


Figure 5: Percent of rat activity each month at Kahanahaiki and two control sites Kapuna and Pahole.

8.4 Citric Acid Trials

New Zealand wildlife managers are considered leaders in rodent management by experts' throughout the world. Although the significant amount of data and research conducted on traps and bait in New Zealand is helpful for implementation in Hawaii, OANRP has documented difficulties and conditions that are not experienced in New Zealand. For example, bait removal by slugs and other invertebrates is a major issue that is not experienced to the same degree in New Zealand. OANRP has seen slugs completely consume the long lasting Goodnature rat lure in the A24s within a few weeks of deployment (see Figure 6). For the A24s to be fully effective the bait must last much longer than this. Methods considered for deterring slugs include adding copper tape to traps, using Sluggo around traps, and bait additives. Adding copper tape to traps did not prevent slugs from accessing bait. Many of our traps are set to protect rare snails, and adding Sluggo in those areas would be prohibited.

Figure 6: *Limax maximus* slug consuming bait out of an A24 bottle.

We conducted a trial to see if adding 5% citric acid to the Goodnature rat lure would deter consumption by slugs (see Figure 7). The results were very encouraging as the citric acid deterred almost all of the slugs from consuming any bait (see Chapter 9, Section 9.2 of this document). This could be a big breakthrough for our rodent control program. We are currently planning to incorporate citric acid into all of our baits and will monitor the results.

Figure 7: Setting up citric acid bait trial.

8.5 Rapid Response, Triple Threat Grids, Addition of Traps to Sites

We continue to see new and unique ways that rats are impacting and damaging plant species that we manage. It is also very hard to predict when and how the rat damage will occur. This year we observed the first ever basal damage to a *D. waianaeensis* wild population in Mohiakea gulch, Lihue MU. It was generally believed that basal damage occurs when rats are in need of water due to dry conditions, however this summer did not appear to be very dry. In response to this we started implementing "Rapid Response" grids at some plant populations subject to basal damage: *L. cyrtandrae, H. oahuensis, S. nuttallii, C. grimesiana,* and *D. waianaeensis.*

These grids will be baited year round with more frequent checks during the fruiting season and other times when plants are particularly vulnerable. Within the grids we began to diversify the trap types and baits used to hopefully catch rats faster once they have entered the area. At some sites we are using a combination of Ka Mates, Victors, and A24s together, which we are calling the "triple threat". Currently we are baiting the Victors with peanut butter, the Ka Mates with fresh coconut and the A24s with the Goodnature rat lure. We are going to monitor the results and adjust trap types and baits accordingly.

After evaluating data from some of the smaller grids we started to notice that the percent of traps with rat captures was very high. We have always known that the small size of our grids does not reduce the population of rats but rather just removes the individuals within the area and that the grids are consistently re-invaded. However, once traps have been installed we have rarely observed damage to rare taxa except for fruit predation within populations of *C. superba* and *D. waianaeensis*, see Figure 8. We are increasing the total number of traps within the small grids to more effectively control damage and/predation. We have been successful at adding more traps without substantially increasing the amount of time needed to re-bait the grid.

Figure 8: Two rats consuming fruits from a population of *D. waianaeensis* within a rodent control grid.

8.6 SOPs

In an effort to create more consistency and proficiency in our rodent control operations, we created protocols to be used when checking the traps. The protocols lay out the correct way to install, re-bait, and maintain the various types of traps and tracking tunnels that we use. This is necessary due to the turnover within the technician positions at OANRP and contractor Pono Pacific. We have been observing many traps with incorrect tab positions, not enough bait and severely damaged traps in need of repair or replacement, see Figure 9. These protocols will be continually updated and evaluated as new tools and techniques become available (see Appendix 8-2).

Figure 9: Tab in left picture is set too low, tab in middle picture is set too high, and tab in right picture is perfect with the correct amount of bait.

8.7 Ohikilolo Safety Stand down And Use of Remaining D-50

In April of 2015 a non-OANRP incident with unexploded ordinance occurred in Makua Valley forcing the shutdown of all operations including rodent trapping at Ohikilolo until December of 2015. Rodent control at Ohikilolo consists of 53 A24s and 133 victor snap traps to protect *A. mustelina* and *P. kaalae.* Evidence of rodent predation on *P. kaalae* was observed upon return to the site, and rat activity was at the highest level (34.6%) ever recorded at that site (see Figure 11). Just by chance staff had installed a game camera to observe a large cluster of *P. kaalae* fruit on the ground in March of 2015, and the camera took photos during the entire 8 month shutdown. Photos showed that *R. rattus* and *M. musculus* visited the area almost every night and would periodically take fruits (see Figure 10). This occurred until there were no longer any fruits visible within the camera range (approximately 6 months), after which very few photos were taken of rodents in the area as they had probably moved on to another cluster. It was unexpected to see *M. musculus* removing fruits as this species was not considered to be a threat to *P. kaalae*. It is not clear if the seed is damaged or if they are just removing the outer fruit. This is a potential issue as we have seen periods of very high *M. musculus* percent tracking at Ohikilolo and other sites. Further investigation into *M. musculus* and their threats to managed species is needed.

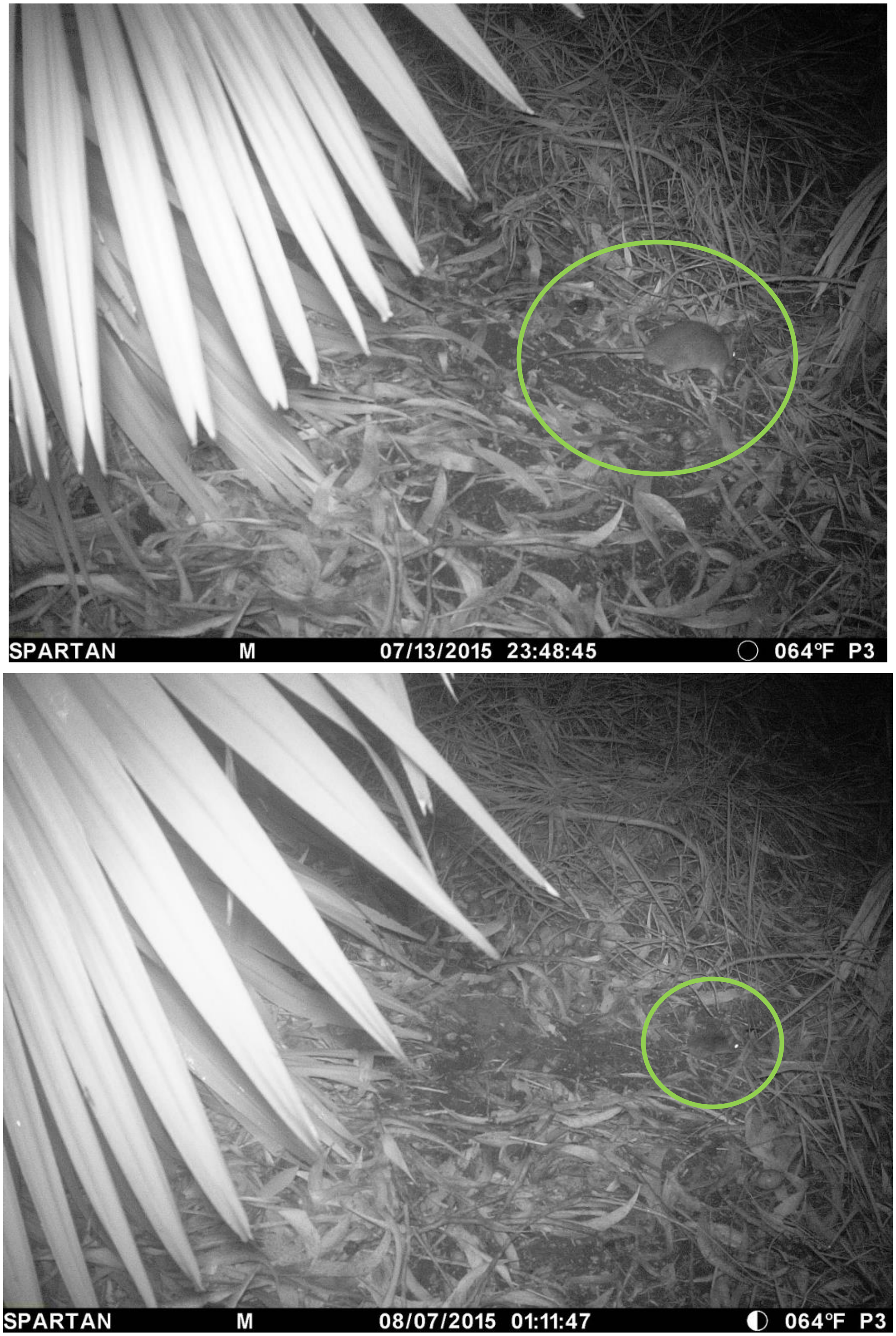


Figure 10: Picture on top of *R. rattus* taking *P. kaalae* fruit, and picture on bottom of *M. musculus* possibly taking *P. kaalae* fruit.

Ohikilolo was chosen as the site to use up excess D-50 bait from the Kahanahaiki hand broadcast, as the size of the area (5ha) was equal to the broadcast area application rate of the remaining bait, and would benefit *P. kaalae*,. The operation was conducted within label requirements and occurred on June 7th and 14th. No carcasses of rodents or non-targets were found by staff while conducting other operations within the area three weeks after the broadcast. Tracking tunnels are monitored every 6 weeks at this site and were monitored the night before the first broadcast. The percent activity the night before the first broadcast was 7.4%, 5 weeks later it was 0%, and 12 weeks after it was 14.8% which is higher than pre-broadcast levels, Figure 11. To successfully control rodents using Diphacinone at Ohikilolo a much larger broadcast area would be needed.

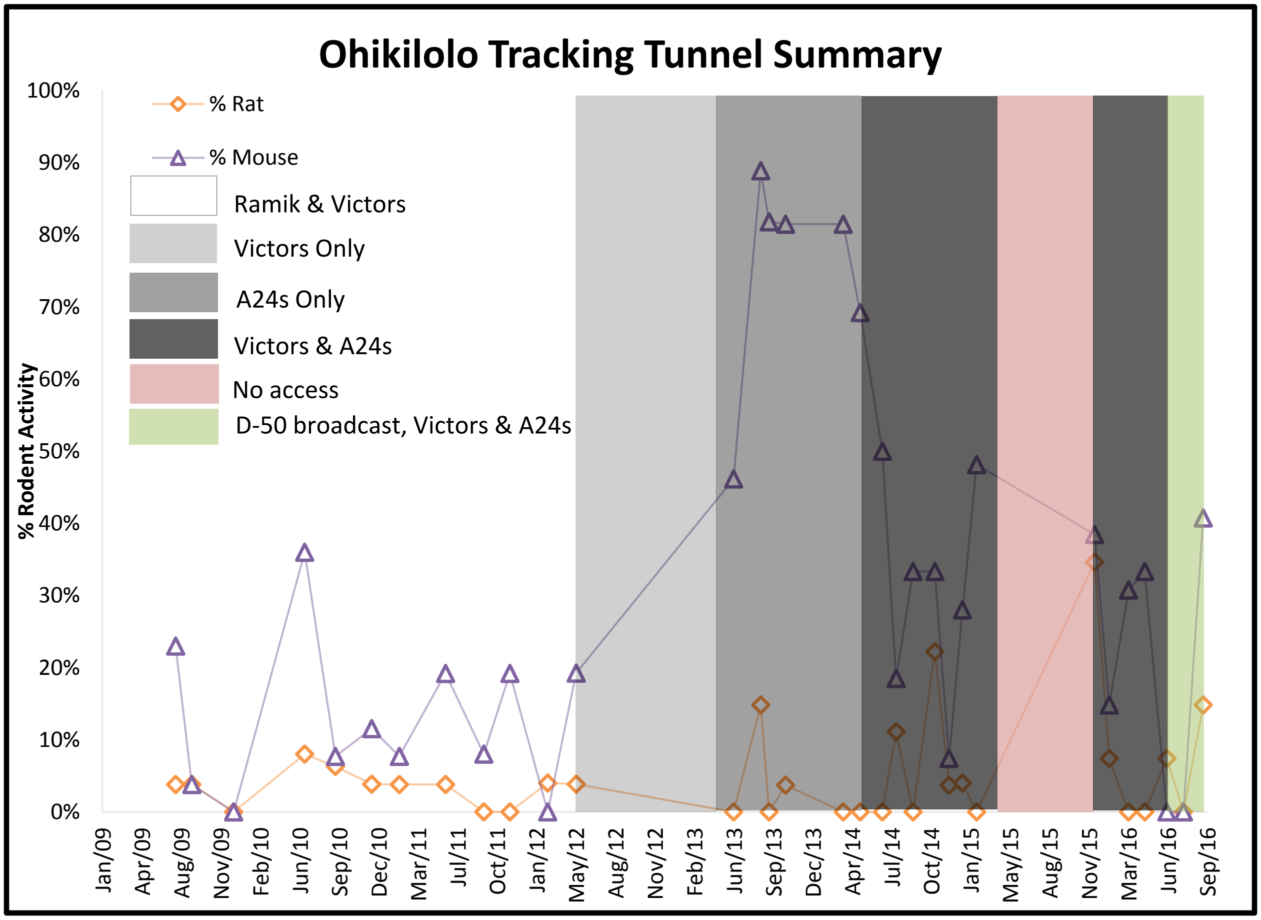


Figure 11: Percent of rodent activity at Ohikilolo.

8.8 FUTURE PLANS

Large scale grids of A24s may prove to be more cost effective and beneficial for MU wide rat control compared with large scale grids of Victor traps; however, additional methods of control may be needed to effectively achieve percent tracking goals in combination with traps, such as hand or aerial broadcasts of Diphacinone-50. OANRP will use the Diphacinone-50 pilot project findings and tracking tunnel results from Kahanahaiki to determine future rat control at other MUs. Over the next year OANRP will continue to utilize all trapping methods in combination at some sites to see if more effective control is achieved.

We will continue to work with the A24 trap and bait to maximize its full potential. One development that we are excited about is the auto lure baiting device from Goodnature (see Figure 12). This device delivers a constant bait supply of about 3 grams per week to the opening of the A24 trap. The hope is that this will increase the amount of catches because the rodents will be able to see fresh bait near the trigger, enticing them into the trap. Another potential benefit of this device is that it may last 3-6 months, thus eliminating the need for monthly checks and saving time and money. We are currently conducting a “head to head” trial between the auto baiting devices and our standard method at Makaha. This trial will be replicated at another site within the year.

Figure 12: Auto lure baiting device installed and functioning in A24 trap.

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CHAPTER 9: ALIEN INVERTEBRATE CONTROL PROGRAM

Summary

This chapter describes the status and outcome of actions carried out under the direction of the Oahu Army Natural Resource Program (OANRP) Alien Invertebrate Control & Research Specialist which, this year, included the successful renewal of a Special Local Needs (SLN) permit for the use of Sluggo in natural areas. Modifications to the permit are discussed here and were implemented following its expiration and renewal in October 31, 2015. We increased our slug control efforts to include eight vulnerable plant populations thereby expanding the Sluggo application area by 65%. Details on which species are protected and their locations are outlined in section 9.1.

This year we completed research aiding in the development of a rat bait with slug-repellent properties. We found that the addition of 5% citric acid to the rat bait repelled slugs while remaining attractive to rodents. The complete study appears in section 9.2.

We continue to survey for and assist in the control of two incipient invertebrate pests which have not yet naturalized: the Coconut Rhinoceros Beetle (*Oryctes rhinoceros*) and the Little Fire Ant (*Wasmannia auropunctata*), as well inspecting high risk areas for invasive ants (Hymenoptera, Formicidae). None have been detected in 2015-2016 in areas surveyed (Schofield Barracks and surrounding environs). The status of those efforts are reported in section 9.3 and 9.4.

9.1 SUMMARY OF SLUG CONTROL ACTIONS JULY 1, 2015-JUNE 30, 2016

Background: Slugs can cause dramatic declines in the survival of rare native Hawaiian plants (Joe & Daehler 2008). Control of slugs using the organic molluscicide Sluggo® (trademark omitted from the rest of this document) (Neudorff, Germany) was shown to encourage seedling germination and recruitment of certain rare plant species (Kawelo *et al*. 2012) in particular those within the Campanulaceae. In 2010 Sluggo was approved for forest use by the Hawaii Department of Agriculture (HDOA) under a Special Local Needs (SLN) permit. We solicited, and received, letters of support from agencies which use this product for rare plant conservation. We included these, as well as our research since 2010 (http://manoa.hawaii.edu/hpicesu/dpw_slug.htm) pertaining to slug control and compiled it into a single application packet for Sluggo SLN renewal (the permit expired October, 31 2015). Some modifications to the prior label were requested by the Department of Land and Natural Resources (DLNR) because of concerns about non-target impacts to native snails. The previous label stated: "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 must not be applied within 20 m of any tree known to harbor endangered Hawaiian tree snails (*Achatinella* spp.)." It now instructs: "Do not apply within 20 m of known populations of endemic Hawaiian snail species from the following rare families or subfamilies: *Amastridae, Achatinellinae* and *Endodontidae*." *Achatinella,* though not mentioned by name in the new label, remains protected as it is included in the subfamily *Achatinellinae.* The approved label appears in Figure 1 with the new wording highlighted. It may be accessed online via the HDOA webpage (http://hawaii.gov/hdoa/labels/sln/1004_2020.pdf). Notice that the tradename has been changed from FirstChoice to LeafLife Sluggo. The subregistratant (Loveland), the manufacturer (Neudorff) and the formulation remains the same, as well as the EPA registration number. HDOA confirmed that the SLN is valid for both Sluggo products.

SECTION 24(c) REGISTRATION

LEAF LIFE® SLUGGO®
SNAIL AND SLUG BAIT
FOR CONTROL OF NON-NATIVE SLUGS AND SNAILS IN FORESTED AREAS FOR CONSERVATION PURPOSES
EPA Reg. No. 67702-3-34704
EPA SLN No. HI – 100004
Issue Date: 10/28/2015
Expiration Date: 10/27/2020

LABELING INFORMATION FOR DISTRIBUTION AND USE ONLY IN FORESTED AREAS WITHIN THE STATE OF HAWAII

This label is valid until October 27, 2020 or until otherwise amended, withdrawn, cancelled or suspended.

DIRECTIONS FOR USE

This label and the federal label for this product must be in the possession of the user at the time of pesticide application.

Follow all application directions, restrictions, and precautions on this Supplemental label and the main EPA-registered label. It is a violation of federal law to use this product in a manner inconsistent with its labeling.

PURPOSE: For the control of slugs and non-native snails in forested areas to protect native, threatened and endangered Hawaiian plants.

HOW AND WHERE TO APPLY: Scatter the slug and snail bait granules on the soil around the base of the plants to be protected. Scatter granules by hand or with a granular or broadcast spreader. Use 20 to 44 lbs. per acre (0.5 to 1 lbs per 1,000 square feet). Apply the higher rates if the infestation is severe or if the area is heavily watered or after long periods of heavy rain. Reapply as the bait is consumed or at least every two weeks. Do not place in piles. If the ground is dry, wet it before applying bait. The soil should be moist but with little or no standing water.

WHEN TO APPLY: Apply bait in the evening, as slugs travel and feed mostly by night or early morning.

ACCEPTED
October 28, 2015
Under Hawaii Pesticides Law as Supplement to Product No. 8378.129

USE RESTRICTIONS:
- Bait must not be applied within 6.1 m (20 feet) of any body of water, including lakes, ponds or rivers.
- Area must be thoroughly searched by experienced malacologists during the day and at least one night prior to application of NEU1165M Slug and Snail Bait granules to ensure that non-target endemic Hawaiian snail species are not impacted. Do not apply within 20 m of known populations of endemic Hawaiian snail species from the following rare families or subfamilies: *Amastridae*, *Achatinellinae* and *Endodontidae*). Report any evidence of suspected poisoning of Hawaiian snails to the Pesticides Branch of the Hawaii Department of Agriculture, phone: (808) 973-9401.

24(c) Registrant:

Loveland Products Inc.
P.O. Box 1286
Greeley, CO 80632

Figure 1: Renewed Sluggo SLN permit. It is valid through October 27, 2020. Changes from the previous label are highlighted.

This SLN has made large scale slug suppression possible around rare plants in the wild. In response, OANRP has expanded its slug control program every year since the SLN approval in 2010. Though this remained the case in 2015-2016, we discontinued slug control at two reintroduced plant populations: *Cyanea superba* subsp. *superba* (population reference code PAH-A; hereafter referred to as *C. superba*) in the Pahole Natural Area Reserve (NAR) and *Phyllostegia mollis* (population reference code EKA-D) in the Ekahanui Forest Reserve. In the case of *P. mollis,* by May 2016, only one plant remained and did not justify continued effort (Table 1, row one shows a decrease in slug control). While a number of *C. superba* persist in Pahole, we are shifting our efforts towards Palikea where the ratio of seedling recruitment per mature pant is much higher (see *C. superba* 5 Year Plan in this document).

We controlled slugs to order to protect 8 species in 9 Management Units (MUs) across an area equal to 7 acres, a 65% increase (in area) from the previous year (4.2 acres) (Fig. 2). Rare plant species which received Sluggo treatments at a rate of 1 lb. Sluggo per 184 m^2 per month (half the maximum label rate) appear in Table 1. New or expanded areas receiving slug control this year are shown in bold. Two populations are remote and only receive Sluggo once every 6 to 8 weeks (marked with *).

Table 1: List of rare plant species treated monthly with Sluggo. Bold lettering indicates changes from the prior year. An asterisk (*) indicates remote populations which receive Sluggo at a reduced rate.

MU	Plant species treated (Population Reference Code)	Treatment area (m^2)	Sluggo required per treatment (lbs.)
Ekahanui	*Cyanea grimesiana* subsp. *obatae* (EKA-C) , *Delissea waianaeensis* (EKA-D), *Schiedea kaalae* (EKA-D)	**2,950 (-1,282)**	**16 (-7)**
Kahanahaiki	*Cyanea superba* (MMR-E & MMR-H), *S. nuttallii* (MMR-E), *S. obovata* (MMR-C & MMR-G)	1,650	9
Kaluaa and Waieli	*Delissea waianaeensis* (KAL-C), *S. kaalae* (KAL-B)	**3,500 (+ 1,900)**	**20 (+ 11)**
Makaha	*Cyanea longiflora* (MAK-B), *C. grimesiana* subsp. *obatae* (MAK-B), *S. obovata* (MAK-A), *S. nuttallii* (MAK-A)	**2,450 (+ 450)**	**13 (+ 3)**
Opaeula Lower	***Cyrtandra dentata* (OPA-F*)**	**1,000***	**5.5***
Pahole	*Schiedea nuttallii* (PAH-D & PAH-E), ***C. grimesiana* subsp. *obatae* (PAH-D), *S. kaalae* (PAH-C), *Euphorbia herbstii* (PAH-G & PAH-R, PAH-F & PAH-S), *C. longiflora* (PAH-A & PAH-I)**	**8,496 (+ 5,496)**	**46 (+ 30)**
Palikea	*Cyanea grimesiana* subsp. *obatae* (PAK-A & PAK-B), *C. superba* (no pop code), ***Phyllostegia hirsuta* (PAK-A)**	**4,625 (+ 2,405)**	**25 (+13)**
Upper Kapuna	*Schiedea kaalae* (KAP-A)	**1,100 (+ 394)**	**6 (+ 2)**
West Makaleha	*Cyanea longiflora* (LEH-B), *S. obovata* (LEH-A, LEH-C & **LEH-B***)	**2,461 (+ 1,265)**	**13.5 (+7.5)**

Figure 2: Locations of rare plant species within Managament Units (MUs) undergoing slug control in the Waianae Mountains. A single slug control site in the Koolau Mountains (Opaeula Lower) is not shown.

9.2 Development of a rat bait with slug-repellent properties

Introduction: Slugs are generalist feeders that are attracted to the peanut butter baits used in rat traps (both A24 automatic and Victor snaps). Bait consumption by slugs is an impediment to successful rat control in a number of ways. Slugs can consume all of the bait or make it less attractive to rats (via slime) and large slugs can trigger the snap traps. Our goal was to determine whether citric acid added to a peanut butter bait at a 5% concentration would repel slugs while remaining attractive to rats. For the purposes of these experiments, we used food grade 100% granular citric acid.

We conducted three studies in pursuit of these goals. Study 1 involved a two-choice food experiment wherein captive slugs were offered the peanut butter bait with and without citric acid to investigate food preference. Here we refer to the former (5% citric acid) bait as the ‘test’ bait and the latter as the ‘control’ bait. Study 2 involved a single-choice feeding experiment wherein captive slugs were provided only the test bait for two weeks to reveal whether they would consume it if faced with starvation. In both Study 1 & 2 we used GoodNatures Rat Lure. This is the lure regularily used in the A24 traps. Study 3 was a field trial wherein we investigated whether Victor snap traps set with test and control baits caught similar numbers of rats after a two week period. For the final study we used Skippy brand peanut butter for the bait as this is the standard bait we use for our Victor snap traps.

Study 1: Slug food preference experiment.

Methods: Fifty slugs were collected from the Waianae Mountains in Oahu during the month of March 2016 (Table 2). These were kept moist and fed lettuce, carrots and Beneful brand dog food until the start of the trial on April 19th. Slugs were not starved prior to this experiment. The trial ended two weeks later on May 3rd. During this period slugs were kept in individual plastic containers and offered 2 g of the test and 2 g of the control bait, dyed with red and green food coloring respectively. Small slugs (<3 g in weight) were housed in 3 ounce cups 7 cm in diameter while larger ones (>3 g) were placed in 8 ounce cups 11 cm in diameter (Fig. 3). Every 48 hours, each slug and their baits were weighed, cages cleaned of feces, and observations made on the condition of the bait such as whether any evidence of feeding occurred (radula marks) or whether mold was present.

Table 2: Count, weight and species identity of slugs used in feeding trial.

Slug species	Count (n)	Avg. weight (g)	Standard dev.
Deroceras laeve	28	0.3	0.16
Limax maximus	18	3.2	2.43
Limax flavus	3	0.7	0.25
Lehmannia valentiana	1	1.4	*n/a*

Figure 3: Photo of a *Deroceras laeve* (left) and *Limax maximus* (right) showing bait arrangement and container types. The *D. laeve* is in the small (3 oz.) cup while the *L. maximus* is in the larger (8 oz.) cup.

Results: The weight of both the test and control bait over time is shown in Figure 4.

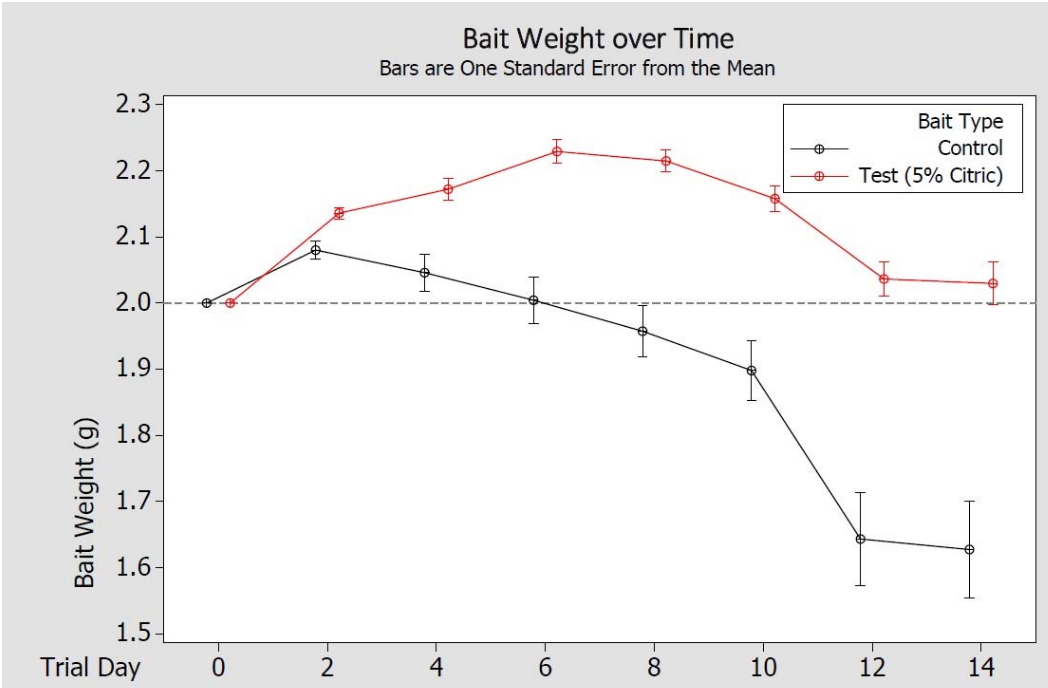

Figure 4: Weight (g) of the test and control bait over two weeks. The dotted line indicates the initial weight of the bait on day 0 of the trial (2 g). By the final day of the trial, the test bait did not differ significantly from 0 indicating it was not consumed by slugs.

Both baits gained weight on day 2 (Fig. 4). We believe this was due to the bait imbibing moisture while in the containers. These were kept saturated so that the slugs would not dry out. The test bait peaks on day 6 at about 2.2 grams while the control bait only loses weight after day 2 due to slug consumption. Notably, there was no evidence of slugs eating the test bait, while radular marks were evident on the control bait. We had hoped that the food coloring used to distinguish between bait types might retain color when passed through the slug, indicating preference. This was not the case however, as slug feces were usually clear or white. Bait weights at the conclusion of the study differed significantly with the control bait preferred over the test bait (Kruskal-Wallace test of medians $P<0.000$). Overall the control bait was reduced, on average, 18% over two weeks whereas the test bait remained unchanged.

Change in bait weight alone underestimates the effect of the citric acid, however. Table 2 shows that slug size varied considerably. The smallest *D. leave* weighed 0.1 g while the largest *L. maximus* was 7 g. If both consume 1 g of bait, that is 10 times the weight of former and only 14 % of the latter. When the amount of bait consumed is considered as a percent of overall slug weight, the contrast is more evident (Fig. 5). Again, the difference was significant (Kruskal-Wallace test of medians $P<0.000$). On average, slugs consumed more than half of their body weight (60.5%) exclusively from the control bait. This demonstrated the test bait to be totally resistant to slug consumption when other food is available.

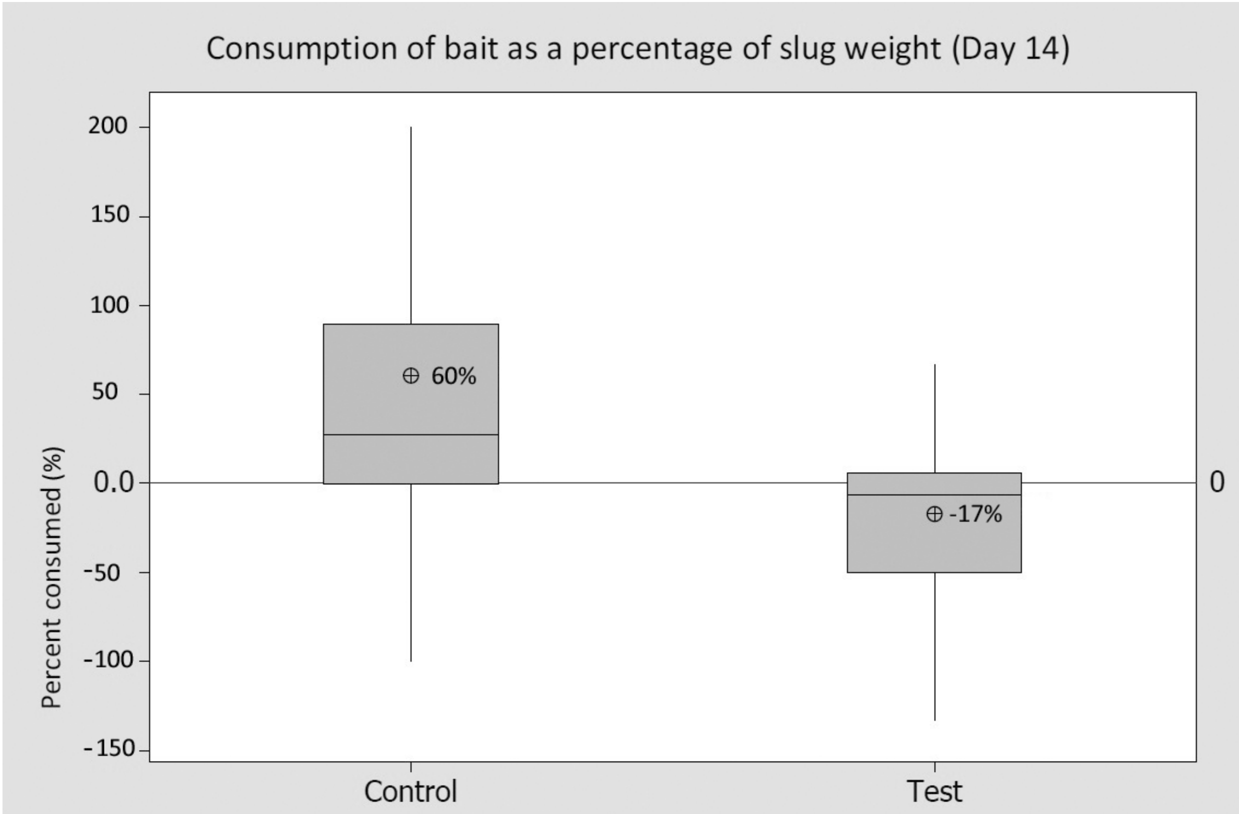

Figure 5: Boxplot showing consumption of control and test baits as a proportion of slug body weight.

Study 2. Single-choice food consumption trial

Methods: Following our discovery that the test bait was avoided in the presence of the control bait, we wanted to determine whether slugs would consume the test bait *if given no other choice*. To achieve this we exposed slugs to 9 g of test bait spread evenly across 3 petri dishes with a 4 cm diameter. An identical number of petri dishes with test bait were maintained for comparison and not exposed to slugs. Slugs used in Study 1 were placed together in a single enclosure measuring 29 X 16 cm and a depth of 10 cm (Fig. 6). Unlike the previous experiment, these slugs were not tracked individually, therefore statistical analysis was not possible as there was only a single replicate.

Figure 6: Slugs in single enclosure with test bait.

Slugs were kept moist and fed lettuce, carrots and dog food (as in Study 1) before exposure to the test bait. By the start of Study 2, on May 17, 2016, a number of slugs had died leaving 30 available for use. On this date, we placed 3 dishes of the test bait into the slug enclosure and 3 outside. Every 2 to 4 days for 14 days slugs were weighed and bait inside and outside the enclosure weighed. Close to half of the slugs died during this time, (47%) perhaps due to lack of food. These were removed as soon as they were found to prevent necrophagy. The number, weight and species of slug at the beginning and end of the trial are shown in Table 3.

In addition, we observed in Study 1 that the test bait appeared resistant to mold. As a side experiment, we compared mold formation on 3 petri dishes with test baits against the same number of control baits for 2 weeks. None of these were exposed to slugs.

Table 3: Slug number and identity at the beginning vs. end of trial.

Slug species	Trial Day	Count (n)	Total weight (g)
Deroceras leave	0	13	3.3
Deroceras laeve	14	3	0.7
Limax maximus	0	16	48.1
Limax maximus	14	12	37.3
Limax flavus	0	1	4.2
Limax flavus	14	1	4.0

Results: Over time, the average weight of the slug-exposed baits (n=3) vs. the no-slug baits were similar (Fig. 7). As they imbibed water, all baits gained weight and the final weights only differed by 0.2 g between treatments indicating little to no consumption of the bait by slugs. The high mortality of slugs during this time also suggests slugs died rather than consume the test bait.

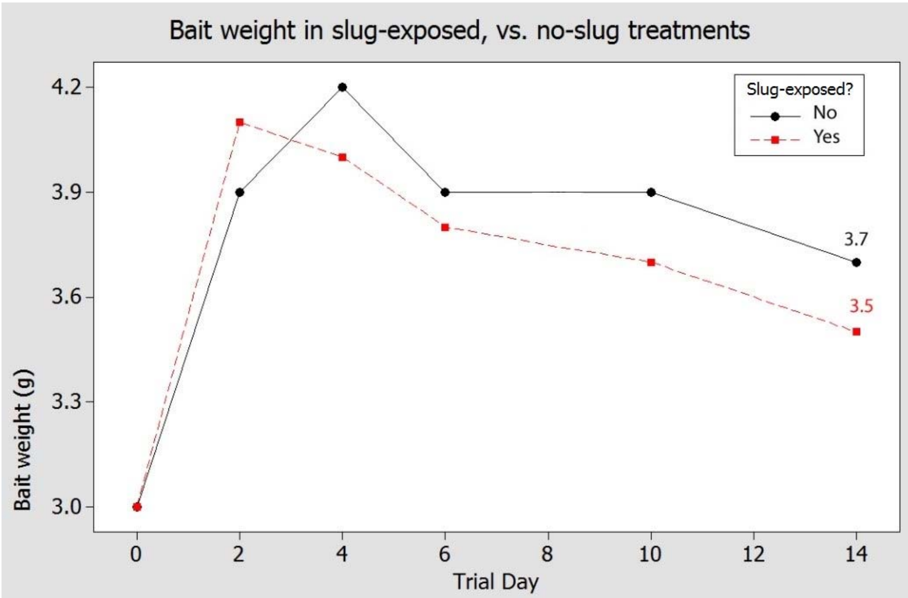

Figure 7: Mean weight of both bait types over time.

There were a number of constraints in the design of this particular experiment. Firstly, though we had 3 petri dishes in each treatment, they were not independent and so were treated as a single data point. Secondly, so many slugs died that the exposure treatment was inconsistent (slug pressure diminished as time progressed). Despite this, there was no evidence from this trial that slugs would consume the test bait under any circumstances. In the field, we think it *very* likely that slugs will avoid rat bait with 5% citric acid as there are many other more palatable foods available.

Mold coverage on the peanut-butter bait was, on average, 100% after 2 weeks vs. 88% on the test bait. While the addition of citric acid did not appear to reduce the mold appreciably, the color and type of mold appeared different between the two baits (Fig. 8).

Figure 8: Photograph of mold on the citric acid baits (bottom row) vs. the unadulterated baits (top row) showing visual differences in mold types.

Study 3. Field trial of bait attractiveness to rodents.

Methods: In the previous 2 experiments, we found slugs could be deterred from consuming rat bait with the addition of 5% citric acid. The question remained, however, would the test bait remain attractive to rodents? We carried out a field trial in the Moanalua Forest Reserve from June 1st through June 14th 2016 to see whether traps baited with the test bait caught similar numbers of rats as those using peanut butter alone. We used a pre-existing rat grid of Victor snap traps intended to protect Elepaio bird pairs from rat predation. A map of those Elepaio territories appears in Chapter 6 of this document (Moanalua Valley, Rare Vertebrate Management). We set 167 traps total on the first day of the trial alternating the control bait with the test bait so that both types were represented throughout the grid. Two weeks later we checked each trap and recorded the bait used and whether there was evidence of a rodent catch (hair, tissue, or body).

Results: Rodents were caught in 41 (25%) of all traps set. Of these successful traps, 18 (44%) were set using the control bait (peanut butter) and 23 (56%) using the test bait (peanut butter and 5% citric acid). A Pearson Chi-Square analysis of whether catches differed between bait types was not significant ($P=0.346$). We conclude that there is no evidence that the test bait repelled rodents. We recommend the addition of 5% citric acid to all bait to be used in areas with slugs.

9.3 Survey of Invasive Ant Species

Background: In Hawaii, ants are most likely to become established around disturbed areas frequented by humans such as bathrooms, campgrounds, fence lines, helipads, and roads (OANRP 2010).

As stated in previous reports (OANRP 2011) OANRP conducts annual surveys of invasive ants in high-risk areas using a standard protocol developed by University of Hawaii entomologists (OANRP 2010). The sampling method involves placing a minimum of 10 vials at set locations baited with SPAM, peanut butter and Karo syrup. Any ants attracted to the bait within one hour are collected. Sampling sites include areas of high human traffic (mentioned above), as well as areas where rare resources may prove vulnerable to ant attack (Fig. 9).

Figure 9: Location of Management Units and ant sampling sites.

Species lists from annual ant surveys are shown in Table 4. Asterisks indicate new ants found during the most recent survey. Species considered medium risk appear in bold, all others are low risk according to a Pacific Invasive Ant Key developed by Saurnat (2012). No high risk species are found in our Management Units (MUs).

Table 4: List of ant species found in each MU. New records for 2015-2016 are marked with an asterisk. Medium risk species are shown in bold.

Management Unit (MU)	Ants recorded prior to 2015	Ants recorded October 2015 - June 2016	Action needed?
East and West OANRP baseyards	***Anoplolepis gracilipes***, *Leptogenys falcigera*, ***Pheidole megacephala***, *Plagiolepis alluaudi*	***Anoplolepis gracilipes***, *Brachymyrmex obscurior**, ***Ph. Megacephala,*** *Pl. alluaudi*	Regular treatment with Amdro, Terro and MaxForce are needed to keep ant numbers low. This will continue through the upcoming year. *Brachymyrmex obscurior* is a minor pest already known from Oahu.
Ekahanui	*Plagiolepis alluaudi, Solenopsis papuana,* ***Technomyrmex albipes***	*Solenopsis papuana*	No action needed.
Kaala	*Cardiocondyla minutior, C. venusula, C. wroughtoni, Ochetellus glaber, S. papuana,* ***Tetramorium simillimum***	No ants found since 2011	Continue annual monitoring of high risk sites
Kahanahaiki	***Anoplolepis gracilipes***, *C. emeryi, C. venusula, C. wroughtoni, L. falcigera, O. glaber, Pl. alluaudi,* ***S. geminata***, *S. papuana,* ***Tc. albipes***, ***Tt. simillimum***	*Solenopsis papuana,* ***Tc. albipes***	No action needed. ***Technomyrmex albipes*** is too widespread for control. ***Solenopsis geminata*** remains absent since 2011 after repeated treatments
Kaluakauila	***Anoplolepis gracilipes***, *C. emeryi, O. glaber, Paratrechina bourbonica,* ***Ph. megacephala***, *Pl. alluaudi, S. papuana,* ***Tc. albipes***	***Anoplolepis gracilipes***, *S. papuana*	No action needed. Species detected are too widespread for control
Kaluaa	***Pheidole megacephala***, *S. papuana*	*Leptogenys falcigera**, ***Ph. megacephala***	No action needed. ***Pheidole megacephala*** is too widespread for control
Koloa cabin	Not sampled prior to March 2016	No ants found	Continue annual monitoring of high risk sites
Lower Opeaula	Not sampled prior to February 2016	No ants found	Continue annual monitoring of high risk sites

Makaha	***Anoplolepis gracilipes*, *Ph. megacephala*,** *S. papuana*, ***Tc. albipes***	***Pheidole megacephala*,** *S. papuana*	***Pheidole megacephala*** is present at low elebation parking lot but too widespread for control. *Solenopsis papuana* detected at outplanting sites
Palikea	*Cardiocondyla venusula*, ***Ph. megacephala***, *S. papuana*	*Solenopsis papuana*	No action needed.
Pahole mid-elevation nursery (Nike site)	***Anoplolepis gracilipes*,** *C. obscurior*, *O. glaber*, *Pl. alluaudi*, ***S. geminata***, *S. papuana*, ***Tc. albipes***, ***Tt. bicarinatum***	*Solenopsis papuana*	No action needed. Both ***A. gracilipes*** and ***S. geminata*** remain absent following treatment

Since its first record on Oahu in December 2013, OANRP has been surveying high risk areas on base to prevent *Wasmannia auropunctata* (the Little Fire Ant, or LFA) from establishment on Schofield Barracks or at any of our soil and pesticide suppliers. No LFA was detected during any of these surveys which are listed in Table 5.

Table 5: LFA survey details July 2015-June 2016.

Location	Date surveyed	Ants detected
BEI Chemicals and Fertiilizers 311 Pacific St # B, Honolulu	February 12, 2016	No ants
Niu Nursery 50 Sand Island Access Rd, Honolulu	February 22, 2016	*Pheidole megacephala*, *Monomorium pharaonis*
New housing area on junction of Lyman and Iolani Road, Schofield Barracks	March 30, 2016	*Pheidole megacephala*
Garden store PX, 903 Cadet Sheridan Road, Schofield Barracks	March 30, 2016	*Pheidole megacephala*

9.4 Coconut Rhinoceros Beetle Trapping

Background: CRB was first detected on Oahu in December of 2013. OANRP currently maintains 18 CRB traps spread throughout Wheeler, Schofield and Wahiawa with a single trap at Dillingham (Figure 10). These are placed near palms and at mulch sites and are checked once every two weeks. Lures are replaced every two months. We have maintained these traps since February 2014. No CRB have been detected at any traps during this period. All information is relayed to HDOA and integrated into CRB distribution maps on Oahu.

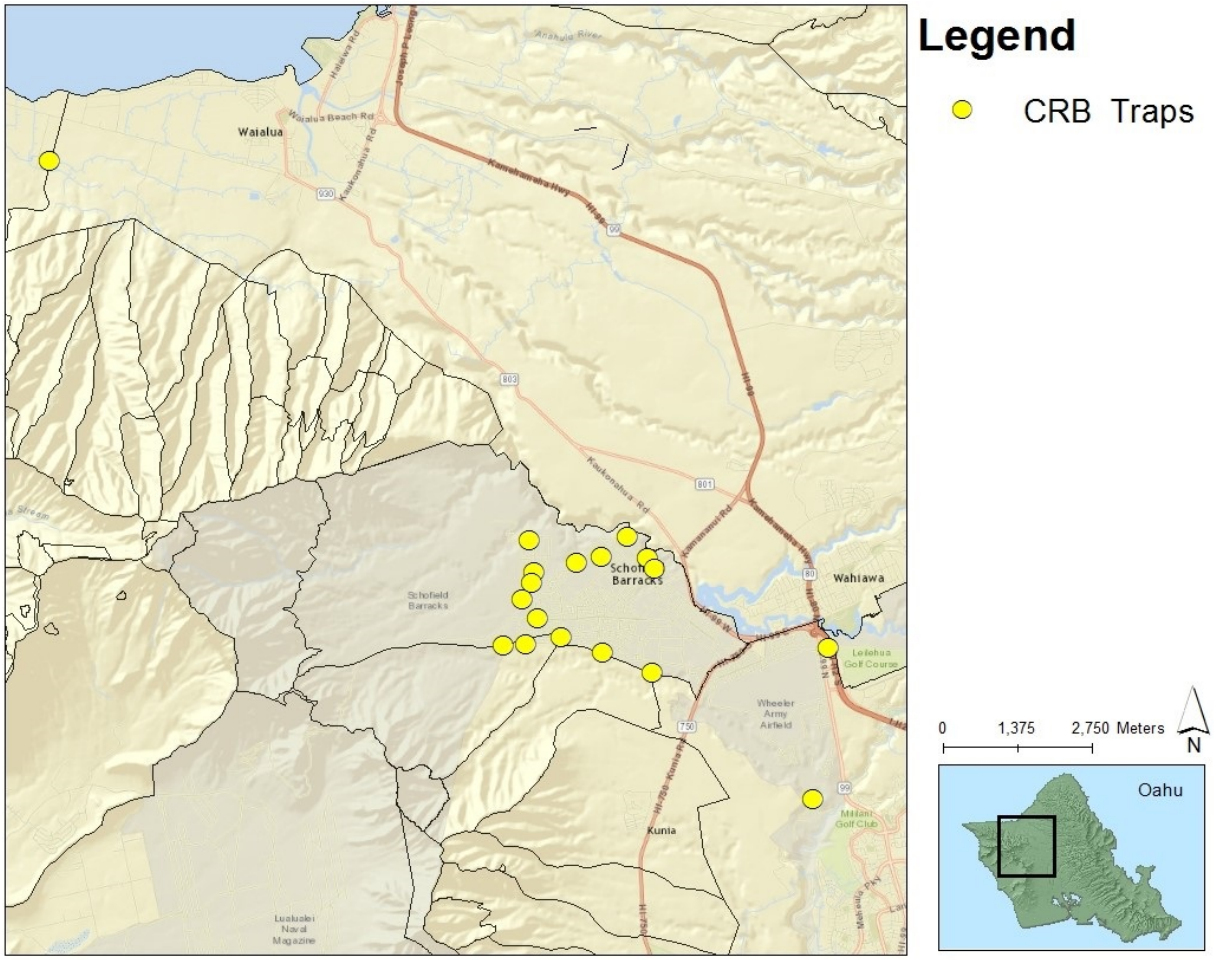

Figure 10: Locations of CRB traps maintained by OANRP.

References

Joe, S. M., and C. C. Daehler. 2008. Invasive slugs as under-appreciated obstacles to rare plant restoration: evidence from the Hawaiian Islands. *Biological Invasions* 10: 245-255

Kawelo, K., S. Ching Harbin, S. Joe, M. Keir and L. Weisenberger. 2012. Unique Reintroduction Considerations in Hawaii. *In* Plant Reintroduction in a Changing Climate. Machinski, J. and K.E. Haskins *Eds*. Island Press

Oahu Army Natural Resource Program. 2011. Chapter 5 section 5.4 Ant Control Actions *in* Status Report for the Makua and Oahu Implementation Plans. On-line: http://manoa.hawaii.edu/hpicesu/DPW/2011_YER/default.htm

Oahu Army Natural Resource Program. 2010. Appendix 7-1 Invasive Ant Monitoring Protocol *in* Status Report For the Makua and Oahu Implementation Plans. On-line: http://manoa.hawaii.edu/hpicesu/DPW/2010_YER/default.htm

Sarnat, E.M. 2012. Pacific Invasive Ant (PIA) Key: Identification guide to invasive ants of the Pacific Islands. University of California Davis. On line: http://itp.lucidcentral.org/id/ant/pia/index.html

TABLE OF CONTENTS

**Starred appendices are printed at the end of Chapter 9. All appendices are included in electronic format on a CD enclosed with this document. Also, they can be found online through the PCSU website at http://manoa.hawaii.edu/hpicesu/dpw_mit.htm.*

Appendix ES-1 Spelling of Hawaiian Names

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

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

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

*Diacriticals unknown

Appendix ES-2

Tutorial: Operating the OANRP Database

Overview
The Oahu Army Natural Resources Program Database (OANRP Database) is a multi-level database, coordinating diverse data from rare plant observations, reintroductions, rare snail monitoring, plant nursery propagation, and weed/ungulate management. The database files are developed with Microsoft Access. It is recommended that Access software versions 2007-2016 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 OANRP Database is based upon the criteria established by the Hawaii Rare Plant Restoration Group (HRPRG). As part of the Makua and Oahu Implementation Plans, the Army Propagation database has been a 15 year effort in developing and coordinating the collection, propagation, management, and tracking of rare species.

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

Several database reports may take a several minutes to compile within the database, thus pdf versions of the three major database reports (Population Unit Status, Threat Control Summary, and Genetic Storage Summary) have been created and may be found in the database reports subdirectory. Therefore, running the database may not be necessary unless more information is needed beyond the pdf version of the reports provided. Data provided is as of June 30, 2016.

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

Questions may be directed to:
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Natural Resources Database Programmer Specialist
Oahu Army Natural Resources Program
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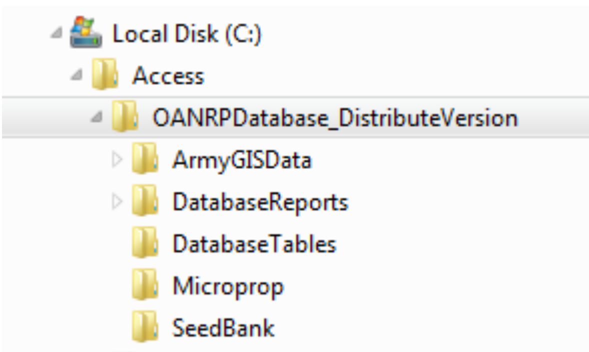
Linda Koch
Natural Resources GIS Specialist
Oahu Army Natural Resources Program
Email: lkoch@hawaii.edu

I. Database Settings

Setting Database Directories and Security Warning

Database directories

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



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

OANRPDatabase_DV.mdb

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

C:\Access\OANRPDatabase_DistributeVersion\ArmyGISData\

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

C:\Access\OANRPDatabase_DistributeVersion\DatabaseTables\OANRPDataTables_DV.mdb

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

C:\Access\OANRPDatabase_DistributeVersion \Microprop\Microprop.mdb

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

C:\Access\OANRPDatabase_DistributeVersion \SeedBank\SeedBankDatabase.mdb

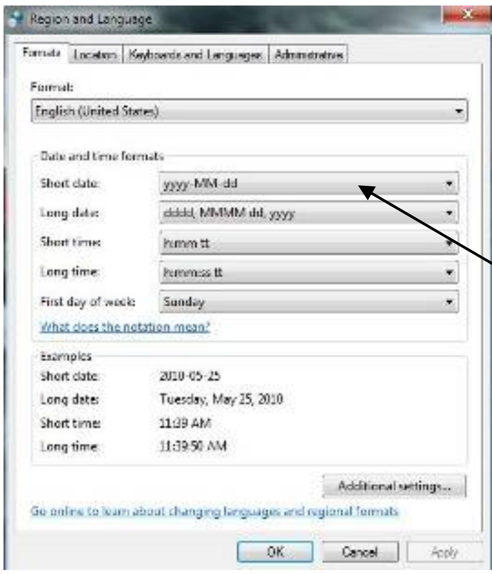
> Army SeedLab Database. Contact Lauren Weisenberger for more information.

C:\Access\ OANRPDatabase_DistributeVersion \TaxaDatabaseReports

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

Setting Default Date Format

The default date format for most computers is normally set to mm/dd/yy. The format can be confusing and not sort properly for Access database records. Although, not required, the date format for computers using this Access database should be changed to yyyy-mm-dd. Examples assume you are using Windows 10.



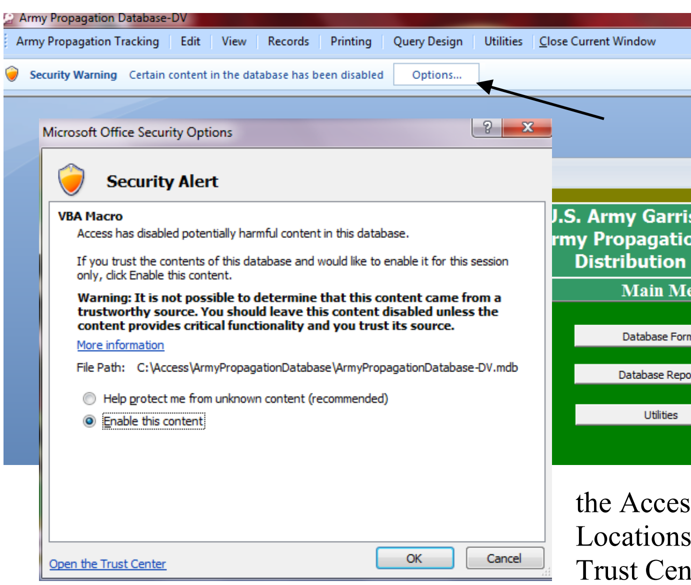
- Open Regional and Language Options by RIGHT clicking the **Start** button, clicking **Control Panel**, clicking **Clock, Language, and Region**, and then clicking **Region.** Under the Formats, change the **Short Date** to **yyyy-MM-dd.**

Change to yyyy-MM-dd

Security Warning

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

To help you manage how executable content behaves on your computer, Office Access 2007-2016 database content must be enabled when the Security Warning appears.

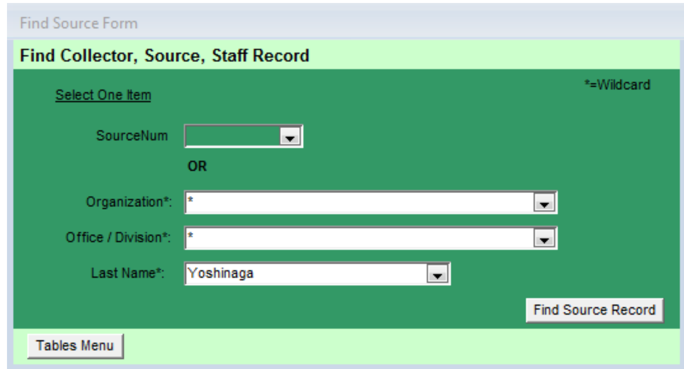


After opening the OANRPDatabase_DV.mdb file in Microsoft Access, click on Options when it appears at the top of your screen.

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

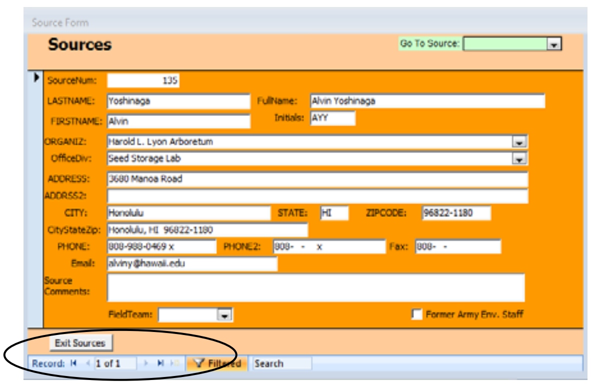
Enabling content will have to be done every time the database file is opened. You may avoid having this Security Warning appear if the Access subdirectory is added to the Trust Center Locations. Contact Roy Kam if you need to establish a Trust Center Location.

Data Search Methods



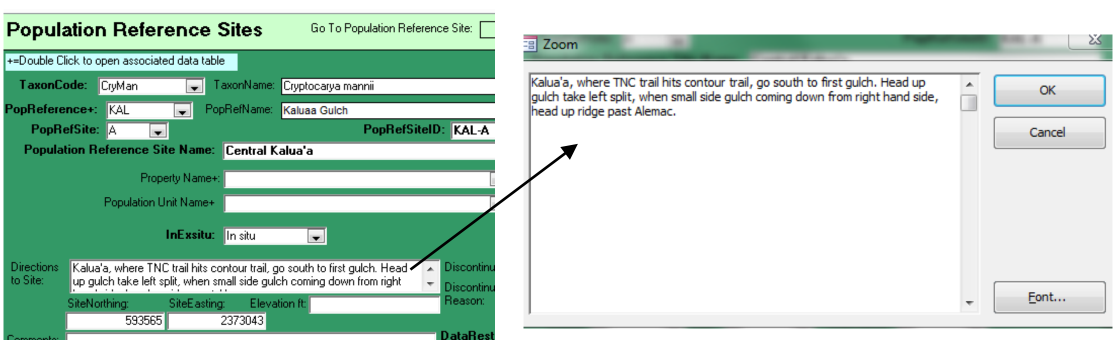
Most data form and report sections start with a Find Form. These Find Forms have drop downs that allow you to find an existing record. In the adjacent example, locating the Sources record for Alvin Yoshinaga.

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



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

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



II. Main Menu

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

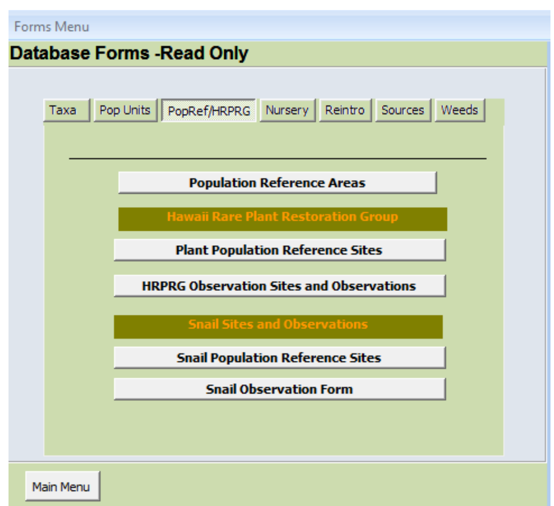
The database is broken up into 2 parts, Database Forms and Database Reports. We will primarily cover the Database reports. Database Forms are self-explanatory and is only for viewing purposes. The forms are provided for detailed review of individual observations. Only pertinent data fields will be discussed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

III. Database Forms

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

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

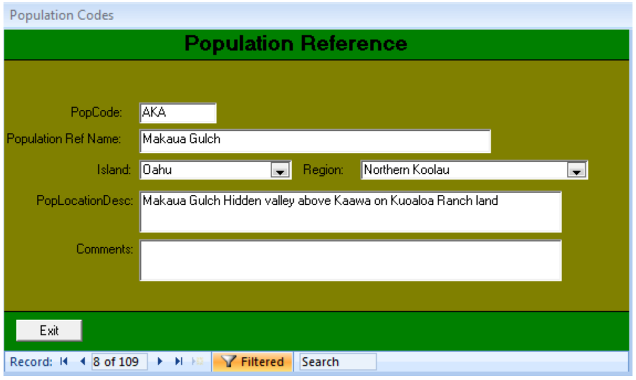
For the purpose of this tutorial, we will discuss forms of the PopRef/HRPRG tab with comprise of the Population Reference and Population Reference Sites. All other sections are supplemental and self-explanatory.



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)



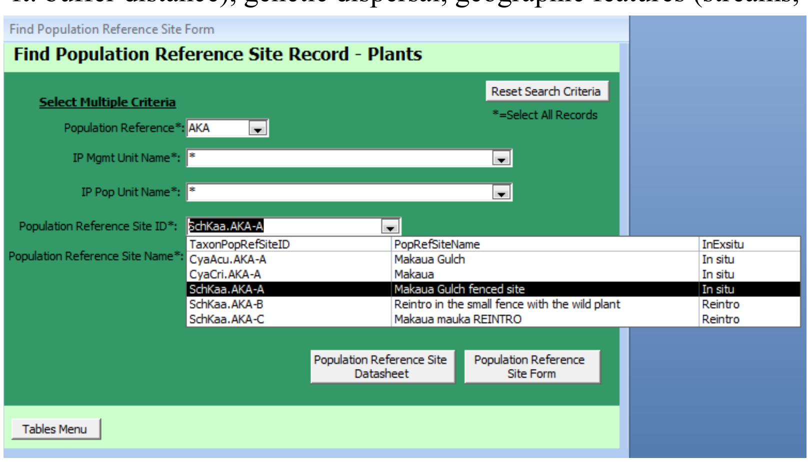
Population Reference, also known as PopRef for short, is a boundary system that allows a consistent identification of plant or animal populations. The PopRef is normally valleys, summits, ahupuaa, bogs, or areas that biologists have continuously acknowledged within observations from past decades.

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

Population Reference Site (PopRefSite)

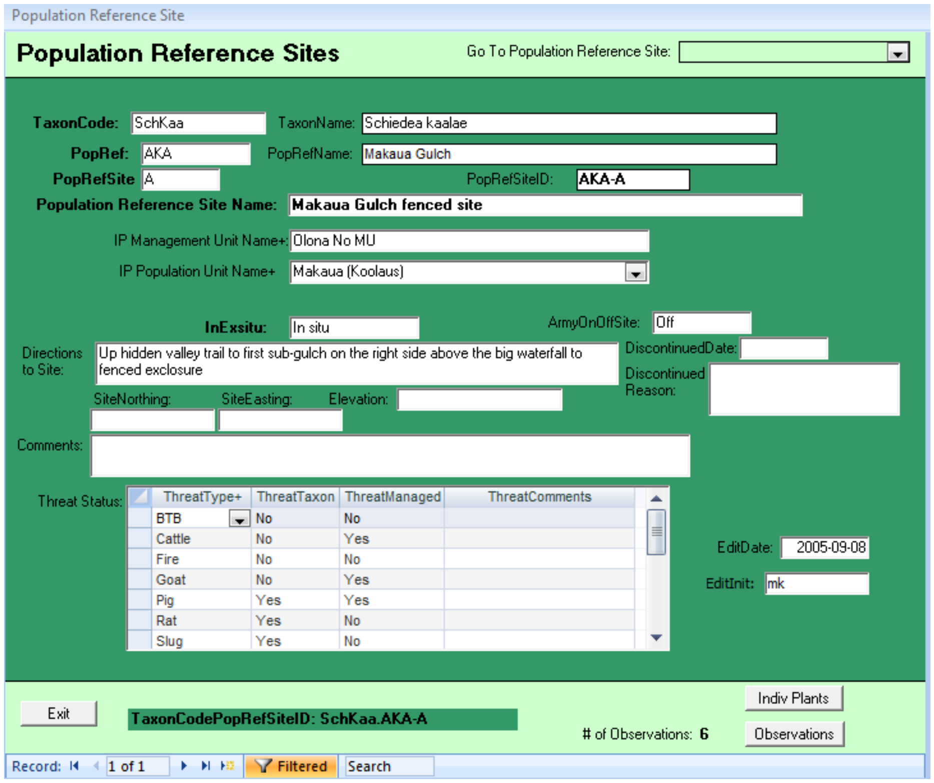
The Population Reference Site (PopRefSite) is the primary data table in establishing plant or animal population sites. The PopRefSite identifies the Population Name, whether it is In situ, Ex situ or Reintro, and provides directions to the site, etc. The PopRefSite is only site information; observation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

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



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.

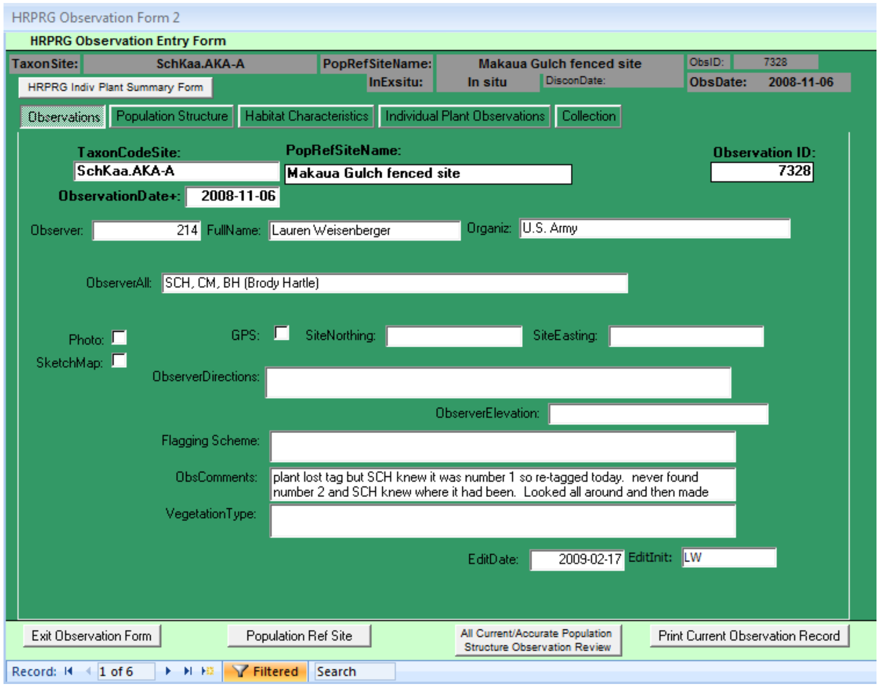
IP Population Unit Name (PopUnit): The PopUnit is used when several PopRefSites need to be tracked together. Such as a taxon with several sites throughout the Northern Waianae Mountains, Northern Waianae could be used as a PopUnit Name.

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

Directions to Site: Detailed directions to locate the population.

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

Observations

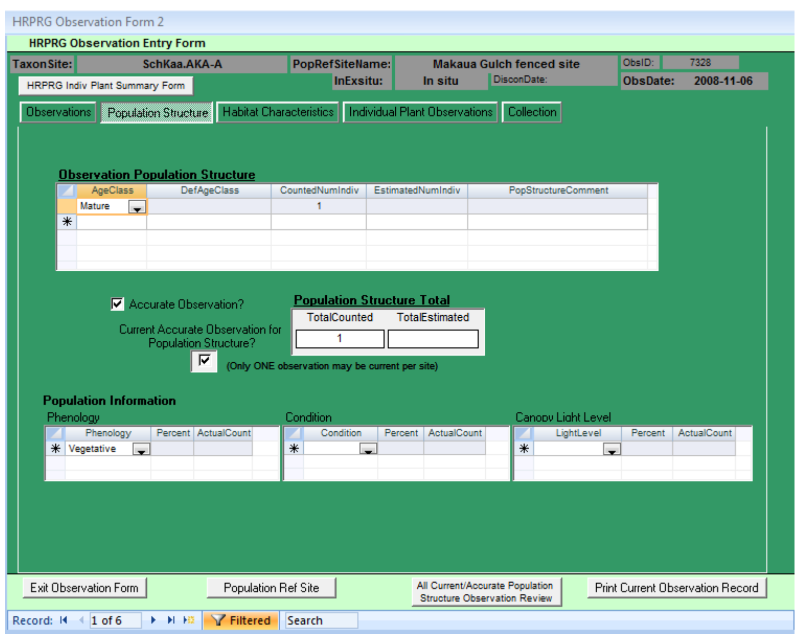


Clicking the Observations button on the bottom of the PopRefSite Form will open up the corresponding Observations.

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

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

Population Structure

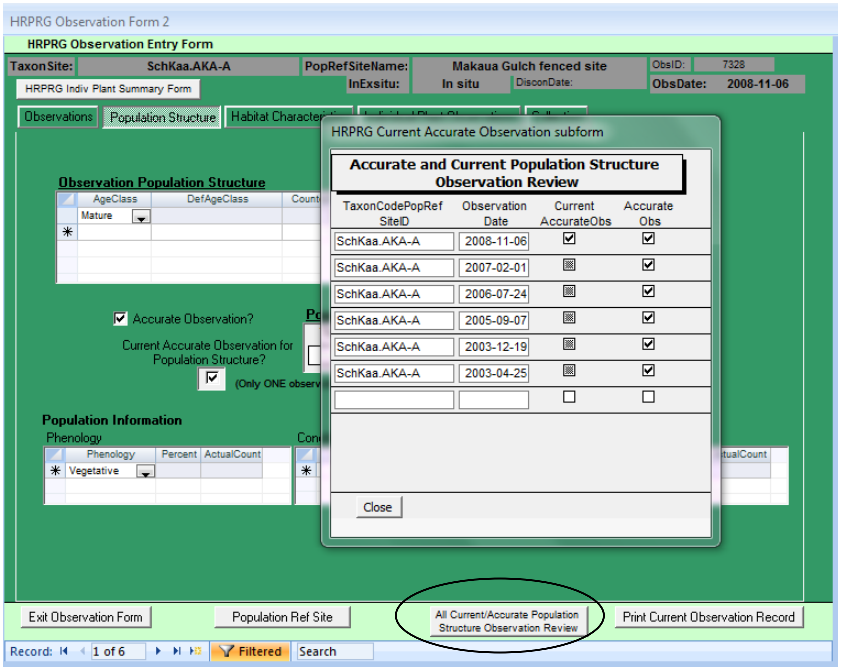


The Population Structure should are always entered for any observations, even if the number of plants observed are incomplete (not all plants observed).

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.

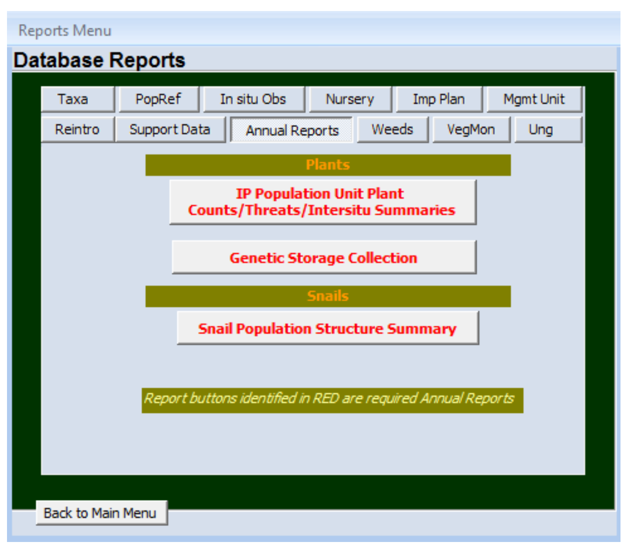


As opposed to the Accurate Observation check box, the **Current Accurate Observation check off box** may only have one observation checked. The Current Accurate represents the population structure that is considered both current and accurate. The most recent observation may not always be the Current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

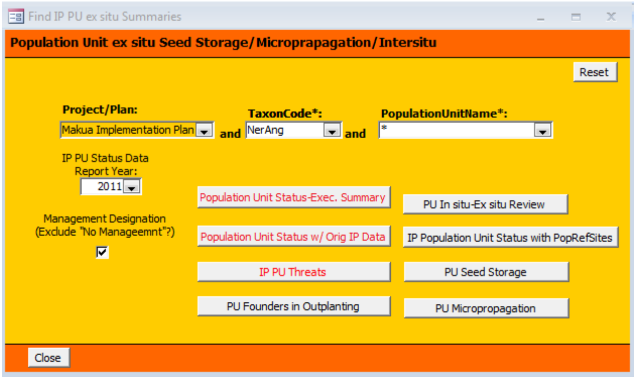
Starting from the Main Menu, click on the Database Reports button. The Database Reports menu provides reports for various sections of the database.



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 2012. Report Year is defined below under Total Mature, Immature and Seedling 2012.

Executive Summary

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

Makua Implementation Plan - Executive Summary - Plants

\# of Stable IP Population Units: 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 2015	# 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	134	0	N/A	100%	Yes	
		Makua	75	68	7	13	126	29	44%	100%	No	
		Manuwai	207	110	97	14	199	12	80%	100%	Yes	
		Waianae Kai Mauka	13	11	2	0	16	46	61%	100%	No	
		Neraudia angulata Total:	419	289	130	28	475	87				2 of 4

Taxon 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 2015	Total Immature 2015	Total Seedling 2015	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	**75**	**36**	**0**	6	11	0	69	25	0	2015-08-31	No monitoring in the last year
	In Total:	22	24	0	75	36	0	**75**	**36**	**0**	6	11	0	69	25	0		

Action Area: Out

TaxonName: Cyanea grimesiana subsp. obatae Target # of Matures: 100 # MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	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	128	22	1	**124**	**17**	**0**	2	1	0	122	16	0	2016-04-07	Some plants died this year
Makaha	Genetic Storage				4	18	0	**13**	**56**	**0**	0	0	0	13	56	0	2016-02-09	More plants were outplanted
North branch of South Ekahanui	Manage reintroduction for stability	5	0	0	83	66	0	**82**	**65**	**0**	0	0	0	82	65	0	2016-05-11	A couple plants died
Palikea (South Palawai)	Manage for stability	3	60	0	108	36	1	**120**	**19**	**1**	7	7	0	113	12	1	2015-10-14	Some more plants matured at the outplanting
	Out Total:	8	60	0	323	142	2	**339**	**157**	**1**	9	8	0	330	149	1		
	Total for Taxon:	30	84	0	398	178	2	**414**	**193**	**1**	15	19	0	399	174	1		

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

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

Management Designation: For PUs with naturally occurring (*in situ*) plants remaining, the designation is either 'Manage for Stability' or 'Genetic Storage'. Some MFS PUs will be augmented with outplantings to reach stability goals. When reintroductions alone will be used to reach stability, the designation is 'Manage Reintroduction for Stability.' When a reintroduction will be used for producing propagules for genetic storage, the designation is 'Manage Reintroduction for Storage'.

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

Total Mature, Immature and Seedling (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 OANRP monitoring data, data from the Oahu Plant Extinction Prevention Program (OPEP) and Oahu NARS staff. The estimates may have changed from last year if estimates were revised after new monitoring data was taken or if the PUs have been split or merged since the last reporting period. The most recent estimate is used for all PUs, but some have not been monitored in several years. Several PU have not been visited yet by OANRP and no plants are listed in the population estimates. As these sites are monitored, estimates will be revised.

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

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

Population Trend Notes: Comments on the general population trend of each PU is given here. This may include notes on whether the PU was monitored in the last year, a brief discussion of the changes in population numbers from the previous estimates, and some explanation of whether the change is due to new plants being discovered in the same site, a new site being found, reintroductions or augmentations that increased the numbers or fluctuations in the numbers of wild plants. In some cases where the numbers have not changed, NRS has monitored the PU and observed no change. When the PU has not been monitored, the same estimate from the previous year is repeated.

Threat Control Summary

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 0%	No	No	No
Makua	Manage for stability	6	Partial 100%	No	No	No	No
South Mohiakea	Genetic Storage	2	Yes	No	No	No	No
West Makaleha	Genetic Storage	13	No	No	No	No	No

Action Area: Out

TaxonName: Alectryon macrococcus var. macrococcus

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Central Kaluaa to Central Waieli	Manage for stability	3	Partial 0%	Partial 0%	No	No	No
Makaha	Manage for stability	29	Yes	Partial 97%	No	No	No
Waianae Kai	Genetic Storage	0	No	No	No	No	No

= Threat to Taxon within Population Unit
No Shading = Absence of threat to Taxon within Population Unit
Ungulate Managed = Culmination of Cattle, Goats, and Pig threats
Yes=All PopRefSites within Population Unit have threat controlled
No=All PopRefSites within Population Unit have no threat control
Partial% =Percent of mature plants in Population Unit that have threat controlled
Partial 100%= All PopRefSites within Population Unit have threat partially controlled
Partial 0%= Threat partially controlled, but no mature plants

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

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

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

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

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

Threat control is defined as:
Yes = All sites within the PU have the threat controlled
No = All sites within the PU have no threat control
Partial %= Percent of mature plants in Population Unit that have threat controlled
Partial 100%= All PopRefSites within Population Unit have threat partially controlled
Partial (with no %) = All PopRefSites within Population Unit have threat partially controlled and only immature plants have been observed.

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

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

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

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

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

Genetic Storage Summary

Genetic Storage Summary   Makua Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	33	2	2	0	36	1	0	0	22	22	44%
Punapohaku	Genetic Storage	4	0	0	0	0	0	4	0	0	0	4	4	100%
Action Area: Out														
Neraudia angulata														
Halona	Genetic Storage	4	10	17	0	0	0	9	0	0	0	8	8	38%
Leeward Puu Kaua	Genetic Storage	9	0	0	0	0	0	1	0	0	0	1	1	11%
Makaha	Manage for stability (backup site)	3	8	12	2	1	0	15	1	0	0	14	14	93%
Manuwai	Manage for stability	0	3	2	0	0	0	4	0	0	0	4	4	100%
Waianae Kai Makai	Genetic Storage	13	0	0	0	0	0	8	0	0	0	8	8	62%
Waianae Kai Mauka	Manage for stability	7	2	9	0	0	0	11	0	0	0	11	11	69%

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
61	27	75	6	5	0	90	4	0	0	74	74

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: Large	Medium	Small	Unk	Threat Control: Ungulate	Weed	Rat	Euglandina rosea	Jackson's Chameleon
Achatinella mustelina												
ESU: A — Pahole to Kahanahaiki												
MMR-A **Kahanahaiki Exclosure**	Manage for stability	224	2016-05-17	111	96	17	0	Yes	Yes	Yes	Yes	No
MMR-O **Giant Olopua**	Manage for stability	0	2015-12-07	0	0	0	0	Yes	No	Yes	No	No
PAH-B **Pahole Exclosure**	Manage for stability	61	2015-02-04	37	14	10	0	Yes	Yes	Yes	Yes	No
	ESU Total:	285		148	110	27	0					

*=Total Snails were Trans Located or Reintroduced

[shaded] = 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.

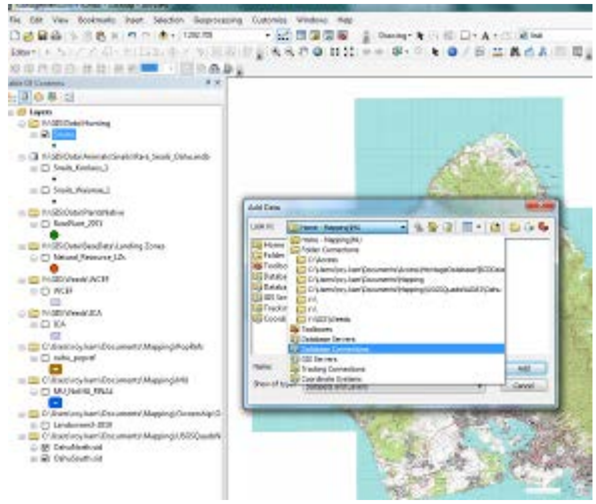
Population Reference Site: The first column lists the population reference code for each field site. This consists of a three-letter abbreviation for the gulch or area name. For example, MMR stands for Makua Military Reservation. Next, a letter code is applied in alphabetic order according to the order of population discovery. This coding system allows NRS to track each field site as a unique entity. This code is also linked to the Army Natural Resource geodatabase. In addition, the "common name" for the site is listed as this name is often easier to remember than the population reference code.

Management Designation: In the next column, the management designation is listed for each field site. The tables used in this report only display the sites chosen for MFS, where NRS is actively conducting management. These sites are generally the most robust sites in terms of snail numbers, habitat quality, and manageability. Other field sites where NRS has observed snails are tracked in the database but under the designation 'no management.' In general, these sites include only a few snails in degraded habitat where management is logistically challenging. The combined total for sites designated as MFS should be a minimum of 300 total snails in order to meet stability requirements.

Population Numbers: The most current and most accurate monitoring data from each field site are used to populate the 'total snails' observed column and the numbers reported by 'size class' columns. In some cases, complete monitoring has not been conducted within this reporting period because of staff time constraints, therefore, older data are used.

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

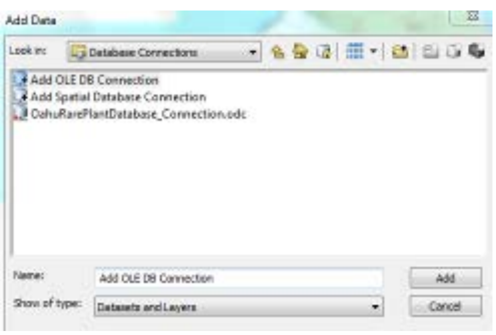
Linking Access Database Query into ArcGIS –Distribution Database Version



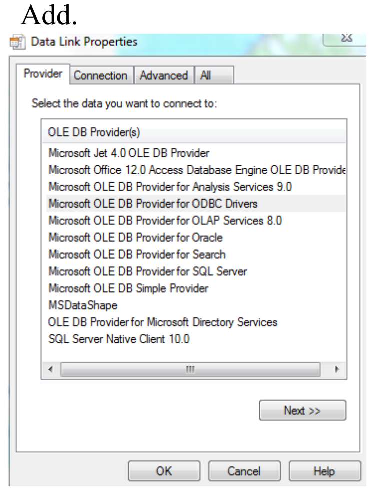
There may be times that information found in the Access database is needed in a GIS map. The following shows you how to link a query from Access into an ArcGIS project. The Population Reference Site query will be used as an example. Note there are several steps needed to bring in an Access Database query.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

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

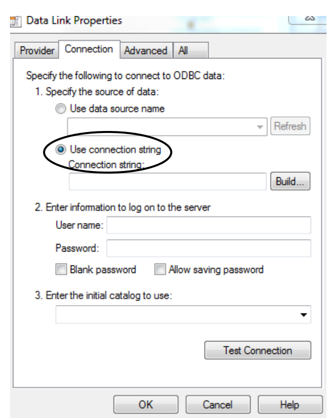
Click on the Add Button, and choose *Database Connections*. If you do not have Database Connections listed (versions ArcGIS 10.3 and up), you will need to add it before you start. Go to ArcCatalog>Customize (Tab)>Customize Mode>Under the Commands Tab, select ArcCatalog (left column) and on the right chose Add OLE DB Connection. Drag Add OLE DB Connection from the Commands list onto the toolbar in ArcCatalog.



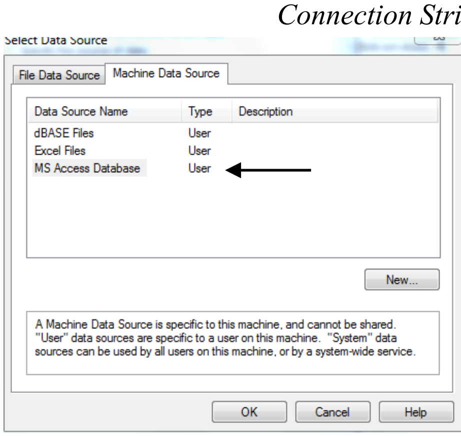
Then select *Add OLE Database Connection*, and click on Add.



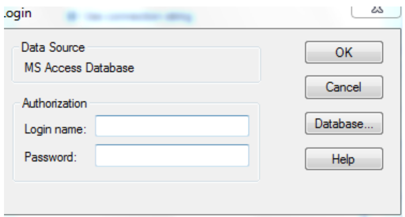
A Data Link Properties window will appear. Select *Microsoft OLE DB Provider for ODBC Drivers*.



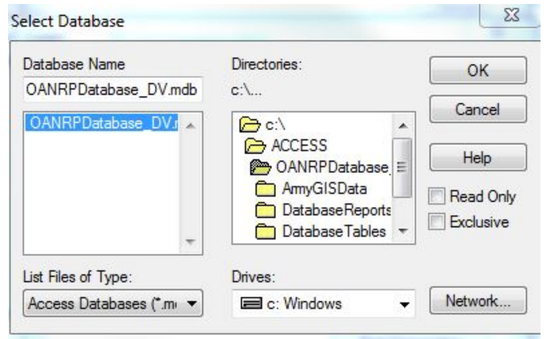
Then in the Data Link Properties window, select the *Connection tab*. Under the Connection Tab, select *Use Connection String* and click on the button *Build*.



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

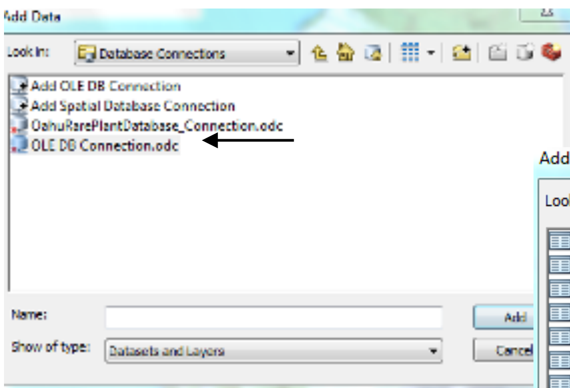


In the Login Window, Click on the *Database* button (leave Login Name and Password blank).

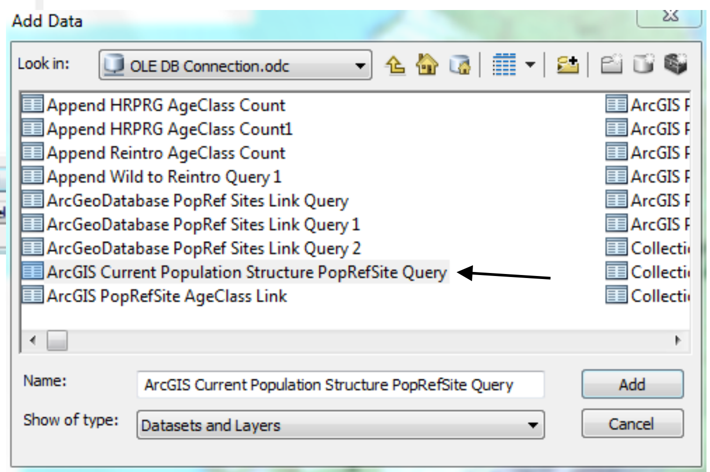


In the Select Database window, change the Drives to C: and browse to C:\Access\OANRPDatabase_DistributeVersion\ OANRPDatabase_DV.mdb

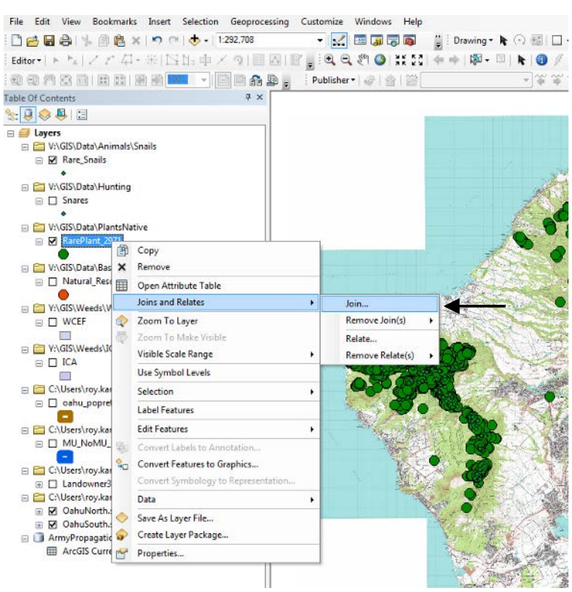
Click Ok to close the windows, until you are back at the Add Data window. You will now see a new OLE DB Connection.odc listed.



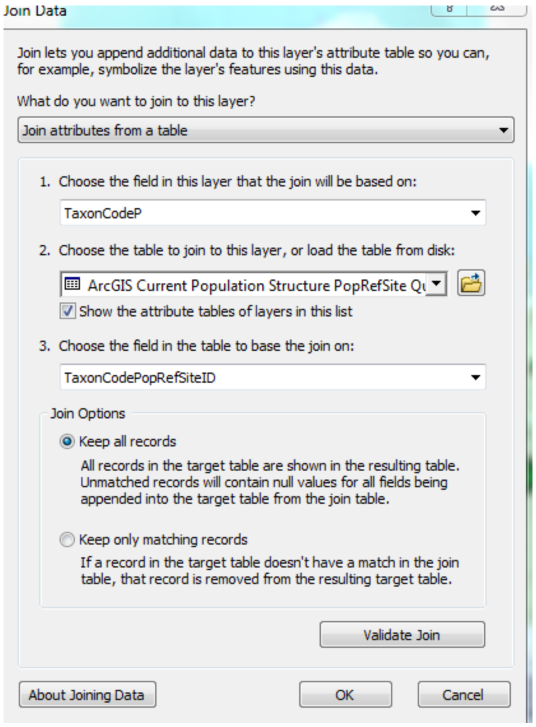
Double click on the OLE DB Connection.odc. The window will then open the Access Database and list all tables and queries.



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



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



The last procedure is to join the Rare Plant shapefile with the Access Query. Select TaxonCodeP from the Rare Plant GIS Shapefile, and TaxonCodePopRefSiteID from the Access database query. The data will now appear together in the Snare shapefile attribute table.

Attribute Table from ArcGIS. Example of Rare Plant shapefile joined to Access Database Query.

Rare Plants GIS Shapefile table data → Access Database data

RarePlants

OBJ	ID	SPECIES	POPULATION	TaxonCodeP	LOCATION	SOU	FULL_SCIEN	X	Y	NATU	Statu	TaxonCode	PopRefName
1	0	AleMacMac	SBW-A	AleMacMac.SBW-A	Mohiakea gulch	JL	Alectryon macrococcus macrococcus	590515.562	2376426.50004	Yes	E	AleMacMac	Schofield Barracks Mil
2	0	AleMacMac	SBW-C	AleMacMac.SBW-C	Puu Kumakalii	JL	Alectryon macrococcus macrococcus	590981.875	2375960.25005	Yes	E	AleMacMac	Schofield Barracks Mil
3	0	AleMacMac	SBW-D	AleMacMac.SBW-D	Puu Kumakalii	JL	Alectryon macrococcus macrococcus	591323.250	2375402.75002	Yes	E	AleMacMac	Schofield Barracks Mil
4	0	SchTri	ALA-C	SchTri.ALA-C	Kaala	JL	Schiedea trinervis	589030.703	2378443.74343	Yes	E	SchTri	Mt. Kaala NAR
5	0	SchTri	SBW-G	SchTri.SBW-G	Puu Kalena	JL	Schiedea trinervis	589641.375	2376627.49997	Yes	E	SchTri	Schofield Barracks Mil
6	0	CyaAcu	ALA-B	CyaAcu.ALA-B	Kaala	JL	Cyanea acuminata	589083.312	2378560.75002	Yes	E	CyaAcu	Mt. Kaala NAR
7	0	CyaGriOba	SBW-A	CyaGriOba.SBW-A	Kaala 2400'	JL	Cyanea grimesiana obatae	590057.000	2378433.99994	Yes	E	CyaGriOba	Schofield Barracks Mil
8	0	CyaCal	NA	CyaCal.ALA-A	Kaala	JL	Cyanea calycina	588965.812	2378293.99994		E	CyaCal	Mt. Kaala NAR
9	0	CyaCal	NA	CyaCal.ALA-A	Kaala	JL	Cyanea calycina	588996.187	2378697.74996		E	CyaCal	Mt. Kaala NAR
10	0	CyaCal	NA	CyaCal.ALA-A	Kaala	JL	Cyanea calycina	589218.125	2378491.00001		E	CyaCal	Mt. Kaala NAR
11	0	CyaCal	NA	CyaCal.SBW-A	Kaala	JL	Cyanea calycina	589493.687	2377636.75002	Yes	E	CyaCal	Schofield Barracks Mil
12	0	CyaCal	NA	CyaCal.SBW-A	Kaala	JL	Cyanea calycina	589268.312	2377825.24999	Yes	E	CyaCal	Schofield Barracks Mil
13	0	CyaCal	SBW-A	CyaCal.SBW-A	Kaala	JL	Cyanea calycina	588881.999	2378048.50004	Yes	E	CyaCal	Schofield Barracks Mil
14	0	CyaCal	SBW-C	CyaCal.SBW-C	Puu Kalena 2300'	JL	Cyanea calycina	590479.812	2376867.99994	Yes	E	CyaCal	Schofield Barracks Mil
15	0	CyaCal	SBW-C	CyaCal.SBW-C	Puu Kalena 2800'	JL	Cyanea calycina	590307.312	2376571.74996	Yes	E	CyaCal	Schofield Barracks Mil

→ Access Database data joined query →

RarePlants

PopRefName	FedStat	TaxonCodePopRefSit	PopRefSiteName	InExsitu	ObservationDate	AccObs	CurAccObs	Immature	Large	Mature	Medium
Schofield Barracks Milita	E	AleMacMac.SBW-A	Mohiakea	In situ	2013-05-20	Yes	Yes	<Null>	<Null>	2	<Null>
Schofield Barracks Milita	E	AleMacMac.SBW-C	North of Puukumakalii (Dead)	In situ	2012-04-04	Yes	Yes	0	<Null>	0	<Null>
Schofield Barracks Milita	E	AleMacMac.SBW-D	Southeast of Puukumakalii	In situ	2012-06-27	Yes	Yes	0	<Null>	0	<Null>
Mt. Kaala NAR	E	SchTri.ALA-C	Lower 2 Poles Ridge	In situ	2002-10-23	Yes	Yes	5	<Null>	5	<Null>
Schofield Barracks Milita	E	SchTri.SBW-G	Kalena, in notch	In situ	2007-08-20	Yes	Yes	0	<Null>	0	<Null>
Mt. Kaala NAR	E	CyaAcu.ALA-B	Kaala, one gulch N of Alstri ridge	In situ	2008-03-13	Yes	Yes	<Null>	<Null>	19	<Null>
Schofield Barracks Milita	E	CyaGriOba.SBW-A	North Haleauau	In situ	2005-10-03	Yes	Yes	0	<Null>	0	<Null>
Mt. Kaala NAR	E	CyaCal.ALA-A	Kaala	In situ	2013-06-06	Yes	Yes	<Null>	<Null>	3	<Null>
Mt. Kaala NAR	E	CyaCal.ALA-A	Kaala	In situ	2013-06-06	Yes	Yes	<Null>	<Null>	3	<Null>
Mt. Kaala NAR	E	CyaCal.ALA-A	Kaala	In situ	2013-06-06	Yes	Yes	<Null>	<Null>	3	<Null>
Schofield Barracks Milita	E	CyaCal.SBW-A	North Haleauau, Below ALA-O populati	In situ	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
Schofield Barracks Milita	E	CyaCal.SBW-A	North Haleauau, Below ALA-O populati	In situ	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
Schofield Barracks Milita	E	CyaCal.SBW-A	North Haleauau, Below ALA-O populati	In situ	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
Schofield Barracks Milita	E	CyaCal.SBW-C	Kaala-Kalena	In situ	2006-10-25	Yes	Yes	<Null>	<Null>	1	<Null>
Schofield Barracks Milita	E	CyaCal.SBW-C	Kaala-Kalena	In situ	2006-10-25	Yes	Yes	<Null>	<Null>	1	<Null>
<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>

APPENDIX ES-3

STUDIES ON HAWAIIAN TREE SNAILS

Brenden Holland
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Current status of captive endangered tree snail populations:
As of our latest lab census (April 2016) we are caring for 504 Endangered Hawaiian tree snails (up from 426 last year at this time), the majority of which, 461, are members of the genus *Achatinella*, from Oahu. The remaining two species in the lab are members of the genus *Partulina*, with 43 individuals (up from 27 last year at this time), from the island of Lanai. The snails are housed in 15 large cages (35 x 20 x 20 cm, total volume of 14,000 cm^3 each) and 6 small cages (20 x 13 x 10 cm, 2,600 cm^3 volume) (large cages shown in Figure 1). Populations exceeding 20 individuals are kept in large cages while for smaller populations (<20 snails), small cages are sufficient. The snail cages are housed in 3 environmental chambers (see Figure 1). Each week we inoculate and grow up about 50 potato dextrose agar plates of tree fungus dietary supplement (see **Fungus Culture**). We currently have a staff of three technicians and one lab manager who are directly involved with care and maintenance of the captive tree snails.

Figure 1. Captive breeding and care entails scheduled daily cage watering, changing, cleaning and documentation of mortality, births, and population status. Cages are changed by exchanging native foliage collected in the field and laboratory cultured leaf fungus, and cleaning and sterilizing the interior and the lid.

General Daily Tasks
Incubators are checked and inspected daily, first in the morning and at the end of each work day, at a minimum. Priority system checks include visual examination of rubber sprinkler stopper placement. Stoppers are sealed, and in place, temperature panels are

checked throughout each day. Note that operating temperatures have been corrected via Hobo® data loggers and analog thermometers, such that panels do not always reflect target temperatures. Thermal profile printouts, are affixed to upper left side of each chamber door. Internal drainage systems should also be checked daily for leaks, overflows, and clogged nozzles or drains.

Environmental Chambers - We currently use three diurnal incubators, also referred to as environmental chambers, for snail propagation in the Hawaiian Tree Snail Conservation facility at the University of Hawaii, Manoa. The units currently in operation, are manufactured by Precision Thermo Scientific 818 (Model # 3751), two are newer Thermo Scientific (Model # 3751), and one VWR Sheldon Manufacturing (Model # 2015) (Figure 2). All of the environmental chambers run on 120 volts, and are equipped with electronic programmable temperature and photoperiod controls, as well as alarms in the event that the temperatures exceed preset high or low set-point limits. Light bulbs used in each chamber are full spectrum, 40 watt, 48 inch fluorescent bulbs, producing between 1,980 and 3,300 lumens. Chambers require regular maintenance, including periodic light bulb and drain tube replacement, rust removal and repainting, fuse replacement and temperature calibration.

Figure 2. Environmental chambers, showing Thermo model and control panel.

Temperature - For snails collected from to upper-elevation habitat (670 + m.), chamber temperature is maintained at 20° C during the 12 hr day (light) cycle and 16° C during the 12 hr night (dark) cycle (*Achatinella lila, A. bulimoides, A. livida, A. fuscobasis, A. decipiens*). For the snails collected from slightly lower elevation habitat, day temperature is set slightly warmer, to 21° C, and at night is 18° C (*A. mustelina, A. fulgens, A. apexfulva, Partulina variabilis, P. semicarinata*). We currently have Hobo® data loggers (on loan from SEPP). We are keeping these in all active chambers, and we currently monitor temperature profiles, to ensure that actual operating temperatures are within range and that chambers are holding consistent temperature profiles.

By monitoring chamber temperatures we have found that each internal actual operating temperature differs slightly from the control panel setting and display, by differing amounts, such that temperatures shown on panels vary slightly among chambers. We have incrementally adjusted each chamber thermal control, so that internal temperatures are now set correctly to thermal targets. Conversions are shown on printouts placed on the left side of each chamber door. We have two chambers set to actual internal operating temperatures of higher elevation habitat, 20°C day and 16° C night, and one chamber as shown above, at the lower elevation temperature profile, 21° C day and 18° C night.

Cage Changing & Cleaning Procedure

We have developed a stepwise, standardized procedure for cleaning individual snail cages. Strict adherence to these steps is essential to the maintenance of populations of tree snails. Changing schedule is: each week for small cages, every two weeks for large cages. We keep track of fungus consumption at each changing cycle, and the general rule of thumb is between 2 and 4 plates (or discs) for large cages and one plate or less for small. We carefully document and measure new births, as well as any mortality during each cycle.

Fungus Culture

Cultured fungus is provided as a supplement for captive tree snail dietary requirements. We maintain a line of fungus that is fed to all snails. The Potato Dextrose Agar (PDA)(Difco or Cole Parmer) medium on which the fungus grows is supplemented with calcium carbonate to help with shell maintenance and growth. Fungus culture is done in several steps, the first is preparing and sterilizing the PDA, then pouring the PDA plates (Figure 3), and finally is inoculating the cured PDA plates. Currently we prepare 45-50 Petri plates per week.

Figure 3. Image shows fungus spatulas (left) and plates of cultured fungus (right).

Leaf and Branch Collection

Once per week, plant material is collected for snail cages by hiking on designated trails and clipping small branches from native host plants. In the field, personnel wear general hiking apparel including closed-toed hiking or running shoes, sun protection, rain gear, and carry bottled water, sun screen and at least one cell phone. In addition, clippers and large trash bags are required. Hawaiian tree snails typically prefer host trees with glabrous leaves (shiny, smooth leaves), including Ohia lehua (*Metrosideros polymorpha*) as well as other native species such as Kopiko (*Psychotria grandilora*), Kawa'u (*Ilex* *anomala*), Olopua (*Nestigis sandwicensis*), Pāpala (*Pisonia umbellifera*), Akiahala (*Broussaisia arguta*), Lama (*Diospyros sandwichensis*), and Alani (*Melicope* sp.). These tree species are the main focus of leaf collections for tree snail maintenance. Branches are cut and collected in the field using hand-held clippers. Branches are maintained as intact as possible, to maximize the time that they remain fresh. *Freycinetia arborea* (I'e i'e) is another host plant favored by tree snails. I'e i'e leaves have an unusual structure, and are long and thin, and can be acquired in the field by pulling them away from the lower portion of the cluster along the stem at the base, 3-5 leaves at a time, rather than clipping. Thanks to the recent work done with our collaborators in the Botany Department, we now know that at a given locality, the microbial community tends to be the same on native and non-native tree surfaces. This has allowed us to slightly expand the scope of host plant leaf collecting to now include several nonnative broad leaved tree species, that we harvest from mid-elevation forests along with the usual native host plants, Octopus tree (*Schefflera actinophylla)* and Ti plant (*Cordyline fruticosa*). Short branches with well-developed foliage, of approximately 30 cm are generally preferred for clippings. Leaves tend to remain fresher, longer this way, as opposed to cutting shorter twigs. Generally, if given an option, we do not clip branches with flowers, fruit, seeds or other reproductive structures. Also since tree snails feed on the microbial phyllosphere (leaf and branch surface fungal community), which is not as likely to be well-developed on immature plants, therefore we do not collect juvenile or undeveloped leaves, buds or branches. Leaves collected in the field are doused with water in the collection bags, maintained in shade when possible, and kept wet in the field.

In the lab, all branches and leaves are sprayed with water and placed at 4º C in closed plastic trash bags. Plant material can continue to be used for 5 to 7 days following collection and this way leaves will stay fresh within snail cages until the next scheduled cleaning.

Publications (accepted within the past 18 months, with assistance of OANRP support)

Van Kleeck, M.J. & **B.S. Holland**. Chemical control of the invasive Jackson's chameleon. *International Journal of Pest Management* (in revision)

O'Rorke, R., **B.S. Holland**, G.M. Cobian, K. Gaughen & A.S. Amend. (2016) Enhancing captive breeding of endangered species by determining dietary preferences. *Biological Conservation* (in press)

Holland, B.S., L.M. Chiaverano & C.K. Howard. (2016) Diminished fitness in an endemic Hawaiian snail in nonnative host plants. *Ethology, Ecology and Evolution* (in press)

Van Kleeck, M.J., L.M. Chiaverano & **B.S. Holland.** (2015) Prey-associated head-size variation in an invasive lizard in the Hawaiian Islands. *Biological Journal of the Linnean Society* 116(3):626-636.

O'Rorke R., G.M. Cobian, **B.S. Holland**, M.R. Price, & A.S. Amend. (2015) Dining local: the diet of a snail that grazes microbial communities is geographically structured, *Environmental Microbiology* 17(5):1753-1764.

APPENDIX ES-4

Molecular assessment of wild *Achatinella mustelina* diet
Quarterly Report – April, 2016
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Food Similarity Between Proposed Donor and Enclosure Snail Sites

If populations of *Achatinella mustelina* in difficult-to-access areas are to be successfully relocated to enclosures at sites more amenable to conservation efforts, it must be assured that conditions at the proposed sites are similar to those where the snails currently reside. One factor that may be important is the availability of preferred snail food sources. We are determining whether epiphytic microbial communities are similar between donor and proposed enclosure sites by sequencing DNA amplicons of material swabbed from the surface of leaves at each location. At each current and proposed snail site, leaves from at least 10 plants were recorded, collected and returned to the lab. In the lab, leaf surfaces were swabbed and these swabs were subjected to DNA sequencing to determine species composition. If leaf-surface microbial communities are similar between current and proposed sites, it is an indication that food source and availability will not be limiting factors in snail health at proposed sites following translocation. If microbial communities are dissimilar, further work will be done to determine whether these differences are functionally meaningful and/or whether it is possible to inoculate plant surfaces at the proposed sites with microbial food sources from the current sites to ease any potential snail relocation shock.

Donor Site Proposed Site
Skeet Pass - Ka'ala Bog
Culvert 69 - Three Points
Ekahanui - Palikea Area

Fungal ITS genetic marker regions were amplified and sequenced at the University of Hawaii HIMB Genetics Core Facility. The resulting reads were then combined into probable operational taxonomic units which were used to construct dissimilarity measures between sites.

Map removed to protect rare resources. Available upon request

Fi

Figure 1 - Map of sampling locations (Waianae range)

Results

There was a significant difference (Anosim; P=0.001) in epiphyte fungal community structure between the four sites near Kaala summit (Kaala Bog, Culvert 69, Skeet Pass, and Three-Points) and the three sites near Palikea (DS Palikea, Kaaikukai, and Ekahanui). There was no detectable difference between any of the current/proposed site pairings, however (See Fig. 3). Thus, it does not seem likely that any snails moved to proposed enclosure locations will encounter significantly different food sources from their currently paired extant sites and food sources will not be limiting factors in snail health following translocation.

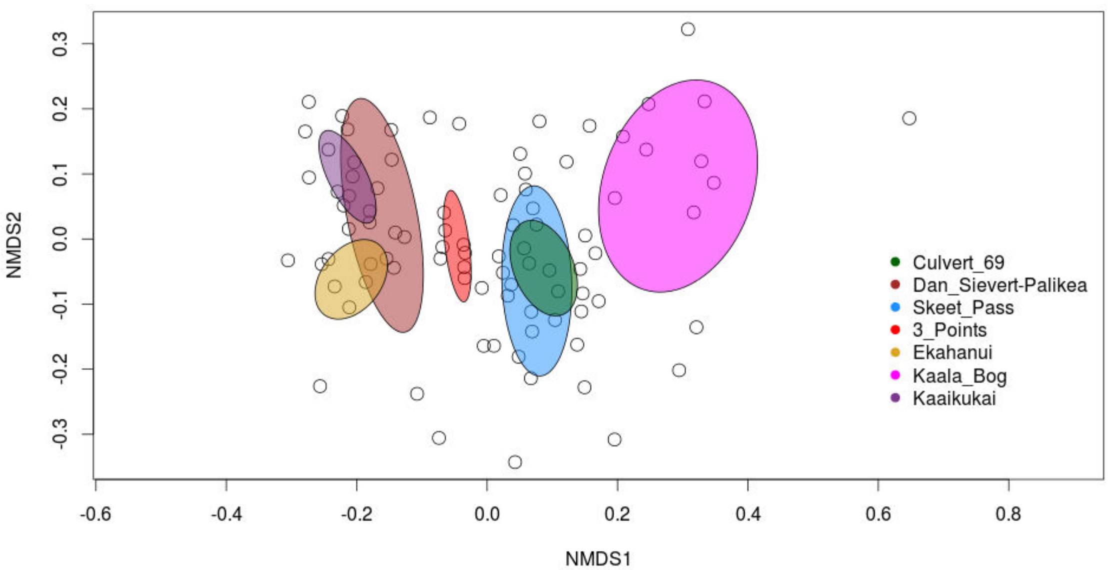
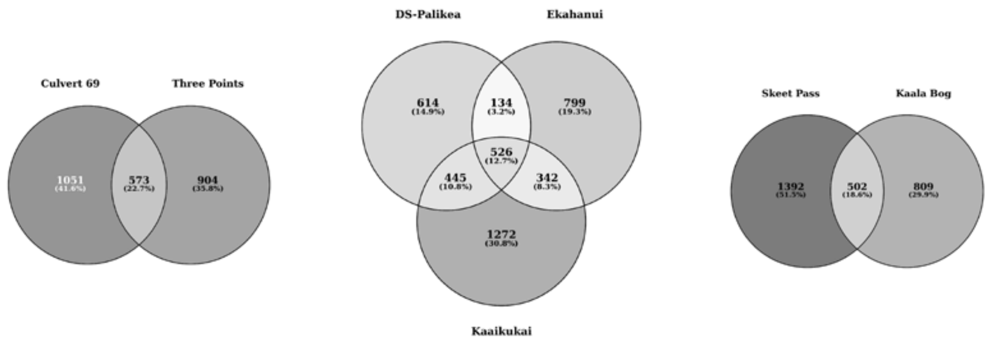


Figure 2 - NMDS projection of epiphyte fungal communities. Ellipses represent the standard deviation of point scores around the group centroid.

Phyllostegia endophytes and pathogen resistance

Phyllostegia mollis and *Phyllostegia kaalaensis* are federally listed endangered plant species endemic to Oahu, HI. There are currently no known wild populations of *P. kaalaensis* and the few wild populations of *P. mollis* are failing to demonstrate long-term survival. Greenhouse populations of these plants are maintained by the Army Natural Resources division, but they show marked susceptibility to fungal pathogens, particularly the powdery mildew, *Neoerysiphe galeopsidis*. Greenhouse populations are, therefore, dependent on regular fungicide treatments which are impossible to maintain once individuals have been out-planted to habitats within their native ranges. Current scientific consensus is that the fungi which coexist within plant tissues form an integral part of plant fitness. These beneficial endophytic and mycorrhizal fungi are not present in plants that have received regular fungicidal treatments, so they are not present in out-planted populations of *P. mollis* or *P. kaalaensis*. One of the major benefits that host plants receive from mutualistic fungi is increased resistance to disease, as mutualistic fungi can outcompete pathogens for habitable living space or even actively repel invasive fungi through excreting chemical compounds. The essentially sterile plants are presumed, therefore, to be highly susceptible to attack by pathogenic fungi in the environment. We have completed a pilot study on the efficacy of transplanting fungal endophytes from healthy wild populations of *P. mollis* and *P. hirsuta* into



ANOSIM statistic R: -0.03114
Significance: 0.619

ANOSIM statistic R: -0.06877
Significance: 0.837

ANOSIM statistic R: -0.08435
Significance: 0.91

Figure 3 Shared OTUs between current/proposed site pairings. The proportions of OTUs unique to each site do not constitute statistically significant differences

greenhouse-raised *P. mollis* and *P. kaalaensis* individuals. Two experimental transplantation methods were tested: 1) Isolating individual fungal strains from wild hosts, culturing them in the lab, and spraying them onto the leaves of greenhouse-raised individuals; 2) Preparing a low-tech slurry from leaves of wild individuals, filtering out large particles, and spraying this onto the new host plants. The first method has the benefit that we know exactly what we are applying to the new host leaves, the second method has the benefit of potentially passing on beneficial fungi that are not amenable to laboratory culture. Preliminary results were intriguing. The cultured fungal isolates did not appear to confer any advantage over the control group with respect to disease severity, but the group receiving the slurry of wild leaves showed delayed mortality and decreased disease severity for a time (Fig. 4). By the end of one month all plants had generally succumbed to *N. galeopsidis* but the "leaf slurry" treatment warrants further investigation, as it showed some benefit, at least for the first three weeks. By this time the pathogen load on the other two treatments was essentially 100%, with all leaf surfaces covered with sporulating fungus and the slurry-treated plants, in such close proximity, did not last long after. We are nearing the end of a second round of tests, and the results are similar and even more pronounced. DNA from the inoculae and the initial plant endophyte loads was sequenced and the results are surprising. Roughly 90% of the fungal reads from the leaf slurry treatment, which is showing so much promise, come from *N. galeopsidis,* the same pathogen that appears to be killing the plants (Fig. 5). Leaf samples have been taken at regular intervals during both rounds of testing to track the colonization of plant tissues by fungal inoculae. When these samples are sequenced it will be clearer what fungi were able to establish in the plants, and whether the plants treated with the leaf slurry have been colonized by any strains of *N. galeopsidis*.

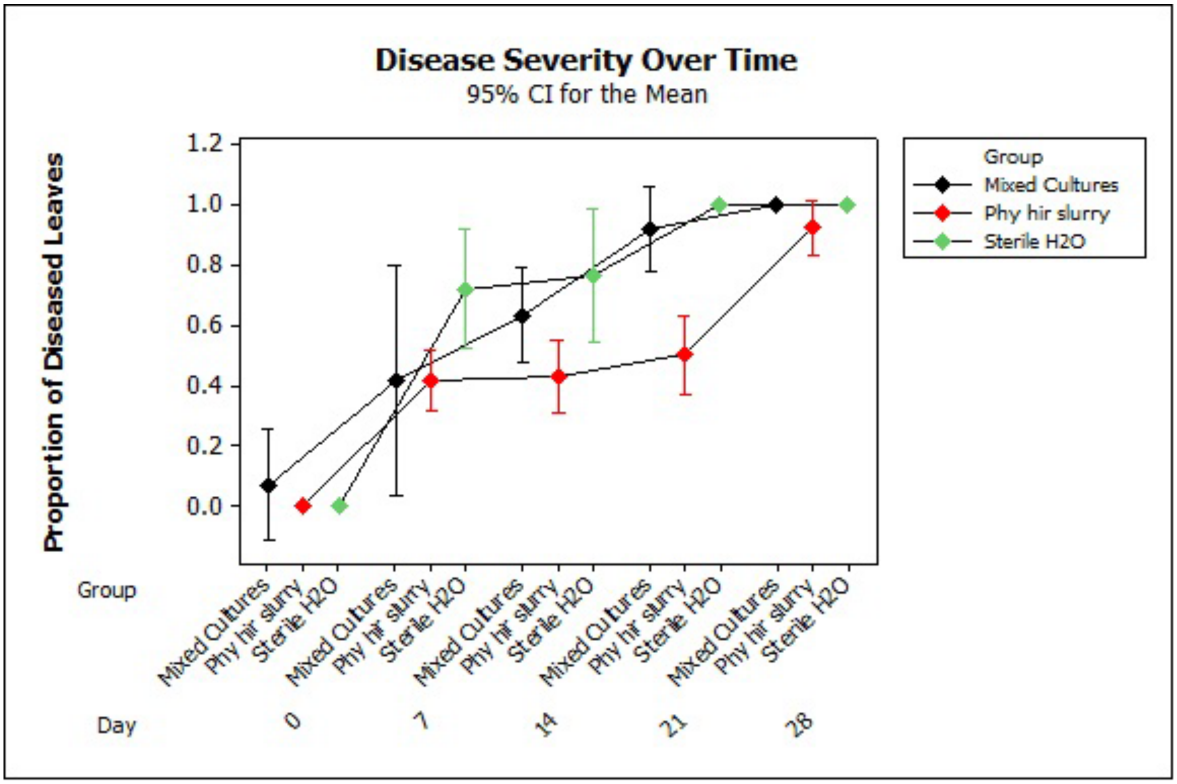


Figure 4 - The proportion of diseased leaves over time. The slurry from healthy wild leaves (shown in red) conferred a longer time until full onset of disease.

Other work

Captive (laboratory) snail (*Achatinella mustelina)* populations are dependent on microbes from wild leaves to supplement their diet. These leaves are obtained by regular field forays which are costly and time consuming. The ability to grow diverse microbial communities on laboratory-amenable plants would be a major convenience for maintaining healthy laboratory snail populations. We are in the early stages of investigating the efficacy of such a system using the model plant *Arabidopsis thaliana*. An initial study is under way to examine the factors that determine the composition of a newly-forming microbial community, such as would be seeded onto the plants in order to grow "snail food." This plant is very fast growing and there are thousands of curated ecotypes that display a wide range of phenotypic traits, so it potentially offers a highly customizable "delivery system" for supplementing snail captive diets without constant trips into the field.

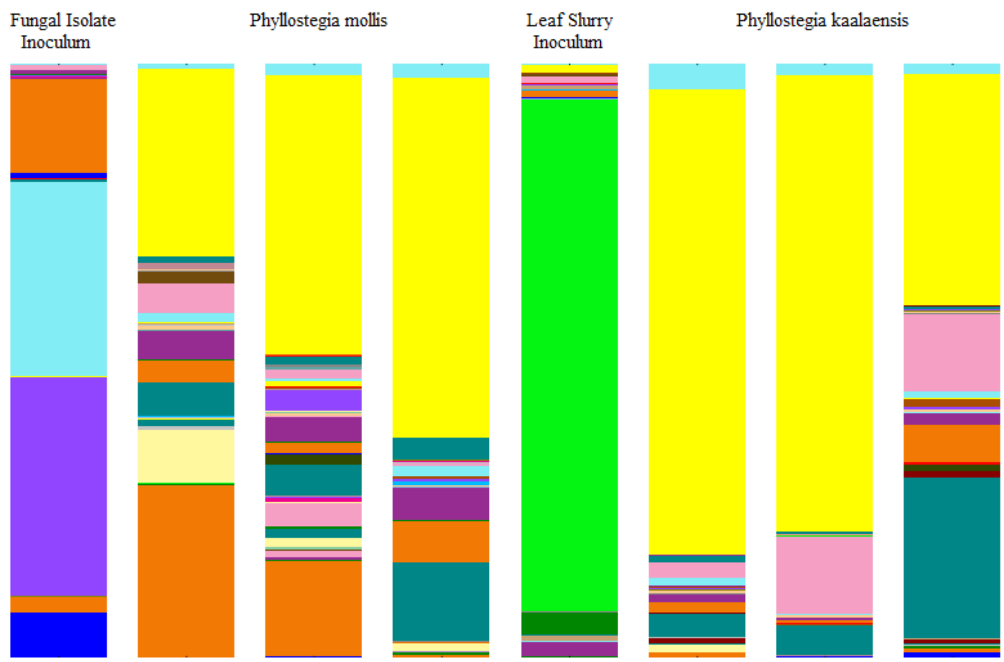


Figure 5 - Stacked bar chart of fungal species identities in initial starting conditions of Phyllostegia experiment. The two inoculae, and three replicates of each plant species. The bright green bar in the Leaf Slurry Inoculum represents N. galeopsidis.

APPENDIX ES-5

ADAPTIVE GENETICS OF HAWAIIAN TREE SNAILS & CLIMATE CHANGE

Final Quarter Report, 2015

Dr. Michael Hadfield & Dr. Melissa Price

Accomplishments

Whole mitochondrial genomes have been compared across the range of *Achatinella mustelina*. These results suggest the same management approach as COI alone (Holland and Hadfield's 2002 paper), suggesting no change to the current management approach of 5 or 6 discrete ESUs, with populations grouping along the Waianae ridgelines.

However, when nuclear evidence was considered (a scan/survey of thousands of sites across the entire genome), we observed a more nuanced picture. For example, Makaha (ESU D) always groups with Koiahi and Ohikilolo (ESU B). Puu Hapapa (ESU D) groups with Ekahanui (ESU E) about 50% of the time. On the other hand, some populations are very much the same for both nuclear and mitochondrial markers. ESU C (Haleauau and Skeet Pass) always groups together, separate from the others. The populations on the three ridges that meet on top of Mt. Kaala (from ESUs B, C, D) separate out from one another with both mitochondrial and whole-genome approaches.

Based on these initial results, populations that are far apart geographically, even though they are lumped in the same ESU based on mitochondrial gene sequences, should NOT be lumped into the same enclosure simply because they are in the same ESU, particularly for ESUs B and D, which stretch a considerable distance. Unsurprisingly, total DNA evidence suggests that snail populations that are closer together geographically are more closely related genetically, and things that are farther apart are less related. Pulling nearby populations into enclosures should be enough to combat inbreeding, if that is the goal. In light of climate change, we still recommend ONLY moving snails to wetter, cooler locations, and never to locations that are warmer or drier than source locations.

GIS modeling has been scaled down to the level of ESUs. The climate-change modeling results, which have now been projected for both 25 and 60 years, suggest urgent management actions will be necessary in the near future, but we are not ready to make a specific recommendation. We may need to start intentionally mixing populations to help with adaptation to climate change. If populations are mixed for this purpose, individuals must ALWAYS be moved from drier, warmer environments to wetter, cooler environments, and not the other way around.

Forecast

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

APPENDIX ES-6

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

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During the last quarter, the research project titled, "Assessment of effects of rat removal on arthropods, and development of arthropod monitoring protocols, on conservation lands under US Army management," conducted by Dr. Paul Krushelnycky, completed nearly all final dataset analysis. These findings made up a portion of a presentation titled “Conserving native insect communities: insights from management projects in Hawaii”, which was presented at the Pacific Branch meeting of the Entomological Society of America, on April 4, 2016, in Honolulu.

APPENDIX ES-7

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

Annual Statement of Work, September 2016

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Background

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

FY16 progress and results

During fiscal year 2016, graduate student Sumiko Ogura-Yamada completed the majority of field work planned for the project. This included work in three general areas: developing methods for monitoring and controlling *S. papuana* in the field, conducting a field experiment to assess effects of *S. papuana* on arthropod communities, and conducting a field experiment to assess the effects of *S. papuana* on native *Drosophila* reproduction.

A. Development of monitoring and control methods for *S. papuana*

Study Sites

A monitoring bait preference and a pesticide bait preference test were conducted in two forested sites on Oʻahu that supported high densities of *S. papuana*, as determined by prior distribution mapping (Ogura-Yamada & Krushelnycky, unpub. data). The first site was located within University of Hawaii's Harold L. Lyon Arboretum, in lowland, introduced wet forest in Mānoa Valley in the Koʻolau Mountain range (150 m elevation, 3836 mm annual rainfall (Giambelluca et al 2013)). The second site was located in mixed native and introduced mesic forest in Pahole Natural Area Reserve (NAR) in the Waiʻanae Mountain Range (480 m elevation, 1375 mm annual rainfall (Giambelluca et al 2013)). A pesticide bait efficacy test was conducted only at Pahole NAR.

Monitoring bait preference

Methods

Four food baits containing varying amounts of sugar, oil and protein were chosen to compare relative attractiveness to *S. papuana*: 1) light corn syrup (Karo, ACH Food Companies), 2) peanut butter (Jif Creamy, J.M. Smucker Company), 3) SPAM (Hormel Foods), and 4) tuna/corn syrup blend (one can of tuna (Chicken of the Sea International) in water, drained, and blended with 1/3 cup light corn syrup in a food processor). Corn syrup (Eow & Lee, 2007), peanut butter (Lee, 2002; Causton et al. 2005; Hara et al. 2014), processed meats (Porter & Tschinkel 1987; Peck et al. 2015), and tuna/ corn syrup blends (Keeler, 1980; Krushelnycky et al. 2011) have been used in attracting a variety of ants in bait preference studies (Lee, 2002; Eow & Lee, 2007, Hara et al. 2014) and ant monitoring (Keeler, 1980; Porter & Tschinkel 1987; Causton et al. 2005; Krushelnycky et al. 2011; Peck et al. 2015)

Baits (approximately a 1.5 cm diameter quantity of corn syrup, tuna/corn syrup blend, and peanut butter, and one piece of SPAM approximately 1 x 1 x 0.5 cm) were placed in paper cupcake wrappers and presented next to each other at replicate stations, which were approximately 20 m apart, at each site. The cupcake wrappers prevented liquid baits from spilling, while allowing ants access to the baits both on the upper surface and underneath as the baits soaked through the paper. Ant numbers on each bait were recorded (top and bottom of wrapper summed) every hour for three hours. The preference test was conducted on June 18, 2015, at Lyon Arboretum, using 25 replicate stations, and on August 1, 2015, at Pahole NAR, using 24 replicate stations. Stations with fewer than 24 ants total across all bait types and hours (i.e., <2 ants/bait/hour on average) were removed from the data set; this left 16 replicate stations at Lyon Arboretum and 19 replicate stations at Pahole NAR. Due to unequal variances among groups, Welch's ANOVA followed by Games-Howell multiple comparison test was used to compare log-transformed numbers of ants among all bait types for each hour at each site. Numbers of ants were subsequently also compared across hours at each site for the two most attractive baits (peanut butter and SPAM, see Results). To compare relative detection rates for the four baits, we compared proportions of stations that attracted any *S. papuana* after one hour at each site, using a Chi-square contingency table. For peanut butter and SPAM, we also compared proportions of stations attracting ants at one and two hours at each site, using Fisher's Exact Test. Statistical tests were performed using Minitab v. 17.1.

Results and Discussion

Among the four foods evaluated as potential monitoring baits, SPAM and peanut butter generally attracted more ants than corn syrup and the tuna/corn syrup blend at most of the time intervals at both sites (Fig. 1). However, these differences were not always statistically significant (see Fig. 1) due to high variation in ant numbers among replicate stations. For SPAM and peanut butter baits, mean recruitment increased over time, but most of these differences were not statistically significant. Specifically, numbers of *S. papuana* at peanut butter baits did not differ among hours at either Lyon Arboretum ($F = 0.34$, $p = 0.716$) or Pahole NAR ($F = 2.08$, $p = 0.140$), nor did they differ among hours at SPAM baits at Lyon ($F = 1.34$, $p = 0.278$). On the other hand, ant numbers at SPAM baits at Pahole did differ significantly over time ($F = 4.12$, $p = 0.025$), with recruitment at hour 3 being significantly higher than at hour 1 (Games-Howell test, $p = 0.022$). Differences between hours 1 and 2 were marginally significantly different ($p = 0.060$) and differences between hours 2 and 3 not statistically significant ($p = 0.881$) for SPAM at Pahole.

SPAM and peanut butter also tended to attract *S. papuana* to a higher percentage of baits offered, relative to the other two baits (Fig. 2). Again, these differences were not always statistically significant. After one hour, an interval commonly used for ant monitoring and distribution mapping (Blachly & Forschler, 1996; Lee et al., 2003; Starr et al., 2008), there was a significant association between percentage of baits occupied and bait type at Pahole NAR (Chi-square = 10.556, $p = 0.014$), with SPAM and peanut butter baits exhibiting higher than expected occupancy, and corn syrup and tuna/corn syrup blend exhibiting lower than expected occupancy. At Lyon Arboretum, there was no significant association between percentage of baits occupied and bait type (Chi-square = 5.830, $p = 0.120$). For peanut butter baits, there was no significant difference in occupancy rates between hours 1 and 2 at either Lyon (Fisher's Exact Test, $p = 1$) or Pahole (Fisher's Exact Test, $p = 0.693$). Similarly, there was no significant difference in occupancy rates between hours 1 and 2 at SPAM baits at Lyon (Fisher's Exact Test, $p = 0.172$) or Pahole (Fisher's Exact Test, $p = 0.232$).

These results indicate that both SPAM and peanut butter should be effective baits for monitoring relative densities of *S. papuana* and for mapping *S. papuana* distributions. Temporal trends suggested that exposing baits for more than one hour may increase their performance to some degree, both in terms of higher recruitment and higher bait detection, but these trends were relatively weak and usually statistically non-significant. The cost of additional monitoring time may therefore not offset these benefits. Of the two baits, peanut butter is the more practical choice. It is much cheaper than SPAM, requires no preparation and is easy to use in the field, does not spoil after opening, and adheres to monitoring cards or other monitoring markers. The high attractiveness and ease of use of peanut butter has made it an effective bait for monitoring a variety of other ant species, particularly those in the myrmecine subfamily, such as *Wasmannia auropunctata*, *Monomorium pharaonis*, *Monomorium destructor*, *Pheidole* spp., *Solenopsis geminata*, and others (Lee 2002, Causton et al. 2005, Starr et al. 2008).

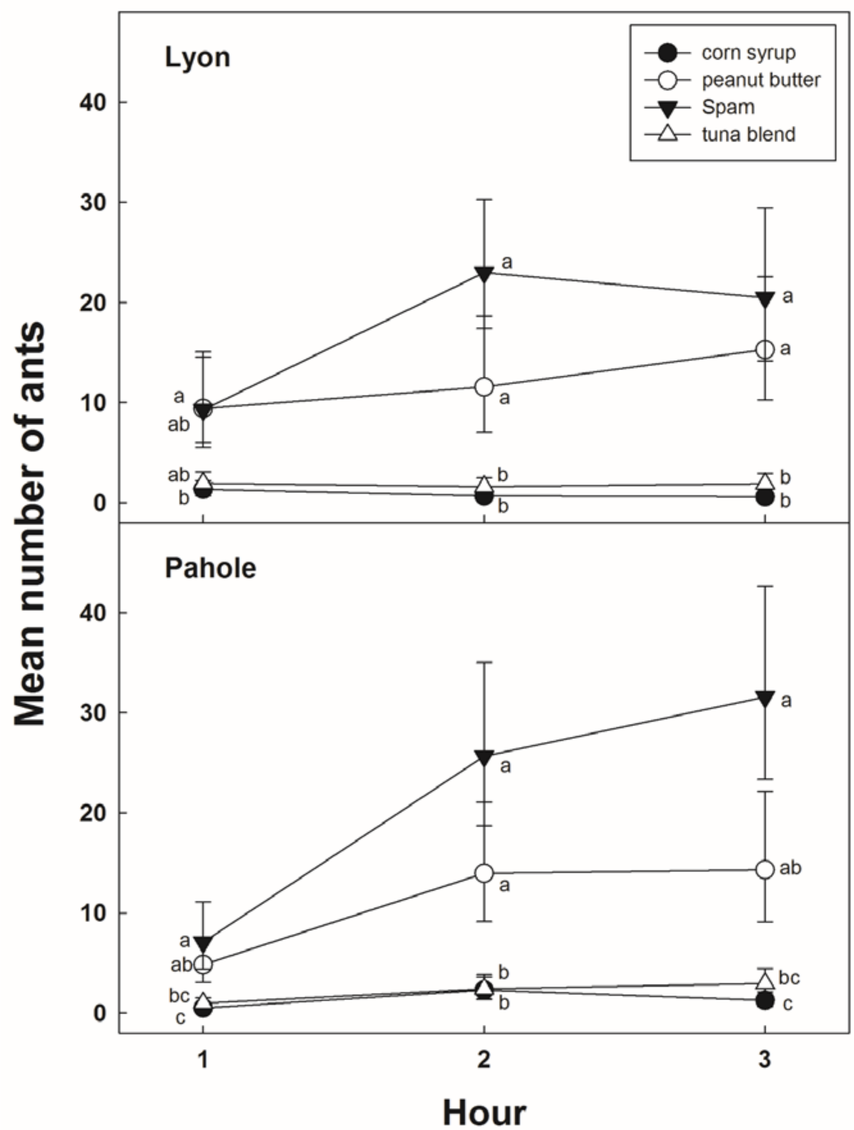

Figure 1. Mean number (±SE) of *S. papuana* attracted to food baits at Lyon (top) and Pahole (bottom) over the course of three hours. Means sharing the same letters within each hour at each site are not significantly different (Welch's ANOVA and Games-Howell posthoc test on log-transformed counts, α=0.05; depicted means and SEs are back-transformed).

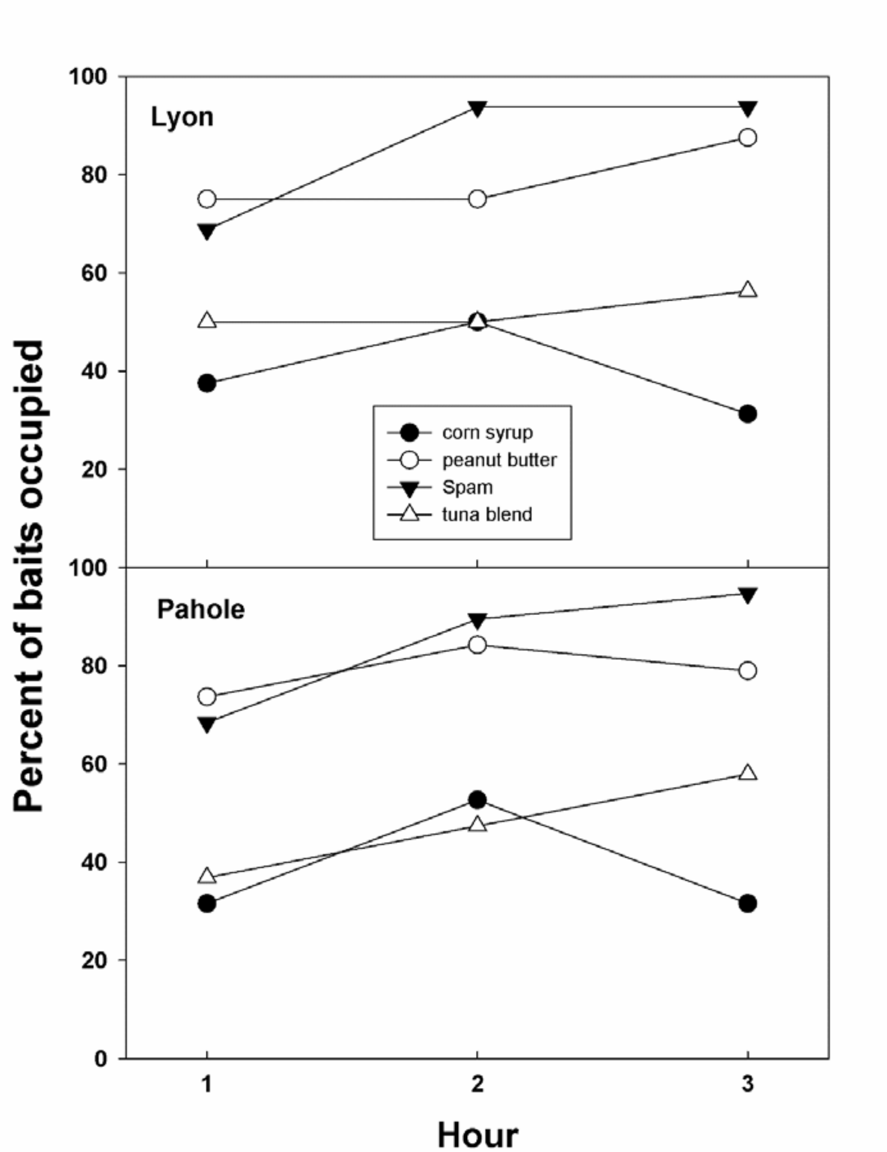

Figure 2. Percent of baits occupied by *S. papuana* at Lyon (top) and Pahole (bottom) over the course of three hours.

Pesticide bait preference

Methods

Pesticides formulated in attractive baits have the potential to be an effective ant control method because the delayed killing action allows the toxicant to be distributed through the colony (Stringer et al., 1964). Five granular commercial pesticidal ant baits were chosen to compare relative attractiveness to *S. papuana*: 1) Advion Fire Ant Bait (0.045% Indoxacarb, Syngenta Corporation), 2) Amdro Ant Block (0.88% Hydramethylnon, AMBRANDS), 3) Extinguish Plus (0.365% Hydramethylnon and 0.250% S-Methoprene, Wellmark International), 4) MaxForce Complete Brand Granular Insect Bait (1% Hydramethylnon, Bayer Environmental

Science), and 5) Siesta (0.063% Metaflumizone, BASF Corporation). These baits were chosen because they target *Solenopsis* fire ants, or because they have been found to be attractive or effective against other species in the subfamily Myrmicinae (Williams et al., 2001.; Oi & Oi, 2006; Warner et al., 2008; Hara et al., 2014). Advion Fire Ant Bait, Amdro Ant Block, Extinguish Plus, and Siesta are all based on a similar bait matrix composed of corn grit saturated with soybean oil. MaxForce Complete possesses two bait matrix types: a corn grit/soybean oil-based granule and a protein-based granule.

One half teaspoon of each bait was placed into paper cupcake wrappers and presented next to each other at replicate stations at both sites, and ant numbers were recorded every hour for three hours as described for the monitoring bait preference test. The pesticide preference test was conducted on September 18, 2015, at Pahole NAR, using a total of 25 replicate stations, and on November 6, 2015, at Lyon Arboretum, using 25 replicate stations. After excluding stations with fewer than 24 ants total across all bait types and hours, 10 stations at Pahole NAR and 23 stations at Lyon Arboretum remained for analysis. Numbers of ants (log transformed) were compared among bait types at each hour and site as described for the monitoring bait preference test.

Results and Discussion

The relative attractiveness of the five pesticidal ant baits differed somewhat by location, and large variation among replicate stations resulted in little consistent statistical separation between the baits (Fig. 3). Amdro Ant Block tended to attract the highest or second highest number of ants at both sites, but the relative positions of the other baits varied among sites. In particular, Siesta attracted a relatively high number of ants at Pahole, but the least number of ants at Lyon. The latter result was unexpected, because preliminary testing conducted at Lyon in February of 2015 suggested that Siesta was similar or greater in attractiveness than Amdro Ant Block (Ogura-Yamada, unpub. data). There may therefore be some variation in relative attractiveness tied to season or other unknown factors. Since pesticide baits are generally available to ants for longer periods of time, we did not assess using statistics whether bait attractiveness increased across the three monitoring hours.

The relatively weak and/or inconsistent differences in attractiveness among the baits is not very surprising given that they are all based completely or in part on similar corn grit and soybean oil granule matrices. However, each bait may have additional unknown proprietary ingredients that may influence attractiveness, and some active ingredients may exhibit repellency for certain ant species (Stringer et al. 1964; Reimer & Beardsley 1990; Montgomery et al. 2015)

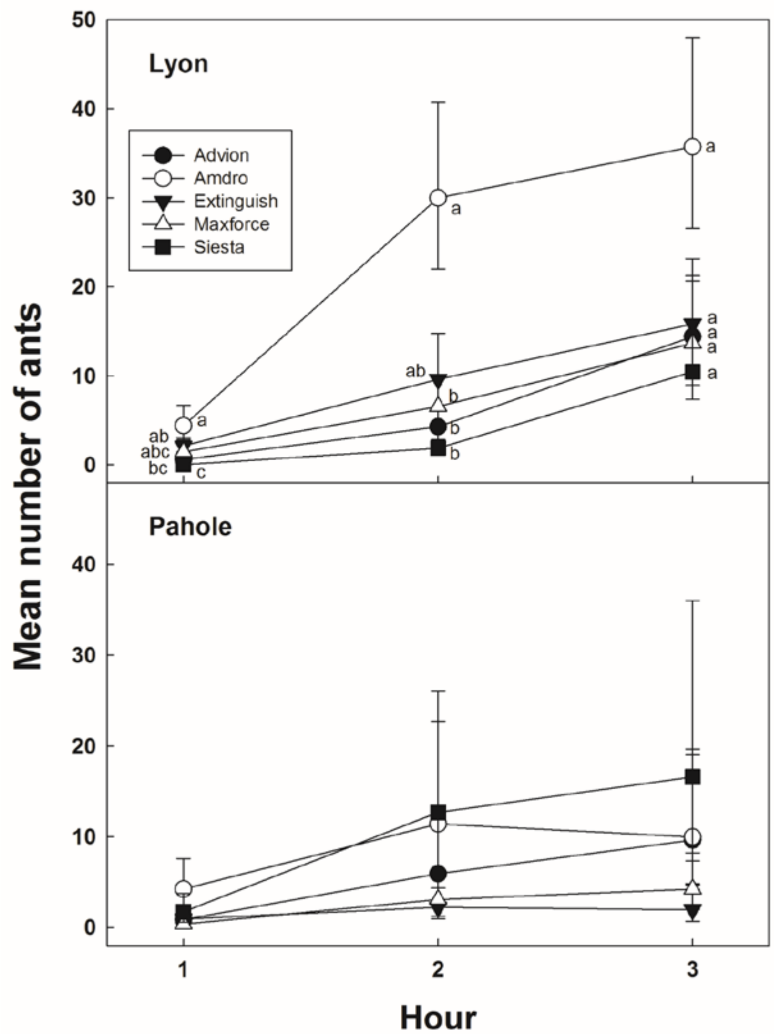

Figure 3. Mean number (±SE) of *S. papuana* attracted to pesticidal baits at Lyon (top) and Pahole (bottom) over the course of three hours. Means sharing the same letters within each hour are not significantly different (Welch's ANOVA and Games-Howell posthoc test on log-transformed counts, α=0.05; depicted means and SEs are back-transformed). None of the means were significantly different at any hour at Pahole.

Pesticide Bait efficacy trial

Methods

We chose two baits, Amdro Ant Block and Siesta, to test efficacy of ant reduction over an eight-month period in field plots at Pahole NAR. Nine 5x5 m plots were established on July 3, 2015, and pre-treatment ant densities were determined in each plot: ants were counted on the top and bottom of 25 monitoring cards (one half of a 7.6 x 12.7 cm index card) baited with a smear of peanut butter. Cards were placed on the ground every 1.25 m in a grid pattern, and collected after 1.5 hours. The nine plots were subsequently randomly assigned to one of three treatments

(Amdro Ant Block, Siesta, or untreated control), with the exception that the two lowest-density plots were assigned to the control treatment to ensure that the pesticide baits were tested in plots with high ant densities. Mean pre-treatment ant densities were nevertheless fairly similar across the three treatment groups (see below). Nine bait stations, separated by 2.5 m in a grid pattern, were placed in each plot testing the two pesticide baits. The bait stations were constructed of 3.81 cm (1.5 in) long sections of 3.18 cm (1.25 in) diameter PVC tubing, fitted with PVC endcaps on the upper end. The open bottoms were screened with Amber Lumite Screen (530 µm mesh size, Lumite Inc.) fastened with PVC cement (Oatey SCS.), which allowed access to *S. papuana* workers but excluded most other non-target arthropods. Each station was supplied with 1.24 g of Amdro or 0.63 g of Siesta ant baits contained within a disposable polypropylene tea bag, which allowed ants to imbibe pesticide-laden oil from the baits while facilitating the periodic replacement of baits. Stations were staked to the ground to ensure that the endcaps shielded the bait from rain, and that contact between the screened opening and the ground was maintained.

Baits were replaced every four to seven weeks, for a total of five times, during the experiment, which ended on March 5, 2016. Ant densities in the plots were assessed on each of these dates using the peanut butter card monitoring methods described above. During each bait replacement event, bait stations were also systematically shifted such that every point located on a grid with 1.25 m spacing received a station by the second event in September, 2015. Bait stations were subsequently returned to their original positions for the remainder of the trial, except to target occasional localized surges in ant numbers in plots. Because we had only three replicate plots for each treatment, we present only descriptive statistics for trends in ant densities in the plots. To assess whether the bait station spacing interval (2.5 m grid) was effective in the Amdro and Siesta plots, we compared reductions in numbers of ants at the 25 monitoring stations in each plot (1.25 m grid) on the first monitoring event, 28 days after bait station placement, according to the distance of monitoring stations from the nearest bait station. The superimposed bait station and monitoring grids resulted in monitoring points that were either immediately adjacent to a bait station, 1.25 m from the nearest station, or 1.8 m from the nearest station. We compared reductions in ant numbers with a two factor ANOVA for each bait type, including the factors monitoring point position (n = 75) and plot number (n = 3) to control for individual plot differences. These tests were performed using Minitab v. 17.1.

Results and Discussion

Amdro was developed to combat the Red Imported Fire Ant, *Solenonpsis invicta,* after the banning of Mirex (Williams et al. 2001), and has been on the market since 1980. It is a widely used bait that has been highly effective against *Pheidole megacephala* (Reimer & Beardsley 1990; Hoffmann & O'Connor 2004; Plentovich et al. 2008, 2011), *W. auropunctata* in certain situations (Causton et al. 2005), and *S. geminata* to variable degrees (Hoffmann & O'Connor, 2004; Plentovich et al. 2008, 2011; Hoffmann et al. 2011). Siesta, a fairly newer product registered in 2007, has been shown to be effective against *P. megacephala* (Warner et al. 2008) and *S. invicta* (Thompson, 2008), and attractive to *W. auropunctata* (Hara et al. 2014). We chose to assess the efficacy of these two baits for controlling *S. papuana* in field plots in natural forest because both exhibited relatively high attractiveness to *S. papuana* at one or both of our bait preference test sites. Plots treated with Amdro generally had a greater reduction in ant densities than those treated with Siesta (Fig. 4). Ant counts in the Amdro plots dropped by 90.4 (± 4.5) % of pre-treatment levels by 28 days after bait station placement, and averaged 96.2 (±

1.1) % reduction from pre-treatment levels throughout the duration of the experiment (Table 1). Numbers of ants in the Siesta plots were very similar to those in the control plots, both of which exhibited a strong reduction from October through December 2015, possibly caused by seasonality or weather events, followed by a resurgence by February of 2016 (Fig. 4). In contrast, Amdro plots exhibited only a very small resurgence. The reason for the apparent lower efficacy of Siesta bait is unknown, but in preliminary tests with a different bait station design that made entry and exit more difficult, we observed many dead *S. papuana* workers after several hours inside stations containing Siesta, but many fewer inside stations containing Amdro. We therefore suspect that the lower efficacy of Siesta is related to the speed with which metaflumizone kills very small ants like *S. papuana*, rather than to issues with bait attractiveness.

This experiment also confirmed that our bait station design and spacing interval are effective for controlling *S. papuana* when using Amdro Ant Block. The interior of the bait stations remained fairly dry provided that the stations were not dislodged, the design made it relatively easy to replace bait, and we observed very few ants or other arthropods trapped inside them. The strong reduction in *S. papuana* numbers at monitoring stations indicated that this ant was able to easily access the bait, which was not the case in preliminary trials with a bait station design used for Argentine ants (Krushelnycky et al. 2011). The latter bait station allows entry into a PVC tube only through small holes in caps on both ends, which appears to be too restrictive to entry and exit for *S. papuana* (Ogura-Yamada unpub. data). There was also no strong evidence that the bait station spacing interval (2.5 m) was too large to achieve effective bait coverage: the magnitude of reduction in ant numbers at monitoring stations 28 days after station placement was not significantly related to distance from the nearest bait station for either Amdro Ant Block ($F = 1.79$, $p = 0.174$) or Siesta ($F = 2.30$, $p = 0.107$). In Siesta plots, however, there was a non-significant pattern suggesting potentially weaker reduction at greater distances from bait stations, which was absent in Amdro Ant Block plots (Fig. 5). It is possible that a greater spacing interval may remain effective with Amdro Ant Block bait, although some observations in preliminary trials suggest that *S. papuana* forages relatively short distances and may not effectively retrieve baits located more than several meters away from nests.

Although the attractiveness of Amdro Ant Block was not overwhelmingly stronger than the other baits tested (Fig. 3), it was consistently attractive to *S. papuana*, and has other characteristics that make it a good option for controlling *S. papuana* in natural areas. It is widely available, relatively inexpensive, and has the broadest label language regarding allowable uses, including in forested areas. The EPA (1998) considers hydramethylnon, the active ingredient in Amdro Ant Block, to be of low acute toxicity, unlikely to contaminate ground water, of low concern to birds, and to have minimal effects on terrestrial non-target organisms when used for insect control. Hydramethylnon degrades quickly when exposed to light (Vander Meer et al., 1982), so presenting the bait in stations can not only reduce non-target exposure but also prolong the potency of the bait (Taniguchi et al. 2003).

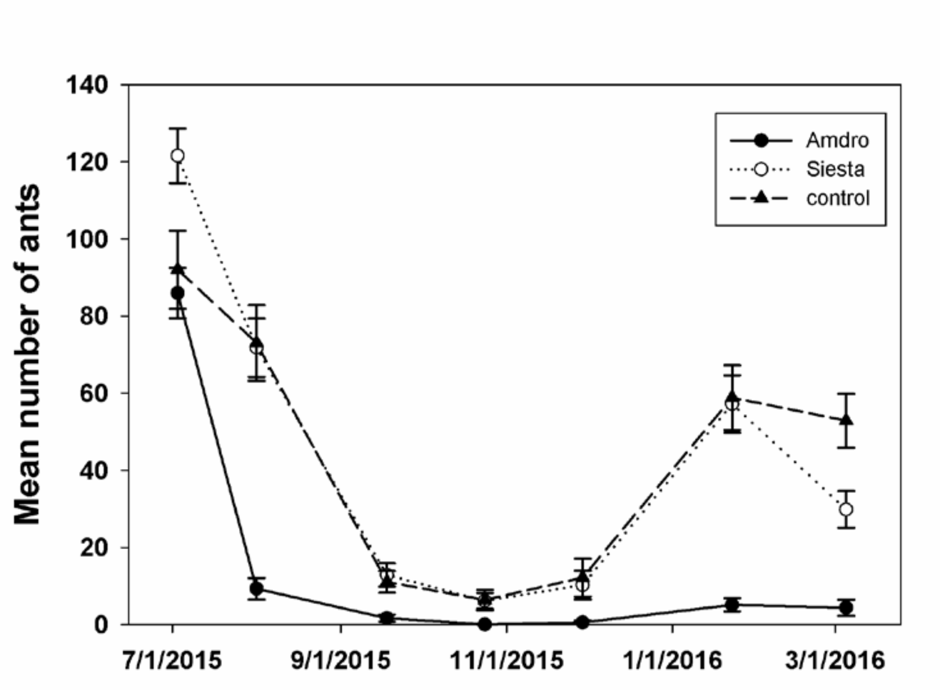

Figure 4. Mean (±SE) number of *S. papuana* in field plots treated with Amdro Ant Block and Siesta baits.

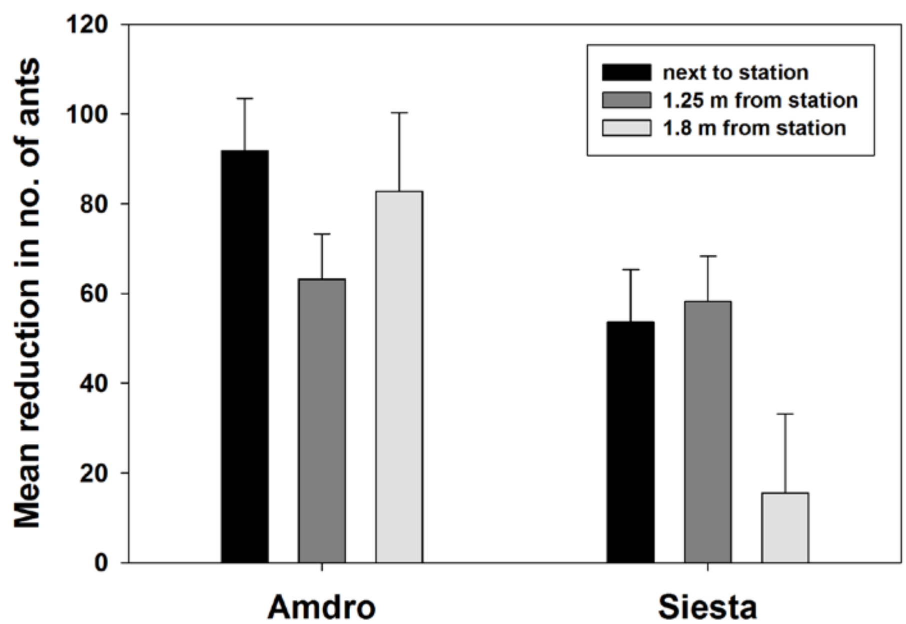

Figure 5. Mean (±SE) reduction in number of *S. papuana* 28 days after bait stations were deployed in the field plots, categorized by distance of monitoring points from bait stations. There was no significant difference (based on ANOVA, α=0.05) in degree of reduction among distances for either ant bait.

B. Effects of *S. papuana* on arthropod communities

During fiscal year 2016, S. Ogura-Yamada completed field work on this aspect of the project. Ants were suppressed for one year in the six treatment plots established in FY15 at four field sites (Ekahanui, Puu Hapapa, Pahole and Kahanahaiki), five of which were 20 x 20 m in size, and the sixth was 10 x 10 m due to restrictive topography. Ants were controlled using Amdro Ant Block bait in the same bait stations and using the same application protocol described above for the bait efficacy trial. These methods proved to be similarly effective in the larger plots: numbers of *S. papuana* were reduced on average by 83.63 (± 2.79) % over the course of one year in the treated plots, compared to an average increase of 58.73 (± 15.63) % from pre-treatment levels (with the exclusion of one extreme plot) in paired, untreated plots. At the end of this year, post-treatment arthropod sampling was completed in the plots in April-May of 2016. Sorting and identification of the arthropod samples is nearing completion, after which changes in arthropod communities following ant suppression will be compared to changes in untreated control plots.

C. Effects of *S. papuana* on native *Drosophila* reproduction

This aspect of the project plans to compare emergence rates of adult *Drosophila* flies from pieces of larval host plant material in the presence and absence of *S. papuana* in the field. This realistic experimental test of *S. papuana* impacts on *Drosophila* reproduction requires the successful oviposition of adult females on suitable host plant material, the development of larvae on the host plant material, and the capture of emerging adults in the field. Each of these steps is challenging, but progress was made during FY16 to advance this goal.

The relatively common, non-listed species *Drosophila crucigera* is being used as a surrogate for listed *Drosophila* species, since it uses the same, relatively common host plant (*Pisonia* spp.) as some of the listed species. A captive lab colony of *D. crucigera* was established in Dr. Ken Kaneshiro's *Drosophila* rearing lab in FY15 using wild-caught individuals provided by Dr. Karl Magnacca. This colony crashed several times for unknown reasons, and eventually perished. However, a successful colony was finally re-established in FY16 from additional wild flies captured by K. Magnacca. In this latest attempt, separate iso-lines were maintained from individual females, and currently several of these lines are highly productive.

Several methods were also tested for collecting, inoculating, and promoting the rotting process for pieces of *Pisonia umbellifera*, in order to create suitable oviposition and larval feeding substrate. Adult flies have been found to readily oviposit on the branch pieces, and in one test, several flies successfully emerged following development in branch pieces. Further discussions with Drs. Kaneshiro and Magnacca have led to a finalized plan for preparing the host plant material for the field trial. A cage design was also developed for capturing emerging adults in the field trial.

The upcoming experiment will install these cages in the same field plots that were used to investigate effects of *S. papuana* on the wider arthropod community (section B, above). Several months ahead of the trial, we will redeploy bait stations in the treated plots of each pair, in order to suppress ant numbers again. Subsequently, host plant branch pieces will be exposed to adult *D. crucigera* in the lab, and will then be placed inside the cages in both the treated and control field plots, and emerging adult flies will be captured in the cages using baited fruit fly traps and yellow sticky traps. This experiment is planned for the fall to early winter of 2016.

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APPENDIX ES-8

MEASURING THE EFFECTS OF MICROBIAL PLANT SYMBIONTS ON NATIVE PLANT RESTORATION

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Summary

1) Assess differences in the community structures of the obligate mycorrhizal fungal symbionts associated with invasive and native host plant communities on Oahu, Hawaii.
2) Experimentally test the possible benefits of incorporating mycorrhizal inoculations into native plant restoration practices to increase their success.

Results

So far the results from this project have yielded the first systematic tests for differences among mycorrhizal communities associated with native versus invasive host plants in Hawaii. Interestingly, we have found that while the community composition of arbuscular mycorrhizal fungi (AMF) among heavily invaded and uninvaded soils within watersheds does not significantly differ, the presence of invasive host plants leads to a systematic decrease in AMF species richness, especially at small spatial scales. Also, we have found that there are significant differences in AMF communities between watersheds independent of host identity (native or invasive). What this means for land management practices is that considerations for the management soil microorganisms (at least for mycorrhizal fungi) should be made at the scale of watersheds. Future studies are needed to determine if there is an effect of a decrease in AMF richness has on native plant restoration success, native plant recruitment and regeneration. It is an encouraging result that at least at the scale of watersheds, AMF species do not appear to face extinction with plant invasions rather just local extirpations. This means that restoring native AMF communities within watersheds may be feasible. However, because we do not have *a priori* knowledge of which AMF species are the most beneficial to native host plants the restoration of native plant communities may benefit from increasing overall AMF richness at outplanting sites to similar levels found in native soils. We suggest that one means of accomplishing this may be to pre-inoculate greenhouse-grown seedlings destined for outplanting with AMF from native soils prior to introducing them into the field. Additional targets studies that examine the responses of native hosts to specific AMF are also needed. The outcomes of this work so far have recently been submitted to the journal *New Phytologist* for publication and are currently under peer-review.

Next steps

We are currently in the planning stages for two supplemental projects. One aimed at testing the efficacy of inoculating one of Oahu's most endangered plant species *Phyllostegia kaalensis* with AMF from congeneric and parent populations to increase the survival of this species upon outplanting. The second is examining the role of AMF in ameliorating water stress in native plant populations of Hawaii that are predicted to be impacted by increased drought conditions due to climate change.

APPENDIX ES-9

Role of fungal endophytes and epiphytes in endangered species conservation

Year-end Report – September, 2016

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Phyllostegia endophytes and pathogen resistance

Highlights:

- Greenhouse populations of Phyllostegia are dependant on regular fungicide treatments, possibly making them prone to infection when outplanted
- A filtered slurry from the leaves of wild relatives was effective at reducing powdery mildew infections
- It is probable that the antagonistic yeast, *Pseudozyma aphidis*, is conferring some resistance to fungal diseases
- Future goals are to isolate and grow *P. aphidis* for further tests and to incorporate outplanting of treated plants

Phyllostegia mollis and *Phyllostegia kaalaensis* are federally listed endangered plant species endemic to Oahu, HI. There are currently no known wild populations of *P. kaalaensis* and the few wild populations of *P. mollis* are failing to demonstrate long-term survival. Greenhouse populations of these plants are maintained by the Army Natural Resources division, but they show marked susceptibility to fungal pathogens, particularly the powdery mildew, *Neoerysiphe galeopsidis*. Greenhouse populations are, therefore, dependent on regular fungicide treatments which are impossible to maintain once individuals have been out-planted to habitats within their native ranges.

Current scientific consensus is that the fungi which coexist within plant tissues form an integral part of plant fitness. These beneficial endophytic and mycorrhizal fungi are not present in plants that have received regular fungicidal treatments, so they are not present in out-planted populations of *P. mollis* or *P. kaalaensis*. One of the major benefits that host plants receive from mutualistic fungi is increased resistance to disease, as mutualistic fungi can outcompete pathogens for habitable living space or even actively repel invasive fungi through excreting chemical compounds. The essentially sterile plants are presumed, therefore, to be highly susceptible to attack by pathogenic fungi in the environment.

We have completed two rounds of testing on the efficacy of transplanting fungal endophytes from healthy wild populations of *P. mollis* and *P. hirsuta* into greenhouse-raised *P. mollis* and *P. kaalaensis* individuals. Two experimental transplantation methods were tested: 1) Isolating individual fungal strains from wild hosts, culturing them in the lab, and spraying them onto the leaves of greenhouse-raised individuals; 2) Preparing a low-tech slurry from leaves of wild individuals, filtering out large particles, and spraying this onto the new host plants. The first method has the benefit that we know exactly what we are applying to the new host leaves, the second method has the benefit of potentially passing on beneficial fungi that are not amenable to laboratory culture.

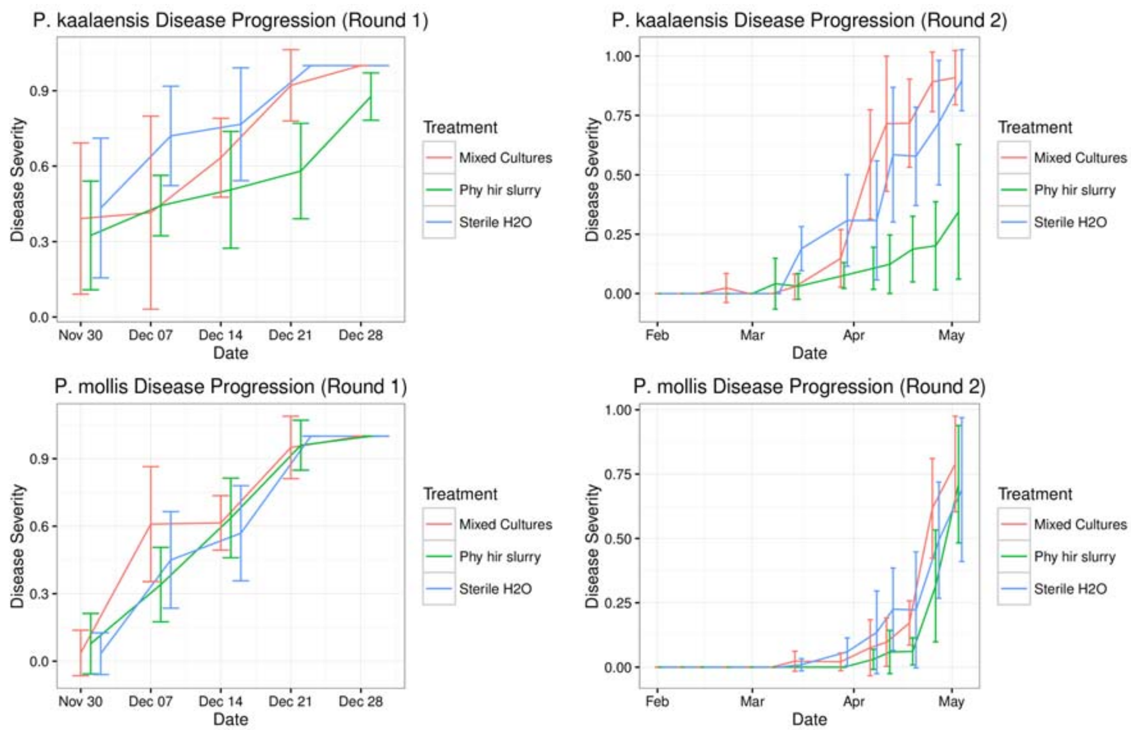


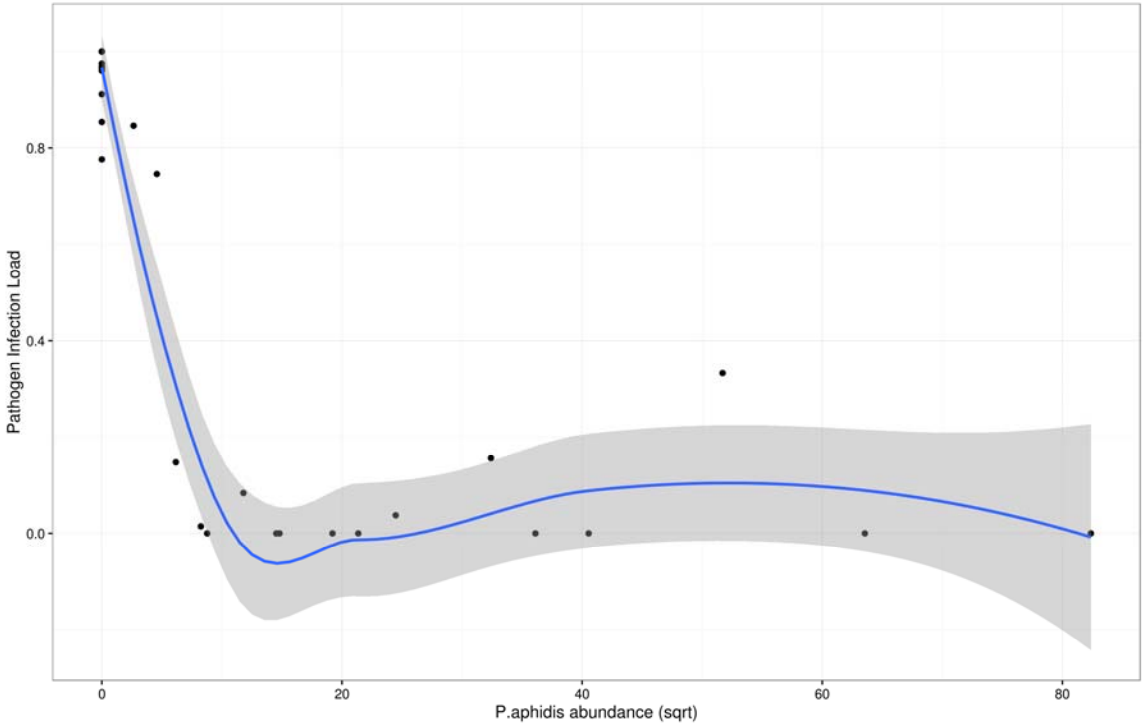
Figure 1: P. kaalaensis and P. mollis disease progression showing both rounds of tests.

Preliminary results are promising. The cultured fungal isolates did not appear to confer any advantage over the control group with respect to disease severity in either trial, but the group receiving the slurry of wild leaves showed delayed mortality and decreased disease severity in both cases. Figure 1 shows results for both plant species during both rounds of testing.

DNA from the inoculae and the plant endophyte loads was sequenced and the results are surprising. Roughly 90% of the fungal reads from the leaf slurry treatment, which showed such effectiveness against disease, come from *N. galeopsidis,* the same pathogen that appears to be killing the plants. However, there is a strong correlation between reduced disease and the presence of the basidiomycete yeast, *Pseudozyma aphidis* (Figure 2). It is likely that this yeast, which is a mycoparasite, is antagonistic against *N. galeopsidis* and could be an effective way of limiting pathogen damage without relying on fungicides.

Three *P. kaalaensis* plants treated with the leaf slurry have been outplanted in the Ekahanui snail enclosure and have been reported to be healthy after more than 3 months. Next steps will include isolating and testing *P. aphidis* as an inoculum on its own, along with scaling the inoculation method for army use and outplanting efforts.

Figure 2: Pathogen load on P. kaalaensis as a function of Pseudozyma aphidis abundance. As P. aphidis abundance increases, there is a sharp decline in N. galeopsidis infections.



Arabidopsis as a tractable laboratory system for feeding *Achatinella mustellina* snails

Highlights:

- *Achatinella* snails raised in the laboratory depend on regular time-consuming collections of leaves to supplement their diet of foliar epiphytes
- The ability to grow epiphytic fungi found in wild snail habitats in a tractable plant system would greatly ease conservation efforts for this species
- We are testing the ability to transplant wild epiphytes onto *Arabidopsis* leaves under varying environmental conditions
- Growth has completed, DNA has been extracted and is being prepared for sequencing to determine our success

Captive (laboratory) snail (*Achatinella mustelina)* populations are dependent on microbes from wild leaves to supplement their diet. These leaves are obtained by regular field forays which are costly and time consuming. The ability to grow diverse microbial communities on laboratory-amenable plants would be a major convenience and cost-savings for maintaining healthy laboratory snail populations.

We are investigating the efficacy of such a system using the model plant *Arabidopsis thaliana* (Figure 3). An study is under way to examine the factors that determine the composition of a newly-forming microbial community, such as would be seeded onto the plants in order to grow “snail food.” This plant is very fast growing and there are thousands of curated ecotypes that display a wide range of phenotypic traits, so it potentially offers a highly customizable “delivery system” for supplementing snail captive diets without constant trips into the field.

Plants were grown in sterile conditions and were inoculated with fully-factorial combinations of four epiphytic fungi. Additional treatments include whole microbiome slurries from two field sites: The current snail location, Skeet Pass, and the proposed enclosure site for this population, Kaala Bog. The experiment was replicated under normal and drought-stressed conditions to concurrently investigate the role of epiphytic microbes in plant health. The design allows us not only to determine the feasibility of transplanting snail-associated food organisms into a laboratory setting, but the role of phylogenetic relatedness in determining fungal colonization outcomes, and whether this has any functional role in plant health. Growth trials have been completed and DNA libraries are being generated from each plant surface for sequencing.

Figure 3: Arabidopsis thalliana in growth chamber. This ecotype has nice "snail-friendly" leaves and can be grown from seed in 4 weeks.

APPENDIX ES-10

ASSESSMENT OF THE SHORT AND LONG-TERM STABILITY GOALS FOR ENDANGERED HAWAIIAN FLORA MANAGED BY OAHU ARMY NATURAL RESOURCE PROGRAM

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The primary activities that were conducted last quarter are:

1. I installed twenty-five tracking tunnels (50 cm x 10 cm x 10 cm; Connovation Limited, Auckland, New Zealand), with tracking cards inserted (The Black Trakka Gotcha Traps LTD, Warkworth, New Zealand), throughout the *D. waianaeensis* study site to calculate the percentage of *D. waianaeensis* fruit consumed by black rats (*Rattus rattus*). These data will be used to assess the effect of rodent control on *D. waianaeensis* population dynamics.

2. I collected the *D. waianaeensis* Kal-C demographic data (i.e., survival, growth, and reproduction) for the 2015-2016 growing season.

3. I developed predictive models to quantify the synergistic effects of climate change and invasive species on *Schiedea obovata* population dynamics, which is a rare species managed by the Oahu Army Natural Resources Program.

4. I started writing an advanced draft of my third manuscript for this project. Following completion of this manuscript and comments/revisions by my co-authors, this paper will be submitted for review in a peer-reviewed journal, such as Conservation Biology. For a brief overview of this manuscript, refer to the below title and abstract.

Drought and herbivory influence the population dynamics of an island endemic shrub, *Schiedea obovata*

Abstract: Climate projections suggest environmental conditions will increase in inter-annual variability over time, with an increase in the severity and duration of extreme drought and rainfall events. Based on bioclimatic envelope models, it is projected that changing precipitation patterns will drastically alter the spatial distributions and density of plants and be a primary driver of biodiversity loss. However, many other underlying mechanisms, such as boom-and-bust cycles of

herbivory pressure, can impact plant vital rates (i.e., survival, growth, and reproduction) and population dynamics. In this study, we combined a classical drought tolerance experiment with a size-structured population projection model to elucidate how changing precipitation patterns and temporal variability in herbivory pressure will likely impact the persistence of a rare plant population reintroduction. For this study, we used a Hawaii endemic short-lived shrub, *S. obovata.* To isolate the influence of changing precipitation patterns on plant vital rates, we conducted a control greenhouse experiment. For this experiment, we manipulated gravimetric soil water content (GSWC) and drought intensity. To mimic realistic field GSWC for our 'control' greenhouse treatment, we used the mean field GSWC during the dry season. To evaluate the influence of temporal variability in herbivory pressure on plant dynamics, we used data from a previous field experiment. Preliminary results suggest that prolonged drought will have a greater impact on seedling survival, relative to a proportional decrease in daily precipitation. Furthermore, the synergistic impacts of severe drought and herbivory on plant dynamics will be greater than their independent effects. Directly linking complex interactions of multiple environmental stressors will become increasingly important as ecosystems are continually degraded by human induced changes in the environment (e.g. climate change and biological invasion).

APPENDIX ES-11

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

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MAKAHA VALLEY VEGETATION MAPPING ANALYSIS

Gigapan
4 additional Gigapan mosaics were collected in Kahanahaiki and processed. Michelle Akamine was trained on the use of the new system on a separate outing to capture Kahanahaiki subunit II.

U**A**V
RMH delivered the final ortho-aerial data product as a combination of the fixed wing and multirotor. This was used in image classification.

WV-3
Orthorectification was conducted of the WV-3 data with the help of Dr. Qi Chen at UH Manoa. A lidar generated DEM was used in the process for high accuracy.

eCognition
I traveled to the Big Island for training with Stephen Ambagis with Resource mapping. Image classification was conducted with WV-3 and validated with the UAV dataset. Working to improve the resulting classification over the next quarter.

A committee meeting was held in March to plan the way forward to completion. Q2 will focus on completion of image analysis and cost analysis, followed by thesis writing with a goal of defending in July for an August completion and graduation.

MEMORANDUM FOR RECORD

SUBJECT: Kahuku Training Area Fires, Lightning Forge, Week of February 9th

1. Summary

<u>Impacts to Natural Resources:</u>

A handful of small fires were observed in the Kahuku Training Area. These fires burned a combined total of 0.826 acres in Oio gulch in the Charlie 2 Area (Figure 1). The fires burned mainly non-native vegetation, ironwood (*Casuarina equisitifolia*) and strawberry guava (*Psidium cattleianum*) (Figure 2). The endangered *Eugenia koolauensis* occurs in Oio gulch at higher elevation and thus was unaffected by these fires. The specific cause of the fires is uncertain, however, they occurred during the Lightning Forge Training Event. There were pyrotechnics being used in forested areas where they are not authorized. Pyrotechnics are only authorized on bare soil so as not to ignite any vegetation. Trip flares were also used. The flare, mount and burn marks on the trees are shown in Figure 3. In addition, empty smoke grenades were found near one of the fire sites. Another possible ignition source discussed were unauthorized camp fires. The Army Wildland Fire response was exceptional, the crew managed to keep all of these fires at a relatively small fire by addressing them immediately and constructing fire line.

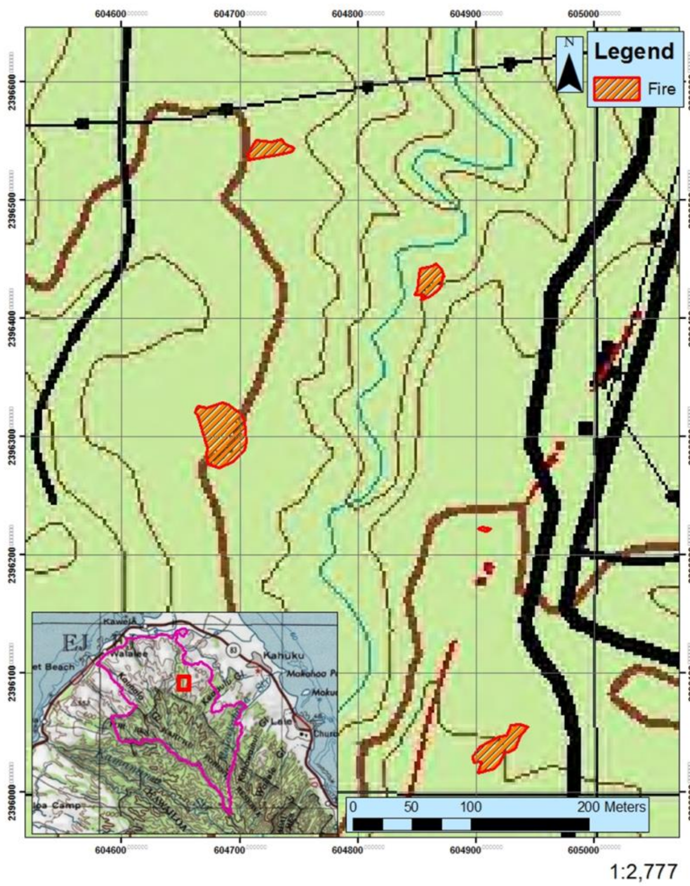

Figure 1. Topographic map showing the locations of the Kahuku Training Area fires. Inset: Kahuku Training Area outlined.

Figure 2. Burned ironwood (*Casuarina equisitifolia*) at one of the sites.

Figure 3. Evidence of unauthorized trip flare training.

Figure 4. The perimeter of one of the burn sites. The live material near the burn is strawberry guava (*Psidium cattleianum*), which is likely to colonize the area.

2. Plant species burned in the fire are listed in the table below. Some invasive tree species that occur along the perimeter of these fires are likely to colonize the newly disturbed habitat, which include *Psidium cattleianum*, *Casuarina equisitifolia* and *Leuceana leucocephala* (Figure 4). Evidence of this invasion was observed during the survey, when small *Psidium cattleianum* seedlings were found in the burned area.

Native Plants	
Scientific Name	**Common Name**
Carex wahuensis	carex
Metrosideros polymorpha	ʻōhiʻa lehua
Osteomeles anthyllidifolia	ʻūlei
Psydrax odorata	alaheʻe
Sphenomeris chinenesis	palaʻā
Wikstroemia oahuensis	ʻākia

Non-Native Plants	
Scientific Name	**Common Name**
Andropogon virginicus	broomsedge
Ardisia elliptica	shoebutton ardisia
Arundina gramminifolia	bamboo orchid
Bidens alba	Spanish needle, beggartick
Casuarina equisitifolia	ironwood
Chamaechrista nictitans	Japanese tea, partridge pea
Clidemia hirta	clidemia, Koster's curse
Conyza bonariensis	hairy horseweed
Cyclosorus parasiticus	woodfern
Desmodium incanum	Spanish clover
Emilia sonchifolia	Flora's paintbrush
Eucalyptus spp.	eucalyptus
Ficus spp.	ficus
Grevillea robusta	silk oak
Lantana camara	lantana
Leuceana leucocephala	haole koa
Lindsaea ensifolia	lindsaea
Macaranga mappa	bingabing
Macaranga tenarius	small-leaved macaranga
Passiflora edulis	passion fruit, lilikoʻi
Passiflora suberosa	huehue haole
Phymatosorus grossus	lauaʻe
Pimenta dioica	allspice
Pinus luchuensis	Luchu pine
Polygala paniculata	bubble gum plant
Psidium cattleianum	strawberry guava
Pteridium aquilinum	kīlau

Non-native Plants	
Scientific Name	**Common Name**
Schinus terebinthifolius	christmas berry
Spermacoce assurgens	button weed
Sphagneticola trilobata	wedelia
Sporobolus indicus	smut grass
Stachytarpheta dichotoma	ōwī
Stachytarpheta urticifolia	ōwī
Syzigium cuminii	java plum
Syzygium jambos	rose apple
Urochloa maxima	guinea grass

3. Miscellaneous Observations
   - DPW Environmental Natural Resource staff observed incredible amounts of trash during our fire surveys (Figure 6). Used MRE wrappers, toilet paper, and other trash were littered around the area. A small roadblock of Concertina wire was left partially in the roadway (Figure 5). Near the Concertina wire was a large grid of barbed wire that ran in a crisscross pattern through the trees. The barbed wire was set at ankle height and covered an area of about 0.5 acres.
   - Three UXO were found near the fires. They were reported to EOD by DPW Environmental staff and were found to be old bazooka rounds. They were disposed of on site (on 3/1/16).
   - Cultural Resource staff observed units departing Kahuku following Lightning Forge without visiting the washrack which is a mandatory requirement per Army Biological Opinions and 25th ID policy.

Figure 5. Concertina wire left partially in the roadway.

Figure 6. Boxes of MRE trash were littered near the sites of the fires.

4. Lesson Learned
    - The unauthorized use of pyrotechnics needs to be addressed. Officers in charge attend a briefing from range control and should know what is permissible on site. More enforcement is needed on site during training operations and prior to range clearing. Soldiers should have their RSO/OIC cards pulled when disobeying the training SOP.
    - DES fire reports needs more information on cause of the fire. The military grids used are not accurate enough to find small fires in the field, they are only accurate to within one kilometer.
    - Trash and training materials should not be left anywhere in Kahuku Training Area. They should be disposed of immediately. This is basic sanitation and personal hygiene.
    - Response from the Army Wildland fire was excellent. Fires lines were dug and all fires were kept to small localized areas. In tota,l there were five fires with only 0.826 acres burned in total. Many of the fires did not get large enough to burn the canopy. At many of the sites, scorch marks were below 15 feet and several of the large trees were still living.
5. POC for this post fire survey is Kapua Kawelo, Acting Natural Resource Manager, 655-9189, hilary.k.kawelo.civ@mail.mil.

Kapua Kawelo
Biologist/Acting Natural Resource Manager
USAG-HI

DEPARTMENT OF THE ARMY
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HEADQUARTERS, UNITED STATES ARMY GARRISON, HAWAII
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REPLY TO
ATTENTION OF

DEC 01 2015

Office of the Garrison Commander

Mary Abrams
Field Supervisor
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Honolulu, Hawaii 96850

Dear Ms. Abrams:

This letter is to inform you of a fire that occurred on Schofield Barracks, East Range, on October 29, 2015. The fire burned a total of 5.78 acres; fortunately, much less than the 15 acre estimate that was originally reported in Michelle Mansker's email of November 5, 2015. The fire occurred in an area designated as Critical Habitat for the Oahu Elepaio (Enclosure 1). The Army Wildland Fire Program coordinated fire-fighting actions and resources which included Aviation Brigade helicopters. The fire was deemed extinguished on November 6, 2015. Please find enclosed the fire report from the Directorate of Emergency Services (Enclosure 2). The fire burned primarily native koa forest with staghorn fern understory and some introduced forestry plantings along the ridgeline. See illustrative photos at Enclosure 3. Also, please find enclosed, a list of plants which were burned in this fire (Enclosure 4).

The fire appears to have been caused by human activity. Although the fire occurred on Army controlled lands, the area at issue is also frequented by unauthorized local hunters and hikers. The Army utilizes this part of East Range primarily for Jungle Training Exercises. Jungle training is designed to prepare Soldiers for successful tactical operations in a jungle environment, including survival skills, land navigation, waterborne operations, rope-assisted movements, and jungle combat techniques. Additionally, units often practice skills at night and sometimes over an extended period in simulated jungle warfare scenarios.

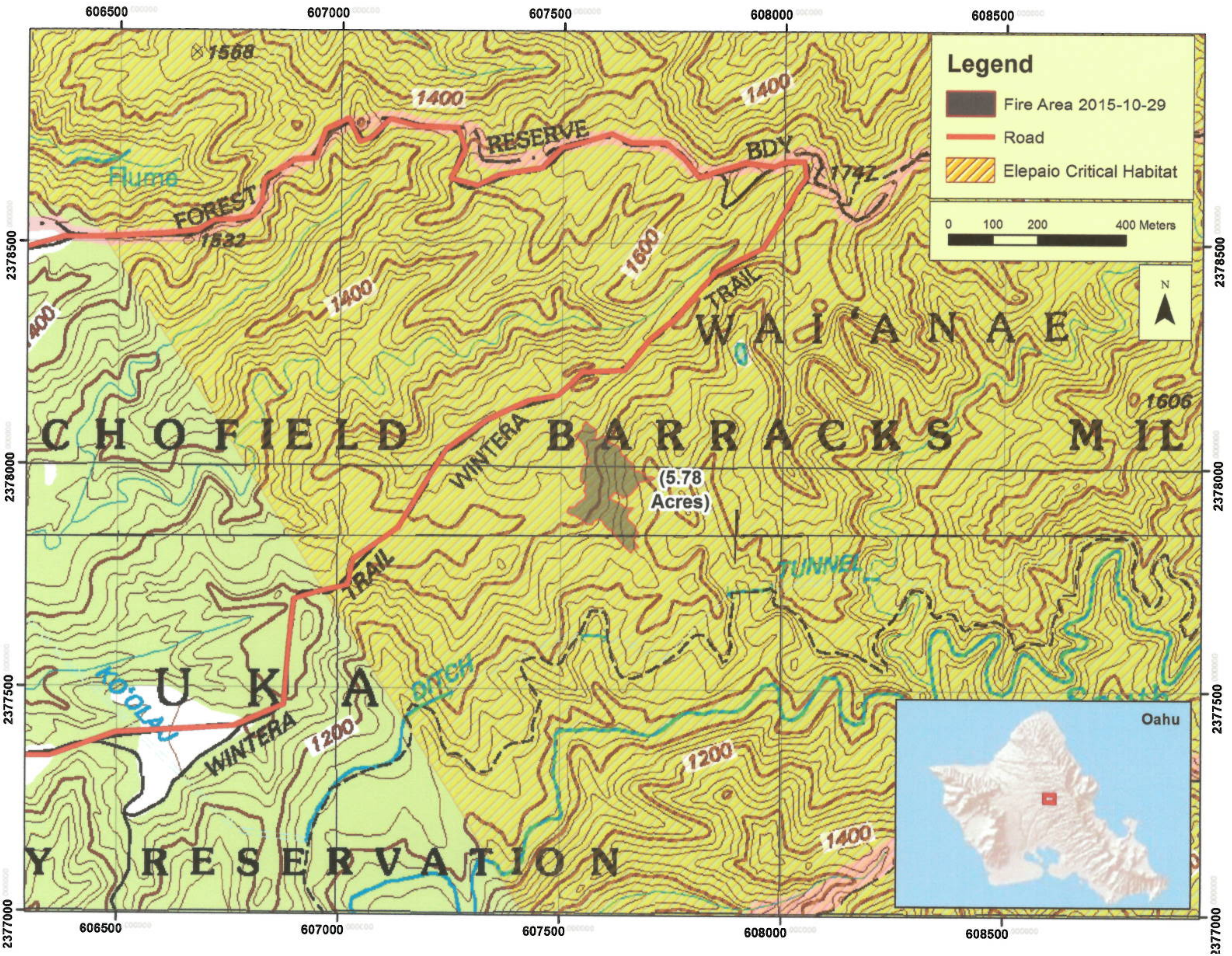
The use of this portion of Schofield Barracks, East Range, for jungle training is essential for developing jungle survival skills for our soldiers. The Army takes this fire very seriously, especially as it impacted Elepaio Critical Habitat. Thus, prior to units being approved for jungle training on East Range in Critical Habitat, experienced trainers will review exercise plans to ensure that all planned activities are consistent with safe and proper use of these lands. As an additional precautionary measure, the Army will ensure that all soldiers receive education and instruction on the Elepaio Critical Habitat and the types of activities and conduct that are permissible when operating in these sensitive areas.

As you should now be well aware, the Army will be reinitiating Section 7 Consultation on all Oahu Army Training Lands. As such, the Biological Assessment that is currently being prepared will certainly include measures to reduce risk of adversely impacting critical habitat and environmental damage. If you have any questions, please contact Ms. Kapua Kawelo, Biologist, DPW Environmental Division at (808) 655-9189 or by email, hilary.k.kawelo.civ@mail.mil.

Sincerely,

Richard A. Fromm
Colonel, US Army
Commanding

Enclosures



Legend
Fire Area 2015-10-29
Road
Elepaio Critical Habitat
0 100 200 400 Meters
N
Oahu
(5.78 Acres)
CHOFIELD BARRACKS MIL
UKA
Y RESERVATION
WAI'ANAE
WINTERA
TRAIL
FOREST
RESERVE
BDY
Flume
KO'OLAU
DITCH
TUNNEL
1568
1532
1742
1606
1400
1600
1200
606500
607000
607500
608000
608500
2377000
2377500
2378000
2378500

IR/CCIR # 150976 ADD-ON 9

REPORTING IOC, EOC, EAC: USAG-HI IOC/SSG Cassells/TOR: 021806WNOV15

Subject: Incident Report 150976

1. Category: 3-21(i)

2. Type of Incident: Range Fire

3. Date and Time:

   a. DTG of Incident: 291541WOCT15
   b. DTG of Receipt: 291541WOCT15

4. Location of Incident: East Range (Grid FJ 07517802), Schofield Barracks, HI

5. Personnel Involved:

   a. Subject:

      (1) Name: N/A
      (2) Rank or Grade: N/A
      (3) SSN: N/A
      (4) Race: N/A
      (5) Sex: N/A
      (6) Age: N/A
      (7) Position: N/A
      (8) Security Clearance: N/A
      (9) Unit and Station of Assignment: Directorate of Emergency Services
      (10) Duty Status: N/A
      (11) Drugs/Alcohol: N/A
      (12) Did the Service Member return from support of OND/OEF within the last 365 days? N/A

6. At 061530WNOV15, FESD reported that the East Range (ER12) burn site has been under observation for more than 72 hours without any evidence of hotspots. FESD has declared this fire extinguished.

This is a final report.

A request will be submitted for 1 x UH-60 to conduct aerial recon and buckets drops (if required) at 010900WNOV15

This is a final report for the day. The next update will be provided after the 010900WNOV15 recon.

The following bucket and flight hour information is from the 31 OCT 15 support.

UH-60M, Tail #510, 0 Buckets Dropped with .7 Flt Hours

At 311000WOCT15, FESD conducted an aerial assessment of the fire and reported 80% containment with no change to acres burnt. FESD observed smoke from smoldering embers within the east/southeast fire containment area. A request has been submitted for 1 x UH-60 to return to the fire site for water bucket operations. FESD will establish an Incident Command on East Range road and will release the aircraft if heavy showers occur on the training area or if the fire is 100% contained. The next update will be provided prior to 1500 hours today.

The following bucket and flight hour information is from the 30 OCT 15 support.

UH-60M, Tail #547, 14 Buckets Dropped with 4.0 Flt Hours

At 301730WOCT15, FESD reported that the fire at ER-12 is 70% containment with a total of 15 acres burned. The FESD crew and UH-60 aircraft have been able to prevent the spread of this fire by attacking perimeter hotspots and smoldering debris within the fire line. The UH-60 that was conducting water bucket operations was released from the fire site at 1715 due to favorable weather conditions. FESD personnel ceased active firefighting operations at 1730 hours. The Incident Commander (IC), Mr. Bryson Kamakura, will not require an overnight fire watch. FESD personnel will make an assessment of the fire site at 310900WOCT15. This fire will be declared extinguished if there have been no signs of fire activity over the next 72 hours. An Aviation Mission Request (AMR) has been submitted to have 1 x UH-60 conduct an aerial recon at 0900 and 1 x UH-60 to be on prepared to launch in support of fire suppression operations by 1000 hours. No injuries or damage to Govt. property was reported.

Mr. Fred Makinney, Chief, DES Operations reports the following; on 291541WOCT15, local authorities reported a brush fire near East Range. Preliminary findings indicate the fire was 1000 meters south of East Range road. Wildland fire crews monitored the fire overnight and conducted an aerial recon at 300900WOCT15 and determined the fire was on Army property. 1 x UH-60 began water bucket drops at 301010WOCT15. Approximately 10 acres have been


Panorama of burn site, South Kaukonahua, Schofield Barracks East Range


Burned Koa forest


Burned Eucalyptus/Paperbark forest

The following is a list of plant species burned in the fire are listed in the table below. Some aggressive invasive tree species occur along the perimeter of the fire and are likely to colonize the newly disturbed habitat. These include *Falcataria molucanna*, *Heliocarpus popayensis*, *Cecropia obtusifolia* and *Spathodea campanulata.*

Native Plants	
Scientific Name	Common Name
Acacia koa	koa
Antidesma platyphyllum	hame
Bobea elatior	ahakea
Cibotium chamisoi	hapu'u
Dicranopteris linearis	uluhe
Freycinetia arborea	ie'ie
Gahnia beechii	
Huperzia phyllantha	
Ilex anomala	kawa'u
Metrosideros polymorpha	ohi`a
Nephrolepis exaltata	kupukupu
Planthonella sandwichensis	`ala`a
Psilotum nudum	moa
Psychotria manniana	kopiko
Scaevola gaudichaudiana	naupaka kuahiwi
Sphenomeris chinensis	pala`a

Non-Native Plants	
Scientific Name	Common Name
Ardesia elliptica	shoebutton ardisia
Clidemia hirta	Koster's curse
Cordyline fruticosa	Ti
Corymbia citriodora	lemon-scented gum
Eucalyptus robusta	Swamp Mahogany
Lophostemon confertus	Brush box
Melaleuca quiquinervia	Paperbark
Nephrolepis brownii	
Phlebodium aureum	
Psidium cattleianum	Strawberry guava
Syncarpia glomulifera	Turpentine Tree

Ecosystem Restoration Management Plan
OIP Year 10-14, Oct. 2016 - Sept. 2021
MUs: Kaala Army and Kaala NAR

Overall OIP Management Goals:

- Form a stable, native-dominated matrix of plant communities which support stable populations of IP taxa.
- Control ungulate, weed, predatory snail, rodent, and slug threats to allow for stabilization of IP taxa.

Background Information

Location: Highest peak of Oahu in the central Waianae Mountains

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

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

Acreage: 178 acres (Kaala Army = 120 acres, Kaala NAR = 58 acres)

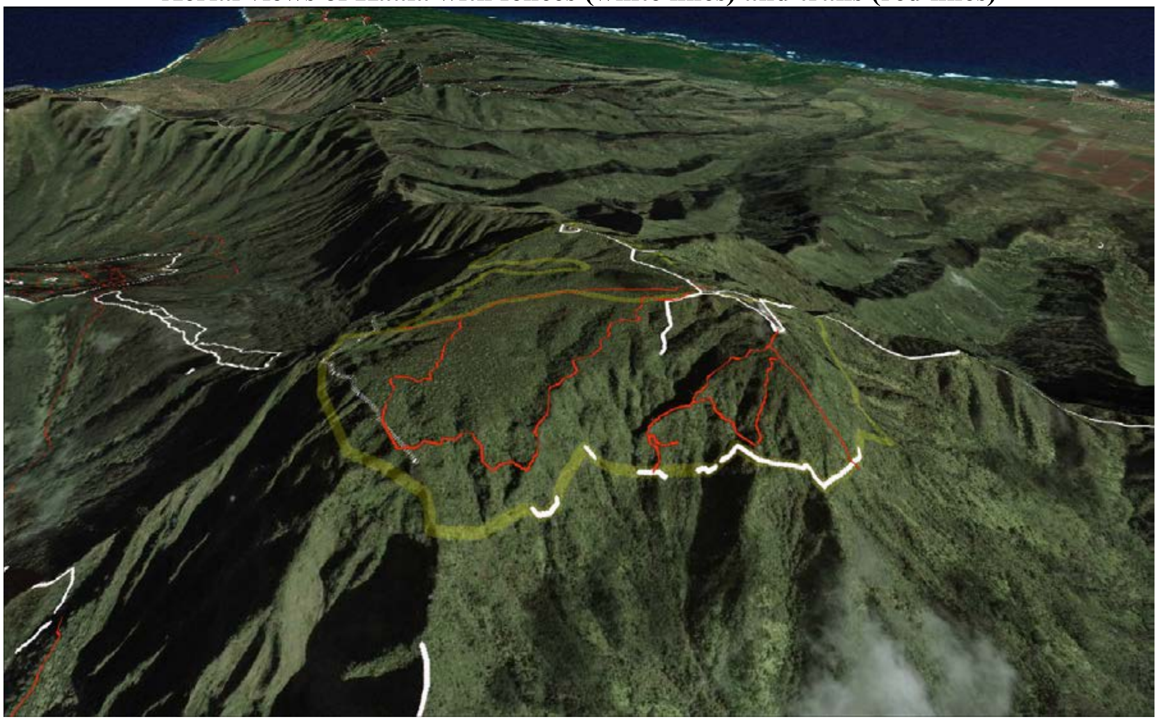
Elevation range: 3,400 to 4,020 ft.

Description: Bog and surrounding montane wet community; plateau and surrounding cliffs of Kaala peak; Moderate to steep slopes and cliffs, including small ridges and gulch bowls. The MU extends down into wet-mesic forest into Haleauau at approximately the 3,000 ft. elevation level. Kaala is a very unique area, the wettest site in the Waianae Mountains, the highest point on Oahu, dominated by wet native forest and home to a variety of rare taxa. Major threats to Kaala are ungulates and weeds. NRS actions have been geared towards mitigating these threats over the years. To accomplish meaningful threat control, NRS must work with the State, as both pigs and weeds cross property boundaries.

Native Vegetation Types

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

Aerial views of Kaala with fences (white lines) and trails (red lines)



Primary Vegetation Types at Kaala

Wet forest

Wet forest slope

MIP/OIP Rare Resources:

Organism Type	Species	Pop. Ref. Code	Population Unit	Management Designation	Wild/ Reintroduction
Plant	*Cyanea acuminata*	ALA:A-D,G-J,N,S,Y	Kaala	MFS T1	Wild
Plant	*Labordia cyrtandrae*	ALA:A-C, G-W	Kaala	MFS T1	Both
Plant	*Phyllostegia hirsuta*	ALA-A	Kaala	MFS T1	Reintro
Plant	*Schiedea trinervis*	ALA:A-E, G, J-T, Y, X	Kaala	MFS T1	Both
Snail	*Achatinella mustelina*	ESU-D	Kaala	MFS	Wild

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

Other Rare Taxa at Kaala MU:

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

Rare Resources at Kaala:

Labordia cyrtandrae *Schiedea trinervis*

Cyanea acuminata *Achatinella mustelina*

Left: Native *Succinea*, and Right: Happy Face Spiders (*Theridion grallator*)

Rare Resources Locations at Kaala

Map removed to protect rare resources. Available upon request

MU Threats to MIP/OIP MFS Taxa:

Threat	Taxa Affected	Localized Control Sufficient?	MU scale Control required?	Control Method Notes
Pigs	All	No	Yes	MU partially fenced
Goats	All	No	Yes	Goats present in Waianae valleys bordering Kaala. Control being planned with the State
Rats	All	Yes	Unknown	Traps installed around AchMus
Predatory snails	*Achatinella mustelina*	Yes	No	*Oxychilus alliarius* (garlic snail) is present but not in the vicinity of *A. mustelina*. *Euglandina rosea* is not found in this area
Slugs	*Cyanea acuminata, Labordia cyrtandrae, Phyllostegia hirsuta, Schiedea trinervis*	Yes	No	Sluggo application around LabCyr and PhyHir
Ants	Potential threat to *Drosophila substenoptera*	Unknown	Unknown	Some available, depends on species

Weeds	All	No	Yes	Mulitple control techniques used. Aerial control options, including HBT, are being considered.
Fire	No threat			

*Note: 'Localized Control' refers to management in a discrete portion of the MU, such as directly around a rare taxa site, as opposed to 'MU Scale Control, which refers to management across the entire MU.

Regarding some of the MIP/OIP rare plant taxa, with the new delineation of the Schofield Action Area, species such as *L. cyrtandrae* and *S. trinervis* may be dropped from the list of OANRP managed species in the future following consultation, as Army training impacts to these species is negligible.

Management History:

- 1996-2016: *Hedychium gardnerianum* control including sweeps of WCAs and aerial surveys.
- 1996-2009: Sporadic goat control in Lower Kaala NAR.
- 2006: 90% of Strategic fencing completed mainly in Haleauau Gulch portion of Kaala Summit through partnership effort between BWS, State of Hawaii, TNC and Army NRS.
- 2006-2009: Pig control at Kaala MU using dogs, traps, and snaring.
- 2006-2009: *Sphagnum palustre* control research.
- 2007-2016: *Juncus effuses* and *Crocosmia crocosmifolia* control with volunteers, led by Outreach Program.
- 2009: Goat control efforts initiated along Waianae Kai headwall area.
- 2009: Sphagnum control begins with staff and volunteer efforts.
- 2012: MU fence completed around Lihue, encompassing the area below the Kaala cliffs
- 2012: Snaring initiated in Lihue, significantly reducing ungulate pressure on the Kaala strategic fences.
- 2015: Plans to complete additional fencing on the Waianae Kai and Makaha facing ridges of Kaala are developed; proposed fences are mapped and measured
- 2016: The first small scale rodent trapping grid was installed around the *L. cyrtandrae* ALA-S. A total of 70 traps (35 Victor and 35 KaMate) were installed after observing high take of flowers and fruits by rodents.
- 2016: *Puccina* rust now significantly impacting *Metrosideros* spp. First detected on Oahu approximately in 2008.
- 2016: Site visit conducted and area selected for a tree snail predator exclosure near tram tower on Army land.
- 2016: Initial *Sphagnum* control completed on Army land. Annual retreatment and monitoring phase ongoing.
- 2016: Construction of ungulate control fence along Kaala road started.

Ungulate Control

Identified Ungulate Threats: Pigs, Goats

Threat Level: High

Primary Objectives:

- Maintain MU as pig and goat free.

Strategy:

- Eradication of pigs in the MU. Eradication of all pigs within Lihue fence (SBW) and population reduction of goats through aerial and ground hunting efforts in the headwaters of Waianae Kai and Makaleha will reduce pressure on the Kaala fences and minimize potential ingress through strategic fence sections of Kaala.
- Construct fenceline along upper rim of Waianae Kai to eliminate ingress.
- Construct fenceline along Kaala Road from summit area to 3 pts. fence to segment goat and pig populations and facilitate removal efforts.
- Set and monitor snares to control any pigs that enter Kaala around the strategic fences.

Monitoring Objectives:

- Biannual fence checks completed in Kaala from 2009-2015. Quarterly fence checks done in Lihue since 2013.
- Detect any pig sign in the summit fence area while conducting rare plant monitoring or other weed control work in the MU.
- Monitor pig transect along the transect trail quarterly.

Management Responses:

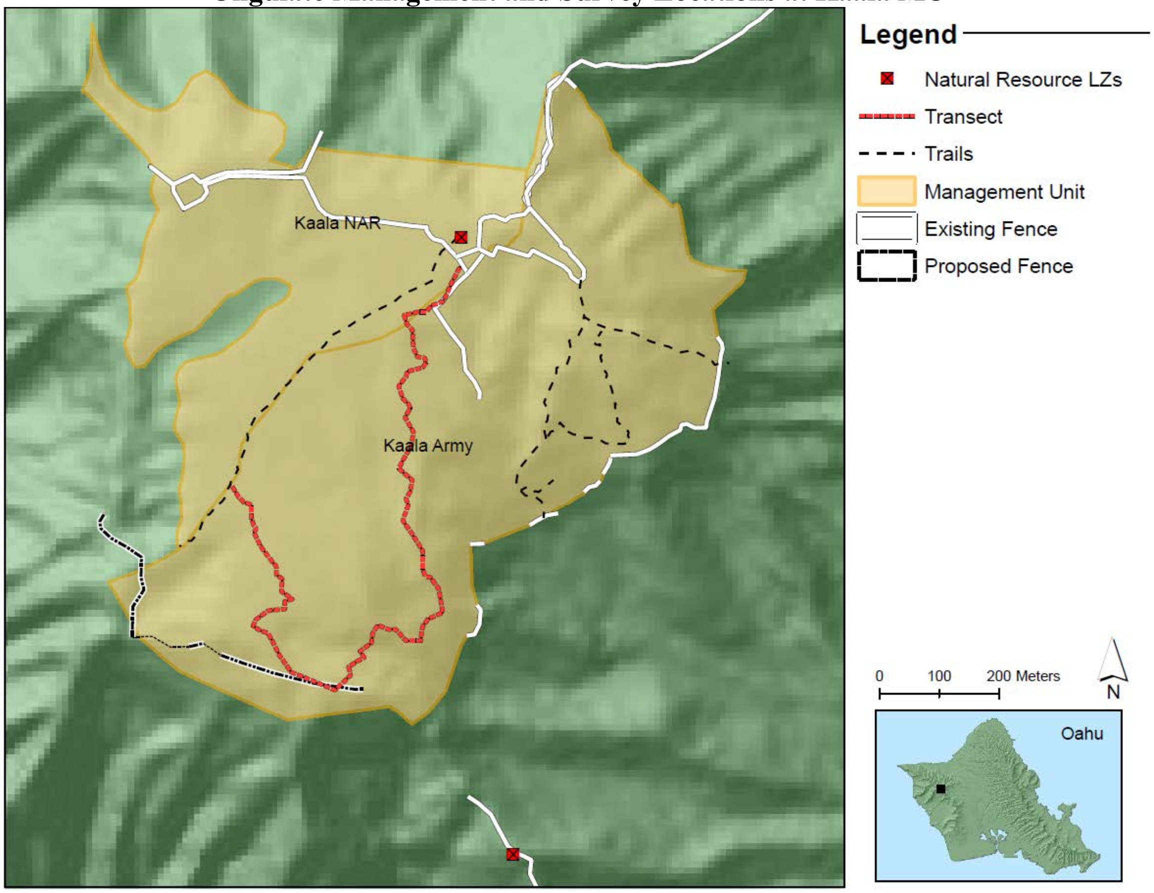
- If any ungulate activity is detected within the fenced unit, scale up snaring efforts and implement more frequent snare checks.

Maintenance issues

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

Fence integrity will be monitored four times annually. All fence sections are checked during bi-annual snare checks. Fences are also checked after extreme rainfall events. In particular, the Haleauau area fence line requires regular checks because of many streams in the area. Monitoring for ungulate sign also occurs during the course of other field activities. As of 2016, the Kaala road fence is under construction with completion slated by the end of calendar year 2016. The State of Hawaii will have responsibility for the maintenance of this watershed/NAR fence. In 2017, OANRP will contract the construction of a small fence linking the strategic fence above South Haleauau to the end of the boardwalk area. The purpose of this fence will be to eliminate pig ingress from the headwaters of Waianae Kai into the summit area. This last fencing project should make the summit area of Kaala pig free. Maintenance of this fence will be done by OANRP since the majority of the fenceline is on Army land (see proposed fence on map below)

Ungulate Management and Survey Locations at Kaala MU



Metrosideros polymorpha

Epiphytes

Weed Control

Weed Control actions are divided into 4 subcategories:

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

These designations facilitate different aspects of MIP/OIP requirements.

Vegetation Monitoring

Vegetation monitoring has not been initiated yet for the Kaala MU, but WorldView satellite imagery may be an option for future monitoring. Monitoring has not been done given the sensitivity of the habitat to trampling, the difficulty of hiking through dense, steep, and dissected terrain, and the predominately native habitat of the Kaala summit area.

Surveys

Army Training: Infrequently

Other Potential Sources of Introduction: NRS, pigs, birds, recreational hikers

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

Management Objective:

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

Monitoring Objectives:

- Conduct road surveys, including parking areas, every year (RS-Kaala-01).
- Survey two transects for weeds annually; Boardwalk (WT-Kaala-01) and Transect Trail (WT-Kaala-03).
- Quarterly surveys of the Kaala campsite (OS-Kaala-01) and Landing Zone (LZ-SBW-082) .
- Annual aerial surveys (as needed) mainly for ginger detection
- Note unusual, significant, or incipient alien taxa during the course of regular field work.

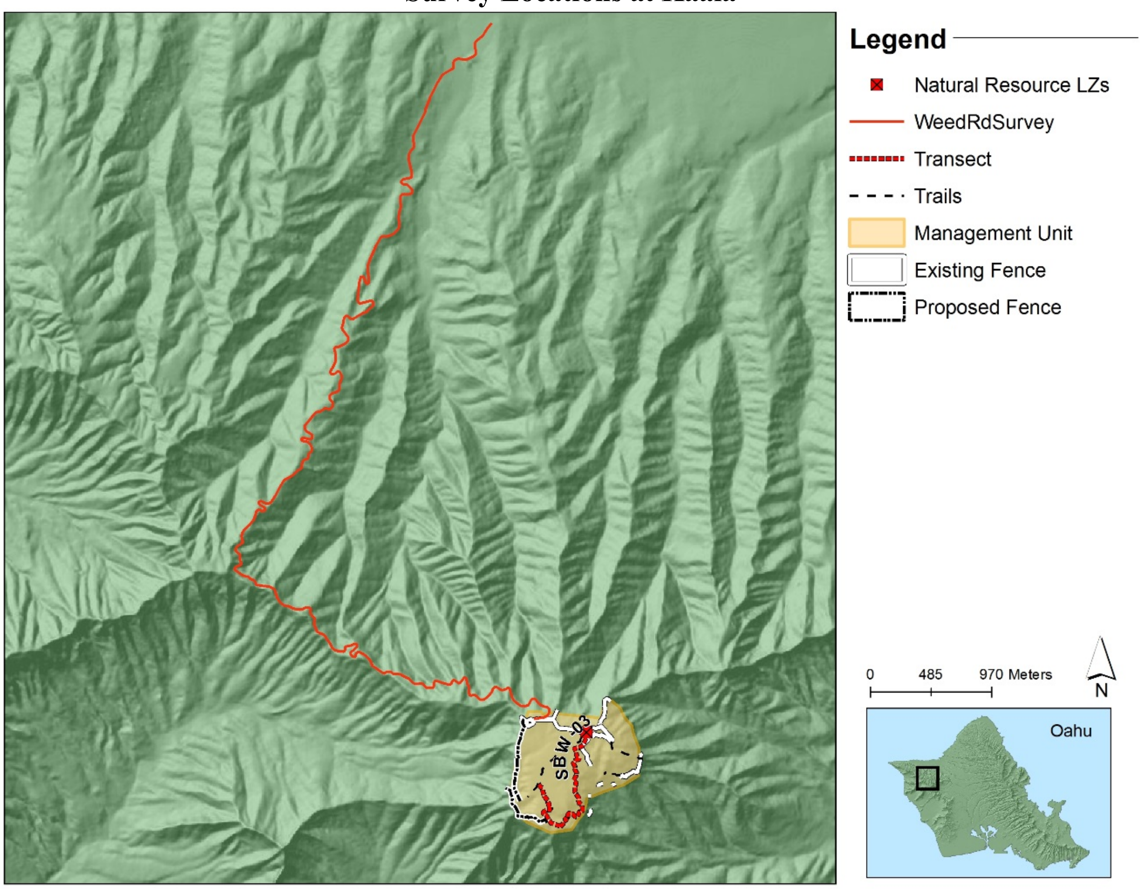
Management Responses:

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

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

The Kaala road will be surveyed annually, since it is heavily used by staff, and may rarely be used by the Army. There is one LZ at Kaala, located just off the road, outside of the FAA gate, next to the boardwalk trailhead. It is rarely used, as permission must be granted by the FAA. If used, the LZ should be surveyed, not to exceed once per quarter. The State maintains a shelter just off the road; this grassy clearing is used as a campsite. Staff will survey the campsite whenever used, not to exceed once per quarter. There are two weed transects in the MU. One is along the boardwalk, the most heavily used trail. The other is along a trail/ungulate transect. Both are surveyed annually. See the *Survey Locations at Kaala* map.

Survey Locations at Kaala



Incipient Taxa Control (ICAs)

Management Objectives:

- As feasible, eradicate species identified as high priority incipient invasive aliens in the MU by 2021.
- Conduct seed dormancy trials for all high priority incipients by 2021.

Monitoring Objectives:

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

Management Responses:

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

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

The table below summarizes incipient invasive taxa at Kaala. Note that this MU was not described in the original MIP, and therefore is not included in Appendix 3.1 of the MIP, which lists significant alien species and ranks their potential invasiveness and distribution. This table supplements Appendix 3.1 by identifying target species for Kaala. While the list is by no means exhaustive, it provides a good starting point for discussing which taxa should be targeted for eradication in the MU. Three management designations are possible: Incipient (small populations, eradicable), Control Locally (significant threat posed, may or may not be widespread, control feasible at WCA level), and Widespread (common weed, may or may not pose significant threat, control feasible at WCA level).

ICAs have been identified for ten taxa at Kaala. Most of these species are located close to the FAA facility or along a road, trail, or transect (see ICA map below). One ICA, for *Elaeocarpus grandis*, has been eradicated, but 33 ICAs remain active. Since the State conducts management in the Kaala NAR MU, OANRP efforts focus in the Kaala Army MU; however, OANRP does conduct work at several roadside ICAs on State land. Wherever possible, staff utilize volunteers to conduct ICA work; volunteers control many of the *Crocosmia x crocosmiiflora*, *Juncus effusus*, and *Sphagnum palustre* ICAs. Details on taxa and ICAs are in the table below. Actions for each ICA are listed in the Action Table at the end of this document.

Summary of Target Taxa

Taxa	Management Designation	Notes	No. of ICAs
Anthoxanthum odoratum	Incipient	Alien grass discovered in 2009. First record on Oahu. Highly invasive in pastures on the Big Island. The population appears to be limited to the beginning of the boardwalk and the trailhead/LZ. Very few plants have been seen in recent years, but detection can be difficult when the grass is vegetative.	1
Araucaria columnaris	Incipient	One tree, likely planted. Potential for invasiveness has been observed elsewhere. No recruitment has been seen on site. Removing the tree is not currently a control priority, but should be considered in future.	0
Begonia foliosa	Widespread	Observed across the MU. NRS don't know how serious a threat this taxon poses, but control this taxa around rare taxa sites. This plant is thought to grow from cuttings, and control methods need to be researched.	0
Begonia hirtella	Widespread	Observed across the MU, primarily in drainages, less common than *B. foliosa*. Low priority for control. Control methods not well known.	0
Clidemia hirta	Widespread	This is one of the dominant weeds at Kaala, Control in WCAs, particularly around rare taxa sites.	0

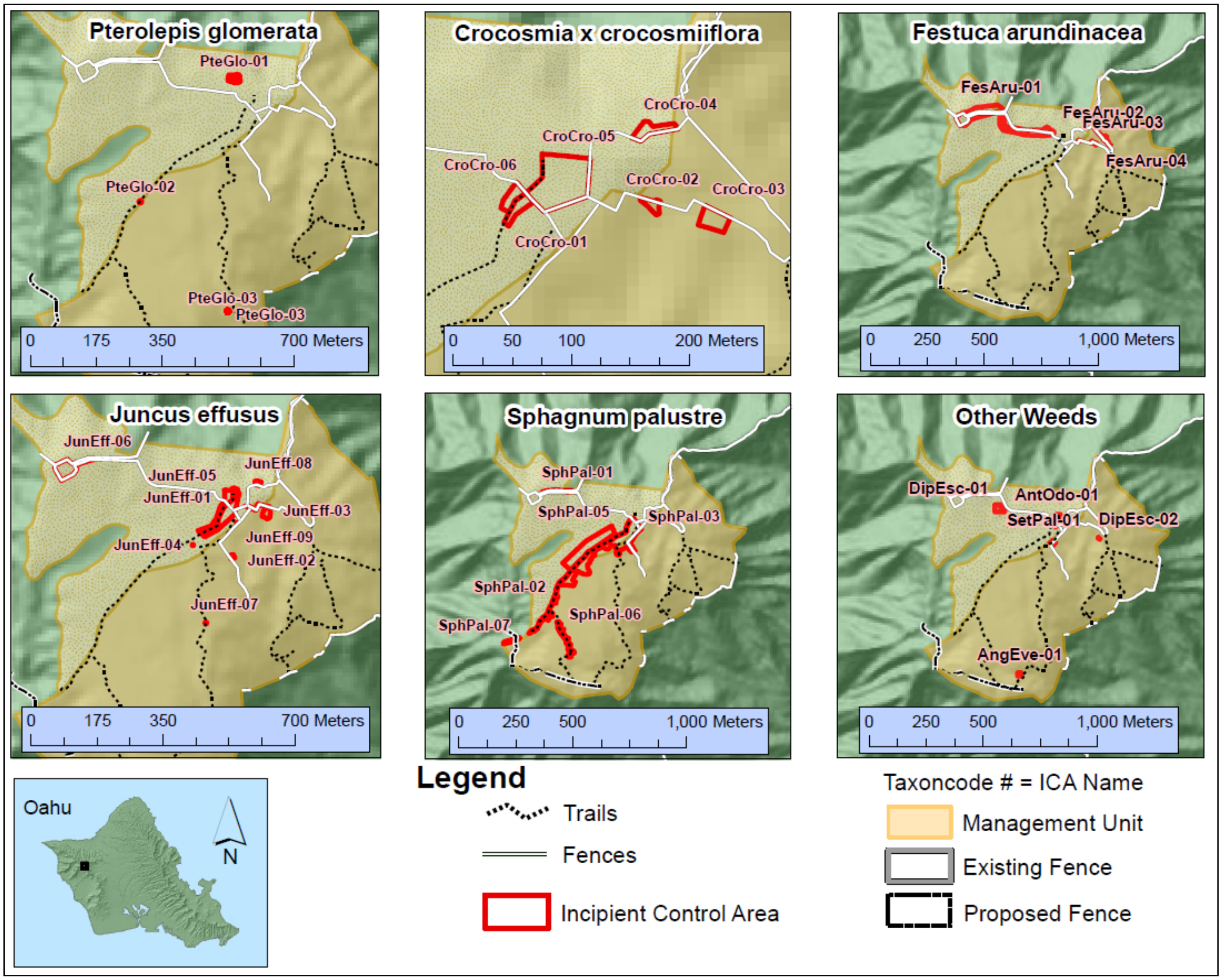
Crocosmia x crocosmifolia	Incipient	This species likely escaped from ornamental plantings at the FAA exclosure. Eradication will be difficult to achieve, as the population includes areas inside the FAA exclosure, on State land, and on Army land. However, NRS feel preventing the spread of *C. crocosmifolia* is an important goal; NRS have seen it dispersing down the boardwalk and it can displace all other understory species in dense infestations. This taxon appears mostly to spread vegetatively, via corms, but does occasionally set seed. Seed viability was studied and seeds do not persist longer than 3 months. Control is ongoing with volunteer groups. The primary control technique is manual removal of bulbs. Herbicide sprays are being tested, and are needed to achieve eradication.	6
Diplazium esculentum	Incipient	This invasive fern thrives in wet areas and can grow to several feet in height. It has been found in two areas, one along road and one below FAA exclosure. Difficult to identify, but easy to control by handpulling or spraying.	2
Elaeocarpus angustifolius	Incipient	One tree, likely planted. Potential for invasiveness has been observed elsewhere. Tree was treated and is now dead . No recruitment observed. ICA declared extirpated in 2012.	(1 – extirpated)
Festuca arundinacea	Incipient	This highly invasive grass is difficult to identify when it is vegetative. The primary infestation is found along the radio tower road and around the radio tower exclosure. Outlier sites have been found around the FAA exclosure. This grass is controlled via foliar spraying or handpulling	4
Fraxinus uhdei	Control locally	While few *T. ciliata* are known from the bog flats, many trees have been seen during aerial surveys in valleys backing up to Kaala. This taxon should be treated wherever found, as part of regular WCA efforts. This is a candidate for aerial control, if an effective herbicide/ application method is identified.	0
Hedychium coronarium	Incipient	This taxon is a huge problem in the Koolau mountains, although it is considered less invasive than *H. gardnerianum*. One patch, around 10x20m in size, was known from State land near the radio towers. This patch rarely flowered, and no seed were seen. The State has conducted some control work on the patch, and therefore it is not an OANRP priority. If requested, OANRP will assist the State with further control efforts.	0
Hedychium gardnerianum	Control locally	Originally planted as an ornamental near the FAA facility, this species has spread widely. It is found across the bog flats (on both Army and State lands) and has spread down cliffs and into Haleauau (Lihue). Aerial surveys in 2009 showed that it had not spread into Makaha and Waianae Kai. Eradication would be extremely difficult/impossible to achieve without a major increase in resources. This species is highly invasive and poses a major threat to rare taxa and native forest integrity. Control is ongoing in WCAs. Candidate for aerial herbicide control on cliffs, remote areas of Lihue.	0
Juncus effusus	Incipient	This taxa is known from sites around the radio tower exclosure, the FAA exclosure, the boardwalk, and the transect trail. In addition, large patches have been known from State land just north of the boardwalk. This sedge is highly invasive and poses a significant threat to the area. OANRP conducted a buried seed trial and found that seeds form a persistent seed bank, lasting at least 7 years in soil. This highlights the threat posed, but also suggests that eradication may be very difficult to achieve. Volunteers conduct most *J. effusus* control, digging out roots and bagging seed heads (taken to H-power for disposal). Efforts have been effective, but plants are still found at most ICAs.	9

Leptospermum scoparium	Control locally	Several plants were found in the bog flats during WCA sweeps in 2002-2005. There is a moderate-sized infestation known from the Kumaipo ridge; this is likely the source population. No plants have been seen in the bog flats on subsequent sweeps, but the Kumaipo infestation is still thriving and is an ICA in the Makaha MU. Control was conducted at Kumaipo around 2003-04 but aerial surveys in 2009 noted the population had rebounded. Interagency control efforts are needed at the Kumaipo site. Aerial treatment techniques need to be identified to use at Kumaipo. At Kaala, if any new plants are found, new ICAs may be created. Plants that are felled do not resprout and do not require herbicide treatment.	0
Meleleuca quinquenervia	Control locally	Plants occasionally were found during WCA sweeps in the early 2000s, but no plants have been found recently. No large stands known nearby; unclear where plants are dispersing from. This taxon should be controlled whenever found during regular WCA sweeps.	0
Odontonema cuspidatum	Control locally	This shrub appears to have originated from plantings outside the FAA exclosure and spreads vegetatively. Since no flowers or fruit were seen at the site, staff collected cuttings, which were grown until they flowered, resulting in positive identification.While this taxon is highly invasive and forms dense stands, it appears to have a limited distribution at Kaala and is in a degraded site. Control is conducted with volunteers as part of a restoration project in WCA-02. Plants are handpulled, and slash is sprayed with glyphosate. Cut stumps are treated with herbicide.	0
Psidium cattleianum	Widespread	Patches of this invasive tree are scattered across Kaala. These stands tend to be small, and are targeted by NRS during WCA sweeps.	0
Pterolepis glomerata	Incipient	Highly invasive, this groundcover is well-established in the Koolaus, but is incipient in the Waianaes. Three sites are known in the MU; one at the campsite, one on the boardwalk, and one on the transect trail. Just outside of the MU, another site is known on the trail leading to Kumaipo. This taxon may have been introduced to the MU via staff or recreational hikers or both. This species spreads quickly and is difficult to eradicate due to its cryptic nature and suspected seed persistence. Despite this, control efforts have been effective. No plants have been seen at the boardwalk site since 2014, only 1 plant has ever been seen at the transect trail site, and very few plants are found at the camp site at any one time. This taxon continues to be a high priority for eradication	3
Rubus argutus	Widespread	The bane of NRS at Kaala. This taxon is the most common weed in the MU, forms dense stands, and is a thorny hazard to staff. Control techniques have been tested, but it is difficult to achieve 100% kill with any known techniques. New trials were installed in 2016 to test clip and drip options. Although this taxon is highly invasive, it is a low priority for control due to its density. It is controlled at rare taxa sites.	0
Setaria palmifolia	Incipient	Only one site is known for this taxa, an invasive grass that thrives in wet, shady conditions. All known plants were killed, and no recruitment has been seen. Since this grass can be difficult to spot, and seed persistence is unknown, the ICA needs to be monitored for 10 years before it can be declared eradicated (2019)	1
Sphaeropteris cooperii	Control locally	This invasive tree fern is widespread across Oahu, but uncommon at Kaala. In aerial surveys in 2009, many plants were seen in valleys backing up to Kaala, particularly Haleauau. This fern should be controlled whenever found, particularly during WCA sweeps. Plants can simple be cut down, no herbicide is necessary. This is a candidate for targeted aerial control.	0

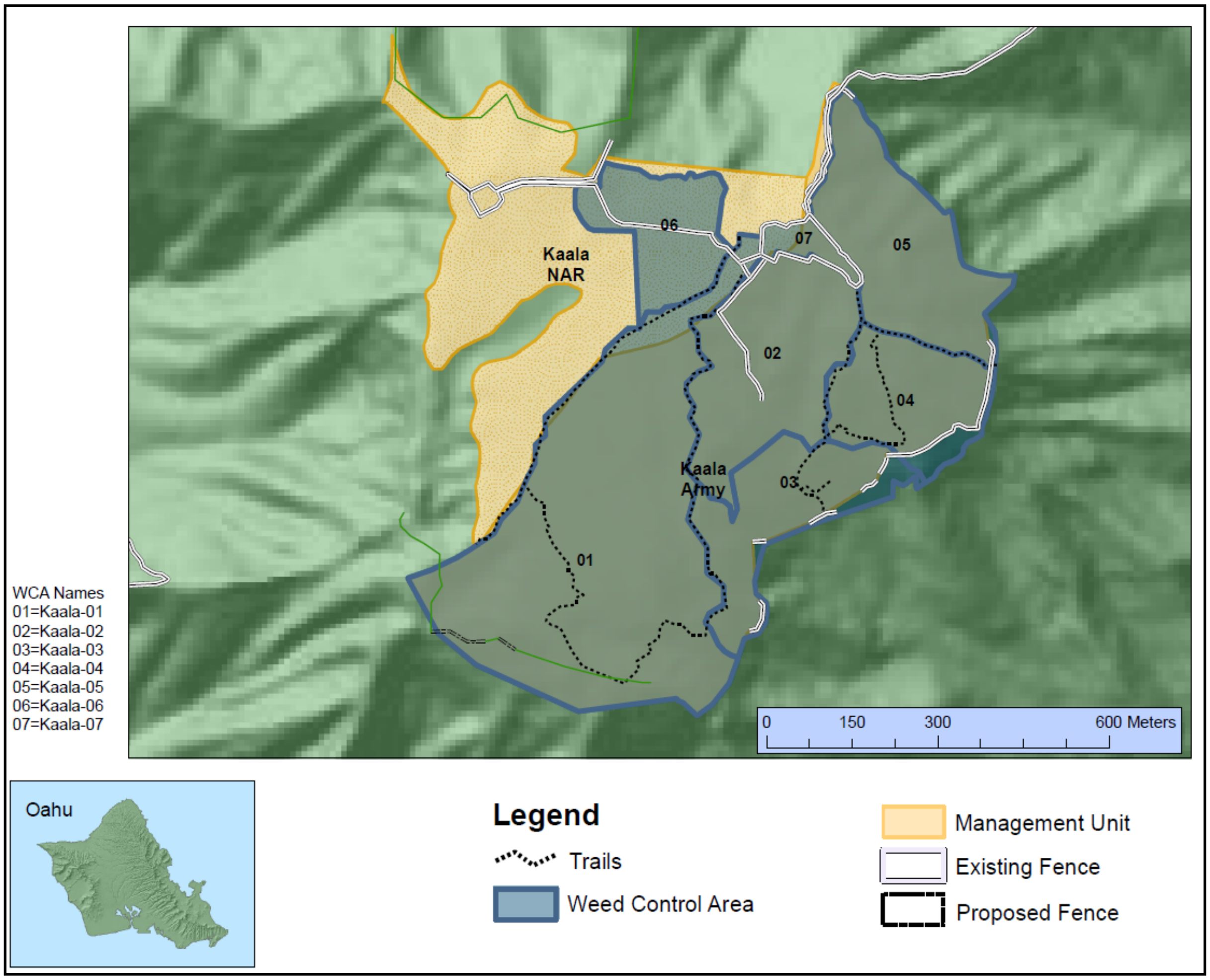
Sphagnum palustre	Incipient	Originally planted along the boardwalk, this invasive moss spread across a large portion of the bog flats on both Army and State land. OANRP efforts focus on Army land, but include treating both sides of the boardwalk to reduce the likelihood of dispersal, as well as controlling a satellite infestation along the radio tower road and occasionally assisting NEPM staff with sprays in the State core. On the Army side of the boardwalk, initial control has been completed and staff are now in the process of re-treating scattered patches of moss. Volunteers control the moss in a 3m buffer along the boardwalk, while staff sweep the area beyond that buffer. Staff also treat two outlier sites, one along the transect trail, and one along the Kumaipo trail. Foliar sprays of a 10% dilution of Burnout (formerly St. Gabriel's Mosskiller) are effective, although efficacy is reduced if the moss is in standing water.	6
Toona ciliata	Control locally	While not common in the Kaala MUs, many trees were seen during 2009 aerial surveys in valleys backing up to Kaala. This tree should be controlledas part of WCA efforts. This is a candidate for aerial control, if an effective treatment is found.	0

C. crocosmifolia volunteer trip at Kaala

Incipient Control Areas at Kaala



Weed Control Areas at Kaala



Ecosystem Management Weed Control (WCAs)

<u>OIP Goals:</u>

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

<u>Management Objectives</u>:

- Determine whether alien vegetation cover goals are being met around rare taxa and across the MU.
- Maintain/reach 50% or less alien vegetation cover in the understory and canopy across the MU.

<u>Management Responses:</u>

- Increase/expand weeding efforts if shorter intervals are needed between weeding efforts.

The Kaala MUs are two of the few MUs in the Waianae Mountains dominated by native vegetation. Kaala is divided into two MUs along the boardwalk, which generally follows the property line: Kaala Army (the eastern portion of the summit of Kaala, from the boardwalk to Lihue) and Kaala NAR (the western portion of the summit, owned and managed by the State). OANRP conducts relatively little work in Kaala NAR MU, which is actively managed by NEPM, and focus management in the Kaala Army MU. Although MU vegetation monitoring has not been conducted at Kaala, NRS observe that it is likely that it meets the 50% or less alien cover goal for the OIP. Vegetation across the MU includes *Metrosideros polymorpha, Cheirodendrom platyphyllum, Cheirodendron trigynum, Broussasia arguta, Melicope clusiifolia, Ilex anomala, Cibotium* spp., *Machaerina angustifolia, Dianella sandwicensis*, and numerous other native ferns, herbs, and mosses. Most of the MU is divided into WCAs to facilitate data tracking and control efforts (see Incipient and Weed Control Areas map above).

The primary weed threats at Kaala are *H. gardnerianum,* and *P. cattleianum*. Since both taxa are found throughout the MU, weed sweeps are conducted to find and treat individual plants. Generally, a sweep involves staff lining up several meters apart at a fixed starting point, such as the boardwalk, then surveying at a set bearing across the WCA. The sweep stops at a set point, then the group flips around and sweeps back to the starting point, parallel to the first bearing. The goal of a sweep is to have high confidence that all target weeds are found and treated in the surveyed area. Often a hip chain is used along one edge of a sweep to ensure that no gaps occur when the line flips. In steep terrain, sweeps must go around cliffs and avoid other hazards. A modified sweep, utilizing spotters at vantage points (often with binoculars) can ensure good coverage even in steep areas. Aerial surveys are sometimes used to identify outlier targets as well.

The *H. gardnerianum* control strategy has evolved over the years. Initial plans were ambitious (sweeping each WCA every other year) and have been modified to take into account the large size of the WCAs, steepness of terrain, thick vegetation, and competing priorities. Staff estimate that a three year re-visitation cycle would allow *H. gardnerianum* plants to be treated before maturing and setting seed. This means that one or two of the Kaala Army MU WCAs (1-5) must be swept each year. The Green team is the lead on WCA sweeps. To assist them, the EcoRest team has taken over sweep duties at the largest WCA, Kaala-01. NRS track numbers of all treated *H. gardneriaum*, divided by size class. This data is helpful in determining whether control efforts are resulting in fewer plants found in a given area.

Aerial and ground surveys show that there are many large, mature patches of *H. gardnerianum* in steep areas, on the Kaala cliffs, and below Kaala in Haleauau (Lihue MU). Ideally, all locations of *H. gardnerianum* must be treated to effectively protect rare resources in both the Kaala and Lihue MUs. Currently, efforts focus on all hikable areas of Kaala, . Aerial sprays are necessary to treat plants growing on cliffs and in Lihue. A couple aerial treatment techniques have been tested, with some success, but further trials are needed. Staff worked with Dr. James Leary (CTAHR) to test the efficacy of Herbicide Ballistic Technology (HBT) on cliff-side ginger. Projectiles with the active ingredient imazapyr were used, based on a successful trial Dr. Leary conducted on Kauai. Unfortunately, the remote nature of the ginger made it difficult to monitor, and the imazapyr projectiles had a short shelf life, making them logistically difficult to work with. Staff will continue to work with Dr. Leary on HBT, as this is the most promising option for treating plants on cliffs. Staff also worked with an Army contractor to spray a large monotypic ginger patch in Lihue with a ball sprayer. The treated plants died back, but required follow-up treatment. There is always a risk of non-target impact with aerial treatment; staff need to determine how to mitigate this risk, particularly to rare taxa, before using aerial treatment techniques

Psidium cattleianum is scattered sparsely across the MU, with most stands found on the slopes and gullies bordering the bog flats. It has the potential to expand its range at Kaala, and is a control priority. Due to the wet environment, cut *P. cattleianum* slash can resprout, and both slash and stumps must be treated with herbicide. Staff may experiment with using a cocktail of Garlon 4 and Milestone to reduce the likelihood of resprouts. Other tree weeds are occasionally found on Kaala, including *M. quinquenervia* and *T. ciliata*. All canopy weeds should be controlled during WCA sweeps.

WCA: Kaala-01 (Boardwalk to Transect Trail)

Veg Type: Wet Forest

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

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

Notes: Also known as the Bog Flats, this WCA encompasses the top of Kaala, on Army land and is bounded on two sides by the boardwalk and the transect trail. This is a largely intact area dominated by *Metrosideros polymorpha* (ohia). Other dominant natives include *Cheirodendron platyphyllum* (lapalapa) *Cheirodendron trigynum* (olapa) *Coprosma ochracea* (pilo) and *Ilex anomala* (kawau). Rare taxa include *S. trinervis, C. acuminata*, *L. cyrtandrae, L. oahuensis,* and *C. calycina*. There is one large outplanting of *L. cyrtandrae* within this WCA, and keeping the area surrounding outplants free of grass and *R. argutus* is a priority.

H. gardnerianum is the primary threat. Previous control efforts have been effective at reducing numbers of mature plants, particularly along the boardwalk. Past control data suggests that *H. gardnerianum* is not evenly distributed across the entire WCA, however portions of the WCA have never been surveyed. NRS will use previous sweep records and new surveys to identify if there is a *H. gardnerianum* zone. If there is, NRS will sweep this zone every three years, and will treat the remaining portion of the WCA at a longer interval (perhaps every six years). *P.cattleianum* is relatively uncommon in the bog flats portion of the WCA, but is much more common on the slopes; it is also a high priority for control during sweeps. *M. quinqueveria* and *L. scoparium* have been found in this WCA in the past, albeit in very small numbers. The major understory weed threats are *C. hirta* and *R. argutus*; these will be treated primarily around rare taxa sites. The EcoRest field team will sweep the entire WCA in 2016-2017 for all major targets.
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At the trailhead, there are several incipient species in an open, weedy area. Removing the alien grasses and herbs allows volunteers to more easily find and remove incipient taxa, but maintaining open ground is not sustainable, as other weeds continually colonize the site. NRS are experimenting with common native transplants to rehabilitate the bare ground, reduce grass cover, and hopefully displace incipient taxa.

Control of the incipient invasive moss *S. palustre* has created open areas along the boardwalk trail, some of which have been colonized by alien grasses. These grasses will be treated, as necessary, to prevent further alien grass incursion into the bog.

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

Veg Type: Wet Forest

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

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

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

WCA: Kaala-03 (Lower Rainbow Ridge)

Veg Type: Wet Forest

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

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

Notes: This WCA is steep and ends abruptly in cliffs which lead down into Central Haleauau. *Schiedea trinerva, L. cyrtandrae andC. acuminata* are present, as well as *G. petaloidea* in gulches. A high number of *L. cyrtandrae* are found in this WCA, including part of an outplanting. *Cyanea calycina*, *N. melastoma*, *L. hypoleuca* are also present. There are many mature *H. gardnerianum* patches in the WCA. It is not possible to sweep the entire WCA, as parts of it are too steep. *Rubus argutus* is thick in the draws and slopes. NRS will experiment with alternative survey/control methods on the steep slopes. This is one of the most challenging WCAs in which to control weeds, as many large patches of *H. gardnerianum* are found on inaccessible cliff areas and in close proximity to rare plants, making aerial spraying risky and difficult. Additionally, weed sweeps of the lower cliff areas are complicated by rare snails, which are present on weed species that are targeted for removal, including *H. gardnerianum* and *P. cattleianum*.

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

Veg Type: Wet Forest

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

Targets: *Hedychium gardnerianum*, *P. cattleianum*, and *C. hirta* in areas where abundant.

Notes: This WCA is steep and ends abruptly in cliffs which lead down to Central Haleauau. It is bordered on two sides by access trails. Rare taxa present include *S. trinervis*, *L. cyrtandrae*, *P. hirsuta*, and *G. petaloidea* in gulches. *Rubus argutus* is thick, especially in gulches. Much of this area is too steep to safely sweep. NRS will prioritize treating mature *H. gardnerianum* in hikable areas and will investigate alternative techniques for surveying and treating cliffside plants. There are numerous patches of *H. gardnerianum* below the fenceline, in Haleauau (Lihue MU). NRS will seek to control these through aerial techniques. This is a frequently visited WCA, as there are outplantings of *L. cyrtandrae* and *P. hirsuta*, and general weeding along trails is conducted while doing rare plant actions. This WCA has many flat bowls around the upper elevations and aerial surveys are beneficial for finding mature *H. gardnerianum* patches that are not visible from the ground.

WCA: Kaala-05 (Blue Trail to Kamaohanui)

Veg Type: Wet Forest

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

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

Notes: This WCA is very steep, and there is little hikable area. Rare taxa present include *C. acuminata*, *S. trinervis*, *L. cyrtandra, C. calycina* and *G. petaloidea* in gulches. One outplanting of *L. cyrtandra* is located within this WCA. *Rubus argutus* is thick, especially in gulches and *H. gardnerianum* is the primary weed target. NRS prioritizes control of *H. gardnerianum* throughout the WCA, however, steep areas above the cliffs and the area on the cliffs themselves are loaded with mature *H. gardnerianum*. There is no effective way to control these patches at present, as staff currently do not have a valid Aerial Spray Statement of Need for the project. The steepness and high winds along the cliffs make aerial spraying challenging, but not impossible. A combination of ball spraying and HBT may be effective. Additional methods could include rappelling, however, this is very time consuming and only worthwhile to weed around endangered plants. There are also numerous patches of *H. gardnerianum* below the cliffs in Lihue.

WCA: Kaala-06 (North of Boardwalk/Road)

Veg Type: Wet Forest

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

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

Notes: This WCA is located on State land. Rare taxa present include *S. trinervis* and *M. christophersenii*. NRS will work with NEPM and support State weed control efforts, as feasible and as requested. This may include joint aerial surveys for *H. gardneriaum* and canopy weeds. This WCA is also home to sizable infestations of *S. palustre* and *J. effusus*, which have hampered sweep efforts, as both taxa are easily dispersed by staff walking through the area. Parts of this WCA lie outside the fenced portion of Kaala; in these areas, pig damage is considerable. Parts of the WCA are steep, and parts are thick with *R. argutus*. The campsite and shelter are included in this WCA; actions at the campsite include surveys for incipient weeds and maintaining the grass surrounding the shelter area (shared between OANRP and NEPM).

WCA: Kaala-07 (FAA Enclosure)

Veg Type: Wet Forest

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

Targets: *Hedychium gardnerianum*.

Notes: The FAA enclosure is dominated by grass and has little other vegetation. It is regularly mowed by facility staff. Occasionally, patches of *H. gardnerianum* establish inside of the fence. Much of the enclosure can be visually surveyed from outside the fence, but NRS must seek permission from the National Guard and Federal Aviation Administration (FAA) to enter the enclosure to control any *H. gardnerianum* seen. Staff should monitor the site during the course of other field activities, but also should check it thoroughly once every 2-3 years.

WCA: Kaala-08 (Radio Tower Reintros)

Veg Type: Wet Forest

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

Targets: *Hedychium gardnerianum, Clidemia hirta, Rubus argutus, Psidium cattleianum*.

Notes: Sandwiched between the Radio Tower Road to the south and the Kaala Road to the north this WCA is on Kaala NAR. The area is dominated by native vegetation and home to non-MFS reintroductions of *S. trinervis* and *L. cyrtandrae*. These reintroductions have not thrived, and are not being maintained. Staff may assist with weed control efforts led by the State, but are not otherwise planning to conduct weed control. This may change if the Army is tasked with managing *M. christophersenii*, which occurs in the WCA.

Left: *Cheirodendron platyphyllum* canopy. Right: *Dianella sandwicensis* fruit

Taxa Considerations for Restoration Actions

Native Taxon	Outplant?	Seedsow/ Division/ Transplant?	Notes
Cheirodendron spp.	Yes	No	Tree. There are two taxon at Kaala, *C. trigynum* and *C. platyphyllum*. Test utility of either or both species as restoration plantings.
Cibotium spp.	Unknown	Division/ Transplant	Fern. Staff collected trunk buds and planted them near the trailhead. They are very slow-growing, and may or may not be effective as restoration plantings.
Cyperus polystachios	Unknown	Unknown	Sedge. This sedge recruits naturally in disturbed areas, and may be a good candidate for seed sows.
Dianella sandwicensis	Yes	Division/ Transplant	Herb. This species has been used in other MUs for restoration plantings, but transplants at Kaala have not always thrived, possibly because the ground at the trailhead is especially wet. It might be a good candidate at other planting sites.
Gunnera petaloidea	Unknown	Unknown	Herb. This large-leaved plant forms dense clumps, and may effectively shade out weeds. Propagation techniques need to be investigated.
Machaerina angustifolia	Unknown	Division/ Transplant	Sedge. This sedge forms large clumps, up to a meter across, and likely would physically displace weeds. Some transplants have been done at Kaala, with limited success. This taxon should be investigated further.
Metrosideros polymorpha	Yes	Unknown	Tree. One of the most common trees at Kaala, this taxon may be slow growing in the wet, bog habitat. Test utility as a restoration planting.

Rodent Control

Species: Black rats (*Rattus rattus*)

Threat level: High

Control method: Victor and KaMate traps

Seasonality: N/A

Number of snap grids: 1

Primary Objective:

- To implement rodent control if determined to be necessary for protection of rare plants and tree snails.
- Construct predator exclosure for long-term protection of *Achatinella mustelina*

Monitoring Objective:

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

Rodent Control:

- Potentially threatened resources are widespread throughout the Kaala MU. The habitat quality is very high in the Kaala MU. Rare plant populations have been impacted by rodents in the past and no rodent control was in place. Airlayers on the branches of some *L. cyrtandrae* plants have been eaten in the past and it is strongly suspected that rodents have girdled the bases pf plants and eaten the fruit off of some *C. acuminata* and possibly *L. cyrtandrae* fruits. Recent observations for the *L. cyrtandrae* revealed a high number of flowers and fruits predated by rodents. In February 2016, OANRP implemented a localized small scale rodent trapping grid, consisting of a total of 70 traps (35 Victor and 35 KaMate) around *L. cyrtandrae* population ALA-S. Additional traps will need to be installed around wild and reintroductions sites in the future, following pollination for fruit collection. Also, rat trapping will be conducted around a future snail jail in Kaala MU. Traps will be checked and re-set every 6 weeks during each quarter; however during flowering and fruiting season (May-August & December-February), traps will be checked and re-set every 2 weeks.

Labordia cyrtandrae flowers

Predated fruit (bagged) of *L. cyrtandrae* ALA-S

Slug Control

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

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

Control level: Localized

Seasonality: Probably year-round as area is extremely wet

Number of sites: Two; *Labordia cyrtandrae* reintroduction and *Phyllostegia* reintroduction

Primary Objective:

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

Management Objective:

- Control slugs; using Sluggo around the *L. cyrtandrae* populations as needed.

Monitoring Objectives:

- Annual census monitoring of *L. cyrtandrae* populations to monitor slug damage.

Effective mollusicicides have been identified (Sluggo) and initial control programs are ongoing in other MU's. A slug control program has also been intiated in Kaala MU, following surveys for rare snails, as slugs are observed feeding on *L. cyrtandrae* reproductive structures. Given rarity, slow growth and long lifespan of *L. cyrtandrae* leaves, and the dioecism of *L. cyrtandrae* species any slug damage can be significant.

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

Predatory Snail Control

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

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

Control level: Localized

Seasonality: Unknown

Number of sites: 1 *Achatinella mustelina* site

Acceptable Level of Activity: Unknown

Primary Objective:

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

Management Objective:

- Continue to develop better methods to control predatory snails
- Keep sensitive snail populations safe from predatory snails via currently accepted methods (such as hand removal of alien snails, construction of barriers which prevent incursion from alien snails)
- Construct predator exclosure near FAA station and remove all predatory snails.

Monitoring Objectives:

- Annual or every other year census monitoring of *A. mustelina* population to determine population trend.
- Annual searches for predatory snails to confirm their absence in proximity to *A. mustelina.*
- Follow *Euglandina* search effort flow chart for exclosure.

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

Oxychilus alliarus

Ant Control

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

Threat level: Low

Control level: Only for new incipient species

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

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

Acceptable Level of Ant Activity: Acceptable at present densities

Primary Objective:

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

Management Objective:

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

Monitoring Objective:

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

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

Fire Control

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

Action Table

The table below is a comprehensive list of threat control actions planned for the MU for the next five years. Actions are grouped by type; for example, Ungulate Control or Ant Control. Weed control actions are grouped into the following categories: General Survey, ICA, or WCA code. Cells filled with hatch marks denote the quarters in which an action is scheduled. IP years run from October of one year through September of the next. Therefore, Quarter 4 (October-December) is listed first for each report year, followed by Quarter 1 (January-March), Quarter 2 (April-June), and Q3 (July-September). Species names are written as six-digit abbreviations, such as 'JunEff' instead of *Juncus effusus*, for brevity.

Action Type	Actions	OIP Year10 Oct 2016-Sept2017				OIP Year 11 Oct 2017-Sept2018				OIP Year 12 Oct 2018-Sept2019				OIP Year 13 Oct 2019-Sept2020				OIP Year 14 Oct 2020-Sept2021			
		4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
Restoration	Develop plan and schedule for common reintroductions																				
General Survey	RS-Kaala-01: Survey road from the first gate to the FAA enclosure. If see any soil/fill stockpiles, survey carefully around them and note location.																				
	WT-Kaala-01: Survey Kaala boardwalk annually, starting from gate at trailhead to end of boardwalk around 720m.																				
	WT-Kaala-03: Survey transect on Kaala summit, annually. Transect intersects boardwalk around 590, and loops south then north to hit old spur fence near boardwalk trailhead.																				
	OS-Kaala-01: Survey Kaala campsite whenever used, not to exceed once per quarter. If not used, do not need to survey.																				
	LZ-SBW-082: Survey Kaala LZ whenever used, not to exceed once per quarter. If not used, do not need to survey																				
ICA AngEve	Kaala-AngEve-01: Monitor/Control AngEve on transect trail annually. Prevent any plants from reaching maturity.																				
ICA AntOdo	Kaala-AntOdo-01: Monitor/control AntOdo near trailhead twice a year.																				

Action Type	Actions	OIP Year10 Oct 2016-Sept2017				OIP Year 11 Oct 2017-Sept2018				OIP Year 12 Oct 2018-Sept2019				OIP Year 13 Oct 2019-Sept2020				OIP Year 14 Oct 2020-Sept2021			
		4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
ICA CroCro	Kaala-CroCro-01: [Volunteer] Monitor/control CroCro along Army side of boardwalk. Focus on keeping CroCro out of bog. Pick and remove from field any potentially viable fruit.																				
	Kaala-CroCro-02: [Volunteer] Monitor/control CroCro at site on southwest of FAA. Focus on forest edge and drainage area. Pick and remove from field any potentially viable fruit.																				
	Kaala-CroCro-03: Monitor/control CroCro at site on southeast of FAA. Experiment with chemical control. Pick and remove from field any potentially viable fruit. (trial pending)																				
	Kaala-CroCro-04: Monitor/control CroCro at site on southeast of FAA. Experiment with chemical control. Pick and remove from field any potentially viable fruit. (trial pending)																				
	Kaala-CroCro-05: [Volunteer] Monitor/control CroCro at LZ/trailhead. Focus on forest edge. In short term, keep off fence and trail. Pick and remove from field any potentially viable fruit. Experiment with chemical control. Experiment with backhoe/manual control. Low priority action																				
	Kaala-CroCro-06: [Volunteer] Monitor/control CroCro on state side of boardwalk at trailhead. Coordinate actions with State. Focus on keeping CroCro out of bog; target forest edge. Pick and remove from field any potentially viable fruit.																				
ICA DipEsc	Kaala-DipEsc-01: Monitor/control DipEsc at site along Kaala road 2-4x year, as needed. Treat via handpulling, clip&drip w/G4, or targeted foliar sprays (glyphosate).																				

Action Type	Actions	OIP Year10 Oct 2016-Sept2017				OIP Year 11 Oct 2017-Sept2018				OIP Year 12 Oct 2018-Sept2019				OIP Year 13 Oct 2019-Sept2020				OIP Year 14 Oct 2020-Sept2021			
		4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
	Kaala-DipEsc-02: Monitor/control DipEsc at site by zombie tunnels 2-4x year, as needed. Treat via handpulling, clip&drip w/G4, or targeted foliar sprays (glyphosate).																				
ICA FesAru	Kaala-FesAru-01: Monitor/control FesAru across entire ICA quarterly. Coordinate control efforts with National Guard mowing schedule, as feasible. Treat with glyphosate, monitor effectiveness. Consider using pre-emergent along road.																				
	Kaala-FesAru-02: Monitor/control FesAru at site on Kamaohanui side of FAA quarterly. Coordinate control efforts with National Guard mowing schedule, as feasible. Treat with glyphosate, monitor effectiveness. Consider using pre-emergent along fence.																				
	Kaala-FesAru-03: Monitor/control FesAru at site in corner of FAA fence, on south side, quarterly. Coordinate control efforts with National Guard mowing schedule, as feasible. Treat with glyphosate, monitor effectiveness. Consider using pre-emergent along fence. Allow kikuyu to take over area.																				
	Kaala-FesAru-04: Monitor/control FesAru at site close to tower in FAA fence, on southeast side, quarterly. Coordinate control efforts with National Guard mowing schedule, as feasible. Treat with glyphosate, monitor effectiveness. Consider using pre-emergent along fence. Allow kikuyu to take over area.																				
ICA JunEff	Kaala-JunEff-01: [Volunteer] Monitor/control JunEff along boardwalk core. Sweep entire area 2x year (or less if warranted). Handpull plants and remove from field; take to H power for incineration.																				

Action Type	Actions	OIP Year10 Oct 2016-Sept2017				OIP Year 11 Oct 2017-Sept2018				OIP Year 12 Oct 2018-Sept2019				OIP Year 13 Oct 2019-Sept2020				OIP Year 14 Oct 2020-Sept2021			
		4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
	Kaala-JunEff-02: Monitor/control JunEff at Wing Fence annually. Handpull plants and remove from field; take to H power for incineration. Long lived seeds; consider eradicated when 20 years with no seed (2023).																				
	Kaala-JunEff-03: [Volunteer] Monitor/control JunEff at northeast site (south of FAA) 2x year. Handpull plants and remove from field; take to H power for incineration.																				
	Kaala-JunEff-04: [Volunteer] Monitor/control JunEff at west outlier off boardwalk (transect tag 160) annually. Handpull plants and remove from field; take to H power for incineration. Long lived seeds; consider eradicated when 20 years with no seed (2028).																				
	Kaala-JunEff-05: [Volunteer] Monitor/control JunEff along State side of boardwalk and trail/culvert. Handpull plants and remove from field; take to H power for incineration. Spray large plants in culvert when needed. Communicate with state for all activities here.																				
	Kaala-JunEff-06: Monitor/control JunEff around Radio tower, on state side of Kaala, 2x year. Handpull plants and remove from field; take to H power for incineration.																				
	Kaala-JunEff-07: Monitor/control JunEff on transect trail at tag #510 every 6 months/annually. Handpull plants and remove from field; take to H power for incineration. Long lived seeds; consider eradicated when 20 years with no seed.																				
	Kaala-JunEff-08: Monitor/control JunEff on north side of FAA exclosure, near USGS marker, every 6 months/ annually. Handpull plants and remove from field; take to H power for incineration. Long lived seeds; consider eradicated when 20 years with no seed (2024).																				

Action Type	Actions	OIP Year10 Oct 2016-Sept2017				OIP Year 11 Oct 2017-Sept2018				OIP Year 12 Oct 2018-Sept2019				OIP Year 13 Oct 2019-Sept2020				OIP Year 14 Oct 2020-Sept2021			
		4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
	Kaala-JunEff-09: Monitor/control JunEff at beginning of Spur Fence annually. Handpull plants and remove from field; take to H power for incineration. Long lived seeds; consider eradicated when 20 years with no seed.																				
ICA PteGlo	Kaala-PteGlo-01: Monitor/control Ptego at Kaala State camp site quarterly. Pick and remove from field any potentially mature fruit. Consider using pre-emergent herbicides.																				
	Kaala-PteGlo-02: Monitor/control Ptego at boardwalk site, station 430 quarterly. Pick and remove from field any potentially mature fruit. Consider using pre-emergent herbicides. Consider digging up soil around plants.																				
	Kaala-PteGlo-03: Monitor/control Ptego at transect trail site, by LabCyrALA-W, quarterly. Pick and remove from field any potentially mature fruit. Consider using pre-emergent herbicides. Consider digging up soil around plants.																				
ICA SetPal	Kaala-SetPal-01: Monitor/control SetPal along spur fence from FAA annually. Handpull and remove plants from the field.																				
ICA SphPal	Kaala-SphPal-01: [Volunteer] Monitor/control sphagnum along radio tower road. Communicate with State about work at this site. Utilize handpulling and St. Gabriel's moss killer for control. Spray is ineffective in standing water, so time efforts for when moss and culvert/ depression are dry.																				
	Kaala-SphPal-02: [Volunteer] Control Sphpal along boardwalk, on State side of MU, as requested by State. Control only in boardwalk corridor, (1-2m from boardwalk). Spray with moss killer. Exercise care to prevent the spread of Sphpal via footwear or gear.																				

Action Type	Actions	OIP Year10 Oct 2016-Sept2017				OIP Year 11 Oct 2017-Sept2018				OIP Year 12 Oct 2018-Sept2019				OIP Year 13 Oct 2019-Sept2020				OIP Year 14 Oct 2020-Sept2021			
		4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
	Kaala-SphPal-03: [Volunteer] Control Sphpal along boardwalk, on Army side of MU, within 3m of boardwalk or to infestation edge (especially in 0-140m, 460-520m, 560-610m, 630-740m). Spray with moss killer. Exercise care to prevent the spread of Sphpal via footwear or gear. Re-treatments should be at least 6 months after initial control.																				
	Kaala-SphPal-03: Control Sphpal core along boardwalk, on Army side of MU once a year. Spray with citric/clove moss killer. Exercise care to prevent the spread of Sphpal via footwear or gear. Outreach treating all areas within 3m of boardwalk. Only work in following zones on boardwalk, rest covered by Outreach: 140-460m, 520m-560m, 610-630m. Treat identified hotspots. Follow up control efforts should be at least 6 months after treatment.																				
	Kaala-SphPal-03: Take photopoints annually in the Sphpal infestation.																				
	Kaala-SphPal-03: Sweep defined 30m buffer. GPS and control any sphagnum found, and modify buffer shape as needed. Ensure all outlier hotspots are monitored.																				
	Kaala-SphPal-05: Assist State with Sphpal control beyond boardwalk corridor, on State side of MU, AS REQUESTED ONLY. Follow State treatment procedures (survey for native land snails prior; use citric/clove moss killer). Exercise care to prevent the spread of Sphpal via footwear or gear.																				

Action Type	Actions	OIP Year10 Oct 2016- Sept2017				OIP Year 11 Oct 2017- Sept2018				OIP Year 12 Oct 2018- Sept2019				OIP Year 13 Oct 2019- Sept2020				OIP Year 14 Oct 2020- Sept2021			
		4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
	Kaala-SphPal-06: Control SphPal along transect trail between stations 1430 to 1380. Spray with mosskiller, or carefully pull and bag and remove from field. Exercise care to prevent the spread of Sphpal via footwear or gear. Always monitor for sphagnum when walking transect trail.																				
	Kaala-SphPal-07: Survey Kaala to Kumaipo trail, between boardwalk and boulder cable section, for sphagnum outlier patches 1-2 times a year. Treat any patches found with St. Gabe's Mosskiller. Exercise care to prevent the spread of Sphpal via footwear or gear.																				
Kaala-01: Boardwalk to Transect Trail	Control weeds across WCA once every 3 years. Target Hedgar (top priority), Psicat, Melqui, and any other canopy weeds found. Record number/reproductive status of Hedgar found. Treat Clihir as second priority.																				
	Control grasses and other weeds in open area at trailhead and along fence, quarterly or as needed; coordinate with Outreach. This complements ICA control and restoration efforts. Grass: handpull, weedwhack or use glyphosate formulation suitable for wet areas. Other weeds: clip and drip with Garlon or if very wet, handpull and stack slash in pile away from water and spray pile. Coordinate with Foundation or Green staff for specialized tasks, like grass spraying, as needed.																				
	Control weeds around LabCyr ALA-W reintro annually, or as needed. Target Clihir, Rubros, Hedgar, and any other weeds encroaching on rare taxa.																				
Kaala-02: Transect Trail to Rainbow Ridge	Control weeds across entire WCA once every 3 years. Target Hedgar (top priority), Psicat, Melqui, and any other canopy weeds found. Record number/reproductive status of Hedgar found. Treat Clihir as second priority.																				

Action Type	Actions	OIP Year10 Oct 2016-Sept2017				OIP Year 11 Oct 2017-Sept2018				OIP Year 12 Oct 2018-Sept2019				OIP Year 13 Oct 2019-Sept2020				OIP Year 14 Oct 2020-Sept2021			
		4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
	Control sprawling OdoCus in bowl just south of FAA exclosure. Reproduces prolifically vegetatively and has multiple rooting points. Cut and pile plants, then spray pile and cut stump area with foliar spray (backpack or handheld) of glyphosate. Alternatively, treat rooting points with herbicide, standard clip&drip. Allow any missed rooting points to leaf out, then spray foliarly on follow-up visits. Goal is eradication. Whenever working in area, always treat any HedGar found (record #s treated).																				
Kaala-03: Lower Rainbow Ridge	Control weeds across entire WCA once every 3 years. Target Hedgar (top priority), Psicat, Melqui, and any other canopy weeds found. Record number/reproductive status of Hedgar found. Treat Clihir as second priority.																				
	Control weeds around LabCyr ALA-S reintro annually, or as needed. Target Clihir, Rubros, Hedgar, and any other weeds encroaching on rare taxa.																				
	Control weeds around LabCyr ALA-W reintro annually, or as needed. Target Clihir, Rubros, Hedgar, and any other weeds encroaching on rare taxa.																				
Kaala-04: Rainbow Ridge to Blue Trail	Control weeds across entire WCA once every 3 years. Target Hedgar (top priority), Psicat, Melqui, and any other canopy weeds found. Record number/reproductive status of Hedgar found. Treat Clihir as second priority.																				
	Clear/maintain fence. Remove downed trees, spray grass, treat thick understory, as needed.																				
	Control weeds around PhyHir ALA-A and LabCyr ALA-S reintro annually, or as needed. Target Clihir, Rubros, Hedgar, and any other weeds encroaching on rare taxa.																				

Action Type	Actions	OIP Year10 Oct 2016- Sept2017				OIP Year 11 Oct 2017- Sept2018				OIP Year 12 Oct 2018- Sept2019				OIP Year 13 Oct 2019- Sept2020				OIP Year 14 Oct 2020- Sept2021			
		4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
Kaala-05: Blue Trail to Kamaohanui	Control weeds across entire WCA once every 3 years. Target Hedgar (top priority), Psicat, Melqui, and any other canopy weeds found. Record number/reproductive status of Hedgar found. Treat Clihir as second priority. Portions of WCA very steep; use aerial surveys, spotters, to guide control.																				
	Control sprawling OdoCus in on north side of blue trail. Reproduces prolifically vegetatively and has multiple rooting points. Cut and pile plants, then spray pile and cut stump area with foliar spray (backpack or handheld) of glyphosate. Alternatively, treat rooting points with herbicide, standard clip&drip. Allow any missed rooting points to leaf out, then spray foliarly on follow-up visits. Goal is eradication. Whenever working in area, always treat any HedGar found (record #s treated).																				
Kaala-06: North of Boardwalk/Road	Assist State in controlling weeds on NAR side of boardwalk, as requested. Target Hedgar (top priority), Psicat, Melqui, and any other canopy weeds found. Record number/reproductive status of Hedgar found.																				
	Control weedy grasses and understory species Mow grass around the Kaala Shelter in quarters 2 and 4. State staff will be mowing in quarters 1 and 3.																				
Kaala-07: FAA Enclosure	Control all Hedgar inside of the FAA exclosure. Obtain permission prior; may need to submit letter to gain access. Visit every 3 years.																				
Kaala-08: Radio Tower Reintros	Control weeds across WCA every 2-3 years. Focus efforts around reintroductions. (not MFS site, low priority, not scheduled)																				
Rodent Control	Monitor rare plants and tree snails for predation by rats																				

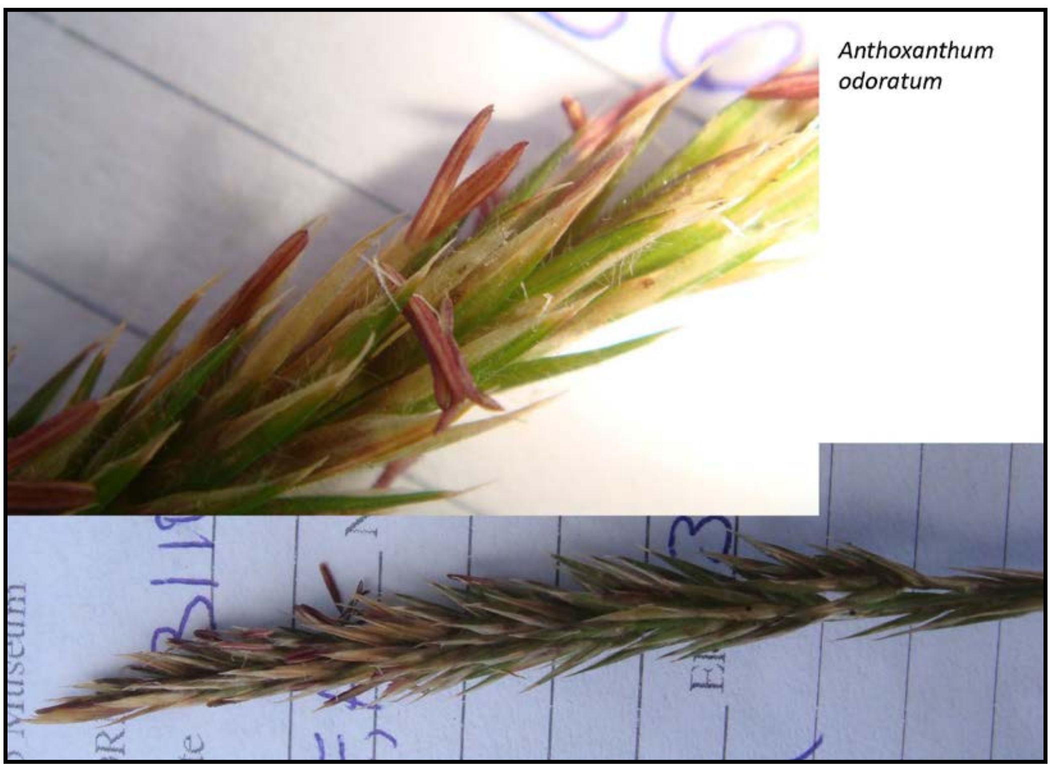
Action Type	Actions	OIP Year10 Oct 2016-Sept2017				OIP Year 11 Oct 2017-Sept2018				OIP Year 12 Oct 2018-Sept2019				OIP Year 13 Oct 2019-Sept2020				OIP Year 14 Oct 2020-Sept2021			
		4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
Slug/Snail Control	Determine need for and feasibility of slug control at Kaala for L. cyrtandrae (and possibly other rare plant species																				
	Determine if any E. rosea or O. alliarus snails are present at the A. mustellina SBW-R site or at other A. mustellina sites in the Kaala MU																				
Ants	Conduct surveys for ants across MU with bait cards as needed																				
Ungulate	Monitor ungulate transect																				
	Check Snares ALA-A/B/C/E																				

Appendix 1: Invasive Grasses of Kaala


Festuca arundinacea


Festuca arundinacea

Anthoxanthum odoratum, sweet vernal grass



Anthoxanthum odoratum

Anthoxanthum odoratum

Pennisetum clandestinum, kikuyu grass

Vulpia bromoides

Setaria parviflora

Holcus lanatus

Ecosystem Restoration Management Plan

Updated July 2016

MIP Year 12-16, Oct. 2016 – Sept. 2021

MU: Ohikilolo Lower

Overall MIP Management Goals:

- Form a stable, native-dominated matrix of plant communities which support stable populations of IP taxa.
- Control ungulate, rodent, fire, and weed threats to support stable populations of IP taxa. Implement control methods by 2021.

Background Information

Location: Northern Waianae Mountains

Land Owner: US Army Garrison Hawaii

Land Manager: Oahu Army Natural Resources Program (OANRP)

Acreage: 70

Elevation Range: 100 – 400ft.

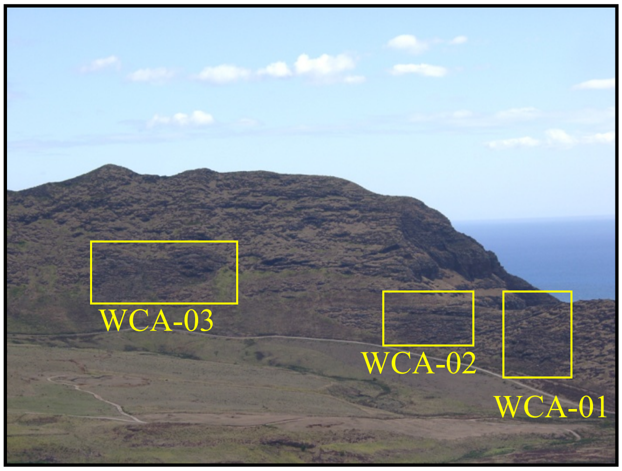
Description: Lower Ohikilolo MU is located in the Makua Military Reservation (MMR). It lies in the southwestern corner of Makua valley, on the bottom section of Ohikilolo ridge where it curves to parallel the ocean. This MU is accessed via the Makua firebreak road and consists of rocky cliffs. Due to a recent unexploded ordinance (UXO) incident, access to this MU was suspended from May 2015 to December 2015. Following a complete UXO clearing of Lower Ohikilolo patches, OANRP has resumed management of the area. While the MU is home to large populations of endangered plants, the overall landscape is highly degraded and weedy, and very fire-prone. The majority of rare taxa management is focused on reducing fuel loads to minimize the risk of fire, as well as outplanting common natives to reduce invasive vascular plants, which includes *Leucaena leucocephala*, *Urocholoa maxima*, *Hiptis Spp.*, *Leonotis nepetifolia, Verbesina encelioides and Melinis repens* coverage in the area. Overall, Lower Ohikilolo is dominated by *U. maxima* and *M. repens* which requires substantial labor to manage. Thus NRS will not manage the entire MU to the same level. Weed control will be focused only around the rare plant populations and surrounding areas, which consist mostly of weedy grasses and scattered native shrubs. However, as a result of recent OANRP weeding actions and common native outplantings, the Weed Control Areas (WCAs) are increasingly being dominated by common native shrub and plant populations including the *Dodonea viscosa*, *Abutilon incanum*, *Erythrina sandwicensis*, *Sida fallax* and *Waltheria indica*.

Native Vegetation Types

Waianae Vegetation Types
Lowland Dry Shrubland/ Grassland
Canopy includes: *Erythrina sandwicensis*, *Myoporum sandwicense, Dodonaea viscosa, Santalum ellipticum, Melanthera tenuifolia, Hibiscus brackenridgei* subsp. *mokuleianus* Understory includes: *Heteropogon contortus, Sida fallax, Eragrostis variabilis, Abutilon incanum, Leptecophylla tameiameiae, Euphorbia celastroides, Waltheria indica, Bidens* sp.

NOTE: For MU monitoring purposes vegetation type is listed based on theoretical pre-disturbance vegetation. Alien species are not noted.

Vegetation Types at Lower Ohikilolo



Ohikilolo Lower MU.

Map removed to protect rare resources

E. celastroides var. *kaenana* patch.

Map removed to protect rare resources

Picture taken from the upper section of the *H. brackenridgei* subsp. *mokuleianus* site, showing the terrain of the MU.

MIP/OIP Rare Resources

Organism Type	Species	Pop. Ref. Code	Population Unit	Management Designation	Wild/ Reintroduction
Plant	*Euphorbia celastroides* var. *kaenana*	MMR-D	Makua	MFS	Wild
Plant	*Hibiscus brackenridgei*	MMR-A MMR-F,G	Makua	MFS	Wild Augmentation

	subsp. *mokuleianus*				
Plant	*Melanthera tenuifolia*	MMR-D	Ohikilolo	GSC	Wild

MFS= Manage for Stability GSC= Genetic Storage Collection

Other Rare Taxa at Ohikilolo Lower MU

Organism Type	Species	Status
Plant	*Capparis sandwicensis*	Species of concern
Plant	*Lobelia niihauensis*	Endangered
Plant	*Silene lanceolata*	Endangered
Plant	*Spermolepis hawaiiensis*	Endangered

Rare Resources at Ohikilolo Lower

Hibiscus brackenridgei subsp. *mokuleianus*

Euphorbia celastroides var. *kaenana*

Spermolepis hawaiiensis

Melanthera tenuifolia

Locations of Rare Resources at Ohikilolo Lower

Map removed to protect rare resources. Available upon request

MU Threats to MIP Taxa

Threat	Taxa Affected	Localized Control Sufficient?	MU scale Control required?	Control Method Available?
Pigs	All	No	Yes	Yes
Goats	All	No	Yes	Yes
Rats	All	Yes	No	Yes
Ants	All	Yes	No	Toxicants exist, but are not effective for all species
Weeds	All	No	Yes	Yes
Fire	All	No	Yes	Yes

*Note: ‘Localized Control’ refers to management in a discrete portion of the MU, such as directly around a rare taxa site, as opposed to ‘MU Scale Control, which refers to management across the entire MU.

Management History

- 1970: Fire from military training burns Makua Valley
- 1984: Fire from military training burns Makua Valley
- 1995: Escaped prescribed fire in Makua burns part of the valley
- 1998: Fire burns part of Ohikilolo Lower MU.
- 1998: Live fire training ceased as a result of a lawsuit by Malama Makua.
- 2000: Perimeter fence completed; fence separates Makua Valley from the adjoining Ohikilolo Ranch, home to a large goat population.
- 2001: *H. brackenridgei* subsp. *mokuleianus* and *E. celastroides* var. *kaenana* found at MU.
- 2001: Grass control begins, with goal of reducing fuel load directly around the recently discovered rare taxa. Intensive management of three fuel breaks around the Upper and Lower Akoko and Hibiscus patch begins. Efforts take hundreds of hours per year and are currently on-going.
- 2003: Escaped prescribed fire in Makua burns half of the valley.
- 2003: A breach in the fence allows goats to cross over into Makua Valley. Goats are removed and fence is repaired.
- 2005: Augmentation of *H. brackenridgei* subsp. *mokuleianus* begins with outplantings.
- 2006: Breach in the fence is repaired and goats are caught.
- 2006: One immature *Cenchrus setaceus* found in Lower Akoko patch. ICA MMR-CenSet-01 created. No plants seen on subsequent visits, despite intensive weed control in area.
- 2007-2008: Needed repairs are made in the Ohikilolo ridge fence, goats continue to breach some areas of the fence. Fires from Farrington Hwy. side of the patches burn up to ridge and threaten patches.
- 2011: *Cenchrus setaceus* plants found along fenceline and in Lower and Upper Akoko patches. New ICA-02 was added and management efforts have increased including periodic aerial sprays.
- 2011-2012: Surveys conducted in 2011 and early 2012 revealed a large infestation of CenSet on the ocean-facing cliffs at the western end of Ohikilolo ridge. The core of the infestation is a gulch just south of Makua Cave. OISC assists with surveys, and begins control on portion of infestation found on private land to the south, in Keaau. ICA MMR-CenSet-02 created.

- 2012: Aerial sprays of MMR-CenSet-02 begin.
- 2014: *H. brackenridgei* subsp. *mokuleianus* are outplanted along the road and around the pavilion.
- 2015-2016: Access restricted due to UXO incident and areas re-cleared by EOD personnel (including beach sections).
- 2015: Hiking traffic to Makua Cave and Ohikilolo Ridge areas significantly increases due to social media and increased public hiking interest.
- 2015: Common natives planted in significant numbers at the *E. celastroides* var. *kaenana* patches.
- 2016: Lower portion of Ohikilolo fence replaced and entirety of MMR fenced.
- 2016: Plantings of *H. brackenridgei* subsp. *mokuleianus* along fence near range control discontinued due to maintenance issues.

Ungulate Control

Identified Ungulate Threats: Pigs and Goats

Threat Level: High

Primary Objective:

- Maintain all of Makua valley as pig and goat free.

Secondary Objective:

- Control pigs and goats if they affect endangered plants in this MU.

Strategy:

- Ohikilolo ridge fence creates a barrier for goat access from Ohikilolo Ranch and Makaha Valley. Pig activity in the Ohikilolo Lower area has historically been minimal, and no fence was built to limit pig activity in the MU.
- Conduct snaring and trapping (as feasible) in MMR primarily in the lower Makua forested areas until pig sign no longer detected.
- Conduct snaring (as needed) inside the Ohikilolo fenceline until goat sign no longer detected.

Monitoring Objectives:

- Conduct Ohikilolo Ridge/Melten fence checks quarterly (Blue team) and monitor fence for fire damage and vandalism.
- Monitor for pig and goat sign while conducting management actions in the MU.

Management Responses:

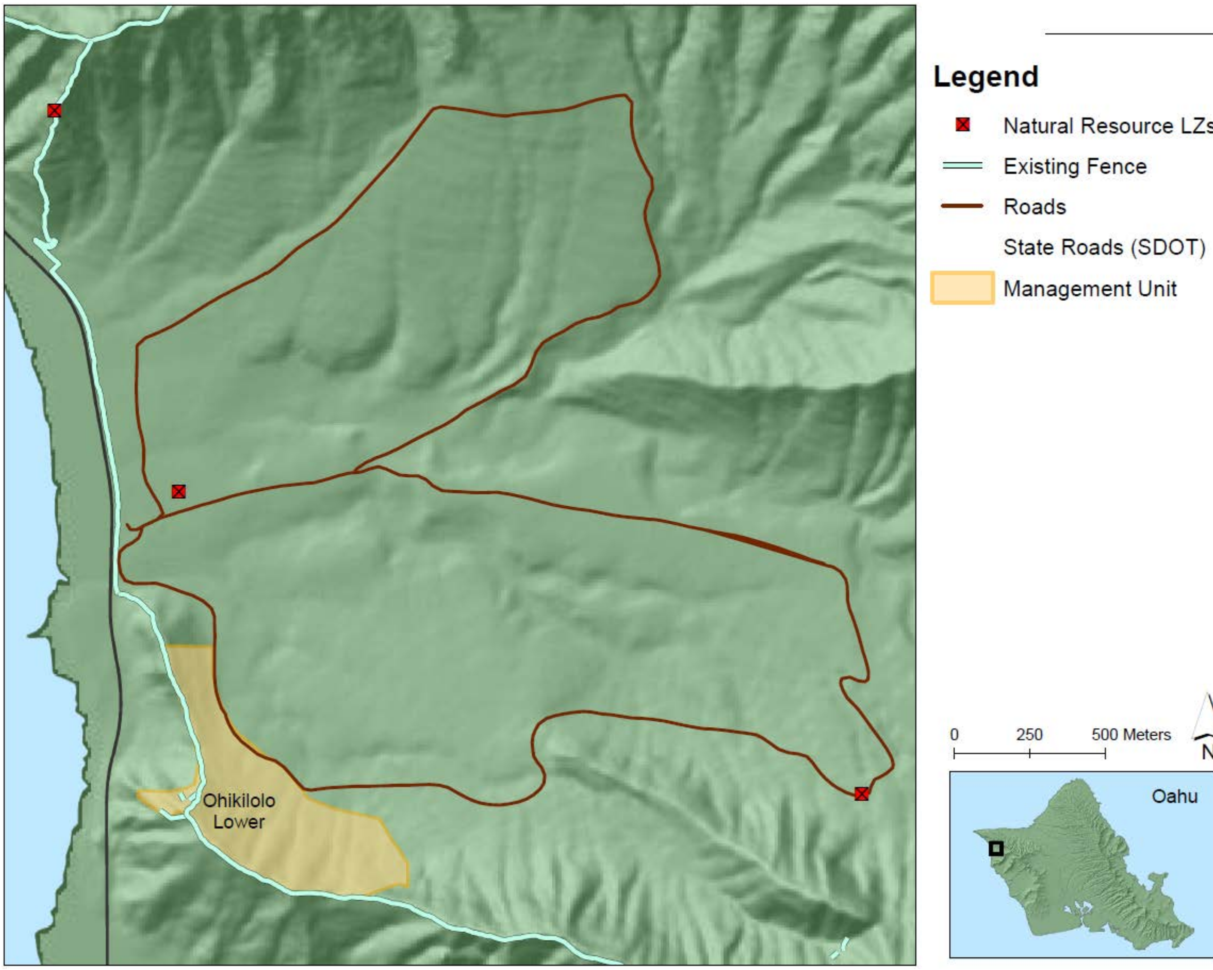
- Implement pig control via snaring if localized damage to plants is observed.

Maintenance Issues

- The major threats to the Ohikilolo Ridge fence include fire, vandalism, and erosion. Snares have been repeatedly vandalized (hung on the fence) by hikers in the area. Camp fires have also been set in the Keeau, Ohikilolo cabin and Ohikilolo Ridge area.
- The small strategic fence above Makua Cave is still accessible to goats. Control of goats through snaring is needed to protect this remnant cliff habitat community, the *Melanthera* plants that may

still be there, and to reduce the potential for goats to spread CenSet. Access in this area is difficult given the steep terrain.

Ungulate Management and Survey Locations at Ohikilolo Lower



Weed Control

Weed Control actions are divided into 4 subcategories:

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

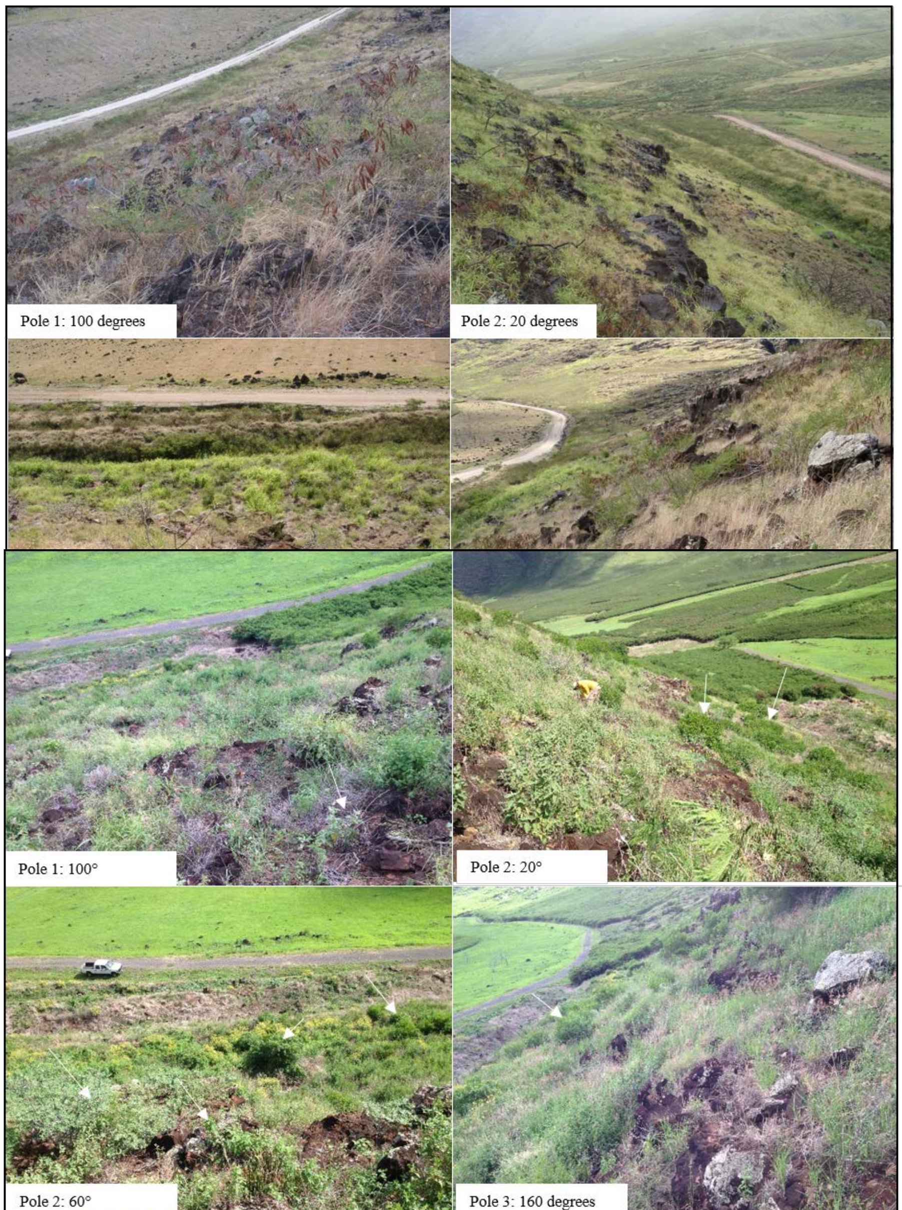
These designations facilitate different aspects of MIP/OIP requirements.

Vegetation Monitoring

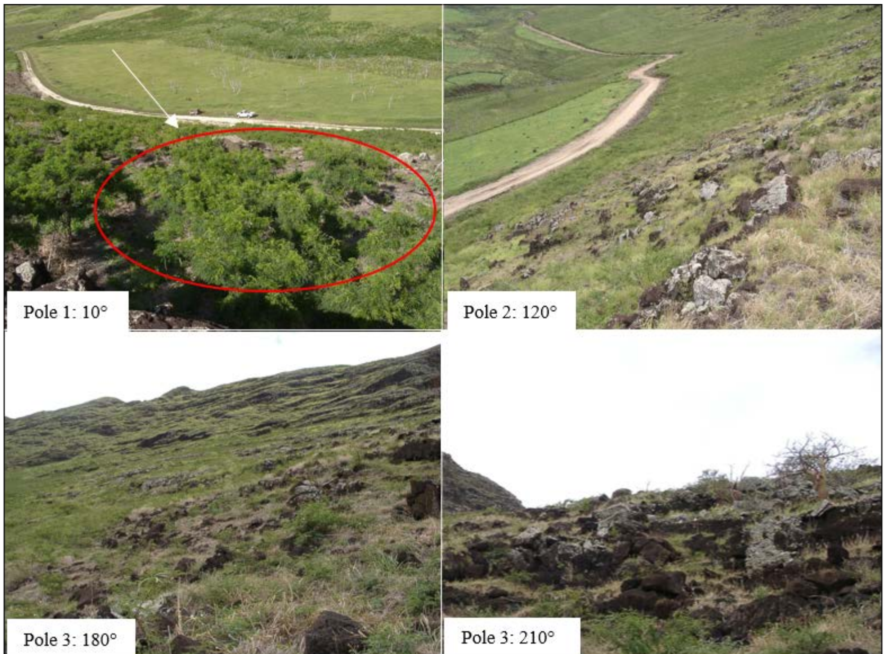
<u>Objectives:</u>

Due to the small size and highly degraded nature of MU, transect protocols implemented at other MUs are not appropriate here. Recruitment of new rare taxa seedlings and increase of native plant vegetation will be monitored to determine if time intervals between scheduled weeding are sufficient. Initial photopoint monitoring of the re-vegetation areas began in 2001 to monitor the change of native shrub cover in WCA-01, -02 and -03 (See pictures below). Monitoring of native shrub cover change for WCA-01, -02, and -03 using Gigapan imagery was then initiated in 2016. Baseline results are included in Appendix A at the end of this document. We assume current alien vegetation management practices are sufficient to decrease fuels and increase the rare plant populations.

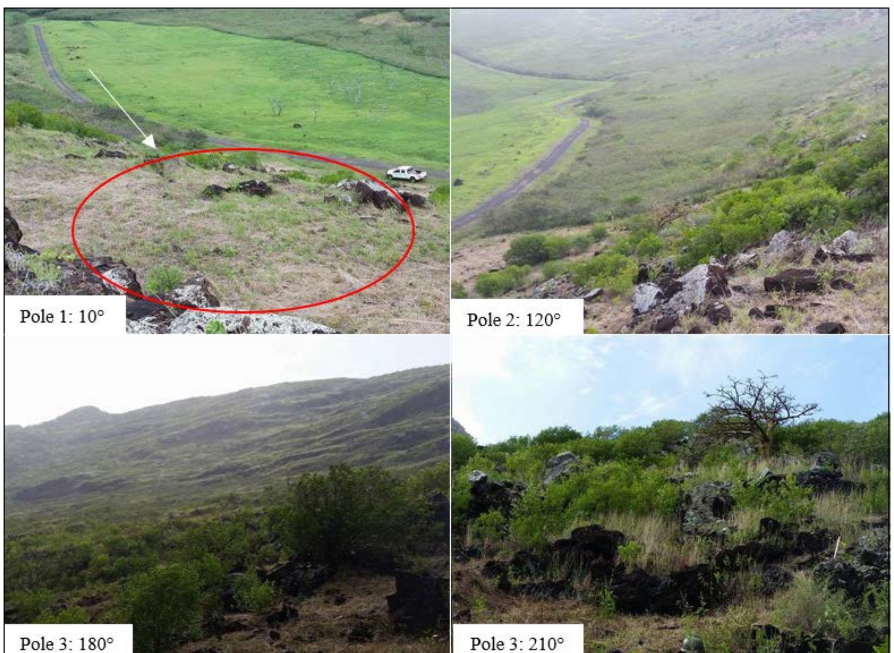
Photopoint Monitoring Ohikilolo Lower



WCA-01. Photopoints are taken at specific locations (Total of 3) in WCA using designated degrees (i.e. 20°, 60°, 100°, 160°). Pictured above are some of the photopoints taken in 2014. Arrows indicate *Waltheria indica, Abutilon indica* and *Dodonea viscosa* recruitment.



WCA-02. Photopoints are taken at specific locations (Total of 3) in WCA using designated degrees (i.e. 10°, 120°, 180°, 210°). Pictured above are some of the photopoints taken in 2002. Arrow in picture of Pole 1: 10° is highlighting an area that was dominated by *Leucaena leucocephala*.



WCA-02. Photopoints are taken at specific locations (Total of 3) in WCA using designated degrees (i.e. 10°, 120°, 180°, 210°). Pictured above are some of the photopoints taken in 2015. Arrow in picture of Pole 1: 10° is highlighting an area that was dominated by *Leucaena leucocephala*. Now same area is clear of *L. leucocephala* and has *Dodonea viscosa* recruitment.

WCA-03. Photopoints are taken at specific locations (Total of 8) in WCA using designated degrees (i.e. 20°, 30°, 90°, 140°, 270°, 300°, 340°). Pictured above are some of the photopoints taken in 2002. Area was dominated by *Urochloa maxima* and *Leucaena leucocephala.*

WCA-03. Photopoints are taken at specific locations (Total of 8) in WCA using designated degrees (i.e. 20°, 30°, 90°, 140°, 270°, 300°, 340°). Pictured above are some of the photopoints taken in 2015 (except Poles 1 and 5 pics taken in 2014). Area once was dominated by *Urochloa maxima* and *Leucaena leucocephala,* but now vegetation is majority *Dodonea viscosa.*

Surveys

Army Training: Yes

Other Potential Sources of Introduction: Recreational hikers (trespassing), Natural Resource Management staff, Makua access events, close proximity to road.

Survey Locations: Roads, Fences, and LZ's.

Management Objective:

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

Monitoring Objectives:

- Firebreak road survey annually
- Survey army LZs annually
- Annual surveys of fencelines and main access trail. Additionally, during course of regular planned actions for endangered taxa, unusual weeds encountered will be noted.

Management Responses:

- New weeds found during surveys along the firebreak road and LZs will be added as ICAs if they are deemed a serious threat to the MU.

Incipient Taxa Control (ICAs)

Management Objective:

- As feasible, eradicate high priority species identified as incipient invasive aliens in the MU by 2019.
- Cooperate with range maintenance staff for control of *C. setaceus* in areas with prohibited access to OANRP staff or areas managed exclusively by range staff with goal of eradication.

Monitoring Objective:

- Visit ICAs at stated re-visitation intervals. Control all mature plants at ICAs and prevent any immature or seedling plants from reaching maturity.
- Use binoculars and spotting scopes to survey buffer areas for *C. setaceus* annually (or more frequently as needed).

Management Responses:

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

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

The table below summarizes invasive taxa at Ohikilolo Lower. This MU was described in Appendix 3.1 of the MIP, which lists significant alien species and ranks their potential invasiveness and distribution. This table supplements Appendix 3.1 by identifying target species for Ohikilolo Lower. While the list is by no means exhaustive, it provides a good starting point for discussing which taxa should be targeted for eradication in the MU. Three management designations are possible: Incipient (small populations, eradicable); Control Locally (significant threat posed, may or may not be widespread, control feasible at WCA level); and Widespread (common weed, may or may not pose significant threat, control feasible at WCA level).

There are currently three ICAs identified for one species, *C. setaceus*, in this MU. In 2006, one immature plant was found in the Lower Akoko Patch; ICA MMR-CenSet-01 was created to track follow-up control, but no plants were seen and the ICA was declared eradicated. In 2011, staff found another plant along the fence above the Upper Akoko Patch, and later surveys revealed a large infestation centered outside the MU, on the ocean-facing cliffs of Ohikilolo ridge. This is ICA MMR-CenSet-02. While the source of the infestation is not known, it is possible that recreational hikers may have introduced it when hiking to a cave or along the fence; C. setaceus is common along the popular Lanikai and Diamond Head trails. Control efforts are on-going and include ground sweeps and aerial sprays. Aerial sprays are necessary in order to target *C. setaceus* plants that are growing on cliffs and extremely steep areas. More thorough surveys are needed in the future to assess the distribution and spread of *C. setaceus*. Although much of the terrain is steep and hazardous to survey by hiking, scoping from vantage points with binoculars and spotting scopes will be the most efficient and effective means to survey.

The aerial image below shows MMR-CenSet-02, and outlines different geographic regions within the ICA. These divisions are helpful when planning actions and field work, particularly since the ICA is so large.

Staff conducted a buried seed trail of *C. setaceus* and found that it does not form a persistent seed bank. No seeds germinated after one year. Therefore, to achieve eradication of an ICA, regular checks must find no plants for at least 2-3 years, which is several times seed longevity, and accounts for the fact that plants may escape detection on any one visit.

Aerial image of the *C. setaceus* infestation.

This year, staff found two outlier locations of C. setaceus along the firebreak road; these are ICAs MMR-CenSet-03 and MMR-CenSet-04. Control activities for all ICAs are detailed in the Action Table at the end of this plan.

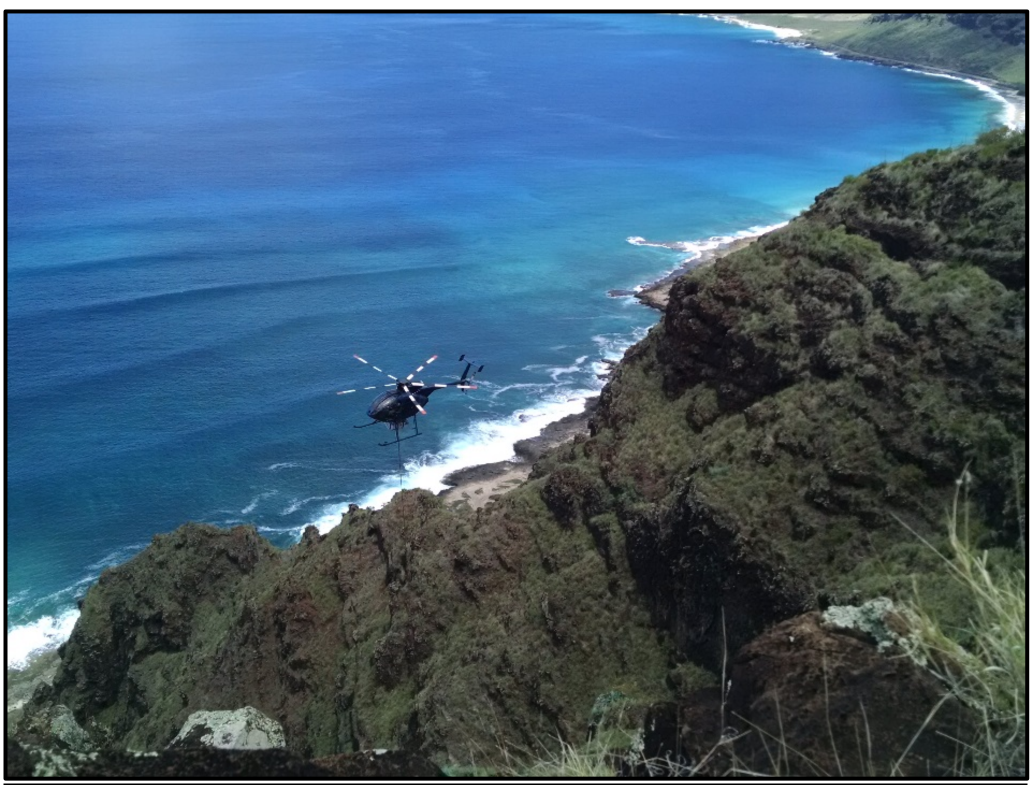
The table below summarizes target taxa considerations at Ohikilolo Lower.

Summary of Target Taxa

Taxa	Management Designation	Notes	No. of ICAs
Acacia farnesiana	Widespread	While this taxon can grow into a tree, it is usually shrub-sized in Ohikilolo Lower. Covered in thorns, it is removed whenever found during weed sweeps. It has been removed from all WCAs.	0

Caesalpinia decapetala	Incipient	One plant was seen growing out of fill along the firebreak road. This ICA has now been eradicated, with no plants seen for more than 10 years. This thorny vine can take over entire gulches. Staff will look for new locations during road surveys.	1 extirpated
Cenchrus setaceus	Incipient	This is one of the most invasive grasses in Hawaii. It is adapted to fire, and thrives in marginal, rocky habitat. It is a high priority for control.	1 extirpated, 3 active
Desmanthus virgatus	Widespread	*D. virgatus* forms dense thickets, and has colonized areas around rare taxa. It is easily controlled via clip and drip treatment of basal stems with Garlon 4 (20% dilution in biodiesel).	0
Kalanchoe pinnata	Widespread	This species' common name is 'Never-die.' It is a drought-tolerant succulent, and thrives on rocky substrates. It appears to use the same habitat as *E. celastroides* and may reduce available habitat for seedling germination. Research is needed to identify effective control measures for this taxon.	0
Leonotis nepetifolia	Widespread	This weedy mint thrives in disturbed areas, and forms dense banks that completely cover open areas. When this annual plant dies, the stalks remain standing for months. When weed control first began at this MU, this taxon was not common, but the weed control regime appears to favor it and other fast-growing annuals.	0
Leucaena leucocephala	Widespread	This is the most common woody plant in the MU. *L. leucocephala* is well-adapted to fire and resilient to disturbance. It can be controlled using a 40% dilution of Garlon 4 Ultra in biodiesel, or using IPA with Milestone.	0
Melinis repens	Widespread	This short statured grass thrives on rocky substrates and is major threat around rare taxa locations. It is removed either via glyphosate sprays or handpulling.	0
Stapelia gigantea	Widespread	A spreading succulent, this taxon was rare in the MU in 2001 and has since spread across rocky areas around *E. celastroides* sites. It appears to use the same habitat as *E. celastroides* and may reduce available habitat for seedling germination. Research is needed to identify effective control methods for this taxon.	0
Urochloa maxima	Widespread	The dominant vegetation in the MU, this grass is well-adapted to fire and has a high burn index. Eliminating it around rare taxa is a priority for reducing fire threat.	0
Verbesina encelioides	Widespread	This fast-growing aster flowers and spreads prolifically. It recently showed up in the MU, and is expected to become more prevalent in weeded areas as it colonizes bare ground.	0

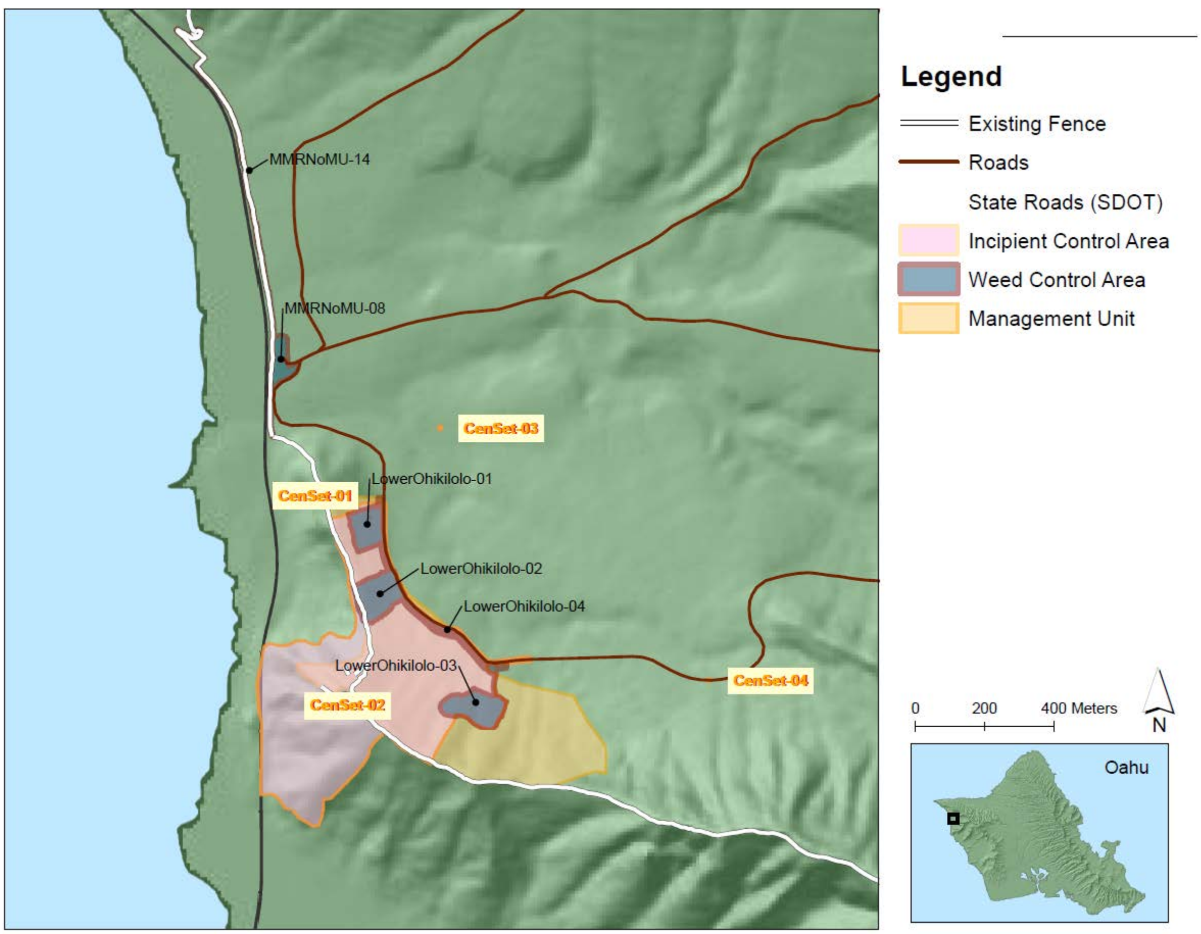
Staff working around *E. celastroides*



Helicopter spraying of *C. setaceus* on cliffs

Ground surveys and sweeps for *C. setaceus* on cliffs

Incipient and Weed Control Areas



Ecosystem Management Weed Control (WCAs)

MIP Goals:

- Within 2m of rare taxa: 0% alien vegetation cover without harming rare taxa
- Within 50m of rare taxa: 0% alien canopy, 10% or less alien grasses, 25% or less alien understory
- Throughout the remainder of the MU: 50% or less alien vegetation cover

Management Objectives:

- Across WCAs, maintain alien cover levels of less than 50%, and work towards native cover levels of more than 50%.
- The remainder of the MU (tan/hatched area on map above) is designated as Priority 2. No objectives are currently identified for this area, which is dominated by *U. maxima* and *L. leucocephala*.

Management Responses:

- Increase/expand weeding efforts if shorter intervals are needed between weeding efforts

Weed control in Lower Ohikilolo by OANRP has mostly been conducted around populations of wild and reintroduced rare plants. The overall weed management strategy for the MU is focused on fuel reduction of large patches of *U. maxima* and *M. repens*. A 20m buffer around the outside of each WCA has been proposed, but contracting of the project has not been completed. Herbicide control of weeds is varied, with Fusilade, a grass-specific herbicide, used around rare taxa, along with hand-pulling weeds. Glyphosate is applied to the remainder of the WCA; while Oust, a pre-emergent herbicide, is applied downslope of rare taxa to suppress the seed bank after initial knockdown of weeds using Roundup/RangerPro. To prevent re-sprouts of *Leucaena leucocephala* in and around the extended buffer area of the WCA, Garlon and/or Milestone is applied. Much of the native cover in Lower Ohikilolo is dominated by *Dodonaea viscosa, Waltheria indica*, *Abutilon incanum*, *Sida fallax,* and a limited number of *Santalum ellipticum and Erythrina sandwicensis. Dodonaea viscosa* are numerous and more abundant throughout the MU due to weeding efforts and the absence of fires, and provide shade in monotypic areas of *U. maxima*. The MU is very weedy except for patches around *D. viscosa*. After spraying and treating for *U. maxima*, invasive weeds such as *L. leucocephala, Leonotis nepetifolia*, *M. repens*, and *Acacia farnesiana*, become dominant and encroach onto the rare and native taxa. The weed structure has changed to fast-maturing weeds, which has heightened the need for restoration plantings, as constant clearing only continues to select for weedy herbs and grasses. Additionally, a weed mat experiment has been conducted in order to help suppress weeds around the *E. celastroides* var. *kaenana* and *H. brackenridgei* subsp. *mokuleianus* plants, with limited success. In addition to weed mat, common native plants such as *D. viscosa*, *E. sandwicensis, and Myoporum sandwicense* have been outplanted to reduce weed control efforts. *D. viscosa* also has also recruited naturally in the WCA's more than other native taxon.

Restoration activities are discussed in the notes section for each WCA. See the table titled 'Taxa considerations for restoration actions,' below, for specific notes on what taxa are suited to Ohikilolo Lower.

WCA: Lower Ohikilolo-01 (Lower Akoko Patch, 2.5 acres)

Veg Type: Dry Shrubland/Grassland

MIP Goal: Less than 25% non-native cover

Targets: All weeds, particularly *U. maxima*, *L. leucocephala,* and *L. nepetifolia.*

Notes: *Euphorbia celastroides* var. *kaenana* is centered in the middle of the WCA. This area is very steep with many exposed rock faces. The bottom of the WCA tapers off to a relatively flat area with two long mounds of soil near the road. Weedy grasses are prevalent throughout the WCA, especially near the top and bottom. The WCA is very dry with limited overstory and is dominated by non-native understory of *U. maxima*, *L. leucocephala, L. nepetifolia*, *M. repens*, and *A. farnesiana*, and the natives *W. indica*, *A. incanum*, *S. fallax*. Woody taxa are limited to the native *D. viscosa* and *E. sandwicensis.* Treatment of most weeds is done by backpack spraying and handpulling around managed taxa. A change in weed composition from *U. maxima* and *M. repens* to monotypic *L. nepetifolia* has recently occurred following the application of Oust near the bottom of the patch. Incorporating weedwacking into chemical control of weeds in this WCA is effective at reducing fuel load, but it is very labor-intensive and results are short-lived. While a majority of the WCA surrounding rare plant populations is very rocky and difficult to outplant common species, the bottom section of the patch near the road has more soil. Future plans to control fuel load and invasive grass expansion into the rare plant zone include outplanting *M. sandwicense*, *Scavola taccada* and *D. viscosa* near the bottom of the patch to provide a native plant barrier and ideally shade out weedy grasses.

WCA: Lower Ohikilolo-02 (Upper Akoko Patch: 3.5 acres)

Veg Type: Dry Shrubland/Grassland

MIP Goal: Less than 25% non-native cover

Targets: All weeds, particularly *U. maxima, L. leucocephala, D. virgatus, A. farnesiana,* and *L. nepetifolia*.

Notes: *Euphorbia celastroides* var. *kaenana* is centered in the middle of this WCA. This area is very steep with exposed rock faces leading up to the ridgeline and fence. Near the top of the WCA, there is a large flat shelf. The WCA is very dry and rocky, and is bordered by thick, invasive shrubland and grasses. Large *D. viscosa* are filling in the WCA following control of monotypic *U. maxima*. The WCA is dominated by non-native *U. maxima*, *L. leucocephala, L. nepetifolia*, *M. repens*, *A. farnesiana* and the natives *W. indica*, *S. ellipticum*, *A. incanum*. Woody taxa are limited to the native *E. sandwicensis* and *D. viscosa*. Weeds are controlled by backpack spraying herbicide and handpulling/careful spraying around managed taxa. A successional emergence of weed replacement is typical after backpack spraying with herbicide. *Leonotis nepetifolia* and *Verbesina encelioides* quickly invade bare ground, making control of these weeds most difficult. Suppression of weeds by chemical treatment has been aided with the addition of ~600 common outplants, including *E. sandwicensis*, *M. sandwicense*, and *Scaevola taccada* focused near the bottom of the WCA and *D. viscosa* along the flat plateau above the catchment tank. The long-term strategy is to fill in bare areas left by chemical control with common outplants and eventually reduce grass cover and herbicide application in the MU. Grass control around common native outplants is critical for their survival. To aid in control of grass, installation of rubber mulch weed rings will be tested for effectiveness around *M. sandwicense.* Future outplantings should prioritize *M. sandwicense,* as it has grows wide quickly, which suppresses grassy species more effectively, and shown high survival in the past. *Stapelia gigantean* and *Kalanchoe crenata* are invasive weeds that colonizing rocky areas favored by EupCelKae. Trials are needed in the future to identify control methods for these species, as there overall ground cover seems to be increasing. Small fires are common on the makai side of the ridge behind WCA-2. To prevent these fires from jumping the ridge down into the WCA, we will control grasses on the ridge area with Oust and glyphosate and keep it as bare as possible to create a fire break. Most of our common outplanting efforts are focused on this WCA, with future plans to expand to other WCAs in the MU.

Left: WCA-2, Upper Patch. Right: WCA-1, Lower Patch.

WCA: Lower Ohikilolo-03 (Hibiscus Patch, 3.6 acres)

Veg Type: Dry Shrubland/Grassland

MIP Goal: Less than 25% non-native cover

Targets: *U. maxima*

Notes: *Hibiscus brackenridgei* subsp. *mokuleianus* is centered in this WCA, which is the largest in the MU. The topography is a combination of rocky cliff faces and rocky slopes, with a mix of rocky and deep soils. Hand weeding and careful herbicide weeding is done around emerging seedlings, as well as backpack spraying for large grass areas. This WCA is dominated by the grasses *U. maxima* and *M. repens*. The WCA contains more mature *D. viscosa* than the other WCAs, most of which have recruited since weed control began. As with the other WCAs in this MU, the area is very dry, steep, and rocky. Additional weeds include *L. leucocephala, L. nepetifolia*, *M. repens*, *Bidens pilosa*, *A. farnesiana* and *Ageratina adenophora*. Upslope areas closer to the ridgeline have recovered well from the 2003 fire with native shrubs now dominating the community. Weed control is aided with the addition of ~100 common outplants concentrated around the upper portion of the WCA near the most recent wild and outplanted *H. brackenridgei* subsp. *mokuleianus*. Future outplantings will include *M. sandwicense* in the lower right portion of the WCA, as there is a small water seep there and it is usually difficult to control invasive grass in the area. Over the next five years, plans for common outplantings include filling in gaps between existing natives across the lower part of the WCA. Provided the outplantings grow quickly, these native plants will be able to establish and shade out invasive grasses.

H. brackenridgei subsp. *mokuleianus* patch of wild and reintroduction plants (WCA-3)

WCA: Lower Ohikilolo-04 (Lower Ohikilolo Roadside, 1.5 acres)

Veg Type: Dry Shrubland/Grassland

MIP Goal: Less than 50% non-native cover

Targets: *U. maxima, L. leucocephala, L. nepetifolia*

Notes: This WCA spans the roadside stretches beneath WCA-01, -02, and -03. These areas are dominated by *U. maxima* and *L. nepetifolia*. The purpose of this MU is to expand the road fuel break and provide additional protection to the entire MU from fire originating from within the firebreak road. Additional weeds include *L. leucocephala,*, *M. repens*, *B. pilosa*, *A. farnesiana* and *A. adenophora*. Trials of herbicide mixtures have also been conducted along this WCA. Control of weeds in this WCA is generally done using a powersprayer on an as needed schedule. Annual road surveys are conducted to monitor the spread of target weeds across theWCA. In 20XX, the Army began consistently mowing a wide band along the inside of the firebreak road directly across from WCAs 01, 02 and 03. This mowed area further reduces fuel loads in the MU. As a result, controlling grass in WCA-04, outside the firebreak road, has become less important for fire threat minimization.

Taxa Considerations for Restoration Actions

Native Taxon	Outplant?	Seedsow/ Division/ Transplant?	Notes
Abutilon incanum	Unknown	Unknown	Herb. Consider testing utility of this species in restoration plantings, particularly in areas around rare taxa.
Dodonea viscosa	Yes	No	Small Tree. Continue dense outplantings. *D. viscosa* forms dense shade which reduces weed growth. It is recruiting naturally in the WCAs.
Erythrina sandwicensis	Yes	No	Tree. Continue outplanting. While this tree is deciduous and does not suppress weeds as well as other taxa on this list, it is an important component of dry forest ecosystems.
Heteropogon contortus	Yes	Yes	Grass. (not sure we want to plant any grasses, including native ones, into area??)
Myoporum sandwicense	Yes	No	Small Tree. Continue outplanting. This species casts dense shade, suppressing weeds. The leaves are thick, and may be a poor fire carrier.
Psydrax odorata	Yes	No	Tree. (not sure we should include this taxon, almost none left in region. But could be useful in Hibiscus patch)
Santalum ellipticum	Yes	No	Small Tree. Continue outplanting. This species casts dense shade, suppressing weeds. The leaves are thick, and may be a poor fire carrier.
Scaevola taccada	Yes		Shrub. Continue outplanting as a green fuelbreak along roadsides.
Sida fallax	Unknown	Unknown	Herb. Consider testing utility of this species in restoration plantings, particularly in areas around rare taxa.

Waltheria indica	Unknown	Unknown	Herb. Consider testing the efficacy of seed sows of this fast-growing plant. May suppress weeds, particularly in areas around rare taxa.

Rodent Control

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

Threat level: Unknown

Current control method: None

Seasonality: N/A

Number of control grids: None

Primary Objective:

- To implement rodent control if determined necessary for the protection of rare plants.

Monitoring Objective:

- Monitor rare plants (*E. celestroides* var. *kaenana* and *H. brackenridgei* subsp. *mokuleianus*) populations to determine impacts by rodents.

MU Rodent Control:

- Currently no rodent control is conducted by OANRP around these taxa since rodents are not deemed a threat at this time. If rare plants are determined to be impacted adversely by rodents OANRP will evaluate the use of localized rodent control for the protection of these species.

Ant Control

Species: Unknown

Threat level: Unknown

Control level: Unknown

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

Number of sites: Two; *Euphorbia celastroides* var. *kaenana* population containing two separate patches

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

Primary Objective: Collect data on species present and control if ant densities are high enough to threaten rare resources.

Management Objective:

- If incipient species are found and deemed to be a high threat or impact on rare taxa, and/or easily eradicated locally (<0.5 acre infestation) begin control.

Monitoring Objective:

- Sample ants at *E. celastroides* var. *kaenana* population including along the road and fenceline. Use samples to track changes in existing ant densities and to alert OANRP to any new introductions.
- Look for evidence of ant tending of aphids or scales on rare plants.

Ants have been documented to pose threats to a variety of resources, including native arthropods, plants (via farming of Hemipterian pests, and deterring effective pollinators), and birds. It is therefore important to know their distribution and density in areas with conservation value. Standardized surveys have not yet taken place but will be considered in the future.

Slug Control

Species: Unknown

Threat level: Unknown

Control level: Unknown

Seasonality: N/A

Number of sites: Currently, no sites within this MU

Primary Objective:

- Eradicate slugs locally to ensure germination and survivorship of rare plant taxa.

Monitoring Objectives:

- Monitor rare plants (*E. celestroides* var. *kaenana* and *H. brackenridgei* subsp. *mokuleianus*) populations to determine impacts by slugs.

MU Slug Control

- There is currently no slug control conducted by OANRP around these taxa since slugs are not considered a threat at this time. If rare plants are determined to be impacted by slugs, OANRP will evaluate the use of slug control for the protection of these species.

Fire Control

Threat Level: High

Available Tools: Fuelbreaks, Visual Markers, Helicopter Drops, Army Wildland Fire Crew.

Management Objective:

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

Preventative Actions

Fire control in the Ohikilolo Lower MU is focused on fuel-break construction and management. Backpack spraying of herbicide is used to control grasses and weeds while reducing the fuel load of the area. The threat of fire is high due to the large fuel load and hot, dry climate, and many fires are intentionally set by vandals along Farrington Highway, near the MU. These fires are set regularly and have a high risk of burning over Ohikilolo Ridge and into the MU. Future weed control along the ridge above the upper akoko patch, on the outside of the MU fence, will be implemented during scheduled WCA spraying to limit the risk of fire burning over the ridge. Removal of the most fire prone weeds (*A. farnesiana, L. leucocephela* and *U. maxima)* remains a high priority within the MU. Sprayed areas with large patches of dead grass are also weedwhacked to reduce standing dead vegetation and create a buffer around endangered taxa. Plans are in place to cut an additional 20m buffer, maintained as bare ground, extending the entire weed control area around each managed plant population. To create a green fuel break buffer for the *E. celestroides* var. *kaenana* patch and decrease power spraying efforts along the road, *S. taccada* plants were outplanted along the bottom edge of this patch. If the outplanted *S. taccada* are successful in suppressing *U. maxima*, more *S. taccada* and other common native plant species will be planted in the future. OANRP will focus on maintaining good communication with the Wildland Fire Working Group to facilitate positive on-the-ground fire response in the event of another fire.

Map removed to protect rare resources

Left: *E. celastroides* area burned by 2003 Makua fire. Right: Lower Ohikilolo fire view from the North.

View of 2011 Ohikilolo Lower fire from C-Ridge

Action Table

The table below is a comprehensive list of threat control actions planned for the MU for the next five years. Actions are grouped by type; for example, Ungulate Control or Ant Control. Weed control actions are grouped into the following categories: General Survey, ICA, or WCA code. Cells filled with hatch marks denote the quarters in which an action is scheduled. IP years run from October of one year through September of the next. Therefore, Quarter 4 (October-December) is listed first for each report year, followed by Quarter 1 (January-March), Quarter 2 (April-June), and Q3 (July-September). Species names are written as six-digit abbreviations, such as 'CenSet' instead of *Cenchrus setaceus*, for brevity.

Action Type	Actions	MIP Year 12 Oct 2016-Sept2017				MIP Year 13 Oct 2017-Sept2018				MIP Year 14 Oct 2018-Sept2019				MIP Year 15 Oct 2019-Sept2020				MIP Year 16 Oct 2020-Sept 2021			
		4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
Vegetation Monitoring	Conduct gigapan monitoring of shrub cover every 3-5 years.										X										
General Survey	RS-MMR-01: Survey both north/south firebreak and side roads. All roads used for training should be included - avoid sites with UXO. Record route with GPS track. If see any soil/fill stockpiles, survey carefully around them and note location.		X				X				X				X				X		
	LZ-MMR-077: Survey Makua Range Control LZ whenever used, not to exceed once per quarter. If not used, do not need to survey. Range control LZ survey		X				X				X				X				X		
ICA	MMR-CenSet-02: Survey Makua for CenSet, define/modify boundaries of infestation, identify core areas, identify areas with scattered plants, and identify any outliers.	X												X							
	MMR-CenSet-02: Sweep walkable areas and control plants found quarterly, transitioning to 2x/year during winter. High priority spots: Upper and Lower ChaCelKae patches; slopes/ledges on makai side of ridge by upper cave; fencelines; bowl on Keaau side of Makua Cave. 2nd priority spots: Hibiscus patch; bottom of cliffs below Melten cliffs. Pick and remove from field any potentially viable fruit.	X	X	X	X	X	X	X	X	X	X			X	X			X	X		
	MMR-CenSet-02: Spray steep portion of infestation aerially, 2-4x per year. Avoid areas near rare plants and areas where hazardous to use heli. Use ball sprayer. Use spotters in heli and/or on ground to guide pilot.	X	X	X	X	X	X	X	X	X	X			X	X			X	X		

Action Type	Actions	MIP Year 12 Oct 2016-Sept2017				MIP Year 13 Oct 2017-Sept2018				MIP Year 14 Oct 2018-Sept2019				MIP Year 15 Oct 2019-Sept2020				MIP Year 16 Oct 2020-Sept 2021			
		4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
	MMR-CenSet-02: Treat cliffside plants with HBT or alternate technique from ground and air. This method is experimental. Use on plants cannot reach with other tools.																				
	MMR-CenSet-02: Survey following regions with binoculars/spotting scope or ground surveys annually for outlying CenSet: 1. Zone between Upper and Lower Chamaesyce patches; 2. Zone between Hibiscus and Upper Chamaesyce patches.																				
	MMR-CenSet-02: Assist OISC with this action as requested. Control plants on the Keaau, private land portion of the infestation via handpulling. Herbicide not allowed by landowner. Pick and remove from field any potentially viable fruit.																				
General WCA	Water catchments: repair/maintain as needed. 3 catchments in MU.																				
Lower Ohikilolo-01: Lower Eupcelkae	Control grasses and herbaceous weeds across entire WCA (excluding marked rare plant zones) quarterly, as needed. Goals: maintain low fuel levels, encourage native recruitment. Primary control methods: spraying, weedwhacking. Only use Oust downslope of rare taxa as Oust will kill ALL germinating seeds.																				
	Control weeds in marked rare plant zones quarterly/as needed. Exercise extreme care when working/spraying around rare taxa and seedlings; NO Oust.																				
	Control woody weeds (LeuLeu, Acafar) across the entire WCA annually. Goal: reduce/maintain coverage at 0%.																				
	Take photopoints in Lower Patch 1x/yr. Use Master Photo sheet to re-take photos.																				

Action Type	Actions	MIP Year 12 Oct 2016-Sept2017				MIP Year 13 Oct 2017-Sept2018				MIP Year 14 Oct 2018-Sept2019				MIP Year 15 Oct 2019-Sept2020				MIP Year 16 Oct 2020-Sept 2021			
		4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
Lower Ohikilolo-02: Upper Eupcelkae	Control grasses and herbaceous weeds across entire WCA (excluding marked rare plant zones) quarterly, as needed. Goals: maintain low fuel levels, encourage native recruitment. Primary control methods: spraying, weedwhacking. Only use Oust downslope of rare taxa as Oust will kill ALL germinating seeds.																				
	Control weeds in marked rare plant zones quarterly/as needed. Exercise extreme care when working/spraying around rare taxa and seedlings; NO Oust.																				
	Control woody weeds (LeuLeu, Acafar) across the entire WCA annually. Goal: reduce/maintain coverage at 0%.																				
	Take photopoints in Upper Patch 1x/yr. Use Master Photo sheet to retake photos.																				
Lower Ohikilolo-03: Hibbra patch	Control grasses and herbaceous weeds across entire WCA (excluding marked rare plant zones) quarterly, as needed. Goals: maintain low fuel levels, encourage native recruitment. Primary control methods: spraying, weedwhacking. Only use Oust downslope of rare taxa as Oust will kill ALL germinating seeds.																				
	Create/maintain buffer fuel break around entire LowerOhikilolo-03. ADD NEW WCA IF THIS ACTION COMPLETED (Need to contract)																				
	Control weeds in marked rare plant zones quarterly/as needed. Exercise extreme care when working/spraying around rare taxa and seedlings; NO Oust.																				
	Control woody weeds (LeuLeu, Acafar) across the entire WCA annually. Goal: reduce/maintain coverage at 0%.																				
	Take photopoints in Hibiscus Patch 1x/yr. Use Master Photo sheet to re-take photos.																				
Lower Ohikilolo-04: Roadway	Control grasses, broadleaves along road corridor quarterly, as needed; not priority when grass being maintained within firebreak. Goal: maintain fuel break along road. Use powersprayer.																				

Action Type	Actions	MIP Year 12 Oct 2016-Sept2017				MIP Year 13 Oct 2017-Sept2018				MIP Year 14 Oct 2018-Sept2019				MIP Year 15 Oct 2019-Sept2020				MIP Year 16 Oct 2020-Sept 2021			
		4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
Rodent Control	Monitor rare plants for predation by rodents																				
	Implement localized rodent control if determined to be necessary for the protection of rare plants																				
Ant Control	Sample ants at *Euphorbia celastroides* var. *kaenana* population																				
	If ants exceed acceptable level begin control																				
Restoration	Outplant commons into Upper Akoko and Hibbra patch																				
Ungulate Control	Melten MMR-D fence: Fence maintenance (as needed)																				
	Melten MMR-D fence: Fence monitor																				

Hatching=Quarter Schedule

Appendix A:

BASELINE RESULTS FOR MONITORING NATIVE SHRUB COVER IN WEEDED AREAS AT *HIBISCUS BRACKENRIDGEI* SUBSP. *MOKULEIANUS* MMR-F AND *EUPHORBIA CELASTROIDES* VAR. *KAENANA* MMR-D, OHIKILOLO LOWER MANAGEMENT UNIT, 2016

BACKGROUND AND METHODS

Baseline data was obtained at Ohikilolo Lower MU to assess change in native shrub cover over time at the weed control areas (WCA) for *Hibiscus brackenridgei* subsp. *mokuleianus* MMR-F (WCA-03) and *Euphorbia celastroides* var. *kaenana* MMR-D (WCA-01 and WCA-02) using gigapixel panoramic imagery (www.gigapan.com). Non-woody plants were not monitored as cover of these plant types is much more variable than shrubs in association with rainfall levels, and due to difficulties distinguishing native vs. non-native taxa in the imagery. Non-native cover was not monitored, as non-native shrub cover is presumed to be minimal as a result of weeding efforts, and non-woody cover for non-native taxa may vary greatly in association the amount of time since the last weeding effort as well as rainfall levels.

Panoramic imagery was obtained in January 2016 using a GigaPan Epic 100 robotic mount fitted with a Canon PowerShot SX30 IS digital camera (Figure 1). Panoramas were stitched using GigaPan Stitch Version 2.1.0161. Imagery was taken following WCA weeding and grass spraying, such that WCA boundaries were readily distinguishable, and any shrubs (woody plants) identified within the WCAs were presumed native. Cover estimates were obtained from sampled areas within an arbitrary grid of images within the panoramas (Figure 2). Sampled images were processed in Adobe Photoshop Elements 10. Within sampled images, all regions containing shrubs were selected using a line drawing tool (Figure 3). Herbaceous plants, succulents and grasses were not selected. The proportion of selected pixels in relation to the total number of pixels within the image was used to estimate cover. In instances where images included non-weeded areas (on WCA edges), cover estimates were derived from the proportion of selected pixels in relation to the total number of pixels within weeded areas. Because weeded areas did not always cover the entire image – in some instances only a small portion of the image depicted weeded areas – mean estimates of percent cover were weighted by the number of pixels within the weeded areas. Statistical analyses were performed in IBM SPSS Statistics Version 24.

RESULTS

At the *H. brackenridgei* subsp. *mokuleianus* MMR-F WCA, native shrub cover among images ranged from 7.4 to 75.5%, with a weighted mean of 37.5% (n = 24). Native shrub cover at the *E. celastroides* var. *kaenana* MMR-D WCAs ranged from 0.3% to 53.6%, with a weighted mean of 17.8% (n = 23).

DISCUSSION

While estimates of percent cover taken from a distant, angled perspective may differ from in situ measurements, differences are not likely substantial, and trends in cover change should be effectively tracked. Native shrub cover is expected to increase over time in response to weeding and outplanting efforts. Re-monitoring should occur at an interval in which change is expected to occur. An interval of three to five years would likely be sufficient. Re-monitoring using GigaPan® imagery should occur following weeding efforts to ensure that shrubs in the imagery are native, and at the same time of year to minimize seasonality influences.

Figure 1. GigaPan® imagery of a) *Hibiscus brackenridgei* subsp. *mokuleianus* MMR-F (WCA-03) and b) *Euphorbia celastroides* var. *kaenana* (WCA-01, right; and WCA-02, left).

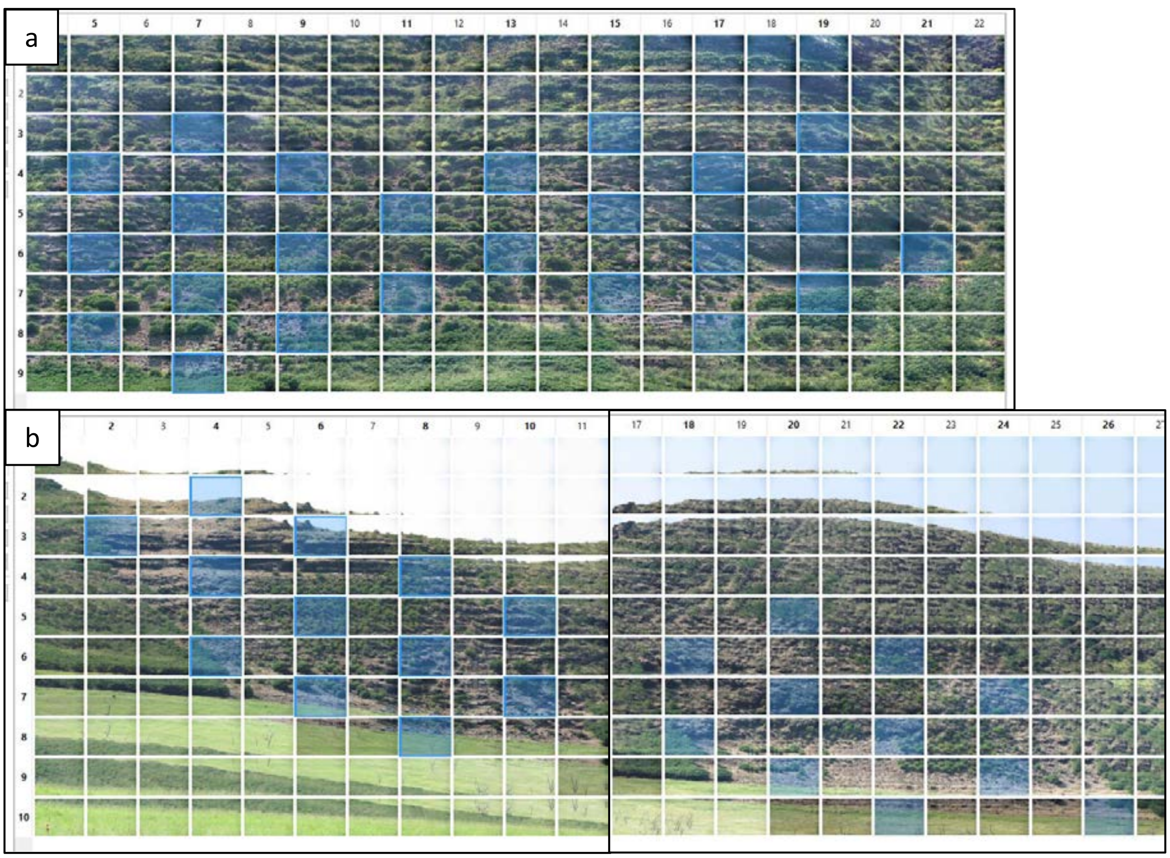


Figure 2. Sampled images (highlighted in blue) from within unstitched panoramas at a) *Hibiscus brackenridgei* subsp. *mokuleianus* MMR-F (WCA-03) and b) *Euphorbia celastroides* var. *kaenana* (WCA-01 and WCA-02).

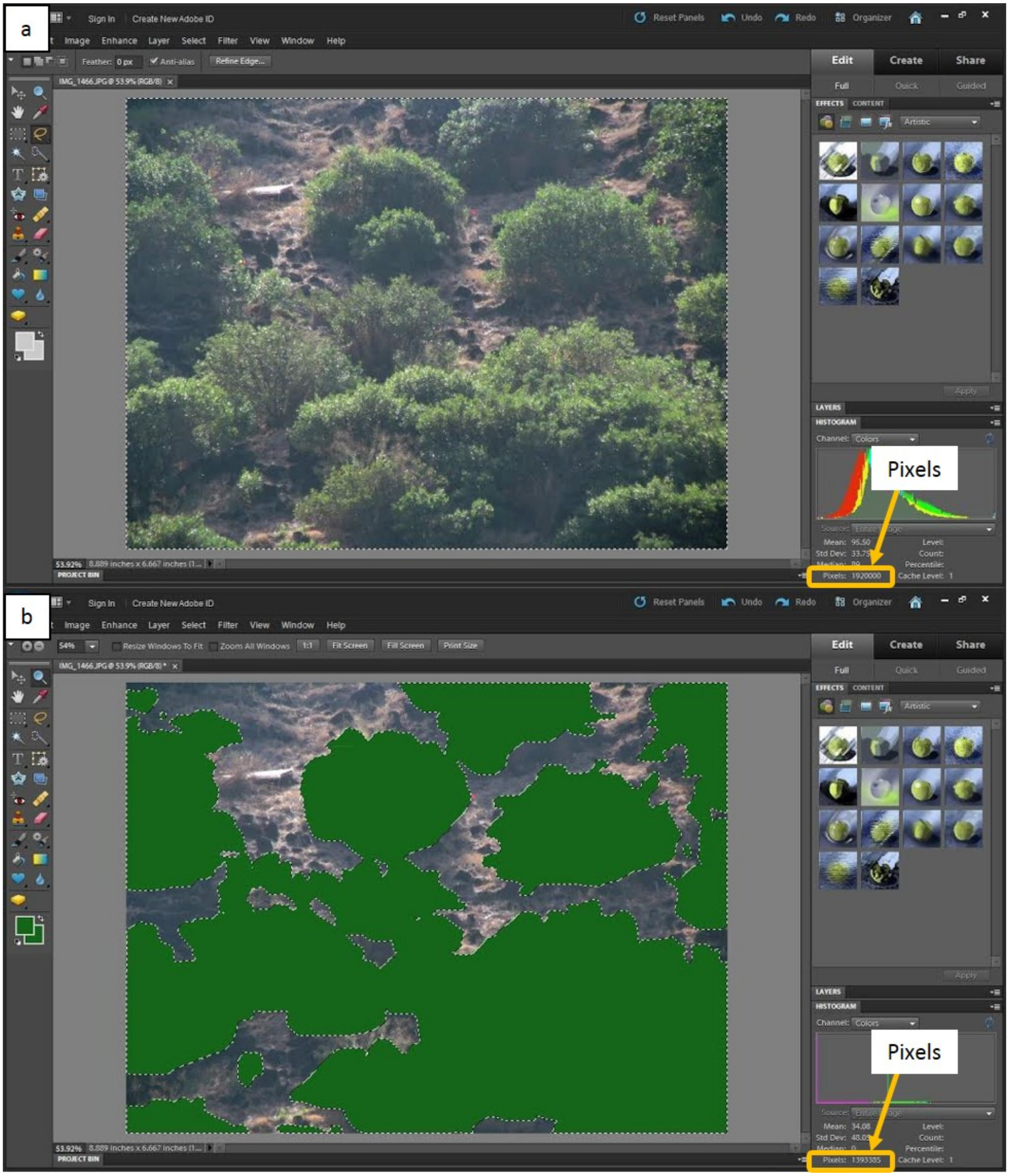


Figure 3. Example of analysis of a sampled image showing total pixels selected for a) the entire image, and b) selected shrub areas within the image, in Adobe Photoshop Elements 10. Estimated cover derived from pixel calculation is 73%.

Dates Updated: September 2016

Ecosystem Restoration Management Plan
MIP Year 11-15, Oct. 2014 – Sept. 2019
MU: Ohikilolo (Upper)

Overall MIP Management Goals:

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

Background Information

Location: Northern Waianae Mountains
Land Owner: U.S. Army: 575 acres, Board of Water Supply: 3 acres
Land Manager: U.S. Army
Acreage: 578 acres
Elevation Range: 800-3050ft
Description: Ohikilolo MU is located in the Makua Military Reservation (MMR). The area is accessed at the mouth of the valley, or by helicopter to LZs throughout the valley. The terrain of the lower portion of the MU includes deep gulches with steep walls, and broad ridges of mixed mesic forest. The upper portion, above the steep sided walls of Makua Valley, is comprised mostly of steep slope to the crest of the ridge.

The Ohikilolo Management Unit (MU) is one of the larger MIP MUs. Management for this MU has long been divided informally among OANRP staff as the two following areas; Ohikilolo (Upper) and Lower Makua. The division is useful for management purposes because the access issues to each of the areas vary; large cliffs run approximately along the 2000 ft contour between the two. Due to unexploded ordinance issues (UXO), Lower Makua also requires contract support from UXO specialists. The two 'areas' have been treated separately in past reports because they are managed by two different field teams. For the purposes of this year end report, they will be reported in Ecosystem Restoration Management Plans as two separate areas within the same MU.

Native Vegetation Types:

Waianae Vegetation Types
Mesic mixed forest
Canopy includes: *Acacia koa*, *Metrosideros polymorpha, Nestegis sandwicensis, Diospyros* spp., *Pouteria sandwicensis, Charpentiera* spp., *Pisonia* spp.,*Psychotria* spp., *Antidesma platyphylum*, *Bobea* spp. and *Santalum freycinetianum*. Understory includes: *Alyxia oliviformis, Bidens torta, Coprosma* spp., and *Microlepia strigosa*

Mesic Mixed Forest and Cliff Habitat at Ohikilolo

MIP/OIP Rare Resources

Organism Type	Species	Pop. Ref. Code	Population Unit	Management Designation	Wild/ Reintroduction
Plant	*Alectryon macrococcus* var. *macrococcus*	MMR-N	Makua	MFS	Wild
Plant	*Dubautia herbstobatae*	MMR-A, B, C, D, E, F, G, H, I	Makaha/Ohikilolo, Ohikilolo Makai, Ohikilolo Mauka	GSC and MFS	Wild
Plant	*Kadua parvula*	MMR-A, B,C, D, E	Ohikilolo	MFS	Wild/Reintroduction (D, E)
Plant	*Melanthera tenuifolia*	MMR-B, C, D, E	Ohikilolo	MFS	Wild
Plant	*Plantago princeps* var. *princeps*	MMR-A, B	Ohikilolo	MFS	Wild/Reintroduction
Plant	*Pritchardia kaalae*	MMR-A, B, C, D, E, H, I, J, K,L,M	Ohikilolo	MFS	Wild/Reintroduction
Plant	*Pritchardia kaalae*	MMR-G	Ohikilolo East and West Makaleha	MFS	Reintroduction
Plant	*Sanicula mariversa*	MMR-A	Ohikilolo	MFS	Wild/Reintroduction
Plant	*Tetramolopium filiforme*	MMR-A,B, C,D,E,F,H,I, J,K,L,M,N,O,P	Makaha/Ohikilolo Ridge and Ohikilolo	GSC and MFS	Wild
Plant	*Viola chamissoniana* var. *chamissoniana*	MMR-A,B, D,E,F,G,H	Makaha/Ohikilolo Ridge and Ohikilolo	MFS	Wild
Snail	*Achatinella mustelina*	MMR-E,F,G, H,I,J,K,L	Ohikilolo		

MFS= Manage for Stability
GSC= Genetic Storage Collection

Other Rare Taxa at Ohikilolo MU:

Organism Type	**Species**	**Status**
Plant	*Dubautia sherffiana*	Rare on Island
Plant	*Lobelia niihauensis*	Endangered
Plant	*Lysimachia remyi*	Rare on Island
Plant	*Lepidium arbuscula*	Endangered
Bird	*Asio flammeus sandwichensis*	State Endangered
Snail	*Leptachatina sp.*	Rare on Island
Snail	*Pleuropoma laciniosa*	Rare on Island
Mammal	*Lasiurus cinereus semotus*	Endangered

Rare Resources at Ohikilolo

Pritchardia kaalae

Viola chamissoniana var. chamissoniana

Sanicula mariversa

Tetramolopium filiforme

Achatinella mustelina

Kadua parvula

Melanthera tenuifolia

Map removed to protect rare resources. Available upon request

MU Threats to MIP/OIP MFS Taxa:

Threat	Taxa Affected	Localized Control Sufficient?	MU scale Control required?	Control Method Available?
Pigs	All	Yes	Yes	MU fenced
Goats	All	Yes	Yes	MU fenced
Rats	All	Unknown	Yes	Combination of snap grid using A-24s, Victor snap traps, hand broadcast of bait
Predatory snails	*Achatinella mustelina*	Unknown	Unknown	No. Limited to hand-removal and physical barriers, but have never been observed at Ohikilolo.
Ants	Unknown	Unknown	Unknown	Some available, depends on species
Slugs	None	N/A	N/A	Yes, Sluggo can be used if no rare snails are present, but not needed for this MU
Weeds	All	No	Yes	Yes, except for cliff areas. Options being developed for cliffs.
Fire	All	No	Yes	Yes

Management History

- 1995-1997: Ground hunts started with the use of contract hunters from the U. S. Department of Agriculture Wildlife Services while plans for a fence to enclose MMR were finalized.
- 1996-1997: The first stretch of fencing (2 km) separating MMR from a public hunting area was completed by the National Park Service and ~8 km of fencing was erected around the eastern perimeter of the valley.
- 1997: Diphacinone bait stations deployed around *Pritchardia kaalae (*PriKaa.MMR-A) population to control rodents.
- 1999: OANRP constructed the Forest Patch Exclosure, a small enclosure that encompasses about two acres of high-quality intact native forest and *A. mustelina* habitat. Contract and Staff ground hunts and snaring continued from 1997-1999 to control numbers of goats.
- 1999: First outplanting of *P. kaalae occurs*
- 2000: Perimeter fence was completed that separates the MU from the adjoining ʻŌhikilolo Ranch and Keaʻau Game Management Area to the south.
- 2000-2004 Large numbers of *Myrisine* sp. trees die off possibly due to drought.
- 2001: September, mature *Araucaria columnaris* tree killed, multiple treatments, fell to ground 2004. December 2001, NRS began to control the many seedlings of AraCol in the area.
- 2001: The last portion of the Ohikilolo Ridge Fence was completed separating the valley from the core populations of goats to the south. OANRP staff employed aerial shooting and "Judas goats" as management tools.
- 2002: December, an incipient population of *Rubus argutus* was discovered near a population of endangered *Kadua parvula*.
- 2003: A breach in the fence allowed at least three goats to cross over to Mākua from Mākaha Valley. These three goats were caught and no more sign has been observed in the area of the breach.
- 2004: NRS completed the PriKaa A Fence, a 450m exclosure encompassing a relatively large portion of the remaining wild *P. kaalae*. Entire MU now free of feral goats.
- 2005: *Ehrharta stipodes* discovered in MU
- 2006: Four goats breached the fence, all were subsequently caught with snares
- 2007-2008: The ʻŌhikilolo ridge fence needed repair work. In 2007 and 2008, goats continued to breach the fence in small numbers. NRS removed seven via snares and continue to make needed repairs to the fence.
- 2009: Cabin constructed.
- 2009: First reproductive *P. kaalae* outplant.
- 2012: Snap grid along with bait stations deployed across forested portions of MU.
- 2014: Diphacinone bait stations removed and A-24 traps deployed in addition to Victor snap trap grid.
- 2015: Ohikilolo fence replaced down to Lower Ohikilolo fence area.
- 2015: Access to Ohikilolo restricted for a period of 10 months due to UXO incident in MMR.
- 2015: Management resumes in December.
- 2016: *Plantago* and *Kadua* reintroductions outplanted in January and February, goat sign detected in upper part of MU, snares in mauka patch and cabin area set.
- 2016: Common natives outplanted in January.
- 2016: additional *Ehrharta stipodes* locations discovered, *Pterolepis glomerata* found on LZ in January.
- 2016: Goat sign detected at red dirt puu area in April, snares set.
- 2016: Translocation of *Achatinella mustelina* at Koiahi (AchMus.MMR-H) to forest patch begins in April, continues in July.
- 2016: Re-read of vegetation monitoring transects completed in June, results pending.

- 2016: Fenceline replaced in Lower Ohikilolo area.
- 2016: Fenceline completed along Makua Rim down to Farrington Highway on north rim, enclosing entirety of Makua Valley.
- 2016: Two goats snared at red dirt puu in June.
- 2016: Trial hand broadcasting of Diphacinone bait pellets conducted in June.

Ungulate Control

Identified Ungulate Threats: Pigs, goats
Threat Level: High
Primary Objective:

- To maintain all areas of the MU as goat-free and the fenced units pig free as well.

Secondary Objective:

- Complete fencing of MU and eradicate animals from within.

Strategy:

- Eradication in the MU and population reduction just outside the MU.

Monitoring Objectives:

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

Management Responses:

- If any goat activity is detected in the MU, implement snaring program.

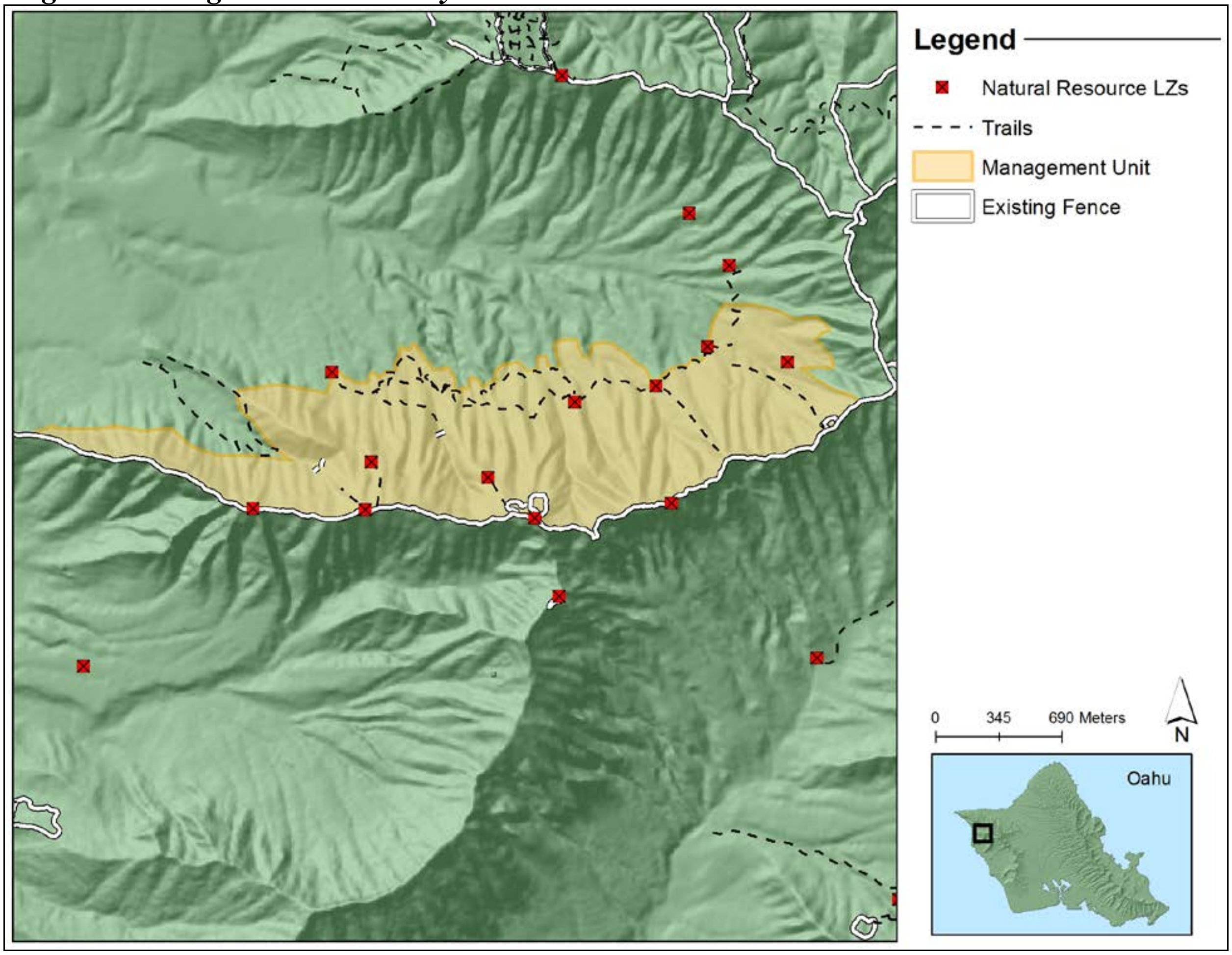
Maintenance Issues

There are seven fences in the Upper and Lower Ohikilolo MU including the large perimeter fence. The major threats to the fence include erosion, fallen trees and rocks, fire and vandalism; there are no major gulch crossings. No incidences of vandalism have been observed, but fence crossover gates have been left open and snares hung on the fenceline. Special emphasis is placed on checking the fence after extreme weather events. Although there is no known pig presence in the Ohikilolo Upper MU, there is a significant amount of goat pressure on the fence from the Keaau Game Management Area and Makaha Valley adjacent to the southwestern rim fence. Monitoring for ungulate sign will occur during the course of other field activities.

Ungulate Control Actions:

Year	Action	Quarter
MIP YEAR 11 Oct.2014 through MIP YEAR 15 Sept.2019	• Check MU fence for breaches • Maintain fence and install snares for goat ingress	• 1-4 • 1-4

Ungulate Management and Survey Locations at Ohikilolo



Weed Control

Weed Control actions are divided into 4 subcategories:

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

These designations facilitate different aspects of MIP/OIP requirements.

Vegetation Monitoring

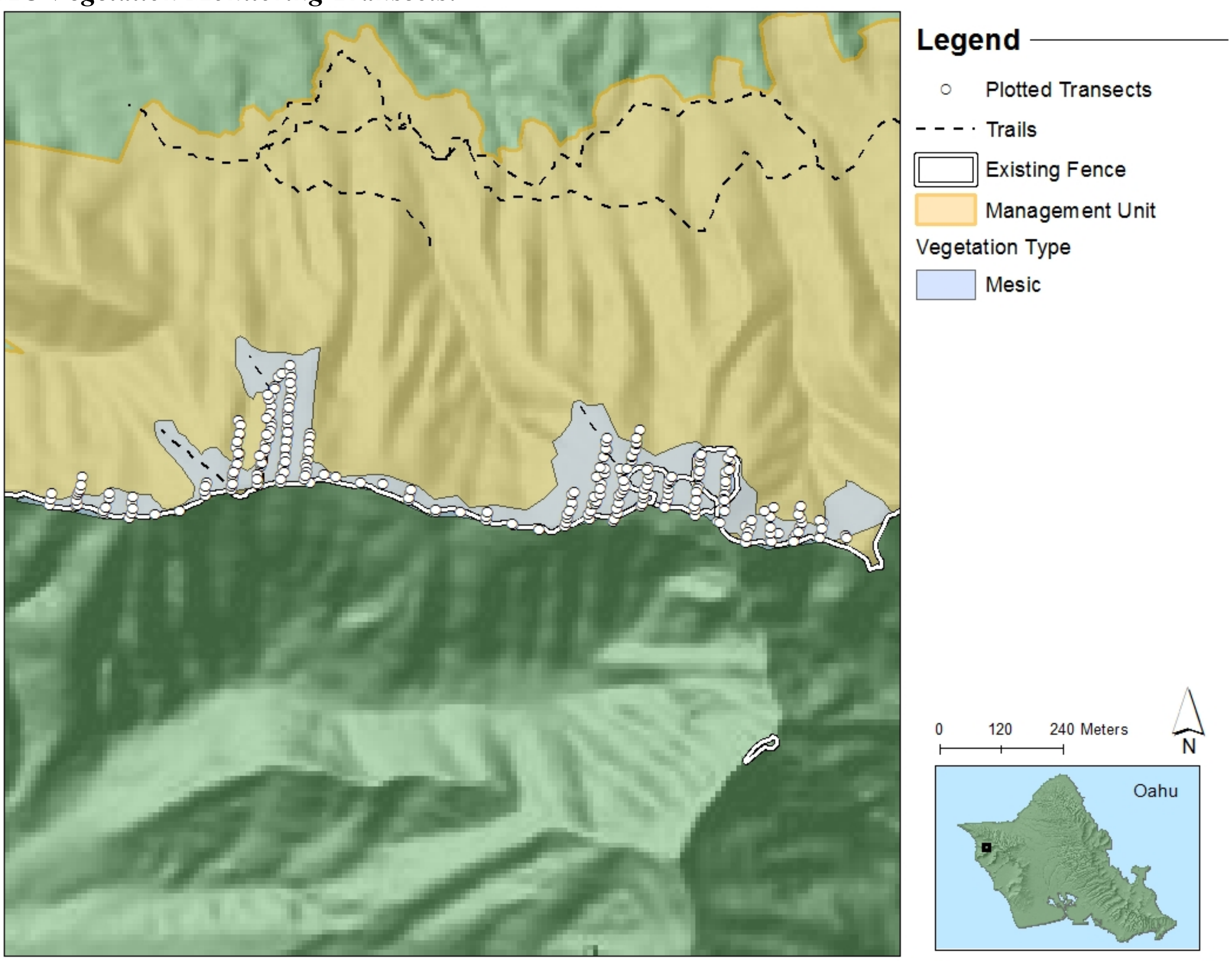
Objectives:

- Re-read vegetation monitoring transects in quarter 2 of 2016 (MIP year 12).
- Re-read subset of vegetation monitoring transects located in priority areas in quarter 2 of 2019 (MIP year 15).

MU Vegetation Monitoring

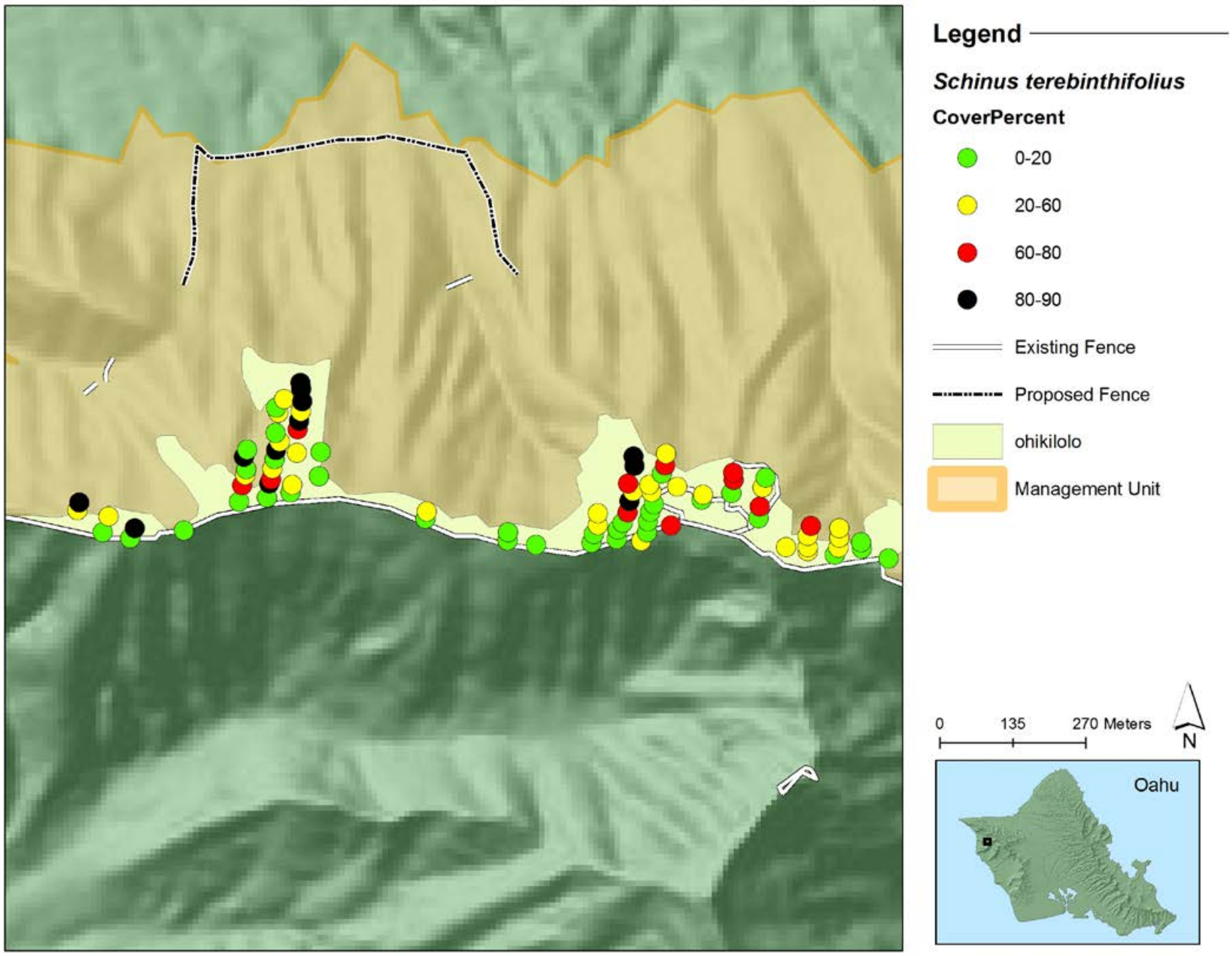
Vegetation monitoring will be conducted for both the Ohikilolo (Upper) and Lower Makua sections of this MU (Refer to background information for discussion on reasons for division of the MU). From May-June of 2016 vegetation monitoring was conducted for the Upper Ohikilolo portion of the MU. Current vegetation monitoring does not include the inaccessible cliff section of the MU for safety reasons. Until a safe method for this type of monitoring is developed NRS will continue to qualitatively monitor the cliff communities. The total effort for the 2016 monitoring including commute time was 469 hours. The data from the 2016 monitoring is still being processed and will not be available for this report, therefore the 2010 and 2013 data will be reported.

MU Vegetation Monitoring Transects:



2010 MU Vegetation Monitoring Baseline Analyses

The mean alien vegetation cover in the understory was 61% with 90% confidence interval for the mean of 56% and 66%. The mean alien canopy cover was 30% with 90% confidence interval for the mean of 25% and 35%. Ohikilolo is extremely fragmented, portions of the management unit are dominated by *Schinus terebinthiflius* while other sections are comprised of mostly intact mesic forest (refer to WCA discussions for more detail). Out of the 30% alien canopy cover, *S. terebinthiflius* occupied 27% of that space in 2010. Due to it's invasive characteristic and ecosystem altering habit *S. terebinthiflius* poses a major threat to the health of the ecosystem. NRS will continue to contain current monotypic stands of *S. terebinthiflius* and control it around rare species and native forest patches. In order to track the decline/expansion of the monotypic patches percent canopy cover maps for *S. terebinthiflius* will be generated for each monitoring dataset and compared. A baseline map of *S. terebinthiflius* is shown below.



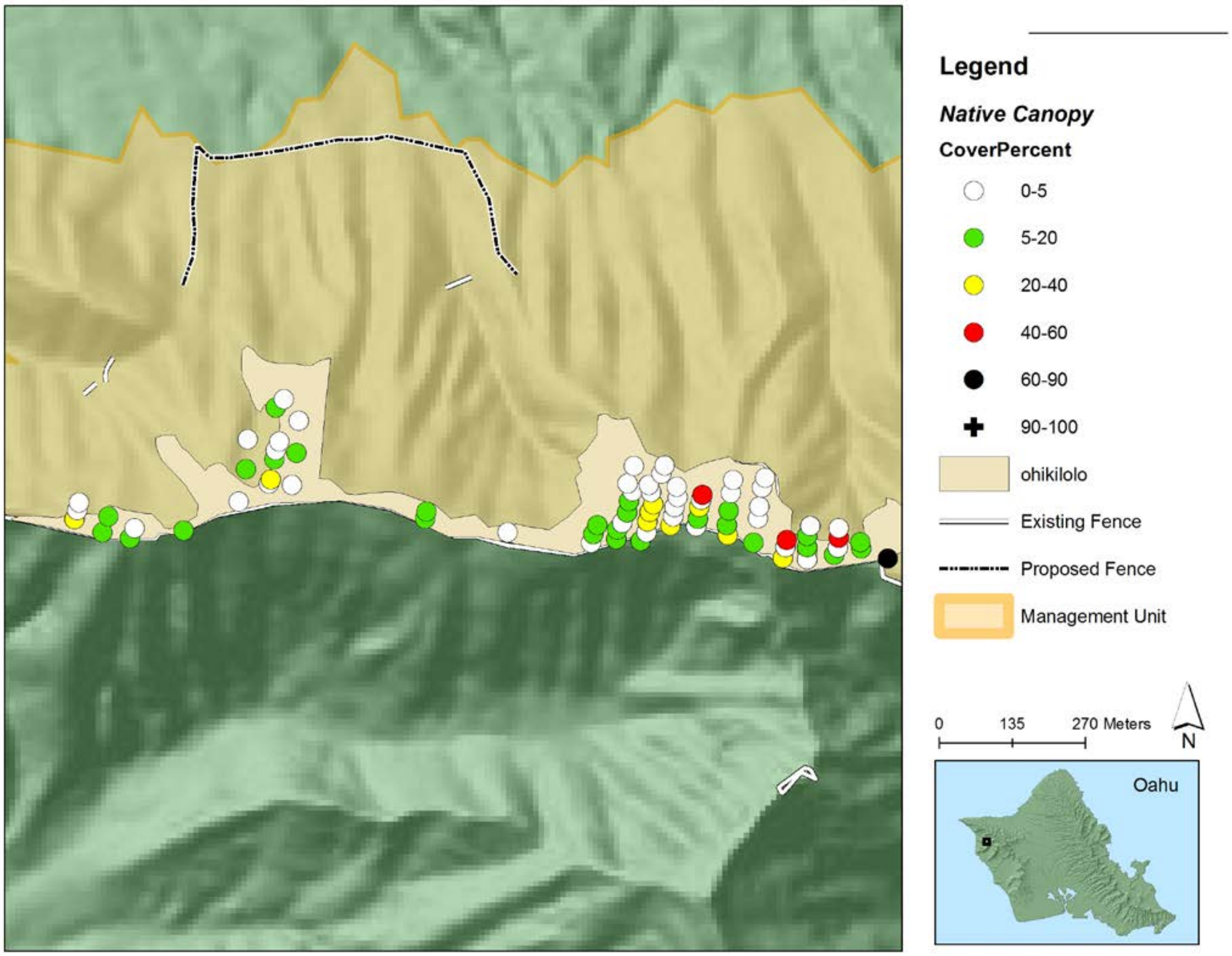
Several species at Ohikilolo, while too widespread to control as incipient, are of particular interest to NRS due to their distribution, density, and invasive characteristics. Currently, the species which fall within this category are controlled in localized areas around rare taxa. One invasive fern of particular concert due to its ability to create thick mat forming understory cover was *Blechnum appendiculatum.* The mean percent cover of *B. appendiculatum* was 28%. *B. appendiculatum* weed control techniques are currently being researched and MU scale control options will be reconsidered once results have been analyzed and feasibility discussed.

Melinis minutiflora is an invasive grass which is currently controlled around rare plant taxa and along the trails and fencelines. MU vegetation monitoring will be used to track the movement and spread of *M. minutflora*. If data shows a rapid increase in percent cover change for *M. minutflora* across the MU additional control will be considered.

Species that are not treated as incipient but for which NRS have zero tolerance in Ohikilolo include *Psidium cattleianum*, *Psidium guajava*, *Passiflora suberosa*, *Leucaena leucocephala*, *Casuarina* sp., *Toonia ciliata*, and *Syzygium cumini*. During vegetation monitoring 26 new locations of species from this list were noted and treated. *Grevillea robusta* is another taxon that, with the expectation of the cliff communities, is treated as zero tolerance for mature plants. In 2010 *G. robusta* mean percent cover in the canopy was 2% and .45% in the understory. The total number of plots that *G. robusta* occurred in was 21 plots in the canopy and 34 in understory. The five year goal for *G. robusta* is to treat all mature plants found within the MU.

MU % Vegetation Cover Anaylsis 2010							
Variable	Stations	Mean	Standard Error Of the Mean	Standard Deviation	Q1	Median	Q3
Native Shrub	133	16.77	1.69	19.46	2.5	7.5	25
Native Fern	133	18.17	2.18	25.12	0.5	7.5	30
Native Grass	133	24.28	2.28	26.27	2.5	15	35
Bryophytes	133	5.39	1.12	12.97	0.5	0.5	2.5
Total Native Understory	133	46.38	2.57	29.59	25	45	75
Alien Shrub	133	26.27	1.96	22.62	7.5	25	35
Alien Fern	133	28.73	2.94	33.94	2.5	7.5	55
Alien Grass	133	25.04	2.43	28.07	0.5	15	40
Bare Ground	133	12.9	1.97	22.73	0.5	2.5	15
Total Alien Understory	133	60.94	2.94	33.86	30	65	95
Total Native Canopy	133	15.32	1.95	22.43	0	2.5	25
Total Alien Canopy	133	30.16	2.82	32.57	0.5	15	55
Total Canopy	133	42.59	2.92	33.7	7.5	45	75

Percent Vegetation Cover for *Schinus terebinthiflius* 2010							
Variable	Stations	Mean	Standard Error of the Mean	Standard Deviation	Q1	Median	Q3
% Understory Cover	133	15.98	1.64	18.94	0.5	7.5	25
% Canopy Cover	133	27.03	2.75	31.74	0	15	45



<u>2013 MU Priority Area 1 Vegetation Monitoring Analyses</u>

During baseline vegetation monitoring at Ohikilolo Upper MU in 2010, it was documented that large portions of the MU were dominated by non-native vegetation, and much of this area does not receive active management. Because of this it was decided to re-monitor the actively managed areas on a more frequent interval to document more short term changes, and to allow for a faster response time for situations that would trigger new management actions. The MU was divided into two separate priority areas, with the actively managed region established as Priority area 1, and the rest of MU as Priority area 2 (See figure below). It was decided to monitor Priority area 1 every three years (51 plots), and to re-monitor the entire MU every six years (133 plots). Priority area 1 was re-monitored in 2013 (detailed monitoring results are included in Appendix 1-5 of the 2013 Status Report). The entire MU was re-monitored in 2016, analysis has not been concluded at the time of this report.

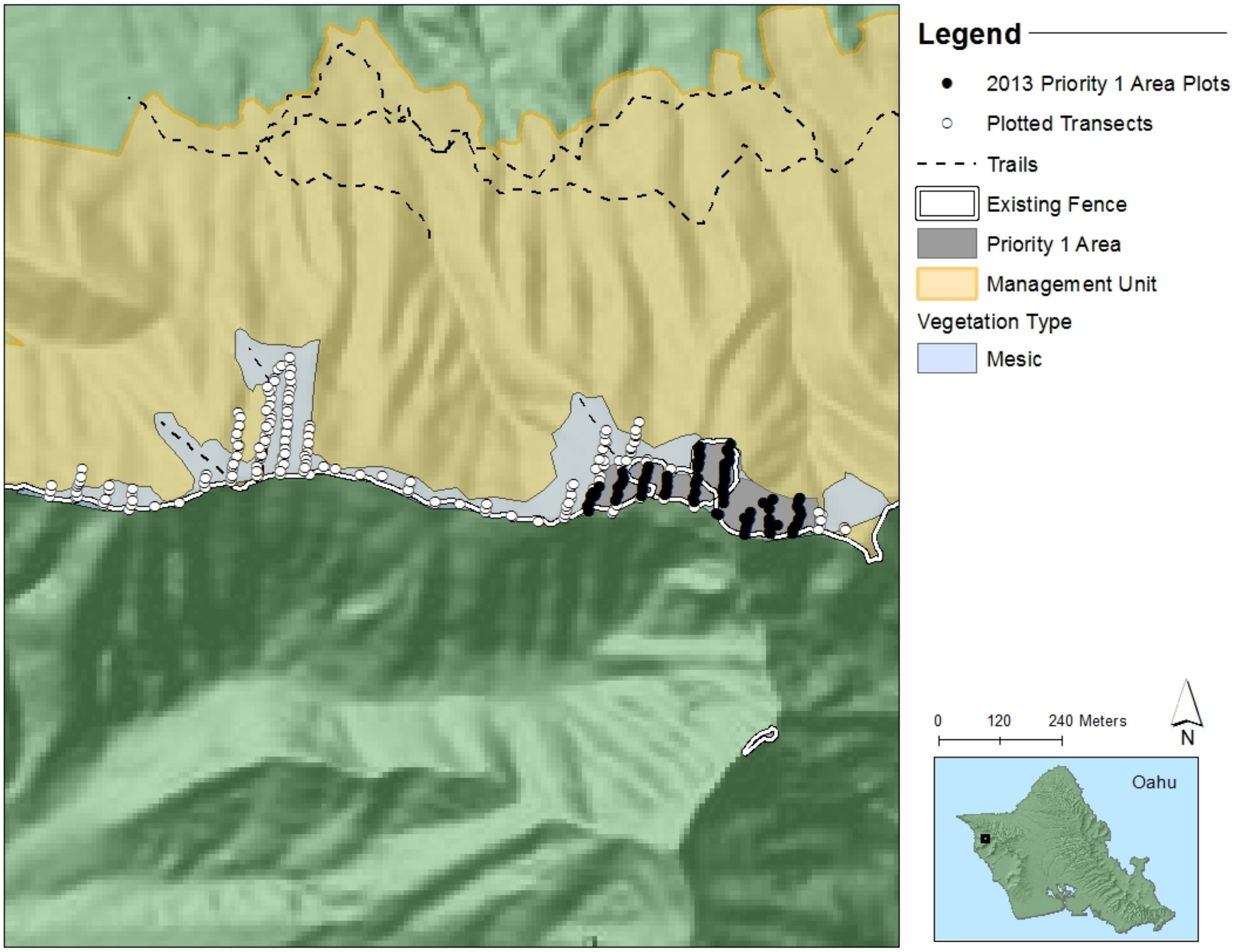


Figure 1: Location of vegetation monitoring plots at Ohikilolo Upper MU Priority area 1.

Results: In 2013, the MIP goal was met for having <50% non-native understory and canopy, as well as >50% native understory, in Priority area 1 (see table below). The goal was not met for having >50% native canopy. However, it is unknown if this goal is relevant in areas that may have consisted of shrubland or grassland habitats rather than densely canopied forests, prior to habitat alteration by non-native species. There were no significant changes in percent cover of native or non-native understory or canopy between 2010 and 2013.

Table: Median percent cover of native and non-native vegetation in the understory and canopy among monitored plots (n = 51) at Ohikilolo Upper MU Priority area 1

	Median percent cover		
Vegetation classification	**2010**	**2013**	**MIP goals met**
Non-native understory	45	45	yes
Non-native canopy	15	15	yes
Native understory	65	55	yes
Native canopy	25	25	no

During monitoring in 2013 it was noticed that *Carex meyenii* was very prevalent, occurring in 91% of the plots, and was present in both native-dominated and highly disturbed areas. There was concern that the prevalence of this species in the data may have masked any potential changes in other native understory growth form categories. The percent cover change was looked at specifically for ferns and shrubs, and there was no significant difference for the ferns, but there was a marginally significant increase in cover for native shrubs ($p = 0.052$). Overall, *C. meyenii* does not seem to be masking any major changes within native understory.

The data was also analyzed to see if there were any differing patterns of change in cover in areas with high vs. low native canopy cover. In areas with < 50% native canopy, there was no significant change in percent cover for any of the vegetation categories. However, in areas with > 50% native canopy, there was a significant increase in native canopy cover ($p = 0.007$), with a change in the median native canopy cover from 55% in 2010 to 65% in 2013.

There were no significant changes in species frequency or species richness among plots, and no updates for the MU priority weed list.

Summary: Results from vegetation monitoring at Ohikilolo Upper MU Priority area 1 in 2013 indicate that weeding efforts during the prior three years were sufficient to prevent further expansion and encroachment of non-native vegetation. Native canopy cover increased in areas with high native canopy cover, but remained unchanged in areas with low native canopy cover.

Since the plant community monitoring protocol was designed to address multiple MU level management goals, the following results were separated into sections. The goals, monitoring objectives, and statistical thresholds used for analysis came from the MIP.

Monitoring Actions:

Year	Action	Quarter
MIP YEAR 12 Oct.2015 through Sept.2016	• Conduct vegetation monitoring across the accessible areas of Upper Ohikilolo.	• 2
MIP YEAR 15 Oct.2018 through Sept.2019	• Conduct vegetation monitoring across the priority 1 area of Upper Ohikilolo.	• 2

Surveys

Army Training?: No
Other Potential Sources of Introduction: NRS, goats, recreational hikers
Survey Locations: Roads, Landing Zones, Fencelines, High Potential Traffic Areas.

Management Objective:

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

Monitoring Objectives:

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

Surveys are designed to be the first line of defense in locating and identifying potential new weed species. At Ohikilolo, landing zones are checked when used (not exceeding once per quarter), and transects along fencelines are inventoried quarterly. LZs within the MU include the following: Ohikilolo Mid (76), Pisonia (74), Koiahi (72), Red Dirt (70), and Makua Big Ridge (71). LZ surveys for this MU also include the Nike Site LZ. This Nike Site LZ is not in the MU, however it is where gear and personnel are usually flown from when accessing LZs in the Ohikilolo MU. Vehicle and personnel traffic across the Nike Site LZ is present; therefore quarterly surveys for both weeds and invasive insects at this LZ are important. Additionally, the road up to the Nike site is also surveyed once a year to track weed movement along the road, and to detect and prevent any new incipient weeds from being transported by vehicle or helicopter.

Weed Survey Actions:

Year	Action	Quarter
MIP YEAR 11 Oct.2014 through MIP YEAR 15 Sept.2019	• Survey LZs once per quarter (no use, no survey)	• 1-4 (if used)

Incipient Control Areas

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

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

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

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

The table below summarizes incipient invasive taxa at Ohikilolo (Upper). Appendix 3.1 of the MIP lists significant alien species and ranks their potential invasiveness and distribution. Each species is given a weed management code: 0 = not reported from MU, 1 = incipient (goal: eradicate), 2 = control locally. While the list is by no means exhaustive, it provides a good starting point for discussing which taxa should be targeted for eradication in an MU. NRS supplemented and updated Appendix 3.1 with additional target species identified during field work. In many cases, the weed management code assigned by the MIP has been revised to reflect field observations. ICAs are not designated for every species in the table below; however, occurrences of all species in the table should be noted at Ohikilolo. ICAs have been designated for taxa with astericks.

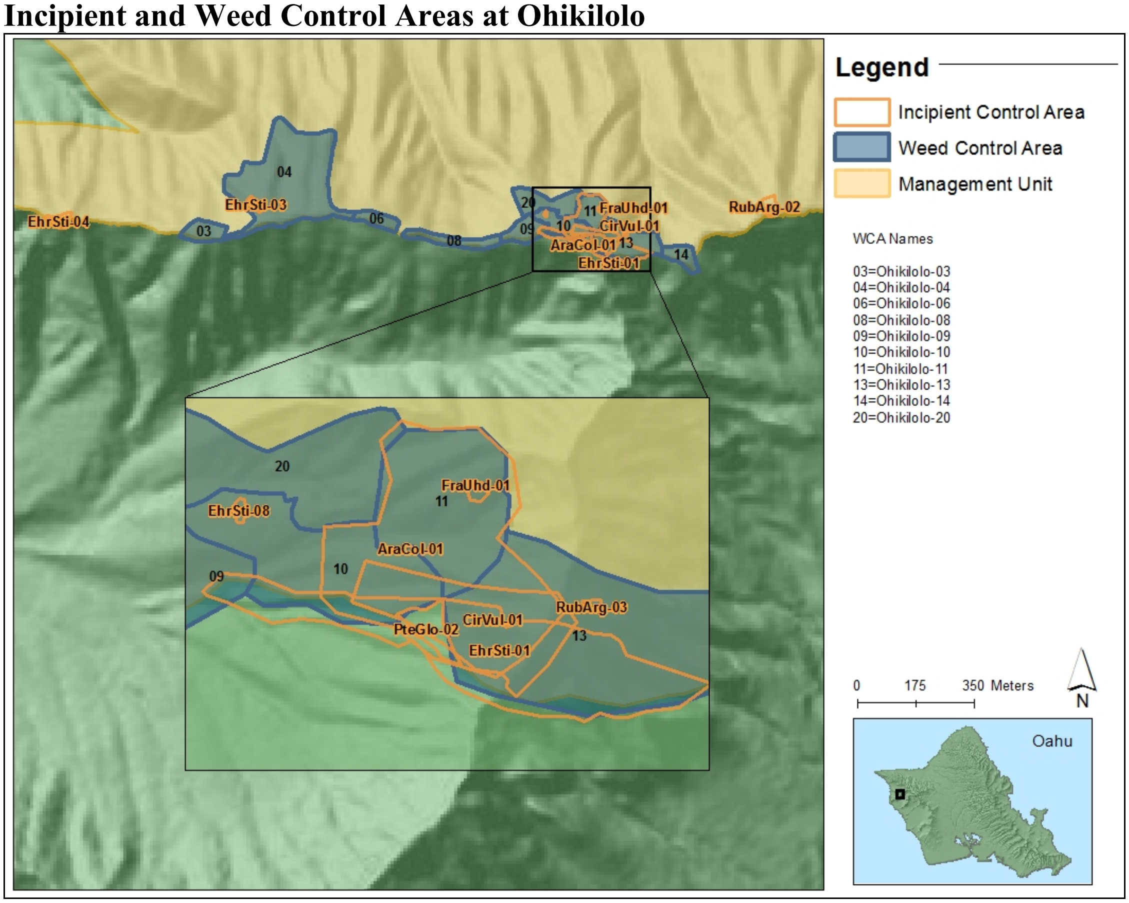
Summary of Potential ICA Target Taxa

Taxa	MIP weed mgmt.. code		Notes	No. of ICAs
	Original	Revised		
*Araucaria columnaris**	1	1	Nearby mature plant is dead. Will continue to sweep ICAs for immature individuals; zero tolerance for individuals in WCAs. Have observed seeds in area blown in from outside the MU. Therefore, reassessment of eradication goals may be needed.	1
Axonopus fissifolius	1	2	Grass is prevalent on Ohikilolo LZ, but does not impact forest patches greatly. Will continue to control locally with other grasses during grass sweeps.	0
Blechnum appendiculatum	2	2	Zero tolerance for isolated patches found during weed sweeps. Will procede with *B. appendiculatum* related monitoring objectives (see WCA section below).	0
*Cirsium vulgare**	0	1	Treated as an ICA since 2002. Will continue to sweep/treat every 6 months.	1
*Ehrharta stipoides**	0	1	First recognized in 2005; ongoing treatment since that date. Population is however increasing, likely due to irregularity of treatment and treatment method. Assess efficacy of Roundup 1% over Fusilade II, perform life cycle study, determine effective treatment intervals.	1
*Fraxinus uhdei**	0	2	Few plants found over the course of weed control history at Ohikilolo. Will continue to treat locally with other weeds during sweeps once determined ICA is clear of recruits.	2
Grevillea robusta	2	2	Targeted for control in all WCAs, especially WCAs along main crest line.	0
Morella faya	1	0	Controlled in 1999. Has not been seen since. If found again will create an ICA	0
Passiflora suberosa	0	2	Has been identified in several WCAs. Will be targeted for local control. If population increases dramatically will consider more aggressive control.	0
*Pterolepis glomerata**	0	1	An immature plant and a newly mature plant (flower and immature fruit only) were discovered on the camp LZ in January 2016. An ICA has been established and additional surveys will be conducted to determine the extent of the population.	1
*Rubus argutus**	0	1	No reproductive individuals seen since 2005. Resprouts often found; need to refine control measures to reduce re-treatment. ICAs checked every 6 months.	2

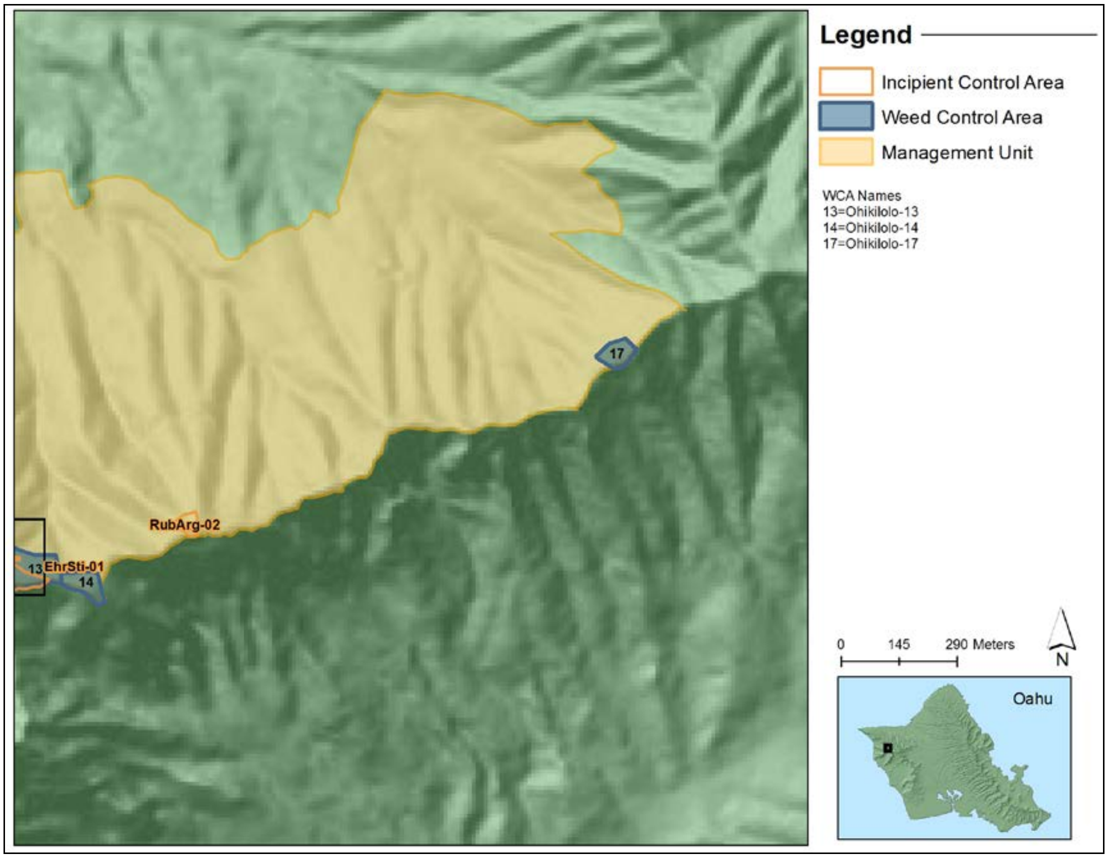
ICA Actions

Year	Action	Quarter
MIP YEAR 11 Oct.2014 through MIP YEAR 12 Sept.2016	• Discontinue Aracol ICA; treat as targets in WCAs and treat only as frequently as visit WCA. • Continue control at Cirvul ICA • Continue control at Rubarg -02 ICA • Continue control at Rubarg -03 ICA • Continue control at Ehrsti ICA's • Continue control of PteGlo ICA and survey for new plants	• 1 • 1,3 • 1,3 • 2,4 • 1-4 • 1-4
MIP YEAR 13 Oct.2016 through Sept.2017	• Declare eradication of Frauhd ICA if no individuals found Qtr 4 2016. • Perform life cycle study on EhrSti • Perform herbicide trials on EhrSti to determine most effective treatment	• 4 • 1 • 1
MIP YEAR 13 Oct.2016- through MIP YEAR 15 Sept.2019	• Continue control at Cirvul ICA till reach eradication • Continue control at Rubarg -02 ICA till reach eradication • Continue control at Rubarg -03 ICA till reach eradication • Continue control at EhrSti ICA's • Contine control at for PteGlo ICA's	• 1 • 1,3 • 2,4 • 1-4 • 1-4

Incipient and Weed Control Areas at Ohikilolo



Incipient and Weed Control Areas at Ohikilolo



Ecosystem Management Weed Control (WCAs)

<u>MIP Goals:</u>

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

<u>Management Objectives</u>:

- 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.

<u>Management Responses:</u>

- Increase/expand/re-prioritize weeding efforts if MU vegetation monitoring (conducted every 3 years) indicates that goals are not being met.
- Outplant common natives to increase native canopy/understory cover and reduce weed control efforts

Ecosystem level management at this MU has been conducted throughout the less steep, forest patches (WCA 10 & 13 in maps above). While these forest patches are a unique vegetation type for such a narrow ridge, very few MIP rare plant species are found in this habitat. Current management helps preserve the forest found on this ridge, however, *Prichardia kaalae* and *Achatinella mustelina* are the only MIP species that benefits from management of this vegetation type. Management for the rare cliff MIP species is currently limited by the steepness of the terrain. Weed control methods on rappel, or through ballistic technology are not well developed, however site preparation for OANRP outplantings have been conducted. Weed control on cliff areas will need to be explored given declining habitat for rare cliff species.

Weed management in the forest patches has also been historically prioritized because the areas had overall more native cover to begin with. Due to the history of consistent weed control in these forest patches, re-visitation frequencies have lessened, and effort will now be made to expand into new weedier areas.

Prioritizing weed control in the various WCAs is a critical step to meet MIP goals and still needs to be done for this MU plan. Weed control coupled with planting common natives is required for many areas.

Schinus terebinthifolius is one of the most widespread and worst weeds throughout the MU. Results are still pending for IPA trials. Regardless of those IPA trials, more aggressive control of this weed tree is needed in the various WCAs. Control will need to be selective and phased over time in numerous areas to avoid replacement with other weed species (grasses and weedy ferns).

While weed control directly around rare plant populations on cliffs will be difficult, there are a few management actions that have been identified as benefiting the greater ridge ecosystem, thereby benefiting the rare species as well. One of these actions is thinning *Schinus terebinthifolius*. This weedy tree is well known for growing large and falling over, in addition to using water resources. The ground is severely disturbed, causing greater erosion and invasion by other weeds, and the fallen tree often continues to grow, excluding any understory beneath the mass of tree. *Grevillea robusta* is similar in that it becomes unstable as it grows taller in shallow soil on cliffs. Thinning these tree species along and just off the crest of ridges can help preserve the integrity of steep habitat onto which rare species can spread. Thinning non-native tree species directly adjacent to native species also allows native tree canopies to occupy that space overtime. Common native species will be evaluated for their potential to replace these trees in steep areas where erosion is an issue.

WCA Ohikilolo-03 Prikaa-I

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native cover

Targets: All weeds and grasses with emphasis on slow removal of *S. terebinthifolius* and *G. robusta*. Still need to evaluate control of *B. appendiculatum.*

Notes: *Prichardia kaalae* reintroduced in this area. *A. mustelina* may also still be present, however translocation began in 2016. Conduct gradual removal of canopy weeds, focusing on *S. terebinthifolius* and *G. robusta* to foster native recruitment. Minimize changes to light levels, but open canopy around *P. kaalae* reintroductions to give them more sun. Remove understory weeds, focusing on shrubs, herbs, and *Christella parasitica.* Plant *Dodonea viscosa* in large numbers to complement weedy canopy removal. Determine other appropriate species to use such as *Myrsine lessertiana, Pleomele forbsii,* and *Nestigis sandwichensis.*

Actions:

Year	Action	Quarter
MIP YEAR 11 Oct.2014 through	• Assess/control weedy grasses throughout reintroduction area. Control within WCA, but focus on perimeter to prevent ingress.	• 1

MIP YEAR 15 Sept.2019	• Conduct annual sweep for understory weeds and gradual removal of canopy weeds. • Annually assess common reintroduction options and usefulness; plant as needed	• 1 • 4

WCA Ohikilolo-06 Sanmar MMR-A

Veg Type: Mesic Mixed Forest
MIP Goal: Less than 25% non-native cover
Targets: Grasses, *Bidens pilosa, Bidens alba, Stachytarpheta dicotoma, Ageratina adenophora*, *S. terebinthifolius* and *G. robusta*.
Notes: Weed control is focused around *S. mariversa* in this WCA. Weed control also benefits *K. parvula, V. chamissoniana* subsp. *chamissoniana, D. herbstobatae* found on cliffs nearby and below the WCA. The WCA is just off the main ridge crest of Ohikilolo and control is therefore limited by steep terrain. Only a limited amount of area in *S. mariversa* habitat is accessible for weed control without rappel gear, and the WCA size reflects this. Weed control will be conducted every two years, to remove weedy trees gradually, focusing on *S. terebinthifolius,* and *G. robusta*. Some shade benefits *S. mariversa* (anecdotal observations from Kamaileunu Ridge) and tree removals will need to be balanced against light levels for this species. Weedy grass/shrub control around *S. mariversa* will be evaluated annually. Conduct all weed control in spring (grasses in particular), when *S. mariversa* is visible to minimize trampling potential. Sweep through population, but also focus on edges, especially at bottom, to expand habitat, and along fence to prevent ingress.

Actions:

Year	Action	Quarter
MIP YEAR 11 Oct.2014 through MIP YEAR 15 Sept.2019	• Evaluate need for weedy grass/shrub control; control as needed • Control weedy trees gradually	• 2 • 2

WCA Ohikilolo-08 Ridge Crest and Slope

Veg Type: Mesic Mixed Forest
MIP Goal: Less than 50% non-native cover
Targets: *Schinus terebinthifolius, G. robusta,* various weedy grasses
Notes: Weed control is conducted in this WCA in order to protect habitat for a variety of MIP species on the upper slopes at the top of the cliffs, just below the ridge crest. Weedy trees are targeted for gradual removal to prevent further erosion of the ridge, and allow for native canopy regeneration. This WCA is also very steep, and the majority of the weed control will be conducted on the ridge crest. A complete sweep of the entire WCA will be expected within a 3 year timeline. A re-sweep will be conducted 3 years later.

Actions:

Year	Action	Quarter
MIP YEAR 11 Oct.2014 through MIP YEAR 15 Sept.2019	• Remove all *G. robusta* and some *S. terebinthifolius* to maintain some canopy. Focus along ridge crest and down side ridges where feasible. Work to sweep entire WCA in 3 years. Spray grasses as needed.	• 1

WCA Ohikilolo-09 Makai Gulch

Veg Type: Mesic Mixed Forest
MIP Goal: Less than 25% non-native cover

Targets: All *Grevillea robusta* will be targeted in this WCA, and *S. terebintifoilus* will be gradually removed. There is a large suite of understory weeds, and all will be targeted.

Notes: As per the MIP year 6, this WCA was expanded to include more forest patch, and included several *A. macrocarpus var. macrocarpus* individuals. However there are no remaining live *A. macrocarpus var. macrocarpus* left in the WCA. Due to a decline in the need for weed control in neighboring forested WCAs, weed control has been expanded to this weedier, yet similar forest patch. Weedy trees will be removed gradually to minimize light changes. Grass spray will follow annually as needed. Common native reintroductions of *A. koa, D. sicosa, Myrsine lessertiana,* and *Microlepia strigosa* within the light gaps will help to shade out these grasses over time.

Actions:

Year	Action	Quarter
MIP YEAR 11 Oct.2014 through MIP YEAR 15 Sept.2019	• Continue to conduct current weed sweep (from upper to lower regions) in areas with high density of native cover. • Spray grasses annually, focus on fenceline and newly weeded areas • Assess WCA for common outplantings	• 1,3 • 3 • 4

WCA Ohikilolo-10 Forest Patch Exclosure

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native cover

Targets: All weeds are targeted for removal. Understory weeds include: *Stachytarpheta australis, Rubus rosifolius, Ageratina adenophora, Clidemia hirta* and a variety of grasses. Very few non-native canopy trees remain in this WCA, and all are targeted for removal.

Notes: Due to the high density of native cover, this WCA has one of the longest histories of weed control at Ohikilolo. It was also the area targeted first for fencing before all the goats were removed from Makua Valley. This area was highly impacted by goats browsing on the native vegetation; fencing and goat removal has contributed greatly to native regeneration. In this WCA, there is a large *P. kaalae* reintroduction as well as many *A. mustelina*. The long term weed control along with fencing has decreased many weedier pockets found throughout this WCA exclosure. Common native reintroductions of *A. koa, Myrsine lessertiana,* and *Microlepia strigosa* have also been used to fill in weedy areas and more plantings are needed along the fenceline corridor to minimize edge effects as well as provide for more snail habitat. Weed control currently consists of weed sweeps through the entire WCA for all weeds every 2-3 years. A few weedier areas and the fence zone should be targeted more frequently. Grasses are also targeted throughout the entire WCA annually as needed.

Actions:

Year	Action	Quarter
MIP YEAR 11 Oct.2014 through MIP YEAR 15 Sept.2019	• Control grass throughout forest exclosure annually • Control weeds in weedy zones (below LZ, sanmar reintro, fenceline) annually. • Conduct weed sweeps across entire forest patch exclosure every 2-3 years • Monitor common reintroductions as needed	• 3 • 3 • 3 • 3

WCA Ohikilolo-11 Prikaa A Patch

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% native cover.

Targets: Understory: *A. adenophora*, *L. camara, Stachytarpheta australis, A. riparia.*
Overstory: *Schinus terebinthifolius*

Notes: This WCA surrounds the largest patch of wild *P. kaalae*. This WCA has not had a significant amount of weed control as it is steep and as *P. kaalae* seedlings began to emerge throughout the patch, the threat of trampling was a concern. The patch is now full of hundreds of immature *P. kaalae* and trails been made through the patch to reduce trampling. Along with the *P. kaalae*, the canopy in the WCA is dominated by *Meterosideros tremuloides* and *Schinus terebinthifolius*. *S. terebinthifolius* has been thinned around the *P. kaalae* and continual slow removal of *S. terebinthifolius* is planned throughout the WCA.

Grass sprays will also be important follow-up to *S. terebintifolius* removal. There is a significant amount of *Melinus minutiflorus* throughout the WCA. In the past there was concern that spraying grasses in the WCA with the grass specific herbicide, Fusilade would affect *P. kaalae* seedlings, also monocots. Spray trials were conducted on freshly germinated seedlings, and about 2 year old greenhouse *P. kaalae* plants. No detrimental effect to these plants was noted. Additionally grass sprays have been conducted in a field trial to look for effects of Fusilade (used with surfactant) on *P. kaalae*. No affect was observed from the field trials so grass sprays will be conducted annually, or as needed.

Common native reintroductions of *D. viscosa* are targeted for this WCA as there is a significant amount of eroded, bare dirt area on the edge of the *P. kaalae* patch. *M. minutiflorus* covers a good portion of this erosion scar, and will not be removed until something else can be planted to stabilize the soil there. *B. appendiculatum* also accounts for a significant amount of ground cover within the WCA. *Prichardia kaalae* consistently germinate through this mat of ferns, and therefore aggressive removal of the fern in this sensitive WCA will not be initiated until much more is understood about potential *B. appendiculatum* effects and control. Mass plantings of *D. viscosa* with *B. torta* seed sow over several years on the erosion area beginning at the top may help to stabilize the slope.

Actions:

Year	Action	Quarter
MIP YEAR 11 Oct.2014 through MIP YEAR 15 Sept.2019	• Conduct canopy/understory weed control annually • Evaluate potential for use of common natives; select species to use • Spray grasses annually, or as needed • Plant common natives if deemed useful	• 2 • 2 • 2 • 2

WCA Ohikilolo-13 Mauka Patch/Lancam Gulch

Veg Type: Mesic Mixed Forest

MIP Goal: Less than 25% non-native cover

Targets: Understory: *R. rosifolius, L. camara, B. appendiculatum, A. riparia, S. australis* and *Erigeron karvinskianus*
Overstory: *S. terebinthifolius*

Notes: Another *P. kaalae* reintroduction is established in this WCA, and *A. mustelina* are found here as well. This WCA also has a long history of weed control. This WCA was also greatly impacted by goat browse. Since the removal of goats, there has been a significant increase in native fern and *F. arborea* cover. The areas with dense native cover are still patchy, but are modestly increasing. Weed sweeps are conducted through the entire WCA, but more frequent efforts target weedier patches between native areas, or on the edges of native areas to allow for expansion.

A significant amount of grass is present throughout this WCA, especially in the more open areas where canopy is lacking. Biannual grass sprays may be initially required to set grass back, and later reduced to annually. Common native shrubs and understory are ideal for the weedier areas of this WCA where there is eroded bare ground, or areas densely covered in grass. Common reintroductions already established will be monitored every 1-2 years depending on how long ago they were planted.

Erigeron karvinskianus is currently spreading and needs aggressive control to reduce the impacts of this habitat modifying weed.

The incipient weed *Ehrharta stipoides* was found several years ago in this WCA and is targeted for complete eradication as an ICA. This grass occurs in isolated patches in several areas, and spread of any kind will not be tolerated. This grass is problematic to treat as it does not respond well to the grass specific herbicide Fusilade (Fluazifop-p-Butyl). Staff have seen effective control of small patches with Glyphosate, although the seedlings of the grass seem to be able to reach maturity faster than the six weeks return interval that the staff is currently operating under. Growth trials of the grass, as well as trials of other grass specific herbicides would help to determine the best control method for *E. stipoides.*

This WCA is where *B. appendiculatum* control trials were conducted and monitored, and techniques developed in these trials have been used across several MU's. There are slopes in this MU where the understory is completely dominated by the weedy fern, most notably in areas lacking overstory. Most control measures are rather aggressive at this point, and these methods will have to be weighed against the benefit for native cover and or the establishment of other understory weeds. Further investigations into control of this fern will continue to take place in this MU in areas where no rare species will be affected.

During the 10 months period in 2015/2016 when the MU was closed for access to OANRP staff, *R. rosifolius* gained significant presence in the understory. Currently there are trials being conducted in the Kahanahaiki MU to determine the best control technique for this shrub.

<u>Actions</u>:

Year	Action	Quarter
MIP YEAR 11 Oct.2014 through MIP YEAR 15 Sept.2019	• Conduct weed sweeps across WCA twice a year. Remove canopy gradually, focus on *A. macrococcus* and *M. lessertiana* gulches. Use more aggressive control in Lancam Gulch and along cabin slope. • Spray grass across WCA quarterly to annually • Monitor common reintros planted quarter 1 2008 as needed (*M. strigosa*) • Monitor common reintros planted 2004 and 2005 as needed (*A. koa*) • Monitor common reintros planted 2016 as needed (mixed). • Determine methods for *B. appendiculatum* control and monitoring and establish plots. • GPS lower portion of WCA to ensure includes all suitable *P. kaalae* habitat for reintroduction and prior weed control	• 2,4 • 2,4 • 3 • 3 • 3 • 1 • 4

WCA Ohikilolo-14
Veg Type: Mesic Mixed Forest
MIP Goal: Less than 25% native cover
Targets: *Melinus minutiflora* and other weedy grasses
Notes: This WCA focuses around management for *T. filiforme.* The WCA has a steep, almost pyramid shape, throughout which a population of *T. filiforme* is found. The weed control goal for this WCA is to keep grasses such as *M. minutiflora* from occupying this steep, rocky niche habitat. Grass control has only been conducted at this WCA once so far. The steep, fragile terrain, and the frequent high winds make grass control very difficult within this WCA. Grass control will continue with a grass specific herbicide in handsprayers, or small backpack sprayer, and only on days when winds are low. Due to steep terrain, management other than grass spray is very limited.

Actions:

Year	Action	Quarter
MIP YEAR 11 Oct.2014 through MIP YEAR 15 Sept.2019	• Spray grass throughout WCA as needed, balance with potential damage to fragile habitat	• 1

WCA Ohikilolo-17 Ctenitis Ridge
Veg Type: Mesic Mixed Ridge
MIP Goal: Less than 25% non-native cover
Targets: Gradually remove *S. terebinthifolius.* Target all understory species focusing on patches of *A. adenophora* and other understory weeds.
Notes: This WCA is the only WCA east of Ohikilolo-14. It is a smaller WCA, and management has been conducted in this area because a reintroduction of *P. kaalae* has been established and fenced. The area has patches of *M. tremuloides* canopy, however does not have a continuous dense native cover. The area has benefited from the gradual weed control of *S. terebinthifolius* and removal of dense thickets of *A. adenophora*. *M. strigosa* has also been planted with hopes of establishing a denser native ground cover. Common reintroductions will continue, and will be monitored annually until well established. *B. appendiculatum* is a problem in this WCA as with many others in this MU and control is needed. Grass spray has not yet been conducted in this WCA, however *M. minutiflora* patches have been noted and a spray regime will be implemented if determined necessary.
Actions:

Year	Action	Quarter
MIP YEAR 11 Oct.2014 through MIP YEAR 15 Sept.2019	• Conduct weed sweeps targeting area around *P. kaalae* biannually • Monitor/plant common natives particularly along ridgeline • Spray grasses if needed	• 2,4 • 4 • 2

WCA Ohikilolo-20 Butterfly below Exclosure
Veg Type: Mesic Mixed Ridge
MIP Goal: Less than 25% non-native cover
Targets: All *G. robusta, P. cattleianum,* and *Toona ciliata* will be targeted in this WCA, and *S. terebintifoilus* will be gradually removed. There is a large suite of understory weeds, but will only be targeted around rare plant species.
Notes: This WCA is makai of the WCA's Ohikilolo-09 & 10. It is a relatively large WCA although not all of the terrain is walkable. There are wild *P. kaalae* on either side of the WCA, scattered individuals of *D. herbstobatae, Melicope makahae, Chrysodracon forbseii,* and a

population of *A. mustelina.* The few weed control sweeps that have been conducted here have been on the ridges on the eastern and western sides of the WCA. The area has benefited from the gradual weed control of *S. terebinthifolius* on the western side known as "big ridge". Canopy weeds will be the main target of limited weed sweeps in this WCA, understory weeding will occur around rare plant species.

Actions:

Year	Action	Quarter
MIP YEAR 11 Oct.2014 through MIP YEAR 15 Sept.2019	• Control canopy species across WCA, focusing on Psicat, Grerob, Toocil, AraCol and any other less common species. Sweep walkable areas of WCA every 3 years.	• 4

Rodent Control

Threat level: High
Current control method: A-24s, snap traps, hand broadcast of rodenticide
Seasonality: Year-Round
Number of control grids: 5,133 snap traps and 53 A-24s total

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

Management Objective:
- Continue to maintain trapping grid around *Achatinella mustelina* and rare plant populations.
- Less than 10% activity levels in rat tracking tunnels.
- Continue to evaluate results of hand-broadcast of rodenticide for MU wide protection.

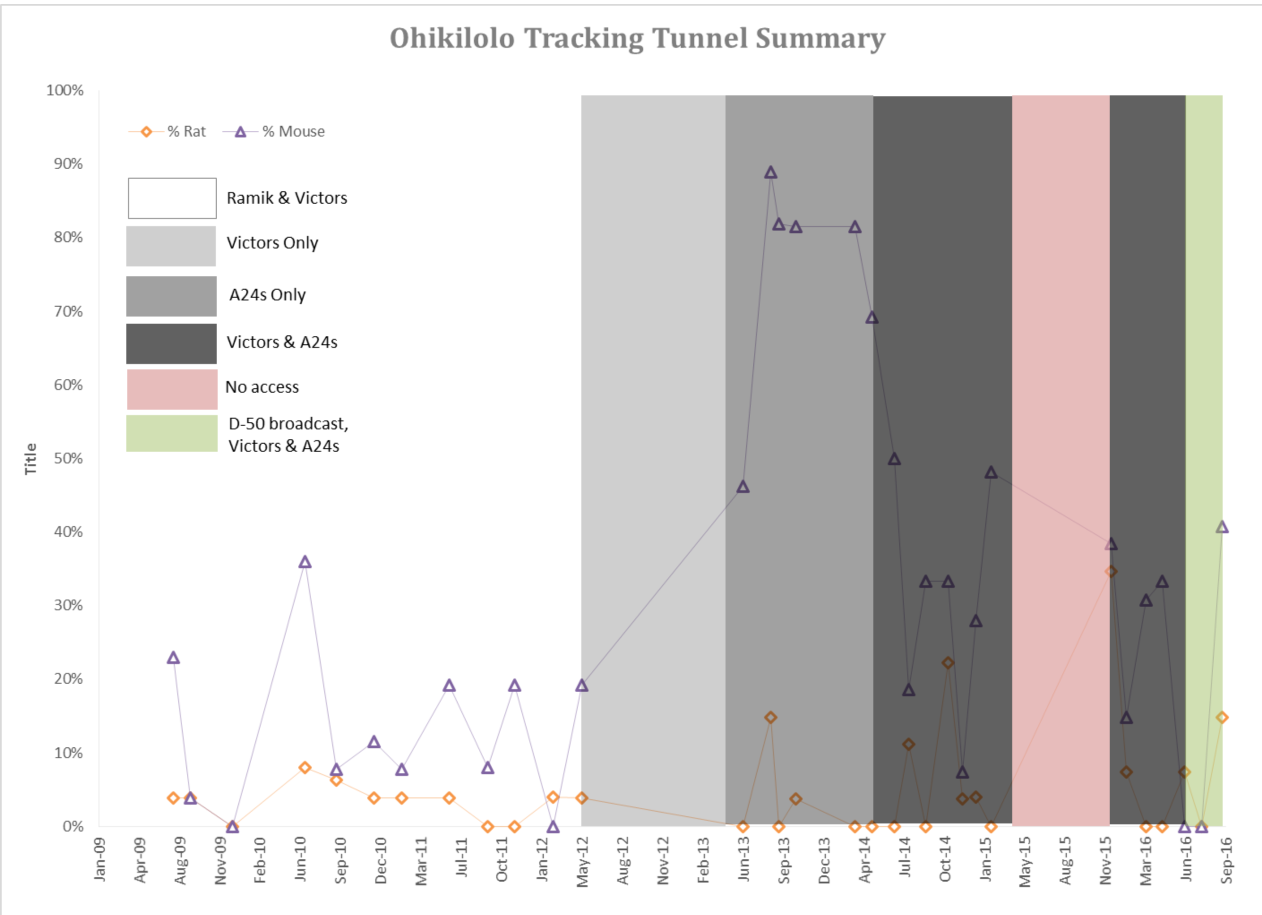
Monitoring Objectives:
- Monitor tracking tunnels to determine rodent activity within trap grid once a quarter.
- Monitor ground shell plots for predation of *A. mustelina* by rats.
- Monitor *P. kaalae* and *Pteralyxia macrocarpa* as focal species to determine the occurrence of fruit predation by rats.

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

Localized Rodent Control:
- Grids are centered around and extend slightly beyond the boundaries of the populations being protected. Monitoring of rat activity via tracking tunnels will be vital in determining whether control is having the desired effect, as will intensive monitoring of the rare snail and plant populations.

Hand broadcast Trial:

- As stated in the rodent management chapter in the year end report for 2016, Ohikilolo was chosen as the site to use up excess D-50 (Diphacinone) bait from the Kahanahaiki hand broadcast, as the size of the area was equal to the broadcast area application rate of the remaining bait, and would possibly benefit *P. kaalae*,. The operation was conducted within label requirements and occurred on June 7th and 14th. No carcasses of rodents or non-targets were found by staff while conducting other operations within the area three weeks after the broadcast. Tracking tunnels are monitored every 6 weeks at this site and were monitored the night before the first broadcast. The percent activity the night before the first broadcast was 7.4% and 5 weeks later there was 0% rodent activity. However, when the tunnels were run September 6th the tunnels were tracking at 14% rats and 40% mice, which is unfortunately above average. Further analysis is needed to determine if D-50 is a viable tool for rodent control at Ohikilolo.



MU Rodent Control Actions:

Year	Action	Quarter
MIP YEAR 13 Oct.2016 through Sept.2017	• Evaluate efficiency/efficicacy of D-50 usage at Ohikilolo	1
MIP YEAR 11 Oct.2014 through MIP YEAR 15 Sept.2019	• Maintain trapping grid and monitoring tunnels twice quarterly • Hand broadcast D-50 if determined to be effective	1,2,3,4 TBD

Predatory Snail Control

Species: *Euglandina rosea* (rosy wolf snail), *Oxychilus alliarus* (garlic snail)
Threat level: Low (*E. rosea* not found in MU, *O. alliarus* not confirmed)
Control level: Localized
Seasonality: Unknown
Number of sites: *Achatinella mustelina* sites
Acceptable Level of Activity: Unknown
Primary Objective: Reduce predatory snail populations to a level optimal for *Achatinella mustelina* survival.

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

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

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

Predatory Snail Control Actions:

Year	Action	Quarter
MIP YEAR 11 Oct.2014 through MIP YEAR 15 Sept.2019	• Determine if any *E. rosea* or *O. alliarus* snails are present in proximity to *A. mustelina* populations • Implement control as improved tools become available • Continue sanitation protocols for each access	• 1-4

Ant Control

Species: *Pheidole megacephala, Ochotellus glaber* amongst other species
Threat level: Low
Control level: Only for new incipient species
Seasonality: Varies by species, but nest expansion observed in late summer, early fall
Number of sites: 3 (Cabin, Landing Zone, Trails)
Acceptable Level of Ant Activity: Acceptable at present densities
Primary Objective: Eradicate incipient ant invasions and control established populations when densities are high enough to threaten rare resources.

Management Objective:

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

Monitoring Objective:

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

Ants have been documented to pose threats to a variety of resources, including native arthropods, plants (via farming of Hemipterian pests), and birds. The distribution and diversity of ant species in upland areas on Oahu, Ohikilolo, has only begun to be studied and changes over time. Impacts to the rare species present in Ohikilolo remain unknown, but it is likely they are having some type of effect on the ecosystem at large. NRS have already conducted some surveys across Ohikilolo to determine which ant species are present and where they are located. Surveys were conducted using a standardized sampling method (see Appendix Invasive Ant Monitoring Protocol, this document). Only half of six surveys attempted have yielded ants, suggesting ants are at low densities in this area. Species present are widely established and control is not recommended at this time.

Ant Control Actions:

Year	Action	Quarter
MIP YEAR 11 Oct.2014 through MIP YEAR 15 Sept.2019	• Conduct surveys for ants across MU with bait cards annually • Analyze results of surveys, develop management recommendations • Implement control as needed • Continue sanitation protocols for each access	• 3

Fire Control

There is no recent history of fires burning close to this section, Ohikilolo (Upper), or the MU. The area is somewhat protected by barren cliffs, however it is still assumed that fire is a threat to this area of the MU. The best way to address fire threats will be through early response and assistance from Wildland Fire crews to any fires in Makua Valley or adjacent areas. Additionally, NRS will use resources to assist in controlling fires in Makaha and Keaau Valleys on the south side of the MU.

Camp fires were started in the adjacent Keeau area and lower down on the ridgeline. Campfires perhaps pose a greater threat than fires which start in the lower reaches of Makua and Keeau. This is a difficult area to police and additional signage is needed as a preventative action.

Action Table

Species names are written as six-digit abbreviations, such as 'TooCil' instead of *Toona ciliata*, for the sake of brevity.

Action Type	Actions	MIP Year 11 Oct 2014- Sept 2015				MIP Year 12 Oct 2015- Sept 2016				MIP Year 13 Oct 2016- Sept 2017				MIP Year 14 Oct 2017- Sept 2018				MIP Year 15 Oct 2018- Sept 2019			
		4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
Ungulate Control	Maintain fence and install snares for goat ingress as needed																				
Vegetation Monitoring	Conduct vegetation monitoring across the accessible areas of Upper Ohikilolo.																				
	Conduct vegetation monitoring across the priority 1 area of Upper Ohikilolo.																				
General Survey	Survey LZs once per quarter (no use, no survey)																				
ICA MMR-AraCol-01	Discontinue Aracol ICA; treat as targets in WCAs and treat only as frequently as visit WCA.																				
ICA MMR-CirVul-01	Monitor/control CirVul twice a year for MIP years 11 & 12, then once a year until eradication achieved. Survey entire ICA. Pick and remove from field any potentially mature fruit.																				
ICA MMR-RubArg-02	Monitor/control Rubarg at Hedpar below red dirt puu twice annually. Use spades to dig roots/runners out of ground. Treat with 40% G4 or other strong chemical.																				
ICA MMR-RubArg-03	Monitor/control Rubarg in lancam gulch twice annually. Use spades to dig roots/runners out of ground. Treat with 40% G4.																				
ICA MMR-EhrSti-01	Perform life cycle study to determine proper retreatment interval. Perform Herbicide trials to determine the best treatment.																				

Action Type	Actions	MIP Year 11 Oct 2014-Sept 2015				MIP Year 12 Oct 2015-Sept 2016				MIP Year 13 Oct 2016-Sept 2017				MIP Year 14 Oct 2017-Sept 2018				MIP Year 15 Oct 2018-Sept 2019			
		4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
ICA MMR-EhrSti-01	Monitor/control Ehrsti at Pinetree LZ site quarterly, or more often as possible. Pick and remove from field any potentially mature fruit. This species is cryptic and can be difficult to id. Consider using preemergents.																				
ICA MMR-EhrSti-03	Monitor/control Ehrsti at Koiahi site quarterly. Pick and remove from field any potentially mature fruit. This species is cryptic and can be difficult to id. Consider using preemergents.																				
ICA MMR-EhrSti-04	Monitor/control Ehrsti at White X site quarterly. Pick and remove from field any potentially mature fruit. This species is cryptic and can be difficult to id. Spray with preemergents.																				
ICA MMR-EhrSti-08	Monitor/control Ehrsti at old SanMar reintro site in Forest Exclosure quarterly, or 6x year if possible. Pick and remove from field any potentially mature fruit. This species is cryptic and can be difficult to id. Consider using preemergents.																				
ICA MMR-FraUhd-01	Declare eradication of Frauhd ICA if no individuals found Qtr 2 2016.																				
ICA MMR-PteGlo-02	Monitor/control Pteglo at Ohikilolo Pinetree LZ quarterly. Pick and remove from field any potentially mature fruit. Use OUST herbicide to exhaust seedbank. Remove soil as feasible.																				
ICA MMR-PteGlo-03	Monitor/control Pteglo at Ctenitis Fence line quarterly (minimum 2x year). Pick and remove from field any potentially mature fruit. Use OUST herbicide to exhaust seedbank. Remove soil as feasible.																				
WCA Ohikilolo-03	Control weedy grasses throughout reintroduction area, as needed. Sweep within WCA, but focus on perimeter to prevent ingress.																				

Action Type	Actions	MIP Year 11 Oct 2014- Sept 2015				MIP Year 12 Oct 2015- Sept 2016				MIP Year 13 Oct 2016- Sept 2017				MIP Year 14 Oct 2017- Sept 2018				MIP Year 15 Oct 2018- Sept 2019			
		4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
	Conduct annual sweep for understory weeds and gradual removal of canopy weeds.																				
	Annually assess common reintroduction options and usefulness; collect *D. viscosa,* plant as needed.																				
WCA Ohikilolo-06	Evaluate need for weedy grass/shrub control; control as needed																				
	Control weedy trees gradually, every 2 years as needed. Minimize light level changes, particularly around Sanmar.																				
WCA Ohikilolo-08	Remove all *G. robusta* and some *S. terebinthifolius*. Focus along ridge crest and down side ridges where feasible. Work to sweep entire WCA in 3 years																				
WCA Ohikilolo-09	Control both canopy and understory weeds; remove weedy trees gradually to minimize light changes. Focus on patches of native forest. Always target AraCol. Conduct follow up sweeps every 6 months																				
	Conduct grass control across WCA, as needed annually. Check every 6 months. Focus on fencelines, and around native forest patches.																				
	Assess WCA for common outplantings																				
WCA Ohikilolo-10	Control grass throughout forest exclosure annually																				
	Control weeds in weedy zones (below LZ, sanmar reintro, fenceline) annually.																				

Action Type	Actions	MIP Year 11 Oct 2014-Sept 2015				MIP Year 12 Oct 2015-Sept 2016				MIP Year 13 Oct 2016-Sept 2017				MIP Year 14 Oct 2017-Sept 2018				MIP Year 15 Oct 2018-Sept 2019			
		4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
	Conduct weed sweeps across entire forest patch exclosure every 2-3 years																				
	Monitor common reintroductions as needed																				
WCA Ohikilolo-11	Conduct canopy/understory weed control annually																				
	Plant common natives if deemed useful																				
	Spray grasses annually, or as needed																				
WCA Ohikilolo-13	Conduct weed sweeps across WCA twice a year. Remove canopy gradually, focus on *P. macrococcus* and *M. lessertiana* gulches. Use more aggressive control in Lancam Gulch and along cabin slope.																				
	Spray grass across WCA twice a year																				
	Monitor common reintros planted as needed																				
	GPS lower portion of WCA to ensure includes all suitable *P. kaalae* habitat for reintroduction and prior weed control																				
	Determine methods for *B. appendiculatum* control and monitoring and establish plots.																				
WCA Ohikilolo-14	Spray grass throughout WCA as needed, balance with potential damage to fragile habitat																				
WCA Ohikilolo-17	Conduct weed sweeps targeting area around *P. kaalae* biannually																				

Action Type	Actions	MIP Year 11 Oct 2014-Sept 2015				MIP Year 12 Oct 2015-Sept 2016				MIP Year 13 Oct 2016-Sept 2017				MIP Year 14 Oct 2017-Sept 2018				MIP Year 15 Oct 2018-Sept 2019			
		4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
	Spray grasses if needed																				
	Plant common natives particularly along ridgeline																				
WCA Ohikilolo-20	Control canopy species across WCA, focusing on Psicat, Grerob, Toocil, AraCol and any other less common species. Sweep walkable areas of WCA every 3 years																				
Rodent Control	Evaluate efficiency/efficacy of D-50 usage at Ohikilolo																				
	Maintain trapping grid and monitoring tunnels twice quarterly																				
	Hand broadcast D-50 if determined to be effective (TBD)																				
Ant Control	Conduct surveys for ants across MU with bait cards annually																				

Ecosystem Restoration Management Plan
MIP Year 12-16, Oct. 2016-Sept. 2021
OIP Year 9-13, Oct. 2016-Sept. 2021
MU: Kamaili

Overall OIP Management Goals:

- Form a stable, native-dominated matrix of plant communities which support stable populations of IP taxa.
- Control ungulate, weed, predatory snail, rodent, and slug threats in the next five years to allow for stabilization of IP taxa. Implement control methods by 2021.

Background Information

Location: Leeward side of Northern Waianae Mountains, southwestern base of Makaha Valley
Land Owner: City and County of Honolulu Board of Water Supply (BWS)
Land Manager: U.S. Army Garrison Hawaii
Acreage: 2.83 acres (Kamaili Makai, western fence), 6.73 acres (Kamaili Mauka, eastern fence)
Elevation range: 1,800 to 2,200 ft.
Description: Kamaili is a sub gulch located in the lower reaches of Makaha Valley, with moderate to steep slopes and small cliffs. It is divided by several small ridges and gullies. Due to the challenging terrain the MU is divided into two small fence units. One is located on the western side of the gulch, the other on the eastern side of the gulch. Kamaili Mauka fence contains two small gulches with a dividing ridge and is twice the area of Kamaili Makai. The Kamaili Makai fence has one small gulch running through the middle of the fence and incorporates a strategic fence section on the northwestern corner. A campsite and landing zone are located between the two fences to facilitate management work.

Native Vegetation Types:

Waianae Vegetation Types
Mesic mixed forest
Canopy includes: *Antidesma pulvinatum, Diospyros* spp., *Hibiscus arnottianus* subsp. *arnottianus, Myrsine lanaiensis, Nestegis sandwicensis, Sapindus oahuensis, Rauvolfia sandwicensis* Understory includes: *Alyxia stellata, Bidens torta, Coprosma* spp., and *Microlepia strigosa*
NOTE: For MU monitoring purposes vegetation type is assigned based on theoretical pre-disturbance vegetation. Alien species are not noted.
NOTE: For MU monitoring purposes, vegetation types were subdivided using topography (gulch, mid-slope, ridge). Topography influences vegetation composition to a degree. Combining vegetation type and topography is useful for guiding management in certain instances.


Looking into Kamaili gulch from Makaha subunit I. Arrows indicating fence locations.

MIP/OIP Rare Resources:

Organism Type	Species	Pop. Ref. Code	Population Unit	Management Designation	Wild/ Reintroduction
Plant	*Abutilon sandwicensis*	MAK-B, MAK-C	Makaha Makai	(OIP) MFS	Wild
Plant	*Flueggea neowawraea*	MAK-C	Makaha	(MIP) MFS	Wild
Plant	*Neraudia angulata*	MAK-C, MAK-D	Makaha Makai	(MIP) MFS	Both
Plant	*Nototrichium humile*	MAK-C	Makaha	(MIP) GSC	Wild

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

Other Rare Taxa in and near Kamaili MU:

Organism Type	**Species**	**Federal Status**
Plant	*Chrysodracon forbesii*	Endangered
Plant	*Korthasella degeneri*	Endangered
Plant	*Lipochaeta lobata* subsp.*leptophylla*	Endangered
Plant	*Melanthera tenuifolia*	Endangered
Plant	*Schiedea hookerii*	Endangered
Bird	*Chasiempis ibidis*	Endangered

Rare Resources at Kamaili:

Thumbs up for *Neraudia angulata* MAK-D reintroduction

Abutilon sandwicensis MAK-C in mauka fence

Nototrichium humile in flower

Rare Resources Locations at Kamaili:

Map removed to protect rare resources. Available upon request

MU Threats to MIP/OIP MFS Taxa:

Threat	Taxa Affected	Localized Control Sufficient?	MU scale Control required?	Control Method Notes
Pigs	All	No	Yes	MU fenced
Goats	All	No	Yes	MU fenced. Goat control efforts in the region will be planned with the State
Rats	All	Yes	Unknown	No impacts documented in area at this time, so no control currently needed.
Slugs	Slugs are a possible threat to *Abutilon* seedlings, and are a known threat to *Neraudia*	Yes	No	Sluggo may be used if no rare native snails are present in the area

Xylosandrus compactus (BTB)	*F. neowawraea*	No	No	No proven methods currently available
Weeds	All	Yes	Yes	Multiple control techniques are available. Herbicide may be used per a waiver from HBWS, and all use must conform to the restrictions of the waiver (only triclopyr and glyphosate approved).
Fire	All	No	Yes	OANRP is part of the interagency wildlands fire group.

Management History

The Kamaili MU was created fairly recently and is located in a small gulch in Makaha Valley. Surveys and collections of plants have been made over the years to secure species managed by OANRP. The implementation team decided to designate the *N. angulata* population in Kamaili as Manage for Stability in place of Waianae Kai due to poor success of outplantings in Waianae Kai and repeated fence failures.

- 1700-1800s: Intensive subsistence agriculture transforms lower reaches of Makaha Valley.
- 1900s: Ranching and coffee farming continue to modify portions of Makaha Valley with further deforestation.
- 1930-1950s: Reforestation effort by Territorial Government across portions of Makaha Valley.
- 1987: Board of Water Supply gains control of water resources and management of Makaha Valley.
- 2006: OANRP conducts surveys and begins collecting *F. neowawraea*, *A. sandwicensis,* and *N. angulata* from Kamaili area.
- 2010: Forest fire burns lower reaches of Makaha Valley, comes near Kamaili area.
- 2013: LZ built and fence construction started in September.
- 2013: Fence construction complete and deemed ungulate free.
- 2015: First planting of *N. angulata* outplanting, in May.
- 2015: Initial baseline vegetation monitoring conducted using point intercept method.
- 2016: *N. angulata* Manage for Stability designation changed from Waianae Kai MU to Kamaili MU.

Ungulate Control

Identified Ungulate Threats: Pigs, Goats
Threat Level: High

Primary Objectives:

- Maintain MU as pig and goat free.

Strategy:

- Maintain the enclosures as ungulate free of pigs and goats in the MU. Eradication of all pigs and goats within the Kamaili fence units (MAK-E) is complete.

Monitoring Objectives:

- Quarterly fence checks 2015-2021.
- Detect any pig or goat sign in the fence while conducting rare plant monitoring or other weed control work in the MU.

Management Responses:

- If any ungulate activity is detected within the fenced units, implement hunting and/or snaring and trapping program.
- Supplement existing fence with Fickle Fence material if outside pressure is forcing ungulates into the units.

Maintenance issues

The major threats to the fence include falling rocks from steep areas above the units, streams carrying rocks down gulches into the fence, fallen trees, and pigs uprooting areas beneath the fence line. Both fences have problem areas where rocks struck and damaged the fence in the past. If these occurrences are detected repeatedly in the same location, baffles above the fence will be deployed.

Quarterly checks (including maintenance) on fence integrity will be conducted, as well as, monitoring for ungulate sign during the course of other field activities. Fences are also checked after extreme weather events. Given the small sizes of the fence, it is especially important that ungulates do not enter and become trapped in the fence as extensive damage can quickly occur.

Makaha is a popular hunting location for local hunters. Vandalism has been an issue in the past with fences in neighboring areas. Building relationships with local hunters and educating them about the need for fences to protect native resources has been successful in building community awareness and reducing incidences of vandalism. Snares are not used to eradicate pigs or goats in the fences due to the chance of a hunter's dog getting into one of the enclosures. Smaller pigs, if pressured, can penetrate the panel fences that enclose these units. If this is noted, the existing fence will be supplemented with fickle wire fence.

Weed Control

Weed Control actions are divided into five subcategories:

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

These designations facilitate different aspects of MIP/OIP requirements.

Vegetation Monitoring

Vegetation monitoring was initiated at both Kamaili Makai and Kamaili Mauka subunits using point intercept methods to document cover composition and change in the understory and canopy. Results are included in Appendices A and B at the end of this document.

Surveys

Army Training: No
Other Potential Sources of Introduction: NRS, pigs/goats, birds, hikers/hunters, wind
Survey Locations: Roads, Landing Zones, Camp Sites, fencelines, High Potential Traffic Areas

Management Objective:

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

Monitoring Objectives:

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

Management Responses:

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

Surveys are designed to be the first line of defense in locating and identifying potential new weed species. Roads, landing zones, 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.

The Makaha BWS Road will be surveyed every other year, from the first gate (makai of the heiau) to the end of the road. The parking area at the end of the road is used as an LZ; it will be surveyed whenever it is used, not to exceed once per quarter. There is one LZ between the Kamaili fences, and less than 30m away from it is a drop zone and camp site (see map XX below). Both the LZ and camp site will be surveyed whenever used, not to exceed once per quarter. No weed transects have been created at Kamaili, but staff are directed to note unusual weeds when conducting regular monitoring of fencelines.

Incipient Taxa Control (ICAs)

Management Objectives:

- As feasible, eradicate species identified as high priority incipient invasive aliens in the MU by 2017.
- Conduct seed dormancy trials for all high priority incipients.

Monitoring Objectives:

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

Management Responses:

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

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

The table below summarizes invasive taxa at Kamaili. Appendices A and B also list additional non-native taxa in the two units. Note that this MU was not described in the original MIP, and therefore is not included in Appendix 3.1 of the MIP, which lists significant alien species and ranks their potential invasiveness and distribution. This table supplements Appendix 3.1 by identifying target species for Kamaili. The list below provides a good starting point for discussing which taxa should be targeted for eradication in an MU. Three management designations are possible: Incipient (small populations, eradicable), Control Locally (significant threat posed, may or may not be widespread, control feasible at WCA level), and Widespread (common weed, may or may not pose significant threat, control feasible at WCA level). Currently there are no incipient species controlled in Kamaili. NRS staff will monitor the MU and report any new invasive taxa.

Summary of Target Taxa

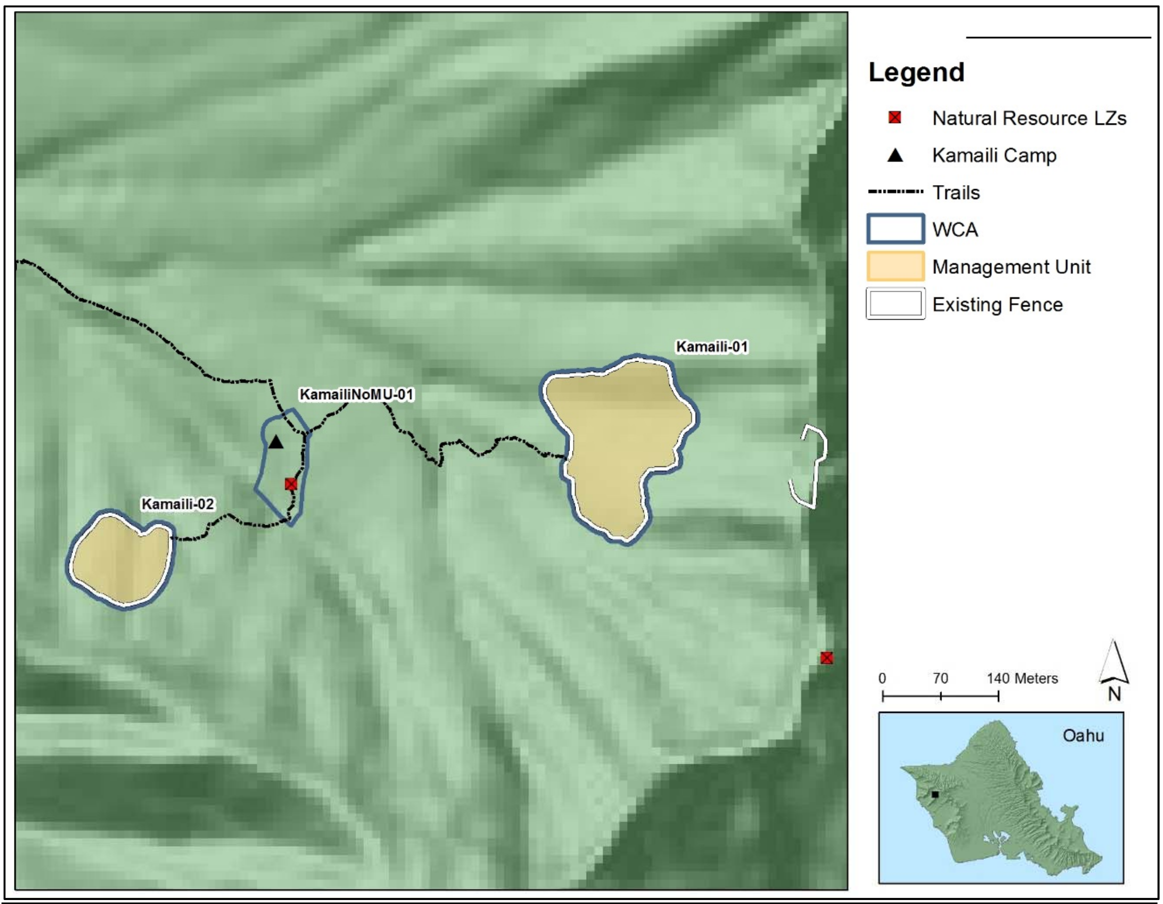
Tax	Management Designation	Notes	No. of ICAs
Abutilon grandiflora	Control locally	Observed across the MU in sunny locations. Control in WCAs, particularly near *Abutilon sandwicensis* populations, due to the concern of hybridization.	0
Adiantum hispidulum	Widespread	Observed across the MU. Low priority for control, at least until a control method is identified. This fern thrives in shady areas, and has a WRA score of 18 (very high). Target around rare taxa sites..	0

Ageratina riparia	Widespread	Observed across the MU. Low priority for control. Target around rare taxa sites.	0
Aleurites moluccana	Widespread	This large tree prefers gulches and draws and is found throughout Makaha. It should be targeted for gradual removal within the WCAs.	0
Blechnum appendiculatum	Widespread	Control in WCAs near rare plants and other native dominated areas. This habitat-altering, invasive fern forms dense mats if left unchecked.	0
Coffea arabica	Control locally	Widespread elsewhere in Makaha, little *C. arabica* is known from the Kamaili fences. It can form dense monocultures and is highly invasive. Zero tolerance for *C. arabica* within Kamaili fences.	0
Cordia alliodora	Control locally	One of two locations found on Oahu (Waimea Valley is other site). Localized at Kaneaki Heiau, appears to be naturalizing. Control if found near or in MU.	0
Dicliptera chinensis	Widespread	Mostly found in the Makai fence in small patches. Thrives in shady habitat, and can form dense mats. Control near rare taxa.	0
Fraxinus uhdei	Control locally	This large tree was used for forestry plantings in the mid-1900s. It is fast-growing and fruits prolifically. Very few are known from the Kamaili MU. They will be removed from the fences gradually.	0
Grevillea robusta	Widespread	Widespread throughout the valley. Trees shade out *Abutilon sandwicensis*. Time control with common native plantings, focusing near rare taxa. Selectively control trees as part of WCA efforts. Aminopyralid (Milestone) was effective in controlling *Grevillea robusta* in Makaha I/II MU. OANRP is no longer permitted to apply this pesticide due to the agreement with Board of Water Supply.	0
Kalanchoe pinnata	Widespread	A common dry forest weed, *Kalanchoe* reproduces vegetatively from cut leaves and stems. It sometimes forms dense stands. It should not be controlled via clip-and-drip treatments, as cut material may regrow. Plants should be treated with a foliar spray of glyphosate or foliar drizzle of Garlon 4.	0
Montanoa hibiscifolia	Control locally	Escaped from cultivation. Known to create monotypic stands in mesic forests. Found outside the fences, mostly in small numbers. Large patch of plants near LZ. Zero tolerance within fences.	0
Leuceana leucocephala	Widespread	Only a few small patches of plants in fence. This drought and fire tolerant tree thrives in dry conditions. Control during WCA efforts using a 40% dilution of Garlon 4 Ultra in biodiesel. As light levels change there might be an increase in population.	0
Melia azedarach	Control locally	Only a few trees found within fences. Thrives in mesic-dry forest, disperses over great distances, but does not tend to form dense stands. Control during WCA efforts. Can be controlled with basal bark application in an 8 inch band.	0
Melinus minutifolia	Widespread	This grass invades open areas, especially fencelines, and forms fuels which are a fire risk. Control when grass prohibits NRS to thoroughly inspect the fences, and treat all large patches within the fences.Zero tolerance within fence.	0

Oplismenus hirtellus	Widespread	Dominant grass in the understory. It thrives in shade and can form dense mats. Control around rare taxa to encourage recruitment. Treat regularly to maintain at low levels.	0
Paspalum conjugatum	Control locally	Currently, *P. conjugatum* is not a major component of the understory. However, it readily takes advantage of open gaps, and even thrives in shady areas. It may become a problem as weeded areas are opened. Large patches can be carefully treated with foliar sprays of glyphosate, and small patches can be handpulled. It should be controlled in the course of regular WCA work.	0
Passiflora suberosa	Widespread	Widespread vine in MU. It has a WRA of 12 (very high), roots from multiple nodes, smothers surrounding vegetation, and is labor-intensive to remove. Control around rare taxa as part of WCA efforts.	0
Psidium cattleianum	Widespread	This is one of the most invasive, habitat-altering trees in Hawaii. It is widespread in Makaha, but relatively little is present in the Kamaili fences. It is a target for control in WCA efforts.	0
Psidium guajava	Widespread	This prolifically fruiting tree is found scattered throughout Waianae forests. It should be controlled in the course of WCA efforts, and eliminated from the fences.	0
Rivinia humilis	Widespread	Widespread and dominant in the understory. Low priority until it can be replaced with a native species. This weed quickly recolonizes areas from which it has been weeded, reducing the benefit of control efforts. Investigate seed longevity	0
Schinus terebinthifolius	Widespread	Widespread across the MU, mostly in the mauka fence. Trees shade out *Abutilon sandwicensis* and rip apart slopes when they fall over. Time control with common native outplantings, focusing removal efforts near rare taxa and more native areas.	0
Sideroxylon persimile	Control locally	Widespread on the northern and eastern slopes of Makaha valley, and scattered across the lower elevations of Kamaili gulch. Not known from inside the management unit. This taxon has a WRA score of 8 (invasive), and thrives in dry-mesic forest. One mature tree was found along the trail from camp to Kamaili Makai. Control when found.	0
Spathodea campanulata	Widespread	This tree is scattered across the valley. It colonizes open areas, and can grow to more than 10m in height. It should be controlled wherever found within the Kamaili fences.	0
Syzygium cumini	Widespread	This tree has a wide distribution. It thrives on slopes and in gulches, and forms dense shade. Large trees are difficult to kill, and often require multiple treatments. *Syzygium* may host *Puccinia* rust, which targets native Myrtaceae such as *Eugenia* and *Metrosideros*. It should be gradually removed from within both fences.	0
Toona ciliata	Widespread	Widespread across the entire valley and MU, mostly in gulch bottoms. It has not yet fully invaded the Kamaili fences. High priority to remove. Selectively control trees as part of WCA efforts, and have zero tolerance for trees over 2m in height.	0

Triumfetta semitriloba	Widespread	Widespread across MU. The seeds of this shrub are covered in burrs, allowing it to easily hitchhike on staff and feral ungualtes. It thrives in disturbed areas. Uncommon in other orange team MUs. Pull during weed control efforts, as well as, along trails, on LZ, and at Campsite.	0
Urochloa maxima	Control locally	This fire-prone grass can form dense stands. It is the dominant vegetation in the makai portions of Makaha. Isolated patches are found at Kamaili and should be controlled during WCA work. Zero tolerance within WCAs or along fencelines.	0

Ecosystem Management Weed Control and Restoration (WCAs)



<u>OIP/MIP Goals:</u>

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

<u>Management Objectives</u>:

- Reduce alien cover in both understory and canopy across the MU, working towards goal of 50% or less alien vegetation cover. .

- Increase native cover in both understory and canopy across the MU, working towards a goal of 50% or more native vegetation cover.
- All portions of the MU are within 50m of rare taxa.

Management Responses:

- Revise weeding strategy if MU vegetation monitoring (conducted every 5 years) indicates that goals are not being met.

Vegetation monitoring (Appendices A and B) indicates that the Kamaili MU does not currently meet any of the MU vegetation cover goals, with the exception of native canopy cover in the Kamili-02 WCA (61% cover) and non-native cover in the understory in Kamaili-01 (28%). The forest at Kamaili is dominated by alien vegetation, and while pockets of native forest persist, meeting MU goals will be challenging. There are two WCAs in the MU, one around each fence and one WCA outside of the MU. The MU is small, and rare taxa are found throughout both fences. The entire MU is within 50 m of a rare taxa, meaning the general IP goal is actually for 25% or less alien vegetation cover in both understory and canopy; this is an even more challenging goal. We propose that the 50% alien cover goal be used, instead of the 25% cover goal.

BWS currently allows us to apply herbicide in Makaha Valley under a special permit, and are strongly encouraging us to reduce herbicide usage and expand our restoration toolbox. To this end, we hope to use a combination of weed control and restoration actions (outplanting, seed sowing, transplanting), in harmony, at Kamaili.

Restoration activities are discussed in the notes section for each WCA. See the table titled 'Taxa considerations for restoration actions,' below, for specific notes on what taxa may be used at Kamaili.

WCA: Kamaili-01 (Mauka Fence; 6.73 acres)

Vegetation Type**:** Dry-Mesic forest

OIP/MIP Goal**:** 25% or less alien cover (rare taxa in WCA). Management goals are nearly met for both non-native vegetation in the understory (28%), and for native vegetation in the canopy (43%).

Notes: This WCA contains two patches of *A. sandwicensis*, one *F. neowawraea,* and a few individuals of *N. humile*. The north end of the WCA is oriented along a small ridge. The WCA then spans a little gully to the south, then another small ridge, and ends on the lower slopes of the second ridge. In general the ridges have more native forest, while the gullies are weed dominated. The WCA consists of four management zones: Lama Zone, Talus Gulch Zone, Rare Plant Zone, and Fence Corridor. Removing fuel-forming alien grasses, particularly *U. maxima* and *M. minutiflora* will be a priority across the WCA.

Since the rare plant zones are primarily in weed dominated habitat, canopy control and understory weed control ideally should be undertaken in conjunction with common native reintroduction efforts. Maintaining a managed buffer around the rare taxa is a high priority to promote regeneration of *A. sandwicensis* and *N. humile*. Removal of canopy trees needs to be balanced against light level changes, and staff availability to conduct follow-up maintenance. The area likely had a fairly open understory in the past, as with other more intact dry-mesic forest areas, and currently maintains a fairly open understory, with 67% non-vegetated cover.

The Lama Zone is predominantly native and will be a high priority for weed control. Although there are few rare taxa directly in the Lama Zone, it abuts the Rare Plant Zones and contributes towards vegetation cover goals. Removing targets, such as, *G. robusta, S. terebinthifolius*, and *T. ciliata,* will be key in maintaining canopy goals for this MU. However, selective efforts are needed given the potential for aggressive colonization by other non-natives and very slow growth of *D. sandwicensis. Toona ciliata* removal is a higher priority than other canopy weeds in this zone, as this taxa has great potential to completely overrun the WCA. Other, less common tree weeds, such as *S. cumini* and *M. azedarach* will also be targeted for gradual removal.

Intense restoration is needed in the Talus Gulch Zone of the WCA, but is a low priority except for weed control around rare taxa. Native taxa in the Talus Gulch Zone have been repeatedly struck with rocks. The weed species have outcompeted the natives due to their resilience to the constant rock fall. This zone is a good candidate for a restoration site. A portion of the gully could be opened up to create a light gap, which would be restored with a combination of common native outplantings, seed sows and transplants. Incorporating baffles could be installed to protect the common outplantings, as well as the bottom of the fence. Staff have noted natural recruitment of native plants in the area as well. Some taxa being considered for restoration actions included *Raovulfia sandwicensis, Pisonia* spp., and *Sapindus oahuensis*.

The rare plant zones (north gulch and south gulch) requires phased control of weeds and selective control of canopy weeds. Areas near the main *A. sandwicensis* clusters need to be defined and starting points selected. Initial areas should be no larger than can be adequately maintained. Ground cover species like weedy ferns, vines, and grasses should be treated first, then larger understory species, then selective removal of canopy trees. Treated trees will likely need to be cut down, bucked, and debris piled into slash piles. Initial control trips are needed about one to two times per quarter (see action table at the end of this document) with supplemental planting with fast growing species like *Dodnea viscosa, Pisonia sandwicensis,* and *Pipturus albidus*. Aggressive follow up is needed for understory weeds like *B. appendiculatum* and grasses once light levels increase.

The Fence Corridor will be maintained (inside and outside) anytime grass or weeds prohibit us from checking the fences thoroughly. A catchment is now on site to facilitate weed control. Caution is needed when spraying along portions of the fenceline given recruitment of *A. sandwicensis* along the line. Removal of *S. terebinthifolius* is needed in some areas to prevent damage to the fence by uprooting or downfall.

WCA: Kamaili-02 (Makai fence; 2.83 acres)

Vegetation Type**:** Dry-Mesic forest

OIP/MIP Goal: 25% or less alien cover (rare taxa in WCA). Management goals are currently not met for non-native vegetation in the understory (71%), but the goal is met for native vegetation in the canopy (61%)..

Targets: All weeds, particularly *D. chinensis*, *G. robusta P. suberosa, S. terebinthifolius, T. ciliata. C. arabica, S. cumini, S. campanulata,* and *U. maxima* to promote regeneration of rare and other native taxa.

Notes: Like Kamilia Mauka, this area consists of four zones: Lama Zone, Talus Gulch Zone, Rare Plant Zone, and Fence Corridor and has similar management prescriptions for each zone. This WCA stretches from a ridge on the eastern end, across a gully, to a central ridge, and ends on the far side of the ridge by a cliff. The central ridge hosts a *N. angulata* reintroduction on its eastern slope, and a wild *A. sandwicensis* site on its western flank. Much of the central ridge is blanketed by *R. humilis*.

Canopy control and weeding in rare plant zones is ideally undertaken in conjunction with common native reintroduction efforts. Removal of canopy trees needs to be balanced against light level changes. The unit has a fairly dense understory as only 26% of the unit is non-vegetated.

Grevillea robusta and S. terebinthifolius will be selectively killed throughout the Lama Zones (primarily on the ridges) and around *A. sandwicensis* to slowly increase light levels. This is mostly on the *N. angulata* reintroduction ridge. Sweeps across the whole area should gradually thin the alien canopy, and all understory weeds need treatment except *R. humilis*. Native fern outplants could be trialed as a replacement for *R. humilis* in spots.

Intense restoration is needed in the Talus Gulch Zone of the WCA but is a low priority. The Talus Gulch Zone is a good candidate for common native outplantings. Common natives selected for this area, such as *Dodnea viscosa,* needs be hardy enough to withstand rockfall.
N. angulata was augmented in to the fence in 2015 and will be the main focus of this WCA; mainly controlling *P. suberosa, D. chinensis*, and other herbaceous weeds.

The main rare plant zones (N. angulata reintroduction and *A. sandwicensis* patch along western edge) require similar thinning of the canopy. *Grevillea robusta* removal efforts along the western edge have already benefitted the *A. sandwicensis* plants in the area. Keeping open some bare soil areas near the rare plants is important for recruitment. Grasses and weedy fern species will need to be kept in check. Outplanting natives (e.g., *P. zeylanica*) to compete with *R. humilis* should be trialed particularly along the western edge.

The Fence Corridor will be maintained (inside and outside) anytime grasses or weeds prohibit us from checking the fences thoroughly. Removal of *S. terebinthifolius* is needed in some areas to prevent damage to the fence by uprooting or downfall.

WCA: KamailiNoMU-01 (LZ)

Vegetation Type**:** Dry-Mesic forest

OIP/MIP Goal: None. Landing Zone (LZ)

Targets: *M. hibiscifolia*, *Conyza bonariensis*, *Ageratum conyzoides, T. ciliata,* and *S. terebinthifolius* when it prohibits safe landing of the helicopter.

Notes: WCA efforts will be focused on maintaining the LZ, drop zone and campsite, as well as, controlling a monotypic patch on *M. hibiscifolia.* The boundary of the WCA needs to be GPSed to include the entire *M. hibiscifolia* patch, as well as the adjacent camp drop zone. The *M. hibiscifolia* patch appears to be somewhat isolated, and is fairly monotypic. It is a priority for control, after work within the MU itself, because it reproduces quickly, disperses via wind, and forms dense stands that are difficult to walk through. Controlling this patch will reduce the chance of *M hibiscifolius* becoming a problem within either MU fence.

The LZ is almost always overgrown with weeds on every quarterly trip to Kamaili. Suppressing herbaceous growth will improve safety and free up staff from constantly clearing the LZ. Conversations about planting sterile grasses to suppress herbaceous weeds and improve LZ safety have been discussed. Species selection, as well as permission from BWS still needs to be attained. Other options including constructing a small platform, or installing weed matting.

Taxa considerations for restoration actions:

Native Taxon	Outplant?	Seedsow/ Division/ Transplant?	Notes
Antidesma pulvinatum	Yes	No	Tree. Grow from cuttings or seed.
Bidens torta	No	Seed sow	Herb. Easily grown via seed sows.
Canavalia galeata	Yes	No	Vine. May not provide enough weed suppression to be worthwhile
Carex meyenii	Yes	Seedsow/Division	Sedge. Grow from seed. Seed sows slow to germinate but effective.
Dodonea visoca	Yes	No	Small tree. Grow from seed.
Hibiscus arnottianus	Yes	No	Tree. Fast-growing. Grow from cuttings.
Metrosideros polymorpha	Yes	No	Tree. Slow-growing. Grow from cuttings or seed.
Microlepia strigosa	Maybe	Division	Fern. Survives transplanting in mesic environments.
Myrsine lanaiensis	Yes	No	Tree. Grow from cuttings or seed.
Nestegis sandwicensis	Yes	No	Tree. Grow from cuttings or seed.
Pipturus albidus	Yes	Seedsow/Transplant	Small tree. Fast growing. Known to grow from seed sows.
Pisonia sandwicensis	Yes	Seedsow/Transplant	Tree. Fast growing. Easy to propagate. Some located just ouside of Kamaili Mauka. Know to grow from seed sows.
Planchonella sandwicensis	Yes	No	Tree. Grow from cuttings or seed. Slow growing.
Plumbago zeylanica	Yes	Transplant?	Herb/ground cover. Grow from cuttings or seed. Unknown if transplanting effective.
Psydrax odorata	Yes	No	Tree. Grow from cuttings or seed.
Rauvolfia sandwicensis	Yes	Transplant?	Tree. Some natural recruitment on site. Grow from cuttings or seed.
Sapindus oahuensis	Yes	No	Tree. Grow from cuttings or seed.
Sida fallax	Yes	No	Shrub. Grow from cuttings or seed.

Rodent Control

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

Threat level: Unkown

Current control method: None

Seasonality: N/A

Number of control grids: None

Primary Objective:

- To implement rodent control if determined necessary for the protection of rare plants.

Monitoring Objective:

- Monitor rare plant (*N. angulata* and *A. sandwicensis)* populations, as well as other native species to determine impacts by rodents.

MU Rodent Control:

- Currently no rodent control is conducted by OANRP at Kamaili, since rodents are not deemed a threat at this time. If rare plants are determined to be impacted adversely by rodents, OANRP will evaluate the use of localized rodent control for the protection of these species. Given the small size and dry habitat, a grid of A-24 traps might effectively reduce rat numbers to allow for even greater regeneration of fruiting canopy species like *R. sandwicensis* which already recruits more readily than other native canopy species and this would be good for habitat restoration.

Ant Control

Species: Unknown

Threat level: Unknown

Control level: Unknown

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

Number of sites: Four; Two populations of *N. angulata* and two populations of *A. sandwicensis*

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

Primary Objective: Collect data on species present and control if ant densities are high enough to threaten rare resources, or if incipient, high-risk species are found.

Management Objective:

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

Monitoring Objective:

- Sample ants at campsite, LZ, rare taxa sites, DZ, and fencelines to track changes in existing ant densities and to alert OANRP to any new introductions.
- Look for evidence of ant tending of aphids or scales on rare plants.

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. Since 2006, we sample ants 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 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 for later identification.

Standardized surveys have not yet taken place.

Slug Control

Species: Unknown, likely *Deroceras laeve* and *Limax maximus* present

Threat level: Unknown

Control level: Unknown

Seasonality: Less abundant in the dry season (May-August)

Number of sites: Potentially four sites, two populations of *Neraudia angulata* and two populations of *A. sandwicensis*

Primary Objective:

- Eradicate slugs locally to ensure germination and survivorship of rare plant taxa.

Monitoring Objectives:

- 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, 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, apply Sluggo monthly until slug numbers are reduced.

Management Objective:

- Enhance seedling germination via reduction of seedling predators. Count numbers of new recruits during annual rare plant monitoring events.

Fire Control

Threat Level: Medium

Available Tools: Fuel breaks, Visual Markers, Helicopter Water Drops, Honolulu Fire Department.

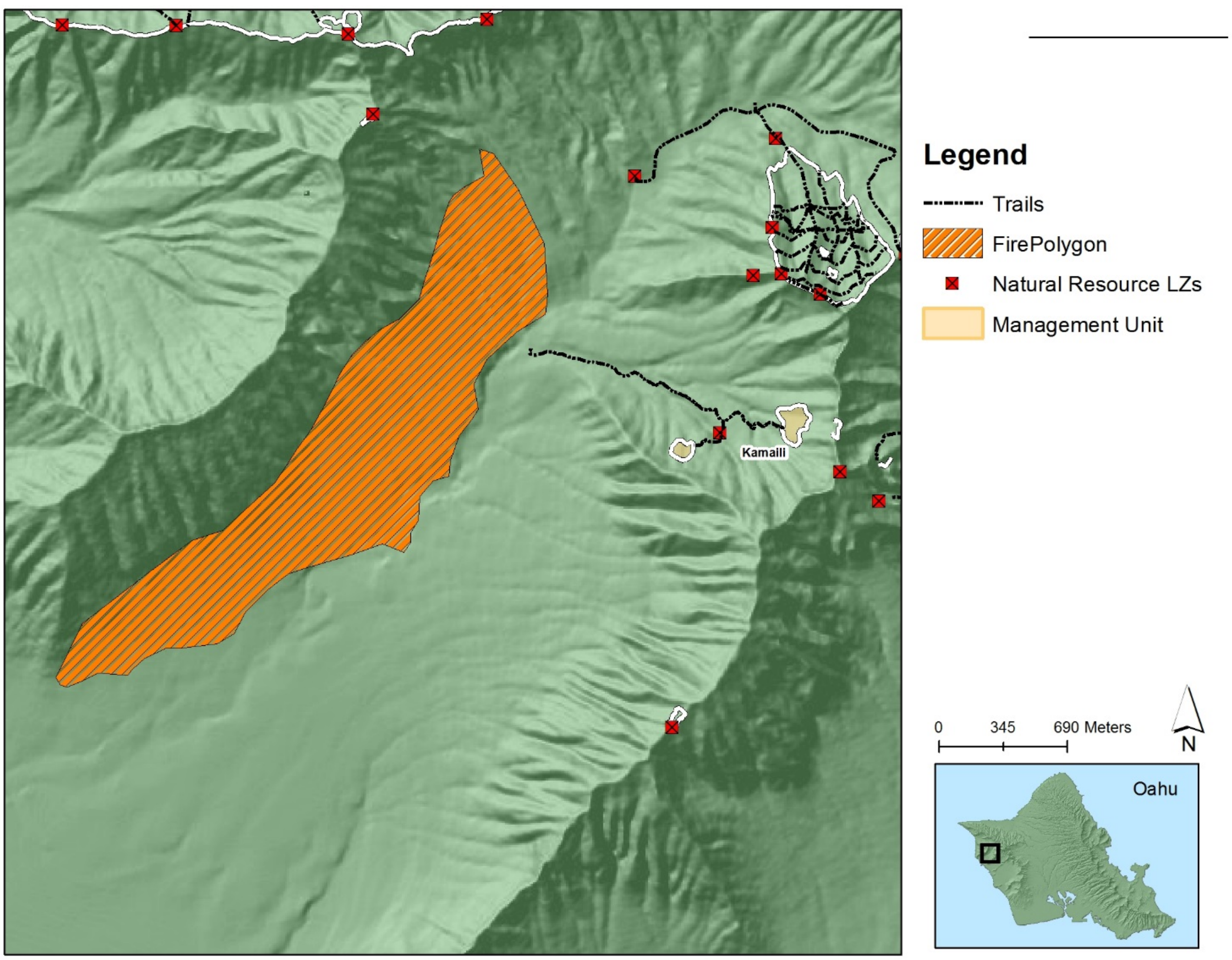
Management Objective:

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

Preventative Actions

Since most ignitions are started by people, fires in Makaha normally start in the lower section of the valley closer to civilization. The majority of the fuel load in Makaha is located on the south facing slopes and in lower elevations where fire had previously burned. BWS has been constructing a fire break on the southern slopes to mitigate this threat. The fire break utilizes tree species to shade out grasses and reduce fire loads at strategic points. Keeping fence corridors clear, as well as, reducing fuel load around high value portions of the MU can provide somewhat of a fuel break. Depending on the location of the fire and what resources are threatened Honolulu Fire Department, State, or Military may assist in fire suppression. In recent years OANRP has provided helicopter support for wildland fire suppression when fire threatens rare resources OANRP manage. OANRP will focus on maintaining good communication with the Wildland Fire Working Group to facilitate aggressive on-the-ground fire responses.

Burned Areas in Makaha near Kamaili in 2010.



Action Table

Species names are written as six-digit abbreviations, such as ‘TooCil’ instead of *Toona ciliata*, for the sake of brevity.

Action Type	Actions	OIP Year 9 Oct 2016- Sept 2017				OIP Year 10 Oct 2017- Sept 2018				OIP Year 11 Oct 2018- Sept 2019				OIP Year 12 Oct 2019- Sept 2020				OIP Year 13 Oct 2020- Sept 2021			
		4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
Ungulate Control	Quarterly fence checks Identify and scope high probability ungulate usage areas																				
	Create Baffles																				
Vegetation Monitoring	Conduct baseline vegetation monitoring across MU																				
	Conduct MU vegetation monitoring every 5 years (2021 Q3)																				
General Survey	LZ-Kamaili-199: Survey Kamaili LZ whenever use, not to exceed once per quarter. If not used, no need to survey.																				
	LZ-MAK-096: Survey Makaha Parking Area LZ whenever use, not to exceed once per quarter. If not used, no need to survey.																				
Common Native	Common native collection: collect/monitor fruit from common native plants across Kamaili for propagation or storage. Use Collection Needs list: V: Programmatic /Common Natives /Collection Needs. Action includes monitoring plant phenology.																				
	Kamaili-01: Common native restoration actions in WCA: Scoping, Planting (outplant, sows, divisions/ transplants), Monitoring (plant monitoring, watering).																				

Action Type	Actions	OIP Year 9 Oct 2016- Sept 2017				OIP Year 10 Oct 2017- Sept 2018				OIP Year 11 Oct 2018- Sept 2019				OIP Year 12 Oct 2019- Sept 2020				OIP Year 13 Oct 2020- Sept 2021			
		4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
General WCA	Kamaili-02: Common native restoration actions in WCA: Scoping, Planting (outplant, sows, divisions/ transplants), Monitoring (plant monitoring, watering).																				
	Water source for both fences (fine tune, install, construct, lay line, etc).																				
	Scoping trips for ecosystem restoration related projects in Kamaili. As needed.																				
Kamaili-01 (Kamaili Mauka)	Sweep through lama-dominated ridges, native canopy zones 1-2x year. Control understory weeds and gradually remove canopy weeds; avoid creating large light gaps; target TooCil, GreRob, SpaCam, and other uncommon canopy weeds.																				
	Control weeds around the two Abusan sites 1-2 times per year.																				
	Control SchTer and other weeds in gulch areas (northern gulch and southern gulch). Control understory, remove SchTer aggressively, conduct consistent follow-up weed control and restoration.																				
	Clear/maintain weeds along fenceline, as needed.																				
Kamaili-02 (Kamaili Makai)	Sweep through lama-dominated ridges, native canopy zones once a year. Control understory weeds, except Rivhum, and gradually remove canopy weeds; avoid creating large light gaps; target TooCil, SpaCam, CofAra and other uncommon canopy weeds.																				

Action Type	Actions	OIP Year 9 Oct 2016-Sept 2017				OIP Year 10 Oct 2017-Sept 2018				OIP Year 11 Oct 2018-Sept 2019				OIP Year 12 Oct 2019-Sept 2020				OIP Year 13 Oct 2020-Sept 2021			
		4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
	Control understory and select canopy weeds around the NerAng MAK-B reintro site, 2 times per year. Qtrs 2 and 4																				
	Control SchTer and other weeds in gulch. Control understory, remove SchTer aggressively, conduct consistent follow-up weed control and restoration.																				
	Control understory and gradually remove select canopy weeds around the western Abusan sites 1-2 times per year.																				
KamailiNoMU-01 (Kamaili LZ and Camp)	Map perimeter of MonHib patch, use to modify WCA boundary. MonHib flowers in winter. Consider heli survey.																				
	Maintain LZ and keep clear for safe helicopter use. This may involve removing trees, and clearing shrubs. Conduct as needed. Consider erosion matting or a platform.																				
	Control MonHib next to LZ and in gulch to west and south. This is an isolated patch, and goal is to prevent it from spreading to the exclosures.																				
Rodent Control	Implement localized rodent control if determined to be necessary for the protection of rare plants.																				
Ant Control	Sample ants at LZ, Campsite, near rare taxa, and on fenceline																				
Predatory Snail Control	Implement control if deemed necessary																				
Slug Control	Determine slug species present and estimate baseline densities to help guide future control if deemed necessary																				

Appendix A:

VEGETATION MONITORING OF KAMAILI MAUKA MANAGEMENT UNIT, 2015

INTRODUCTION

Vegetation monitoring was conducted at Kamaili Mauka Management Unit (MU) in July and September 2015 in association with MIP/OIP requirements for long term monitoring of vegetation composition and change over time (OANRP 2008a). This MU encompasses 6.73 acres. Fencing and ungulate removal was completed in 2014. 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 the percent cover of native plant species is greater than 50% across the MU, or is increasing towards that threshold recommendation.

METHODS

Point intercept monitoring was used to assess 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, with notations for uppermost canopy species (the highest taxa at a given location). A 5 millimeter diameter, 6 foot tall pole was used to determine "hits" in the understory (live vegetation that touches the pole) along an outstretched measuring tape at regular intervals. A laser pointer affixed to the pole was used to determine laser "hits" in the canopy at these same points, where the point falls within the perimeter of a tree's canopy. The uppermost taxa among overlapping canopy was denoted as such. Locations where no vegetation was intercepted in the understory was recorded as soil, leaf litter, or rock. Point intercepts were located every 2.5 meters (m) along 9 transects spaced 15-30 m apart for a total of 505 points (Figure 1). Transects were oriented east/west (magnetic) generally from every third fence

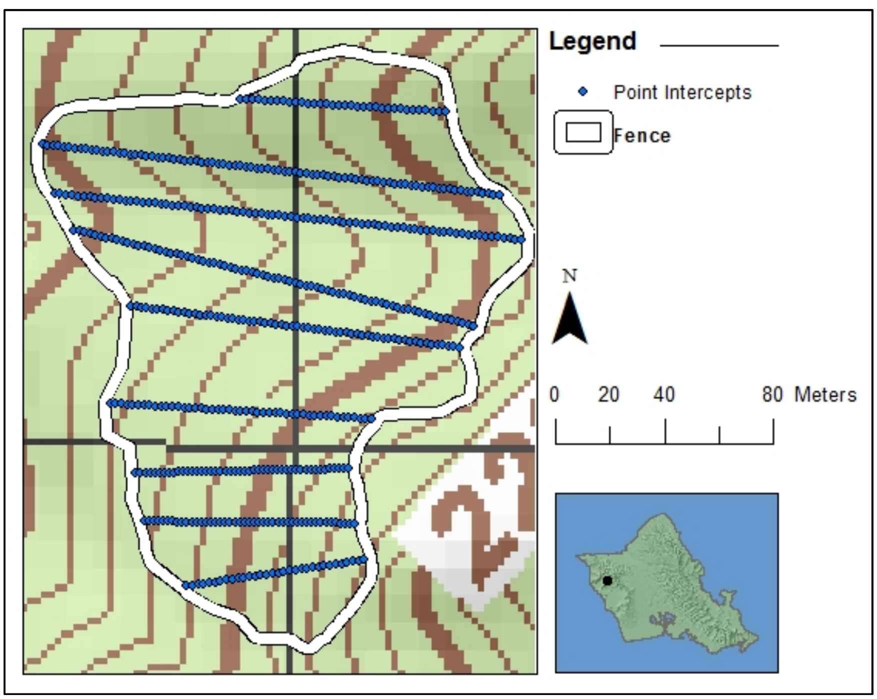


Figure 1. Locations of point intercepts along transects at Kamaili Mauka MU, 2015.

marker, with the starting point for the first transect randomly chosen among fence markers. Approximations of percent cover were obtained from the proportion of "hits" among all intercepts. Because infrequent and/or low cover taxa were less likely to be accounted for using point intercept monitoring, a list of all taxa anecdotally observed during the course of monitoring was created. Predictions of taxa occurrence were made using Geostatistical Analyst, ArcGIS 10.3.

RESULTS

Management goals were met for non-native vegetation cover in the understory (28%), and were nearly met for native vegetation in the canopy (43%) (Table 1). Non-native cover exceeded native cover in both the understory and canopy. The understory was largely non-vegetated, while the canopy cover was nearly continuous, and often multilayered with both native and non-native taxa (31% overlapping native and non-native canopy cover). Half of the non-vegetated understory contained leaf litter, while the remainder consisted of equal proportions of soil and rock substrata. Seven native and 18 non-native species were identified in the understory during monitoring, with *Oplismenus hirtellus* (12.1%) and *Adiantum hispidulum* (8.1%) most prevalent. Eleven native and 14 non-native taxa were recorded in the canopy, dominated by *Schinus terebinthifolius* (66.7%), *Diospyros sandwicensis* (30.9%), *Toona ciliata* (13.1%), *Aleurites moluccana* (9.7%), and *Grevillea robusta* (9.7%) (Table 2). The uppermost canopy was similarly dominated by the same taxa (Table 3). A total of 36 taxa (33% native) were identified during point intercept monitoring. Anecdotal observations of 31 additional taxa (45% native) were made while monitoring, but were not intercepted (Table 4). Predicted locations (using ordinary kriging[1]) of native and non-native taxa indicate patchy distributions in the understory and canopy (Figures 2 and 3).

Table 1. Percent cover of native and non-native taxa and non-vegetated areas in the understory and canopy, as well as soil, leaf, and rock substrata within non-vegetated understory.

	Understory (%)	Canopy (%)	Uppermost Canopy (%)
Native	7	43	21
Non-native	28	86	77
Non-vegetated (total)	67	2	2
Non-vegetated (leaf litter)	*33*		
Non-vegetated (soil)	*17*		
Non-vegetated (rock)	*16*		

[1]**Note to readers less familiar with geostatistical analyses:** Ordinary kriging is a statistical method used in association with geographic information to create maps, for example as in this report, to show predicted locations of one or more variables, with the probability of occurrence indicated by color coded values. It maps probable, not actual, distributions. Known locations are used to predict presence/absence in unsampled locations. This method also includes statistical analyses of prediction error that indicate how well the model works, by removing known data points and predicting what they should be. When used in association with point intercept data, locations of taxa and taxon groupings with higher cover, particularly those that tend to occur in clusters, may be more accurately predicted. Those with low cover and spotty distributions will have considerably less certainty when mapped. For example, *Psidium cattleianum*, which often occurs in expansive monotypic stands, would likely be consistently encountered during monitoring, versus tiny ferns such as *Lepisorus thunbergianus*, as chances of intercepting it are very low, even if there are numerous widely scattered individuals. As such, prediction maps for only taxon groupings (native and non-native) and the most predominant taxa are presented in this report.

Table 2. Species percent cover in the understory and canopy. Native taxa are in boldface.

Understory	Cover (%)	Canopy	Cover (%)
Oplismenus hirtellus	12.1	*Schinus terebinthifolius*	66.7
Adiantum hispidulum	8.1	***Diospyros sandwicensis***	30.9
Diospyros sandwicensis	5.0	*Toona ciliata*	13.1
Rivina humilis	4.4	*Aleurites moluccana*	9.7
Schinus terebinthifolius	2.6	*Grevillea robusta*	9.7
Toona ciliata	1.8	***Sapindus oahuensis***	6.9
Passiflora suberosa	1.0	*Syzygium cumini*	4.4
Diospyros hillebrandii	0.6	*Psidium guajava*	3.2
Blechnum appendiculatum	0.4	***Psydrax odorata***	2.8
Dodonaea viscosa	0.4	***Hibiscus arnottianus***	2.4
Melinis minutiflora	0.4	***Nestegis sandwicensis***	2.4
Psidium guajava	0.4	***Metrosideros polymorpha***	1.2
Psydrax odorata	0.4	***Pisonia sandwicensis***	1.2
Salvia coccinea	0.4	***Abutilon sandwicense***	1.0
Triumfetta semitriloba	0.4	*Melia azedarach*	1.0
Ageratina adenophora	0.2	***Dodonaea viscosa***	0.6
Kalanchoe pinnata	0.2	***Canavalia galeata***	0.4
Lantana camara	0.2	***Diospyros hillebrandii***	0.4
Leucaena leucocephala	0.2	*Leucaena leucocephala*	0.4
Melia azedarach	0.2	*Passiflora suberosa*	0.4
Microlepia strigosa	0.2	*Spathodea campanulata*	0.4
Passiflora edulis	0.2	*Buddleja asiatica*	0.2
Pisonia sandwicensis	0.2	*Fraxinus uhdei*	0.2
Sapindus oahuensis	0.2	*Passiflora edulis*	0.2
Syzygium cumini	0.2	*Psidium cattleianum*	0.2

Table 3. Uppermost canopy species percent cover (native taxa in boldface).

Uppermost canopy	Cover (%)	Uppermost canopy	Cover (%)
Schinus terebinthifolius	44.2	***Hibiscus arnottianus***	0.6
Diospyros sandwicensis	13.3	***Psydrax odorata***	0.4
Toona ciliata	10.5	*Buddleja asiatica*	0.2
Grevillea robusta	9.3	***Canavalia galeata***	0.2
Aleurites moluccana	6.3	*Leucaena leucocephala*	0.2
Sapindus oahuensis	4.8	*Melia azedarach*	0.2
Syzygium cumini	3.8	*Passiflora edulis*	0.2
Metrosideros polymorpha	1.2	*Psidium cattleianum*	0.2
Psidium guajava	1.2	*Spathodea campanulata*	0.2
Nestegis sandwicensis	0.8		

Table 4. Species anecdotally observed but not intercepted during monitoring. Native taxa are in boldface.

Abutilon grandifolium	***Doodia kunthiana***	***Plectranthus parviflorus***
Adiantum radianum	***Doryopteris decipiens***	*Pluchea carolinensis*
Ageratina riparia	*Indigofera suffruticosa*	***Psilotum nudum***
Alyxia stellata	***Lepisorus thunbergianus***	***Rauvolfia sandwicensis***
Carex meyenii	*Mesosphaerum pectinatum*	***Santalum freycinetianum***
Cheilanthes viridis	*Oxalis corniculata*	*Sida rhombifolia*
Cocculus orbiculatus	*Paspalum conjugatum*	***Strongylodon ruber***
Conyza bonariensis	***Peperomia tetraphylla***	*Urochloa maxima*
Cordyline fruticosa	*Phlebodium aureum*	*Verbena litoralis*
Crassocephalum crepidoides	***Planchonella sandwicensis***	*Youngia japonica*
Cyperus hypochlorus* var. *hypochlorus		

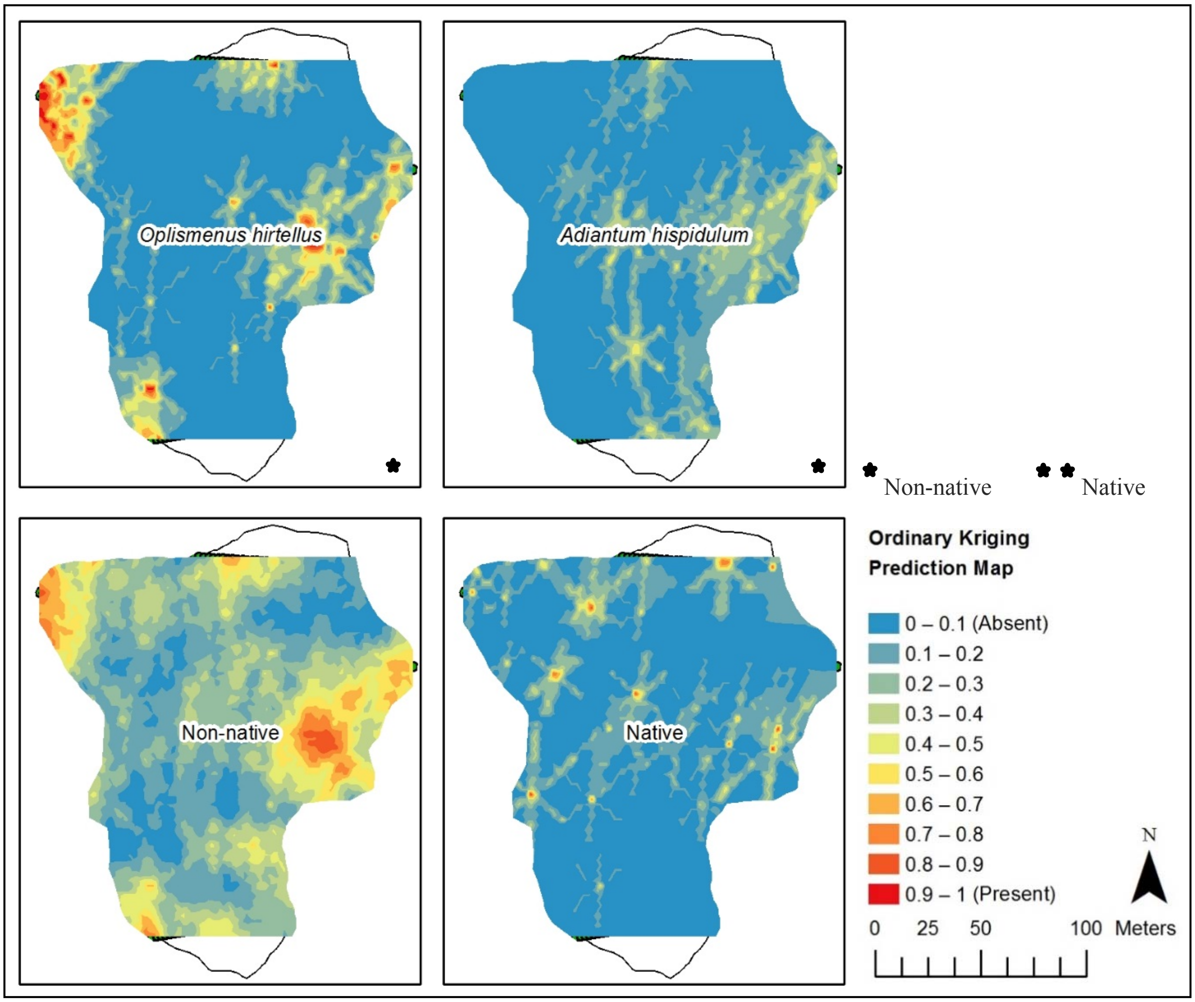


Figure 2. Ordinary kriging predicted locations of understory taxa, showing most prevalent species as well as overall non-native and native cover. Probability of occurrence is scaled from zero (shown in blue, indicating absence) to one (shown in red, indicating presence).

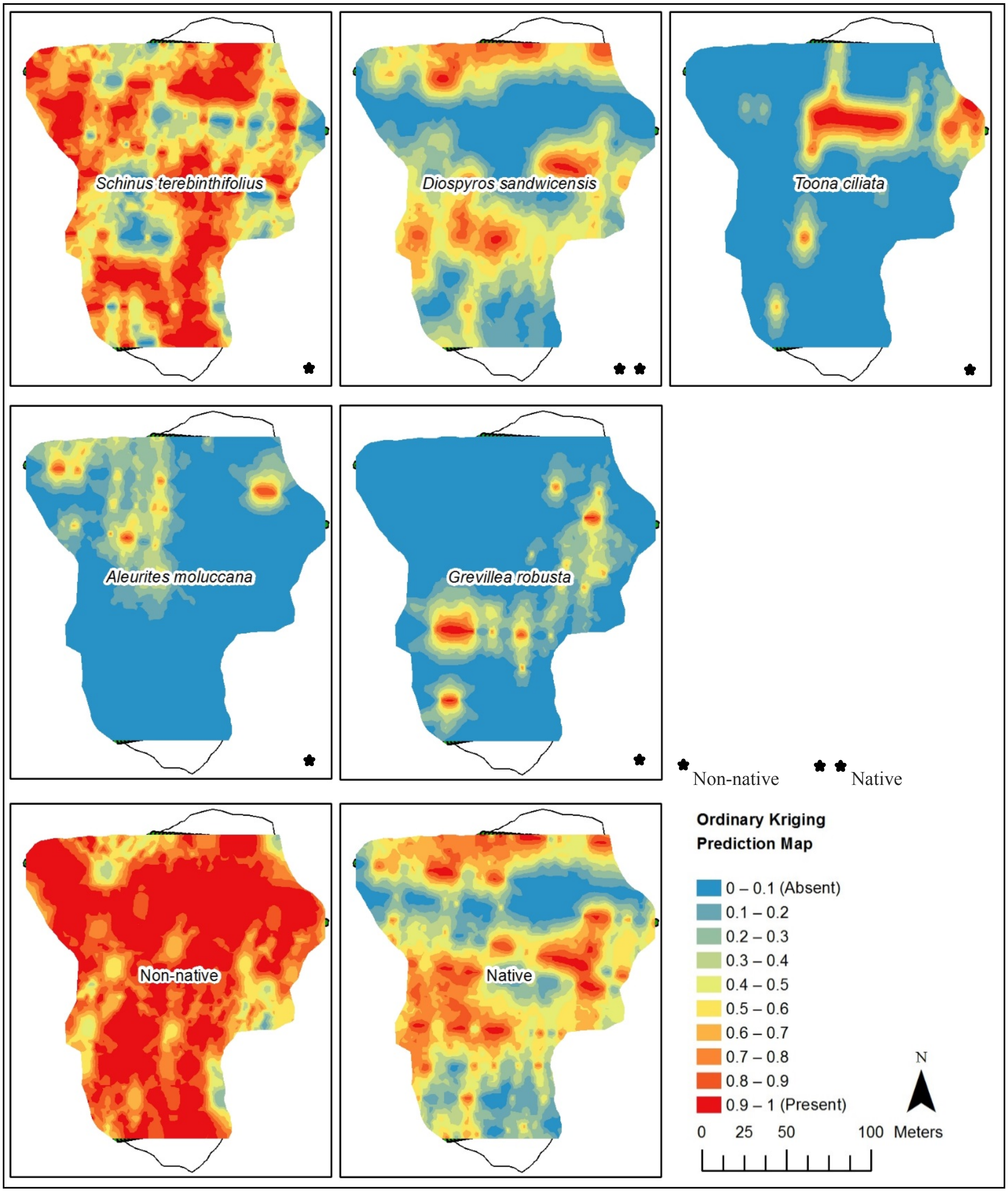


Figure 3. Ordinary kriging predicted locations of canopy taxa, showing most prevalent species as well as overall non-native and native cover. Probability of occurrence is scaled from zero (shown in blue, indicating absence) to one (shown in red, indicating presence).

DISCUSSION AND RECOMMENDATIONS

Efforts towards achieving IP goals for native and non-native cover in the understory and canopy at Kamaili Mauka MU should be prioritized based on the most relevant needs for the area. Increasing native understory cover from 7 to > 50% may be an impractical endeavor, and possibly an inappropriate goal, as intact *D. sandwicensis*-dominated dry forests do not necessarily have such high native understory cover. Increasing native canopy cover from 43 to > 50% is feasible, though not likely to be rapid, as many native dry forest trees grow slowly. Reduction of non-native canopy cover from 86% to < 50% may be challenging, but progress may be made towards that goal. While the goals are currently met for non-native understory, efforts should be made to maintain low cover. Predicted locations (using ordinary kriging) of non-native, native, and co-occurring canopy are shown in Figure 4 in reference to known locations of rare taxa, and may be used as a guide for planning areas of canopy weed removal. Many of the rare taxa points are located in areas with high non-native cover. Rare taxa primarily consist of *Abutilon sandwicense*, which responds positively to alien canopy removal. Active restoration may be targeted around rare taxa, to include non-native canopy removal and plantings of common native species, recognizing that these weedy zones will require regular follow-up control efforts to prevent the proliferation of understory weeds. In areas where native and non-native canopy co-occur, non-native canopy may be gradually removed to minimize the creation of light gaps and subsequent proliferation of non-native understory. Approximately one-third of the MU has such overlapping canopy, with potential for selective canopy removal. Problematic understory and vine taxa, including grasses, *Ageratina riparia*, *Passiflora edulis*, *Passiflora suberosa*, and *Triumfetta semitriloba*, should be targeted to prevent their expansion. *Toona ciliata,* and to a lesser extent *G. robusta* and *A. moluccana*, should be controlled in and around the fence to maintain low levels. Less common canopy weeds should be targeted for gradual removal: *Syzygium cumini*, *Fraxinus uhdei*, *Spathodea campanulata*, *Melia azedarach*, *Psidium guajava*, and *Psidium cattleianum*.

Map removed to protect rare resources

Figure 4. Ordinary kriging predicted locations of native, non-native, and co-occuring native and non-native canopy cover. Probability of occurrence is arbitrarily scaled from one (shown in blue, indicating occurrence of only native canopy) to five (shown in red, indicating occurrence of only non-native canopy), with overlapping native and non-native canopy (value of 3) shown in yellow. Color gradients between blue and yellow indicate the range in probability of only native canopy vs. mixed native and non-native canopy occurrence. Color gradients between yellow and red indicate the range in probability of mixed native and non-native canopy vs. only non-native canopy occurrence.

Appendix B:

VEGETATION MONITORING OF KAMAILI MAKAI MANAGEMENT UNIT, 2015

INTRODUCTION

Vegetation monitoring was conducted at Kamaili Makai Management Unit (MU) in September 2015 in association with MIP/OIP requirements for long term monitoring of vegetation composition and change over time (OANRP 2008a). This MU encompasses 2.83 acres. Fencing and ungulate removal was completed in 2014. 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 the percent cover of native plant species is greater than 50% across the MU, or is increasing towards that threshold recommendation.

METHODS

Point intercept monitoring was used to assess 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, with notations for uppermost canopy species (the highest taxa at a given location). A 5 millimeter diameter, 6 foot tall pole was used to determine "hits" in the understory (live vegetation that touches the pole) along an outstretched measuring tape at regular intervals. A laser pointer held against the pole was used to determine laser "hits" in the canopy at these same points, where the point falls within the perimeter of a tree's canopy. The uppermost taxa among overlapping canopy was denoted as such. Locations where no vegetation was intercepted in the understory was recorded as soil, leaf litter, or rock. Point intercepts were located every 1 meter (m) along 5 transects spaced approximately 20 m apart with a total of 516 points (Figure 1). Transects were oriented north/south (magnetic) from every other fence marker, with the start point for the first transect randomly chosen among fence markers. Approximations of percent cover were obtained from the proportion of "hits" among all intercepts. Because infrequent

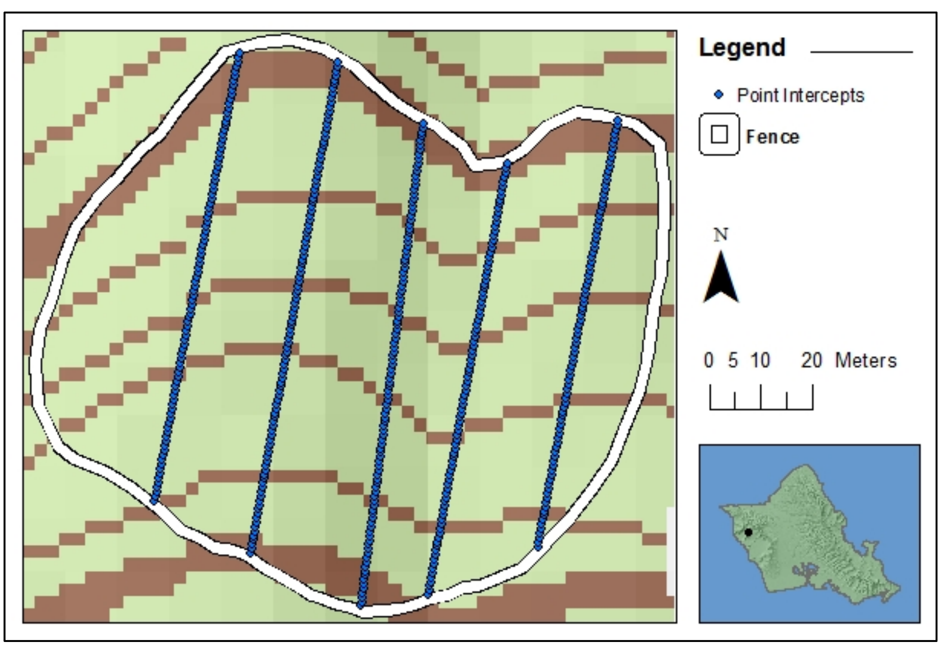


Figure 1. Locations of point intercepts along transects at Kamaili Makai MU, 2015.

and/or low cover taxa were less likely to be accounted for using point intercept monitoring, a list of all taxa anecdotally observed during the course of monitoring was created. Predictions of taxa occurrence were made using Geostatistical Analyst, ArcGIS 10.3.

RESULTS

Management goals were met for native vegetation in the canopy (61%), but were not met for the native understory (7%) or non-native canopy (78%) and understory (71%) (Table 1). A quarter of the understory was non-vegetated, while the canopy cover was nearly continuous, often multilayered with a combination of both native and non-native taxa (44% overlapping native and non-native canopy cover). Much of the non-vegetated understory contained exposed soil (41%), while the remainder consisted of equivalent proportions of leaf litter and rock substrata. Eight native and 14 non-native species were identified in the understory during monitoring, with *Rivinia humilis* (53.1%), *Oplismenus hirtellus* (15.7%), and *Adiantum hispidulum* (10.5%) most prevalent. Seven native and 11 non-native taxa were recorded in the canopy, dominated by *Diospyros sandwicensis* (50.0%), *Grevillea robusta* (48.1%), and *Schinus terebinthifolius* (27.7%) (Table 2). The uppermost canopy was dominated by the same taxa, but with *Grevillea robusta* (46.1%) predominating over *Diospyros sandwicensis* (14.3%) and *Schinus terebinthifolius* (13.2%) (Table 3). A total of 30 taxa (37% native) were identified during point intercept monitoring. Anecdotal observations of 22 additional taxa (41% native) were made while monitoring, but were not intercepted (Table 4). Predicted locations (using ordinary kriging[1]) of native and non-native taxa indicate patchy distributions in the understory and canopy (Figures 2 and 3).

Table 1. Percent cover of native and non-native taxa and non-vegetated areas in the understory and canopy, as well as soil, leaf, and rock substrata within non-vegetated understory.

	Understory (%)	Canopy (%)	Uppermost Canopy (%)
Native	7	61	22
Non-native	71	78	73
Non-vegetated (total)	26	5	5
Non-vegetated (soil)	*11*		
Non-vegetated (leaf litter)	*8*		
Non-vegetated (rock)	*8*		

[1]**Note to readers less familiar with geostatistical analyses:** Ordinary kriging is a statistical method used in association with geographic information to create maps, for example as in this report, to show predicted locations of one or more variables, with the probability of occurrence indicated by color coded values. It maps probable, not actual, distributions. Known locations are used to predict presence/absence in unsampled locations. This method also includes statistical analyses of prediction error that indicate how well the model works, by removing known data points and predicting what they should be. When used in association with point intercept data, locations of taxa and taxon groupings with higher cover, particularly those that tend to occur in clusters, may be more accurately predicted. Those with low cover and spotty distributions will have considerably less certainty when mapped. For example, *Psidium cattleianum*, which often occurs in expansive monotypic stands, would likely be consistently encountered during monitoring, versus tiny ferns such as *Lepisorus thunbergianus*, as chances of intercepting it are very low, even if there are numerous widely scattered individuals. As such, prediction maps for only taxon groupings (native and non-native) and the most predominant taxa are presented in this report.

Table 2. Species percent cover. Native taxa in boldface.

Understory	Cover (%)	Canopy	Cover (%)
Rivina humilis	53.1	***Diospyros sandwicensis***	50.0
Oplismenus hirtellus	15.7	*Grevillea robusta*	48.1
Adiantum hispidulum	10.5	*Schinus terebinthifolius*	27.7
Passiflora suberosa	7.0	*Melia azedarach*	9.7
Diospyros sandwicensis	4.1	***Sapindus oahuensis***	8.7
Schinus terebinthifolius	1.9	*Toona ciliata*	6.2
Lantana camara	1.2	*Passiflora suberosa*	5.8
Psydrax odorata	0.8	***Antidesma pulvinatum***	3.7
Mesosphaerum pectinatum	0.6	***Psydrax odorata***	3.7
Sapindus oahuensis	0.6	*Syzygium cumini*	2.7
Plumbago zeylanica	0.4	*Psidium guajava*	1.7
Rauvolfia sandwicensis	0.4	*Leucaena leucocephala*	1.4
Toona ciliata	0.4	*Passiflora edulis*	1.2
Ageratina riparia	0.2	***Korthalsella degeneri***	0.8
Blechnum appendiculatum	0.2	*Lantana camara*	0.8
Digitaria insularis	0.2	***Rauvolfia sandwicensis***	0.6
Doryopteris decipiens	0.2	***Nestegis sandwicensis***	0.2
Grevillea robusta	0.2	*Spathodea campanulata*	0.2
Leucaena leucocephala	0.2		
Peperomia blanda	0.2		
Peperomia tetraphylla	0.2		
Triumfetta semitriloba	0.2		

Table 3. Uppermost canopy species percent cover (native taxa in boldface).

Uppermost canopy	Cover (%)
Grevillea robusta	46.1
Diospyros sandwicensis	14.3
Schinus terebinthifolius	13.2
Melia azedarach	7.4
Toona ciliata	4.8
Sapindus oahuensis	3.1
Antidesma pulvinatum	2.9
Psydrax odorata	1.0
Syzygium cumini	1.0
Leucaena leucocephala	0.6
Passiflora edulis	0.2
Rauvolfia sandwicensis	0.2

Table 4. Species anecdotally observed but not intercepted during monitoring. Native taxa are in boldface.

Abutilon grandifolium	*Kalanchoe pinnata*
Abutilon sandwicense	***Lepisorus thunbergianus***
Ageratina adenophora	***Myrsine lanaiensis***
Ageratum conyzoides	***Neraudia angulata***
Aleurites moluccana	***Planchonella sandwicensis***
Cheilanthes viridis	***Plectranthus parviflorus***
Coffea arabica	*Salvia coccinea*
Conyza bonariensis	***Sida fallax***
Cordyline fruticosa	*Sida rhombifolia*
Dodonaea viscosa	*Sida spinosa*
Hibiscus arnottianus* subsp. *arnottianus	*Urochloa maxima*

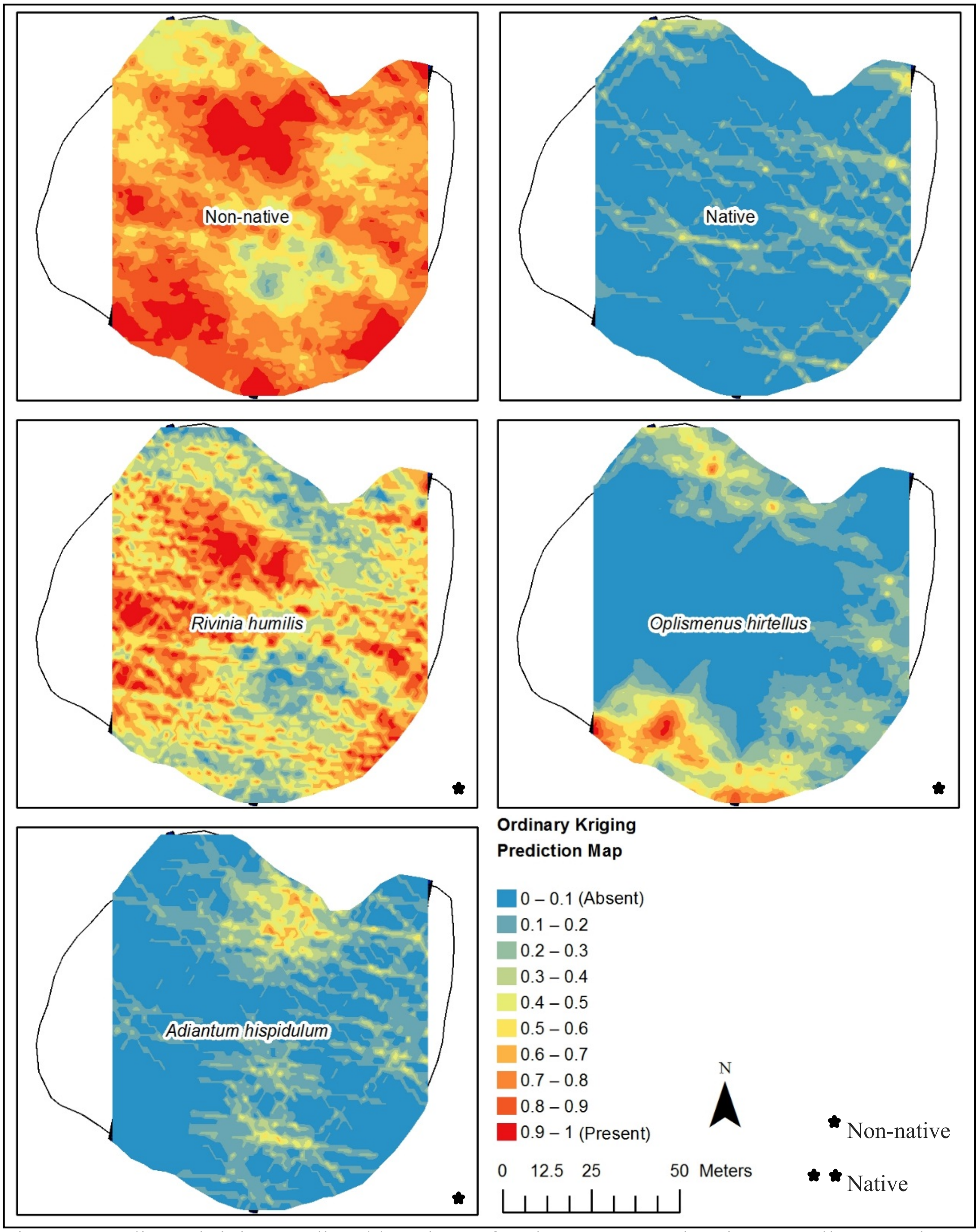


Figure 2. Ordinary kriging predicted locations of understory taxa, showing overall non-native and native cover as well as most prevalent species. Probability of occurrence is scaled from zero (shown in blue, indicating absence) to one (shown in red, indicating presence).

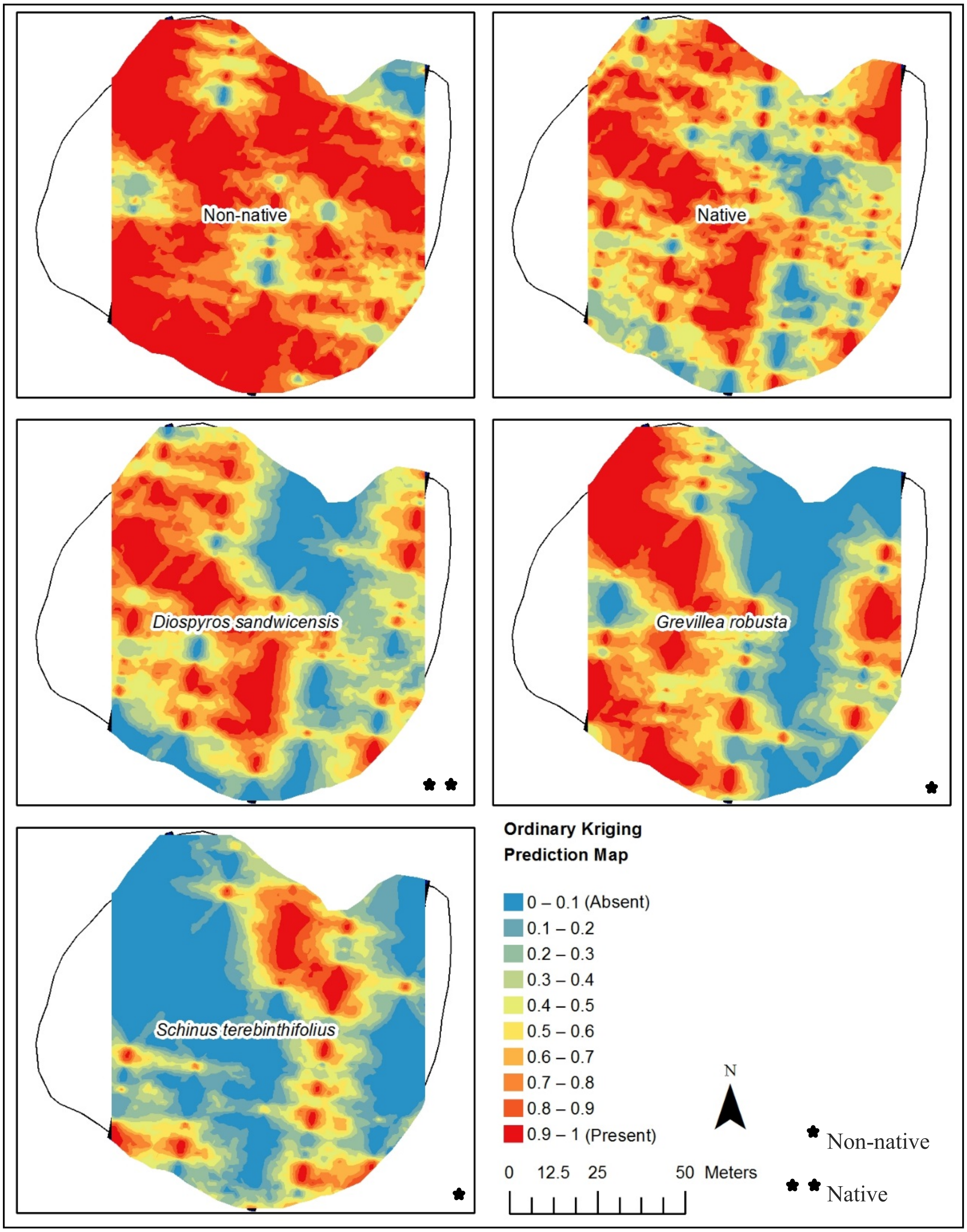


Figure 3. Ordinary kriging predicted locations of canopy taxa, showing overall non-native and native cover as well as most prevalent species. Probability of occurrence is scaled from zero (shown in blue, indicating absence) to one (shown in red, indicating presence).

DISCUSSION AND RECOMMENDATIONS

Efforts towards achieving IP goals for native and non-native cover in the understory and canopy at Kamaili Makai MU should be prioritized based on the most relevant needs for the area. Increasing native understory cover from 7 to > 50% may be an impractical, and possibly an inappropriate goal, as intact *D. sandwicensis*-dominated dry forests do not necessarily have such high native understory cover. Reducing non-native understory from 71% to < 50% may be challenging, given the prevalence of *R. humilis*, which may be difficult to replace with native taxa. Reduction of non-native canopy cover from 78% to < 50% may also be challenging, but progress may be made towards that goal. Predicted locations (using ordinary kriging) of non-native, native, and co-occurring canopy are shown in Figure 4 in reference to known locations of rare taxa, and may be used as a guide for planning areas of canopy weed removal. Rare taxa primarily consist of *Abutilon sandwicense*, which responds positively to alien canopy removal. Active restoration may be targeted around rare taxa, to include non-native canopy removal and plantings of common native species, recognizing that these weedy zones will require regular follow-up control efforts to prevent the proliferation of understory weeds. In areas where native and non-native canopy co-occur, non-native canopy may be gradually removed to minimize the creation of light gaps and subsequent proliferation of non-native understory. Nearly one-half of the MU has such overlapping canopy, with potential for selective canopy removal. Problematic taxa, including grasses (particularly *Urochloa maxima*), *Coffea arabica*, and *Passiflora suberosa*, should be targeted to prevent their expansion. Less common canopy weeds should be targeted for gradual removal: *Toona ciliata*, *Melia azedarach*, *Syzygium cumini*, *Psidium guajava*, *Spathodea campanulata*, and *Leucaena leucocephala*. Future point intercept monitoring should include outermost transects aligned closer to MU boundaries, to have a greater areal extent for geostatistical analysis.

Figure 4. Ordinary kriging predicted locations of native, non-native, and co-occurring native and non-native canopy cover. Probability of occurrence is arbitrarily scaled from one (shown in blue, indicating occurrence of only native canopy) to five (shown in red, indicating occurrence of only non-native canopy), with overlapping native and non-native canopy (value of 3) shown in yellow. Color gradients between blue and yellow indicate the range in probability of only native canopy vs. mixed native and non-native canopy occurrence. Color gradients between yellow and red indicate the range in probability of mixed native and non-native canopy vs. only non-native canopy occurrence.

Appendix 3-5

O'AHU INVASIVE SPECIES COMMITTEE

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

Annual Progress Report
October 1, 2014—September 30, 2015

Devil weed (*Chromolaena odorata*) in the Kahuku Training Area

Summary of Project Objectives:
The O‘ahu Invasive Species Committee (OISC) was founded by a concerned group of citizens and land managers volunteering their weekends to control fountain grass and miconia on O‘ahu. Since then, OISC has grown into a partnership of federal, state and municipal agencies with a full-time field crew that works across all land ownerships. OISC's mission is to control incipient invasive species—wherever on the island they occur—before they become established in high-value natural areas.

The O‘ahu Army Natural Resources Program (OANRP) is a founding partner of OISC and one of OISC's most supportive partners throughout its 13-year history. OISC is a project of the Pacific Cooperative Studies Unit of the University of Hawai‘i at Mānoa. OISC and OANRP are working together to control *Chromolaena odorata* at the Kahuku Training Area.

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

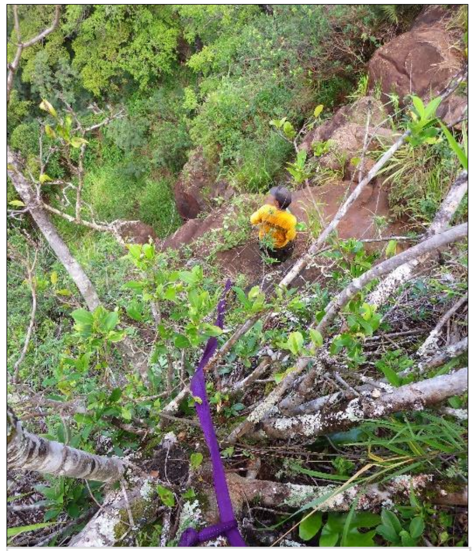
> Between 2006 and 2009, botanical surveys of all publicly accessible roads on O‘ahu were conducted by OISC's O‘ahu Early Detection program. *C. odorata* was not found during these surveys. This means that it is unlikely *C. odorata* was introduced somewhere else and dispersed onto KTA. *C. odorata*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

OISC is working with OANRP to control and suppress *C. odorata* from the Kahuku Training Area. OISC is responsible for:

- Surveying subunits 3,4,7,8 and 10.
- Removing *C. odorata* in areas where there are five or fewer plants.
- Flagging areas with more than five plants (called "hotspots") for later aerial or ground spraying by OANRP.
- Re-surveying hotspots treated by OANRP and treating or hand-pulling any surviving plants.
- Communicating results of all surveys directly after they occur via a Google Docs spreadsheet.

Project Accomplishments: October 1, 2014-September 30, 2015.
OISC completed all components of the FY 2015 control plan. Specifically, OISC:

- Conducted two sweeps each through subunits 3, 4, 7, 8, and 10.
- Marked hotspots with flagging or something equivalent for later aerial or ground treatment by OANRP staff.
- Surveyed hotspots after OANRP treatment and followed up with chemical or mechanical control if necessary.
- Treated some hotspots flagged for aerial sprays that OANRP may not be able to get to before the flowering season.
- Treated populations of five or fewer plants when encountered during surveys of subunits 3,4,7,8, and 10.
- Communicated with OANRP via a Google Docs spreadsheet the locations where spray operations of large patches are needed. OISC also used the spreadsheet to note if the treatment was effective.


An OISC crewmember climbed down a dry waterfall to get the devil weed at the bottom.

OISC conducted 10 multi-day trips to control *C. odorata* and averaged 232 fieldwork hours per month. In total, OISC staff dedicated 2,489 field hours and 170 support staff hours to *C. odorata.* OISC surveyed 1,573 acres and treated 683 mature and 3,202 immature plants for a total of 3,885 plants. 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 manages, just the total that were treated by OISC staff. Large hotspots suitable for ground or aerial spraying were flagged for later treatment by OANRP.

The OISC crew conducted multi-day trips and camped to reduce the time spent commuting to the work site. OISC works with OANRP to acquire access using KTA's range control protocols. Working with KTA Range Control has been easier this year since OANRP loaned a Pacmere radio to OISC and OISC obtained a key to the wash rack. OANRP staff observed that *C. odorata* tends to set seed between March and April so management actions are scheduled to minimize the chance that control work will inadvertently spread this species.

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

Challenges:
Temperatures this summer were much higher than usual and the field crew took precautions against heat exhaustion by taking more frequent breaks. The amount of ground covered

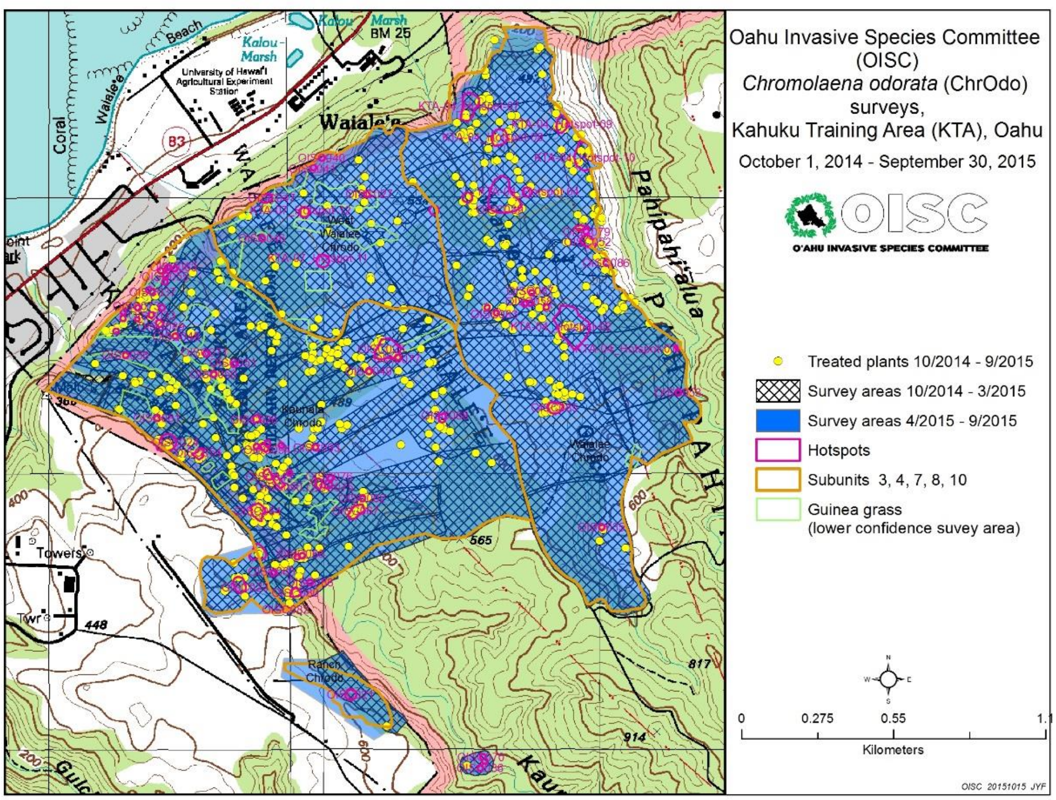
may have been reduced from what could have been achieved with more average summer weather. Surveys through head-high guinea grass have a low confidence level because of the low visibility. These areas are indicated on the map below.

During FY 2015, additional acreage was added to the area OISC needs to survey. Subunit 4 was extended to add 37 acres and subunit 10 was added. However, the additional acreage was finished during the reporting period.

Table 1: OISC *Chromolaena odorata* Work Effort Summary
October 1, 2014-September 30, 2015

Location	Acres Surveyed	Mature Plants Treated	Immature Plants Treated	Total Plants Treated	Effort (Hours)
KTA Subunits 3, 4, 7, 8, 10	1,573	683	3,202	3,885	2,489

Figure 1: OISC *Chromolaena odorata* Work Effort in Kahuku Training Area
October 1, 2014 – September 30, 2015



Data Management:

Guinea grass impairs visibility.

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

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

Public Education & Outreach:

OISC's outreach specialist provided an informational update to the Koʻolauloa and ʻAiea Neighborhood Boards and an identification and reporting workshop to Board of Water Supply maintenance crew at their Kalihi baseyard. She also provided information on identification and reporting methods to the Hawaiʻi Motocross Association at their 4th of July Championship Race.

Other:

There are two other known locations of *C. odorata:* Ahupuaʻa ʻO Kahana State Park and Keaʻiwa State Park in ʻAiea. Initial surveys in Kahana Valley found a number of plants far enough from any roads to require a water catchment system so that there will be enough water to mix the amounts of herbicide necessary for control. While OISC's Outreach Specialist has already obtained Annual Special Use Permits for survey and control inside the park, OISC is still working on permission to remote camp and fly in a water catchment system. During FY 2015, OISC surveyed 50 acres and removed 45 mature and 1193 immature plants. Again, as in KTA, these numbers do not indicate the actual number of plants. More plants were seen within during these surveys. Systematic treatment and control will begin once OISC obtains permission to fly in the water catchment system.

OISC is still working to delimit and treat the ʻAiea population. Plants are spread across State Park, State Forest Reserve, and Honolulu Board of Water Supply land. Surveys this year found additional hotspots at Camp Smith, the headquarters for the United States Pacific Command. All accessible areas of Camp Smith have been surveyed and two significant hotspots were found around the employee parking areas. OISC is working with MCBH environmental staff to find days outside the normal work day to treat this population since the parking areas cannot be closed during work hours. Staff from Marine Corps Base Hawaiʻi and OANRP have joined OISC staff during surveys and treatment.

Staff from MCBH also facilitated access for OISC employees to the Marine Corps managed portion of the land including Camp Smith.

Prior to the *Chromolaena odorata* management trips at KTA, OISC field crews have been conducting day-long surveys for fireweed (*Senecio madagasariensis*) at a windpower facility in Haleʿiwa. In August, OISC crews found one immature plant in the middle of the road leading to some of the turbines (See map below). This was the first time OISC had been to this particular area so there is not a possibility that OISC dispersed it with contaminated gear. The closest plant at 3,600 meters away is the lone immature found by OANRP staff at the Pupukea Boy Scout Camp. Environmental staff at the windpower facility have been informed and have agreed to look for *C. odorata* during their normal operations and inform OISC if they find it.

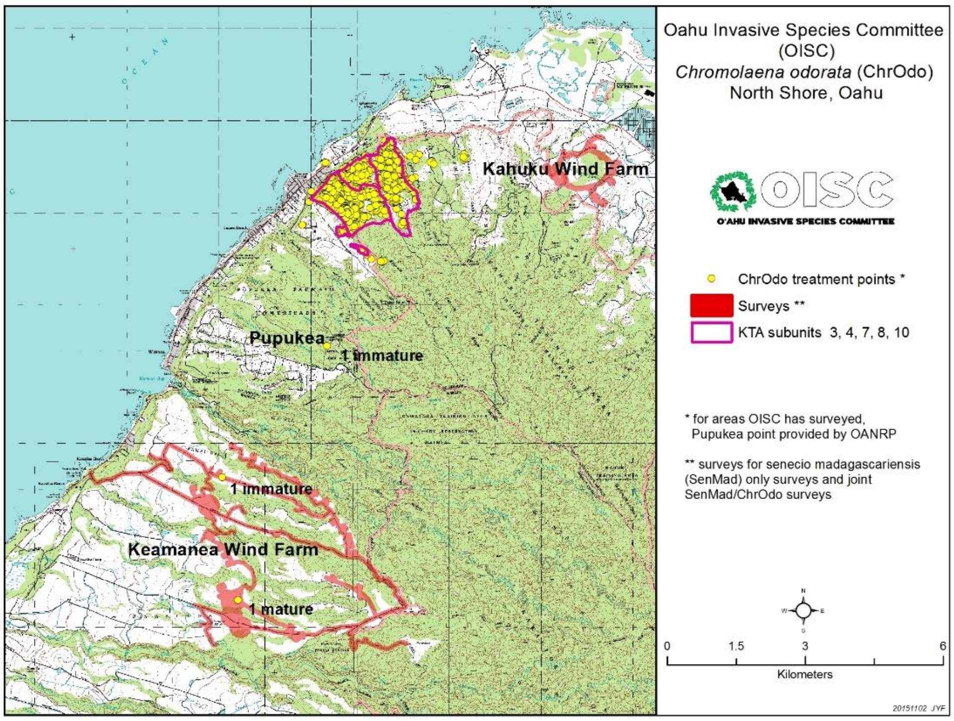


Table 2: OISC *Chromolaena odorata* Work Effort Summary in Ahupuaʻa ʻO Kahana and ʻAiea State Park. October 1, 2014 – September 30, 2015:

Location	Acres Surveyed	Mature Plants Treated	Immature Plants Treated	Total Plants Treated	Effort (Hours)
ʻAiea	322	234	656	890	555
Kahana Valley	50	45	1148	1193	331

Compliance:
OISC is a project of the Pacific Cooperative Studies Unit through the Research Corporation of the University of Hawaiʻi, 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.

Appendix 3-6

OʻAHU INVASIVE SPECIES COMMITTEE

Survey and Control of *Chromolaena odorata* in the Kahuku Training Area, Oʻahu, Hawaiʻi

Annual Progress Report
October 1, 2015—March 31, 2016

OISC crewmember removing devil weed (*Chromolaena odorata*).

Summary of Project Objectives:
Chromolaena odorata, commonly known as devil weed, is a state-listed noxious weed that is toxic to livestock, people and other plants. It possesses the ability to root vegetatively, produces up to 800,000 wind-dispersed seeds a year and is a fire promoting species that forms dense, monotypic stands of vegetation. The Oʻahu Army Natural Resources Project (OANRP) discovered *C. odorata* at the Kahuku Training Area (KTA) on the north shore of Oʻahu in January 2011 as part of its early detection program. 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.

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.


Surveying through guinea grass in Kaunala gulch.

The aim of this project is to contain or eradicate *Chromolaena odorata,* commonly called devil weed, from the Kahuku Training Area (KTA). Eradication at KTA will reduce the threat of this species spreading to natural areas that may contain protected species. At KTA, OISC conducts sweeps of designated subunits and flags devil weed infestations for later treatment by OANRP. This method allows consistent monitoring of devil weed treatments to ensure that areas that may need re-treatment are noted and any new infestations mapped. OISC's responsibilities are:

- Surveying and monitoring treatment of subunits 3,4,7,8 and 10 within the Alpha 1 Range of Kahuku Training Area (KTA). This includes state land leased by the military and used by the public as a motorcross recreational area on the weekends.
- Flagging areas as "hotspots" for follow-up treatment by OANRP. Hotspots are defined as areas with more than five plants or areas that would be inefficient to treat without a power sprayer or an aerial spray.
- Monitoring hotspot treatment and recording amount of re-growth after treatment.
- Removing outlier *C. odorata* outside of hotspots.
- Treating re-growth inside previously treated hotspots if this can be accomplished without delaying surveying (otherwise area is flagged for follow-up treatment by OANRP).
- Communicating results of all monitoring through a Google Docs spreadsheet.

Project Accomplishments: October 1, 2015—March 31, 2016.

Fieldwork:

OISC conducted four multi-day trips to control *C. odorata* for a total of 973 fieldwork hours. In addition the OISC crew:

- Conducted survey sweeps over 676 acres.
- Marked hotspots with flagging or something equivalent for later aerial or ground treatment by OANRP staff.

- Treated a total of 566 mature and 3,302 immature plants. 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 OANRP manage, just the total that were treated by OISC staff.
- Mapped monotypic fields of guinea grass for possible alternate survey techniques since these areas have a lower confidence level.
- Took points that appeared to be good areas to use gigapan technology—a technique OANRP has begun to use for other species.
- Assisted OANRP staff with power spray treatment of hotspots OISC 022, 024 and 080.

One camp trip had to be cut short due to an intern that would not follow the instructions of OISC field leaders and had to be delivered back to OISC's baseyard. OANRP staff were informed of the incident by phone as soon as it happened.

Getting to the root of the matter. OISC crewmember ensuring the entire plant is removed.

Data Management and Coordination:

During the reporting period, OISC staff entered observations for each hotspot into the Google Docs Hotspot Spreadsheet and quality controlled data from the field entered into the database. In addition staff did the following:

- Obtained permission from a private landowner adjacent to KTA that facilitated OANRP's access into hotspots OISC 022, 024 and 080.
- Organized meeting with environmental staff of Marine Corps Base Hawaiʻi, OANRP and OISC to coordinate treatment efforts and begin discussions to coordinate biocontrol research.
- OISC and OANRP met to ensure the Google Docs Hotspot Spreadsheet was communicating the information necessary to both organizations. Staff decided to keep OISC's monitoring notes for the past 4 visits so the history of 2 years (each hotspot is surveyed twice in one year). This ensures the information needed to evaluate whether a

hotspot should be deactivated or not will be displayed. OISC will strive to merge adjacent hotspots together. OANRP may combine further if it makes treatment easier.

- OISC and OANRP met with the Hawaiian Electric Company (HECO) to discuss the transmission lines that run through the *C. odorata* survey area. HECO said that we did not need to seek permission from them to survey or treat along transmission lines. We provided brochures for their staff and discussed the necessity of washing boots, gear and trucks after working in areas infested with *C. odorata.*

OISC staff began communicating with OANRP staff to discuss the use of drones over guinea grass fields. Guinea grass grows thickly and is usually well over six feet tall making it hard to see very far in any direction. Survey confidence in guinea grass is low and it also presents a safety risk; cliffs and drop offs are sometimes hidden in the grass. Drones may be able to find *C. odorata* on the edges of these fields or plants that have grown above the grass.

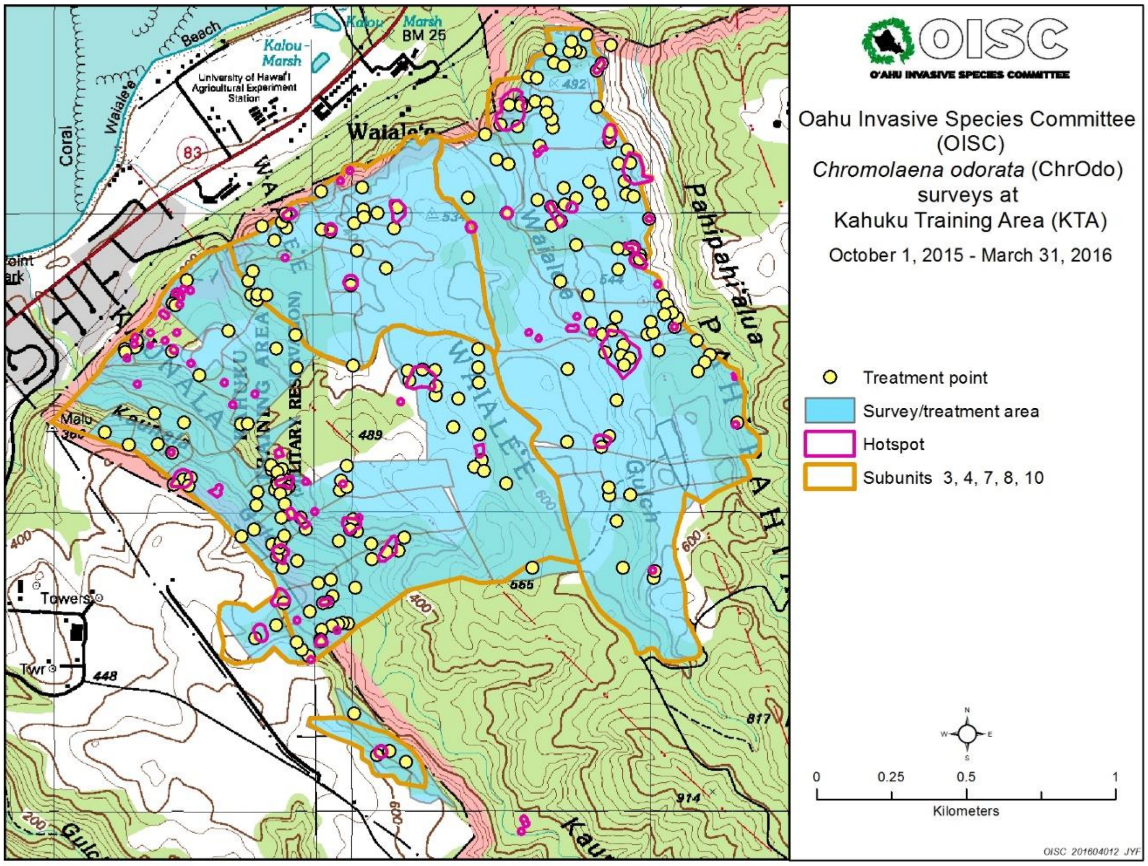
Challenges:
The dirt road into the survey area was extremely degraded and after a rainy spell, OISC's 4WD trucks got stuck. The road has since been re-graded making entry much easier. The crew saw many plants in Pahipahiʻālua gulch that were inaccessible by foot because of the steep terrain. Aerial sprays may be necessary here for both hotspots and individual outlier plants. Motorcross activities continue to spread plants. While surveying, the crew saw plants along the motorcross trails used by the public on the weekends. The crew noted an area where earth had been mounded and disturbed, presumably to create a more exciting trail. A *C. odorata* was found in in the mound. The field crew also expressed a little confusion over the definition of a hotspot and asked for a clear cutoff criteria for when it was acceptable decision to leave treatment to OANRP. After discussion, it became clear that there were too many variables to decide on a hard and fast rule. The OISC Manager and Field Supervisor reassured the field crew leaders that their judgement for whether it is inefficient to treat a population with hand sprayers or by hand-pulling will be trusted. As long as they are as detailed as possible when filling out the hotspot spreadsheet the area will be treated.

Table 1: OISC *Chromolaena odorata* Work Effort Summary at Kahuku Training Area October 1, 2015-March 31, 2016

Location	Acres Surveyed	Mature Plants Treated	Immature Plants Treated	Total Plants Treated	Effort (Hours)
KTA Subunits 3, 4, 7, 8, 10	676	566	3,302	3,868	973*

*This includes 45 hours of OANRP staff time.

Figure 1: OISC *Chromolaena odorata* Work Effort in Kahuku Training Area
October 1, 2015 – March 31, 2016



***C. odorata* Activites Supported with Other Funds:**

Public Education & Outreach:
The OISC manager talked to the Oʻahu Pig Hunters Association about *C. odorata* as well as *Miconia calvescens* and Rapid ʻŌhiaʻa Death. OISC also printed *C. odorata* pest alert rack cards to give out at events and presentations.

Surveys and Control for *C. odorata* outside of the Kahuku Training Area (KTA)
ʻAiea: OISC conducted a 697-acre aerial survey in ʻAiea and did not see any large patches. We do not expect to see small individual plants on an aerial survey. The survey was primarily for *Miconia calvescens,* which was also not seen. At Camp Smith, the crew removed a large *C. odorata* from a parking area and conducted additional surveys and treatment. Marine Corps Base Hawaiʻi Environmental staff assisted with access onto Camp Smith and bought us the parts to resurrect our power sprayer, which made treating the large patches at Camp Smith much more efficient. The crew also treated a large hotspot along the ʻAiea Loop Trail.

Kahana: OISC met with the Ahupuaʻa ʻO Kahana park manager to discuss aerial treatment options. The field crew also conducted limited control work.

Kaukonahua (Wahiawā):
Portions of Schofield Barracks fall inside OISC's search area for *Miconia calvescens* and was up for survey for that species. Since the area is suitable habitat and used by the military there seemed to be a reasonable probability that *C. odorata* had been dispersed here so the crew surveyed for both species. None was found.

Removing the "Giant ChrOdo Megabush"—as the field crew called it—from a Camp Smith parking lot

Keamanea and ʻŌʻio (Haleʻiwa):
The OISC crew usually surveys portions of these two watersheds for fireweed (*Senecio madagascariensis*) before the KTA camp trips. One mature and one immature were found in the portion of the wind farm that is located in Keamanea watershed.

Table 2: OISC *Chromolaena odorata* Work Effort Summary on non-KTA lands. October 1, 2014 – September 30, 2015:

Location	Aerial Acres Surveyed	Ground Acres Surveyed	Mature Plants Treated	Immature Plants Treated	Total Plants Treated	Effort (Hours)
ʻAiea	697.836	558.555	368	5,984	6,302	185
Kahana Valley		11.5910	1,067	1,897	2,964	40
Kaukonahua (Wahiawā)		64.980	0	0	0	72
Keamanea		240.610	1	1	2	40
ʻŌiʻo (Haleʻiwa)		74.2320	0	0	0	48
Total	**697.836**	**949.968**	**1,436**	**7,882**	**9,268**	**385**

Compliance:
OISC is a project of the Pacific Cooperative Studies Unit through the Research Corporation of the University of Hawaiʻi, 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.

Appendix 3-7

OAHU ARMY NATURAL RESOURCES PROGRAM
MONITORING PROGRAM

VEGETATION MONITORING OF *ACHATINELLA MUSTELINA* ESU-E ENCLOSURE, 2016 PRE-CLEARING RESULTS

INTRODUCTION

Vegetation monitoring was initiated for the proposed *Achatinella mustelina* ESU-E predator resistant enclosure at Palikea. The enclosure is located approximately 20 meters (m) north of the existing snail enclosure for ESU-F snails, and is estimated to encompass approximately 2500 m^2 (Figure 1). The area is dominated by non-native vegetation, with low native cover in the understory and canopy. Prior to construction, non-native trees will be removed and all slash processed/compacted using a chipper. Once the enclosure is completed, active native plant restoration will begin. Vegetation monitoring will be conducted to document change in vegetation cover and canopy openness, with a goal of achieving a native plant dominated community favorable for *A. mustelina* habitat. Baseline pre-clearing vegetation monitoring was completed in June 2016.

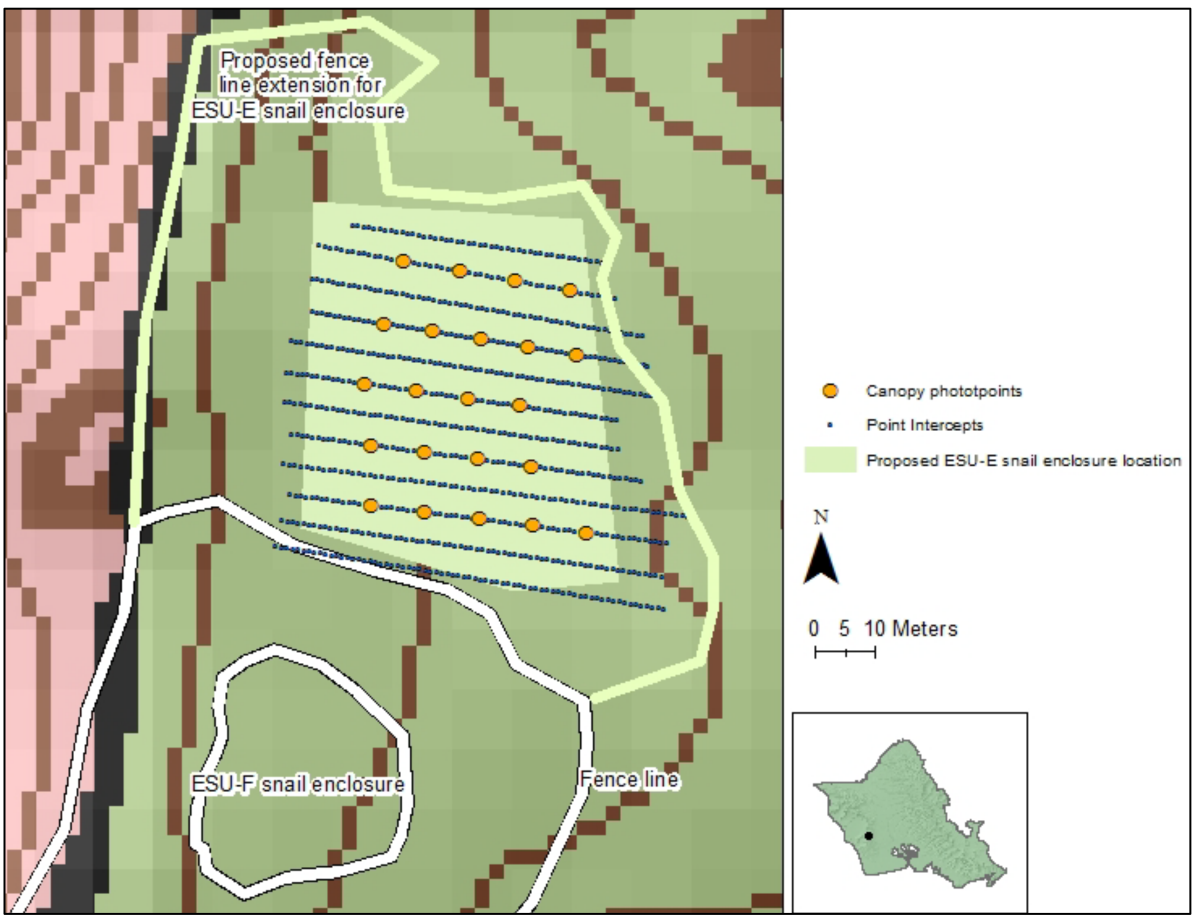


Figure 1. Location of proposed *Achatinella mustelina* ESU-E snail enclosure at Palikea, showing point intercept transects and canopy photopoint locations.

METHODS

Canopy and understory cover: Point intercept monitoring was used to measure 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, 6 foot tall 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. To gain a better understanding of cover changes within the understory, particularly relevant in the early restoration years, and as means of guiding restoration and weeding efforts, vegetation "hits" were recorded separately from 0 – 1 m above ground level (AGL) and 1 – 2 m 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 was recorded as non-vegetated. Point intercepts were located every 1 m along transects spaced 5 m apart with a goal of achieving at least 500 points[1]. Transects were oriented east/west off of an arbitrarily placed axis running north/south through the center of the enclosure area. Locations of the sampled points are not permanent. Transect lines extended beyond the proposed enclosure boundary during monitoring, in the event that the actual location of the enclosure wall differs from the proposed route. Resulting sampled points that fall outside the actual boundary wall upon completion will not be included in future analysis. Approximations of percent cover were obtained from the proportion of "hits" among all intercepts. Prediction maps[2] of taxa occurrence were created using Geostatistical Analyst, ArcGIS 10.3.

Canopy openness: Hemispherical photography was used to document canopy openness. This complements the canopy cover data (where cover measures were based on tree perimeters), by providing data on light availability beneath the canopy layer. Photographs (n = 23) were taken using a fish-eye lens at 2 m AGL, aimed 180° from the ground, every 10 m along alternate transects. Gap Light Analyzer (GLA), Version 2.0 was used to measure canopy openness in the hemispheric photographs.

Supplemental data: Permanent photopoints were established (marked with PVC posts) for visual documentation of change in each cardinal direction for each of 5 points. An Onset HOBO U23-001 data logger will be installed on site to document hourly temperature and relative humidity. 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.

[1]*A priori analysis of a sample size necessary to detect a 10% change (from proportions 0.45 to 0.55) with an alpha of 0.05 and power of 0.90, with 1:1 sample sizes, is 427 for chi-square one-tailed analysis (change is expected to occur in one direction) and 524 for two-tailed analysis (change may occur in either direction) (G* Power Version 3.1.9.2). A goal of around 500 points would be reasonable for either one- or two-tailed analyses.*

[2]*Maps created using statistical methods in association with geographic information to show predicted locations of one or more variables, with the probability of occurrence indicated by color coded values. The analysis maps probable, not actual, distributions. Known locations are used to predict presence/absence in unsampled locations. This method also includes statistical analyses of prediction error that indicate how well the model works, by removing known data points and predicting what they should be. When used in association with point intercept data, locations of taxa and taxon groupings with higher cover, particularly those that tend to occur in clusters, may be more accurately predicted. Those with low cover and spotty distributions will have considerably less certainty when mapped. As such, prediction maps for only taxon groupings (e.g., native, non-native) and the most predominant taxa will be created.*

Monitoring schedule: Monitoring will occur immediately pre- and post-chipping, and then annually for 5 years to track change in association with vegetation restoration. Once native vegetation fills in, the monitoring interval may be extended to every 2-3 years, and eventually to every 5 years.

PRE-CLEARING RESULTS

Non-native canopy (vegetation > 2 m AGL) was nearly continuous across the planned location for the snail enclosure, intermittently mixed with native canopy in < 20% of the area (Table 1). Average canopy openness among photopoints was 17.3% (n = 22). Approximately half of the lower portion of the understory (0-1 m AGL) was vegetated, with non-native taxa covering a third of the area, at times intermixed with native vegetation, which covered < 20% of the area. The upper portion of the understory (1-2 m AGL) was slightly less vegetated, with a similar amount of non-native cover, but < 10% native cover. Nine non-native and six native species were identified in the lower understory during monitoring, with non-native taxa *Psidium cattleianum* (20.4%) and *Clidemia hirta* (11.6%), and the native taxon *Nephrolepis exaltata subsp. hawaiiensis* (13.7%), most prevalent (Table 2). Six non-native and 12 native species were intercepted in the upper understory, primarily non-native taxa *Clidemia hirta* (19.1%) and *Psidium cattleianum* (15.0%). The canopy was dominated by non-native taxa *Psidium cattleianum* (79.6%) and *Schinus terebinthifolius* (36.5%), as well as native taxa *Metrosideros polymorpha* (8.8%) and *Freycinetia arborea* (6.0%). A total of 28 species (57% native) were identified during point intercept monitoring. Anecdotal observations of 17 additional taxa (88% native) were made while monitoring, but were not intercepted (Table 3). Several preferred snail host taxa were either intercepted (*F. arborea* and *M. polymorpha*) or anecdotally observed (*Antidesma platyphyllum* and *Myrsine lessertiana*) within the proposed enclosure site. Geostatistically predicted locations (using ordinary kriging) of most native and non-native taxa indicate patchy distributions in the understory and canopy, with the exception of the non-native taxon *P. cattleianum*, with locations nearly continuous throughout the canopy (Figures 2 - 4).

DISCUSSION

The presence of preferred snail host trees along with other native taxa in the understory and canopy provides a starting point for the establishment of appropriate snail habitat. However, the presence of tall *M. polymorpha* and thickets of *F. arborea* also presents a challenge for predatory snail removal. Large *F. arborea* thickets may need to be trimmed back to facilitate effective searches for *Euglandina rosea*, and/or the enclosure boundary wall placement may be shifted to avoid including *F. arborea* thickets. These plants are expected to grow and recover if trimmed, and in the future may require ongoing management (trimming and/or training) in order to keep the enclosure open enough to conduct effective *E. rosea* searches.

It is anticipated that there will be a flush of understory weeds in response to the non-native canopy removal that will require ongoing maintenance until native vegetation is restored. Care should be taken in particular to manage and prevent the spread of the ecosystem altering grass *Ehrharta stipoides*, as it was observed during monitoring and is prevalent in the Palikea area.

Table 1. Percent cover of native and non-native taxa and non-vegetated areas in the understory and canopy (n = 786 point intercepts).

	Understory 0-1 m	Understory 1-2 m	Canopy > 2 m
Non-native	35.9	34.7	94.3
Native	18.4	7.1	17.7
Non-vegetated	50.8	60.9	2.3

Table 2. Species percent cover (n = 786 point intercepts). Native taxa in boldface. *Snail preferred host plant.

Taxon	% cover
Understory 0-1 m	
Psidium cattleianum	20.4
Nephrolepis exaltata* subsp. *hawaiiensis	13.7
Clidemia hirta	11.6
Paspalum conjugatum	4.1
Microlepia strigosa	2.7
Rubus rosifolius	1.9
Freycinetia arborea*	1.7
Ehrharta stipoides	1.0
Blechnum appendiculatum	0.9
Asplenium contiguum	0.6
Metrosideros polymorpha*	0.3
Schinus terebinthifolius	0.3
Asplenium macraei	0.1
Cyclosorus parasiticus	0.1
Passiflora suberosa	0.1
Understory 1-2 m	
Clidemia hirta	19.1
Psidium cattleianum	15.0
Freycinetia arborea*	3.2
Nephrolepis exaltata* subsp. *hawaiiensis	1.7
Schinus terebinthifolius	0.9
Metrosideros polymorpha*	0.6
Kadua affinis	0.5
Microlepia strigosa	0.4
Rubus rosifolius	0.4
Cibotium chamissoi	0.3
Coprosma longifolia	0.3
Antidesma platyphyllum*	0.1
Broussaisia arguta	0.1
Cheirodendron trigynum	0.1
Morella faya	0.1
Passiflora edulis	0.1
Psychotria mariniana	0.1
Wikstroemia oahuensis* var. *oahuensis	0.1
Canopy > 2 m	
Psidium cattleianum	79.6
Schinus terebinthifolius	36.5
Metrosideros polymorpha*	8.8
Freycinetia arborea*	6.0
Morella faya	3.4
Clidemia hirta	3.2
Kadua affinis	1.0
Grevillea robusta	0.9
Cheirodendron trigynum	0.8
Passiflora edulis	0.8
Coprosma longifolia	0.6
Melicope clusiifolia	0.5
Broussaisia arguta	0.3
Cibotium chamissoi	0.3
Psychotria mariniana	0.3
Scaevola gaudichaudiana	0.3

Table 3. Species anecdotally observed but not intercepted during monitoring. Native taxa are in boldface. *Snail preferred host plant.

Asplenium caudatum	***Myrsine lessertiana****
Athyrium microphyllum	***Peperomia tetraphylla***
Coprosma foliosa	***Psilotum nudum***
Dianella sandwicensis	***Psychotria hathewayi***
Dryopteris glabra	***Smilax melastomifolia***
Epidendrum x obrienianum	***Streblus pendulinus***
Ilex anomala	***Vandenboschia davallioides***
Labordia kaalae	*Youngia japonica*
Lepisorus thunbergianus	

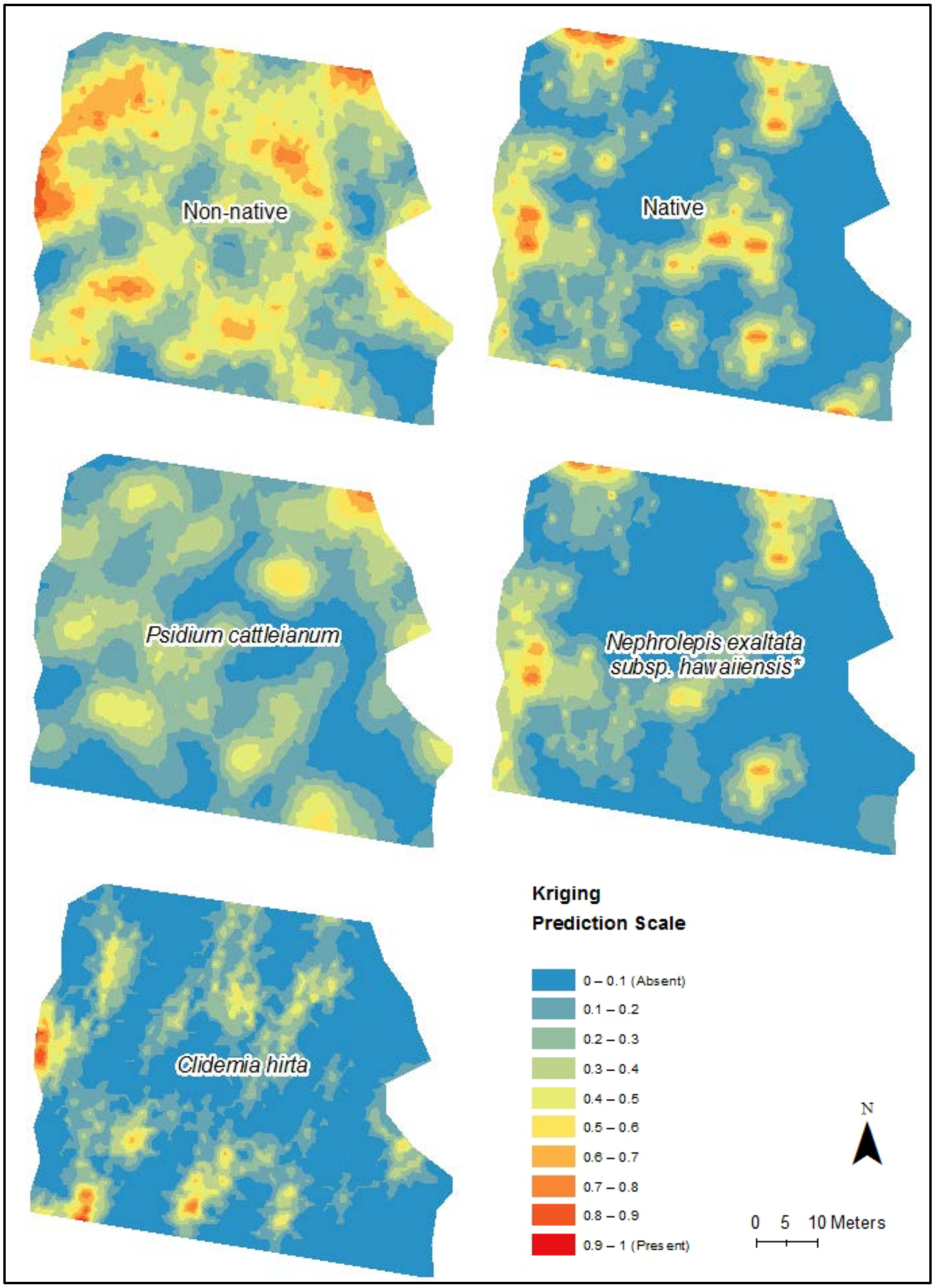


Figure 2. Ordinary kriging predicted locations of understory taxa from 0-1 m AGL, showing overall non-native and native cover as well as most prevalent species. Probability of occurrence is scaled from zero (shown in blue, indicating absence) to one (shown in red, indicating presence). *Native taxa.

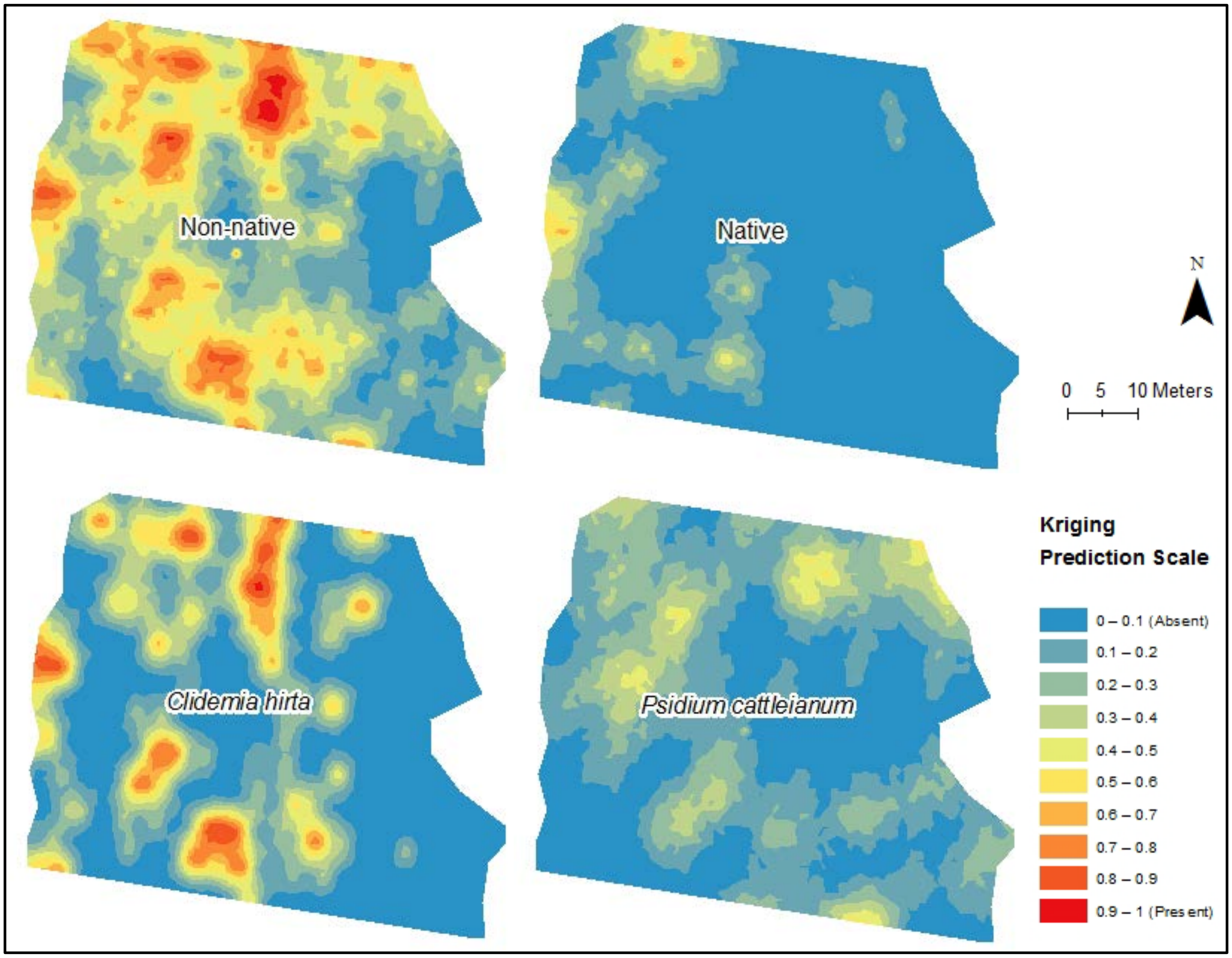


Figure 3. Ordinary kriging predicted locations of understory taxa from 1-2 m AGL, showing overall non-native and native cover as well as most prevalent species. Probability of occurrence is scaled from zero (shown in blue, indicating absence) to one (shown in red, indicating presence).

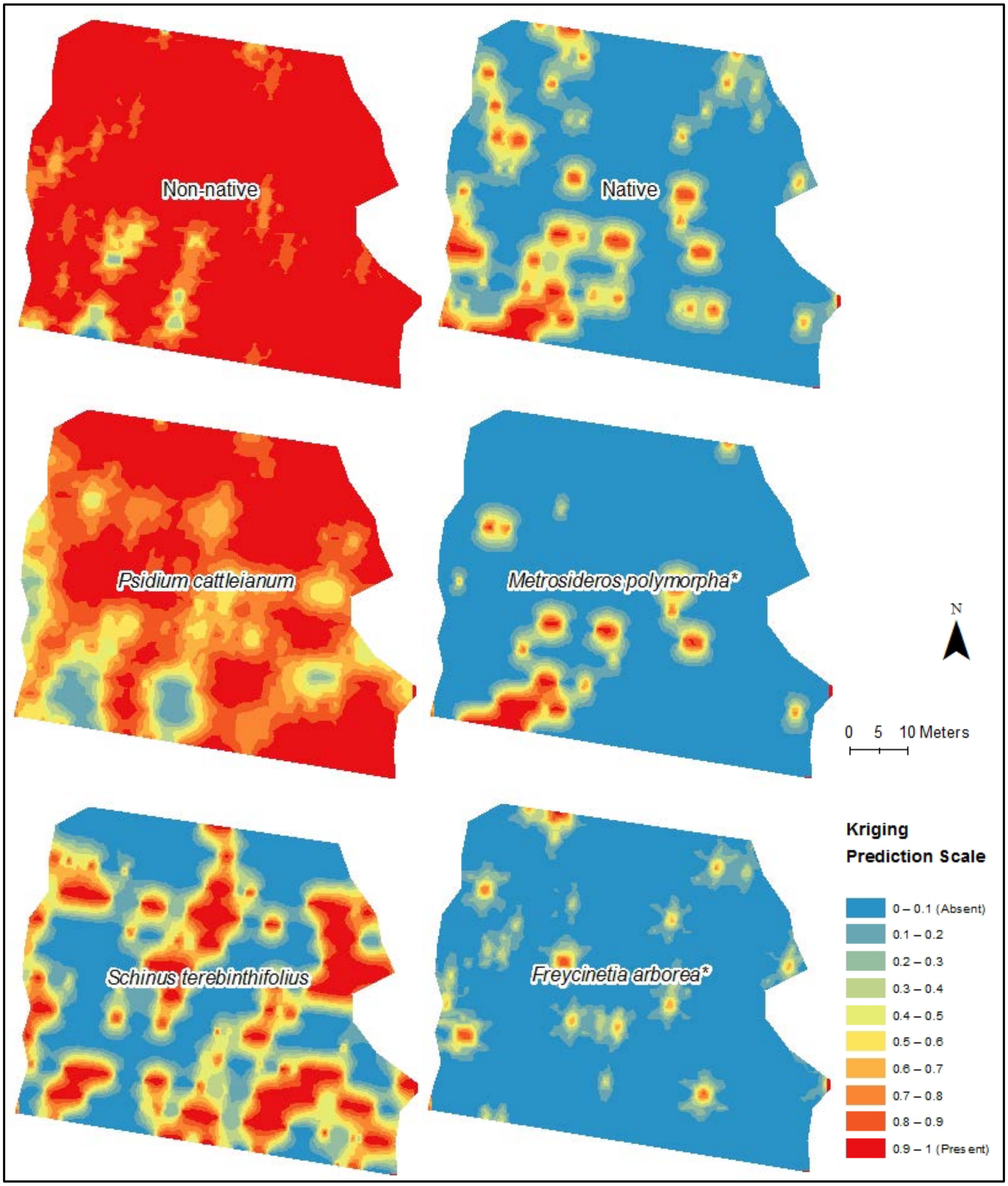


Figure 4. Ordinary kriging predicted locations of canopy taxa (> 2 m AGL), showing overall non-native and native cover as well as most prevalent species. Probability of occurrence is scaled from zero (shown in blue, indicating absence) to one (shown in red, indicating presence). *Native taxa.

OAHU ARMY NATURAL RESOURCES PROGRAM
MONITORING PROGRAM

RESULTS OF KAHANAHAIKI CHIPPER SITE VEGETATION MONITORING FIVE YEARS AFTER INITIAL CLEARING

INTRODUCTION

Kahanahaiki Management Unit (MU), located in the northern Waianae Mountains, is home to a variety of endangered plants, one endangered tree snail, and some high-value stands of mesic forest. The Oahu Army Natural Resource Program (OANRP) manages Kahanahaiki MU with the goal of protecting rare taxa and improving habitat. Kahanahaiki is heavily invaded with non-native plants. *Psidium cattleianum* is the dominant invasive tree in the MU, occurring in dense monocultures. Few native species thrive in *P. cattleianum* stands, and it is not appropriate or preferred habitat for rare taxa. Seeds remain viable in the soil for less than three months (Uowolo and Denslow, 2008). This suggests that if control is timed before fruiting periods in summer and winter, recruitment from seed can be minimized. While most management efforts historically and currently focus on weeding around native forest patches, vegetation monitoring conducted in 2009 indicated that non-native taxa comprised more than 50% cover across the MU. More aggressive efforts were needed to push non-native cover below the 50% threshold and meet restoration goals. To that end, staff built on informal trials conducted in 2002 which indicated that clear-cutting and chipping slash from *P. cattleianum* monocultures (100 m^2) efficiently controlled the invasive tree while allowing re-colonization by native plants, particularly the native tree *Acacia koa*. In 2010, staff identified a large stand of *P. cattleianum* in the southern, mostly flat end of the MU. Patches of native forest bordered the site and some mature *A. koa* persisted within the *P. cattleianum* stand. In 2010 and 2012, 0.9 ha of *P. cattleianum* in this area was clear-cut with chainsaws, and a chipper (Bandit model 65 XP) was used to grind up large slash piles (Figure 1). Clearing was timed to coincide with the senescence of the *P. cattleianum* seed bank, three to six months post-fruiting, to minimize seedling germination. Substantial natural recruitment of *A. koa* was anecdotally observed on the site. Native plant restoration efforts were limited to one opportunistic outplanting of *Canavalia galeata*, and extensive hand-broadcasting of *Bidens torta*. Extensive follow-up weed control was conducted, consisting of "clip and drip" herbicide treatment. The objective of the "chipper site" project was to reduce alien vegetation cover, increase native vegetation cover and diversity, and connect surrounding native forest patches, ultimately working towards management goals of < 50% non-native and > 50% native vegetation cover in the MU. Monitoring was conducted to document change in vegetation cover, frequency, and richness in association with this project.

METHODS

Monitoring of understory and canopy vegetation following clear-cutting was conducted in 2012 and 2015. To obtain frequency and richness data, all native and non-native species present in the understory and canopy were recorded in 1 x 3 m plots. Native and non-native understory percent cover was categorically recorded in 1 m^2 plots (using portions of the same 1 x 3 m plots used for documenting frequency and richness) as 0-25, 25-50, 50-75, or 75-100%. Canopy cover estimates (native and non-native taxa combined) were obtained using Gap Light Analyzer (GLA), Version 2.0 software (Frazer et al. 1999) from hemispheric photographs of the canopy taken from the center of each 1 x 3 m plot. Non-permanent plots were randomly located within chipped areas as well as adjacent untreated areas with similar vegetation cover and composition (used as a control, representative of conditions prior to treatment). Areas cleared in 2010 and 2012 were each monitored in 2012 and 2015, allowing for a range in time elapsed following clear-cut treatment from less than one month to five years post-chipping (Table 1). Canopy cover, understory cover, and species richness were analyzed using Kruskal-Wallis tests. Species frequencies were analyzed using chi-square and Fisher's exact tests. Analyses were performed in IBM SPSS Statistics Version 20.

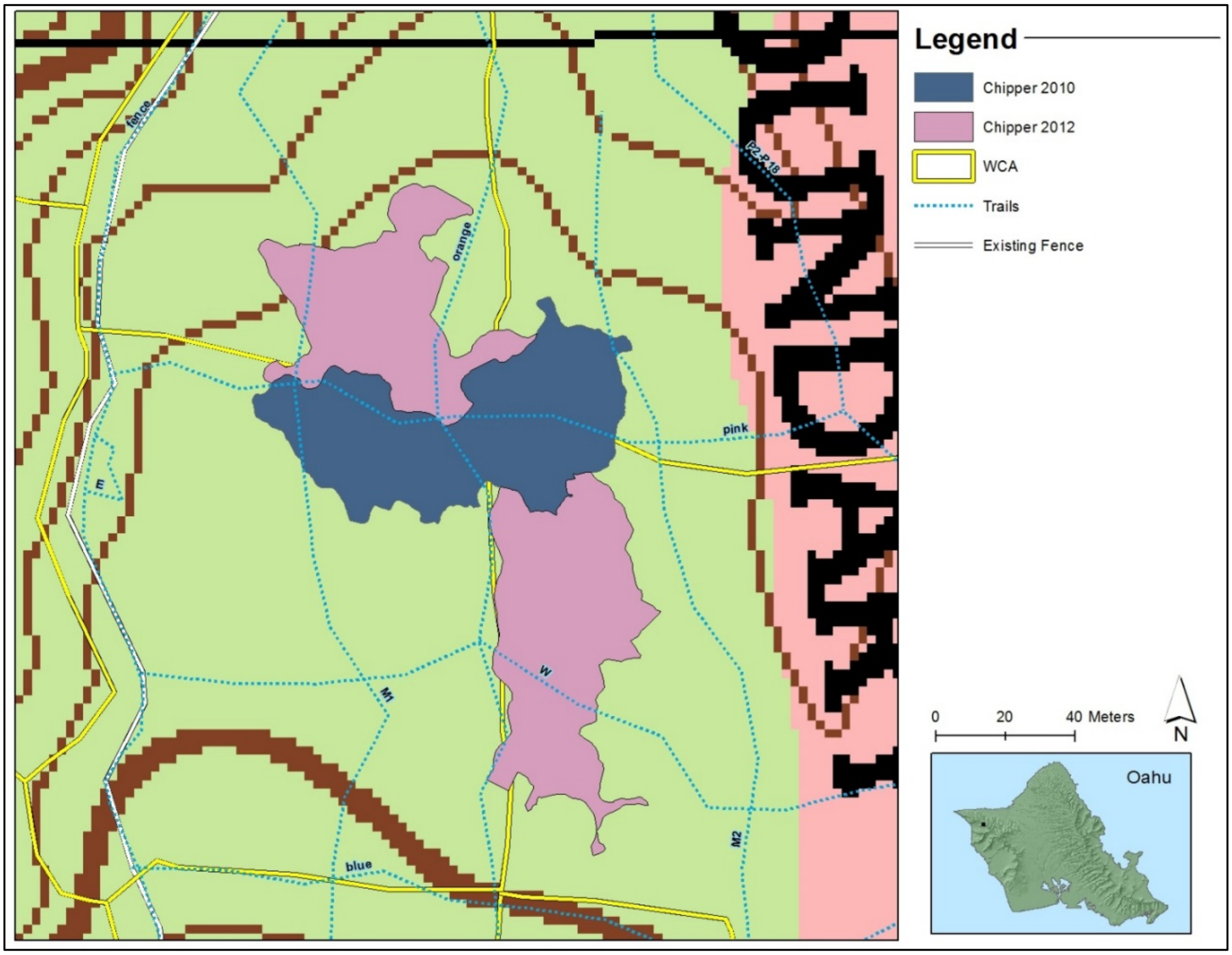


Figure 1. Locations of areas clear-cut of non-native vegetation using chainsaws and a chipper in 2010 and 2012 in Kahanahaiki MU, Oahu.

Table 1. Monitoring time intervals of plots in clear-cut areas in Kahanahaiki MU.

Time elapsed following chipper treatment	Year chipped	Year monitored	n
Control	N/A	2012	21
< 1 month	2012	2012	20
2 years	2010	2012	23
3 years	2012	2015	20
5 years	2010	2015	20

RESULTS

Canopy

Prior to chipping, the area was densely canopied (> 75% median cover) and dominated by non-native taxa (primarily *P. cattleianum* and *Schinus terebinthifolius*), with the native vine *Alyxia stellata* also occurring frequently, and the native tree *Metrosideros polymorpha* present to a lesser extent (Figures 2-4). Immediately following treatment, the canopy was largely open (< 25% median cover) and dominated by native species (mainly *Metrosideros polymorpha* and *A. koa*). After two years, canopy cover remained low and predominantly native, with *A. koa* becoming more prevalent. After three to five years, the canopy continued to refill (35-41% cover) with predominantly native taxa (mostly *A. koa, A. stellata, M. polymorpha* and *Psydrax odorata*), and to a lesser extent with non-native taxa (largely *Passiflora edulis* and *S. terebinthifolius*). Striking reductions in non-native taxon frequencies over the span of five years post-treatment occurred for *P. cattleianum* and *S. terebinthifolius* (Table 2). Native species frequency changes after five years included a marked increase in *A. koa*, and an overall decline in *A. stellata*. However, *A. stellata* rebounded significantly between less than one month and five years post-chipping (from 0 to 45%, chi-square: p = 0.001).

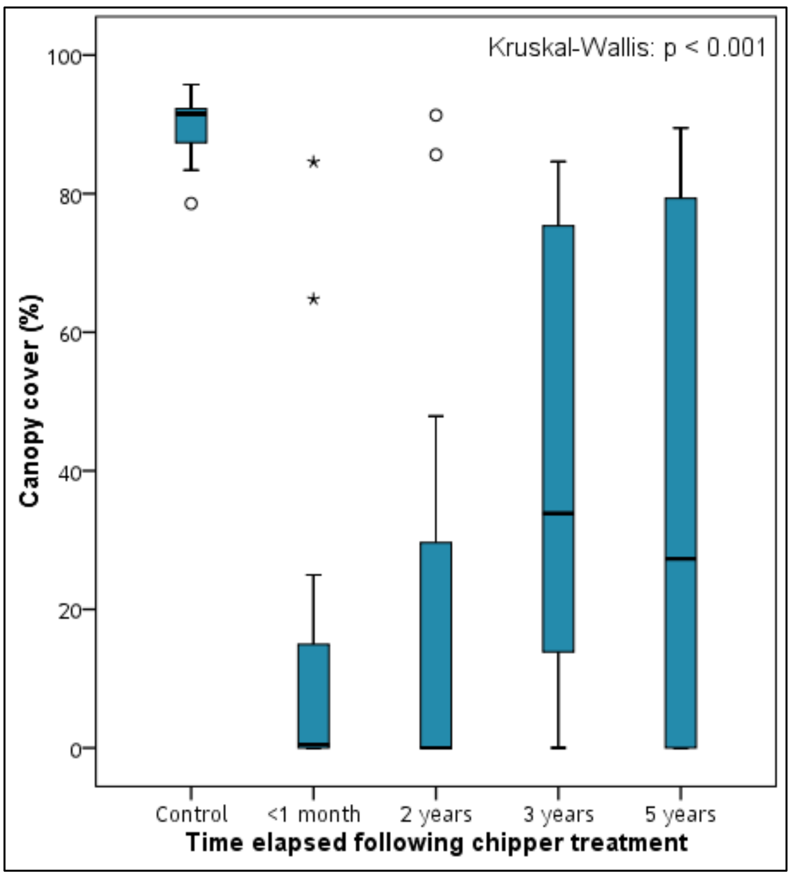


Figure 2. Boxplots of canopy cover over time following chipper treatment at Kahanahaiki. Cover includes both native and non-native taxa.

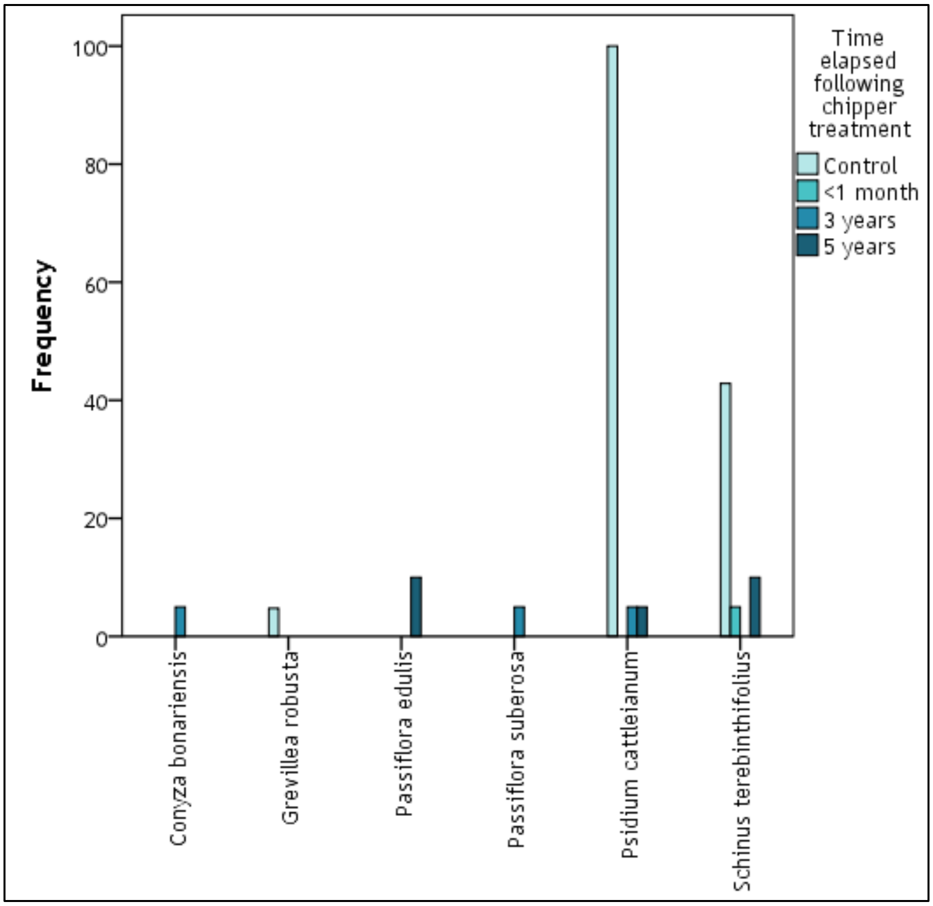


Figure 3. Non-native taxon frequencies in the canopy among plots over time following chipper treatment at Kahanahaiki MU. No non-native canopy occurred in plots at two years post-treatment.

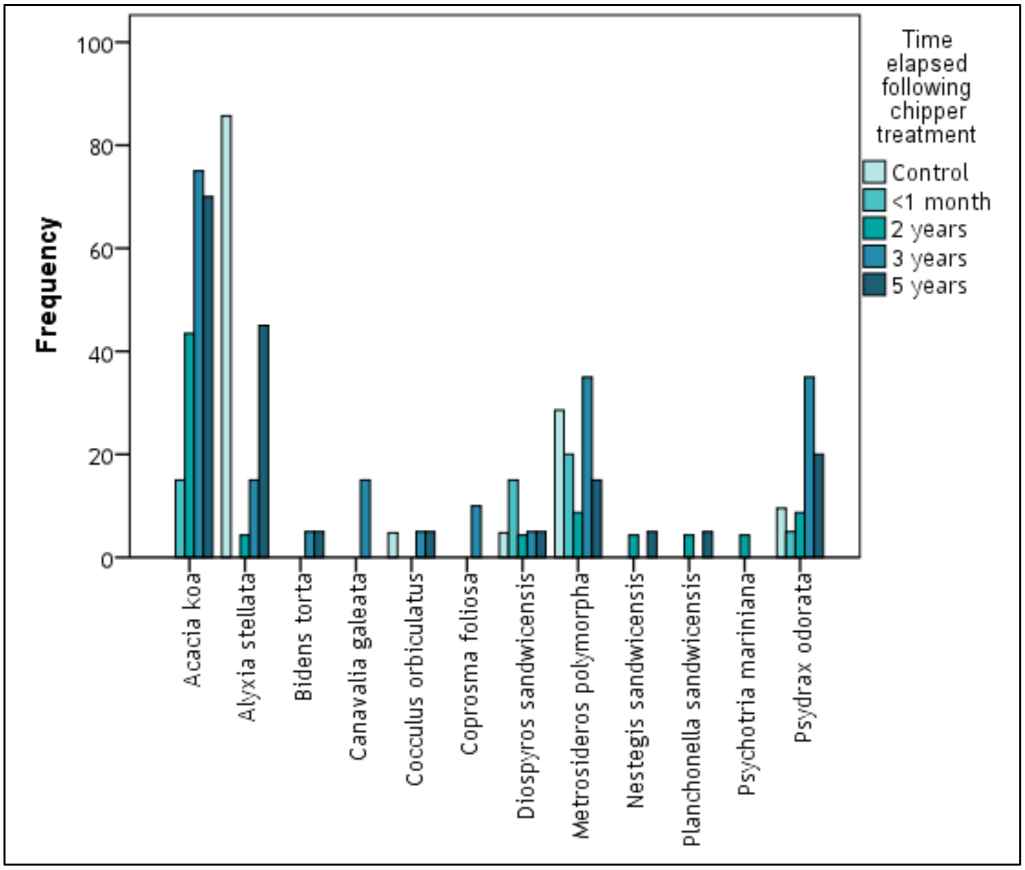


Figure 4. Native taxon frequencies in the canopy among plots over time following chipper treatment at Kahanahaiki MU.

Table 2. Frequency (%) among plots in the control group and five years post-chipping for taxa with significant changes over time. Native taxa are in boldface. Significance values derived from Kruskal-Wallis tests for all time intervals.

	control	5 years post-treatment	p
Canopy			
Acacia koa	0	70	< 0.001[a]
Alyxia stellata	86	45	0.006[a]
Psidium cattleianum	100	5	< 0.001[a]
Schinus terebinthifolius	43	10	0.018[a]
Understory			
Acacia koa	0	75	< 0.001[a]
Bidens torta	0	60	< 0.001[a]
Clidemia hirta	5	40	0.009[b]
Cocculus orbiculatus	0	30	0.009[b]
Conyza bonariensis	0	35	0.004[b]
Coprosma foliosa	5	45	0.004[b]
Crassocephalum crepidoides	0	45	< 0.001[b]
Dianella sandwicensis	0	45	< 0.001[b]
Mesosphaerum pectinatum	0	40	0.001[b]
Psidium cattleianum	90	25	< 0.001[a]
Rubus rosifolius	0	65	< 0.001[a]

[a]chi-square, [b]Fisher's exact

Understory

Similar to the canopy, the understory was also densely covered with non-native vegetation (predominantly *P. cattleianum*) prior to chipping, and had a decrease in non-native vegetation cover immediately and continuing up to five years following chipping, and an increase in native vegetation cover by two years after chipping (Table 3). Thirty-three non-native taxa and thirty-one native taxa were present in the understory (Figures 5 and 6). Increases in frequencies occurred for several non-native taxa by five years post-chipping, including *Clidemia hirta*, *Conyza bonariensis*, *Crassocephalum crepidoides*, *Mesosphaerum pectinatum*, and *Rubus rosifolius*. In parallel with its change in the canopy, there was a significant reduction in *P. cattleianum* after five years. Numerous native taxa also had marked increases in frequency by five years, including *A. koa*, *B. torta*, *Cocculus orbiculatus*, *Coprosma foliosa*, and *Dianella sandwicensis*. Though *A. stellata* had a major decline (from 86 to 0%) in the first month following chipping (chi-square: $p = 0.002$), this taxon rebounded by five years to prior levels (80%, chi-square: $p = 0.679$).

Table 3. Median percent cover of native and non-native understory vegetation over time following chipper treatment. Significance values derived from Kruskal-Wallis tests for all time intervals.

Time elapsed following chipper treatment	Non-native	Native
Control	75-100	0-25
< 1 month	0-25	0-25
2 years	0-25	25-50
3 years	25-50	25-50
5 years	0-25	25-50
p	< 0.001	< 0.001

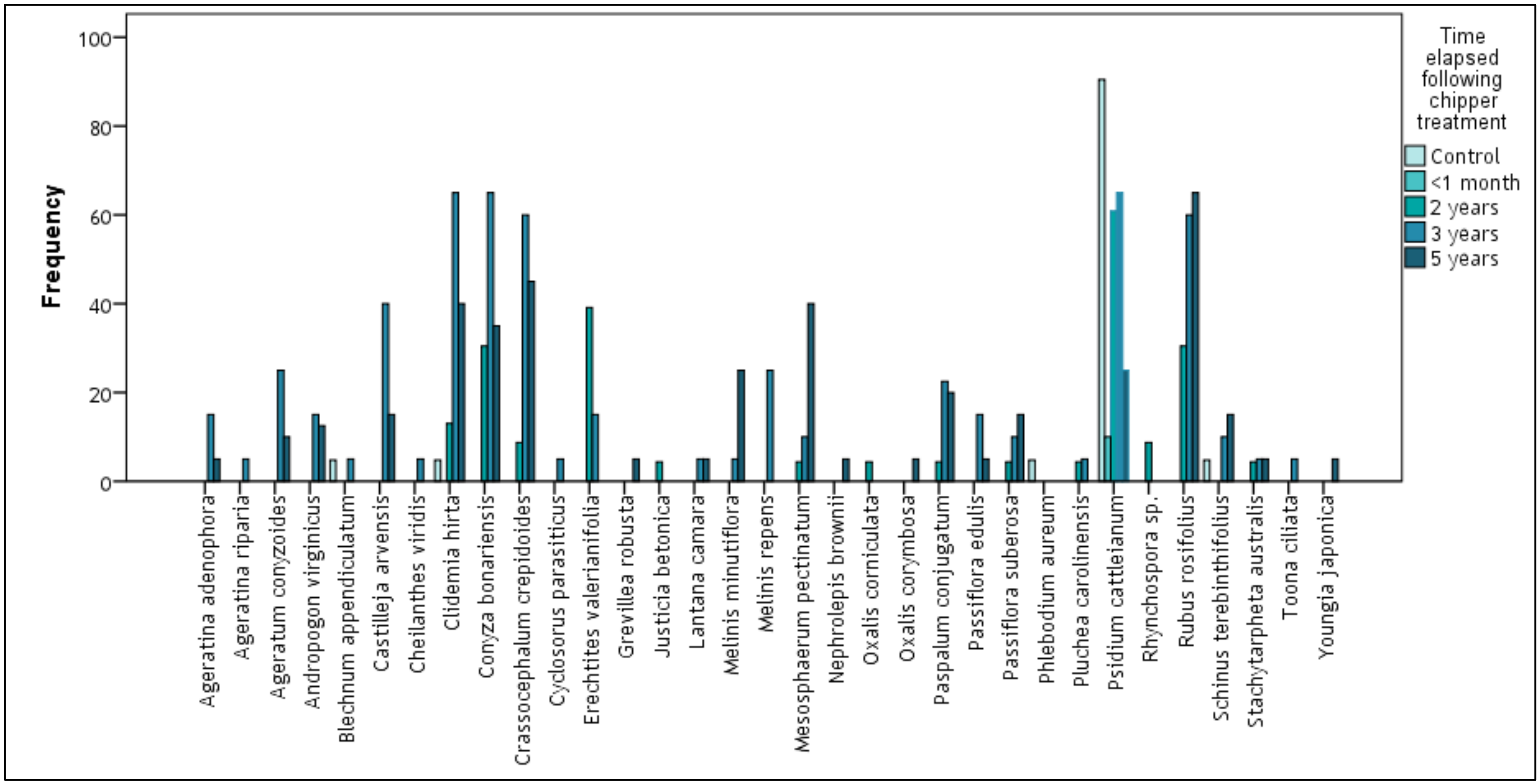


Figure 5. Non-native taxon frequencies in the understory among plots over time following chipper treatment at Kahanahaiki MU.

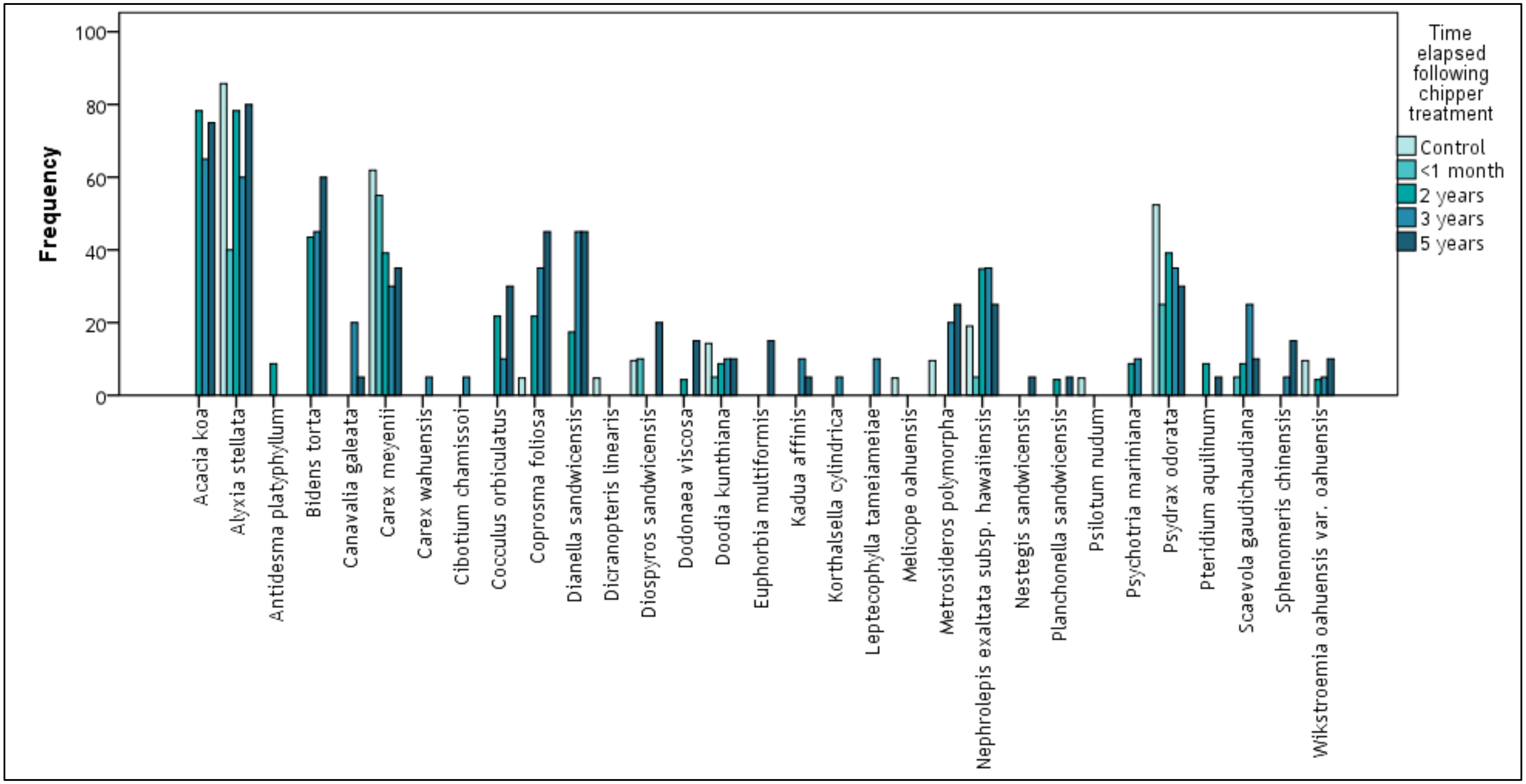


Figure 6. Native taxon frequencies in the understory among plots over time following chipper treatment at Kahanahaiki MU.

Species richness
Non-native and native canopy and understory median species richness among plots changed significantly over time following chipper treatment (Kruskal Wallis: $p < 0.001$ each) (Figure 7). Non-native canopy richness declined following treatment, while native canopy richness declined within the first two years (largely due to the decline in *A. stellata*) followed by an increase by three years. Non-native understory richness increased after two years, while native understory richness initially declined, but then increased by two to five years post-chipping. Total species diversity among all plots declined initially for the non-native and native canopy and understory, but became more diverse for all but the non-native canopy, which rebounded only to its original level (Figure 8).

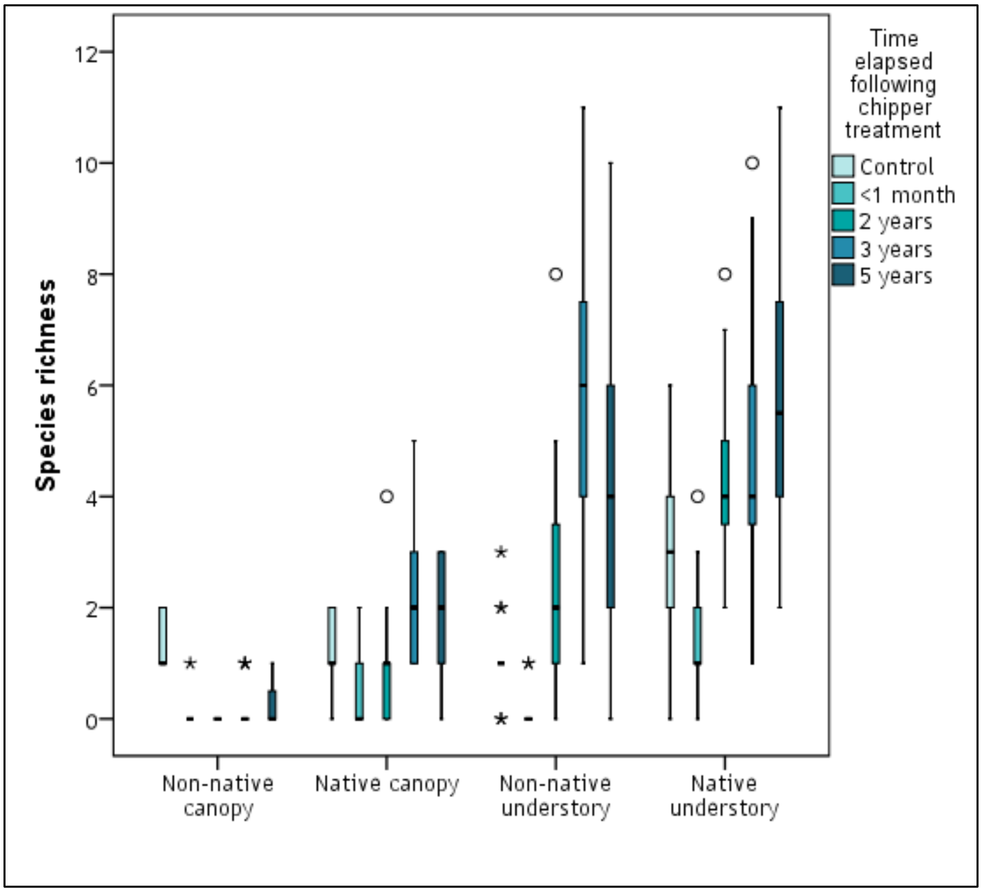


Figure 7. Boxplots of species richness among plots in the non-native and native canopy and understory in chipped areas over time at Kahanahiki MU

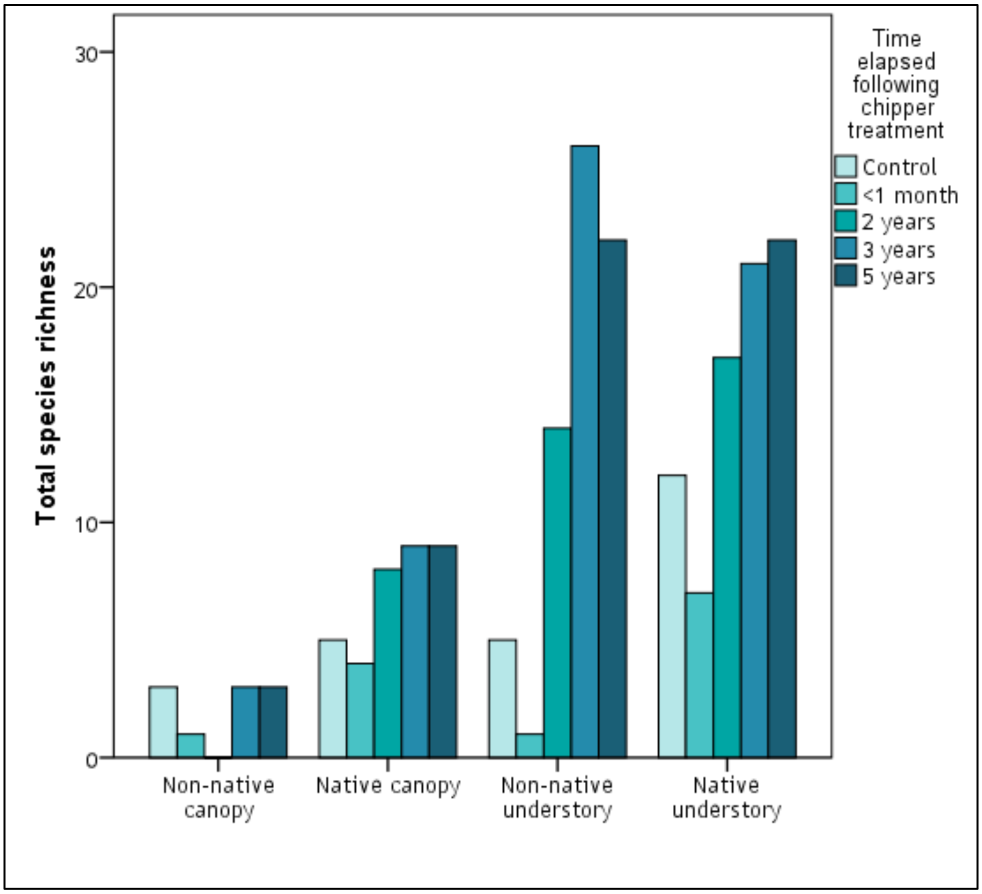


Figure 8. Total species observed among all plots in chipped areas over time at Kahanahiki MU

SUMMARY AND DISCUSSION

Dramatic changes occurred in the native and non-native canopy and understory in the five years following the initiation of clearcutting with chainsaws and a chipper in a non-native dominated region in Kahanahaiki MU. Cover, richness, and frequencies of tree species declined in the non-native canopy, but increased for the native canopy. Though richness and frequencies of several taxa increased in both the non-native and native understory, overall cover markedly declined for non-native, and increased for native, vegetation. While rebounding levels of non-native taxa occurred in the understory, the change in non-native composition is noteworthy. The non-native species (*C. hirta*, *C. bonariensis*, *C. crepidoides*, *M. pectinatum*, and *R. rosifolius*) that colonized the understory are known to colonize and thrive in disturbed areas, and are assumed to have less inhibiting effects on native taxa recovery as compared with the *P. cattleianum*-dominated community that was present prior to clearing. It was presumed that such taxa would colonize the area, and that this new mixed native and non-native community would be capable of supporting greater native diversity and cover. Yet, it was understood that on-going follow-up weeding would be necessary to avoid exchanging one non-native community for another.

Management goals of < 50% non-native canopy and understory cover were achieved and maintained, and progress towards the goal of > 50% native canopy and understory cover was made over the five year period following chipper treatment. Despite this progress, Kahanahiki MU vegetation monitoring results revealed that median native understory and canopy cover remained unchanged, and non-native understory and canopy increased, between 2009 and 2015 for the MU, as the areal extent of the chipper site project was insufficient to effect beneficial change on an MU scale (OANRP, 2015). Many additional aggressive projects such this would be necessary to influence MU scale progress towards management goals.

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Buried Alive: Assessing Soil Seed Bank Persistence to Assist in Invasive Species Eradication

Michelle Higashi, Lauren Weisenberger, Julia Lee, Jane Beachy: O´ahu Army Natural Resources Program, Honolulu, Hawai´i

ABSTRACT

Understanding the seed biology of invasive plant species can assist managers in achieving eradication, particularly as it applies to scheduling treatment intervals (in conjunction with plant phenology) and monitoring for recruitment following removal of all target plants. Knowledge of seed bank potential, or how long seeds remain viable when in the ground, is critical to defining eradication for a taxon. Over the last ten years, the O'ahu Army Natural Resources Program (OANRP) collected mature fruits from nine naturalized or incipient invasive species to classify their soil seed bank type. Seeds from each of the species were kept in dark, wet conditions in the laboratory and/or buried in durable bags six inches below ground in the field. Bags and seeds were retrieved and sown at regular intervals to assess viability. As a result, taxa were classified as having transient, short-term persistent, or long-term persistent soil seed banks. This information will assist in developing control strategies and determining eradicability for these taxon, on a species and site level.

BACKGROUND

OANRP mitigates for threats that impact endangered species found in and around Army training areas (Fig. 1). This includes removal of both naturalized and incipient invasive plant species. While habitat restoration is the goal of most weed control efforts, select incipient invasive taxa are targeted for eradication. Determining the persistence of the soil seed of target weeds guides both habitat restoration and eradication efforts, and is critical to identifying if/when eradication of a specific infestation can be achieved. Species persist in the soil seed bank for varying amounts of time (Table 1).

Table 1. Soil Seed Bank Potential Definitions

Soil Seed Bank Type	Seed Viability
Transient	up to 1.5 years
Persistent, Short Term	1.5-5 years
Persistent, Long Term	longer than 5 years

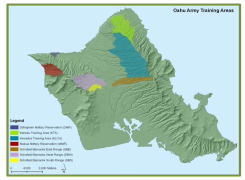


Fig.1. O´ahu Army Training Areas

METHODS

Seeds were opportunistically collected during weed removal activities in OANRP management areas.

__Initial Viability Assay__: Temperature, water, and light are important external factors affecting seed germination. Imbibition (uptake of water) of seeds is necessary for germination, while the presence of light can be a trigger for certain species. For this study, we considered a seed to have germinated when a radicle (root) and cotyledons formed. A subsample of each collection was sown in Petri dishes of 1% water agar in Percival© seed germination chambers (Fig. 2, exposed to light and moisture; average daily and nightly temperatures to mimic conditions at 2000' elev., northern Wai´anae Mountains).

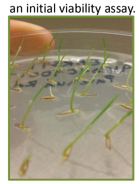


Fig. 2. Seeds of *E. stipoides* germinating in an initial viability assay.

Fig. 3. (left to right) Collecting *C. odorata* seeds in the field. Installing *S. condensatum* buried seed trial. The *C. setaceus* buried seed trial; located in the taxon's preferred habitat .

__Field Trials__: Seeds were sealed in polyester fabric bags and buried 6 inches below the soil surface near existing populations (Fig. 3). Buried bags were retrieved at regular intervals.

- **Dark, Buried:** Seeds that had germinated in the buried bags were counted.
- **Light, After Buried:** Intact, non-germinated seeds were sown on agar and put in the growth chambers, exposed to light, and all germinating seeds were counted (similar methods as Initial Viability Assay).

__Lab Trials__: Seeds were sown on agar in Petri dishes, wrapped in one layer of plastic wrap, followed by two layers of aluminum foil to keep light out. Seeds had enough moisture to remain imbibed (absorbed necessary amount of water to allow for germination) throughout dark treatment. Dishes were placed in germination chambers and retrieved at regular intervals.

- **Dark, Imbibed**: Seeds that had germinated in the dark were counted.
- **Light, After Imbibed**: Petri dishes were unwrapped and intact, non-germinated seeds were sown on agar and kept in the growth chambers, exposed to light, and all germinating seeds were counted.

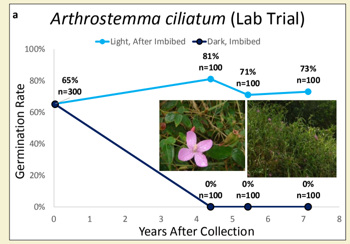
Results from these germination trials (Fig. 5) were interpreted to classify type of soil seed bank. Species with seeds that germinate in the absence of light (Dark, Imbibed treatment (Lab Trial)) were classified as transient or not likely to form persistent seed banks. Species with seeds where viability declined (or was projected to decline) to ~0% by approx. 5 years (or projected) when exposed to light upon removing from buried bag or dark/imbibed treatment were classified as persistent, short-term. Seeds with little decline in viability after 5 years were classified as persistent, long-term (Table 2).

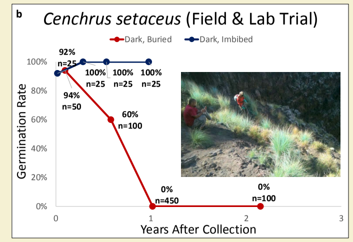
Fig.4. Seeds of *E. stipoides* that germinated during the Dark/Imbibed Lab treatment.

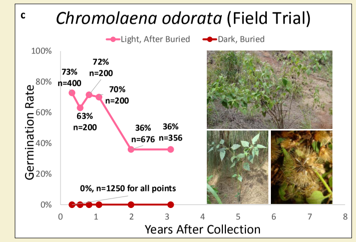
References:

- Hawaii-Pacific Weed Risk Assessment. 2015. www.hpwra.org
- Walck et al. 2005. Defining transient and persistent seed banks in species with pronounced seasonal dormancy and germination patterns. Seed Science Research **15**: 189-196

RESULTS - SOIL SEED BANK POTENTIAL







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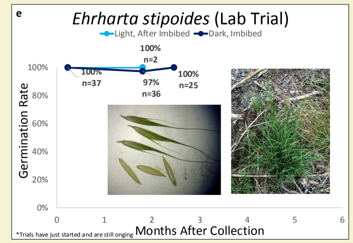
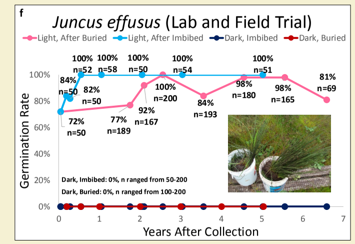
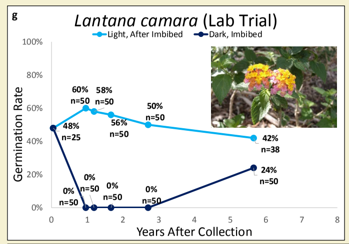
Crocosmia x crocosmiiflora (Field Trial)

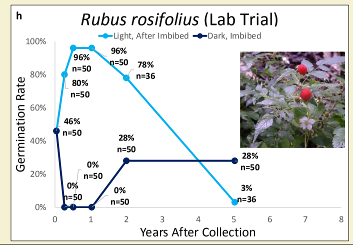
Time Since Collection	Germ (Dark, Buried)	Germ (Light, After Buried)
	Initial Viability 60%	
4month	0%*	0%
6month	0%*	0%
1year	0%*	0%
2year	0%*	0%

*seeds likely germinated in buried bag and subsequently rotted









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Schizachyrium condensatum (Field Trial)

	Initial Viability	Germ (Dark, Buried) 6 months	Germ (Light, After Buried) 6 months
Collection 1	56%	0%	37%
Collection 2	18%	0%	13%

Fig. 5. Seed Viability Graphs & Tables. Graphs a-c, e-h indicate Field Trial, Lab Trial, or both (see methods for definitions). For graphs a, b, and e-h navy blue lines indicate germination that took place while seeds were in the dark, imbibed treatment (Lab Trial); turquoise lines (not in b) indicate germination of those seeds upon exposure to light (unwrapped). For graphs b, c, and f, red lines indicate germination that took place while seeds were buried (Field Trial), and pink lines indicate germination of those seeds upon exposure to light (unburied). Each navy blue or red point on a graph represents the germination in the dark at one interval (either 2 bags of seeds or 1 dish) that was exposed to light (corresponding turquoise or pink point at same time (x-axis) interval).

Table 2. Species Summaries for Soil Seed Bank Persistence. The Hawaii-Pacific Weed Risk Assessment evaluates the potential invasiveness of non-native plant species. Scores above 6 indicate high risk for invasiveness. *C. crocosmiiflora* has not been evaluated, but is a recognized invasive species in Hawai´i. Species with seeds that germinate without light and upon imbibition do so when they have absorbed enough water for germination. Other species have seeds that can remain in dark/imbibed treatment for years before germinating. If more than one collection per species, initial viability is an average.

Species	Family	HPWRA Risk	Habit	Year Test Began	Field Trial	Lab Trial	Initial Viability	Germinates Without Light?	Soil Seed Bank Type
Arthrostemma ciliatum	Melastomataceae	High (7)	herb	2007-ongoing		x	65%	no	Persistent, Long Term
Cenchrus setaceus	Poaceae	High (26)	grass	2012-2013	x	x	92%	yes (upon imbibition)	Transient
Chromolaena odorata	Asteraceae	High (28)	herb	2011-ongoing	x		73%	no	Persistent, Short Term
Crocosmia x crocosmiiflora	Iridaceae	-	herb	2008-2010	x		60%	yes (upon imbibition)	Transient
Ehrharta stipoides	Poaceae	High (19)	grass	2015-ongoing		x	100%	yes (upon imbibition)	Transient
Juncus effusus	Juncaceae	High (21)	rush	2007-2015	x	x	72%	no	Persistent, Long Term
Lantana camara	Verbenaceae	High (32)	shrub	2005-2012		x	48%	yes (after 5 years)	Persistent, Short Term
Rubus rosifolius	Rosaceae	High (10)	herb	2005-2011		x	46%	yes (after 2 years)	Persistent, Short Term
Schizachyrium condensatum	Poaceae	High (13)	grass	2013-ongoing	x		37%	no	Persistent (ongoing)

MANAGEMENT IMPLICATIONS

- Seed dormancy can complicate the assessment of soil seed bank persistence and needs to be identified and considered in determining soil persistence.
- Additional, extended trials are necessary for replication to verify seed bank classification and to continue testing species with suspected long-term persistent soil seed banks.
- Assuming no ingress of seeds or other propagules, isolated infestations of species with transient seed banks (*C. setaceus, C. crocosmiiflora,* and *E. stipoides*) have a good prognosis for eradication. Such infestations should be monitored at least 1.5 years following the removal of the last mature plant.
- Given that plant detection rates vary widely based on terrain, vegetation, staff, detectability of small size classes, etc., it is prudent to assume that some plants will escape detection for one or more control trips. Conservative managers may therefore choose to define eradication as no plants found for at least two times the duration of the soil seed bank.
- Species which form persistent, short term seed banks pose a greater challenge for eradication than those which form transient seed banks, and may require a decade of monitoring following eradication of the last known individual plant. Species which form persistent, long term seedbanks will require decades of consistent effort to achieve eradication.
- If habitat restoration, rather than eradication, is the goal, seed bank persistence is one factor to consider when determining time between weed control trips and setting realistic tolerance levels for select weeds in work sites.

No Need for Devil Weed: Eradication Efforts and Challenges in Controlling *Chromolaena odorata*

Taylor Marsh and Jane Beachy: Oahu Army Natural Resources Program

O'ahu Army Natural Resources Program

ABSTRACT

Chromolaena odorata, an Asteraceae commonly known as Devil Weed or Siam Weed, is native to North America, from Florida and Texas to Mexico and the Caribbean, and is a documented agricultural and ecological pest in tropical Asia, West and South Africa, and parts of Australia. The species has been referred to as one of the 100 worst weeds in the world (IUCN). *Chromolaena* was first reported in Hawaii by Oahu Army Natural Resources Program (OANRP) staff in 2011 when it was spotted on an annual road survey in the Army's Kahuku Training Area. Since detection, OANRP has repeatedly swept over 370 hectares across the Kahuku infestation, and spent nearly 2.000 person hours in this effort. Delimiting surveys were completed in Kahuku in 2013, and few populations outside the core infestation area were detected. However, smaller populations of *Chromolaena* have since been detected on Oahu at Aiea, Kahana, and two additional Army training ranges. OANRP current control strategy is to: 1.) survey and control across the defined infestation area every six months to a year; 2.) control locations with high densities of plants (hotspots) before the annual reproductive season (November - April); 3.) conduct annual aerial sprays of the core infestation (approximately 4 ha) before reproductive season; 4.) survey an 800 meter buffer around the infestation area and outlier populations, documenting and controlling new plants. Additional necessary but challenging efforts to eradicate this taxa from the island include surveying high-priority areas across the entire island of Oahu, securing funding and staff for control efforts, improving spray equipment, broadening public outreach efforts in high-use areas where *Chromolaena* is present, and supporting sanitation and inspection protocols within the Army. OANRP is dedicated to eradication of *Chromolaena* on Army lands, and supports eradication island-wide.

BACKGROUND

C. odorata not only an ecological threat but a toxic agricultural threat as it can cause diarrhea or in extreme cases, death to livestock through ingestion of the leaves. To humans it can cause skin reactions and asthma in allergy prone people. Ecologically, the species can tolerate a broad range of climates and soil conditions and can tolerate severe dry periods. It is very suitable for tropical climates and prefers open sunny areas to partial shaded areas. It rapidly colonizes disturbed or cleared areas and once established is alleleopathic. The plant is also a known host for pests, pathogens, and fungal diseases

Fig. 1. (above left) New flowers usually starting in November. **(middle)** Mature fruit lasting until around April. **(right)** Leaves

REPRODUCTIVE BIOLOGY AND SEED BANK PERSISTENCE

C. odorata can mature in one year and begin producing seed which can reach a count of 800,000 per individual per year. A seed burial trial was conducted where seeds were sealed in polyester fabric bags and buried 6 inches below the soil surface near an existing population in Kahuku. Buried bags were retrieved at regular intervals.

- **Dark, Buried:** Seeds that had germinated in the buried bags were counted.
- **Light, After Buried:** Intact, non-germinated seeds were sown on agar and put in growth chambers, exposed to light, and all germinating seeds were counted.

Results: *Chromolaena odorata* initially had a 73% germination rate when exposed to light but after 2 year had dropped to a 36% germination rate. This is a substantial drop in viability after 2 year. This seed trial is still ongoing but we predict that the amount of germination will continue to drop, and anticipate this species will have a short-term (5 years) persistent seed bank.

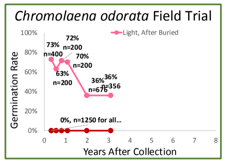


Fig. 2. For this graph, red lines indicate germination that took place while seeds were buried (Field Trial), and pink lines indicate germination of those seeds upon exposure to light (unburied). Each red point on the graph represents the germination in the dark at one interval (either 2 bags of seeds or 1 dish) that was exposed to light (corresponding pink point at same time (x-axis) interval).

DISPERSAL CHALLENGES

DISTRIBUTION

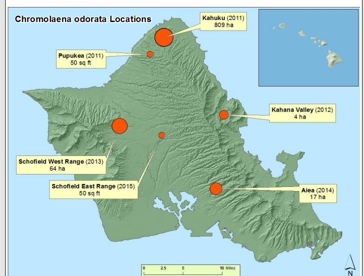


Fig. 3. This Map shows the general locations of *Chromolaena* known on Oahu. The size of the dots represents the population size (number of plants found to date) with the Army's Kahuku Training Area as the largest infestation.

ARMY

What is being done to control the spread by the Army and soldiers?

- Training area BRAVO 1 containing the highest density of plants in KTA has been closed to training.
- No Mowing signs and roped off areas have been set up.
- Policy memo has been published enforcing mandatory use of vehicle washrack.
- Non-functioning washrack has been rebuilt and is now fully operational.
- Posters and fliers have been posted at KTA Range Control office.

Fig. 4. (left to right) "No Mowing" signs set up in Schofield West Range Soldier washes down vehicle at washrack.

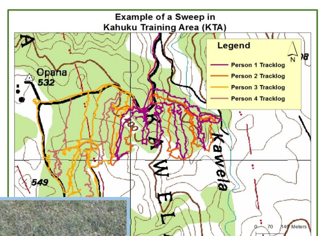
OUTREACH

Since this is not just a problem on Army lands, how do we inform the public or other relevant parties?

- Create informational fliers and posters and distribute them to all necessary parties.
- In 2012, OANRP and the Oahu Invasive Species Committee (OISC) gave a presentation to the Hawaii Motocross Association and community urging riders to clean all vehicles and gear and to report any finds of Devil Weed.
- Contact partner agencies and the conservation community via list serve and email. Our cooperation with OISC on this project is ongoing and constant as they are working on *Chromolaena* sites outside of Army lands.
- Contact Marines who also train at KTA.

CONTROL TECHNIQUES AND STRATEGIES

GROUND SWEEPS



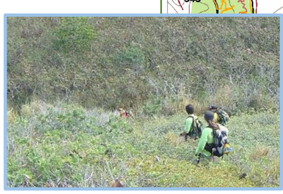


Fig. 6. (Left) Field crew lines up to sweep. **(Right)** An ideal sweep where all team members are lined up and spaced out evenly to get the best coverage.

METHOD:
The "Sweep" technique is used to reduce the number of plants that are sometimes missed during a survey by lining up as team and spacing each team member out evenly. Then the team moves a set compass bearing in search for plants. Communication throughout the sweep is crucial to keep the line organized and to respond to any new plants found.

BUFFERS:
When outlier plants are first detected, 200 meter and sometimes 800 meter buffers are drawn around the point(s) and the entire buffer is swept . If more plants are found, the buffers will keep expanding until the population is delineated. See Surveys section to the right for an example of a buffer.

THE ROLE OF OUR PARTNERS:
OANRP pays the Oahu Invasive Species Committee to sweep half of the KTA infestation biannually.

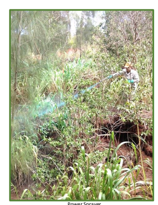
HOTSPOT TREATMENTS

Fig. 5. A typical *Chromolaena* hotspot in a disturbed, open area in KTA complete with a motocross trail down the middle of it. All brown branches seen here are Devil Weed.

WHAT'S A HOTSPOT YOU ASK?
We define a Hotspot as any Devil Weed population that either has more than 10 mature plants (containing fruits or flowers) present OR any population that has a significant seedling recruitment potential, i.e. a number of matures had just seeded and it was in prime habitat for recruitment (sunny and open).

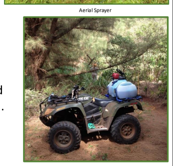
HOW DO WE CONTROL HOTSPOTS?

- **Power Spray:** This is by far the most effective and successful tool in our shed because its pressure can penetrate through patches of plants and treat the soil with pre-emergent herbicide.
- **Backpack Spray** any hotspots that are not accessible via vehicle and power sprayer. This is less efficient, especially if you need to put out large volumes of herbicides for large patches of target plants.
- **Aerial Spray** any hotspots that are not accessible via power or backpack spraying. These hotspots once found, must be flagged well for aerial treatment so that the pilot can easily identify the area from the air as Devil Weed is difficult to see from the air.
- The **ATV sprayer** seen in the picture was used but proved to be less effective than expected. It was limited in the places it could go because the sprayer and tank made it extremely top-heavy thus giving it the potential to flip.



Power Sprayer

Aerial Sprayer



ATV Sprayer

AERIAL HOTSPOT SPRAYS

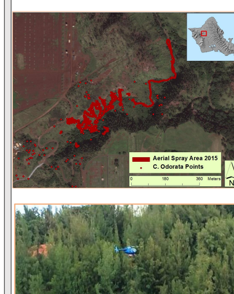


Fig. 6. (Above) Aerial Spray in action in Kahuku and a closer look at the spray "ball" nozzle. **(Below)** A map showing what has been aerially sprayed to date.

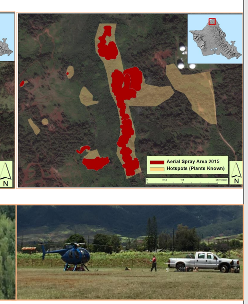


Fig. 7 . (Above) Beginning of aerial spray operations at West Range. **(Below)** A map showing what has been aerially sprayed in West Range to date and the locations of historic *Chromolaena* plants.

SURVEYS

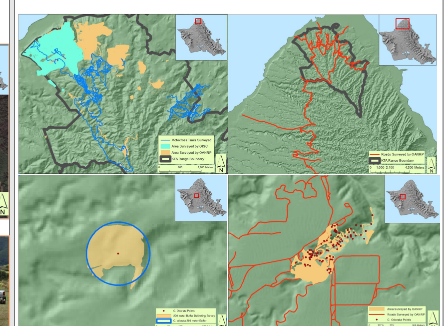


Fig. 8. (Above left and right) In Kahuku Training Area, 490 hectares have been annually swept, 274 km of trails surveyed, and 367 km of roads have been surveyed to date. **(Bottom left and right)** These maps show the East and West Range *C. odorata* site where surveys have been done.

DISCUSSION

It is clear that a much larger effort is needed if *C. odorata* is to be eliminated from Oahu. New finds at Schofield's East Range and Aiea this year alone highlight the ease with which *C. odorata* moves on vehicles and humans. It seems likely that there are other, unknown infestations located off Army training facilities; surveys need to be conducted across the island to better understand the scope of the infestation and set realistic goals. Securing adequate funding for surveys and control is essential to the eradication goal. Furthermore, biosecurity plays a vital role in preventing further establishment of *C. odorata* on Oahu from likely sources like Guam, where the species is widespread and can easily come over to Oahu via military vehicles, gear and personnel. In particular, quality inspections and enforcement of incoming troops and military shipments is key to ensuring that there are no further introductions of Devil Weed to either Oahu or the island of Hawaii, where there is the Army's Pohakuloa Training Area. It would also be beneficial to explore and fund research for biocontrol since this species, once established, takes so much effort and resources to contain.

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2. *Chromolaean odorata*: A Highly Invasive Weed . manoa.hawaii.edu/hpicesu/DPW/chrodo_flier.pdf

Assessing the most effective weed control re-treatment interval for *Clidemia hirta*-dominated areas at Opaeula Lower Management Unit, Oahu

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INTRODUCTION

The goal of this study was to guide Oahu Army Natural Resources Program (OANRP) weed control planning for *Clidemia hirta* at Opaeula Lower Management Unit (MU), where dense understory cover of this weed occurs (Fig. 1). This species is targeted due to its ecosystem altering characteristics and tendency to create thick monotypic stands. Several questions are addressed pertaining to the effect of weeding *C. hirta*-dominated areas. To what extent does *C. hirta* and other weed taxa rebound if an area is not re-weeded for 6, 12 or 18 months? In the course of weeding a small degree of understory native vegetation trampling occurs. Does re-weeding at 6 months cause further damage to native vegetation? How does species diversity change in response to weeding at different intervals? How long does it take for <10 cm tall *C. hirta* plants (typically not treated during weeding) to become reproductive? Does canopy cover change in response to understory weeding within 18 months?

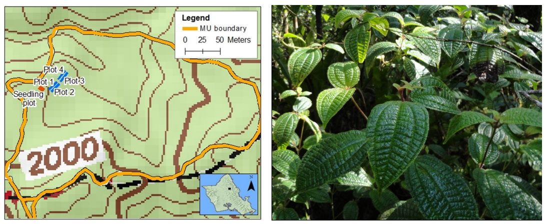

Figure 1. a) Locations of study plots at Lower Opaeula Management Unit, Oahu, and b) photo of *Clidemia hirta*

METHODOLOGY

Field Methods: Plots (5 x 21 m) were monitored in May 2013 (month 0) and November 2014 (month 18) among 4 weeding treatments:

Plot 1: control plot – not weeded
Plot 2: weeded at 0 & 6 months
Plot 3: weeded at 0 & 12 months
Plot 4: weeded at 0 months

Understory percent cover (using point intercept, n = 80 points), species richness (in 1 m^2 quadrats, n = 20), and canopy openness (using hemispheric photographs, n = 20) were monitored. To assess *C. hirta* maturation time, 50 individuals < 10cm tall were tagged within a 5 x 5 m plot, and monitored every 6 months from May 2013 to November 2014. Weeding included all non-grass mature and immature plants and most seedlings.

Data Analysis: Analysis included chi-square and Fisher's exact tests for change in understory cover within plots over time, and differences between plots at the end of the trial; t-tests for species richness change over time; and ANOVA with Tukey's post-hoc comparisons for differences in species richness between plots at the end of the trial, and for canopy openness in hemispheric photographs derived using Gap Light Analyzer (GLA), Version 2.0 software (Frazer et al. 1999). Analysis of change in non-grass weeds and non-vegetated area was based on initial weed cover in Plot 1, as Plots 2, 3, and 4 were weeded prior to baseline monitoring. Anecdotal observations determined that weed cover was similar among all 4 plots at the start of the trial.

RESULTS

Non-native understory percent cover: There was a significant decrease in *C. hirta* ($p < 0.001$) and total weed cover ($p < 0.001$), but a significant increase in total weed cover excluding *C. hirta* ($p < 0.001$), among all weeded plots (Fig. 2 and 3). The most commonly occurring grass, *Paspalum conjugatum*, also increased significantly from very low (Plots 2 and 4) and low (Plot 3) to moderately low cover in all weeded plots. At the end of the trial, *C. hirta* cover differed significantly among all plots, ranging from very low to high in relation to the time elapsed since the last weeding effort (6, 12, and 18 months prior for Plots 3, 2, and 4, respectively, and Plot 1 never weeded). Total weed cover differed among plots ($p < 0.001$) except for Plots 2 and 3, ranging from moderate to very high, also in relation to time since weeding last occurred. Total weed cover excluding *C. hirta* differed among plots ($p < 0.001$) with the exception of Plots 3 and 4, ranging from moderately low (Plot 1) to moderate (Plot 2) to moderately high/moderate (Plots 3 and 4).

Native understory percent cover: There was a significant increase in native cover (from low to moderate) for Plots 2 and 3 ($p < 0.001$). Though initially absent, by the end of the trial, *Acacia koa* was present in all plots at very low cover, representing a small significant increase in Plots 2 and 4 ($p = 0.024$). *Cibotium chamissoi* had a small significant increase in the control plot ($p = 0.044$), and a larger increase in Plots 2 and 3 ($p < 0.001$). *Nephrolepis exaltata* subsp. *hawaiiensis* had a significant increase (from very low to low cover) in Plot 2.

Non-vegetated percent cover: There was a very small significant increase in non-vegetated area in Plot 2 ($p = 0.022$) from very low to low percent cover.

Species richness: Non-native species richness increased significantly in Plots 3 ($p < 0.001$) and 4 ($p = 0.001$) (Fig. 4). At the end of the trial, there were significant differences in non-native species richness between plots ($p = 0.001$), with pairwise differences between Plot 1 and Plots 3 and 4 (Plot 1 vs. 3: $p = 0.001$; Plot 1 vs. 4: $p = 0.049$). There was a marginally significant increase in native richness in Plot 3 ($p = 0.057$).

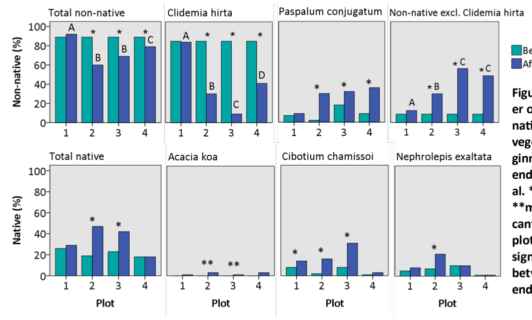

Figure 2. Percent cover of non-native and native understory vegetation at the beginning (before) and end (after) of the trial. *Significant, **marginally significant, change within plots. Letters denote significant difference between plots at the end of the trial.

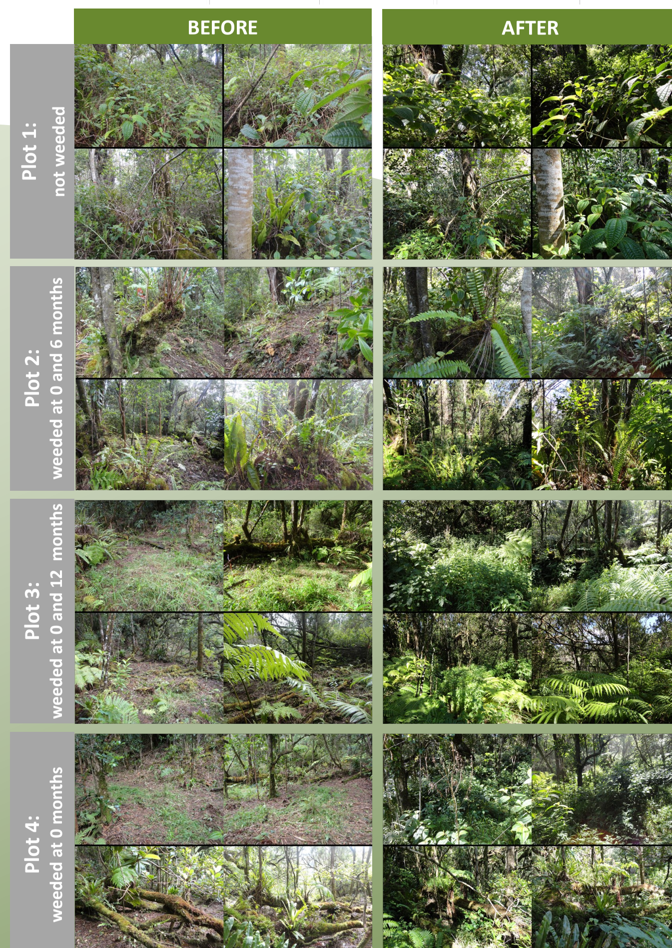

Figure 3. Photopoints of plots at the beginning and end of the trial, with images taken from the north, east, south and west corners (shown counterclockwise from top right image) of each plot.

Maturation time: Among the tagged *C. hirta*, one individual was mature by 12 months, and 43% of the remaining live plants were mature by 18 months. Many of the immature plants remained small, and were beneath dense *C. chamossoi* cover. A treefall occurred between months 12 and 18, and created a light gap that may have prompted *C. hirta* growth and maturation. At the end of the trial, all plots had mature *C. hirta*, including Plot 3, which was weeded only 6 months earlier.

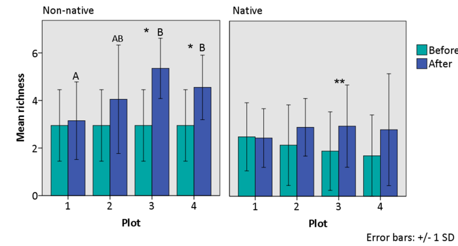

Figure 4. Mean non-native and native species richness at the beginning and end of the trial. *Significant, **marginally significant, change within plots. Letters denote significant difference between plots at the end of the trial.

Canopy openness: There was no significant change in canopy openness among the weeded plots, yet, there were significant differences among plots at the end of the trial ($p < 0.001$) (Fig. 5). Plot 2 was more open than all other plots, while Plot 4 was the least open.

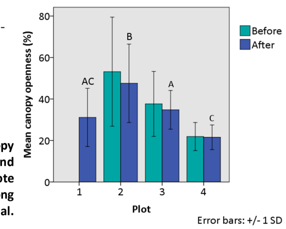

Figure 5. Mean percent canopy openness at the beginning and end of the trial. Letters denote significant differences among plots at the end of the trial.

SUMMARY AND RECOMMENDATIONS

Understory cover: Weeding *C. hirta*-dominated understory at Lower Opaeula produces reduced *C. hirta* cover paired with an increase in native cover after 18 months if initial weeding is followed by additional weeding 6 or 12 months later. However, substantial increased cover of non-native weeds other than *C. hirta* occurred, particularly the alien grass *P. conjugatum*. The plot weeded only once had very poor results after 18 months, with no change in native cover, and a resurgence of non-native cover to nearly as high as it was prior to weeding. ***Re-weeding (including grass control) should occur within 6 to 12 months, in order to allow native cover to expand, and prevent weed cover from returning to near prior levels.***

Species richness: Increased weed species richness resulted from a 12 to 18 month delay in re-weeding. As native species richness did not change substantially, the increase in native cover that occurred in the plots weeded twice was largely an expansion of species already present. ***Because C. hirta-dominated areas are partially replaced by other weed taxa, care should be taken to ensure that more problematic weeds do not become established.***

Maturation time: Though the minimum time for *C. hirta* maturation from the small immature stage was 12 to 18 months in the seedling plot, the presence of mature plants in a plot weeded only 6 month prior to the end of the trial suggests that the minimum time to maturation is < 6 months, and may be influenced by light availability. ***If there is an impetus to deplete the* C. hirta *seed bank, weeding should occur more frequently than 6 months, particularly in areas with greater light availability. Additionally, weeding must be ongoing, as* C. hirta *forms a long lived seed bank (Brooks and Setter, 2012). However, such a high frequency of weeding will limit the total area that is feasible to weed. Additionally, there will likely be a continual influx of* C. hirta *seeds from the surrounding areas. Depletion of the* C. hirta *seed bank is likely an impractical endeavor.***

Canopy openness: Differences in understory change among plots may have been influenced by differences in light availability, as canopy openness differed among plots. ***Clearcutting non-native canopy in this area is not advised, unless there are resources to follow up and prevent* C. hirta *from becoming established.***

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Frazer, G. W., C. D. Canham, and K. P. Lertzman. 1999. Gap Light Analyzer (GLA), Version 2.0: Imaging software to extract canopy structure and gap light transmission indices from true-colour fisheye photographs, users manual and program documentation. Copyright © 1999: Simon Fraser University, Burnaby, British Columbia, and the Institute of Ecosystem Studies, Millbrook, New York.

Efficacy of Undiluted Herbicide Injections on Tropical Woody Tree Species in Hawaii

Julia Gustine Lee and Jane Beachy: Oahu Army Natural Resources Program • James Leary: University of Hawaii at Manoa

Abstract: Hawaii hosts a wide array of non-native, woody trees, that are considered to be invasive pests which threaten the integrity of delicate native ecosystems and adversely impact watershed health. The Oahu Army Natural Resource Program (OANRP) is tasked with conducting habitat restoration to support endangered species protection, and to this end conducts hundreds of hours of weed removal annually. OANRP's default control method uses a 20% dilution of a triclopyr product in biodiesel, applied with or without cuts to the basal area of woody tree weeds. Anecdotally, this technique is mostly successful at killing target species, but applications are un-calibrated; high doses may mask mediocre results. To identify more efficient and effective control techniques for invasive trees, trials were installed on Oahu in 2010 to examine the efficacy of low doses of four active ingredients (imazapyr, aminopyralid, glyphosate, and triclopyr). The treatment technique, Incision Point Application (IPA), involves making discrete, regularly spaced cuts around the trunk of a tree, and applying a measured amount of undiluted herbicide to each cut. Treated trees were monitored for up to two years. Performance was measured by recording defoliation and cambium health over time. Surprisingly, triclopyr was the least effective product tested. Imazapyr exhibited the greatest success, providing the most effective control across the greatest number of species. Using the results of these trials, OANRP has begun controlling canopy weeds across large acreages.

Background: The Incision Point Application (IPA) method is a calibrated, clean, and efficient field technique for administering lethal herbicide doses directly to the exposed vascular systems of invasive woody species. The IPA technique is a refinement of the more traditional "frill cut" or "hack-n-squirt" basal application methods by minimizing the cutting action to small incisions around the base of the tree at equidistant points, less than a complete girdle. It also precisely delivers known amounts of herbicide to each incision. This technique utilizes a small, sharp implement (e.g. a hatchet) for making the incision and either a veterinary draw-off syringe or calibrated dropper (Fig.1) for metering the herbicide. Knowing the most effective herbicides for each target species optimizes the IPA technique with the smallest lethal dose, allowing applicators to carry less weight into the field and leave the smallest chemical footprint in the environment.

Methods:

Treatment:

- Label 16 or 20 trees of relatively uniform circumference and measure and record each trunk circumference at 50cm from soil surface.
- Sort tree numbers by circumference size from smallest to largest and group into blocks of 4 starting with the smallest. Randomly assign one of the four herbicide treatments to each of the trees per block. Label trees with assigned herbicide.
- Use 'matrix of tree circumference with matching incision treatments' (Leary, 2010) to determine cuts per tree for each trial (based on size range of trial trees).
- Make cuts at equidistant points around the base of the trunk, approximately 20-50cm above the soil surface. All trees in a trial receive the same number of cuts. Administer 0.5 ml of herbicide concentrate to each cut.

Monitoring:

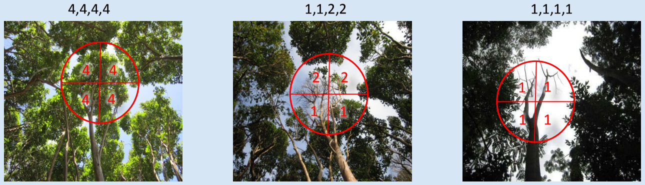
- Record canopy defoliation ratings every 90-100 days for up to 3 years.
- Visually subdivide leaf canopy into four equal quadrants. These designations can be arbitrary and different for each tree.
- Visually rank each quadrant 1-4 for level of defoliation for a total of four rank values for each tree unit (Fig. 2). 100% defoliation and ultimately complete cambium death (checking for dead tissue), were used as measures of efficacy.

Figure 1: Species herbicide trial equipment

Figure 2: Canopy defoliation rating system:

1- 100% defoliation (no intact leaves, unless fully necrotic and desiccated)
2- >50% defoliation (even if a single leaf is present in the canopy, up to 99% defoliation)
3- <50% defoliation (mostly intact canopy with observable defoliation and/or necrosis)
4- 0% defoliation (no observable defoliation)

no defoliation 4,4,4,4 | partial defoliation 1,1,2,2 | complete defoliation 1,1,1,1



References:
(Leary, 2013: A Practitioner's Guide for Testing Herbicide Efficacy with the IPA Technique on Invasive Woody Plant Species),
http://www.ctahr.hawaii.edu/oc/freepubs/pdf/WC-11.pdf;

Results: Aminopyralid and Imazapyr had superior performance compared to Glyphosate and Triclopyr (Fig. 3). For all species where an herbicide was identified as effective, one (or in some cases both) of these two active ingredients was either the most, or second most effective. It was not uncommon to observe apparently ineffective treatments after 100 days, but that ranked as effective at 200-300 days after treatment. No herbicide was effective enough to recommend for: *Acacia confusa*, *Citharexylum caudatum* or *Syzygium cumini*. In the case of *Syzygium cumini*, results from two separate trials were inconsistent, and death was only observed in the smallest of trees. There was no effect for *Corymbia citriodora* at the dose given during the trial. Effective cut spacing for most species was between 15 and 25 cm.

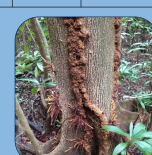
Figure 3: Active Ingredient (A.I.) efficacy summary. Triclopyr= TCP (red), Glyphosate=GLY (beige), Aminopyralid= AMP (brown), Imazapyr=IMZ (green). Results are for days after treatment given in column 2. Best performing herbicide for each species is bolded, and second best is in italics. Recommended cut spacing was made by dividing the circumference of the largest tree(s) effectively controlled by the number of cuts administered in that species trial.

Species	Days after treatment	TCP # 100% defoliated/ # dead	GLY # 100% defoliated/ # dead	AMP # 100% defoliated/ # dead	IMZ # 100% defoliated/ # dead	Recommended Treatment: Herbicide	Recommended Treatment: Cut spacing (0.5ml/cut)
Acacia confusa (n=16)* Fabaceae	916	0/0	0/0	2/0	0/0		
Fraxinus uhdei (n=20) Oleaceae	305	0/0	0/0	2/1	3/2	**IMZ** *AMP*	**15cm-20cm** *15cm*
Araucaria columnaris (n=20) Araurcariaceae	640	0/0	1/0	5/1	2/2	**AMP** *IMZ*	**15cm** *15cm*
Ardisia elliptica (n=20) Myrsinaceae	481	0/0	0/0	1/0	5/5	**IMZ**	**15-20cm**
Callitris columellaris (n=20) Cupressaceae	430	0/0	2/unk	2/unk	0/0	**GLY** *AMP*	**15cm** *15cm*
Casuarina glauca (n=20) Casuarinaceae	430	2/2	0/0	2/2	0/0	**AMP** *TCP*	**10cm** *10cm*
Citharexylum caudatum (n=20)* Verbenaceae	333	0/0	0/0	0/0	1/0		
Coffea arabica (n=20) Rubiaceae	640	1/0	0/0	1/0	5/4	**IMZ**	**25cm**
Cordia alliodora (n=20) Boraginaceae	669	2/0	0/0	1/0	2/0	**IMZ**	**15-20cm**
Corymbia citriodora (n=20) ** Myrtaceae	343	0/0	0/0	0/0	0/0		
Cryptomeria japonica (n=20) Cupressaceae	580	0/0	5/5	5/5	0/0	**AMP** *GLY*	**20cm** *20cm*
Elaeocarpus grandis (n=20) Elaeocarpaceae	454	0/0	0/0	0/0	3/2	**IMZ**	**20cm**
Fraxinus uhdei (n=20) Oleaceae	640	2/1	0/0	1/0	5/4	**IMZ**	**15-20cm**
Grevillea robusta (n=16) Proteaceae	785	4/4	n/a	4/4	4/3	**AMP** **TCP** *IMZ*	**25cm** **25cm** *20cm*
Heliocarpus popayenensis (n=20) Tiliaceae	305	1/0	1/0	2/2	4/4	IMZ **AMP**	20cm **20cm**
Leptospermum scoparium (n=20) Myrtaceae	453	0/0	5/4	1/1	5/5	**IMZ** *GLY*	**25cm** *20cm*
Leucaena leucocephala (n=16) Fabaceae	513	0/0	0/0	4/4	0/0	**AMP**	**20cm**
Melaleuca quinquenervia (n=20) Myrtaceae	453	0/0	1/1	4/4	5/5	**IMZ** *AMP*	**25cm** *10cm*
Morella faya (n=20) Myricaceae	580	1/0	2/2	5/4	5/4	**IMZ** *AMP*	**15-20cm** *15-20cm*
Pimenta dioica (n=20) Myrtaceae	641	0/0	0/0	3/3	5/4	**IMZ** *AMP*	**15-20cm** *15-20cm*
Psidium guajava (n=20) Myrtaceae	563	1/1	2/0	1/0	4/2	**IMZ**	**25cm**
Schefflera actinophylla (n=16) Araliaceae	435	0/0	4/4	4/4	4/4	**GLY** **IMZ** **AMP**	**10-15cm** **10-15cm** **10-15cm**
Schinus terebinthifolius (n=16) Anacardiaceae	559	1/0	1/0	4/3	4/3	**IMZ** **AMP**	**5-10cm** **5-10cm**
Spathodea campanulata (n=16) Bignoniaceae	531	0/0	0/0	1/1	4/3	**IMZ**	**20cm**
Syzygium cumini (n=20) **	481	1/1	0/0	0/0	1/0		
Syzygium cumini (n=16) ** Myrtaceae	443	0/0	0/0	0/0	1/1		
Toona ciliata (n=16) Meliaceae	916	4/3	0/0	1/0	4/4	**IMZ** *TCP*	**15cm** *15cm*
Trema orientalis (n=20) Ulmaceae	461	1/1	2/2	4/4	4/4	**IMZ** *AMP*	**15-20cm** *15-20cm*
Total species adequately controlled with active ingredient		**3**	**4**	**15**	**20**		
**re-trial with best herbicide to determine dosing*							
***re-trial all herbicides with higher dosing*							

Ideal IPA hatchet cut

12 cuts in *S. cumini* trial, however only 1 of 20 trees died after 481 days

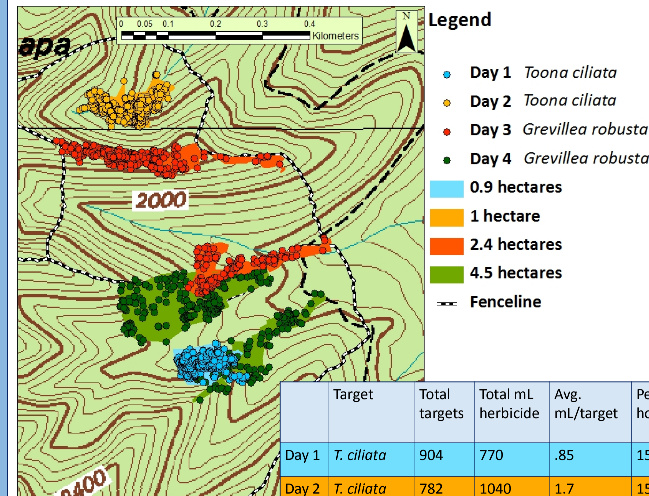
Surrounding native understory and canopy of treated tree remain in good health



Callusing and aerial roots in response to triclopyr treatment

IPA operational control: OANRP now uses the IPA technique operationally for control of *Toona ciliata* and *Grevillea robusta* across large portions of managed areas. As an example, Figure 4 illustrates four individual days of control efforts for these two targets within a fenced management unit. Area controlled is highly influenced by target density. Quantities of herbicide used per target are remarkably low.

Figure 4: IPA Operational treatment example, Kaluaa, Oahu



	Target	Total targets	Total mL herbicide	Avg. mL/target	Person hours
Day 1	*T. ciliata*	904	770	.85	15
Day 2	*T. ciliata*	782	1040	1.7	15
Day 3	*G. robusta*	450	1460	3.2	20
Day 4	*G. robusta*	373	825	2.2	21

Above photos: Operational gear continues to evolve as tools are field tested.

Above photo: Defoliated *G. robusta* (right) next to a healthy *Acacia koa* (left). Aminopyralid is known for efficacy on Fabaceae, and therefore nearly all area treated on day 4 (Fig. 4) was monitored for non-target effects to *A. koa*, a native hardwood Fabaceae. No non-target effects were observed to *A. koa*, however a single *Alyxia stellata* wraped around a treated *G. robusta* died.

Above photo: Slope with defoliated *G. robusta*. The speed of control with IPA allows for greater landscape weed management.

Conclusions:

- IPA offers a measured, clean, cost effective, and efficient field technique for administering lethal doses to invasive woody species.
- Conducting IPA herbicide species trials, although a somewhat long-term (ideally 2 years) commitment, are an important step in determining effective herbicide and dose rate for effective control of target species throughout the Hawaiian islands.
- Imazpyr and Aminopyralid are two herbicides that field managers should consider stocking in their herbicide supply for control with the IPA method.

Acknowledgements: Thank you to the following land managers and owners for their support with these trials: Amanda Hardman and the State of Hawaii NARS division, Laurant Pool and Waimea Valley and Paul Zweng in Waikane Valley.

Restoring *Psidium cattleianum* dominated forest in the Wai‘anae Mountains, Hawai‘i

Jane Beachy, Julia Gustine Lee and Michelle Akamine
O‘ahu Army Natural Resources Program, Pacific Cooperative Studies Unit and USAG-HI Directorate of Public Works, Environmental Division, Schofield Barracks

Abstract:
Diverse mesic forests in the northern Wai‘anae Mountains of O‘ahu support a vibrant mix of endangered species. Unfortunately, much of this forest is heavily invaded by *Psidium cattleianum*, an exotic tropical tree hailing from South America. The invasive characteristics of *P. cattleianum* are well documented, as is the threat it poses to native taxa. The Oahu Army Natural Resource Program (OANRP) conducted an informal trial investigating strategies for removal of *P. cattleianum* monocultures (100m²) which suggested clear-cutting and chipping slash efficiently controlled the invasive tree while allowing re-colonization by native plants. Based on this, in 2010 and 2012 OANRP removed 0.9 ha of dense *P. cattleianum* from Kahanāhaiki Gulch with the goal of reducing alien vegetation cover, increasing native vegetation cover and diversity, and connecting surrounding native forest patches. This project included flying a chipper into the site to grind up large slash piles. Clearing work was done by full-time staff in 2010, and by a combination of full-time and temporary staff in 2012. As feasible, initial clearing was timed to coincide with the senescence of the *P. cattleianum* seed bank, 3-6 months post fruiting, to minimize seedling germination. Volunteers conducted much of the follow-up weed control. Encouragingly, the native tree *Acacia koa* recruited heavily into the site. One opportunistic restoration outplanting was conducted of *Canavalia galeata*. Extensive hand-broadcast of a fast growing native herb, *Bidens torta*, was performed. Photopoints were used to document the dramatic changes at the site. Plots comparing the areas cleared in 2010 and 2012 indicate that while both native vegetation cover and species richness dropped one month after clearing, after five years, both recovered and greatly exceeded pre-clearing levels, while *P. cattleianum* cover remained low. While this aggressive strategy had high initial costs, with a moderate level of follow-up, native forest reclaimed the area.

Project Description:

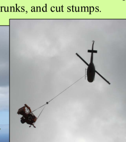
The Kahanāhaiki Management Unit (MU), located in the northern Wai‘anae Mountains, is home to a variety of endangered plants, one endangered tree snail, and some high-value stands of mesic forest. OANRP manages Kahanāhaiki, with the goal of protecting rare taxa and improving habitat. The MU is fenced free of ungulates and rats are suppressed throughout via a rodent trap grid. Like much of O‘ahu's mesic forest, Kahanāhaiki is infested with non-native plants. While initial efforts focused weeding around native forest patches, vegetation monitoring conducted in 2009 indicated that non-native taxa comprised more than 50% cover across the MU. More aggressive efforts were needed to push non-native cover below the 50% threshold and meet restoration goals. To that end, staff built on informal trials conducted in 2002 which indicated that clearing stands of *Psidium cattleianum* could trigger vigorous growth of the native hardwood tree *Acacia koa*.


Acacia koa


P. cattleianum with green, immature fruit. Controlling trees before fruit matures red is ideal.

Psidium cattleianum (strawberry guava, waiawi), forms dense monocultures, grows quickly, has allelopathic properties, forms deep shade, and has tasty, bird-dispersed fruit (HPWRA, 2012). Few native species thrive in *P. cattleianum* stands, and it is not appropriate or preferred habitat for rare taxa. It is the dominant weed in Kahanāhaiki. Seeds remain viable in the soil for less than three months (Uowolo and Denslow, 2008). This suggests that if control is timed before fruiting periods in summer and winter, recruitment from seed can be minimized. *P. cattleianum* is susceptible to triclopyr (Garlon 4) applied to basal bark (< 3" diameter), girdled trunks, and cut stumps.

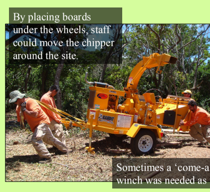
In 2010, staff identified a large stand of *P. cattleianum* in the southern, mostly flat end of the MU. Patches of native forest bordered the site and some mature *A. koa* persisted within the *P. cattleianum* stand. At the time, no rare taxa were known from within site. Staff began clear-cutting the *P. cattleianum* with chainsaws. To minimize the volume of slash created, a wood-chipper was flown into the work site. The chipper, Bandit model 65 XP, weighs 2,850 lbs, and was flown into place by a contracted Huey helicopter ($3,000/hr). In the 2002 trial, a small, lightweight chipper was used; while it was easy to transport, the small chipper required staff to spend large amounts of time cutting slash small enough to fit the hopper, and was simply not efficient in the field.



Left and above: Flying the chipper into Kahanāhaiki.


Other gear was flown to the work site with a Hughes 500.


Working at the project site. When not in use, the chipper was covered with a protective tent.

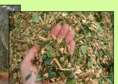

The chipper easily handled 6" diameter trunks.

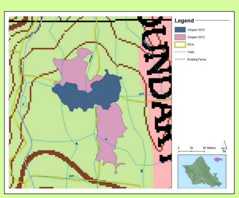

By placing boards under the wheels, staff could move the chipper around the site.

Sometimes a 'come-along' winch was needed as well.

During clearing work, staff discovered the endangered tree snail, *Achatinella mustelina*, on a tree in the site. Work halted due to the threat of accidentally chipping snails or creating an inhospitably hot environment. Staff developed a protocol to follow in future to avoid potential *A. mustelina* impacts, including conducting both night and daytime snail surveys.


Achatinella mustelina

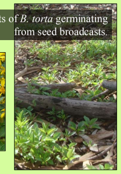

Decomposing chips release heat; to minimize the risk of fire, many small piles of chips were made.




Young *A. koa*.

Hundreds of *A. koa* germinated across the work site, prior to any other colonizers. To provide cover across the area, staff broadcast locally collected *Bidens torta* seed. Previous trials indicated such broadcasts effectively created robust stands of the perennial shrub.


Bidens torta

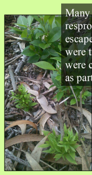

Carpets of *B. torta* germinating from seed broadcasts.

Project Phase	Duration	Effort (person hours)	Area Cleared (ha)
2010 Clearing	2 months	456	0.36
2012 Clearing	5 months	519	0.54
All Clearing (sum)	7 months	975	0.90
Re-treatment and follow up weed control	5 years	1,027	-

In 2012, staff continued clearing work at the site. While permanent staff conducted all clearing work in 2010, in 2012 at least half the work was carried out by temporary staff. Between 2010 and 2015, follow-up weed control and site maintenance was carried out by both staff and volunteers. More time was spent on follow-up work than initial clearing.


Aerial view of the work site, late 2010


Volunteers provided critical assistance by conducting follow-up weed control.


Many *P. cattleianum* stumps resprouted, likely because they escaped herbicide treatment, or were treated too long after they were cut. They were re-treated as part of maintenance work.

References:

Franzer, G. W., Canham, C. D., and Lertzman, K. P. 1999. Gap Light Analyzer (GLA), Version 2.0: Imaging software to extract canopy structure and gap light transmission indices from true-color fisheye photographs, users manual and program documentation. Copyright © 1999: Simon Fraser University, Burnaby, British Columbia, and the Institute of Ecosystem Studies, Millbrook New York.

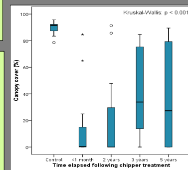
Hawaii-Pacific Weed Risk Assessment. 2012. *Psidium cattleianum*. www.hpwra.org [2015 Sept. 11]

Uowolo, Amanda L. and Denslow, Julie S. 2008. Characteristics of the *Psidium cattleianum* (Myrtacea) Seed Bank in Hawaiian Lowland Wet Forests. *Pacific Science* vol. 62 no. 1:129-135

Vegetation Monitoring Methodology:

Monitoring of understory and canopy vegetation following *P. cattleianum* clearcutting was conducted in 2012 and 2015. During monitoring, all native and non-native species present in the understory and canopy in 1x3m plots were recorded. Hemispheric photographs of the canopy were taken from the middle of each plot, with canopy cover measured using Gap Light Analyzer (GLA), Version 2.0 software (Frazer et al. 1999). Native and non-native understory percent cover was categorically recorded in 1x1m plots as 0-25, 25-50, 50-75, or 75-100%. Canopy cover, native and non-native understory cover, and species richness were analyzed using Kruskal-Wallis tests. Species frequencies were analyzed using chi-square and Fisher's exact tests. Analyses were performed in IBM SPSS Statistics Version 20.

Percent Cover

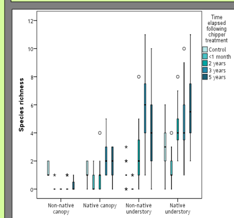


Left: total canopy cover over time. Prior to chipping, the area was densely canopied and dominated by non-native taxa. Immediately following clearing, the canopy was largely open. After 2 years, canopy cover remained low and was predominantly native. After 3-5 years, the canopy continued to refill primarily with native taxa.

Right: understory cover over time. Similar to canopy cover, non-native vegetation dominated prior to chipping, but decreased immediately after chipping ($p < 0.001$), and stayed low for 5 years. Native vegetation cover increased ($p < 0.001$) by 2 years after chipping.

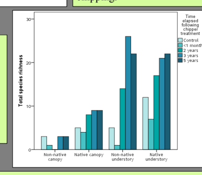
Time elapsed after chipping	Non-native understory	Native understory
Control	75-100%	0-25%
< 1 month	0-25%	0-25%
2 years	0-25%	25-50%
3 years	25-50%	25-50%
5 years	0-25%	25-50%

Species Richness

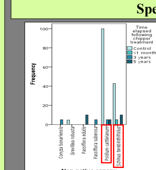


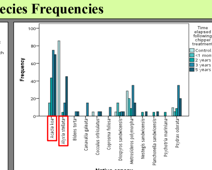
Left: species richness among plots in chipped areas over time. Median species richness changed significantly ($p < 0.001$ each) over time in all categories. Non-native understory richness increased after 2 years, while native understory richness initially declined (primarily due to the decline of *A. stellata* immediately following chipping), and later increasing by 2-5 years post-chipping.

Right: total species observed among all plots in chipped areas over time. Initially, diversity declined for all categories. From 2-5 years, all categories became more diverse except for the non-native canopy, which rebounded only to its original level.

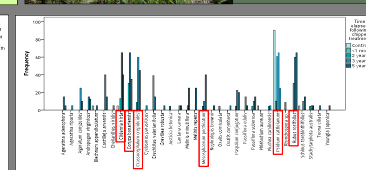


Species Frequencies





Above: Non-native (left) and native (right) taxon frequencies in the canopy among plots over time. Notable non-native taxa changes include reductions in *P. cattleianum* (100 to 5%, $p < 0.001$) and *S. terebinthifolius* (43 to 10%, $p = 0.018$). Interesting native taxa changes include increases in *A. koa* (0 to 70%, $p < 0.001$) and fluctuations in *A. stellata* which experienced a net decline (86 to 45%, $p = 0.006$). However, *A. stellata* rebounded significantly ($p = 0.001$) between < 1 month, when no plants were noted, and 5 years post-chipping.



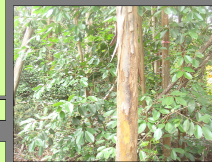
Native Taxa	Frequency Change	P value
Acacia koa	0 to 75%	< 0.001
Bidens torta	0 to 60%	< 0.001
Cocculus orbiculatus	0 to 30%	0.009
Coprosma foliosa	5 to 45%	0.004
Dianella sandwicensis	0 to 45%	< 0.001
Alyxia stellata	86 to 80%	-

Above: Native (left) and non-native (right) taxon frequencies in the understory among plots over time. Notable changes are highlighted in the tables to either side. While removing *P. cattleianum* created large light gaps, allowing for the proliferation of a variety of other weeds, it also allowed for the recovery of a host of native plants. Many of the weeds colonizing the project area are short-lived and sun-loving (for example, *C. bonariensis*) and are expected to decline as canopy cover increases. Other weeds, such as *C. hirta*, thrive in shade and will require continued follow-up. The native taxa found in the site, span a variety of growth forms and light preferences. Interestingly, *A. stellata* frequency first decreased to 0, before recovering almost to original levels. The dramatic increase in *A. koa* is key to the recovery of the area.

Non-native Taxa	Frequency Change	P value
Clidemia hirta	5 to 40%	0.009
Conya bonariensis	0 to 35%	0.004
Crassocephalum crepidioides	0 to 45%	< 0.001
Mesosphaerum pectinatum	0 to 40%	0.001
Rubus rosifolius	0 to 65%	< 0.001
Psidium cattleianum	90 to 25%	< 0.001

Photopoint Methodology:

Flagged and tagged PVC poles were installed throughout the proposed work site. Photos were taken from the poles in the four cardinal directions. A compass and print-outs of the September 2010 set of photopoints aided staff in lining up each photo. Unfortunately camera type, focal length, and precise angle varied over the years due to changes in observers. The photopoint series below showcase the dramatic changes seen at the project site.



2010 June
Prior to clearing. All clearing completed here in June and July.

Few native plants are visible in this stand of *P. cattleianum*.

The entire project area was covered in a dense stand of *P. cattleianum*, typical of this photo. A variety of size classes are present, although most trees ranged from 5-15 cm in diameter.

2010 Sept.
2 months post-clearing

While most vegetation was chipped, large limbs and trunks were stacked into piles. Leafy branches comprised the greatest volume of slash, and were the highest priority for chipping. Volunteers used some limbs and chips to line access trails.

Piles of chips cover most of the cleared area. Staff limited the size of chip piles to reduce the likelihood of compost fires. Re-sprouting *P. cattleianum* stumps are visible in the foreground. Note the spindly *Psydrax odorata* tree uncovered during clearing in the center of the photo.

2011 July
12 months post-clearing

On the right side of the photo, large *B. torta* shrubs cover much of the open ground. In the fore-ground, a fast growing *A. koa*, has already reached 1 m in height. In the background, note the stand of mature *A. koa* uncovered during clearing.

Large *B. torta* plants colonize open ground, excluding deep chip piles. *Alyxia stellata* vines appear to be recovering in the foreground, after being trampled during initial clearing.

2012 July
24 months post-clearing

Within two years, *A. koa* saplings have obscured the view from this photopoint. These trees are between 1.5 – 2.5 m tall.

Native understory plants filled in much of the open area. Note the *A. koa* saplings in the background, yellow flowers of *B. torta* in the mid-ground, and the tangle of *A. stellata* in the foreground.

2013 April
33 months post-clearing

While many of the hundreds of *A. koa* recruits did not survive, the trees visible here thrived, and just three years after clearing form a canopy. Note the twining vine *A. stellata* climbing through the *A. koa* branches on the left side of the photo.

The *P. odorata* is notably fuller, perhaps due to increased light, decreased competition, or reduced allelopathic effects. Much of the background is completely filled with *A. koa* saplings. Tall *B. torta* shrubs dominate the mid-ground.

2014 Dec.
53 months post-clearing

Prior to clearing, *A. stellata* was the most common native species in the canopy. Unsurprisingly, *A. stellata* levels dropped greatly post-clearing, but as is evident in this photo, the vine rebounded vigorously over time.

The understory has completely filled in four years after clearing. While short-lived *B. torta* is still present, other native species now thrive in the site. A canopy of *A. koa* is visible in the background.

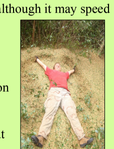
2015 July
60 months post-clearing

Very encouraging results are visible after five years. Not only has *A. koa* formed a canopy, but native plants have also colonized the understory. Large patches of *Nephrolepis exaltata* subsp. *hawaiiensis* stretch across the ground.

The change evident in this photopoint series is dramatic. Despite the drastic techniques used, native vegetation reclaimed the project site. Regular follow-up weeding was critical to preventing the proliferation of understory weeds during this time.

Conclusions:

- Restoration of *P. cattleianum* stands through aggressive weed control (clearcutting and chipping) can be highly effective.
- Native Hawaiian mesic forest can be very resilient. Within 5 years, both understory and canopy coverage reached approximately 50% vegetative cover.
- Seed broadcast of the short-lived perennial shrub *Bidens torta* was successful in creating large beds of this taxon within 2 years. Establishing a native ground cover likely reduced weed invasion.
- Outplanting is not necessary for restoration, although it may speed the process further.
- Follow-up weed control is critical to project success, and must be sustained for at least 5 years after initial clearing.
- The size of the project area should be based on the estimated area staff can commit to conducting follow-up weed control in, rather than the size of the area which can be clearcut in a given season.



Targeted Surveys Provide Opportunities to Assess Threats to Managed Areas

Julia Gustine Lee and Jane Beachy: Oahu Army Natural Resources Program, Schofield Barracks, Oahu

Abstract: Surveys can be the first line of defense in detecting invasive plant species. Effort spent searching targeted areas can provide numerous novel specimens that can be assessed for management action. The Oahu Army Natural Resources Program (OANRP) uses inventory surveys to identify potential new threats to endangered species Management Units (MUs) and to detect and prevent the spread of weeds on Army Training Ranges. These inventories are a low-tech method of detection that have provided valuable results. Each year OANRP surveys approximately 325 km along Army Training Range and MU access roads, 50 helicopter landing zones, 7 high-use field sites (such as campsites), and 15 highly trafficked trails (Fig. 1). With identification assistance from the Bishop Museum and the Oahu Early Detection program (OED), OANRP has documented 29 new island records for O'ahu, 9 new State of Hawaii records, and 13 new records of naturalizing taxa since 2004. Not all new species result in management actions, but early detection provides the opportunity to decide if a particular taxon requires action before it becomes a significant threat to resources in managed areas. The threats posed by new finds are assessed with the use of the Hawaii Weed Risk Assessment (HWRA) program, collection and naturalization data from Bishop Museum, the Smithsonian National Museum of Natural Botany Department, and expert botanical field knowledge. New taxa are assessed and management actions are determined using a management decision matrix.

Background and Methods: Early detection is critical in allowing managers maximum flexibility in addressing incipient or novel invasive weed populations. Once a weed reaches a certain threshold infestation size, they can become too large to effectively control, particularly with limited staff time. OANRP conduct surveys at potential locations of introduction and spread on OANRP managed areas (Fig. 1). The surveys help to address Army requirements to minimize the threat of alien species introductions resulting from range maintenance, construction and training activities within and adjacent to landing zones, trails, and roadsides, as well as to address potential weed spread into areas of native forest managed for rare taxa. Information about the current distribution of a species, its invasiveness, and location are all used to determine an appropriate management response.

On each survey, staff record all non-native taxa observed within the defined survey area (Fig. 2). Survey data are entered into the OANRP Database and the following reports can be generated to assist with taxa assessments: 1) new taxa observed on a survey, 2) a list of surveys for which a particular taxa is present, 3) the date a taxa is first observed on any given survey, and 4) a list of taxa observed on previous survey dates. For species difficult to identify, specimens are sent to Bishop Museum for identification (Fig. 3).

Figure 2: Example survey field form

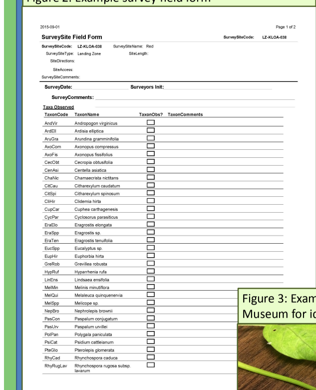


Figure 1: Map of all weed surveys. Surveys are conducted at different intervals and therefore not all surveys shown are completed each year.

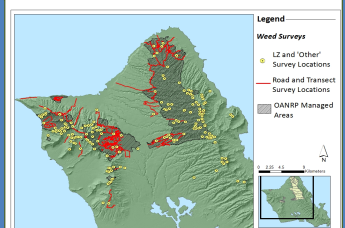
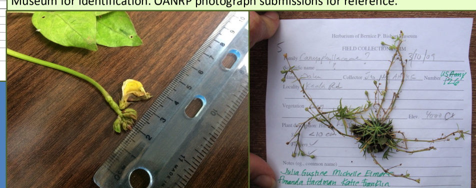
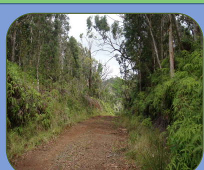


Figure 3: Examples of unknown species and submission form sent to OED staff at Bishop Museum for identification. OANRP photograph submissions for reference.



Survey Types:



Road: Effort varies for each survey depending on length (up to 2 kilometers) and quality of road (paved vs four wheel drive) and can range from half a day to two days to complete. Roads on Army Training Ranges and high-use OANRP access roads are surveyed annually, and the remaining OANRP access roads are surveyed every other year. On Army Training Ranges, road surveys include all drivable roads as well as training sites that appear to have had use. Ranges may be separated into several surveys to facilitate access and tracking. Each year some roads are too overgrown to drive, or new roads are created. Staff take GPS tracks of all areas surveyed to document annual survey effort and to map new roads.

Weed Transect: Most of these surveys are located along corridors of high traffic such as fencelines or staff trails that lead from a trailhead or parking area to an MU.

Camp/Other: These surveys aim to capture any spread of invasive weeds from staff and gear. 'Other' surveys are a catchall for locations of potential contamination and spread such as washrack sediment disposal sites, and sand or gravel stockpiles used to deploy fill across ranges. Surveys of the piles and the surrounding vegetation can give a good idea of which species may be moved to new areas with deployment of materials.

Landing Zone(LZ): Most OANRP LZs are small and located in remote mountainous locations. Army LZs on the other hand are often large fields across which staff conduct surveys. Army LZs are surveyed annually, and OANRP LZs are surveyed quarterly when used within a given quarter.

Evaluations of new taxa: Each year dozens of new species are found on surveys or observed in new locations during the course of other management actions. These taxa range from being widely naturalized on Oahu to new island or state records. Figure 4 illustrates the process used for determining appropriate OANRP management actions ranging from targeting for eradication to no control. Information about species that are found outside of OANRP managed areas and that may warrant further control or monitoring is shared with relevant landowners and partners so that they may assess management priorities. Basic information about individual taxa considered as part of the decision matrix includes: known distribution of taxa, invasiveness (use HWRA for determination), and location found. Additionally, potential control partners, availability of effective control methods, type of location (terrain, accessibility), resources/funding, etc., are also important inputs in deciding how to manage a new invasive species but are often more difficult to evaluate.

Figure 5 shows the process of assessing management actions with examples of species that were found during surveys or incidentally. The list also highlights that assessments and management responses are challenging as taxa information is sometimes incomplete, resources for control may be unavailable, and management responsibility may be best suited to another agency.

Figure 4: Management Decision Matrix

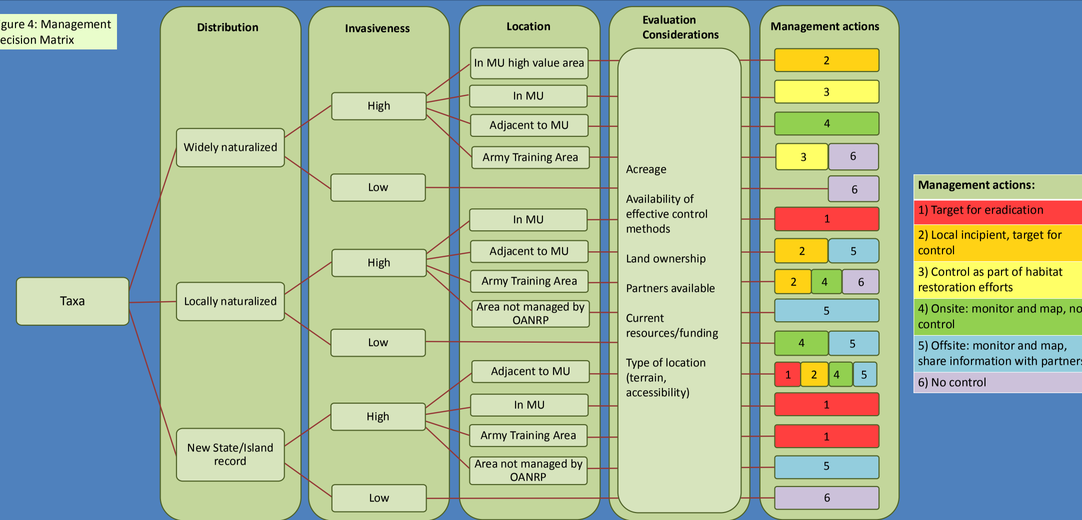


Figure 5: OANRP examples of working species through the decision matrix

Species	Common name	Distribution	Invasiveness	Location	Evaluation considerations	Management actions
Albizia adianthifolia (Fabaceae)	Flat Crown	New State Record	Not thoroughly researched by OANRP staff although observed naturalizing on range	On Army Training Range	Only known from Training Range, but recently observed 2km from core. Appears to behave similarly to *F. moluccana*.	Onsite: Monitor and map naturalizing individuals; if resources and time available for control, should target prioritized plants (4)
Cenchrus setaceus (Poaceae)	Fountain Grass	Locally naturalized	Highly	Adjacent to MU and degraded training area	Grass in a fire prone area on leeward side of island. Seedbank <1 yr; eradicable	Target for eradication (1)
Chromolaena odorata (Asteraceae)	Devil Weed	New State Record	High. Well documented as highly invasive worldwide	In high-use areas of Army Training Range	Likely military introduction therefore OANRP commitment to control. Infestation covers large area, so important to have good strategy.	Target for eradication (1)
Dietes iridioides (Iridaceae)	African Iris	Widely naturalized	Unknown	Inside MU	Small patch near native forest	Local incipient, target for control (2)
Dovyalis hebycarpa (Flacourtiaceae)	Ceylon gooseberry	Locally naturalized	Highly	On Army Training Range	Need to monitor	Onsite: monitor and map, no control (4)
Nephrolepis brownii (Dryopteridaceae)	Rough Sword Fern	Widely naturalized	Highly	Inside MU	Invades disturbed/open areas after canopy control and creates thick understory	Control as part of habitat restoration efforts (3)
Olea Europa (Oleacea)	Wild Olive	Locally naturalizing	Highly	Access road; area not managed by OANRP	On access road to MU, but currently a safe distance from trailhead	Offsite: Monitor and map; share information with partner agencies (5)
Petrorhagia velutina (Caryophyllaceae)	Tunica	New Island Record	Unknown; not likely to become ecosystem altering	On Army Training Range	Small, only found in degraded locations	Not a control priority (6)
Senecio madagascariensis (Asteraceae)	Fire Weed	New Island Record	Not a high threat to OANRP managed areas, but is a State noxious agricultural weed	On Army Training Range	Likely introduced by military training; don't want to spread further	Target for eradication (1)

Conclusions:

- Surveys highlight the way that military training and natural resource management practices can result in unintended introductions and movement of weedy species. Strict sanitation protocols are necessary.
- Time spent looking specifically for invasive weed introduction or spread at regular intervals, increases the chance of identifying an infestation early in establishment.
- Even with targeted surveys, invasive taxa may go unnoticed; surveys conducted at regular intervals are therefore important to catch missed species.
- Identification experts and Bishop Museum records are critical in helping to make management decisions.

OAHU ARMY NATURAL RESOURCES PROGRAM
MONITORING PROGRAM

VEGETATION MONITORING AT KALUAA AND WAIELI MANAGEMENT UNIT, 2015

INTRODUCTION

Vegetation monitoring was conducted at Kaluaa and Waieli Management Unit (MU) in 2015 in association with MIP/OIP requirements for long term monitoring of vegetation composition and change over time (OANRP 2008) (Figure 1). The primary objective of MU monitoring is to assess if the percent cover of non-native plant species is less than 50% across the MU, or is decreasing towards that threshold requirement. The secondary objective is to assess if native cover is greater than 50% across the MU, or is increasing towards that threshold recommendation. Kaluaa and Waieli MU vegetation monitoring occurs on a five-year interval, and took place once previously in 2010 (OANRP 2011). Previous monitoring indicated that goals were met only for the non-native understory cover. The MU consists of three subunits. The Subunit I fence was completed in 2001, Subunit II was completed in 2006, and Subunit III was completed in 2010.

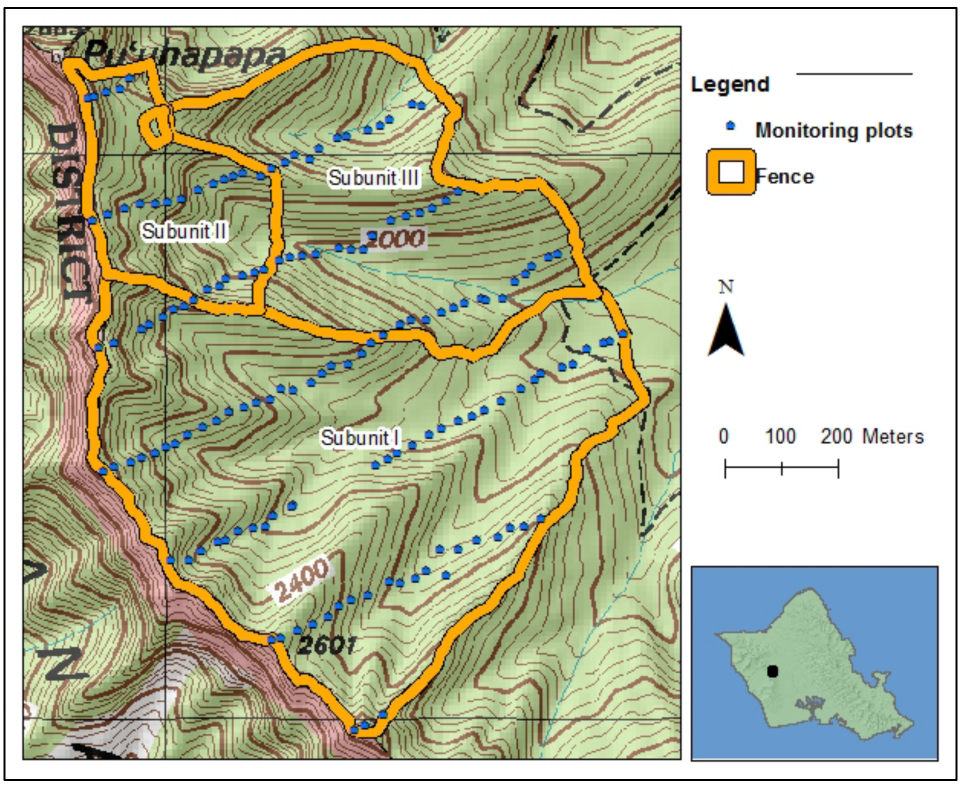


Figure 1. Kaluaa and Waieli MU vegetation monitoring plot locations.

METHODS

In August and September 2015, 148 plots were monitored along seven transects. Transects were spaced approximately 200 meters (m) apart, and plots measuring 5 x 10 m were generally located every

30 m along transects. These same plots were also monitored in 2010 (OANRP 2011). One additional plot was monitored in 2010, but was determined to be too dangerous for monitoring in 2015. Understory [occurring from 0 – 2 m above ground level (AGL), including low branches from canopy species] and canopy (occurring > 2 m AGL, including epiphytes) vegetation was recorded by percent cover for all non-native and native species present. Summary percent cover by vegetation type (shrub, fern, grass/sedge) in the understory, overall summary percent cover of non-native and native vegetation in the understory and canopy, and bare ground (non-vegetated < 25 cm AGL), 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 in 2015, but not documented previously. Monitoring results were compared with data from 2010. Based on MIP recommendations, $\alpha = 0.05$ was used for significance determinations, and only cover changes ≥ 10% were recognized. Additional methodology information is detailed in Monitoring Protocol 1.2.1 (OANRP 2008). All analyses were performed in IBM SPSS Statistics Version 20. These included Wilcoxon signed-rank tests for cover data, paired t tests for species richness data, McNemar's test for frequency data, regression analyses for time spent weeding in association with cover change, and t tests for cover change in plots within vs. outside weed control areas.

RESULTS

Understory and canopy cover categories

Management objectives of having < 50% non-native understory and canopy and > 50% native understory and canopy cover were only met with respect to the non-native understory in 2015 (Table 1). Native understory and canopy percent cover were low (7.5% and 25% median values, respectively). Non-native understory cover was moderate, and non-native canopy cover was high (35% and 85% median values, respectively). There were several significant[1] changes in percent cover of vegetation from previous monitoring results (Figure 2). These included small decreases in cover for native shrubs, total native understory, and bare ground. Both native and non-native canopy (as well as total native and non-native canopy) had small significant increases. In some instances (native canopy and total canopy), significant change occurred in relative distributions, while median values remained unchanged. Only bare ground and non-native canopy met the 10% standard for recognized change in cover. However, caution should be applied in interpreting the results of change in bare ground, as the method for this measurement was not as clearly defined in 2010, and as such was less repeatable. There was also a marginally significant increase in non-native ferns. In 2015, higher native understory cover occurred primarily at mid- and high elevations. Locations of low to high percent cover of non-native understory and native canopy were patchily distributed across the MU. High percent cover of non-native canopy was nearly consistently distributed across the MU (Figure 3). Locations where beneficial and worsening cover changes occurred were patchily distributed (Figure 4).

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

Table 1. Percent cover of native and non-native vegetation categories in the canopy and understory at Kaluaa and Waieli MU from 2010 to 2015. Median values are represented (n = 148). Statistically significant values are in boldface (Wilcoxon signed-rank test). Categories specifically addressed in management objectives are shaded. Arrows indicate increase (↑) or decrease (↓) in cover. *Meets 10% standard for recognized change in cover.

	2010	2015	p	Z	Management objective currently met?
Understory					
Native shrubs	7.5	2.5	**< 0.001**↓	-6.07	
Native ferns	2.5	2.5	0.476	-0.71	
Native grasses	0.0	0.0	0.875	-0.16	
Total native understory	15.0	7.5	**< 0.001**↓	-3.6	No, and may be getting worse
Non-native shrubs	25.0	15.0	0.535	-0.62	
Non-native ferns	2.5	2.5	0.06↑	-1.88	
Non-native grasses	0.0	0.0	0.073	-1.8	
Total non-native understory	35.0	35.0	0.753	-0.31	Yes
Bare ground	85.0	75.0	**< 0.001***↓	-3.68	
Canopy					
Native canopy	25.0	25.0	**0.019**↑	-2.35	No, but may be getting better
Non-native canopy	75.0	85.0	**0.001***↑	-3.33	No, and getting worse
Total canopy	95.0	95.0	**< 0.001**↑	-4.1	

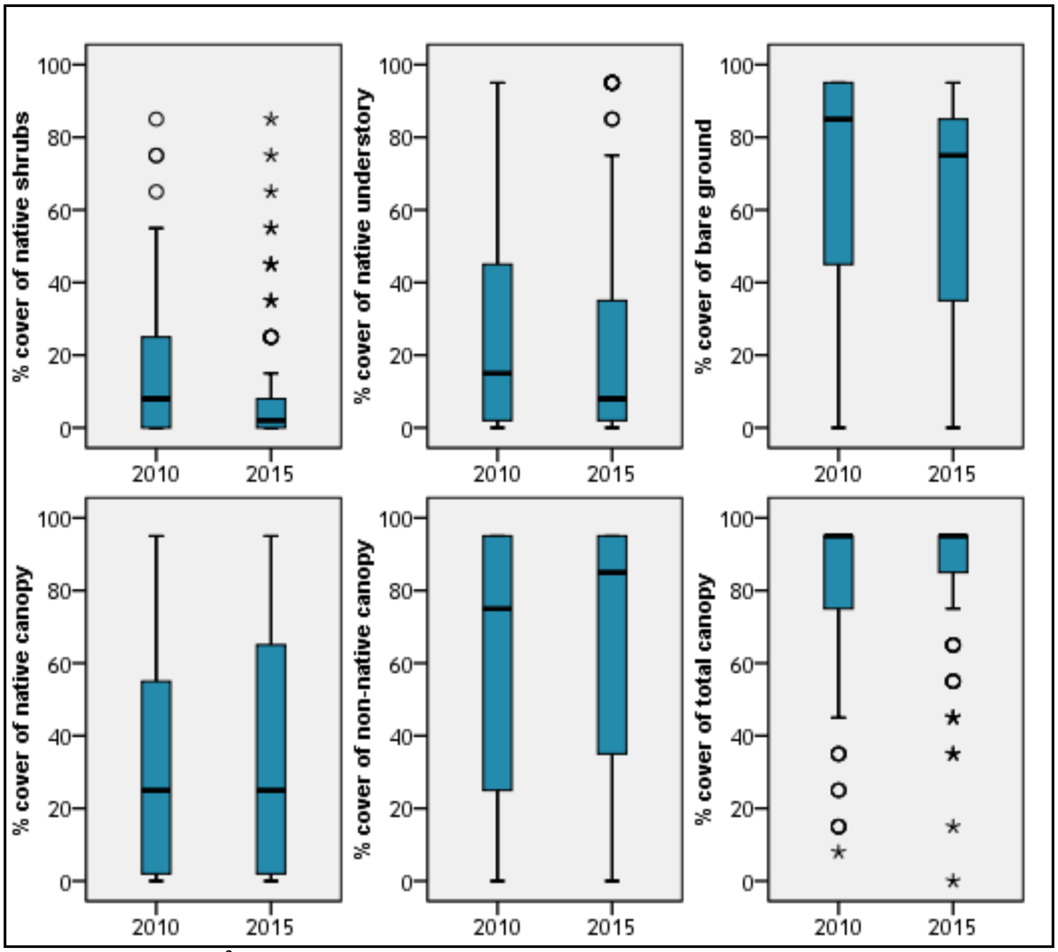


Figure 2. Boxplots[2] for vegetation categories with significant change in percent cover between years 2010 and 2015 in Kaluaa and Waieli MU.

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

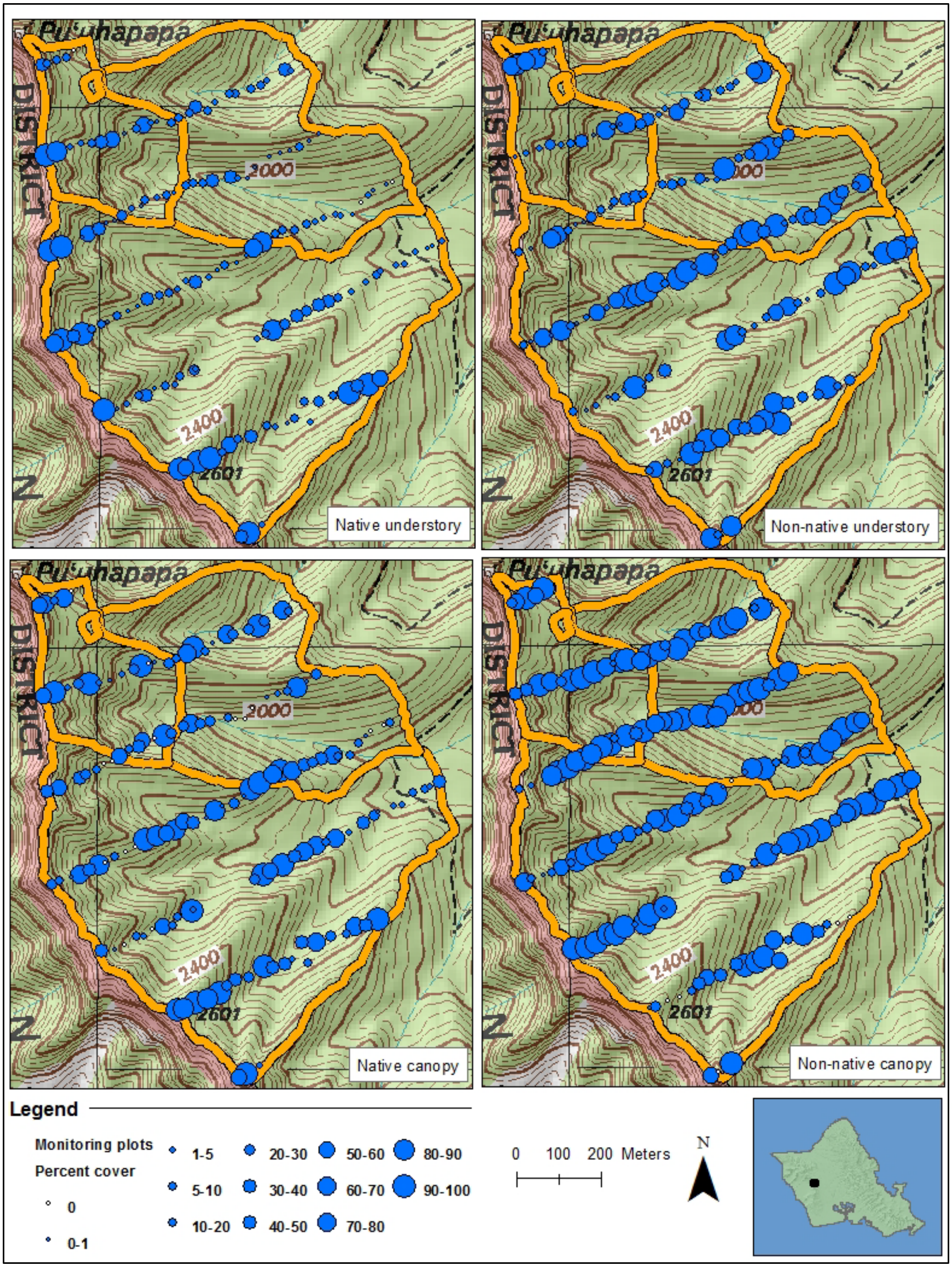


Figure 3. Locations of low to high percent cover of native and non-native understory and canopy vegetation among monitored plots at Kaluaa and Waieli MU in 2015. Larger circles denote higher percent cover, while smaller circles represent lower cover.

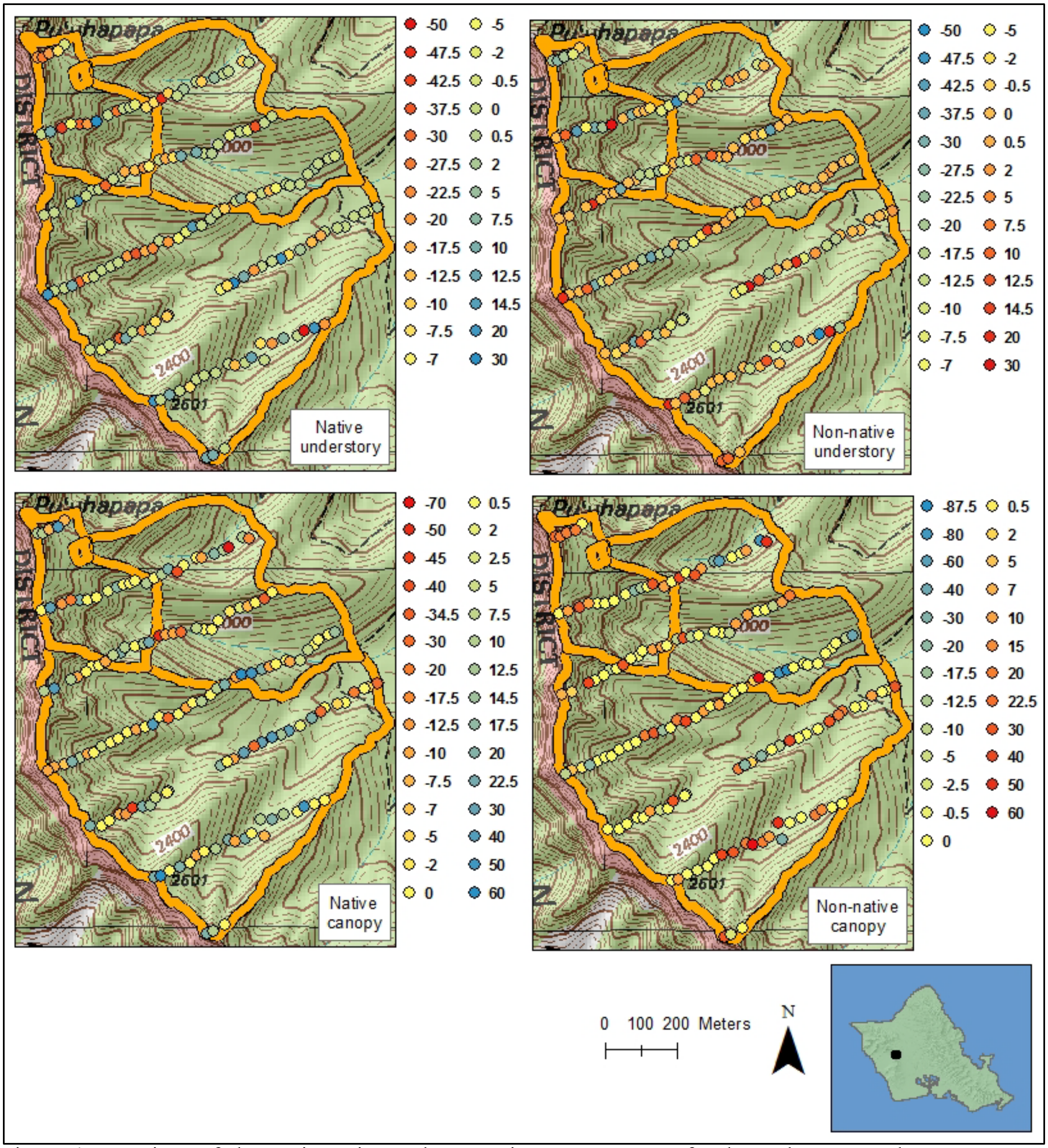


Figure 4. Locations of change in native and non-native percent cover for the understory and canopy vegetation in monitored plots in Kaluaa and Waieli MU between 2010 and 2015. Color gradients are inverted for native and non-native vegetation, such that blue indicates beneficial change, red depicts worsening conditions. Cover change of 0 indicates there was no change in percent cover.

Species richness

During monitoring in 2015, 165 species were recorded in the understory (61% native taxa), and 75 were identified in the canopy (73% native). Most species present in the canopy were also represented in the understory, with the exception of three native species (*Cyanea superba* subsp. *superba*, *Korthalsella degeneri*, and *Nestegis sandwicensis*). Locations of high and low species richness for the native and non-native understory and canopy were primarily patchily distributed across the MU (Figure 5). Species richness differed significantly between the years monitored, with a small decrease in in the non-native understory, and a small increase in the non-native canopy within plots (Table 2). No detectable change occurred in species richness among plots in the native understory or canopy. Despite the significant decrease in non-native understory richness among plots, the overall non-native understory (as well as canopy) diversity for the MU increased slightly. Overall native understory and canopy diversity for the MU decreased. Sixteen new species (62.5% non-native) were found in plots in 2015, while 20 species (30% non-native) were recorded in 2010 but not observed in 2015 (Table 3). The presence or absence of species may be due in part to human error such as misidentification (e.g., difficulties in distinguishing *Korthalsella* taxa), observer bias regarding plot boundaries or amount of time spent searching, or accidental non-recording. The occurrence within plots of short-lived, less common species is expected to vary over time. All of the species that were not present in 2015 were uncommon in previous years, with frequencies less than 0.02.

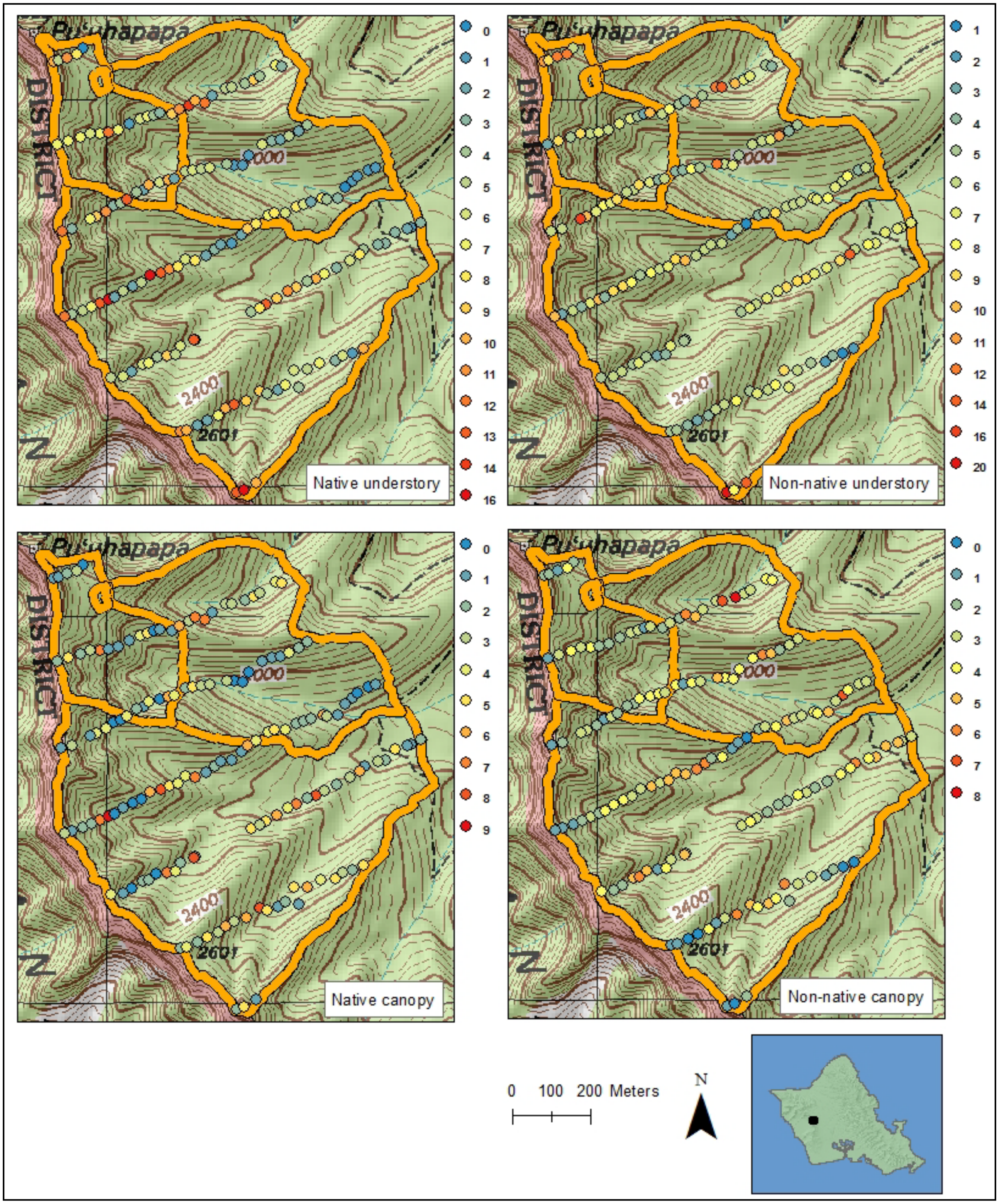


Figure 5. Locations of low to high species richness among plots in the native and non-native understory and canopy in Kaluaa and Waieli MU, 2015. Color gradients of blue to red indicate low to high values, respectively, of the number of species occurring in plots (i.e., blue indicates low diversity, while red indicates relatively higher diversity).

Table 2. Kaluaa and Waieli MU understory and canopy species richness. Mean species richness per plot during vegetation monitoring is shown by year, with the total number of species recorded among all plots in parenthesis (n = 148). P-values obtained from paired t tests. Statistically significant values are in boldface. Arrows indicate increase (↑) or decrease (↓) in richness.

	2010	2015	p	t
Native understory	6.43 (111)	6.17 (101)	0.109	-1.613
Non-native understory	7.39 (60)	6.82 (64)	**0.011**↓	-2.575
Native canopy	2.84 (57)	3.00 (55)	0.096	1.674
Non-native canopy	2.73 (18)	3.16 (20)	**< 0.001**↑	4.231

Table 3. Newly recorded, and no longer present, species from 2015 Kaluaa and Waieli MU monitoring, in the understory and/or canopy. Native taxa are in boldface.

New species recorded in plots in 2015	Species found in plots in 2010 but not recorded in 2015
Adenophorus tenellus	***Alectryon macrococcus var. macrococcus***
Bidens alba	*Anagallis arvensis*
Castilleja arvensis	*Arundina gramminifolia*
Cyrtomium falcatum	***Broussaisia arguta***
Epidendrum x obrienianum	***Cyanea angustifolia***
Eucalyptus robusta	*Drymaria cordata var. pacifica*
Korthalsella cylindrica	***Dubautia laxa***
Korthalsella platycaula	***Ilex anomala***
Myrsine lanaiensis	***Korthalsella complanata***
Oxalis corymbosa	*Leucaena leucocephala*
Peperomia blanda	***Lobelia yuccoides***
Peperomia membranacea	***Lysimachia hillebrandii***
Polystachya concreta	*Melia azedarach*
Syzygium cumini	***Myrsine sandwicensis***
Syzygium jambos	***Neraudia melastomifolia***
Verbena litoralis	*Plantago lanceolata*
	Rumex albescens
	Sapindus oahuensis
	Solanum sandwicense
	Zanthoxylum kauaense

Species frequency

Non-native species that occurred most frequently in plots (present in more than half the plots) in the understory included *Clidemia hirta, Passiflora suberosa, Blechnum appendiculatum,* and *Schinus terebinthifolius,* while those most commonly occurring in the canopy were *S. terebinthifolius* and *P. suberosa* (Table 4). The most frequent native species (in at least a third of the plots) included *Alyxia stellata* and *Doodia kunthiana* in the understory, and *Acacia koa* in the canopy. *Alyxia stellata* is often the final native species remaining in *P. cattleianum* dominated forests (K. Kawelo, pers comm.). Of the 27 rare taxa occurring at Kaluaa and Waieli MU (OANRP 2011), 8 were identified during monitoring in 2015. Analysis of frequency change (McNemar's test) was limited to taxa with at least ten percent change between 2010 and 2015. These included two non-native species each in the understory and canopy, all of which had significant frequency changes (Table 5). Frequency declined for *Toona ciliata* and *Youngia japonica* by 10% each in the understory, and increased for *P. suberosa* (by 12%) and *Toona ciliata* (by 15%) in the canopy.

Table 4. Species frequency among plots (proportion of plots in which a given species occurs) during 2015 Kaluaa and Waieli MU monitoring (n= 148), in order of most to least frequent. Native species are in bold print. *Rare taxa. **Target weed taxa.

Taxon	Freq.	Taxon	Freq.	Taxon	Freq.	Taxon	Freq.
Understory							
Clidemia hirta	0.878	Psidium guajava	0.081	**Selaginella arbuscula**	0.027	**Asplenium excisum**	0.007
Passiflora suberosa	0.777	**Asplenium caudatum**	0.074	**Strongylodon ruber***	0.027	**Asplenium nidus**	0.007
Blechnum appendiculatum	0.574	**Diospyros hillebrandii**	0.074	Urochloa maxima**	0.027	Bidens alba	0.007
Schinus terebinthifolius	0.547	Physalis peruviana	0.074	Andropogon virginicus	0.020	**Bobea elatior**	0.007
Psidium cattleianum	0.473	Aleurites moluccana	0.068	Crassocephalum crepidoides	0.020	Castilleja arvensis	0.007
Cyclosorus parasiticus	0.453	**Antidesma platyphyllum**	0.068	**Cyanea pinnatifida***	0.020	**Charpentiera tomentosa**	0.007
Toona ciliata**	0.385	**Caesalpinia bonduc**	0.068	**Delissea waianaeensis***	0.020	Cheilanthes viridis	0.007
Alyxia stellata	0.358	**Myrsine lessertiana**	0.068	Deparia petersenii	0.020	**Chrysodracon forbesii***	0.007
Lantana camara	0.351	**Psychotria hathewayi**	0.068	**Dryopteris glabra**	0.020	**Clermontia persicifolia**	0.007
Doodia kunthiana	0.345	**Bidens torta**	0.061	**Elaeocarpus bifidus**	0.020	**Ctenitis latifrons**	0.007
Microlepia strigosa	0.297	**Nephrolepis cordifolia**	0.061	**Gahnia beecheyi**	0.020	**Cyrtomium caryotideum**	0.007
Planchonella sandwicensis	0.284	**Psydrax odorata**	0.061	**Huperzia phyllantha**	0.020	**Dryopteris fusco-atra**	0.007
Acacia koa	0.277	**Kadua affinis**	0.054	**Kadua cordata**	0.020	**Elaphoglossum alatum**	0.007
Phlebodium aureum	0.270	Kalanchoe pinnata	0.054	Musa sp.	0.020	Emilia sonchifolia	0.007
Rubus rosifolius	0.270	**Leptecophylla tameiameiae**	0.054	Nephrolepis brownii	0.020	Epidendrum x obrienianum	0.007
Cocculus orbiculatus	0.236	Buddleja asiatica	0.047	**Peperomia tetraphylla**	0.020	Eucalyptus robusta	0.007
Psychotria mariniana	0.196	**Cibotium chamissoi**	0.047	**Phyllanthus distichus**	0.020	**Gynochthodes trimera**	0.007
Metrosideros polymorpha	0.182	**Coprosma longifolia**	0.047	**Pteridium aquilinum**	0.020	**Korthalsella cylindrica**	0.007
Oplismenus hirtellus	0.182	**Kadua acuminata**	0.047	Stachytarpheta australis	0.020	Kyllinga brevifolia	0.007
Coprosma foliosa	0.176	**Labordia kaalae***	0.047	Triumfetta semitriloba**	0.020	Lophostemon confertus	0.007
Asplenium macraei	0.162	**Sphenomeris chinensis**	0.047	**Vaccinium reticulatum**	0.020	**Machaerina angustifolia**	0.007
Melinis minutiflora	0.155	Youngia japonica	0.047	Adiantum hispidulum	0.014	Mesosphaerum pectinatum	0.007
Carex wahuensis	0.142	Cordyline fruticosa	0.041	**Cyperus hypochlorus**	0.014	**Myrsine lanaiensis**	0.007
Grevillea robusta	0.142	**Diplazium sandwichianum**	0.041	Cyrtomium falcatum	0.014	Oxalis corymbosa	0.007
Nephrolepis exaltata	0.142	**Dodonaea viscosa**	0.041	**Diospyros sandwicensis**	0.014	**Peperomia blanda**	0.007
Canavalia galeata	0.135	**Pisonia brunoniana**	0.041	**Doryopteris decipiens**	0.014	**Pittosporum glabrum**	0.007
Dianella sandwicensis	0.128	**Pisonia sandwicensis**	0.041	**Eragrostis grandis**	0.014	Polystachya concreta	0.007
Lepisorus thunbergianus	0.128	Ipomoea cairica	0.034	Erechtites valerianifolia	0.014	Rivina humilis	0.007
Euphorbia multiformis	0.122	Passiflora edulis	0.034	Heliocarpus popayanensis**	0.014	**Sadleria cyatheoides**	0.007
Pipturis albidus	0.122	**Psilotum nudum**	0.034	**Korthalsella platycaula**	0.014	Schefflera actinophylla**	0.007
Pisonia umbellifera	0.122	**Scaevola gaudichaudiana**	0.034	Mallotus phillippenis**	0.014	**Schiedea kaalae***	0.007
Dicranopteris linearis	0.115	**Smilax melastomifolia**	0.034	**Melicope clusiifolia**	0.014	Setaria palmifolia**	0.007
Freycinetia arborea	0.108	Spathodea campanulata**	0.034	Melinis repens	0.014	Setaria parviflora	0.007
Charpentiera obovata	0.101	**Streblus pendulinus**	0.034	**Peperomia membranacea**	0.014	Syzygium cumini	0.007
Conyza bonariensis	0.101	Adiantum radianum	0.027	**Psilotum complanatum**	0.014	**Syzygium sandwicense**	0.007
Dryopteris sandwicensis	0.095	Cyclosorus dentatus	0.027	**Pteralyxia macrocarpa***	0.014	**Vandenboschia cyrtotheca**	0.007
Tectaria gaudichaudii	0.095	**Elaphoglossum paleaceum**	0.027	**Santalum freycinetianum**	0.014	Verbena litoralis	0.007
Paspalum conjugatum	0.088	Erigeron karvinskianus**	0.027	Syzygium jambos	0.014	**Viola chamissoniana**	0.007
Ageratina riparia	0.081	**Melicope oahuensis**	0.027	**Urera glabra**	0.014	**Xylosma hawaiiense**	0.007
Carex meyenii	0.081	**Microlepia speluncae**	0.027	**Adenophorus tenellus**	0.007		
Claoxylon sandwicensis	0.081	**Panicum nephelophilum**	0.027	Ageratum conyzoides	0.007		
Oxalis corniculata	0.081	Salvia occidentalis	0.027	**Asplenium contiguum**	0.007		

Table 4, continued.

Taxon	Freq.	Taxon	Freq.	Taxon	Freq.	Taxon	Freq.
Canopy							
Schinus terebinthifolius	0.676	***Claoxylon sandwicensis***	0.061	***Antidesma platyphyllum***	0.027	***Nestegis sandwicensis***	0.014
Passiflora suberosa	0.554	***Freycinetia arborea***	0.061	***Labordia kaalae****	0.027	***Pteralyxia macrocarpa****	0.014
*Toona ciliata***	0.466	***Diospyros hillebrandii***	0.054	***Lepisorus thunbergianus***	0.027	***Santalum freycinetianum***	0.014
Psidium cattleianum	0.432	***Gynochthodes trimera***	0.054	***Pisonia brunoniana***	0.027	***Syzygium sandwicense***	0.014
Acacia koa	0.351	***Myrsine lessertiana***	0.054	***Smilax melastomifolia***	0.027	***Urera glabra***	0.014
Metrosideros polymorpha	0.297	*Phlebodium aureum*	0.054	*Cordyline fruticosa*	0.020	***Asplenium nidus***	0.007
Planchonella sandwicensis	0.291	***Streblus pendulinus***	0.054	***Kadua affinis***	0.020	***Bobea elatior***	0.007
Psychotria mariniana	0.230	***Cibotium chamissoi***	0.047	***Korthalsella degeneri****	0.020	***Chrysodracon forbesii***	0.007
Alyxia stellata	0.216	***Coprosma foliosa***	0.047	***Korthalsella platycaula***	0.020	***Clermontia persicifolia***	0.007
Aleurites moluccana	0.203	***Dicranopteris linearis***	0.047	*Physalis peruviana*	0.020	***Cyanea superba subsp. superba****	0.007
Grevillea robusta	0.203	*Lantana camara*	0.047	*Rubus rosifolius*	0.020	***Euphorbia multiformis***	0.007
Canavalia galeata	0.122	***Leptecophylla tameiameiae***	0.047	***Scaevola gaudichaudiana***	0.020	***Kadua acuminata***	0.007
Clidemia hirta	0.115	***Pisonia sandwicensis***	0.047	***Charpentiera obovata***	0.014	*Lophostemon confertus*	0.007
Passiflora edulis	0.108	***Psychotria hathewayi***	0.047	***Coprosma longifolia***	0.014	*Melinis minutiflora*	0.007
Psidium guajava	0.108	***Strongylodon ruber****	0.047	***Diospyros sandwicensis***	0.014	***Nephrolepis exaltata***	0.007
Pipturis albidus	0.101	***Caesalpinia bonduc***	0.034	***Elaeocarpus bifidus***	0.014	***Peperomia tetraphylla***	0.007
Pisonia umbellifera	0.101	***Cocculus orbiculatus***	0.034	***Korthalsella cylindrica***	0.014	***Pittosporum glabrum***	0.007
Psydrax odorata	0.088	***Dodonaea viscosa***	0.034	***Melicope oahuensis***	0.014	*Spathodea campanulata***	0.007
Buddleja asiatica	0.061	*Ipomoea cairica*	0.034	*Musa sp.*	0.014		

Table 5. Species frequency change at Kaluaa and Waieli MU between 2010 and 2015. Only taxa with at least 10% change in frequency were analyzed. Frequency values represent the proportion of plots in which species are present (n = 148). Native species are in boldface. P-values obtained from McNemar's test. Arrows indicate increase (↑) or decrease (↓) in frequency.

Species	Frequency 2010	Frequency 2015	% change	p
Understory				
Toona ciliata	0.486	0.385	-10	0.018[a]↓
Youngia japonica	0.149	0.047	-10	< 0.001[b]↓
Canopy				
Passiflora suberosa	0.432	0.554	12	0.002[a]↑
Toona ciliata	0.318	0.466	15	< 0.001[a]↑

[a]Asymptotic significance. [b]Exact significance.

Species cover

Species with frequencies > 0.20 (present in at least 30 plots) in 2010 and/or 2015 were subjected to analysis of cover change (Wilcoxon signed-rank test). Fine scale cover categories between 0 and 10% were lumped into a single value to minimize the influence of very small differences on the analysis. Significant increases in percent cover occurred for one non-native understory species (*B. appendiculatum*), two native canopy species (*A. koa* and *Metrosideros polymorpha*), and three non-native canopy species (*P. suberosa, P. cattleianum,* and *T. ciliata*) (Table 6 and Figure 6). Decreases in percent cover occurred for two species in the non-native understory (*S. terebinthifolius* and *T. ciliata*). The median change in percent cover was 0.0% for all species (as most taxa were absent from more than half of the plots during both years, most plots maintained 0% cover). Among those with significant change in cover, three non-native taxa (*S. terebinthifolius* and *T. ciliata* in the understory, and *P. suberosa* in the canopy) were influenced by small cover changes resulting from being absent in one year, and present in 0-10% cover in the other year. The change in overall non-native canopy percent cover was likely driven by changes in *P. cattleianum* and *T. ciliata* cover, along with cumulative changes among multiple additional taxa.

Table 6. Percent cover change of native and non-native species in the canopy and understory at Kaluaa and Waieli from 2010 to 2015. Only species with frequencies greater than 0.20 (present in at least 30 plots) in 2010 and/or 2015 were analyzed. Native taxa and statistically significant values are in boldface (Wilcoxon signed-rank test, n = 148). Arrows indicate increase (↑) or decrease (↓) in cover.

Species	Median cover change	p	Z
Understory			
Acacia koa	0.0	0.439	-0.775
Alyxia stellata	0.0	0.131	-1.512
Blechnum appendiculatum	0.0	**0.001**↑	-3.437
Clidemia hirta	0.0	0.865	-0.170
Cocculus orbiculatus	0.0	0.099	-1.650
Cyclosorus parasiticus	0.0	0.346	-0.943
Doodia kunthiana	0.0	0.552	-0.595
Lantana camara	0.0	0.078	-1.764
Metrosideros polymorpha	0.0	0.876	-0.156
Microlepia strigosa	0.0	0.244	-1.165
Passiflora suberosa	0.0	0.475	-0.714
Phlebodium aureum	0.0	1.000	0.000
Planchonella sandwicensis	0.0	0.315	-1.006
Psidium cattleianum	0.0	0.247	-1.158
Psychotria mariniana	0.0	0.073	-1.795
Rubus rosifolius	0.0	0.499	-0.675
Schinus terebinthifolius	0.0	**0.008**↓	-2.658
Toona ciliata	0.0	**0.005**↓	-2.818
Canopy			
Acacia koa	0.0	**0.036**↑	-2.102
Aleurites moluccana	0.0	0.756	-0.311
Alyxia stellata	0.0	0.251	-1.147
Grevillea robusta	0.0	0.966	-0.043
Metrosideros polymorpha	0.0	**0.003**↑	-3.001
Passiflora suberosa	0.0	**0.025**↑	-2.239
Planchonella sandwicensis	0.0	0.602	-0.521
Psidium cattleianum	0.0	**0.000**↑	-3.751
Psychotria mariniana	0.0	0.330	-0.974
Schinus terebinthifolius	0.0	0.067↑	-1.834
Toona ciliata	0.0	**0.001**↑	-3.311

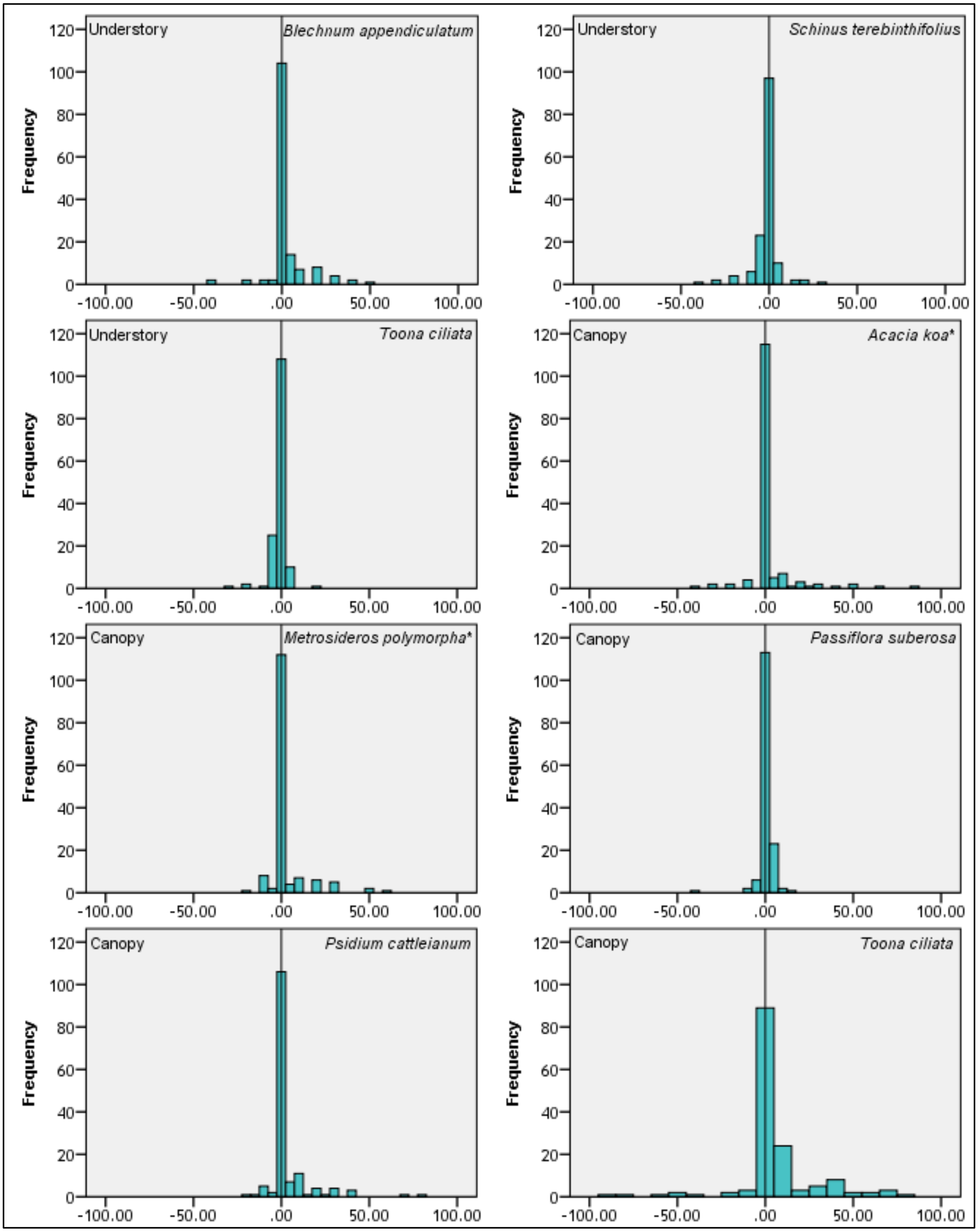


Figure 6. Histograms of percent cover change between 2010 and 2015 at Kaluaa and Waieli, for species with significant changes in cover in the understory and canopy. Solid lines reference 0% cover change (no change in cover within plots). Values > 0 represent increased cover in plots, while those < 0 represent decreased cover. *Native taxa.

Canopy replacement

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

Table 7. Summary of canopy tree species recruitment in the understory during 2015 Kaluaa and Waieli MU monitoring, in order of most to least frequent. Frequency represents the occurrence of tree species with a maximum height < 2 meters (seedlings to small trees) among plots (n = 148). Native species are in boldface. *Rare taxa. **Target weed taxa.

Species	Freq.	Species	Freq.	Species	Freq.
Psidium cattleianum	0.331	***Pisonia sandwicensis***	0.027	*Schefflera actinophylla***	0.007
*Toona ciliata***	0.297	***Psydrax odorata***	0.027	*Syzygium cumini*	0.007
Acacia koa	0.257	***Diospyros hillebrandii***	0.020	***Xylosma hawaiiense***	0.007
Schinus terebinthifolius	0.243	***Labordia kaalae****	0.020	***Bobea elatior***	0.000
Planchonella sandwicensis	0.142	***Psychotria hathewayi***	0.020	***Charpentiera tomentosa***	0.000
Grevillea robusta	0.115	***Dodonaea viscosa***	0.014	***Chrysodracon forbesii****	0.000
Pisonia umbellifera	0.095	***Elaeocarpus bifidus***	0.014	***Cyanea superba* subsp. *superba****	0.000
Metrosideros polymorpha	0.081	***Myrsine lessertiana***	0.014	***Gynochthodes trimera***	0.000
Psychotria mariniana	0.081	*Syzygium jambos*	0.014	*Lophostemon confertus*	0.000
Charpentiera obovata	0.074	***Clermontia persicifolia***	0.007	***Melicope clusiifolia***	0.000
Pipturis albidus	0.074	***Diospyros sandwicensis***	0.007	***Myrsine lanaiensis***	0.000
Aleurites moluccana	0.061	*Eucalyptus robusta*	0.007	***Pittosporum glabrum***	0.000
Claoxylon sandwicensis	0.061	***Freycinetia arborea***	0.007	***Pteralyxia macrocarpa****	0.000
Psidium guajava	0.041	*Heliocarpus popayanensis***	0.007	***Santalum freycinetianum***	0.000
Antidesma platyphyllum	0.034	*Mallotus phillippenis***	0.007	***Syzygium sandwicense***	0.000
Spathodea campanulata	0.034	***Melicope oahuensis***	0.007	***Urera glabra***	0.000
Pisonia brunoniana	0.027				

Weed control

Weed control efforts at Kaluaa and Waieli between the 2010 and 2015 monitoring intervals included approximately 2,366 person hours. The total amount of effort varied among the nine weed control areas (WCA) that encompass the MU, ranging from 8 to 565.25 hours per WCA. Time spent weeding per WCA was weakly negatively correlated with change in native understory cover among the plots in areas where incision point application (IPA) canopy weeding of *T. ciliata* and *G. robusta* occurred (Pearson's correlation: $p = 0.019$, $r^2 = 0.119$, $n = 46$). I.e., native understory declined as time spent weeding per WCA increased, but only in plots that fell within IPA controlled areas; however time spent weeding explained very little of the variance in cover change. Aside from this, changes in native and non-native cover did not correlate with the amount of time spent weeding per WCA.

Between the 2010 and 2015 monitoring intervals, 36.7% of the MU was weeded. Much of the area weeded is attributable to IPA control (IPA control occurred across 26% of the MU, all other forms of weed control encompassed 15% of the MU). Weed control efforts crossed through 49% of the plots between the 2010 and 2015 monitoring intervals (31% fell within IPA control areas, 24% were within areas with all other forms of weeding) (Figure 7). Change in native and non-native cover did not differ among plots weeded vs. not weeded for all forms of weeding combined. Non-native canopy cover increased significantly (from a median of 55 to 70% cover) in plots outside IPA control areas (Wilcoxon: $p \leq 0.001$, $Z = 3.990$), but not within IPA areas (median of 95% cover both years) ($p = 0.818$, $Z = 0.231$) (Figure 8). There was no difference in change in native understory and canopy or non-native understory for plots within vs. outside IPA control areas. Upon further examination of *T. ciliata* and *G. robusta* canopy cover change in association with IPA efforts, the increase in *T. ciliata* cover (noted above) is attributable only to areas without IPA efforts (Wilcoxon: $p \leq 0.001$, $Z = 4.731$). Reduced cover of these taxa did not occur in plots in the IPA areas. Reductions in non-native understory or canopy did not correlate with increases in native or non-native understory or canopy vegetation among the monitored plots.

A third of the 27 target weed species (taxa of special concern for weed management, including incipient species) for Kaluaa and Waieli MU (OANRP 2011) were identified during monitoring, and at least one target taxa was present in 57% of the monitored plots in either the understory or canopy. These included one widespread target taxa (*T. ciliata*), and eight less common target species (*Erigeron karvinskianus, Heliocarpus popayanenesis, Mallotus philippensis, Schefflera actinophylla, Setaria palmifolia, Spathodea campanulata, Triumfetta semitriloba* and *Urochloa maxima*) (Figure 9). Of these, only *T. ciliata* had a high frequency, occurring in 52% of the plots. No incipient non-native taxa were identified in any plots.

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

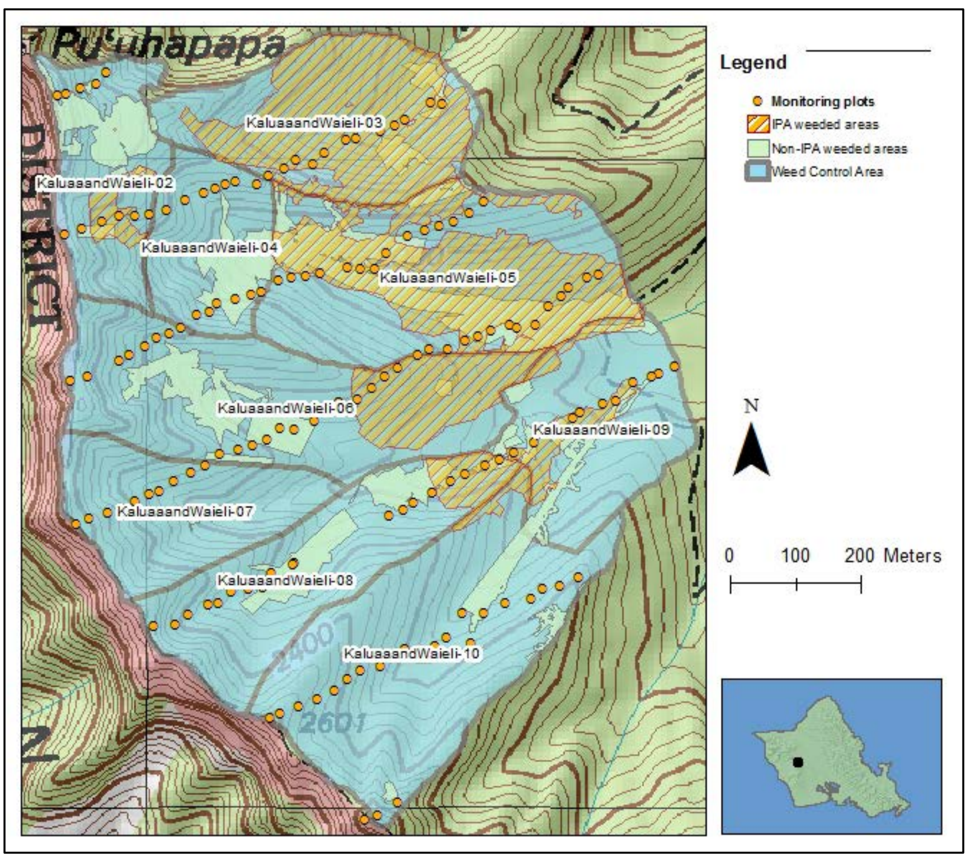


Figure 7. Locations of vegetation monitoring plots at Kaluaa and Waieli MU in relation to weed control areas (WCA) and areas weeded (showing locations with or without IPA control) between the 2010 and 2015 monitoring intervals.

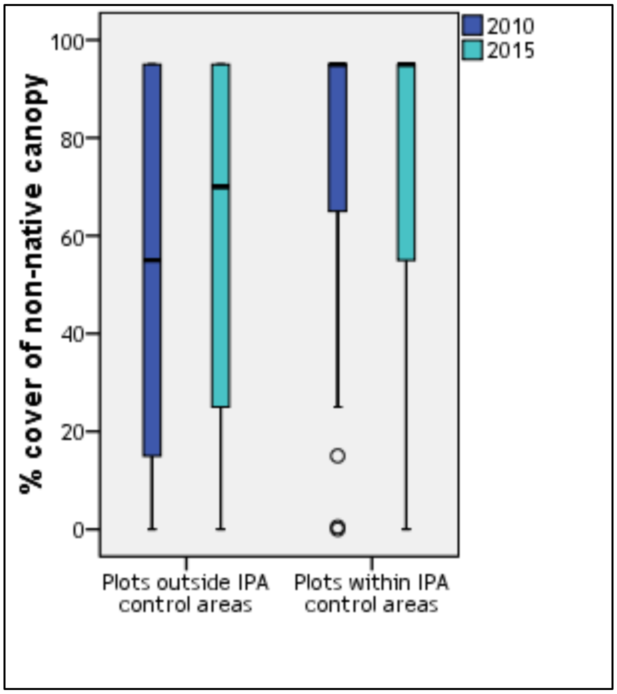


Figure 8. Non-native canopy cover in plots within vs. outside IPA weed control areas in 2010 and 2015.

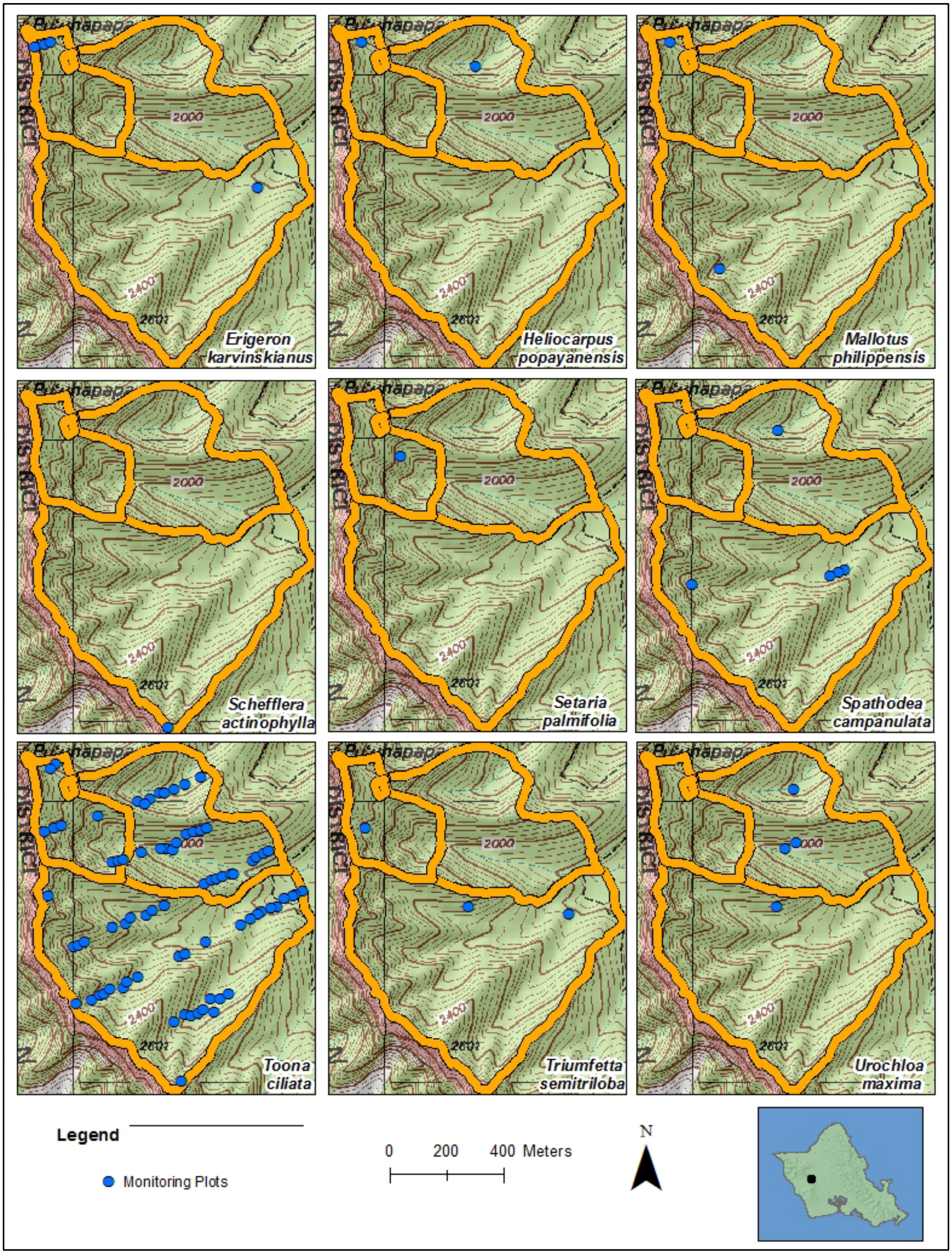


Figure 9. Locations of target taxa in the understory and/or canopy among plots in Kaluaa and Waieli MU in 2015.

SUMMARY AND DISCUSSION

Management objectives were not met for percent cover of native understory, native canopy, and non-native canopy vegetation for Kaluaa and Waieli MU. Objectives were only met for non-native understory percent cover. There were a number of noteworthy significant differences in the 2015 data as compared with five years ago, including:

- Increase in non-native canopy cover
- Decrease in non-native understory richness
- Increase in non-native canopy richness
- Decrease in frequency for non-native understory species:
  - *T. ciliata*
  - *Y. japonica*
- Increase in frequency for non-native canopy species:
  - *P. suberosa*
  - *T. ciliata*
- An increase in percent cover for non-native species:
  - *B. appendiculatum* (understory)
  - *P. suberosa* (canopy)
  - *P. cattleianum* (canopy)
  - *T. ciliata* (canopy)
- An increase in percent cover for native species:
  - *A. koa* (canopy)
  - *M. polymorpha* (canopy)
- A decrease in percent cover for non-native understory species:
  - *S. terebinthifolius* (understory)
  - *T. ciliata* (understory)
- Time spent weeding per WCA was negatively correlated with change in native understory cover among the plots within IPA control areas
- Increase in non-native canopy cover in plots without IPA control
- Increase in *Toona ciliata* (canopy) in plots without IPA control

The beneficial changes that occurred were generally small, while the worsening changes were larger, particularly in the canopy, irrespective of weeding efforts. Given the high level of non-native canopy cover in the MU, management goals of < 50% cover may be unrealistic across the MU. Refinement of management goals to apply specifically to prioritized areas (those with greater potential for restoration) within the MU may result in goals that are more likely to be successfully accomplished.

Toona ciliata frequency and cover decline in the understory paired with an increase in the canopy may be explained in part by vertical growth of individuals that were in the understory in 2010, but reached the canopy by 2015. Plots where *T. ciliata* was absent in the understory in 2015 but present in 2010 were anecdotally observed to have *T. ciliata* individuals in the lowermost portions of the canopy in 2015.

Changes in native and non-native cover resulting from IPA weed control efforts for *T. ciliata* and *G. robusta* are challenging to interpret. While time spent weeding per WCA was weakly negatively correlated with change in native understory cover among the plots within IPA control areas, there was no difference in cover change in plots within vs. outside IPA areas. Time spent weeding may be a poor indicator of effort with respect to IPA control, as considerably more area may be covered in a shorter time as compared with other types of weeding efforts, and could skew the results. The significant increase in non-native cover (including *T. ciliata*), in plots outside, but not inside, IPA controlled areas suggest IPA efforts may be preventing increases in non-native canopy cover within the areas treated. However, IPA treatment occurred in the lower elevations of the MU, where non-native cover was already uniformly high, as opposed to the higher elevation areas where non-native cover was lower. IPA control targeted only the largest mature individuals of two species in attempts to minimize primary seed sources, such that other non-native species and smaller individuals of the targeted taxa remained in the lower reached of the canopy, potentially masking impacts of canopy reduction via IPA. As IPA efforts expand into higher elevations, perhaps resulting canopy reduction will be more apparent.

RECOMMENDATIONS

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

- more aggressive weed control paired with restoration efforts in prioritized areas
- target uncommon weeds when seen (particularly target taxa)
- expand IPA efforts into new areas, including higher elevations with more native cover, and continue IPA efforts within areas already treated, as *T. ciliata* and *G. robusta* grow to the targeted size/stage, as necessary
- monitoring of understory change in direct association with IPA treatments (via a separate monitoring regime) should be done to better understand it's impact on native and non-native understory cover
- there should be critical consideration and discussion of why change in native and non-native cover did not differ among weeded vs. not weeded plots in general, perhaps paired with smaller-scale monitoring of controlled weeding trials

REFERENCES

Oahu Army Natural Resource Program. 2008. Appendix 2.0 MIP/OIP Belt Plot Sampling Monitoring Protocol *in* 2008 Status Report for the Makua Implementation Plan.

Oahu Army Natural Resource Program. 2011. Chapter 1.2.1 Kaluaa and Waieli Ecosystem Restoration Management Unit Plan *in* 2011 Status Report for the Makua and Oahu Implementation Plans.

OAHU ARMY NATURAL RESOURCES PROGRAM
MONITORING PROGRAM

VEGETATION MONITORING AT MANUWAI MANAGEMENT UNIT, 2016

INTRODUCTION

Vegetation monitoring was conducted at Manuwai Management Unit (MU) in February and March of 2016 in association with MIP/OIP requirements for long term monitoring of vegetation composition and change over time (OANRP 2008) (Figure 1). The primary objective of MU monitoring is to assess if the percent cover of non-native plant species is less than 50% across the MU, or is decreasing towards that threshold requirement. The secondary objective is to assess if native cover is greater than 50% across the MU, or is increasing towards that threshold recommendation. Manuwai MU vegetation monitoring occurs on a five-year interval, and took place once previously (OANRP 2011). Previous monitoring indicated that none of the cover goals were met. The MU consist of two fenced subunits, both of which were completed in 2011.

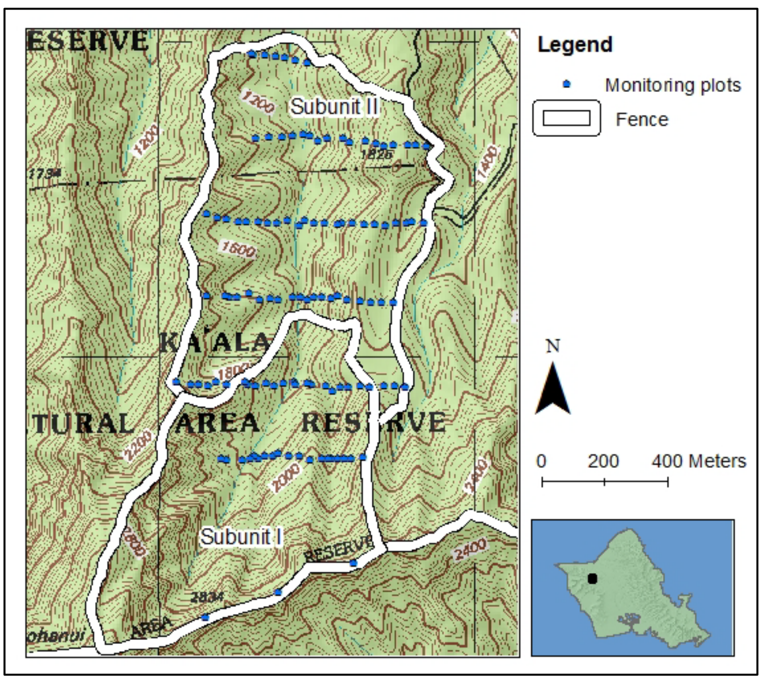


Figure 1. Manuwai MU vegetation monitoring plot locations.

METHODS

In February and March of 2016, 114 plots were monitored. Plots measuring 5 x 10 m were generally located every 40 m along transects. Transects were located in accessible areas (much of the higher elevations in Subunit I are too steep to access), spaced approximately 250 meters (m) apart. Monitoring of these same plots was completed once previously in 2011 (OANRP 2011). During the prior monitoring, 232 plots were monitored, with plots located every 20 m. Post-hoc power analysis of the prior monitoring data determined that the minimum sample size necessary for meeting the sampling objectives was 81 plots (OANRP, 2011). Consequently, the number of plots monitored in 2016 was reduced by half, with every other plot along transects arbitrarily discontinued. During the course of monitoring, two additional plots were not monitored. One plot was determined to be too dangerous for monitoring, and a second could not be relocated. Among the 114 plots monitored in 2016, three were determined to be too dangerous to access, and should be discontinued.

Understory [occurring from 0 – 2 m above ground level (AGL), including low branches from canopy species] and canopy (occurring > 2 m AGL, including epiphytes) vegetation was recorded by percent cover for all non-native and native species present. Summary percent cover by vegetation type (shrub, fern, grass/sedge) in the understory, overall summary percent cover of non-native and native vegetation in the understory and canopy, and bare ground (non-vegetated < 25 cm AGL), 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 in 2016, but not documented previously. Monitoring results were compared with data from 2011. Based on MIP recommendations, $\alpha = 0.05$ was used for significance determinations, and only cover changes ≥ 10% were recognized. Additional methodology information is detailed in Monitoring Protocol 1.2.1 (OANRP 2008). All analyses were performed in IBM SPSS Statistics Version 24. These included Wilcoxon signed-rank tests for cover data, paired t tests for species richness data, and McNemar's test for frequency data.

RESULTS

Understory and canopy cover categories

Management objectives of having < 50% non-native understory and canopy and > 50% native understory and canopy cover were not met in 2016 (Table 1). Native understory and canopy percent cover were low (3.0% and 15% median values, respectively). Non-native understory cover was moderately high, and non-native canopy cover was high (65% and 85% median values, respectively). There were several significant[1] changes in percent cover of vegetation from previous monitoring results. However, only a few of these met the 10% standard for recognized change in cover. These included 10% increases in cover for total non-native understory and non-native canopy, as well as a 40% decrease in bare ground (Figure 2). Caution should be applied in interpreting the results of change in bare ground, as the method for this measurement was not as clearly defined in 2011, and as such was less repeatable. In 2016, low native understory percent cover, and high non-native understory and canopy cover occurred nearly consistently throughout the MU (Figure 3). Locations of low to high native canopy cover were patchily distributed across the MU. Locations where beneficial and worsening cover changes occurred were patchily distributed (Figure 4).

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

Table 1. Percent cover of native and non-native vegetation categories in the canopy and understory at Manuwai MU from 2011 to 2016. Median values are represented (n = 114). Categories specifically addressed in management objectives are shaded. Statistically significant values for categories that meet the 10% standard for recognized change in cover are in boldface (Wilcoxon signed-rank test). Arrows indicate increase (↑) or decrease (↓) in cover.

	2011	2016	p	Z	Management objective currently met?
Understory					
Native shrubs	3.00	3.00	< 0.001 ↓	-6.033	
Native ferns	0.25	0.50	0.005 ↑	-2.816	
Native grasses	0.00	0.00	0.002 ↓	-3.112	
Total native understory	7.50	3.00	< 0.001 ↓	-4.750	No
Non-native shrubs	25.00	25.00	0.267	-1.109	
Non-native ferns	3.00	7.50	< 0.001 ↑	-5.008	
Non-native grasses	0.00	0.50	0.001 ↑	-3.392	
Total non-native understory	55.00	65.00	**0.006** ↑	-2.773	No, and getting worse
Bare ground	85.00	45.00	**< 0.001** ↓	-7.133	
Canopy					
Native canopy	15.00	15.00	0.250	-1.151	No
Non-native canopy	75.00	85.00	**0.001** ↑	-3.294	No, and getting worse
Total canopy	95.00	95.00	0.168	-1.377	

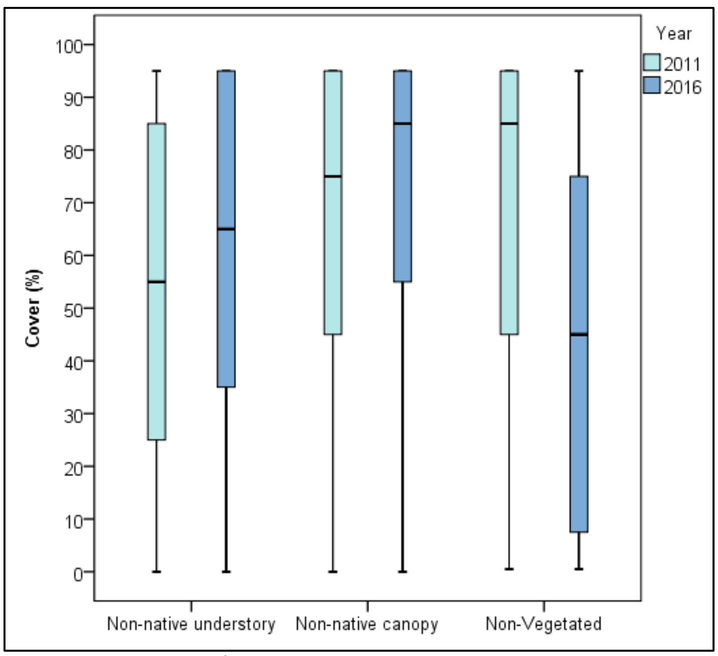


Figure 2. Boxplots[2] for vegetation categories with significant change in percent cover that meet 10% standard for recognized change in cover between years 2011 and 2016 in Manuwai MU.

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

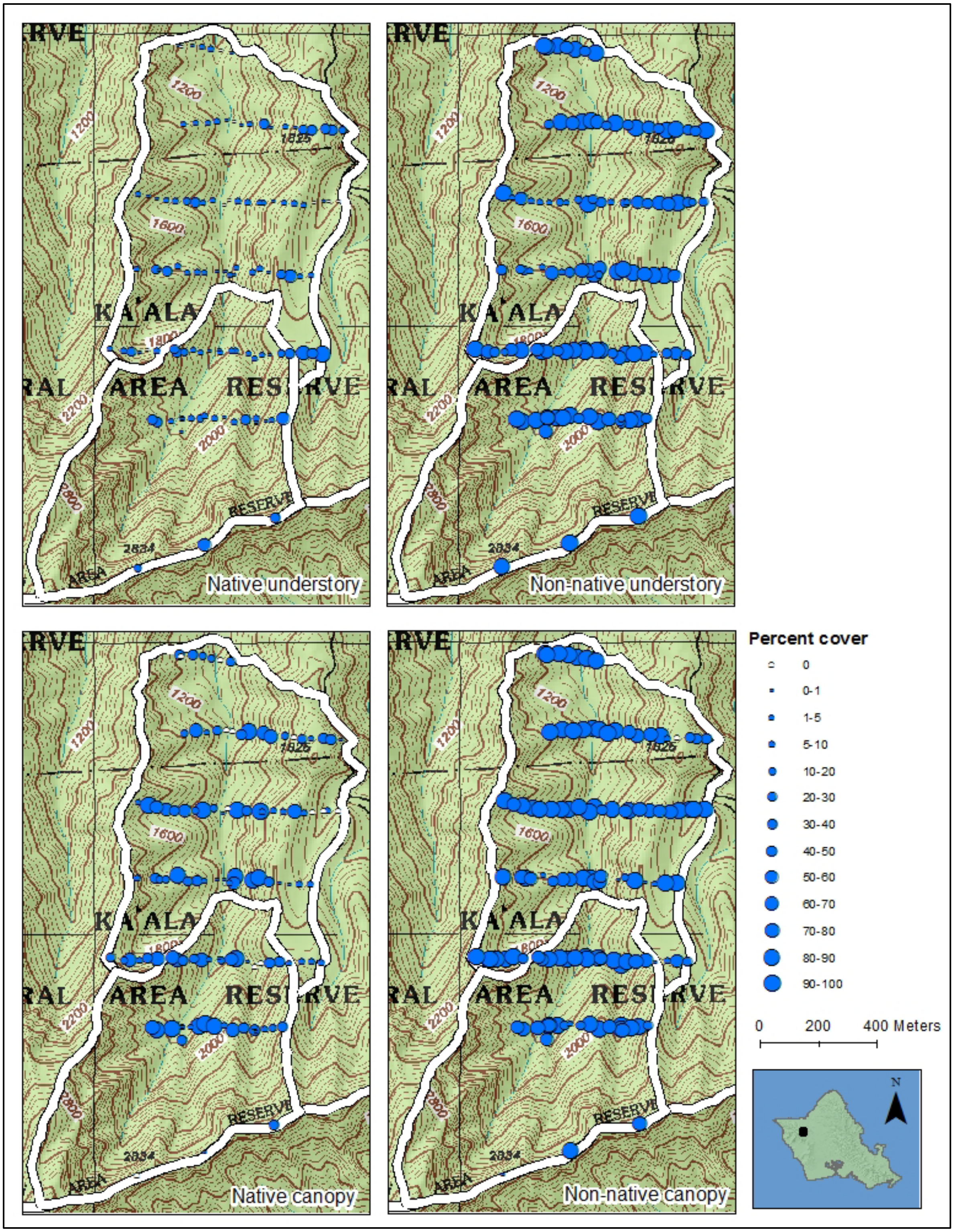


Figure 3. Locations of low to high percent cover of native and non-native understory and canopy vegetation among monitored plots at Manuwai MU in 2016. Larger circles denote higher percent cover, while smaller circles represent lower cover.

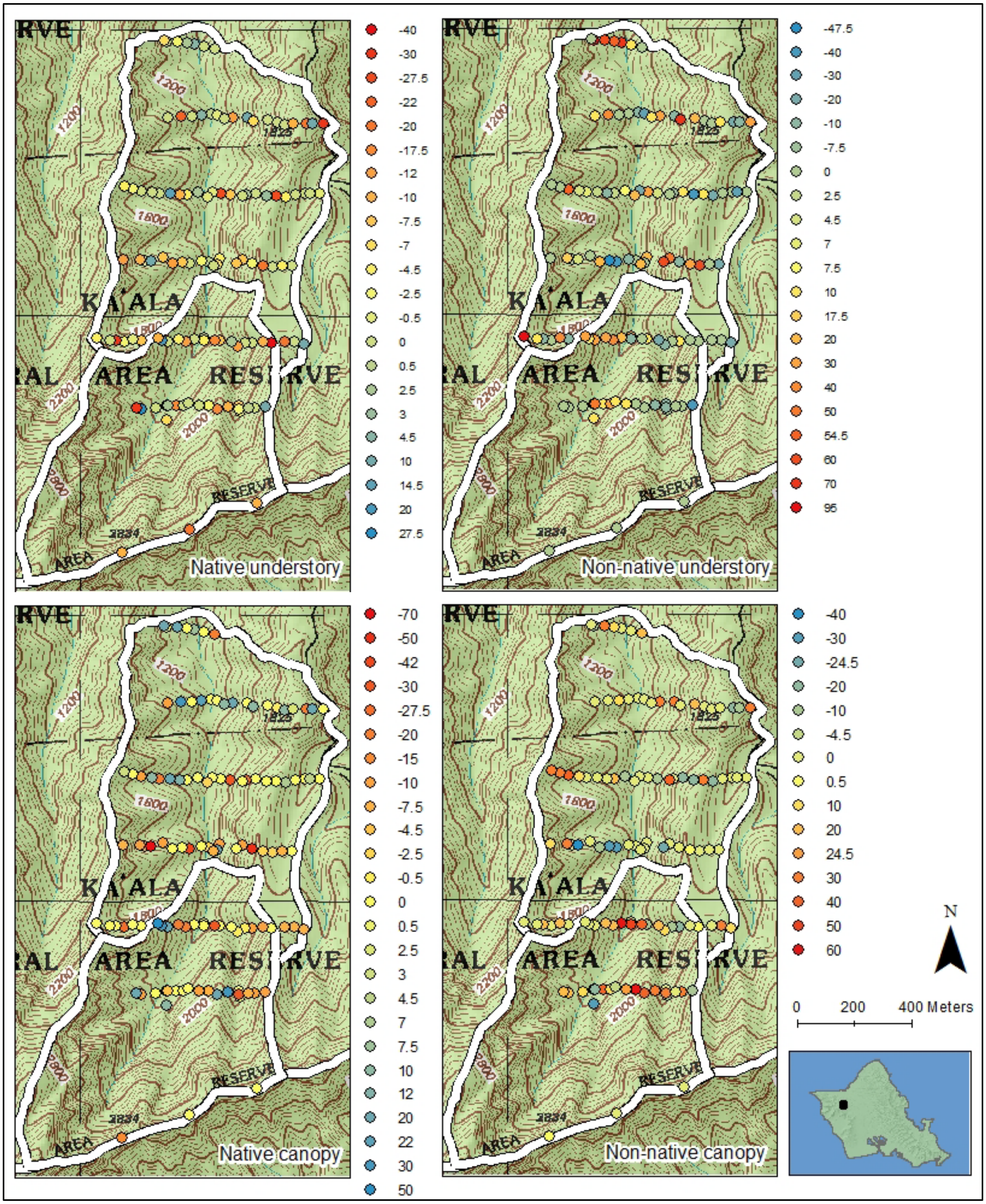


Figure 4. Locations of change in native and non-native percent cover for the understory and canopy vegetation in monitored plots in Manuwai MU between 2011 and 2016. Color gradients are inverted for native and non-native vegetation, such that blue indicates beneficial change, red depicts worsening conditions. Cover change of 0 indicates there was no change in percent cover.

Species richness

During monitoring in 2016, 132 species were recorded in the understory (50% native taxa), and 58 were identified in the canopy (62% native). Most species present in the canopy were also represented in the understory, with the exception of three native species (*Antidesma platyphyllum*, *Cyanea angustifolia, Erythrina sandwicensis*, and *Polyscias sandwicensis*). Locations of high and low species richness for the native and non-native understory and canopy were primarily patchily distributed across the MU, though higher native understory and canopy richness occurred more frequently in the southern portions of the MU (Figure 5). Species richness differed significantly between the years monitored, with an increase in both non-native understory and canopy taxa within plots (Table 2). No detectable change occurred in species richness among plots in the native understory or canopy. The significant increase in non-native understory and canopy richness among plots was paired with an increase in overall diversity for the MU. Overall native understory and canopy diversity for the MU decreased slightly. Twenty-one new species (61.9% non-native) were found in plots in 2016, while 15 species (73.3% native) were recorded in 2011 but not observed in 2016 (Table 3). 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. The occurrence within plots of short-lived, less common species is expected to vary over time. All of the species that were not present in 2016 were uncommon in previous years, with frequencies less than 2%.

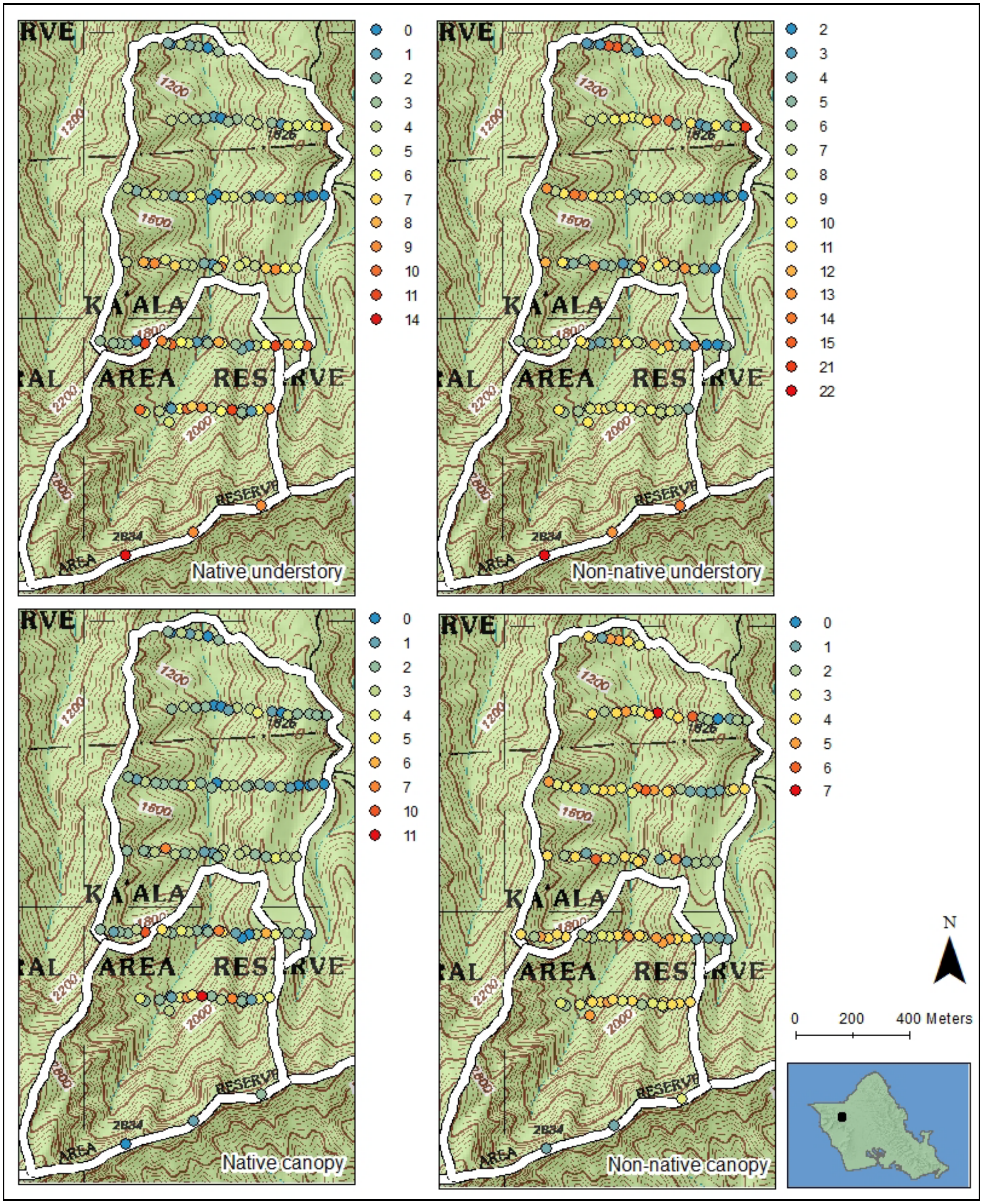


Figure 5. Locations of low to high species richness among plots in the native and non-native understory and canopy in Manuwai MU, 2016. Color gradients of blue to red indicate low to high values, respectively, of the number of species occurring in plots (i.e., blue indicates low diversity, while red indicates relatively higher diversity).

Table 2. Manuwai MU understory and canopy species richness. Mean species richness per plot during vegetation monitoring is shown by year, with the total number of species recorded among all plots in parenthesis (n = 114). P-values obtained from paired t tests. Statistically significant values are in boldface. Arrows indicate increase (↑) or decrease (↓) in richness.

	2011	2016	p	t
Native understory	4.49 (69)	4.46 (66)	0.837	-0.207
Non-native understory	6.72 (56)	8.02 (66)	**< 0.001** ↑	5.602
Native canopy	2.50 (37)	2.46 (36)	0.699	-0.387
Non-native canopy	2.89 (19)	3.29 (22)	**< 0.001** ↑	3.881

Table 3. Newly recorded, and no longer present, species from 2016 Manuwai MU monitoring, in the understory and/or canopy. Native taxa are in boldface.

New species recorded in 2016	Species found in plots in 2011 but not recorded in 2016
Angiopteris evecta	***Coprosma longifolia***
Antidesma platyphyllum	***Crepidomanes minutum***
Ardisia elliptica	*Cuphea carthagenesis*
Caesalpinia bonduc	*Digitaria insularis*
Castilleja arvensis	***Dryopteris sandwicensis***
Cenchrus polystachios	***Gynochthodes trimera***
Centaurium erythraea	***Kadua affinis***
Charpentiera ovata	***Myrsine sandwicensis***
Crassocephalum crepidoides	***Peperomia membranacea***
Cyclosorus dentatus	***Phyllostegia parviflora* var. *lydgatei***
Desmodium incanum	***Plectranthus parviflorus***
Erechtites valerianifolia	***Rauvolfia sandwicensis***
Erythrina sandwicensis	*Sida rhombifolia*
Lophospermum erubescens	***Strongylodon ruber***
Nephrolepis brownii	*Trema orientalis*
Phyllanthus distichus	
Pilea peploides	
Psychotria mariniana	
Pteridaceae indet.	
Pterolepis glomerata	
Sida fallax	

Species frequency

Non-native species that occurred most frequently in plots (present in more than half the plots) in the understory included *Psidium cattleianum, Clidemia hirta, Blechnum appendiculatum,* and *Toona ciliata,* while those most commonly occurring in the canopy were *P. cattleianum* and *T. ciliata* (Table 4). The most frequent native species (in at least a quarter of the plots) included *Diospyros sandwicensis*, *Psydrax odorata*, *Alyxia stellata, Dodonaea viscosa* and *Carex meyenii* in the understory, and *D. sandwicensis* and *P. odorata* in the canopy. Of the 16 rare taxa occurring at Manuwai MU (OANRP 2011), two (*Labordia kaalae* and *Polyscias sandwicensis*) were identified during monitoring in 2016. Analysis of frequency change (McNemar's test) was limited to taxa with at least ten percent change between 2011 and 2016. These included three non-native species in the understory (*Adiantum hispidulum, Clidemia hirta,* and *Passiflora suberosa*) and one non-native species in the canopy (*T. ciliata*), all of which had significant increases in frequency (Table 5).

Table 4. Species frequency among plots (percent of plots in which a given species occurs) during 2016 Manuwai MU monitoring (n= 114), in order of most to least frequent. Native species are in bold print. *Rare taxa. **Target weed taxa.

Taxon	Freq.	Taxon	Freq.	Taxon	Freq.	Taxon	Freq.
Understory							
Psidium cattleianum	85.1	*Conyza bonariensis*	9.6	*Melia azedarach***	3.5	*Ardisia elliptica*	0.9
Clidemia hirta	78.9	*Rubus rosifolius*	9.6	*Paspalum conjugatum*	3.5	***Asplenium nidus***	0.9
Blechnum appendiculatum	76.3	***Wikstroemia oahuensis***	9.6	***Psilotum nudum***	3.5	***Bobea elatior***	0.9
*Toona ciliata***	57.0	***Dianella sandwicensis***	8.8	***Pteridium aquilinum***	3.5	***Caesalpinia bonduc***	0.9
Diospyros sandwicensis	50.0	*Oxalis corniculata*	8.8	***Scaevola gaudichaudiana***	3.5	*Castilleja arvensis*	0.9
Schinus terebinthifolius	42.1	*Passiflora edulis*	8.8	*Setaria parviflora*	3.5	*Cenchrus longisetus*	0.9
Psydrax odorata	40.4	*Aleurites moluccana*	7.9	*Buddleja asiatica*	2.6	*Centaurium erythraea*	0.9
Adiantum hispidulum	37.7	***Lepisorus thunbergianus***	7.9	*Chamaecrista nictitans*	2.6	***Charpentiera ovata***	0.9
Cyclosorus parasiticus	37.7	*Spathodea campanulata***	7.9	***Chrysodracon halapepe***	2.6	***Coprosma foliosa***	0.9
*Syzygium cumini***	34.2	***Bidens torta***	7.0	*Cyclosorus dentatus*	2.6	*Crassocephalum crepidoides*	0.9
Oplismenus hirtellus	30.7	*Leucaena leucocephala*	7.0	***Cyperus hypochlorus* var. *hypochlorus***	2.6	*Cyanthillium cinereum*	0.9
Alyxia stellata	28.1	***Pipturis albidus***	6.1	*Mesosphaerum pectinatum*	2.6	*Desmodium incanum*	0.9
Dodonaea viscosa	27.2	***Sphenomeris chinensis***	6.1	*Oxalis corymbosa*	2.6	***Dicranopteris linearis***	0.9
Carex meyenii	25.4	*Youngia japonica*	6.1	*Phlebodium aureum*	2.6	*Emilia sonchifolia*	0.9
Carex wahuensis	23.7	*Andropogon virginicus*	5.3	***Pisonia brunoniana***	2.6	*Erechtites valerianifolia*	0.9
Lantana camara	23.7	*Begonia hirtella*	5.3	*Triumfetta semitriloba***	2.6	***Freycinetia arborea***	0.9
Microlepia strigosa	22.8	***Kadua acuminata***	5.3	*Ageratum conyzoides*	1.8	***Labordia kaalae****	0.9
Grevillea robusta	20.2	***Nephrolepis exaltata* subsp. *hawaiiensis***	5.3	*Cenchrus polystachios*	1.8	*Lophospermum erubescens*	0.9
Passiflora suberosa	18.4	*Stachytarpheta australis*	5.3	***Charpentiera obovata***	1.8	***Lythrum maritimum***	0.9
Ageratina riparia	17.5	*Ageratina adenophora*	4.4	***Elaphoglossum paleaceum***	1.8	***Microlepia speluncae***	0.9
Sapindus oahuensis	15.8	*Cheilanthes viridis*	4.4	***Eragrostis grandis***	1.8	*Nephrolepis brownii*	0.9
Diospyros hillebrandii	14.9	***Cocculus orbiculatus***	4.4	***Kadua cordata***	1.8	***Paspalum scrobiculatum***	0.9
Coffea arabica	14.0	*Cupressus lusitanica*	4.4	*Melinis repens*	1.8	***Phyllanthus distichus***	0.9
Metrosideros polymorpha	14.0	***Doryopteris decipiens***	4.4	***Metrosideros tremuloides***	1.8	***Pisonia sandwicensis***	0.9
*Urochloa maxima***	14.0	***Eugenia reinwardtiana***	4.4	***Osteomeles anthyllidifolia***	1.8	***Pittosporum confertiflorum***	0.9
Leptecophylla tameiameiae	13.2	***Nestegis sandwicensis***	4.4	***Peperomia tetraphylla***	1.8	*Pluchea carolinensis*	0.9
Psidium guajava	13.2	***Peperomia blanda***	4.4	***Pilea peploides***	1.8	Pteridaceae indet.	0.9
Adiantum radianum	12.3	***Psychotria hathewayi***	4.4	***Planchonella sandwicensis***	1.8	*Pterolepis glomerata***	0.9
Doodia kunthiana	12.3	*Schefflera actinophylla***	4.4	*Plantago lanceolata*	1.8	***Santalum freycinetianum***	0.9
Kalanchoe pinnata	12.3	***Acacia koa***	3.5	***Psychotria mariniana***	1.8	***Scaevola gaudichaudii***	0.9
Melinis minutiflora	12.3	***Canavalia galeata***	3.5	*Acacia confusa***	0.9	***Sida fallax***	0.9
Selaginella arbuscula	12.3	*Deparia petersenii*	3.5	*Angiopteris evecta*	0.9	***Tectaria gaudichaudii***	0.9
Cordyline fruticosa	10.5	***Euphorbia multiformis***	3.5	***Antidesma pulvinatum***	0.9	***Waltheria indica***	0.9

Table 4, continued.

Taxon	Freq.	Taxon	Freq.	Taxon	Freq.	Taxon	Freq.
Canopy							
Psidium cattleianum	71.9	*Coffea arabica*	7.0	*Phlebodium aureum*	2.6	***Asplenium nidus***	0.9
*Toona ciliata***	59.6	***Leptecophylla tameiameiae***	7.0	***Pipturis albidus***	2.6	***Cyanea angustifolia***	0.9
Diospyros sandwicensis	55.3	***Wikstroemia oahuensis***	7.0	***Pisonia sandwicensis***	2.6	***Dicranopteris linearis***	0.9
*Syzygium cumini***	53.5	*Passiflora edulis*	6.1	*Urochloa maxima***	2.6	***Erythrina sandwicensis***	0.9
Psydrax odorata	42.1	***Planchonella sandwicensis***	6.1	*Ageratina adenophora*	1.8	***Kadua acuminata***	0.9
Schinus terebinthifolius	36.8	*Spathodea campanulata***	6.1	***Canavalia galeata***	1.8	***Labordia* sp.**	0.9
Aleurites moluccana	30.7	***Psychotria hathewayi***	5.3	***Eugenia reinwardtiana***	1.8	*Lophospermum erubescens*	0.9
Grevillea robusta	23.7	*Clidemia hirta*	4.4	***Pisonia brunoniana***	1.8	*Melia azedarach***	0.9
Dodonaea viscosa	21.1	***Lepisorus thunbergianus***	3.5	***Pittosporum confertiflorum***	1.8	***Osteomeles anthyllidifolia***	0.9
Metrosideros polymorpha	17.5	***Nestegis sandwicensis***	3.5	***Psychotria mariniana***	1.8	***Peperomia tetraphylla***	0.9
Diospyros hillebrandii	14.0	***Acacia koa***	2.6	***Santalum freycinetianum***	1.8	*Pluchea carolinensis*	0.9
Sapindus oahuensis	13.2	***Bobea elatior***	2.6	*Acacia confusa***	0.9	***Polyscias sandwicensis****	0.9
Alyxia stellata	12.3	*Cupressus lusitanica*	2.6	***Antidesma platyphyllum***	0.9	***Psilotum nudum***	0.9
Psidium guajava	9.6	*Lantana camara*	2.6	***Antidesma pulvinatum***	0.9	*Schefflera actinophylla***	0.9
Chrysodracon halapepe	7.0	*Passiflora suberosa*	2.6				

Table 5. Species frequency change at Manuwai MU between 2011 and 2016. Only taxa with at least 10% change in frequency were analyzed. Frequency values represent the proportion of plots in which species are present (n = 114). Native species are in boldface. P-values obtained from McNemar's test (exact significance). Arrows indicate increase (↑) or decrease (↓) in frequency.

Species	Frequency 2011	Frequency 2016	% change	p
Understory				
Adiantum hispidulum	25.4	37.7	12	<0.001 ↑
Clidemia hirta	66.7	78.9	12	0.001 ↑
Passiflora suberosa	6.1	18.4	12	0.004 ↑
Canopy				
Toona ciliata	48.2	59.6	11	0.002 ↑

Species cover

Species with frequencies > 0.20 (present in at least 23 plots) in 2011 and/or 2016 were subjected to analysis of cover change (Wilcoxon signed-rank test). Fine scale cover categories between 0 and 10% were lumped into a single value to minimize the influence of very small differences on the analysis. Significant increases in percent cover occurred for four non-native understory species (*A. hispidulum, B. appendiculatum, C. hirta,* and *Oplismenus hirtellus*, and one non-native canopy species (*P. cattleianum*) (Table 6 and Figure 6). Decreases in percent cover occurred for one species in the non-native understory (*P. cattleianum)*, two species in the native understory (*A. stellata* and *P. odorata*), one non-native species in the canopy (*Grevillea robusta*), and one native species in the canopy (*D. sandwicensis*) (Figure 7). The median change in percent cover was 0.0% for all species (as most taxa were absent from more than half of the plots during both years, most plots maintained 0% cover).

Table 6. Percent cover change of native and non-native species in the canopy and understory at Manuwai from 2011 to 2016. Only species with frequencies greater than 0.20 (present in at least 23 plots) in 2016 were analyzed. Native taxa and statistically significant values are in boldface (Wilcoxon signed-rank test, n = 114). Arrows indicate increase (↑) or decrease (↓) in cover.

Species	Median cover change	p	Z
Understory			
Adiantum hispidulum	0.00	**< 0.001**↑	-3.94
Alyxia stellata	0.00	**0.034**↓	-2.12
Blechnum appendiculatum	0.00	**< 0.001**↑	-4.49
Carex meyenii	0.00	0.127	-1.53
Carex wahuensis	0.00	1.000	0.00
Clidemia hirta	0.00	**0.006**↑	-2.77
Cyclosorus parasiticus	0.00	0.125	-1.53
Diospyros sandwicensis	0.00	0.315	-1.01
Dodonaea viscosa	0.00	0.319	-1.00
Grevillea robusta	0.00	1.000	0.00
Lantana camara	0.00	0.808	-0.24
Microlepia strigosa	0.00	0.438	-0.78
Oplismenus hirtellus	0.00	**0.004**↑	-2.86
Psidium cattleianum	0.00	**0.017**↓	-2.38
Psydrax odorata	0.00	**0.007**↓	-2.70
Schinus terebinthifolius	0.00	0.985	-0.02
Syzygium cumini	0.00	0.575	-0.56
Toona ciliata	0.00	0.221	-1.23
Canopy			
Aleurites moluccana	0.00	0.625	-0.49
Diospyros sandwicensis	0.00	**0.018**↓	-2.36
Dodonaea viscosa	0.00	0.058↑	-1.90
Grevillea robusta	0.00	**0.016**↓	-2.42
Psidium cattleianum	0.00	**0.004**↑	-2.87
Psydrax odorata	0.00	0.391	-0.86
Schinus terebinthifolius	0.00	0.497	-0.68
Syzygium cumini	0.00	0.296	-1.05
Toona ciliata	0.00	0.077↑	-1.77

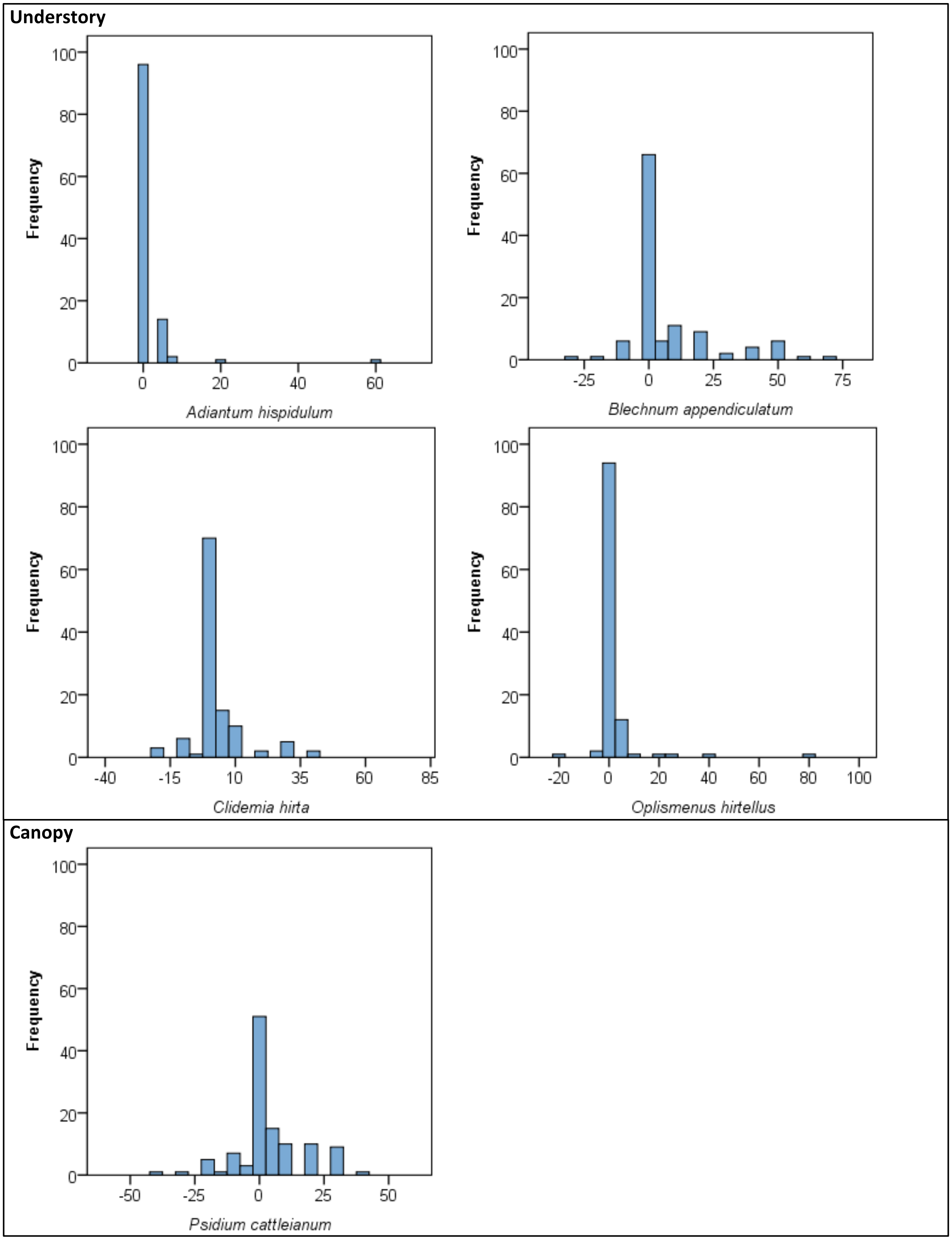


Figure 6. Histograms of percent cover change between 2011 and 2016 at Manuwai, for taxa with significant increases in cover in the understory and canopy. Values > 0 represent increased cover in plots, while those < 0 represent decreased cover. Values equaling 0 represent no change. *Native taxa.

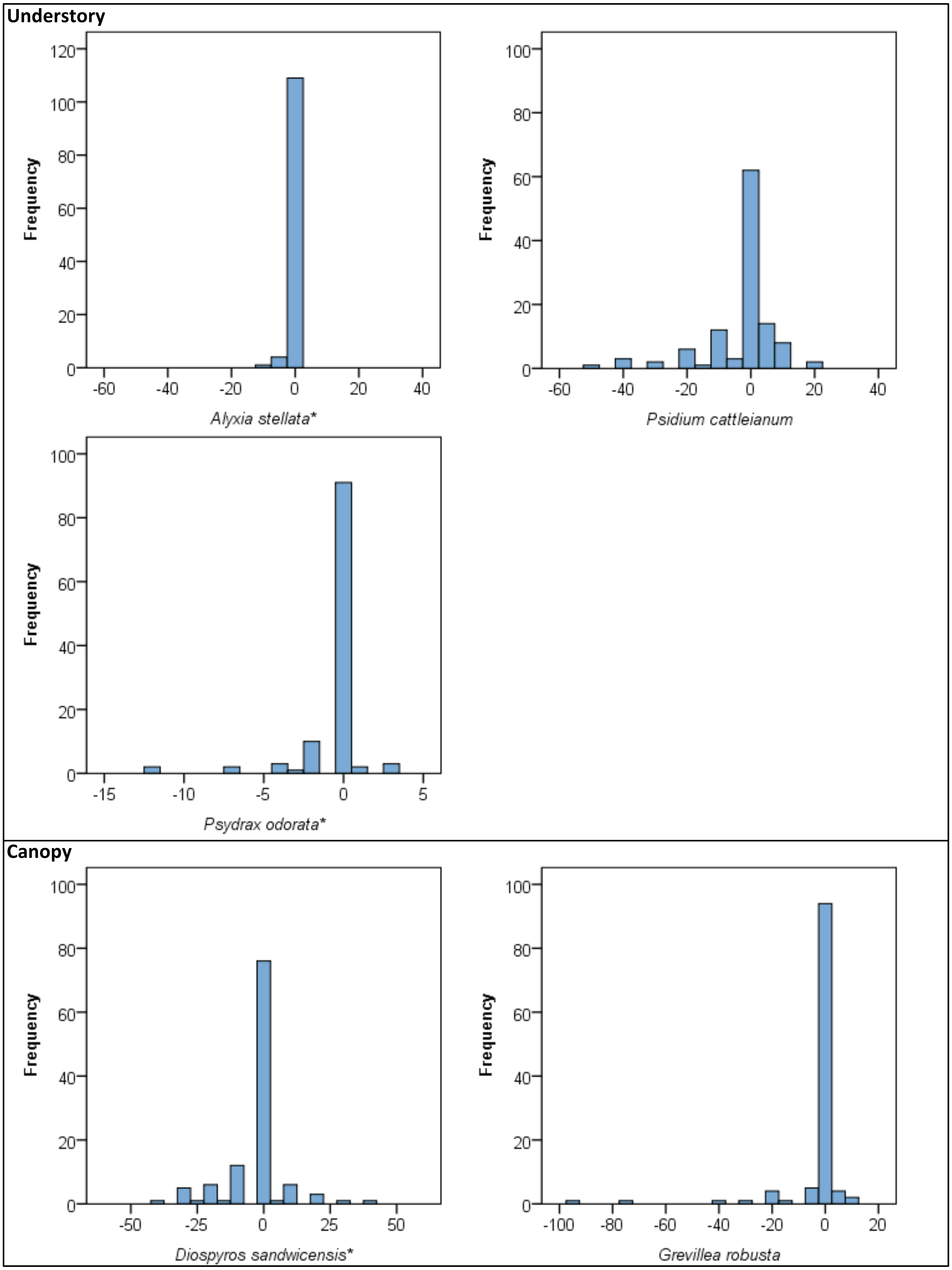


Figure 7. Histograms of percent cover change between 2011 and 2016 at Manuwai, for taxa with significant decreases in cover in the understory and canopy. Values > 0 represent increased cover in plots, while those < 0 represent decreased cover. Values equaling 0 represent no change. *Native taxa.

Canopy replacement

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

Table 7. Summary of canopy tree species recruitment in the understory during 2016 Manuwai MU monitoring, in order of most to least frequent. Frequency represents the percent occurrence of tree species with a maximum height < 2 meters (seedlings to small trees) among plots (n = 148). Native species are in boldface. *Rare taxa. **Target weed taxa.

Species	Freq.	Species	Freq.	Species	Freq.
Psidium cattleianum	71.1	*Aleurites moluccana*	7.0	***Chrysodracon halapepe***	1.8
*Toona ciliata***	48.2	*Spathodea campanulata***	6.1	*Cordyline fruticosa*	1.8
Diospyros sandwicensis	34.2	*Leucaena leucocephala*	5.3	*Cupressus lusitanica*	1.8
Schinus terebinthifolius	28.9	***Metrosideros polymorpha***	5.3	***Nestegis sandwicensis***	1.8
Psydrax odorata	28.1	***Pipturis albidus***	5.3	***Psychotria mariniana***	1.8
*Syzygium cumini***	25.4	***Wikstroemia oahuensis***	5.3	*Acacia confusa***	0.9
Dodonaea viscosa	16.7	*Schefflera actinophylla***	4.4	***Charpentiera ovata***	0.9
Grevillea robusta	14.0	***Eugenia reinwardtiana***	3.5	***Freycinetia arborea***	0.9
Sapindus oahuensis	13.2	*Melia azedarach***	3.5	***Labordia kaalae****	0.9
Diospyros hillebrandii	11.4	*Buddleja asiatica*	2.6	***Pisonia brunoniana***	0.9
Coffea arabica	8.8	***Acacia koa***	1.8	***Pittosporum confertiflorum***	0.9
Psidium guajava	8.8	***Charpentiera obovata***	1.8	***Psychotria hathewayi***	0.9

Weed control

Weed control efforts at Manuwai between the 2011 and 2016 monitoring intervals included approximately 966 person hours. The total amount of effort varied among the fourteen weed control areas (WCA) that encompass the MU, ranging from 0 to 334.25 hours per WCA. Three WCAs were not weeded during that time interval. Between the 2011 and 2016 monitoring intervals, 22.9% of the MU was weeded. The majority of the area weeded is attributable to IPA control (IPA control occurred across 19.5% of the MU, whereas general ecosystem weeding encompassed only 3.7% of the MU). Weed control efforts crossed through 40% of the plots between the 2011 and 2016 monitoring intervals (39% fell within IPA control areas, 3.5% were within areas with general ecosystem weeding) (Figure 8). Due to the prevalence of steep and inaccessible areas, the uppermost elevations received very little weeding, and included only a small number of monitoring plots, thus the higher proportion of plots weeded as compared with the proportion of the MU weeded.

Nine out of the 22 target weed species (taxa of special concern for weed management, including incipient species) for Manuwai MU (OANRP 2011) were identified during monitoring, and at least one target taxa was present in 89% of the monitored plots in either the understory or canopy. These included two widespread target taxa (*T. ciliata* and *S. cumini*), and 7 less common target species (*Acacia confusa, Melia azedarach, Pterolepis glomerata, Schefflera actinophylla, Spathodea campanulata, Triumfetta semitriloba* and *Urochloa maxima*) (Figure 9). Of these, only *T. ciliata* had a high frequency, occurring in 68% of the plots. One new incipient non-native taxa of concern, *Angiopteris evecta*, was identified one plot.

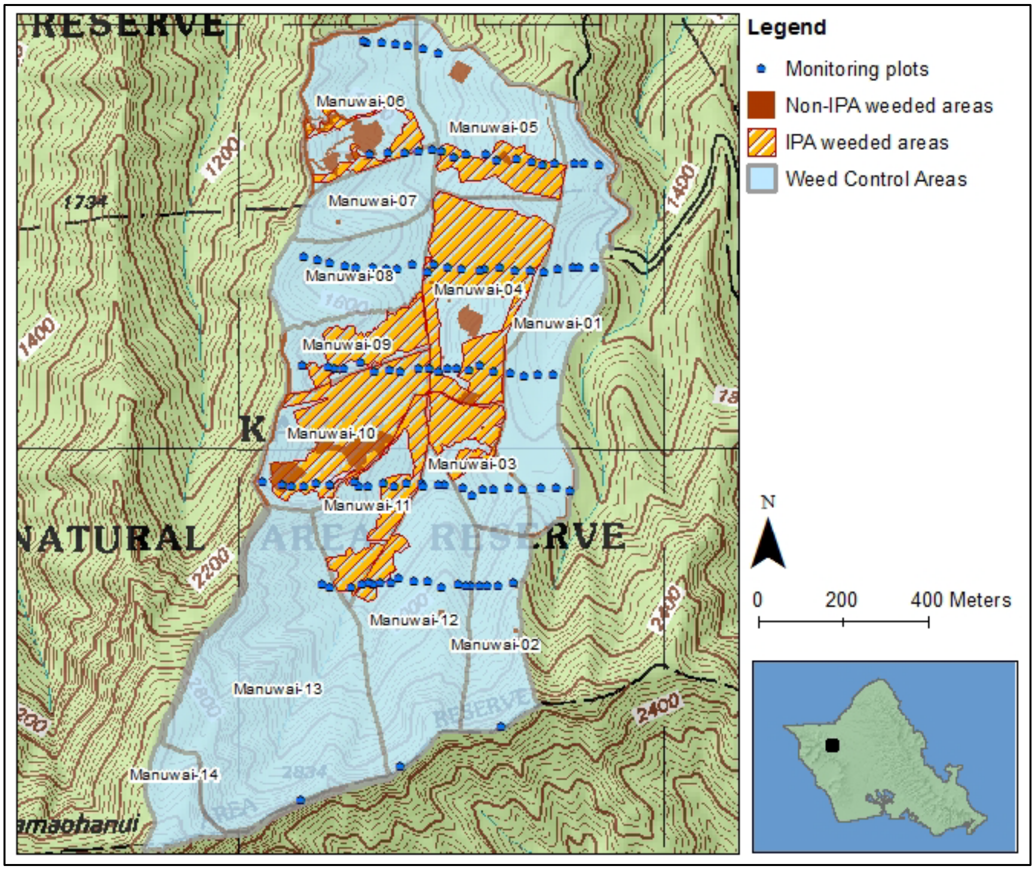


Figure 8. Locations of vegetation monitoring plots at Manuwai MU in relation to weed control areas (WCA) and areas weeded (showing locations with or without IPA control) between the 2011 and 2016 monitoring intervals.

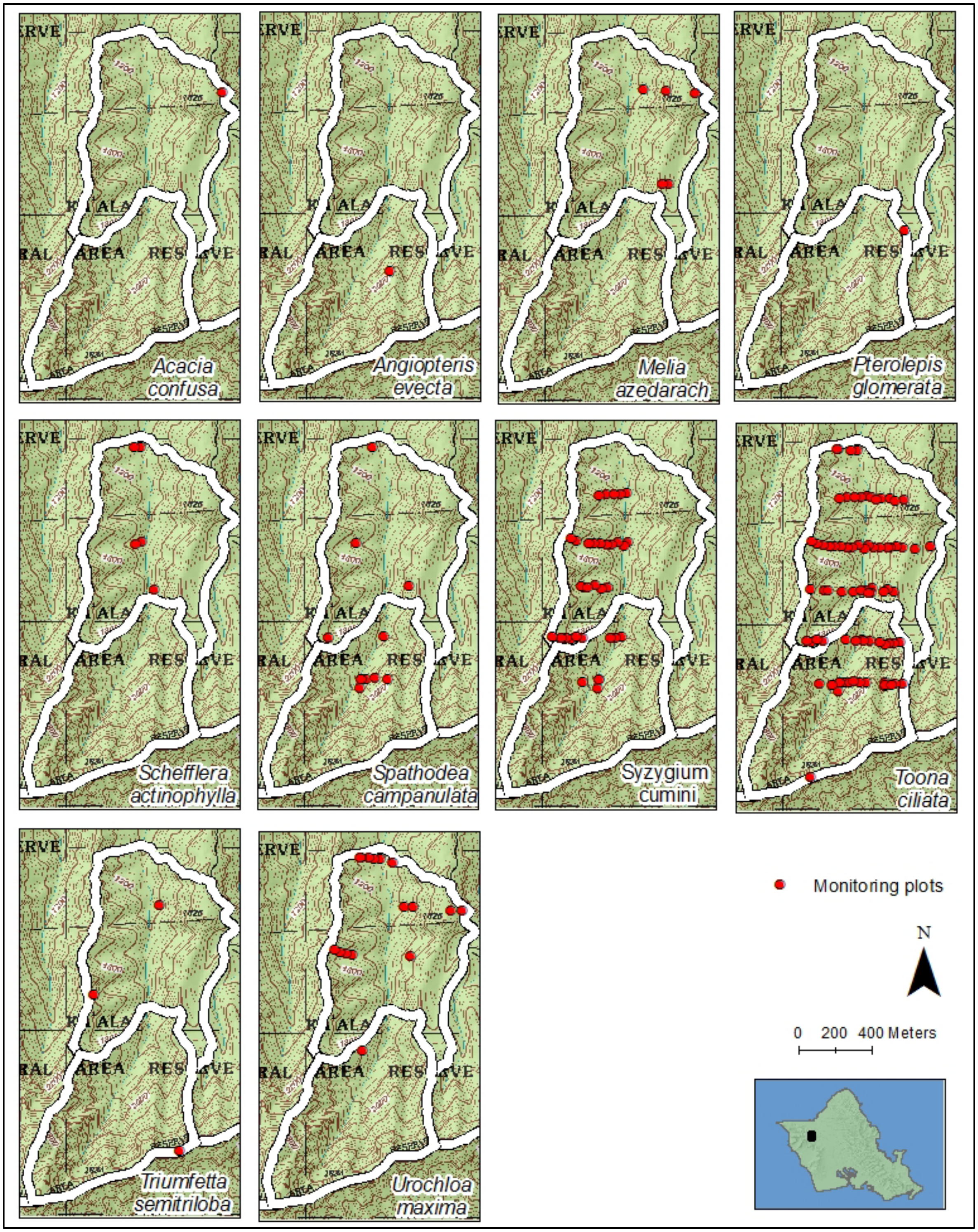


Figure 9. Locations of target taxa and new incipient taxa (*Angiopteris evecta*) in the understory and/or canopy among plots in Manuwai MU in 2016.

In order to discern the impacts of weeding efforts, vegetation percent cover was further scrutinized to examine change in weeded (n = 46) vs. unweeded (n = 68) plots for the native and non-native understory and canopy, as well as canopy *T. ciliata* and *G. robusta*, which were primary IPA target taxa. There was a significant decline in native understory cover both in weeded and unweeded plots (Table 8 and Figure 10). Understory weed cover increased significantly in weeded plots, but not in unweeded plots. There was a significant increase in non-native canopy cover in unweeded plots, but not in weeded plots. No significant change occurred in native canopy cover in either weeded or unweeded plots. There was a significant reduction in *G. robusta* canopy cover among weeded plots but not in unweeded plots. Canopy cover of *T. ciliata* increased significantly in unweeded plots, but there was no difference in weeded plots.

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

Table 8. Percent cover change in weeded (n = 46) and unweeded (n = 68) plots at Manuwai from 2011 to 2016 for taxon groupings and IPA target taxa. Median values for percent cover in 2011 and 2016 are represented. Statistically significant values are in boldface (Wilcoxon signed-rank test). Arrows indicate increase (↑) or decrease (↓) in cover.

	Plots outside weeded areas				Plots inside weeded areas			
	Cover (%)				Cover (%)			
	2011	2016	p	Z	2011	2016	p	Z
Native understory	7.5	5.3	**0.002↓**	-3.041	3.0	3.0	< **0.001↓**	-3.880
Non-native understory	55.0	65.0	0.203	-1.272	45.0	65.0	**0.013↑**	-2.479
Native canopy	15.0	20.0	0.972	-0.035	25.0	15.0	0.054	-1.928
Non-native canopy	70.0	85.0	**0.002↑**	-3.170	85.0	95.0	0.238	-1.181
Grevillea robusta	0.0	0.0	0.436	-778.000	0.0	0.0	**0.015↓**	-2.426
Toona ciliata	0.0	5.0	**0.007↑**	-2.680	5.0	5.0	0.674	-0.421

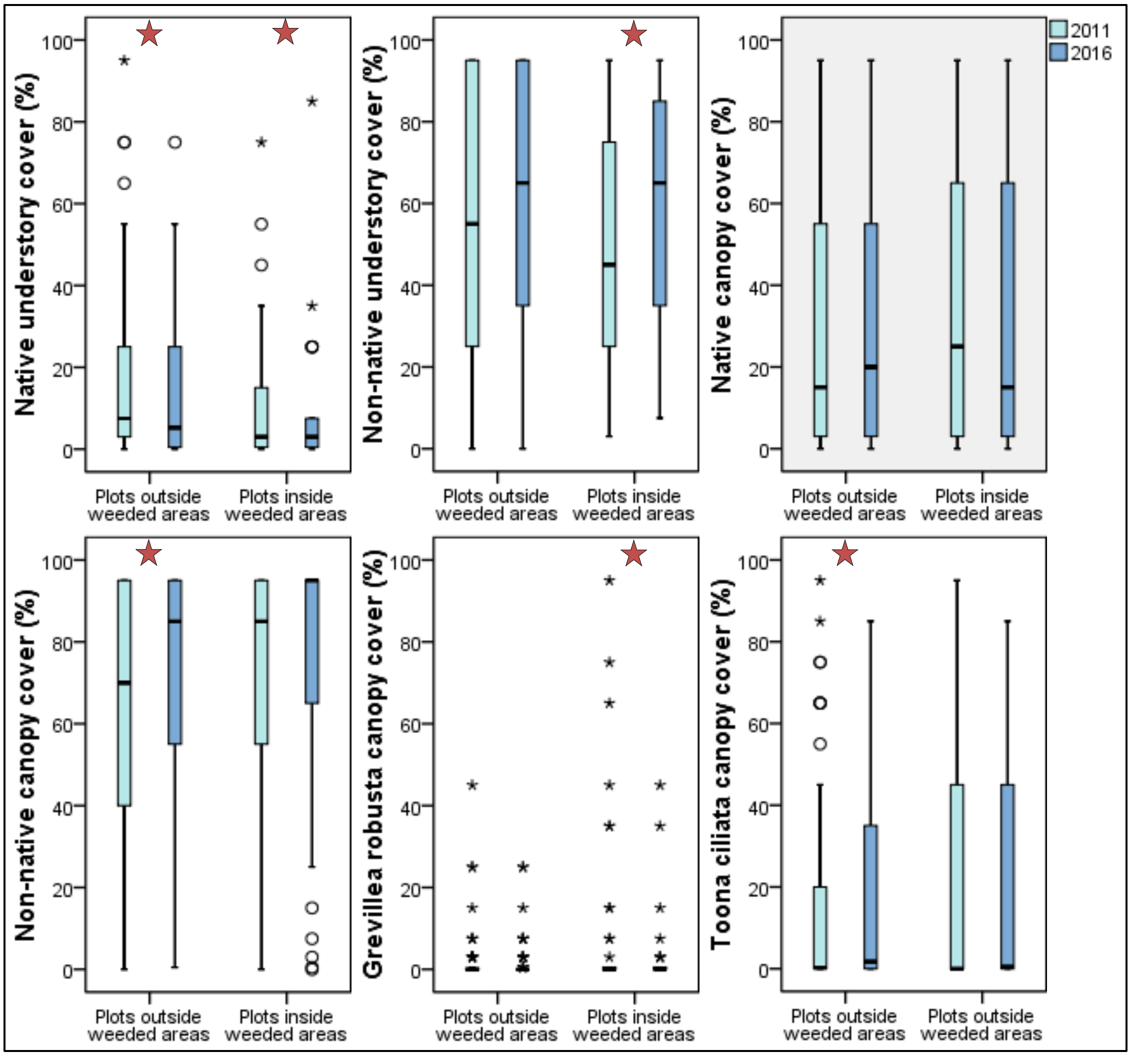


Figure 10. Boxplots of percent cover in plots within (n = 46) vs. outside (n = 68) weeded areas in 2011 and 2016 for taxon groupings and IPA target taxa used in analysis. Stars indicate significant change in cover between 2011 and 2016.

SUMMARY AND DISCUSSION

Management objectives were not met for percent cover of native and non-native understory and canopy vegetation for Manuwai MU. There were a number of noteworthy significant differences in the 2016 data as compared with five years prior, including:

- Increase in non-native understory and canopy cover
- Increase in non-native understory and canopy richness
- Increase in frequency for non-native species:
    - *A. hispidulum* (understory)
    - *C. hirta* (understory)
    - *P. suberosa* (understory)
    - *T. ciliata* (canopy)
- Increase in percent cover for non-native species:
    - *A. hispidulum* (understory)

    - *B. appendiculatum* (understory)
    - *C. hirta* (understory)
    - *O. hirtellus* (understory)
    - *P. cattleianum* (canopy)
- Decrease in percent cover for non-native species:
    - *P. cattleianum* (understory)
    - *G. robusta* (canopy)
- Decrease in percent cover for native species:
    - *A. stellata* (understory)
    - *P. odorata* (understory)
    - *D. sandwicensis* (canopy)
- Percent cover change in weeded plots:
    - Decrease in native understory and *G. robusta* (canopy)
    - Increase in non-native understory
- Percent cover change in unweeded plots:
    - Decrease in native understory
    - Increase non-native canopy and *T. ciliata* (canopy)

Most of the vegetation change that occurred between 2011 and 2016 indicated worsening conditions, with increases in non-native cover, richness and frequency, and declines in some native taxon cover. Given the high level of non-native canopy cover in the MU, management goals of < 50% cover may be unrealistic across the MU. Refinement of management goals to apply specifically to prioritized areas (those with greater potential for restoration) within the MU may result in goals that are more likely to be successfully accomplished. Manuwai MU is challenging to manage, given access limitations during inclement weather, and difficulties associated with working in very steep terrain.

Impacts of weeding efforts were primarily attributed to IPA control of *G. robusta* and *T. ciliata*. These efforts were effective for reduction of canopy *G. robusta* within weeded areas. The pervasiveness of *T. ciliata* throughout the MU presents a considerable management challenge. The significant increase in canopy *T. ciliata*, as well as non-native canopy cover in general, in plots outside, but not inside, weeded areas suggest IPA efforts may be preventing canopy cover increases for that taxon and for non-native cover in general within treated areas. *Toona ciliata* frequency increase in the canopy may be explained in part by vertical growth of individuals that were in the understory in 2011, but reached the canopy by 2016. Because IPA efforts focus on larger individuals in efforts to minimize primary seed sources, the continued presence of smaller individuals within the canopy is to be expected. The prevalence of *P. cattleianum* and smaller individuals of the targeted taxa in the lower reaches of the canopy could potentially mask impacts of canopy reduction via IPA. The increase in non-native understory cover in weeded plots may have been a response to the creation of light gaps in the canopy resulting from IPA treatment. The decline in native understory cover in weeded areas had a similar pattern in unweeded areas, and was not likely influenced by IPA efforts.

Natural resource management staff anecdotally observed increased cover of *Urochloa maxima* in Subunit II within the last year, and expressed concerns that IPA control efforts may exacerbate the problem (Figure 11). Though the frequency of this taxon was too low for statistical analyses, it did appear in more plots in 2016 (in 14% of plots) than in 2011 (in 11% of plots), and cover increased in over half of the plots in which it was observed in 2011, while none had reduced cover.

Figure 11. Photograph showing dense *Urochloa maxima* understory cover in a monitoring plot at Manuwai. Natural resource management technician, Christopher Lum, is uncharacteristically frowning.

RECOMMENDATIONS

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

- designate prioritized areas for management
- refine management goals to focus on prioritized areas
- more aggressive weed control paired with restoration efforts in prioritized areas
- target uncommon weeds when seen (particularly target taxa)
- continue IPA efforts within areas already treated, as *T. ciliata* and *G. robusta* grow to the targeted size/stage, and expand efforts into new areas, including higher elevations with more native cover
- monitoring of understory change in direct association with IPA treatments (via a separate monitoring regime) may be done to better understand it's impact on native and non-native understory cover
- continued discussion and assessment of costs associated with worsening understory conditions resulting from the creation of light gaps associated with large scale IPA canopy removal vs. benefits of controlling IPA target taxa
- aerial spraying of *U. maxima*

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OAHU ARMY NATURAL RESOURCES PROGRAM
MONITORING PROGRAM

EFFICACY OF *CENCHRUS SETACEUS* CONTROL WITHIN THE AERIAL SPRAY ZONE AT MAKUA MMR BETWEEN 2012 AND 2016

INTRODUCTION

Following the discovery of an outbreak of *Cenchrus setaceus* (syn. *Pennisetum setaceum*) on steep ridges and cliffs at Makua MMR, the Oahu Army Natural Resources Program (OANRP) began herbicide treatment using aerial ball sprays and ground control on Army land in 2012 (Figure 1). Due to high fire threat associated with this species as well as its ecosystem altering characteristics, it is on the Hawaii Noxious Weed List, considered a high risk weed species (Division of Plant Industry 2003; Hawaii-Pacific Weed Risk Assessment 2009), and a high priority for extirpation by OANRP. Hundreds of plants were identified in 2012, and as plants still remain as of June 2016, control is ongoing. An aerial spray control area was established, with a management strategy to first treat the core infestation with aerial sprays, and secondarily treat all of the defined aerial spray zone. Follow-up treatment in the core, where accessible, was conducted from the ground. An analysis was conducted to examine the efficacy of control efforts within the aerial spray control area using GigaPan® imagery.

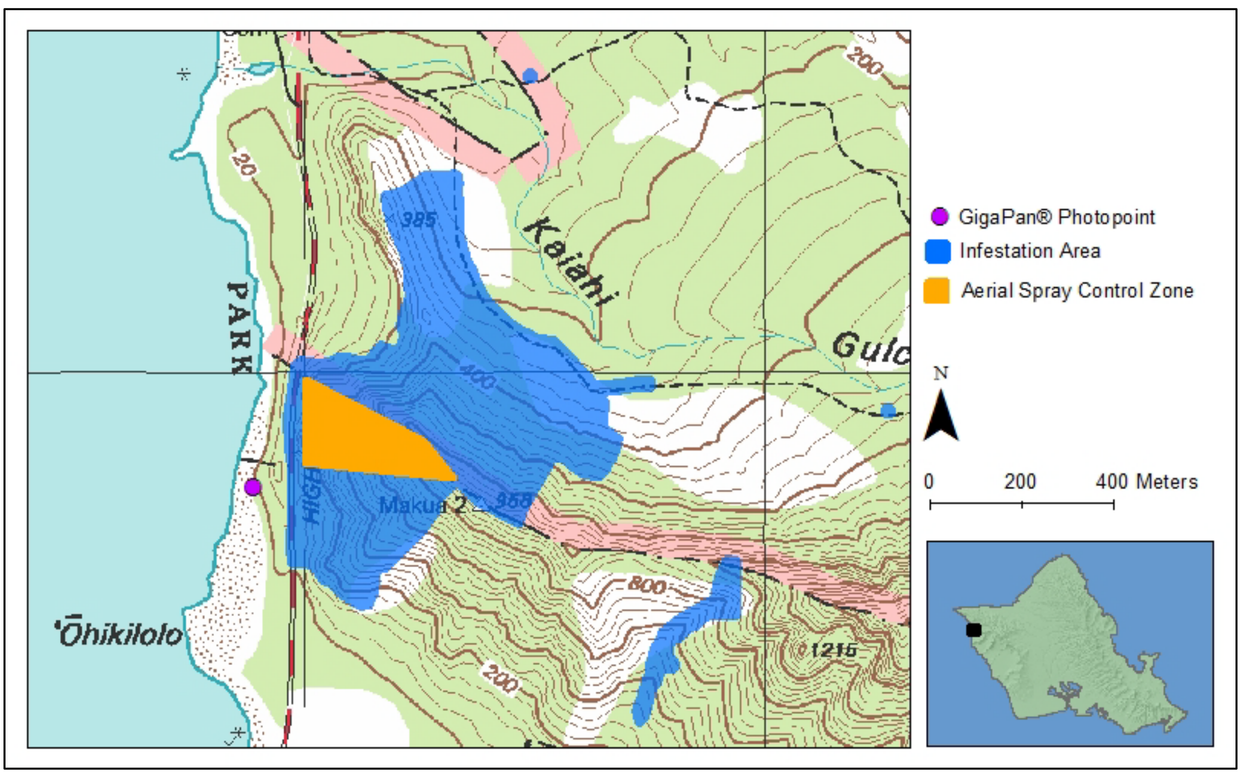

Figure 1. Map showing the location of the aerial spray control zone within the *Cenchrus setaceus* infestation at Makua MMR, and the location of the GigaPan® photopoint used in the analysis.

METHODS

Efficacy of *C. setaceus* control at Makua MMR was analyzed using gigapixel panoramic imagery (www.gigapan.com) of a portion of the aerial spray zone that included the core infestation and as well as surrounding less densely infested areas. Panoramic imagery was obtained using a GigaPan Epic 100 robotic mount fitted with a Canon PowerShot SX30 IS digital camera, between February 2012 and June 2016. Panoramas were stitched using GigaPan Stitch Version 2.1.0161. With this imagery, individual *C. setaceus* plants were identifiable by enlarging selected areas within the panorama (Figure 2). Seven macroplots within one panoramic view were used to count numbers of plants within the core infestation area over time, as a measure of the reduction of population within the most densely colonized region (Figure 3). Macroplots encompassed the majority of the core infestation area. Numbers of plants were similarly counted in seven additional plots outside of the core infestation, to assess population reduction in the surrounding lower density areas. Macroplots sampled roughly half of the low density area visible within the GigaPan® imagery. Friedman's test was used to analyze change over time within plots. Statistical analyses were performed in IBM SPSS Statistics Version 24.

Figure 2. Enlarged portion of GigaPan® image showing live and dead (successfully treated – plants are straw colored) *Cenchrus setaceus* within the core infestation area. Live plants appear bluish in color, as they were just treated with blue-dyed herbicide.

Figure 3. GigaPan® image showing a portion of the *Cenchrus setaceus* aerial control treatment area at Makua MMR, May 2013. Locations of macroplots used to analyze control efficacy are depicted with orange (core infestation area) and blue (low density areas) rectangles. Dead plants (straw-colored) are visible within the core infestation area.

RESULTS

Since *Cenchrus setaceus* was first discovered and treatment initiated on Army land in 2012, the number of plants within the core infestation area declined significantly (Friedman's test: $p < 0.001$) by 78% as of June 2016 (Figure 4). While counts of plants in the adjacent low density areas remained low, there was no significant population reduction (Friedman's test: $p = 0.249$) in those areas.

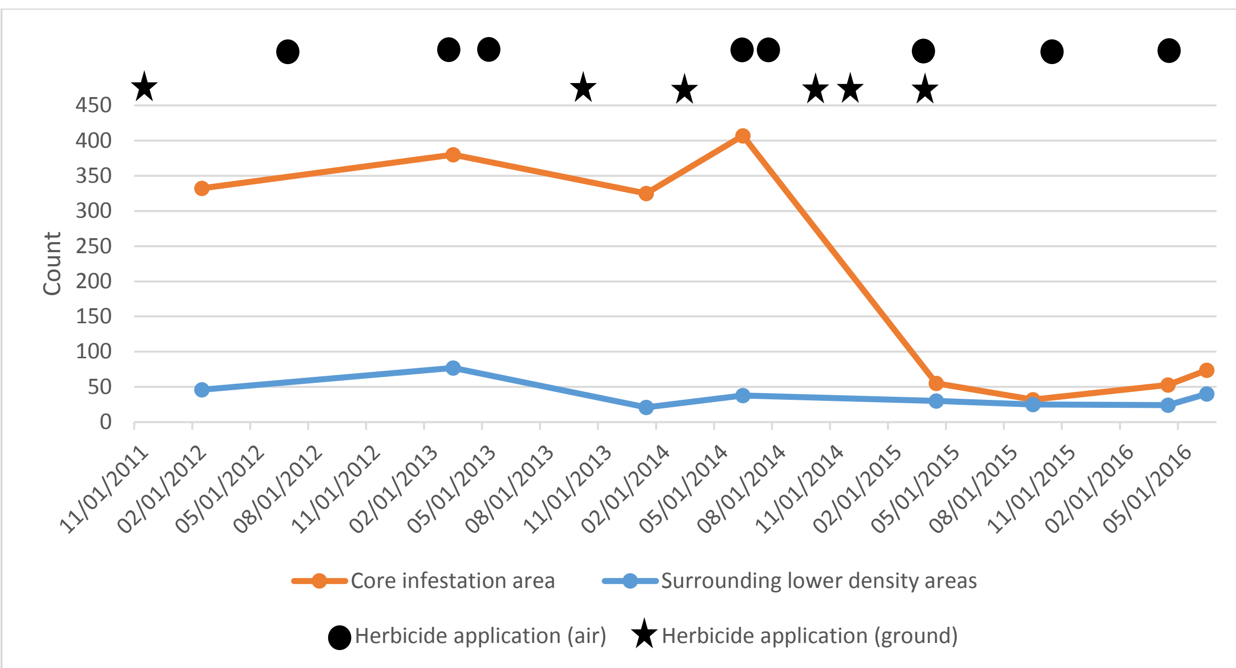

Figure 4. *Cenchrus setaceus* population change over time in macroplots within core infestation (n = 7) and surrounding low density areas (n = 7) at Makua MMR, with herbicide application dates (helicopter and ground sprays) indicated. Counts are combined total numbers of plants visible within all macroplots.

DISCUSSION

The marked reduction in numbers of plants in the core infestation area suggests significant declines within a matter of a few years are achievable for dense populations of *C. setaceus* with hundreds of individuals. The lack of significant reduction of plants in the monitored area adjacent to the core reaffirms the importance of addressing isolated plants and those remaining in low densities. Eradication cannot be achieved without consistent control of the entire infestation. Control of *C. setaceus* within the aerial spray zone at Makua MMR is challenging due to the steep nature of the terrain. Despite these challenges, considerable progress in controlling the core infestation has been accomplished, and efforts may now focus on controlling all plants within the aerial spray zone.

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OAHU ARMY NATURAL RESOURCES PROGRAM
MONITORING PROGRAM

POINT INTERCEPT MONITORING OF UNDERSTORY VEGETATION IN ASSOCIATION WITH IPA CONTROL OF *MORELLA FAYA* AT PALIKEA: RESULTS OF BASELINE MONITORING, 2016

INTRODUCTION

Incision Point Application (IPA) herbicide treatment of problematic non-native trees allows 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 Hawaii Noxious Weed List, and considered a high risk weed species (Division of Plant Industry 2003; Hawaii-Pacific Weed Risk Assessment 2009). Vegetation monitoring of Palikea 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) (OANRP 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 were selectively treated using IPA on November 3-4, 2015 at Palikea, including approximately 116 trees within the MU fence, and 81 outside the fence (Figure 1). 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 IPA treatment of *M. faya* will be documented using point intercept monitoring of a subset of treated trees within Palikea MU. Initial baseline monitoring was conducted within the first few months (December 9 and 14, 2015, and January 6, 2016) following treatment, before substantial canopy reduction and any resulting understory response occurred. Subsequent monitoring of the same trees will occur after one year. Additional monitoring will occur as deemed relevant.

METHODS

Point intercept monitoring was used to assess percent cover of native and non-native taxa in the understory directly below treated *M. faya* trees within Palikea MU. All species “hit” at points along transects were recorded for understory vegetation. A 5 millimeter diameter, 6 foot tall pole was used to determine “hits” in the understory (live vegetation that touches the pole) along an outstretched measuring tape. Point intercepts were recorded at 25 randomly sampled treated trees every meter (m) along 5 m long transects in each cardinal direction from the tree, or alternatively, every 0.5 m along two 5 m long transects oriented North and South, or East and/or West or if slopes were too steep to the North or South (n = 500 points). Using two transects with more closely spaced point intercepts per tree was an effective attempt to expedite the data collection process, as monitoring took longer than expected using four transects with fewer point intercepts per tree. The same methods will be replicated in subsequent monitoring. Substrate in locations where no vegetation was intercepted in the understory was recorded as soil/leaf litter, rock, moss, etc. Trees were marked (with a combination of yellow and orange-black striped flagging) and tagged with unique identification numbers. Approximations of percent cover were obtained from the proportion of “hits” among all intercepts. The overall health (noted as healthy, moderate, poor, 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) were also documented to assess treatment efficacy. Hemispheric photographs

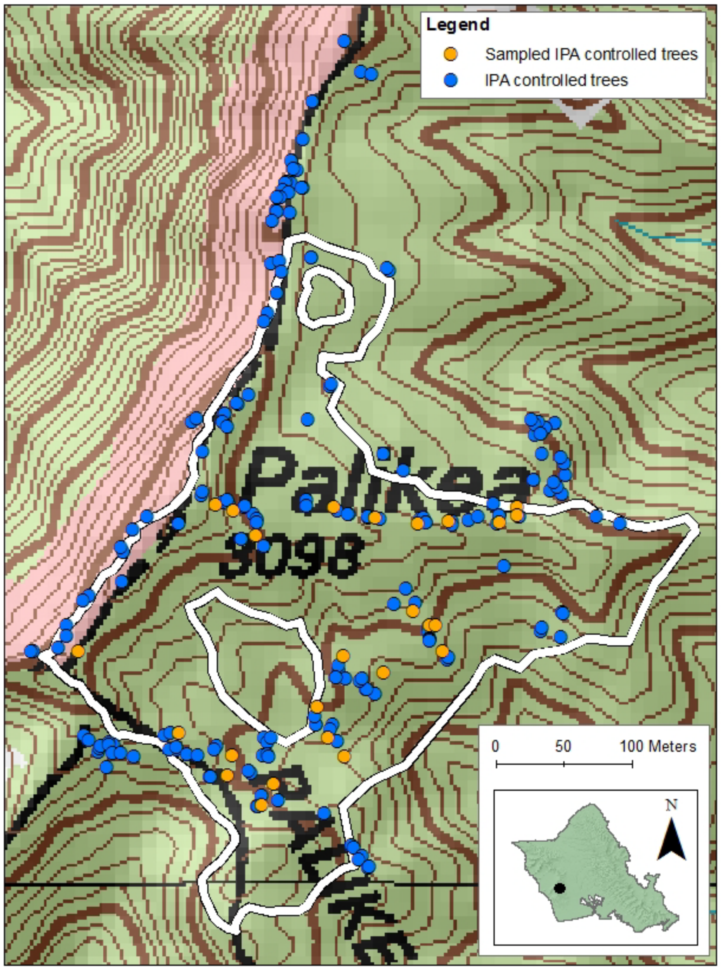

Figure 1. Location of IPA controlled *Morella faya* at Palikea, including locations of trees sampled for monitoring associated understory vegetation response.

(medium effect level) were taken of the canopy on the south-facing side of each sampled tree to document canopy openness. Photographs were taken at 2 m above ground level, aimed 180° from the forest floor. Gap Light Analyzer (GLA), Version 2.0 software (Frazer et al. 1999) was used to analyze percent canopy openness, using the hemispheric canopy photographs.

RESULTS

Understory vegetation cover beneath the sampled IPA controlled *M. faya* trees at Palikea included 47.6% native taxa, 44% non-native taxa, and 26.6% non-vegetated area (Table 1). The most prevalent non-native taxa were *Clidemia hirta* (15.6%), *Morella faya* (6.8%, consisting primarily of portions of the sampled trees), *Rubus rosifolius* (6.4%), and *Blechnum appendiculatum* (6.2%) (Table 2). Predominant native taxa included *Nephrolepis exaltata* subsp. *hawaiiensis* (10.8%), *Dicranopteris linearis* (8.6%), and *Cibotium chamissoi* (5.2%).

Most sampled *M. faya* trees were beginning to show signs of declining health (5 healthy, 15 moderate, 5 poor), wherein leaves were browning and/or beginning to defoliate. All trees had some degree of defoliation, with a median ranking of 3 (< 50% defoliation). Mean canopy openness was 17.7%.

Table 1. Baseline percent cover of native and non-native vegetation in the understory below IPA treated *Morella faya* at Palikea MU.

	Cover (%)
Native	47.6
Non-native	44
Non-vegetated	26.6

Table 2. Baseline percent cover of native and non-native taxa in the understory below IPA treated trees at Palikea MU. Native taxa in boldface

Taxa	Cover (%)	Taxa	Cover (%)
Clidemia hirta	15.6	*Melinis minutiflora*	0.6
Nephrolepis exaltata* subsp. *hawaiiensis	10.8	***Peperomia membranacea***	0.6
Dicranopteris linearis	8.6	***Asplenium caudatum***	0.4
Morella faya	6.8	***Cheirodendron trigynum***	0.4
Rubus rosifolius	6.4	*Cyclosorus parasiticus*	0.4
Blechnum appendiculatum	6.2	***Diplopterygium pinnatum***	0.4
Cibotium chamissoi	5.2	***Doodia kunthiana***	0.4
Ehrharta stipoides	4.8	***Dryopteris sandwicensis***	0.4
Microlepia strigosa	4.2	***Elaphoglossum aemulum***	0.4
Passiflora suberosa	3.8	***Nephrolepis cordifolia***	0.4
Paspalum conjugatum	3.2	***Sphenomeris chinensis***	0.4
Dianella sandwicensis	3.0	*Youngia japonica*	0.4
Psidium cattleianum	2.8	***Antidesma platyphyllum***	0.2
Asplenium macraei	2.2	***Athyrium microphyllum***	0.2
Dryopteris glabra	2.2	***Broussaisia arguta***	0.2
Asplenium contiguum	2.0	***Carex wahuensis***	0.2
Diplazium sandwichianum	1.8	***Coprosma foliosa***	0.2
Metrosideros polymorpha	1.8	*Cyclosorus dentatus*	0.2
Alyxia stellata	1.6	***Cyrtandra waianaeensis***	0.2
Kadua acuminata	1.2	***Elaphoglossum alatum***	0.2
Elaphoglossum paleaceum	1.0	***Melicope oahuensis***	0.2
Freycinetia arborea	1.0	***Pipturis albidus***	0.2
Elaphoglossum crassifolium	0.8	***Vaccinium reticulatum***	0.2
Pittosporum confertiflorum	0.8	***Viola chamissoniana* subsp. *tracheliifolia***	0.2
Deparia petersenii	0.6	***Wikstroemia oahuensis* var. *oahuensis***	0.2
Kadua affinis	0.6		

DISCUSSION

Vegetation monitoring of understory response to IPA control of *M. faya* will provide useful information regarding the extent to which native and non-native cover changes in association with large scale removal of this prevalent canopy species. While data collected from a control group consisting of untreated *M. faya* would have been ideal for use in interpreting change as a direct result of IPA treatment, it was impractical for this project, given the initial plans for subsequent treatment of all *M. faya* in the MU. Results of on-going MU monitoring at Palikea will provide supplemental data that may be used in comparison with any understory vegetation changes at sampled IPA treated trees. E.g., if understory cover changes below sampled trees differs from those on an MU scale (excluding plots with treated *M. faya*), there may be greater confidence that the observed changes at IPA controlled trees are in response to the treatment rather than to other unrelated factors occurring throughout the MU. Vegetation monitoring for Palikea MU in 2014 had similar results to those reported here, with native and non-native understory and non-vegetated cover approximately 10% lower than the baseline cover beneath the sampled IPA treated trees (OANRP 2014). Identical results were not expected, as the sampled areas associated with this project are not necessarily representative of the entire MU.

Though many trees were beginning to show signs of declining health and some degree of defoliation, it is not believed that there was time for any substantial change in understory cover in response to changing light levels during the one to two months' time between treatment and baseline vegetation monitoring. Dying trees retain dead leaves for some time, such that changes in light levels are not immediate. Anecdotal observations several months after baseline monitoring occurred suggest canopy defoliation is well underway, and differences in canopy openness, and possibly in understory cover, are expected for the subsequent monitoring one year post-treatment (Figure 2).

Figure 2. Photograph of Palikea showing defoliation in association with IPA treated *Morella faya* and *Cryptomeria japonica*, March 31, 2016.

Monitoring was intended to take one to two days to complete, however three days were necessary for completion. Locating random pre-selected trees was more time consuming than anticipated, as the initial GIS accuracy was somewhat poor. Subsequent re-monitoring is anticipated to require less field time, due to the installation of flagging and tags, and higher accuracy GIS data taken for each sampled tree during baseline monitoring. Efforts should be made to streamline the sampling process for future IPA monitoring projects.

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OAHU ARMY NATURAL RESOURCES PROGRAM
MONITORING PROGRAM

A TRIAL TO ASSESS THE RATE AND EXTENT OF SEED GERMINATION REDUCTION DURING *CYANEA SUPERBA* SUBSP. *SUPERBA* FRUIT SENESCENCE

INTRODUCTION

Limited dispersal and recruitment of *Cyanea superba* subsp. *superba* occurs at reintroduced populations managed by the Oahu Army Natural Resources Program (OANRP), with the majority of fruits either depredated by rats (seeds are destroyed), or rotting on the plant and falling to the ground with limited subsequent seed germination and seedling survival, despite having typically high seed germination rates in fresh mature fruit (Pender et al. 2013, OANRP 2016a, OANRP 2016b, pers. obs.). Several factors may limit successful recruitment, including microsite specificity, predation of seedlings by slugs, soil moisture, light availability and fruit senescence. In order for OANRP to achieve goals of long term self-sustaining *C. superba* subsp. *superba* populations, these issues must be taken into consideration. Should self-sustainment be ineffective, populations will require on-going replacement via outplanting or seed sowing. Preliminary investigations suggest that germination rates are reduced in *Cyanea superba* subsp. *superba* senesced (mean germination 39.7%, sd 20.6) vs. fresh fruits (mean germination 86.2%, sd 20.3) (n = 10) (OANRP 2015). The degree of senescence was not quantified, but was estimated to be less than 1 week following peak maturation. The reduced germination in seeds from senesced fruit limits recruitment potential in the absence of dispersers, as fresh mature fruits that are not consumed by dispersers will senesce and fall to the ground, and subsequently have reduced potential for germination. This trial explores two questions to gain a more precise understanding of recruitment limitations in association with fruit senescence. What is the rate of decline in seed germination as *C. superba* subsp. *superba* fruits senesce, and at what point are seeds no longer viable? A laboratory trial was conducted to examine these questions as a means of exploring the ability of seeds from progressively senescing fruit to germinate over time.

METHODS

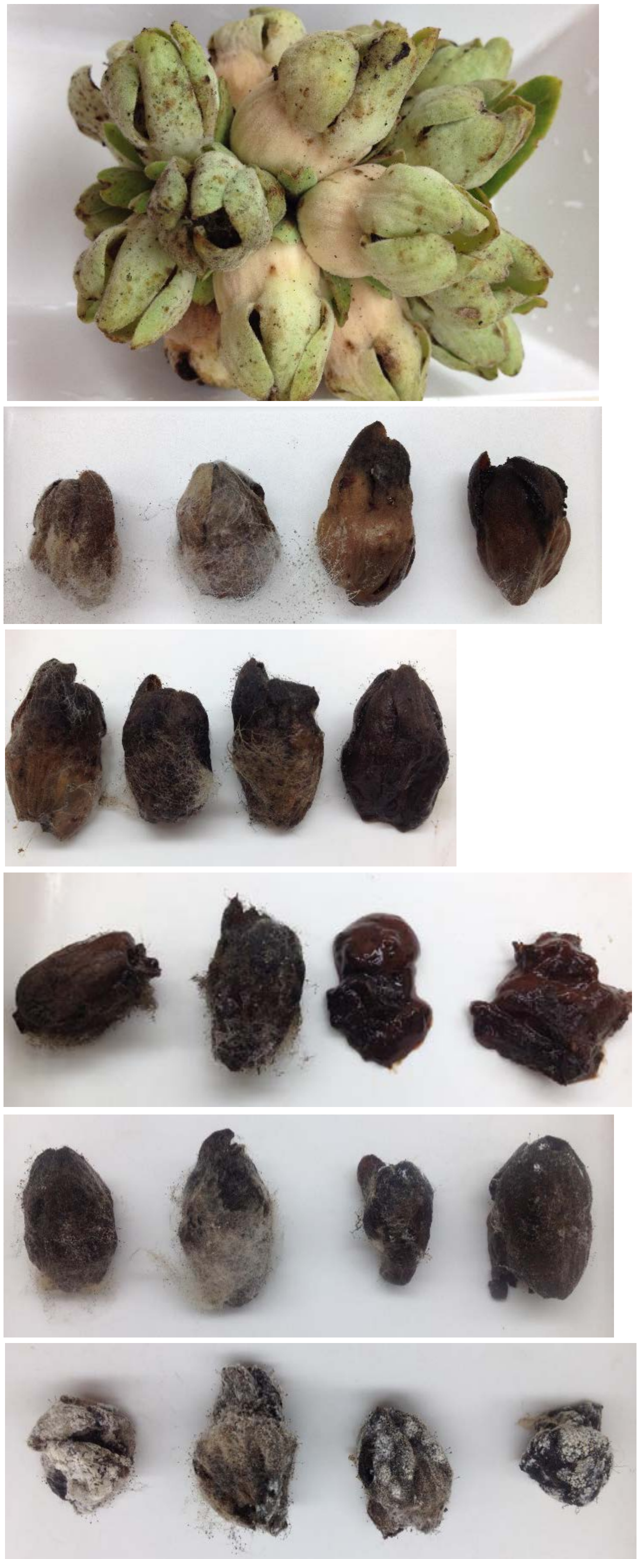
Fresh mature *C. superba* subsp. *superba* fruits were collected from Pahole Management Unit (MU) in December 2015 (Figure 1). A total of 24 fruits were collected from infructescences (not from the ground) from six individuals. Fruits were cleaned and stored individually in a clear plastic container (containing a moist sponge to maintain humid conditions) at ambient room temperature at the OANRP seed lab. Seeds from four randomly chosen fruits were sown twice a week for three weeks, beginning on the collection date, for a total of six viability assay dates. Seeds were sown on agar in petri dishes, including 40 - 50 seeds per fruit (1153 seeds total). Petri dishes were stored in a Percival Controlled Environment Chamber (with diurnal light and temperature settings matching average monthly temperatures for the Nike missile installation at Pahole, at approximately 2100 feet elevation), and examined weekly for germination for a total of 10 weeks. Germination rates (using mean rates among replicates) were compared using ANOVA with post-hoc Tukey's pairwise comparisons in IBM SPSS Statistics Version 24.

Map removed to protect rare resources. Available upon request

Figure 1. Location of *Cyanea superba* subsp. *superba* fruit collection at Pahole MU.

RESULTS

Seed viability differed significantly among fruits allowed to senesce between 0 and 19 days (ANOVA: $P < 0.001$, $F = 9.602$). Fruits began visible rotting quickly (Figure 2), and while seed germination rates were relatively high among seeds sown from fresh fruit, viability was much lower (less than half that of the fresh material) for seeds sown from fruits allowed to senesce for 5 to 12 days (Figure 3). No germination occurred in seeds from fruit that senesced for 15 to 19 days. Seed viability did not decline at a steady rate in accordance with increasing numbers of days senesced. Post-hoc pairwise comparisons between groups revealed seed viability from fresh fruit differed from that of senesced fruit, but there were no differences between days among the senesced fruits. Viability was wide-ranging among individual sampled fruits that senesced between 8 and 12 days, with a single fruit having a seed germination rate of 74% after senescing for 12 days.



Day 1 (fresh)

Day 5 sample

Day 8 sample

Day 12 sample

Day 15 sample

Day 19 sample

Figure 2. Photographs of fresh *Cyanea superba* subsp. *superba* fruit and sampled fruit allowed to senesce for 5 to 19 days.

Figure 3. Mean germination rates of *Cyanea superba* subsp. *superba* seeds from fruit allowed to senesce for 0 to 19 days prior to sowing. Letters denote significant Tukey's pairwise differences between groups.

DISCUSSION

Limitations in *Cyanea superba* subsp. *superba* recruitment cannot be attributed to an inability of the plants to produce viable seeds, as indicated by high seed germination rates that occur among fresh fruit. However, the marked decline in seed germination from fruit that senesced for one to two weeks, followed by a total loss of viability after two weeks of fruit senescence, suggests a potential hindrance to recruitment in the event that fresh seeds are not dispersed by frugivores.

The mechanism responsible for the decline in viability remains unknown. Conditions contributing to viability decline may differ among fruit that have fallen to the ground versus those persisting on the plant. While the amount of time that infructescences remain on the plant has not been quantified, persistence has been anecdotally observed to be at least one week (pers. obs.). Seeds from fresh mature fruit remain viable at ambient room temperature in laboratory storage, with germination rates as high as 62% after 12 years at 24C and 10% relative humidity (OANRP 2016b).

Differences among the replicates in seed viability of sown from fruit allowed to senesce for 5-12 days may be attributable to differing degrees of maturity or senescence already underway when fruits were collected. Only what appeared to be fresh, mature fruit were collected, but may have differed in age by a few days, with some slightly immature, and others slightly senesced. Alternatively, factors differentially affecting individual fruits could be attributed to influences by invertebrates. Diverse invertebrates were observed on and in the fruits at the time of collection, and while processing fruits to extract seeds, with live invertebrates persisting inside fruits up to 19 days. There was no visible direct damage to the seeds by invertebrates.

Should effective dispersers not occur at reintroduced populations of *C. superba* subsp. *superba*, supplemental greenhouse propagation and/or human mediated seed dispersal will be necessary for continued population stability. If effective *C. superba* subsp. *superba* dispersers are identified, considerations should be made to incorporate and/or enhance this interaction at new or existing reintroduction sites.

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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 2015	Total Immature 2015	Total Seedling 2015	**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	1	1	0	**1**	**1**	**0**	1	0	0	0	1	0	2016-05-18	Single tree remaining is still alive
Makua	Manage for stability	15	0	0	11	0	0	**6**	**0**	**0**	6	0	0	0	0	0	2016-03-03	Several trees have died in the last year
South Mohiakea	Genetic Storage	16	1	0	2	0	0	**2**	**0**	**0**	2	0	0	0	0	0	2015-06-23	No monitoring in the last year
West Makaleha	Genetic Storage	40	4	0	13	0	0	**13**	**0**	**0**	13	0	0	0	0	0	2015-05-11	Monitoring showed no change, though trees are in poorer health
	In Total:	73	11	0	27	1	0	**22**	**1**	**0**	22	0	0	0	1	0		

Action Area: Out

TaxonName: Alectryon macrococcus var. macrococcus

Target # of Matures: 50   # MFS PU Met Goal: 0 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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	3	5	0	**3**	**5**	**0**	3	0	0	0	5	0	2015-09-10	Need to revisit one more population still
Makaha	Manage for stability	75	0	2	36	0	0	**29**	**0**	**0**	29	0	0	0	0	0	2015-12-03	Several trees have died over the last year
Waianae Kai	Genetic Storage	16	0	0	1	0	0	**0**	**0**	**0**	0	0	0	0	0	0	2016-06-13	Last known tree died
	Out Total:	141	3	2	40	5	0	**32**	**5**	**0**	32	0	0	0	5	0		
	Total for Taxon:	214	14	2	67	6	0	**54**	**6**	**0**	54	0	0	0	6	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 2015	Total Immature 2015	Total Seedling 2015	**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	319	61	79	**255**	**93**	**32**	61	30	19	194	63	13	2015-11-30	Large decline in mature plants at the Kahanahaiki reintro
Kuaokala	Genetic Storage				1	3	0	**1**	**3**	**0**	1	3	0	0	0	0	2014-04-30	No monitoring in the last year
	In Total:	210	66	0	320	64	79	**256**	**96**	**32**	62	33	19	194	63	13		

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 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Central Ekahanui	Manage for stability	20	0	0	168	89	0	**165**	**122**	**52**	60	53	42	105	69	10	2015-09-17	Some mature plants have died and recruitment increases the immature and seedling counts
Makaha and Waianae Kai	Manage for stability	9	3	0	171	128	5	**161**	**128**	**5**	5	7	5	156	121	0	2015-10-14	Some outplants died
South Huliwai	Genetic Storage	27	0	0	15	13	0	**17**	**13**	**23**	17	13	23	0	0	0	2015-09-16	Some recruitment at this site
	Out Total:	56	3	0	354	230	5	**343**	**263**	**80**	82	73	70	261	190	10		
	Total for Taxon:	266	69	0	674	294	84	**599**	**359**	**112**	144	106	89	455	253	23		

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 2015	Total Immature 2015	Total Seedling 2015	**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	**75**	**36**	**0**	6	11	0	69	25	0	2015-08-31	No monitoring in the last year
	In Total:	22	24	0	75	36	0	**75**	**36**	**0**	6	11	0	69	25	0		

Action Area: Out

TaxonName: Cyanea grimesiana subsp. obatae

Target # of Matures: 100 | # MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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	128	22	1	**124**	**17**	**0**	2	1	0	122	16	0	2016-04-07	Some plants died this year
Makaha	Genetic Storage				4	18	0	**13**	**56**	**0**	0	0	0	13	56	0	2016-02-09	More plants were outplanted
North branch of South Ekahanui	Manage reintroduction for stability	5	0	0	83	66	0	**82**	**65**	**0**	0	0	0	82	65	0	2016-05-11	A couple plants died
Palikea (South Palawai)	Manage for stability	3	60	0	108	36	1	**120**	**19**	**1**	7	7	0	113	12	1	2015-10-14	Some more plants matured at the outplanting
	Out Total:	8	60	0	323	142	2	**339**	**157**	**1**	9	8	0	330	149	1		
	Total for Taxon:	30	84	0	398	178	2	**414**	**193**	**1**	15	19	0	399	174	1		

Population Unit Status - Makua Implementation Plan

Action Area: In

TaxonName: Cyanea longiflora

Target # of Matures: 75 | # MFS PU Met Goal: 1 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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	28	244	2	**63**	**196**	**2**	13	18	2	50	178	0	2016-06-02	More outplants matured this year; but populations declined slightly overall
Pahole	Manage for stability	114	0	0	58	104	21	**60**	**18**	**2**	60	18	2	0	0	0	2016-04-04	A thorough census has shown a substantial decline in the immature age class
	In Total:	180	0	0	86	348	23	**123**	**214**	**4**	73	36	4	50	178	0		

Action Area: Out

TaxonName: Cyanea longiflora

Target # of Matures: 75 | # MFS PU Met Goal: 1 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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	110	207	0	**119**	**187**	**0**	7	2	0	112	185	0	2016-06-15	More outplants matured this year; but populations declined slightly overall
	Out Total:	4	0	0	110	207	0	**119**	**187**	**0**	7	2	0	112	185	0		
	Total for Taxon:	184	0	0	196	555	23	**242**	**401**	**4**	80	38	4	162	363	0		

Population Unit Status - Makua Implementation Plan

Action Area: In

TaxonName: Cyanea superba subsp. superba

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 2015	Total Immature 2015	Total Seedling 2015	**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	58	199	113	**48**	**178**	**1**	0	0	0	48	178	1	2016-04-18	Thorough monitoring in the last year showed a decline
Pahole to Kapuna	Manage reintroduction for stability	31	139	0	95	71	4	**95**	**71**	**4**	0	0	0	95	71	4	2015-06-08	No monitoring in the last year
	In Total:	34	288	0	153	270	117	**143**	**249**	**5**	0	0	0	143	249	5		

Action Area: Out

TaxonName: Cyanea superba subsp. superba

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 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Makaha	Manage reintroduction for stability				27	172	246	**27**	**172**	**246**	0	0	0	27	172	246	2015-04-14	No monitoring in the last year
Manuwai	Manage reintroduction for stability	0	0	0	0	142	0	**0**	**108**	**0**	0	0	0	0	108	0	2016-07-07	Thorough monitoring in the last year showed a decline
	Out Total:	0	0	0	27	314	246	**27**	**280**	**246**	0	0	0	27	280	246		
	Total for Taxon:	34	288	0	180	584	363	**170**	**529**	**251**	0	0	0	170	529	251		

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 2015	Total Immature 2015	Total Seedling 2015	**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	37	76	94	**33**	**142**	**9**	33	142	9	0	0	0	2016-05-13	Monitoring showed seedlings growing into immature plants over the last year
Kawaiiki (Koolaus)	Manage for stability	50	0	0	5	79	0	**13**	**79**	**2**	13	79	2	0	0	0	2016-04-19	More thorough monitoring led to discovering more plants
Opaeula (Koolaus)	Manage for stability	21	5	0	23	107	0	**35**	**161**	**2**	35	161	2	0	0	0	2016-04-27	A thorough census led to more plants being discovered
Pahole to West Makaleha	Manage for stability	300	0	0	603	670	281	**615**	**700**	**286**	615	700	286	0	0	0	2015-09-10	A known site was monitored for the first time last year, numbers added to previous total
	In Total:	423	50	0	668	932	375	**696**	**1082**	**299**	696	1082	299	0	0	0		

Action Area: Out

TaxonName: Cyrtandra dentata

Target # of Matures: 50 | # MFS PU Met Goal: 1 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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 since 2006
	Out Total:				3	0	0	**3**	**0**	**0**	3	0	0	0	0	0		
	Total for Taxon:	423	50	0	671	932	375	**699**	**1082**	**299**	699	1082	299	0	0	0		

Population Unit Status - Makua Implementation Plan

Action Area: In

TaxonName: Delissea waianaeensis

Target # of Matures: 100   # MFS PU Met Goal: 3 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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	240	19	0	**240**	**17**	**0**	3	4	0	237	13	0	2016-06-02	Small changes were noted during monitoring in the last year
Kaluakauila	Manage reintroduction for storage				15	3	0	**15**	**3**	**0**	0	0	0	15	3	0	2014-04-30	No monitoring in the last year
Kapuna	Manage reintroduction for storage				113	46	0	**113**	**46**	**0**	0	0	0	113	46	0	2014-04-29	No census taken in the last year
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	12	23	6	**10**	**15**	**3**	10	15	3	0	0	0	2016-05-25	A thorough census has shown a slight decline in the immature age class
	In Total:	37	1	0	381	91	6	**379**	**81**	**3**	14	19	3	365	62	0		

Action Area: Out

TaxonName: Delissea waianaeensis

Target # of Matures: 100   # MFS PU Met Goal: 3 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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	196	23	0	**196**	**23**	**0**	2	1	0	194	22	0	2015-05-28	No monitoring this last year
Kaluaa	Manage for stability	44	0	0	650	89	6	**598**	**63**	**0**	5	2	0	593	61	0	2016-01-26	Thorough monitoring in the last year showed a decline
Kealia	Genetic Storage	0	7	0	4	13	2	**4**	**13**	**0**	4	13	0	0	0	0	2016-06-01	A thorough census showed no change in population
Manuwai	Manage reintroduction for stability				88	44	0	**88**	**44**	**0**	0	0	0	88	44	0	2015-05-26	No monitoring in the last year
Palawai	Genetic Storage	1	0	0	17	47	0	**24**	**30**	**0**	24	30	0	0	0	0	2016-06-22	A thorough census has shown immature plants transition into mature plants
	Out Total:	59	51	0	955	216	8	**910**	**173**	**0**	35	46	0	875	127	0		

Total for Taxon:	96	52	0	1336	307	14	**1289**	**254**	**3**	49	65	3	1240	189	0

Population Unit Status - Makua Implementation Plan

Action Area: In

TaxonName: Dubautia herbstobatae

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 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Keaau	Genetic Storage	70	0	0	70	0	0	**70**	**0**	**0**	70	0	0	0	0	0	2000-01-01	No monitoring since 2000
Makaha/Ohikilolo	Genetic Storage				350	0	0	**229**	**0**	**0**	229	0	0	0	0	0	2016-06-21	1 of 2 sites was monitored and showed a substantial decline
Ohikilolo Makai	Manage for stability	700	0	0	89	2	0	**89**	**2**	**0**	89	2	0	0	0	0	2013-09-04	A new census was initiated but not yet completed
Ohikilolo Mauka	Manage for stability	1300	0	0	415	9	0	**415**	**9**	**0**	415	9	0	0	0	0	2011-06-07	A new census was initiated but not yet completed
	In Total:	2070	0	0	924	11	0	**803**	**11**	**0**	803	11	0	0	0	0		

Action Area: Out

TaxonName: Dubautia herbstobatae

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 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kamaileunu	Genetic Storage	1	0	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0	2001-01-01	No monitoring since 2001
Makaha	Manage for stability	0	0	0	28	1	0	**79**	**2**	**0**	23	2	0	56	0	0	2016-02-10	A reintroduction increased the number of plants
Waianae Kai	Genetic Storage	5	0	0	10	4	0	**10**	**4**	**0**	10	4	0	0	0	0	2005-06-22	No monitoring since 2005
	Out Total:	6	0	0	38	5	0	**89**	**6**	**0**	33	6	0	56	0	0		
	Total for Taxon:	2076	0	0	962	16	0	**892**	**17**	**0**	836	17	0	56	0	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 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
East Kahanahaiki	Genetic Storage	2	0	0	2	0	0	**2**	**0**	**0**	2	0	0	0	0	0	2010-11-18	No monitoring in the last year
Kaluakauila	Genetic Storage	17	1	0	11	3	0	**11**	**3**	**0**	11	3	0	0	0	0	2010-06-24	No monitoring since 2010
Makua	Manage for stability	36	4	0	85	0	0	**85**	**0**	**0**	85	0	0	0	0	0	2014-12-09	No monitoring 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	150	16	2	**120**	**11**	**0**	120	11	0	0	0	0	2016-02-24	Moniroing showed a slight decline
	In Total:	420	15	0	363	55	2	**333**	**50**	**0**	333	50	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 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
East of Alau	Manage for stability	21	5	0	21	2	0	**20**	**2**	**66**	20	2	66	0	0	0	2015-09-28	Small changes were noted during monitoring in the last year
Kaena	Manage for stability	300	0	0	579	896	0	**880**	**274**	**0**	880	274	0	0	0	0	2015-09-15	A thorough census showed more mature plants than immature plants compared to the last census
Keawaula	Genetic Storage	69	6	0	43	1	2	**43**	**1**	**2**	43	1	2	0	0	0	2014-08-25	No monitoring in the last year
Waianae Kai	Genetic Storage	48	0	0	34	0	0	**34**	**0**	**0**	34	0	0	0	0	0	2011-06-13	No monitoring in the last year
	Out Total:	438	11	0	677	899	2	**977**	**277**	**68**	977	277	68	0	0	0		
	Total for Taxon:	858	26	0	1040	954	4	**1310**	**327**	**68**	1310	327	68	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 2015	Total Immature 2015	Total Seedling 2015	**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	56	52	0	**54**	**44**	**1**	13	9	1	41	35	0	2016-03-23	Monitoring showed a slight decline
Manuwai	Manage reintroduction for stability				0	0	0	**0**	**0**	**0**	0	0	0	0	0	0		The reintroduction will begin once propagules are available
	In Total:	170	0	0	56	52	0	**54**	**44**	**1**	13	9	1	41	35	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 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kaluaa	Manage reintroduction for stability				0	0	0	**0**	**0**	**0**	0	0	0	0	0	0		Reintroduction planned for winter 2016
Makaha	Manage reintroduction for storage				4	31	0	**3**	**12**	**0**	0	0	0	3	12	0	2016-03-14	No monitoring in the last year
	Out Total:				4	31	0	**3**	**12**	**0**	0	0	0	3	12	0		
	Total for Taxon:	170	0	0	60	83	0	**57**	**56**	**1**	13	9	1	44	47	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 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kahanahaiki to Kapuna	Manage for stability	6	26	0	6	123	0	**6**	**130**	**0**	6	0	0	0	130	0	2016-03-15	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	Monitoring showed no change
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	13	123	0	**13**	**130**	**0**	13	0	0	0	130	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 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Central and East Makaleha	Genetic Storage	6	0	0	5	0	0	**4**	**0**	**0**	4	0	0	0	0	0	2015-09-23	One new tree was observed dead
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 since 2006
Makaha	Manage for stability	4	0	0	10	55	0	**9**	**55**	**0**	9	0	0	0	55	0	2016-07-19	One wild tree died
Manuwai	Manage reintroduction for stability	0	0	0	0	35	0	**0**	**45**	**0**	0	0	0	0	45	0	2016-06-21	More plants were added to the outplanting site
Mt. Kaala NAR	Genetic Storage	4	0	0	3	0	0	**3**	**0**	**0**	3	0	0	0	0	0	2014-09-18	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	2015-10-27	Monitoring showed no change
	Out Total:	19	0	0	22	90	0	**20**	**100**	**0**	20	0	0	0	100	0		
	Total for Taxon:	31	26	0	35	213	0	**33**	**230**	**0**	33	0	0	0	230	0		

Population Unit Status - Makua Implementation Plan

Action Area: In

TaxonName: Gouania vitifolia

Target # of Matures: 50 | # MFS PU Met Goal: 1 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Keaau	Manage for stability				55	0	0	**51**	**0**	**0**	51	0	0	0	0	0	2016-06-14	A thorough monitoring showed a decline
	In Total:				55	0	0	**51**	**0**	**0**	51	0	0	0	0	0		

Action Area: Out

TaxonName: Gouania vitifolia

Target # of Matures: 50 | # MFS PU Met Goal: 1 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Makaha (Future Introduction)	Manage reintroduction for stability				0	0	0	**0**	**0**	**0**	0	0	0	0	0	0		Introduction has not begun
Manuwai (Future Introduction)	Manage reintroduction for stability				0	0	0	**0**	**0**	**0**	0	0	0	0	0	0		Introduction has not begun
Waianae Kai	Genetic Storage				3	0	0	**3**	**0**	**0**	3	0	0	0	0	0	2016-06-13	Monitoring has shown no change
	Out Total:				3	0	0	**3**	**0**	**0**	3	0	0	0	0	0		
	Total for Taxon:				58	0	0	**54**	**0**	**0**	54	0	0	0	0	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 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Haleauau	Manage for stability				1	0	0	**1**	**0**	**0**	1	0	0	0	0	0	2016-07-21	Monitoring showed no change
Pahole NAR	Manage reintroduction for stability	8	0	0	4	38	0	**2**	**32**	**0**	0	0	0	2	32	0	2016-03-31	Thorough monitoring in the last year showed a decline in the number of mature and immature outplants and there are two small F1 immature plants
	In Total:	8	0	0	5	38	0	**3**	**32**	**0**	1	0	0	2	32	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 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Makaha	Manage for stability	13	0	0	3	43	0	**11**	**35**	**0**	5	1	0	6	34	0	2016-07-05	Eight of the outplants were oberved to have matured in the last year and no change in the status of the remaining wild plants
Pualii	Manage reintroduction for stability				6	67	0	**16**	**52**	**0**	0	0	0	16	52	0	2016-03-17	Many of the outplants were observed to have matured in the last year and several plants had died after being damaged by high winds
Waianae Kai	Genetic Storage	9	0	1	0	1	0	**0**	**1**	**0**	0	1	0	0	0	0	2014-08-12	No census taken in the last year
	Out Total:	22	0	1	9	111	0	**27**	**88**	**0**	5	2	0	22	86	0		
	Total for Taxon:	30	0	1	14	149	0	**30**	**120**	**0**	6	2	0	24	118	0		

Population Unit Status - Makua Implementation Plan

Action Area: In

TaxonName: Hibiscus brackenridgei subsp. mokuleianus

Target # of Matures: 50 | # MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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				0	16	0	**20**	**38**	**0**	0	5	0	20	33	0	2016-06-14	Thorough monitoring in the last year showed a decline in the number of wild plants and a new outplanting was established to augment the population
Makua	Manage for stability	4	3	0	80	8	0	**124**	**20**	**0**	16	5	0	108	15	0	2016-04-06	Small changes were noted during monitoring the wild plants in the last year and more plants were added to the outplanting site
	In Total:	4	3	0	80	24	0	**144**	**58**	**0**	16	10	0	128	48	0		

Action Area: Out

TaxonName: Hibiscus brackenridgei subsp. mokuleianus

Target # of Matures: 50 | # MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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	5	3	2	**44**	**22**	**0**	3	2	0	41	20	0	2016-06-29	Small changes were noted during monitoring of the wild sites in the last year and a new outplanting was established
Manuwai	Manage reintroduction for stability				160	10	0	**145**	**6**	**0**	0	0	0	145	6	0	2016-01-27	Thorough monitoring in the last year showed a decline as some of the outplants died
Waialua	Genetic Storage	4	9	0	49	85	9	**49**	**85**	**9**	49	85	9	0	0	0	2013-04-02	No monitoring since 2013
	Out Total:	7	10	0	214	98	11	**238**	**113**	**9**	52	87	9	186	26	0		
	Total for Taxon:	11	13	0	294	122	11	**382**	**171**	**9**	68	97	9	314	74	0		

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 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kahanahaiki to Pahole	Manage for stability	161	0	0	147	131	23	**102**	**100**	**150**	102	100	150	0	0	0	2015-09-01	Thorough monitoring in the last year showed a decline
Outplanting site to be determined	Manage reintroduction for stability				0	0	0	**0**	**0**	**0**	0	0	0	0	0	0		Outplanting site to be determined
	In Total:	161	0	0	147	131	23	**102**	**100**	**150**	102	100	150	0	0	0		

Action Area: Out

TaxonName: Kadua degeneri subsp. degeneri

Target # of Matures: 50 — # MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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	78	70	2	**81**	**64**	**28**	19	18	4	62	46	24	2016-07-13	A thorough census has shown immature plants transition into mature plants at both the wild and outplanting sites. New seedlings were found at the outplanting site and an increase in immature plants was observed at the wild site.
Central Makaleha and West Branch of East Makaleha	Manage for stability	47	0	0	23	13	8	**24**	**8**	**19**	24	8	19	0	0	0	2015-09-08	Small changes were noted during monitoring in the last year
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 census taken in the last year
	Out Total:	117	0	0	101	83	10	**105**	**72**	**47**	43	26	23	62	46	24		
	Total for Taxon:	278	0	0	248	214	33	**207**	**172**	**197**	145	126	173	62	46	24		

Population Unit Status - Makua Implementation Plan

Action Area: In

TaxonName: Kadua parvula

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 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Ohikilolo	Manage for stability	66	0	0	100	157	5	**96**	**136**	**0**	76	86	0	20	50	0	2016-07-21	A thorough census has shown a decline
	In Total:	66	0	0	100	157	5	**96**	**136**	**0**	76	86	0	20	50	0		

Action Area: Out

TaxonName: Kadua parvula

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 2015	Total Immature 2015	Total Seedling 2015	**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				0	0	0	**6**	**39**	**0**	0	0	0	6	39	0	2016-05-11	A new outplanting site was established and many of the plants are now mature
Halona	Manage for stability	64	0	0	93	28	19	**31**	**4**	**0**	31	4	0	0	0	0	2016-06-29	A thorough census has shown a substantial decline
	Out Total:	64	0	0	93	28	19	**37**	**43**	**0**	31	4	0	6	39	0		
	Total for Taxon:	130	0	0	193	185	24	**133**	**179**	**0**	107	90	0	26	89	0		

Population Unit Status - Makua Implementation Plan

Action Area: In

TaxonName: Melanthera tenuifolia

Target # of Matures: 50 # MFS PU Met Goal: 3 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kahanahaiki	Genetic Storage	300	0	0	13	6	0	**13**	**6**	**0**	13	6	0	0	0	0	2011-05-04	No census taken 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 census taken in the last year
Keawaula	Genetic Storage	20	20	0	60	33	0	**200**	**50**	**0**	200	50	0	0	0	0	2016-03-30	A thorough census led to more plants being discovered in areas where fewer were observed in previous years
Ohikilolo	Manage for stability	2008	1	0	1109	8	0	**1088**	**11**	**0**	1088	11	0	0	0	0	2016-06-21	Thorough monitoring in the last year showed a decline at one of the known wild sites
	In Total:	2441	21	0	1186	127	0	**1305**	**147**	**0**	1305	147	0	0	0	0		

Action Area: Out

TaxonName: Melanthera tenuifolia

Target # of Matures: 50 # MFS PU Met Goal: 3 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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 census taken in the last year
Mt. Kaala NAR	Manage for stability	250	0	0	121	4	0	**131**	**24**	**0**	131	24	0	0	0	0	2015-09-22	A thorough census led to more plants being discovered but still a substantial decline from the initial estimates
	Out Total:	1130	0	0	936	250	274	**946**	**270**	**274**	946	270	274	0	0	0		
	Total for Taxon:	3571	21	0	2122	377	274	**2251**	**417**	**274**	2251	417	274	0	0	0		

Population Unit Status - Makua Implementation Plan

Action Area: In

TaxonName: Neraudia angulata

Target # of Matures: 100 # MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kaluakauila	Manage reintroduction for stability				65	69	0	**100**	**24**	**1**	0	0	0	100	24	1	2016-03-30	A thorough census has shown immature outplants transition into mature plants
Kapuna	Genetic Storage	1	0	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0	2016-05-16	Monitoring showed no change
Makua	Manage for stability	29	0	22	120	6	0	**68**	**7**	**13**	21	4	0	47	3	13	2016-05-31	A thorough census has shown a substantial decline, mostly at the outplant sites
Punapohaku	Genetic Storage				4	0	0	**4**	**0**	**0**	4	0	0	0	0	0	2014-04-30	No census taken in the last year
	In Total:	30	0	22	189	75	0	**172**	**31**	**14**	25	4	0	147	27	14		

Population Unit Status - Makua Implementation Plan

Action Area: Out

TaxonName: Neraudia angulata

Target # of Matures: 100 # MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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	32	5	0	**4**	**10**	**1**	4	10	1	0	0	0	2016-08-15	Revisiting the wild sites has uncovered population decline
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	52	13	0	**142**	**8**	**0**	3	8	0	139	0	0	2016-02-22	More plants were added to the outplanting site and most immature plants transitioned into mature plants
Manuwai	Manage for stability	12	0	0	115	84	0	**110**	**97**	**14**	0	3	0	110	94	14	2016-06-21	Small changes were noted during monitoring 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 census taken in the last year
Waianae Kai Mauka	Manage for stability	21	25	0	13	3	0	**11**	**2**	**0**	7	2	0	4	0	0	2016-03-15	Revisiting sites has uncovered population decline
	Out Total:	111	39	0	234	105	0	**289**	**117**	**15**	36	23	1	253	94	14		
	Total for Taxon:	141	39	22	423	180	0	**461**	**148**	**29**	61	27	1	400	121	28		

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 2015	Total Immature 2015	Total Seedling 2015	**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	50	2	1	**78**	**4**	**0**	78	4	0	0	0	0	2015-10-28	
Kaluakauila	Manage for stability	200	0	0	160	48	0	**160**	**48**	**0**	160	48	0	0	0	0	2014-08-06	No census taken in the last year
Keaau	Genetic Storage	21	31	0	21	31	0	**21**	**31**	**0**	21	31	0	0	0	0	2004-08-30	No census taken in the last year
Keawaula	Genetic Storage	200	30	0	35	6	0	**70**	**70**	**10**	70	70	10	0	0	0	2016-03-30	A thorough census led to more plants being discovered
Makua (East rim)	Genetic Storage	1	0	0	1	0	0	**1**	**0**	**0**	1	0	0	0	0	0	1997-01-01	No census taken 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	495	167	1	**558**	**233**	**10**	551	233	10	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 2015	Total Immature 2015	Total Seedling 2015	**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
Keawapilau	Genetic Storage	9	1	0	1	0	0	**1**	**0**	**0**	1	0	0	0	0	0	2013-04-17	No census taken 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 census taken 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 census taken in the last year
Manuwai	Manage reintroduction for stability				115	0	0	**112**	**0**	**0**	0	0	0	112	0	0	2016-06-21	Small changes were noted during monitoring in the last year as a few of the outplants died
Nanakuli	Genetic Storage	5	0	0	5	0	0	**0**	**0**	**0**	0	0	0	0	0	0	2016-03-29	Mmonitoring in the last year found no plants but the surrounding area needs to be searched again
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 census taken in the last year
Waianae Kai	Manage for stability	200	0	0	216	54	0	**155**	**135**	**0**	155	135	0	0	0	0	2015-09-23	A thorough census has shown a substantial decline
	Out Total:	446	7	0	402	60	0	**333**	**141**	**0**	221	141	0	112	0	0		
	Total for Taxon:	1280	100	0	897	227	1	**891**	**374**	**10**	772	374	10	119	0	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 2015	Total Immature 2015	Total Seedling 2015	**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 remaining plants at this site
Pahole	Manage reintroduction for stability	10	0	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0	2010-08-10	No remaining plants at this site
Palikea Gulch	Genetic Storage	10	0	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0	2004-09-01	No remaining 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 2015	Total Immature 2015	Total Seedling 2015	**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 remaining plants at this site
Manuwai	Manage reintroduction for stability	0	0	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0	2015-03-18	No remaining plants at this site
Waianae Kai	Genetic Storage	6	2	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0	2004-01-01	No remaining 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: 0 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
North Mohiakea	Manage for stability	20	10	0	39	12	0	**39**	**12**	**0**	39	12	0	0	0	0	2013-05-21	No census taken in the last year
Ohikilolo	Manage for stability	14	0	0	0	0	0	**4**	**50**	**0**	0	0	0	4	50	0	2016-05-23	A new outplanting site was established in the last year and some of the outplants have started to mature
Pahole	Genetic Storage	12	0	0	2	2	0	**4**	**5**	**0**	4	5	0	0	0	0	2016-05-25	Thorough monitoring in the last year found more plants
	In Total:	46	10	0	41	14	0	**47**	**67**	**0**	43	17	0	4	50	0		

Action Area: Out

TaxonName: Plantago princeps var. princeps

Target # of Matures: 50   # MFS PU Met Goal: 0 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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	48	191	0	**7**	**76**	**0**	7	73	0	0	3	0	2016-05-11	A thorough census has shown a substantial decline
Halona	Manage for stability	50	0	0	10	1	0	**6**	**9**	**0**	6	9	0	0	0	0	2016-06-30	Small changes were noted during a thorough monitoring in the last year but a substantial decline from the initial estimates for this site
North Palawai	Genetic Storage	32	0	0	5	1	0	**1**	**0**	**0**	1	0	0	0	0	0	2016-05-23	No census taken in the last year
Waieli	Manage reintroduction for storage				12	30	0	**12**	**30**	**0**	0	0	0	12	30	0	2014-04-14	No census taken in the last year
	Out Total:	98	17	0	75	223	0	**26**	**115**	**0**	14	82	0	12	33	0		
	Total for Taxon:	144	27	0	116	237	0	**73**	**182**	**0**	57	99	0	16	83	0		

Population Unit Status - Makua Implementation Plan

Action Area: In

TaxonName: Pritchardia kaalae

Target # of Matures: 25 # MFS PU Met Goal: 2 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Ohikilolo	Manage for stability	65	408	0	85	1590	0	**85**	**1590**	**0**	72	1178	0	13	412	0	2014-04-23	No census taken in the last year
Ohikilolo East and West Makaleha	Manage reintroduction for stability	0	75	0	4	330	0	**6**	**328**	**0**	0	0	0	6	328	0	2016-04-20	Small changes were noted during monitoring in the last year as two of the outplants were observed to have matured
	In Total:	65	483	0	89	1920	0	**91**	**1918**	**0**	72	1178	0	19	740	0		

Action Area: Out

TaxonName: Pritchardia kaalae

Target # of Matures: 25 # MFS PU Met Goal: 2 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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 census taken in the last year
Makaleha to Manuwai	Manage for stability	138	3	0	122	13	0	**123**	**11**	**0**	123	11	0	0	0	0	2016-07-12	Small changes were noted during monitoring in the last year
Waianae Kai	Genetic Storage	7	2	0	4	5	0	**4**	**5**	**0**	4	5	0	0	0	0	2002-06-12	No census taken in the last year
	Out Total:	146	5	0	127	18	0	**128**	**16**	**0**	128	16	0	0	0	0		
	Total for Taxon:	211	488	0	216	1938	0	**219**	**1934**	**0**	200	1194	0	19	740	0		

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 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Keaau	Manage for stability	16	125	0	0	43	0	**0**	**13**	**16**	0	13	16	0	0	0	2016-04-14	A thorough census of the known area found fewer plants this year
Ohikilolo	Manage for stability	34	128	0	0	216	200	**2**	**158**	**180**	0	5	180	2	153	0	2016-03-03	A thorough census of the known area found fewer plants this year but two were observed to be mature and most of the outplants emerged from dormancy
	In Total:	50	253	0	0	259	200	**2**	**171**	**196**	0	18	196	2	153	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 2015	Total Immature 2015	Total Seedling 2015	**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	5	408	135	**3**	**264**	**6**	3	264	6	0	0	0	2016-03-21	A thorough census of the known area found fewer plants this year
Puu Kawiwi	Genetic Storage	2	0	0	0	8	0	**0**	**0**	**0**	0	0	0	0	0	0	2016-03-15	No plants were observed at this site in the last year
	Out Total:	28	0	0	5	416	135	**3**	**264**	**6**	3	264	6	0	0	0		
	Total for Taxon:	78	253	0	5	675	335	**5**	**435**	**202**	3	282	202	2	153	0		

Population Unit Status - Makua Implementation Plan

Action Area: In

TaxonName: Schiedea kaalae

Target # of Matures: 50

MFS PU Met Goal: 3 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Pahole	Manage for stability	3	0	0	83	145	47	**58**	**67**	**7**	2	0	0	56	67	7	2016-03-09	A thorough census has shown a substantial decline in all age classes
	In Total:	3	0	0	83	145	47	**58**	**67**	**7**	2	0	0	56	67	7		

Action Area: Out

TaxonName: Schiedea kaalae

Target # of Matures: 50

MFS PU Met Goal: 3 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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 census taken in the last year
Kaluaa and Waieli	Manage for stability	2	53	0	166	5	0	**164**	**4**	**0**	0	0	0	164	4	0	2016-05-10	Small changes were noted during monitoring in the last year
Maakua (Koolaus)	Manage for stability	4	0	0	10	0	0	**10**	**0**	**0**	10	0	0	0	0	0	2008-07-02	The sites were visited and 5 plants were observed, but all known sites were not thoroughly searched
Makaua (Koolaus)	Genetic Storage	2	0	0	85	0	0	**85**	**0**	**0**	1	0	0	84	0	0	2012-02-29	No census taken 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 census taken in the last year
South Ekahanui	Manage for stability	10	75	0	160	268	12	**149**	**148**	**0**	9	2	0	140	146	0	2016-01-26	A thorough census has shown a decline in all age classes
	Out Total:	19	128	0	429	273	14	**416**	**152**	**2**	25	2	1	391	150	1		
	Total for Taxon:	22	128	0	512	418	61	**474**	**219**	**9**	27	2	1	447	217	8		

Population Unit Status - Makua Implementation Plan

Action Area: In

TaxonName: Schiedea nuttallii

Target # of Matures: 50   # MFS PU Met Goal: 3 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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	108	112	58	**88**	**35**	**317**	6	0	0	82	35	317	2016-06-13	A thorough census has shown a decline in the number of mature and immature plants and many seedlings were observed
Kapuna-Keawapilau Ridge	Manage for stability	3	1	0	74	0	0	**55**	**2**	**0**	0	0	0	55	2	0	2015-12-28	Thorough monitoring in the last year showed a decline and two new F1 immature plants were observed
	In Total:	51	18	0	182	112	58	**143**	**37**	**317**	6	0	0	137	37	317		

Action Area: Out

TaxonName: Schiedea nuttallii

Target # of Matures: 50   # MFS PU Met Goal: 3 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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	68	43	0	**91**	**5**	**0**	0	0	0	91	5	0	2016-04-12	A thorough census has shown immature plants transition into mature plants
	Out Total:	0	0	0	68	43	0	**91**	**5**	**0**	0	0	0	91	5	0		
	Total for Taxon:	51	18	0	250	155	58	**234**	**42**	**317**	6	0	0	228	42	317		

Population Unit Status - Makua Implementation Plan

Action Area: In

TaxonName: Schiedea obovata

Target # of Matures: 100 # MFS PU Met Goal: 1 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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	283	1028	210	**276**	**1094**	**203**	0	0	0	276	1094	203	2016-04-13	Small changes were noted during monitoring in the last year
Keawapilau to West Makaleha	Manage for stability	24	12	0	58	526	67	**36**	**458**	**36**	11	458	36	25	0	0	2016-05-24	Thorough monitoring in the last year showed a decline
	In Total:	89	37	0	341	1554	277	**312**	**1552**	**239**	11	458	36	301	1094	203		

Action Area: Out

TaxonName: Schiedea obovata

Target # of Matures: 100 # MFS PU Met Goal: 1 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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	146	52	13	**76**	**14**	**0**	0	0	0	76	14	0	2016-06-15	Thorough monitoring in the last year showed a decline
	Out Total:	0	0	0	146	52	13	**76**	**14**	**0**	0	0	0	76	14	0		
	Total for Taxon:	89	37	0	487	1606	290	**388**	**1566**	**239**	11	458	36	377	1108	203		

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 2015	Total Immature 2015	Total Seedling 2015	**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 census taken in the last year
Kalena	Manage for stability				24	93	0	**24**	**93**	**0**	24	93	0	0	0	0	2013-05-21	No census taken 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 census taken in the last year
Makaha/Ohikilolo Ridge	Genetic Storage				300	0	0	**350**	**200**	**0**	350	200	0	0	0	0	2016-06-21	A thorough census found more mature and immature plants
Ohikilolo	Manage for stability	2500	0	0	2394	1464	20	**1902**	**1464**	**20**	1902	1464	20	0	0	0	2016-06-23	A thorough census of just a single site found a substantial decline when none of the over 300 plants were observed
Puhawai	Manage for stability	6	6	0	21	9	2	**3**	**3**	**1**	0	0	0	3	3	1	2016-04-21	Thorough monitoring in the last year showed a decline at this outplanting site
	In Total:	2581	6	0	2809	1607	39	**2349**	**1801**	**38**	2346	1798	37	3	3	1		

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 2015	Total Immature 2015	Total Seedling 2015	**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	20	0	0	**20**	**0**	**0**	20	0	0	0	0	0	2016-07-11	Monitoring in the last year found no change
	Out Total:	20	2	0	20	0	0	**20**	**0**	**0**	20	0	0	0	0	0		
	Total for Taxon:	2601	8	0	2829	1607	39	**2369**	**1801**	**38**	2366	1798	37	3	3	1		

Population Unit Status - Makua Implementation Plan

Action Area: In

TaxonName: Viola chamissoniana subsp. chamissoniana

Target # of Matures: 50 — # MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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 census taken in the last year
Makaha/Ohikilolo Ridge	Genetic Storage	250	0	0	7	0	0	**0**	**0**	**0**	0	0	0	0	0	0	2016-06-21	A thorough census of this site found no remaining plants
Ohikilolo	Manage for stability				386	25	1	**208**	**55**	**0**	208	55	0	0	0	0	2016-06-21	A thorough census of three of the wild sites shows a substantial decline at two, but more observed at the third
Puu Kumakalii	Manage for stability	19	1	0	44	0	0	**44**	**0**	**0**	44	0	0	0	0	0	2004-10-21	No census taken in the last year
	In Total:	309	11	0	477	35	1	**292**	**65**	**0**	292	65	0	0	0	0		

Action Area: Out

TaxonName: Viola chamissoniana subsp. chamissoniana

Target # of Matures: 50 — # MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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	22	5	0	**15**	**5**	**0**	15	5	0	0	0	0	2016-06-29	A thorough census at one of the two sites found a substantial decline. The other site will be surveyed in the coming year
Kamaileunu	Genetic Storage	38	0	0	35	0	0	**35**	**0**	**0**	35	0	0	0	0	0	2000-05-23	No census taken in the last year
Makaha	Manage for stability	50	0	0	68	11	0	**68**	**11**	**0**	68	11	0	0	0	0	2014-05-14	No census taken in the last year
Makaleha	Genetic Storage				18	9	0	**19**	**9**	**1**	19	9	1	0	0	0	2015-06-03	No census taken in the last year
Puu Hapapa	Genetic Storage	10	3	0	7	2	0	**6**	**1**	**0**	6	1	0	0	0	0	2016-05-11	A thorough census has shown a continuing decline
	Out Total:	101	3	0	150	27	0	**143**	**26**	**1**	143	26	1	0	0	0		
	Total for Taxon:	410	14	0	627	62	1	**435**	**91**	**1**	435	91	1	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 2015	Total Immature 2015	Total Seedling 2015	**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	32	59	0	**30**	**49**	**1**	30	49	1	0	0	0	2016-07-28	Almost all sites thoroughly monitored
Kahanahaiki	Manage reintroduction for stability	0	0	0	72	6	0	**72**	**6**	**0**	0	0	0	72	6	0	2015-07-28	More outplants; clonal stock is
Kaluakauila	Manage reintroduction for storage	0	4	0	0	7	0	**0**	**3**	**0**	0	0	0	0	3	0	2016-08-16	No monitoring in the last year
Keaau	Genetic Storage	1	0	10	1	0	10	**1**	**0**	**10**	1	0	10	0	0	0	2002-04-06	No monitoring in the last year
	In Total:	37	92	16	105	72	10	**103**	**58**	**11**	31	49	11	72	9	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 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
East Makaleha	Genetic Storage	2	2	40	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0	2013-09-10	No monitoring in the last year
Ekahanui and Huliwai	Manage for stability	14	30	0	46	118	5	**57**	**118**	**0**	5	37	0	52	81	0	2016-07-25	More outplants are starting to mature
Halona	Genetic Storage	0	0	0	0	0	0	**10**	**5**	**0**	10	5	0	0	0	0	2016-08-15	Thorough monitoring last year
Makaha Makai	Manage for stability	73	27	6	92	133	0	**92**	**133**	**0**	92	133	0	0	0	0	2015-07-08	No monitoring in the last year
Makaha Mauka	Genetic Storage	5	58	4	13	1	0	**13**	**1**	**0**	13	1	0	0	0	0	2015-07-09	No monitoring in the last year
Nanakuli	Genetic Storage	0	0	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0		Have yet to monitor this site
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		Have yet to monitor this site
Waianae Kai	Genetic Storage	2	0	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0	2015-07-09	No monitoring in the last year
West Makaleha	Genetic Storage	0	2	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0	2012-09-17	No monitoring in the last year
	Out Total:	98	158	50	160	263	5	**181**	**268**	**0**	129	187	0	52	81	0		
	Total for Taxon:	135	250	66	265	335	15	**284**	**326**	**11**	160	236	11	124	90	0		

Population Unit Status - Oahu Implementation Plan

Action Area: In

TaxonName: Cyanea acuminata

Target # of Matures: 50 | # MFS PU Met Goal: 3 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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	130	142	0	**130**	**142**	**0**	130	142	0	0	0	0	2015-06-02	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		Have yet to monitor this site
Makaleha to Mohiakea	Manage for stability	85	33	0	151	65	0	**190**	**89**	**0**	190	89	0	0	0	0	2015-10-01	A more thorough monitoring discovered more plants at one site in Kaala
	In Total:	147	46	7	283	207	0	**322**	**231**	**0**	322	231	0	0	0	0		

Action Area: Out

TaxonName: Cyanea acuminata

Target # of Matures: 50 | # MFS PU Met Goal: 3 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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	123	126	50	**123**	**126**	**50**	123	126	50	0	0	0	2015-01-14	No monitoring in the last year
Konahuanui	Genetic Storage	30	0	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0		Have yet to monitor this site
Pia	Genetic Storage	0	0	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0		Have yet to monitor this site
Puukeahiakahoe	Genetic Storage	3	0	0	3	0	0	**3**	**0**	**0**	3	0	0	0	0	0	1997-02-04	Have not yet visited this site
Puuokona	Genetic Storage	1	0	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0		Have yet to visit this site
	Out Total:	39	0	0	207	159	50	**207**	**159**	**50**	207	159	50	0	0	0		
	Total for Taxon:	186	46	7	490	366	50	**529**	**390**	**50**	529	390	50	0	0	0		

Population Unit Status - Oahu Implementation Plan

Action Area: In

TaxonName: Cyanea koolauensis

Target # of Matures: 50

MFS PU Met Goal: 1 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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	106	13	0	**93**	**16**	**0**	93	16	0	0	0	0	2015-10-07	Revisiting sites has uncovered population decline; a few new sites were discovered
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 data since 2001
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 data since 2000
Lower Opaeula	Genetic Storage	3	1	0	1	0	0	**1**	**0**	**0**	1	0	0	0	0	0	2011-07-12	No monitoring since 2011
Opaeula to Helemano	Manage for stability	10	3	0	23	4	0	**22**	**2**	**0**	22	2	0	0	0	0	2015-08-17	Small decline was noted this year
Poamoho	Manage for stability	12	0	0	21	18	0	**20**	**19**	**0**	20	19	0	0	0	0	2015-10-29	Revisiting sites has uncovered population decline; a few new sites were discovered
	In Total:	96	36	6	169	44	0	**154**	**46**	**0**	154	46	0	0	0	0		

Population Unit Status - Oahu Implementation Plan

Action Area: Out

TaxonName: Cyanea koolauensis

Target # of Matures: 50   # MFS PU Met Goal: 1 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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		This site has yet to be monitored
Lulumahu	Genetic Storage	10	0	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0		The site has yet to be monitored
Waialae Nui	Genetic Storage	2	0	0	2	0	0	**2**	**0**	**0**	2	0	0	0	0	0	1990-09-06	No data available as of 1990
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 since 2012
Wailupe	Genetic Storage	15	0	0	1	0	0	**1**	**0**	**0**	1	0	0	0	0	0	2006-08-10	No monitoring since 2006
Waimalu	Genetic Storage	2	0	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0		This site has yet to be monitored by OANRP
	Out Total:	39	0	0	18	2	0	**18**	**2**	**0**	18	2	0	0	0	0		
	Total for Taxon:	135	36	6	187	46	0	**172**	**48**	**0**	172	48	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 2015	Total Immature 2015	Total Seedling 2015	**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	21	26	1	**21**	**26**	**1**	21	26	1	0	0	0	2016-03-30	Only a subset of plants were monitored this year
Kaleleiki	Genetic Storage	25	30	250	14	54	80	**14**	**54**	**80**	14	54	80	0	0	0	2015-05-06	No monitoring in the last year
Kaunala	Manage for stability	48	93	6	20	39	27	**20**	**39**	**27**	20	39	27	0	0	0	2015-06-09	
Malaekahana	Genetic Storage				5	21	0	**5**	**21**	**0**	5	21	0	0	0	0	2014-04-09	No monitoring in the last year
Ohiaai and East Oio	Genetic Storage	5	8	10	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	5	2	0	**6**	**2**	**0**	6	2	0	0	0	0	2015-07-07	No monitoring in the last year, but one new plant was found in a new site
Pahipahialua	Manage for stability	57	234	1	22	6	141	**22**	**6**	**141**	22	6	141	0	0	0	2014-07-23	No monitoring in the last year
	In Total:	169	437	282	96	159	249	**97**	**159**	**249**	97	159	249	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 2015	Total Immature 2015	Total Seedling 2015	**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		This site has yet to be monitored by OANRP
	Out Total:	5	0	0	2	0	0	**2**	**0**	**0**	2	0	0	0	0	0		
	Total for Taxon:	174	437	282	98	159	249	**99**	**159**	**249**	99	159	249	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 2015	Total Immature 2015	Total Seedling 2015	**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	69	0	0	**77**	**0**	**0**	3	0	0	74	0	0	2016-07-19	More plants were planted
Helemano and Poamoho	Manage for stability	18	0	0	17	0	0	**21**	**1**	**0**	21	1	0	0	0	0	2016-06-27	New plants were discovered during surveys, others were observed dead
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	1	0	**10**	**20**	**0**	10	0	0	0	20	0	2016-04-28	A reintroduction was started this year
South Kaukonahua	Genetic Storage	2	0	0	1	0	0	**2**	**0**	**0**	2	0	0	0	0	0	2016-03-30	2 of 4 old sites re-visited, one tree found alive
Upper Opaeula/Helemano	Genetic Storage	1	0	0	1	0	0	**1**	**0**	**0**	1	0	0	0	0	0	2016-03-28	Monitoring showed no change
	In Total:	88	1	0	110	1	0	**124**	**21**	**0**	50	1	0	74	20	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 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Ihiihi-Kawainui ridge	Genetic Storage	2	0	0	2	0	0	**2**	**0**	**0**	2	0	0	0	0	0	1993-01-01	No data available as of 1993
Kahana and Makaua	Genetic Storage	2	0	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0		This site has yet to be monitored by OANRP
Kaipapau to Punaluu	Genetic Storage	4	0	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0		This site has yet to be monitored by OANRP
Kalauao	Genetic Storage	4	0	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0		This site has yet to be monitored by OANRP
Kaluaa and Maunauna	Genetic Storage	1	0	0	2	0	0	**2**	**0**	**0**	2	0	0	0	0	0	2014-06-17	No monitoring in the last year
Kamananui-Malaekahana Summit Ridge	Genetic Storage	13	0	0	3	0	0	**3**	**0**	**0**	3	0	0	0	0	0	2015-08-25	No change observed this year
Kapakahi	Genetic Storage	4	0	0	2	0	0	**2**	**0**	**0**	2	0	0	0	0	0	2016-06-25	1 of 2 sites monitored; no change
Manana-Waimano Ridge	Genetic Storage	4	0	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0		This site has yet to be monitored by OANRP
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		This site has yet to be monitored by OANRP
	Out Total:	36	0	0	10	0	0	**10**	**0**	**0**	10	0	0	0	0	0		
	Total for Taxon:	124	1	0	120	1	0	**134**	**21**	**0**	60	1	0	74	20	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 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kamananui to Kaluanui	Manage for stability	54	45	14	134	112	45	**134**	**112**	**45**	134	112	45	0	0	0	2015-07-29	Monitoring showed no change
Kaukonahua	Manage for stability	76	51	122	55	54	2	**55**	**54**	**2**	55	54	2	0	0	0	2015-07-29	Monitoring showed no change
Lower Opaeula	Manage for stability	9	15	0	18	21	0	**15**	**23**	**0**	15	23	0	0	0	0	2016-07-28	Monitoring showed no change
Ohiaai ridge	Genetic Storage	5	1	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0		This site has yet to be monitored by OANRP
Poamoho	Genetic Storage	38	16	3	21	12	5	**21**	**12**	**5**	21	12	5	0	0	0	2015-06-01	No census taken in the last year
	In Total:	182	128	139	228	199	52	**225**	**201**	**52**	225	201	52	0	0	0		

Action Area: Out

TaxonName: Hesperomannia swezeyi

Target # of Matures: 25 | # MFS PU Met Goal: 2 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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		This site has yet to be monitored by OANRP
Kapakahi	Genetic Storage	1	0	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0		This site has yet to be monitored by OANRP
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 census taken in the last year
Waimano	Genetic Storage	0	0	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0		This site has yet to be monitored by OANRP
	Out Total:	8	0	0	1	4	1	**1**	**4**	**1**	1	4	1	0	0	0		
	Total for Taxon:	190	128	139	229	203	53	**226**	**205**	**53**	226	205	53	0	0	0		

Population Unit Status - Oahu Implementation Plan

Action Area: In

TaxonName: Labordia cyrtandrae

Target # of Matures: 50 # MFS PU Met Goal: 1 of 2

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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	295	40	0	**298**	**51**	**0**	71	0	0	227	51	0	2016-06-02	More plants were added to the outplanting site and more immature outplants transitioned into mature plants
	In Total:	84	16	2	295	40	0	**298**	**51**	**0**	71	0	0	227	51	0		

Action Area: Out

TaxonName: Labordia cyrtandrae

Target # of Matures: 50 # MFS PU Met Goal: 1 of 2

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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				33	48	0	**9**	**5**	**0**	0	0	0	9	5	0	2016-05-25	A thorough census has shown a substantial decline in the number of outplants
	Out Total:				33	48	0	**9**	**5**	**0**	0	0	0	9	5	0		
	Total for Taxon:	84	16	2	328	88	0	**307**	**56**	**0**	71	0	0	236	56	0		

Population Unit Status - Oahu Implementation Plan

Action Area: In

TaxonName: Phyllostegia hirsuta

Target # of Matures: 100 | # MFS PU Met Goal: 1 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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	71	76	0	**96**	**2**	**0**	11	2	0	85	0	0	2016-05-12	A thorough census has shown immature plants transition into mature plants
Helemano and Opaeula	Genetic Storage	14	5	6	1	4	0	**1**	**4**	**0**	1	4	0	0	0	0	2013-11-20	No census taken in the last year
Helemano to Poamoho	Genetic Storage	1	0	0	2	0	0	**2**	**0**	**0**	2	0	0	0	0	0	2016-06-02	Monitoring showed no change
Kaipapau and Kawainui	Genetic Storage	7	0	0	4	0	0	**4**	**0**	**0**	4	0	0	0	0	0	2013-12-17	No census taken 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 census taken in the last year
Kawaiiki	Genetic Storage	0	0	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0	2008-10-09	No census taken in the last year
Koloa	Manage for stability	0	0	0	97	123	1	**114**	**39**	**1**	6	3	1	108	36	0	2016-05-25	A thorough census has shown immature plants transition into mature plants
	In Total:	32	19	6	175	203	1	**217**	**45**	**1**	24	9	1	193	36	0		

Population Unit Status - Oahu Implementation Plan

Action Area: Out

TaxonName: Phyllostegia hirsuta

Target # of Matures: 100 # MFS PU Met Goal: 1 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Hapapa to Kaluaa	Genetic Storage	11	9	7	2	10	0	**1**	**27**	**0**	1	27	0	0	0	0	2016-07-20	Small changes were noted during monitoring in the last year
Kaluanui and Punaluu	Genetic Storage	5	0	0	5	3	0	**5**	**3**	**0**	5	3	0	0	0	0	2011-05-17	No census taken in the last year
Makaha-Waianae Kai Ridge	Genetic Storage	2	0	0	1	0	0	**1**	**0**	**0**	1	0	0	0	0	0	2013-08-27	No census taken 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 census taken in the last year
Puu Palikea	Manage reintroduction for stability				114	127	0	**87**	**55**	**0**	0	0	0	87	55	0	2016-04-12	Thorough monitoring in the last year showed a decline
Waiamano	Genetic Storage				1	0	0	**1**	**0**	**0**	1	0	0	0	0	0	2006-01-01	No census taken in the last year
	Out Total:	18	10	7	123	140	0	**95**	**85**	**0**	8	30	0	87	55	0		
	Total for Taxon:	50	29	13	298	343	1	**312**	**130**	**1**	32	39	1	280	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 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Mohiakea	Genetic Storage	0	4	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0	2015-06-23	No census taken in the last year
	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 2015	Total Immature 2015	Total Seedling 2015	**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	11	1	0	**1**	**0**	**0**	0	0	0	1	0	0	2016-05-11	Many of the outplants were observed to have died in the last year leaving just a single plant
Kaluaa	Manage for stability	38	11	0	88	42	0	**74**	**63**	**0**	0	0	0	74	63	0	2016-02-16	More plants were added to the outplanting site and a decline was observed in the number of mature outplants already at the site
Pualii	Manage reintroduction for stability	0	0	0	11	0	0	**11**	**0**	**0**	0	0	0	11	0	0	2015-05-06	No census taken in the last year
Waieli	Genetic Storage	0	0	0	1	0	0	**1**	**0**	**0**	1	0	0	0	0	0	2012-12-04	No census taken in the last year
	Out Total:	73	11	0	111	43	0	**87**	**63**	**0**	1	0	0	86	63	0		
	Total for Taxon:	73	15	0	111	43	0	**87**	**63**	**0**	1	0	0	86	63	0		

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 2015	Total Immature 2015	Total Seedling 2015	**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	296	351	377	**296**	**351**	**377**	296	351	377	0	0	0	2015-08-04	Monitoring in the last year showed no change
	In Total:	180	196	318	296	351	377	**296**	**351**	**377**	296	351	377	0	0	0		
	Total for Taxon:	180	196	318	296	351	377	**296**	**351**	**377**	296	351	377	0	0	0		

Population Unit Status - Oahu Implementation Plan

Action Area: In

TaxonName: Stenogyne kanehoana

Target # of Matures: 100 | # MFS PU Met Goal: 1 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Haleauau	Manage reintroduction for stability	1	0	0	0	129	0	**281**	**0**	**0**	0	0	0	281	0	0	2016-04-19	
	In Total:	1	0	0	0	129	0	**281**	**0**	**0**	0	0	0	281	0	0		

Action Area: Out

TaxonName: Stenogyne kanehoana

Target # of Matures: 100 | # MFS PU Met Goal: 1 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2015	Total Immature 2015	Total Seedling 2015	**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	26	178	0	**26**	**178**	**0**	0	0	0	26	178	0	2015-03-23	
Makaha	Manage reintroduction for stability				0	130	0	**0**	**60**	**0**	0	0	0	0	60	0	2016-06-15	
	Out Total:	0	79	0	26	308	0	**26**	**238**	**0**	0	0	0	26	238	0		
	Total for Taxon:	1	79	0	26	437	0	**307**	**238**	**0**	0	0	0	307	238	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	1	Yes	Partial 100%	No	No	No
Makua	Manage for stability	6	Partial 100%	Partial 17%	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 Waieli	Manage for stability	3	Partial 0%	Partial 0%	No	No	No
Makaha	Manage for stability	29	Yes	Partial 100%	No	No	No
Waianae Kai	Genetic Storage	0	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary 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	210	Yes	Partial 94%	Partial 27%	No	No
Kuaokala	Genetic Storage	1	No	No	No	No	No

Action Area: Out

TaxonName: Cenchrus agrimonioides var. agrimonioides

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Central Ekahanui	Manage for stability	183	Yes	Partial 67%	Yes	No	No
Makaha and Waianae Kai	Manage for stability	161	Partial 97%	Partial 100%	No	No	No
South Huliwai	Genetic Storage	17	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

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

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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	75	Yes	Partial 100%	Partial 35%	Partial 99%	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	124	Yes	Partial 100%	Partial 48%	No	No
Makaha	Genetic Storage	13	Yes	Partial 100%	Yes	Yes	No
North branch of South Ekahanui	Manage reintroduction for stability	82	Yes	Partial 100%	Yes	Yes	No
Palikea (South Palawai)	Manage for stability	120	Yes	Partial 100%	Yes	Partial 100%	No

[shaded box] = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

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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	63	Yes	Partial 97%	No	Partial 5%	No
Pahole	Manage for stability	60	Yes	Partial 67%	No	Partial 98%	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	119	Yes	Partial 100%	Yes	Partial 6%	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	48	Yes	Partial 100%	Yes	Partial 46%	No
Pahole to Kapuna	Manage reintroduction for stability	95	Yes	Partial 92%	Partial 60%	No	No

Action Area: Out

TaxonName: Cyanea superba subsp. superba

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Makaha	Manage reintroduction for stability	27	Yes	Partial 100%	Yes	No	No
Manuwai	Manage reintroduction for stability	0	Yes	Partial	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary 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	33	Yes	Partial 100%	Yes	No	No
Kawaiiki (Koolaus)	Manage for stability	13	No	No	No	No	No
Opaeula (Koolaus)	Manage for stability	35	Partial 100%	Partial 57%	No	Partial 54%	No
Pahole to West Makaleha	Manage for stability	610	Partial 100%	Partial 84%	No	No	No

Action Area: Out

TaxonName: Cyrtandra dentata

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Central Makaleha	Genetic Storage	3	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary 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	240	Yes	Partial 99%	Partial 12%	No	No
Kaluakauila	Manage reintroduction for storage	15	Yes	No	No	No	No
Kapuna	Manage reintroduction for storage	113	Yes	No	No	No	No
Palikea Gulch	Genetic Storage	1	No	No	No	No	Partial 100%
South Mohiakea	Genetic Storage	10	Yes	Partial 100%	No	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	196	Yes	Partial 99%	Yes	Partial 99%	No
Kaluaa	Manage for stability	598	Yes	Partial 100%	Partial 51%	Partial 51%	No
Kealia	Genetic Storage	4	No	No	No	No	No
Manuwai	Manage reintroduction for stability	88	Yes	Partial 100%	Yes	No	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	229	No	No	No	No	No
Ohikilolo Makai	Manage for stability	89	Yes	No	No	No	No
Ohikilolo Mauka	Manage for stability	415	Yes	No	No	No	No

Action Area: Out

TaxonName: Dubautia herbstobatae

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kamaileunu	Genetic Storage	0	No	No	No	No	No
Makaha	Manage for stability	79	No	Partial 71%	No	No	No
Waianae Kai	Genetic Storage	10	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

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

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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	2	No	No	No	No	No
Kaluakauila	Genetic Storage	11	No	Partial 100%	No	No	No
Makua	Manage for stability	85	Yes	Partial 100%	No	No	Partial 100%
North Kahanahaiki	Genetic Storage	115	No	No	No	No	No
Puaakanoa	Manage for stability	120	No	No	No	No	No

Action Area: Out

TaxonName: Euphorbia celastroides var. kaenana

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
East of Alau	Manage for stability	20	No	Partial 100%	No	No	No
Kaena	Manage for stability	880	No	Partial 100%	No	No	No
Keawaula	Genetic Storage	43	No	No	No	No	No
Waianae Kai	Genetic Storage	34	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary 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	54	Yes	Partial 98%	No	Partial 83%	No
Manuwai	Manage reintroduction for stability	0	Yes	No	No	No	No

Action Area: Out

TaxonName: Euphorbia herbstii

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kaluaa	Manage reintroduction for stability	0	Yes	No	No	No	No
Makaha	Manage reintroduction for storage	3	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

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

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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	6	Yes	Partial 67%	Partial 17%	No	No
Ohikilolo	Manage for stability	1	Yes	No	No	No	No
West Makaleha	Genetic Storage	6	No	No	No	No	No

Action Area: Out

TaxonName: Flueggea neowawraea

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Central and East Makaleha	Genetic Storage	4	No	No	No	No	No
Halona	Genetic Storage	1	No	No	No	No	No
Kauhiuhi	Genetic Storage	1	No	No	No	No	No
Makaha	Manage for stability	9	Partial 44%	Partial 67%	No	No	No
Manuwai	Manage reintroduction for stability	0	Yes	Partial	No	No	No
Mt. Kaala NAR	Genetic Storage	3	No	No	No	No	No
Nanakuli, south branch	Genetic Storage	1	No	No	No	No	No
Waianae Kai	Genetic Storage	1	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary 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	51	No	No	No	No	No

Action Area: Out

TaxonName: Gouania vitifolia

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Makaha (Future Introduction)	Manage reintroduction for stability	0	Yes	No	No	No	No
Manuwai (Future Introduction)	Manage reintroduction for stability	0	Yes	No	No	No	No
Waianae Kai	Genetic Storage	3	Yes	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

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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	1	Yes	Partial 100%	Yes	No	No
Pahole NAR	Manage reintroduction for stability	2	Yes	Yes	Yes	No	No

Action Area: Out

TaxonName: Hesperomannia oahuensis

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Makaha	Manage for stability	11	Yes	Partial 100%	Yes	Partial 55%	No
Pualii	Manage reintroduction for stability	16	Yes	Partial 100%	Yes	No	No
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

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

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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	20	Yes	Partial 100%	No	No	No
Makua	Manage for stability	124	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	44	No	Partial 93%	No	No	No
Manuwai	Manage reintroduction for stability	145	Yes	Partial 100%	No	No	No
Waialua	Genetic Storage	49	Partial 37%	Partial 0%	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	102	Yes	Partial 100%	No	No	No

Action Area: Out

TaxonName: Kadua degeneri subsp. degeneri

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Alaiheihe and Manuwai	Manage for stability	81	Partial 96%	Partial 77%	No	No	No
Central Makaleha and West Branch of East Makaleha	Manage for stability	22	No	Partial 82%	No	No	No
East branch of East Makaleha	Genetic Storage	0	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary   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	112	Yes	Partial 11%	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	6	Yes	Partial 100%	No	No	No
Halona	Manage for stability	31	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: Melanthera tenuifolia

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki	Genetic Storage	13	Partial 100%	No	No	No	No
Kaluakauila	Genetic Storage	4	Yes	No	No	No	No
Keawaula	Genetic Storage	200	No	No	No	No	No
Ohikilolo	Manage for stability	1088	Partial 100%	Partial 0%	No	No	Partial 53%

Action Area: Out

TaxonName: Melanthera tenuifolia

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kamaileunu and Waianae Kai	Manage for stability	815	No	Partial 10%	No	No	No
Mt. Kaala NAR	Manage for stability	131	Yes	Partial 61%	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

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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	100	Yes	Partial 100%	No	No	No
Kapuna	Genetic Storage	0	No	No	No	No	No
Makua	Manage for stability	68	Yes	Partial 68%	No	No	No
Punapohaku	Genetic Storage	4	No	No	No	No	No

Action Area: Out

TaxonName: Neraudia angulata

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Halona	Genetic Storage	4	No	No	No	No	No
Leeward Puu Kaua	Genetic Storage	9	No	No	No	No	No
Makaha	Manage for stability (backup site)	142	Partial 99%	Partial 98%	No	No	No
Manuwai	Manage for stability	110	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	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

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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	78	Partial 100%	Partial 22%	Partial 14%	No	No
Kaluakauila	Manage for stability	160	Yes	Partial 100%	No	No	No
Keaau	Genetic Storage	21	No	No	No	No	No
Keawaula	Genetic Storage	70	No	No	No	No	No
Makua (East rim)	Genetic Storage	1	No	No	No	No	No
Makua (south side)	Manage for stability	50	Partial 100%	Partial 0%	No	No	No
Punapohaku	Genetic Storage	178	No	No	No	No	No

Action Area: Out

TaxonName: Nototrichium humile

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kaimuhole and Palikea Gulch	Genetic Storage	29	No	Partial 90%	No	No	Partial 100%
Keawapilau	Genetic Storage	1	No	No	No	No	No
Kolekole	Genetic Storage	12	Partial 33%	No	No	No	No
Makaha	Genetic Storage	22	No	Partial 64%	No	No	No
Manuwai	Manage reintroduction for stability	112	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	155	Partial 84%	No	No	No	Partial 84%

= 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

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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	Partial	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	No	No	No
Manuwai	Manage reintroduction for stability	0	Yes	Partial	No	No	No
Waianae Kai	Genetic Storage	0	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

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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	39	Yes	No	No	No	No
Ohikilolo	Manage for stability	8	Partial 100%	No	No	No	No
Pahole	Genetic Storage	4	Yes	No	No	No	No

Action Area: Out

TaxonName: Plantago princeps var. princeps

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Ekahanui	Manage for stability	7	Yes	Partial 100%	Yes	No	No
Halona	Manage for stability	6	No	No	No	No	No
North Palawai	Genetic Storage	1	No	No	No	No	No
Waieli	Manage reintroduction for storage	12	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

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

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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	85	Yes	Partial 88%	Partial 88%	No	No
Ohikilolo East and West Makaleha	Manage reintroduction for stability	6	Yes	Partial 100%	No	No	No

Action Area: Out

TaxonName: Pritchardia kaalae

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Makaha	Genetic Storage	1	No	No	No	No	No
Makaleha to Manuwai	Manage for stability	123	Partial 2%	No	No	No	No
Waianae Kai	Genetic Storage	4	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

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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	0	Yes	No	No	No	No
Ohikilolo	Manage for stability	2	Yes	Partial 0%	No	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	3	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

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

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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
Pahole	Manage for stability	58	Yes	Partial 98%	No	Partial 79%	No

Action Area: Out

TaxonName: Schiedea kaalae

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahana	Genetic Storage	8	Yes	No	No	No	No
Kaluaa and Waieli	Manage for stability	164	Yes	Partial 100%	No	Partial 2%	No
Maakua (Koolaus)	Manage for stability	10	No	No	No	No	No
Makaua (Koolaus)	Genetic Storage	85	Yes	No	No	No	No
North Palawai	Genetic Storage	0	Yes	No	No	No	No
South Ekahanui	Manage for stability	149	Yes	Partial 100%	Yes	Partial 99%	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

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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	88	Yes	Partial 99%	Partial 93%	Partial 91%	No
Kapuna-Keawapilau Ridge	Manage for stability	55	Yes	Partial 100%	Yes	No	No

Action Area: Out

TaxonName: Schiedea nuttallii

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Makaha	Manage reintroduction for stability	91	Yes	Partial 100%	Yes	Yes	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

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

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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	232	Yes	Partial 100%	Partial 89%	Partial 89%	No
Keawapilau to West Makaleha	Manage for stability	36	Partial 92%	Partial 97%	No	Partial 42%	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	76	Yes	Partial 100%	No	Yes	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

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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	No	No	No	No	No
Kalena	Manage for stability	24	Yes	No	No	No	No
Keaau	Genetic Storage	30	No	No	No	No	No
Makaha/Ohikilolo Ridge	Genetic Storage	350	No	No	No	No	No
Ohikilolo	Manage for stability	1902	Yes	No	No	No	No
Puhawai	Manage for stability	3	No	No	No	No	No

Action Area: Out

TaxonName: Tetramolopium filiforme

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Waianae Kai	Manage for stability	20	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

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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	208	Yes	No	No	No	No
Puu Kumakalii	Manage for stability	44	No	No	No	No	No

Action Area: Out

TaxonName: Viola chamissoniana subsp. chamissoniana

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Halona	Manage for stability	15	No	No	No	No	No
Kamaileunu	Genetic Storage	35	No	No	No	No	No
Makaha	Manage for stability	68	Yes	Partial 74%	No	No	No
Makaleha	Genetic Storage	19	No	No	No	No	No
Puu Hapapa	Genetic Storage	6	No	No	No	No	No

= Threat to Taxon within Population Unit

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Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

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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	30	Partial 57%	Partial 53%	No	No	Partial 13%
Kahanahaiki	Manage reintroduction for stability	72	Yes	Partial 100%	No	No	No
Kaluakauila	Manage reintroduction for storage	0	Yes	Partial	No	No	No
Keaau	Genetic Storage	1	No	No	No	No	No

Action Area: Out

TaxonName: Abutilon sandwicense

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
East Makaleha	Genetic Storage	0	No	No	No	No	No
Ekahanui and Huliwai	Manage for stability	57	Yes	Partial 79%	No	No	No
Halona	Genetic Storage	10	Partial 100%	No	No	No	No
Makaha Makai	Manage for stability	92	Partial 75%	Partial 75%	No	No	No
Makaha Mauka	Genetic Storage	13	No	No	No	No	No
North Mikilua	Genetic Storage	9	Yes	No	No	No	No
Waianae Kai	Genetic Storage	0	No	No	No	No	Partial
West Makaleha	Genetic Storage	0	No	No	No	No	No

= Threat to Taxon within Population Unit

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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	130	No	No	No	No	No
Kahana and South Kaukonahua	Genetic Storage	2	No	No	No	No	No
Makaleha to Mohiakea	Manage for stability	190	Partial 98%	Partial 63%	No	No	No

Action Area: Out

TaxonName: Cyanea acuminata

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahana and Makaua	Genetic Storage	11	No	No	No	No	No
Kaipapau and Koloa	Genetic Storage	70	Partial 0%	No	No	No	No
Kaluanui and Maakua	Manage for stability	123	No	No	No	No	No
Puukeahiakahoe	Genetic Storage	3	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

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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	93	Partial 82%	Partial 15%	No	No	No
Kamananui-Kawainui Ridge	Genetic Storage	6	No	No	No	No	No
Kaukonahua	Genetic Storage	8	No	No	No	No	No
Kawaiiki	Genetic Storage	4	No	No	No	No	No
Lower Opaeula	Genetic Storage	1	No	No	No	No	No
Opaeula to Helemano	Manage for stability	22	Partial 50%	Partial 9%	No	No	No
Poamoho	Manage for stability	20	No	No	No	No	No

Action Area: Out

TaxonName: Cyanea koolauensis

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Halawa	Genetic Storage	4	No	No	No	No	No
Waialae Nui	Genetic Storage	2	No	No	No	No	No
Waiawa to Waimano	Genetic Storage	11	Partial 45%	No	No	No	No
Wailupe	Genetic Storage	1	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

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

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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	21	Partial 0%	No	No	No	No
Kaleleiki	Genetic Storage	14	Partial 50%	No	No	No	No
Kaunala	Manage for stability	20	Partial 95%	No	No	No	No
Malaekahana	Genetic Storage	5	No	No	No	No	No
Ohiaai and East Oio	Genetic Storage	1	No	No	No	No	No
Oio	Manage for stability	6	Partial 83%	Partial 17%	No	No	No
Pahipahialua	Manage for stability	22	Yes	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

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Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

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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	77	Partial 100%	Partial 97%	No	No	No
Helemano and Poamoho	Manage for stability	21	No	Partial 5%	No	No	No
Kaiwikoele, Kamananui, and Kawainui	Genetic Storage	13	No	No	No	No	No
Lower Peahinaia	Manage for stability	10	Partial 60%	Partial 50%	No	No	No
South Kaukonahua	Genetic Storage	2	No	No	No	No	No
Upper Opaeula/Helemano	Genetic Storage	1	Yes	Partial 100%	No	No	No

Action Area: Out

TaxonName: Gardenia mannii

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Ihiihi-Kawainui ridge	Genetic Storage	2	No	No	No	No	No
Kaluaa and Maunauna	Genetic Storage	2	No	No	No	No	No
Kamananui-Malaekahana Summit Ridge	Genetic Storage	3	No	No	No	No	No
Kapakahi	Genetic Storage	2	No	No	No	No	No
Pukele	Genetic Storage	1	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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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%	No	No	No	No
Kaukonahua	Manage for stability	55	No	No	No	No	No
Lower Opaeula	Manage for stability	15	No	No	No	No	No
Poamoho	Genetic Storage	21	No	No	No	No	No

Action Area: Out

TaxonName: Hesperomannia swezeyi

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Niu-Waimanalo Summit	Genetic Storage	1	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary Oahu Implementation Plan

Action Area: In

TaxonName: Labordia cyrtandrae

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
East Makaleha to North Mohiakea	Manage for stability	298	Partial 90%	Partial 92%	No	No	No

Action Area: Out

TaxonName: Labordia cyrtandrae

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Koloa	Manage reintroduction for stability	9	Yes	No	No	No	No

[shaded box] = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

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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	96	Partial 100%	Partial 98%	No	No	No
Helemano and Opaeula	Genetic Storage	1	Partial 0%	Partial 0%	No	No	No
Helemano to Poamoho	Genetic Storage	2	No	No	No	No	No
Kaipapau and Kawainui	Genetic Storage	4	No	No	No	No	No
Kaukonahua	Genetic Storage	0	No	No	No	No	No
Kawaiiki	Genetic Storage	0	No	No	No	No	No
Koloa	Manage for stability	114	Partial 98%	Partial 98%	No	No	No

Action Area: Out

TaxonName: Phyllostegia hirsuta

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Hapapa to Kaluaa	Genetic Storage	1	Partial 0%	Partial 0%	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	87	Yes	Partial 100%	No	No	No
Waiamano	Genetic Storage	1	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary 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	1	Yes	Partial 100%	Partial 100%	Partial 100%	No
Kaluaa	Manage for stability	74	Yes	Partial 100%	No	No	No
Pualii	Manage reintroduction for stability	11	Yes	Partial 100%	No	No	No
Waieli	Genetic Storage	1	Partial 100%	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary 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	288	Partial 89%	Partial 86%	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: Stenogyne kanehoana

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Haleauau	Manage reintroduction for stability	281	Partial 100%	Partial 100%	No	No	No

Action Area: Out

TaxonName: Stenogyne kanehoana

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kaluaa	Manage reintroduction for stability	26	Yes	Partial 100%	No	No	No
Makaha	Manage reintroduction for stability	0	Yes	Partial	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Genetic Storage Summary   Makua Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	1	0	0	0	0	0	0	0	0	0	0	0	0%
Makua	Manage for stability	6	0	2	0	0	0	2	0	0	0	2	2	25%
South Mohiakea	Genetic Storage	2	0	0	0	0	0	1	0	0	0	1	1	50%
West Makaleha	Genetic Storage	13	0	0	0	0	0	2	0	0	0	0	0	0%
Action Area: Out														
Alectryon macrococcus var. macrococcus														
Central Kaluaa to Central Waieli	Manage for stability	3	0	0	0	0	0	0	0	0	0	0	0	0%
Makaha	Manage for stability	29	0	2	0	0	0	18	0	0	0	5	5	16%
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
54	0	4	0	0	0	23	0	0	0	8	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														
Cenchrus agrimonioides var. agrimonioides														
Kahanahaiki and Pahole	Manage for stability	60	25	46	75	56	0	1	35	13	0	1	14	28%
Kuaokala	Genetic Storage	1	3	0	0	0	0	1	0	0	0	1	1	100%
Action Area: Out														
Cenchrus agrimonioides var. agrimonioides														
Central Ekahanui	Manage for stability	61	52	24	44	20	0	40	14	1	0	35	35	70%
Makaha and Waianae Kai	Manage for stability	5	7	6	5	3	0	9	0	0	0	9	9	82%
South Huliwai	Genetic Storage	17	13	19	22	14	0	20	6	3	0	18	19	53%
		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**	
		144	100	95	146	93	0	71	55	17	0	64	78	

Genetic Storage Summary   Makua Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	6	11	10	14	14	0	10	14	14	0	9	14	88%
Action Area: Out														
Cyanea grimesiana subsp. obatae														
Kaluaa	Manage for stability	2	1	1	3	3	0	1	3	3	0	1	3	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	7	7	10	15	15	5	10	15	15	5	10	15	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
15	19	23	34	34	7	23	34	34	7	22	34

Genetic Storage Summary   Makua Implementation Plan

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Cyanea longiflora														
Kapuna to West Makaleha	Manage for stability	13	18	13	20	20	9	0	20	20	9	0	20	77%
Pahole	Manage for stability	60	18	18	50	50	1	3	48	47	1	1	48	96%
Action Area: Out														
Cyanea longiflora														
Makaha and Waianae Kai	Manage for stability	7	2	3	4	4	2	1	4	4	2	1	4	40%

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
80	38	34	74	74	12	4	72	71	12	2	72

Genetic Storage Summary   Makua Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	2	3	3	3	2	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	2	3	3	3	2	3	3

Genetic Storage Summary   Makua Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	33	142	20	30	30	0	0	29	29	0	0	29	58%
Kawaiiki (Koolaus)	Manage for stability	13	79	0	0	0	0	0	0	0	0	0	0	0%
Opaeula (Koolaus)	Manage for stability	35	161	0	1	1	0	0	1	1	0	0	1	3%
Pahole to West Makaleha	Manage for stability	610	892	0	73	73	0	0	73	73	0	0	73	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
694	1274	20	104	104	0	0	103	103	0	0	103

Genetic Storage Summary Makua Implementation Plan

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Delissea waianaeensis														
Kahanahaiki to Keawapilau	Manage for stability	3	4	9	14	14	1	0	14	14	1	0	14	100%
Palikea Gulch	Genetic Storage	1	0	6	7	7	3	0	7	7	3	0	7	100%
South Mohiakea	Genetic Storage	10	15	5	12	12	0	0	11	11	0	0	11	73%
Action Area: Out														
Delissea waianaeensis														
Ekahanui	Manage for stability	2	1	4	6	6	0	0	6	6	0	0	6	100%
Kaluaa	Manage for stability	5	2	3	8	8	0	0	8	8	0	0	8	100%
Kealia	Genetic Storage	4	13	4	5	5	0	0	5	5	0	0	5	63%
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
49	65	39	82	82	4	0	79	79	4	0	79

Genetic Storage Summary Makua Implementation Plan

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # 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	229	0	0	3	0	0	0	3	0	0	0	0	0%
Ohikilolo Makai	Manage for stability	89	2	0	1	0	0	0	1	0	0	0	0	0%
Ohikilolo Mauka	Manage for stability	415	9	0	1	0	0	0	1	0	0	0	0	0%
Action Area: Out														
Dubautia herbstobatae														
Kamaileunu	Genetic Storage	0	0	1	1	0	0	1	1	0	0	0	0	0%
Makaha	Manage for stability	23	2	18	18	0	0	32	13	0	0	28	28	68%
Waianae Kai	Genetic Storage	10	4	0	5	0	0	3	4	0	0	3	3	30%
		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**	
		836	17	19	29	0	0	36	23	0	0	31	31	

Genetic Storage Summary   Makua Implementation Plan

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Euphorbia celastroides var. kaenana														
East Kahanahaiki	Genetic Storage	2	0	0	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	85	0	28	76	73	0	0	56	47	0	0	47	94%
North Kahanahaiki	Genetic Storage	115	36	3	12	12	0	0	9	6	0	0	6	12%
Puaakanoa	Manage for stability	120	11	4	48	42	0	0	29	28	0	0	28	56%
Action Area: Out														
Euphorbia celastroides var. kaenana														
East of Alau	Manage for stability	20	2	6	26	26	0	0	24	21	0	0	21	81%
Kaena	Manage for stability	880	274	2	68	67	0	0	66	58	0	0	58	100%
Keawaula	Genetic Storage	43	1	6	31	27	0	0	18	10	0	0	10	20%
Waianae Kai	Genetic Storage	34	0	0	0	0	0	0	0	0	0	0	0	0%

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
1310	327	49	264	249	0	0	202	170	0	0	170

Genetic Storage Summary   Makua Implementation Plan

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Euphorbia herbstii														
Kapuna to Pahole	Manage for stability	13	9	45	32	30	0	18	17	15	0	9	17	34%

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
13	9	45	32	30	0	18	17	15	0	9	17

Genetic Storage Summary   Makua Implementation Plan

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Flueggea neowawraea														
Kahanahaiki to Kapuna	Manage for stability	6	0	2	1	1	0	3	1	1	0	2	2	25%
Ohikilolo	Manage for stability	1	0	1	1	0	0	1	0	0	0	1	1	50%
West Makaleha	Genetic Storage	6	0	0	0	0	0	6	0	0	0	1	1	17%
Action Area: Out														
Flueggea neowawraea														
Central and East Makaleha	Genetic Storage	4	0	3	1	1	0	6	1	1	0	5	5	71%
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	0	0	0%
Makaha	Manage for stability	9	0	2	0	0	0	10	0	0	0	3	3	27%
Mt. Kaala NAR	Genetic Storage	3	0	0	1	1	0	2	1	1	0	1	2	67%
Nanakuli, south branch	Genetic Storage	1	0	0	0	0	0	1	0	0	0	1	1	100%
Waianae Kai	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0%

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
33	0	9	4	3	0	31	3	3	0	15	16

Genetic Storage Summary Makua Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	51	0	6	57	50	0	6	48	33	0	3	33	66%
Action Area: Out														
Gouania vitifolia														
Waianae Kai	Genetic Storage	3	0	0	0	0	0	2	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**
54	0	6	57	50	0	8	48	33	0	3	33

Genetic Storage Summary   Makua Implementation Plan

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Hesperomannia oahuensis														
Haleauau	Manage for stability	1	0	0	0	0	0	1	0	0	0	1	1	100%
Action Area: Out														
Hesperomannia oahuensis														
Makaha	Manage for stability	5	1	1	1	1	0	2	0	0	0	2	2	33%
Waianae Kai	Genetic Storage	0	1	2	0	0	0	0	0	0	0	0	0	0%

Total Current Mature	Total Current Imm.	Total Dead and Repres.	Total # Plants w/ >=10 Seeds in SeedLab	Total # Plants w/ >=10 Est Vaible Seeds in SeedLab	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants w/ >=50 Seeds in SeedLab	Total # Plants w/ >=50 Est Viable Seeds in SeedLab	Total # Plants w/ >=3 in Microprop	Total # Plants w/ >=3 Army Nursery	Total # Plants that Met Goal
6	2	3	1	1	0	3	0	0	0	3	3

Genetic Storage Summary   Makua Implementation Plan

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Hibiscus brackenridgei subsp. mokuleianus														
Keaau	Manage for stability	0	5	7	1	1	0	6	1	1	0	6	6	86%
Makua	Manage for stability	16	5	28	35	34	0	36	33	33	0	36	36	82%
Action Area: Out														
Hibiscus brackenridgei subsp. mokuleianus														
Haili to Kawaiu	Manage for stability	3	2	12	0	0	0	15	0	0	0	15	15	100%
Waialua	Genetic Storage	49	85	24	7	5	0	57	3	0	0	57	57	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
68	97	71	43	40	0	114	37	34	0	114	114

Genetic Storage Summary   Makua Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	102	100	21	77	77	0	7	68	63	0	7	64	100%
Action Area: Out														
Kadua degeneri subsp. degeneri														
Alaiheihe and Manuwai	Manage for stability	19	18	19	32	32	1	2	31	29	1	2	30	79%
Central Makaleha and West Branch of East Makaleha	Manage for stability	22	10	24	40	38	0	0	37	31	0	0	31	67%
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
143	128	64	149	147	1	9	136	123	1	9	125

Genetic Storage Summary Makua Implementation Plan

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Kadua parvula														
Ohikilolo	Manage for stability	76	86	67	78	74	0	2	72	67	0	0	67	100%
Action Area: Out														
Kadua parvula														
Halona	Manage for stability	31	4	29	68	64	0	25	59	49	0	6	51	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
107	90	96	146	138	0	27	131	116	0	6	118

Genetic Storage Summary   Makua Implementation Plan

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Melanthera tenuifolia														
Kahanahaiki	Genetic Storage	13	6	23	11	0	0	12	5	0	0	6	6	17%
Kaluakauila	Genetic Storage	4	80	0	9	0	0	16	1	0	0	11	11	100%
Keawaula	Genetic Storage	200	50	0	0	0	0	0	0	0	0	0	0	0%
Ohikilolo	Manage for stability	1088	11	19	16	0	0	8	13	0	0	5	5	10%
Action Area: Out														
Melanthera tenuifolia														
Kamaileunu and Waianae Kai	Manage for stability	815	246	0	0	0	0	0	0	0	0	0	0	0%
Mt. Kaala NAR	Manage for stability	131	24	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**
2251	417	42	36	0	0	36	19	0	0	22	22

Genetic Storage Summary   Makua Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	33	2	2	0	36	1	0	0	21	21	42%
Punapohaku	Genetic Storage	4	0	0	0	0	0	4	0	0	0	4	4	100%
Action Area: Out														
Neraudia angulata														
Halona	Genetic Storage	4	10	17	0	0	0	9	0	0	0	8	8	38%
Leeward Puu Kaua	Genetic Storage	9	0	0	0	0	0	1	0	0	0	1	1	11%
Makaha	Manage for stability (backup site)	3	8	12	2	1	0	15	1	0	0	14	14	93%
Manuwai	Manage for stability	0	3	2	0	0	0	4	0	0	0	4	4	100%
Waianae Kai Makai	Genetic Storage	13	0	0	0	0	0	8	0	0	0	8	8	62%
Waianae Kai Mauka	Manage for stability	7	2	9	0	0	0	11	0	0	0	11	11	69%
		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**	
		61	27	75	6	5	0	90	4	0	0	73	73	

Genetic Storage Summary Makua Implementation Plan

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Nototrichium humile														
Kahanahaiki	Genetic Storage	78	4	1	0	0	0	12	0	0	0	9	9	18%
Kaluakauila	Manage for stability	160	48	1	2	1	0	0	1	1	0	0	1	2%
Keaau	Genetic Storage	21	31	0	0	0	0	0	0	0	0	0	0	0%
Keawaula	Genetic Storage	70	70	1	0	0	0	8	0	0	0	8	8	16%
Makua (East rim)	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0%
Makua (south side)	Manage for stability	43	3	0	0	0	0	0	0	0	0	0	0	0%
Punapohaku	Genetic Storage	178	77	1	0	0	0	36	0	0	0	35	35	70%
Action Area: Out														
Nototrichium humile														
Kaimuhole and Palikea Gulch	Genetic Storage	29	1	12	0	0	0	43	0	0	0	42	42	100%
Keawapilau	Genetic Storage	1	0	4	0	0	0	5	0	0	0	5	5	100%
Kolekole	Genetic Storage	12	0	0	0	0	0	10	0	0	0	10	10	83%
Makaha	Genetic Storage	22	5	0	0	0	0	0	0	0	0	0	0	0%
Nanakuli	Genetic Storage	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	155	135	0	0	0	0	2	0	0	0	2	2	4%

Genetic Storage Summary   Makua Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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**	
		772	374	20	2	1	0	116	1	1	0	111	112	

Genetic Storage Summary   Makua Implementation Plan

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Phyllostegia kaalaensis														
Keawapilau to Kapuna	Manage reintroduction for stability	0	0	1	0	0	1	1	0	0	1	0	1	100%
Pahole	Manage reintroduction for stability	0	0	2	0	0	2	2	0	0	2	1	2	100%
Palikea Gulch	Genetic Storage	0	0	3	0	0	3	3	0	0	3	0	3	100%
Action Area: Out														
Phyllostegia kaalaensis														
Waianae Kai	Genetic Storage	0	0	2	1	0	2	2	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	1	0	8	8	0	0	8	1	8

Genetic Storage Summary   Makua Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	39	12	9	20	20	0	0	19	19	0	0	19	40%
Ohikilolo	Manage for stability	0	0	17	19	18	0	2	12	12	0	0	12	71%
Pahole	Genetic Storage	4	5	2	5	4	0	0	4	4	0	0	4	67%
Action Area: Out														
Plantago princeps var. princeps														
Ekahanui	Manage for stability	7	73	67	68	66	0	3	59	42	0	0	42	84%
Halona	Manage for stability	6	9	22	22	22	0	0	22	18	0	0	18	64%
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
57	99	119	136	132	0	5	118	97	0	0	97

Genetic Storage Summary Makua Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	72	1178	0	1	0	1	0	1	0	0	0	0	0%
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	123	11	0	0	0	1	0	0	0	1	0	1	2%
Waianae Kai	Genetic Storage	4	5	0	0	0	0	0	0	0	0	0	0	0%

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
200	1194	0	1	0	2	0	1	0	1	0	1

Genetic Storage Summary   Makua Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	0	13	32	46	42	0	0	28	8	0	0	8	25%
Ohikilolo	Manage for stability	0	5	56	56	40	0	1	22	17	0	0	17	34%
Action Area: Out														
Sanicula mariversa														
Kamaileunu	Manage for stability	3	264	30	56	56	0	0	42	35	0	0	35	100%
Puu Kawiwi	Genetic Storage	0	0	2	3	3	0	0	3	1	0	0	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
3	282	120	161	141	0	1	95	61	0	0	61

Genetic Storage Summary   Makua Implementation Plan

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Schiedea kaalae														
Pahole	Manage for stability	2	0	0	2	2	2	2	2	2	2	0	2	100%
Action Area: Out														
Schiedea kaalae														
Kahana	Genetic Storage	5	0	4	2	2	8	8	0	0	8	7	9	100%
Kaluaa and Waieli	Manage for stability	0	0	1	1	1	1	1	1	1	1	0	1	100%
Maakua (Koolaus)	Manage for stability	10	0	0	1	1	4	5	0	0	4	3	5	50%
Makaua (Koolaus)	Genetic Storage	1	0	0	0	0	1	1	0	0	1	1	1	100%
North Palawai	Genetic Storage	0	0	1	1	1	1	1	1	1	1	0	1	100%
South Ekahanui	Manage for stability	9	2	8	16	16	13	14	11	8	11	5	15	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
27	2	14	23	23	30	32	15	12	28	16	34

Genetic Storage Summary Makua Implementation Plan

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Schiedea nuttallii														
Kahanahaiki to Pahole	Manage for stability	6	0	41	39	37	2	43	31	15	2	40	41	87%
Kapuna-Keawapilau Ridge	Manage for stability	0	0	2	2	2	0	2	2	1	0	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
6	0	43	41	39	2	45	33	16	2	42	43

Genetic Storage Summary Makua Implementation Plan

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	# of Potential Founders: Current Imm.	# of Potential Founders: Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	Partial Storage Status: # Plants >= 10 Est Viable in SeedLab	Partial Storage Status: # Plants >=1 Microprop	Partial Storage Status: # Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	Storage Goals: # Plants >= 50 Est. Viable in SeedLab	Storage Goals: # Plants >=3 in Microprop	Storage Goals: # Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Schiedea obovata														
Kahanahaiki to Pahole	Manage for stability	0	0	9	5	5	1	0	5	5	1	0	5	56%
Keawapilau to West Makaleha	Manage for stability	11	458	73	79	79	1	0	78	77	0	0	77	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
11	458	82	84	84	2	0	83	82	1	0	82

Genetic Storage Summary   Makua Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	99	62	0	0	60	6	0	0	6	12%
Kalena	Manage for stability	24	93	7	9	8	0	7	9	8	0	7	8	26%
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	1902	1464	38	147	64	0	0	52	6	0	0	6	12%
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	20	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**	
		2366	1798	84	277	154	0	7	127	25	0	7	25	

Genetic Storage Summary Makua Implementation Plan

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # 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	208	55	0	1	0	0	0	0	0	0	0	0	0%
Puu Kumakalii	Manage for stability	44	0	0	12	0	0	8	3	0	0	7	7	16%
Action Area: Out														
Viola chamissoniana subsp. chamissoniana														
Halona	Manage for stability	15	5	6	4	0	0	3	1	0	0	1	1	5%
Kamaileunu	Genetic Storage	35	0	0	0	0	0	0	0	0	0	0	0	0%
Makaha	Manage for stability	68	11	0	0	0	0	0	0	0	0	0	0	0%
Makaleha	Genetic Storage	19	9	2	8	0	0	12	1	0	0	4	4	19%
Puu Hapapa	Genetic Storage	6	1	7	7	0	0	6	4	0	0	1	1	8%

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
435	91	15	32	0	0	29	9	0	0	13	13

Genetic Storage Summary   Oahu Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	30	49	0	16	10	0	0	10	1	0	0	1	3%
Kahanahaiki	Manage reintroduction for stability	0	0	1	1	1	0	1	1	0	0	1	1	100%
Keaau	Genetic Storage	1	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	5	37	8	10	9	0	0	9	4	0	0	4	31%
Halona	Genetic Storage	10	5	0	3	2	0	0	2	1	0	0	1	10%
Makaha Makai	Manage for stability	92	133	1	73	68	0	1	63	55	0	0	55	100%
Makaha Mauka	Genetic Storage	13	1	8	25	14	0	0	22	3	0	0	3	14%
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
160	236	19	130	105	0	2	108	64	0	1	65

Genetic Storage Summary Oahu Implementation Plan

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Alectryon macrococcus var. macrococcus														
Kahanahaiki to Keawapilau	Manage for stability	1	0	0	0	0	0	0	0	0	0	0	0	0%
Makua	Manage for stability	6	0	2	0	0	0	2	0	0	0	2	2	25%
South Mohiakea	Genetic Storage	2	0	0	0	0	0	1	0	0	0	1	1	50%
West Makaleha	Genetic Storage	13	0	0	0	0	0	2	0	0	0	0	0	0%
Action Area: Out														
Alectryon macrococcus var. macrococcus														
Central Kaluaa to Central Waieli	Manage for stability	3	0	0	0	0	0	0	0	0	0	0	0	0%
Makaha	Manage for stability	29	0	2	0	0	0	18	0	0	0	5	5	16%
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
54	0	4	0	0	0	23	0	0	0	8	8

Genetic Storage Summary Oahu Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	130	142	0	4	4	0	0	4	4	0	0	4	8%
Kahana and South Kaukonahua	Genetic Storage	2	0	0	0	0	0	0	0	0	0	0	0	0%
Makaleha to Mohiakea	Manage for stability	190	89	0	7	7	0	1	7	7	0	0	7	14%
Action Area: Out														
Cyanea acuminata														
Kahana and Makaua	Genetic Storage	11	3	0	1	1	0	0	1	0	0	0	0	0%
Kaipapau and Koloa	Genetic Storage	70	30	0	0	0	0	0	0	0	0	0	0	0%
Kaluanui and Maakua	Manage for stability	123	126	0	0	0	0	0	0	0	0	0	0	0%
Puukeahiakahoe	Genetic Storage	3	0	0	0	0	0	0	0	0	0	0	0	0%

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
529	390	0	12	12	0	1	12	11	0	0	11

Genetic Storage Summary   Oahu Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	6	11	10	14	14	0	10	14	14	0	9	14	88%
Action Area: Out														
Cyanea grimesiana subsp. obatae														
Kaluaa	Manage for stability	2	1	1	3	3	0	1	3	3	0	1	3	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	7	7	10	15	15	5	10	15	15	5	10	15	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**	
		15	19	23	34	34	7	23	34	34	7	22	34	

Genetic Storage Summary   Oahu Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	93	16	0	1	1	1	0	1	1	1	0	1	2%
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	2	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
172	48	0	2	2	1	0	2	2	1	0	2

Genetic Storage Summary Oahu Implementation Plan

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Cyrtandra dentata														
Kahanahaiki	Manage for stability	33	142	20	30	30	0	0	29	29	0	0	29	58%
Kawaiiki (Koolaus)	Manage for stability	13	79	0	0	0	0	0	0	0	0	0	0	0%
Opaeula (Koolaus)	Manage for stability	35	161	0	1	1	0	0	1	1	0	0	1	3%
Pahole to West Makaleha	Manage for stability	610	892	0	73	73	0	0	73	73	0	0	73	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
694	1274	20	104	104	0	0	103	103	0	0	103

Genetic Storage Summary   Oahu Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	3	4	9	14	14	1	0	14	14	1	0	14	100%
Palikea Gulch	Genetic Storage	1	0	6	7	7	3	0	7	7	3	0	7	100%
South Mohiakea	Genetic Storage	10	15	5	12	12	0	0	11	11	0	0	11	73%
Action Area: Out														
Delissea waianaeensis														
Ekahanui	Manage for stability	2	1	4	6	6	0	0	6	6	0	0	6	100%
Kaluaa	Manage for stability	5	2	3	8	8	0	0	8	8	0	0	8	100%
Kealia	Genetic Storage	4	13	4	5	5	0	0	5	5	0	0	5	63%
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
49	65	39	82	82	4	0	79	79	4	0	79

Genetic Storage Summary Oahu Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	3	0	0	0	13	0	0	0	6	6	55%
Kaiwikoele and Kamananui	Genetic Storage	21	26	4	0	0	0	26	0	0	0	12	12	48%
Kaleleiki	Genetic Storage	14	54	13	0	0	0	25	0	0	0	2	2	7%
Kaunala	Manage for stability	20	39	8	0	0	0	35	0	0	0	13	13	46%
Malaekahana	Genetic Storage	5	21	0	0	0	0	4	0	0	0	2	2	40%
Ohiaai and East Oio	Genetic Storage	1	1	1	0	0	0	3	0	0	0	1	1	50%
Oio	Manage for stability	6	2	10	0	0	0	15	0	0	0	5	5	31%
Pahipahialua	Manage for stability	22	6	20	0	0	0	31	0	0	0	16	16	38%
Action Area: Out														
Eugenia koolauensis														
Hanaimoa	Genetic Storage	1	0	2	0	0	0	3	0	0	0	1	1	33%
Palikea and Kaimuhole	Genetic Storage	1	0	1	0	0	0	2	0	0	0	2	2	100%
		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**	
		99	159	62	0	0	0	157	0	0	0	60	60	

Genetic Storage Summary   Oahu Implementation Plan

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Flueggea neowawraea														
Kahanahaiki to Kapuna	Manage for stability	6	0	2	1	1	0	3	1	1	0	2	2	25%
Ohikilolo	Manage for stability	1	0	1	1	0	0	1	0	0	0	1	1	50%
West Makaleha	Genetic Storage	6	0	0	0	0	0	6	0	0	0	1	1	17%
Action Area: Out														
Flueggea neowawraea														
Central and East Makaleha	Genetic Storage	4	0	3	1	1	0	6	1	1	0	5	5	71%
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	0	0	0%
Makaha	Manage for stability	9	0	2	0	0	0	10	0	0	0	3	3	27%
Mt. Kaala NAR	Genetic Storage	3	0	0	1	1	0	2	1	1	0	1	2	67%
Nanakuli, south branch	Genetic Storage	1	0	0	0	0	0	1	0	0	0	1	1	100%
Waianae Kai	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0%
		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**	
		33	0	9	4	3	0	31	3	3	0	15	16	

Genetic Storage Summary   Oahu Implementation Plan

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Gardenia mannii														
Haleauau	Manage for stability	3	0	5	0	0	0	5	0	0	0	5	5	63%
Helemano and Poamoho	Manage for stability	21	1	2	0	0	0	18	0	0	0	14	14	61%
Kaiwikoele, Kamananui, and Kawainui	Genetic Storage	13	0	0	0	0	0	1	0	0	0	0	0	0%
Lower Peahinaia	Manage for stability	10	0	2	0	0	0	7	0	0	0	6	6	50%
South Kaukonahua	Genetic Storage	2	0	0	0	0	0	2	0	0	0	0	0	0%
Upper Opaeula/Helemano	Genetic Storage	1	0	0	0	0	0	1	0	0	0	1	1	100%
Action Area: Out														
Gardenia mannii														
Ihiihi-Kawainui ridge	Genetic Storage	2	0	0	0	0	0	0	0	0	0	0	0	0%
Kaluaa and Maunauna	Genetic Storage	2	0	0	0	0	0	2	0	0	0	2	2	100%
Kamananui-Malaekahana Summit Ridge	Genetic Storage	3	0	0	0	0	0	2	0	0	0	1	1	33%
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
60	1	9	0	0	0	38	0	0	0	29	29

Genetic Storage Summary Oahu Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	15	23	0	1	0	0	0	0	0	0	0	0	0%
Poamoho	Genetic Storage	21	12	0	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
226	205	0	1	0	0	0	0	0	0	0	0

Genetic Storage Summary   Oahu Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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														
Labordia cyrtandrae														
East Makaleha to North Mohiakea	Manage for stability	71	0	0	9	8	4	4	8	8	2	1	10	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
71	0	0	9	8	4	4	8	8	2	1	10

Genetic Storage Summary Oahu Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	11	2	6	6	6	4	10	2	2	4	6	8	47%
Helemano and Opaeula	Genetic Storage	1	4	4	2	1	1	4	1	0	1	3	3	60%
Helemano to 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	2	2	0	0	2	2	4	100%
Kaukonahua	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	0%
Kawaiiki	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	0%
Koloa	Manage for stability	6	3	2	2	1	2	7	1	0	2	5	5	63%
Action Area: Out														
Phyllostegia hirsuta														
Hapapa to Kaluaa	Genetic Storage	1	27	10	8	7	8	10	4	4	7	8	9	82%
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	1	1	0	0	1	1	1	100%
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	39	24	19	16	18	34	8	6	17	25	30	

Genetic Storage Summary   Oahu Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	0	0	1	1	0	0	1	0	1	100%
Pahole	Manage reintroduction for stability	0	0	2	0	0	2	2	0	0	2	1	2	100%
Palikea Gulch	Genetic Storage	0	0	3	0	0	3	3	0	0	3	0	3	100%
Action Area: Out														
Phyllostegia kaalaensis														
Waianae Kai	Genetic Storage	0	0	2	1	0	2	2	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	1	0	8	8	0	0	8	1	8

Genetic Storage Summary   Oahu Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	6	6	6	7	3	2	5	7	7	88%
Action Area: Out														
Phyllostegia mollis														
Ekahanui	Manage for stability	0	0	2	2	2	1	2	1	0	1	2	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	1	0	0	1	1	1	100%
Waieli	Genetic Storage	1	0	5	5	5	4	6	4	4	4	6	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
1	0	17	15	15	12	16	9	7	11	16	17

Genetic Storage Summary   Oahu Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	39	12	9	20	20	0	0	19	19	0	0	19	40%
Ohikilolo	Manage for stability	0	0	17	19	18	0	2	12	12	0	0	12	71%
Pahole	Genetic Storage	4	5	2	5	4	0	0	4	4	0	0	4	67%
Action Area: Out														
Plantago princeps var. princeps														
Ekahanui	Manage for stability	7	73	67	68	66	0	3	59	42	0	0	42	84%
Halona	Manage for stability	6	9	22	22	22	0	0	22	18	0	0	18	64%
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
57	99	119	136	132	0	5	118	97	0	0	97

Genetic Storage Summary   Oahu Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	2	0	0	2	2	2	2	2	2	2	0	2	100%
Action Area: Out														
Schiedea kaalae														
Kahana	Genetic Storage	5	0	4	2	2	8	8	0	0	8	7	9	100%
Kaluaa and Waieli	Manage for stability	0	0	1	1	1	1	1	1	1	1	0	1	100%
Maakua (Koolaus)	Manage for stability	10	0	0	1	1	4	5	0	0	4	3	5	50%
Makaua (Koolaus)	Genetic Storage	1	0	0	0	0	1	1	0	0	1	1	1	100%
North Palawai	Genetic Storage	0	0	1	1	1	1	1	1	1	1	0	1	100%
South Ekahanui	Manage for stability	9	2	8	16	16	13	14	11	8	11	5	15	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**	
		27	2	14	23	23	30	32	15	12	28	16	34	

Genetic Storage Summary   Oahu Implementation Plan

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	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	296	351	15	87	86	2	0	86	84	2	0	84	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
296	351	15	87	86	2	0	86	84	2	0	84

Genetic Storage Summary   Oahu Implementation Plan

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Stenogyne kanehoana														
Haleauau	Manage reintroduction for stability	0	0	1	0	0	1	1	0	0	1	1	1	100%
Action Area: Out														
Stenogyne kanehoana														
Kaluaa	Manage reintroduction for stability	0	0	1	0	0	1	1	0	0	1	1	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	2	2	0	0	2	2	2

Genetic Storage Summary   Oahu Implementation Plan

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # 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	208	55	0	1	0	0	0	0	0	0	0	0	0%
Puu Kumakalii	Manage for stability	44	0	0	12	0	0	8	3	0	0	7	7	16%
Action Area: Out														
Viola chamissoniana subsp. chamissoniana														
Halona	Manage for stability	15	5	6	4	0	0	3	1	0	0	1	1	5%
Kamaileunu	Genetic Storage	35	0	0	0	0	0	0	0	0	0	0	0	0%
Makaha	Manage for stability	68	11	0	0	0	0	0	0	0	0	0	0	0%
Makaleha	Genetic Storage	19	9	2	8	0	0	12	1	0	0	4	4	19%
Puu Hapapa	Genetic Storage	6	1	7	7	0	0	6	4	0	0	1	1	8%

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
435	91	15	32	0	0	29	9	0	0	13	13

OAHU ARMY NATURAL RESOURCES PROGRAM
MONITORING PROGRAM

EFFECTS OF AUTOMATED SPRINKLERS AND SHADE CLOTHS ON TEMPERATURE AND RELATIVE HUMIDITY AT EKAHANUI TEMPORARY SNAIL ENCLOSURES

INTRODUCTION

Temperature and relative humidity (RH) were recorded at two *Achatinella mustelina* temporary predator proof enclosures (referred to as "Mamane" and "Spirizona") at Ekahanui comparing conditions inside versus outside (in neighboring trees) the enclosures as well as between sites to assess the influence of automated sprinklers and shade cloths installed at each enclosure. Unexpectedly high mortality of snails following translocation into the enclosures prompted the installation of automated sprinklers (set to run at 10:00 AM and 2:00 PM) and shade cloths to promote wetter and cooler conditions that may provide a more favorable environment for *A. mustelina*. Prior to the addition of sprinklers and shade cloths, comparisons of conditions at the enclosures indicated there were a number of statistically significant differences in mean temperature and median relative humidity inside vs. outside enclosures and between sites during the day and night (January 27 - February 16, 2016, and April 18 – May 5, 2016). Conditions inside were more humid at both sites during both day and night, cooler at both sites at night, cooler at Spirizona during the day (in January-February, but no difference in April-May), and warmer during the day (in January-February, but no difference in April-May) at Mamane, as compared with outside conditions. However, those differences were very small (mean daytime and nighttime differences inside vs. outside were no greater than 0.25 °F and 3.1% RH.), and likely do not signify biologically meaningful differences with respect to environmental requirements for *A. mustelina*. Paired comparisons of temperature and relative humidity inside and outside the enclosures during the times in which sprinklers and shade cloths were concurrently functional (May 16 to May 20, and June 23 to July 11 at Mamane; May 18 to June 15, and July 6 to July 11 at Spirizona) were made using data collected every 30 minutes at each site with Onset HOBO U23-001 data loggers.

RESULTS

Temperature

There were small yet significant differences inside vs. outside enclosures at both sites as well as between sites for temperature during the day and night for the entire duration of time in which sprinklers and shade cloths were concurrently functional (Table 1 and Figure 1). Conditions were slightly cooler inside vs. outside at both enclosures during the day (by a mean of 0.5 °F at Mamane, and 0.9 °F at Spirizona). Differences inside vs. outside at night were minimal at both sites, as were differences between the enclosures during both day and night, with means no greater than 0.2 °F. There were more appreciable differences inside vs. outside the enclosures during drier day times (when relative humidity was < 90% outside the enclosures), as mean temperatures were 0.9 °F cooler at Mamane and 1.5 °F cooler at Spirizona, as compared with outside conditions (Table 2 and Figure 2). Mean differences inside were even greater 30 minutes after the sprinklers were run, by 1.8 °F at Mamane, and 3.7 °F at Spirizona, as compared with outside the enclosures.

Table 1. Temperature (°F) inside vs. outside snail enclosure sites at Ekahanui during the day and night. P-values derived from paired t tests.

		Mamane		Spirizona		Mamane vs. Spirizona (inside)			
		inside	outside	inside	outside	p	t	df	Mean difference (Mamane - Spirizona)
Day	Mean	68.6	69.1	67.5	68.4	0.020	-2.34	220	-0.2
	SD	2.50	2.78	2.72	3.26				
	Minimum	62.7	62.6	61.5	61.5				
	Maximum	74.3	75.2	76.7	80.6				
	p	<0.001		<0.001					
	t	-11.584		-15.936					
	df	625		922					
	Mean difference (out - in)	0.5		0.9					
Night	Mean	65.3	65.2	64.2	64.2	<0.001	4.69	179	0.1
	SD	1.11	1.11	1.31	1.27				
	Minimum	62.7	62.7	61.0	61.5				
	Maximum	69.3	69.3	67.7	67.6				
	p	<0.001		<0.001					
	t	12.626		-5.496					
	df	494		725					
	Mean difference (out - in)	-0.1		0.0					

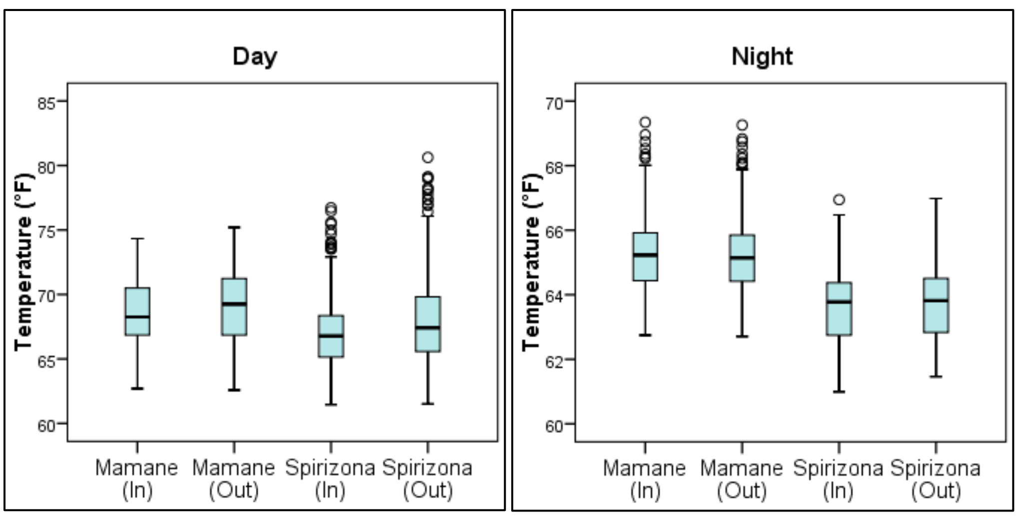


Figure 1. Boxplots[1] of temperature (°F) inside vs. outside temporary snail enclosure sites at Ekahanui during the day and night for the duration of time in which both sprinklers and shade cloths were functional.

[1]Boxplots show the range of data values for a given variable, analogous to a squashed bell curve turned on its side. The shaded boxes depict 50% of the data values, and the horizontal line inside the shaded box represents the median value. Very high or low values relative to the shaded box are indicated by circles (1.5 to 3 times the length of the shaded box) and asterisks (> 3 times the length of the shaded box), while the lines extending above and below the shaded box depict the range in values for all remaining data. Circles and asterisks that appear to be in boldface or are otherwise indistinguishable represent multiple overlapping data points for the same values.

Table 2. Temperature (°F) inside vs. outside snail enclosure sites at Ekahanui during drier day times (relative humidity < 90% outside enclosures) and 30 minutes after sprinklers were run. P-values derived from paired t tests.

	Drier day times				10:30 AM and 2:30 PM			
	Mamane		Spirizona		Mamane		Spirizona	
	inside	outside	inside	outside	inside	outside	inside	outside
Mean	70.2	71.1	69.5	70.9	69.8	71.6	68.5	72.2
SD	2.01	1.83	2.41	2.81	2.20	1.38	1.81	2.88
Minimum	65.6	65.9	64.6	65.1	66.8	69.2	65.1	68.3
Maximum	74.3	75.2	76.7	80.6	74.1	74.4	72.3	80.6
p	<0.001		<0.001		<0.001		<0.001	
t	-14.821		-11.856		-6.767		-8.013	
df	333		381		34		39	
Mean difference (out - in)	0.9		1.5		1.8		3.7	

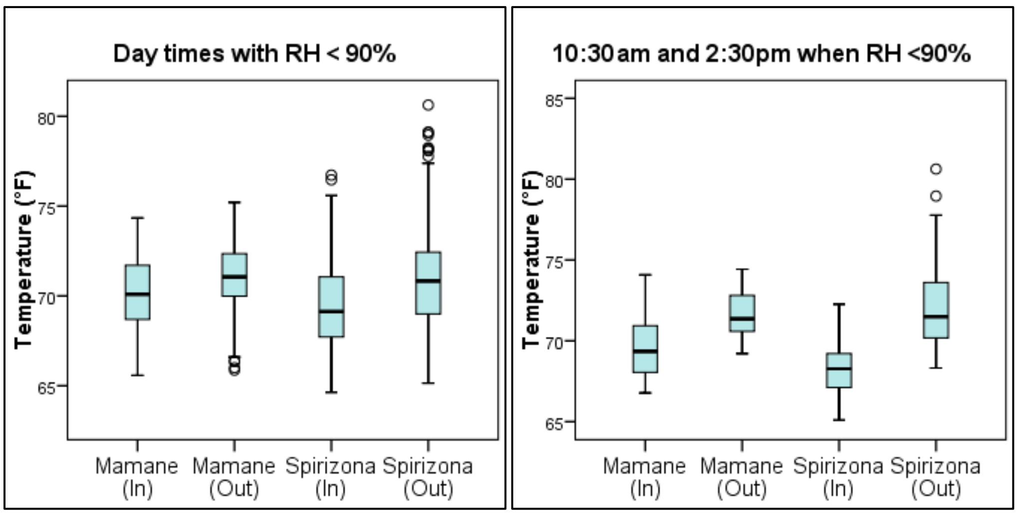


Figure 2. Boxplots of temperature (°F) inside vs. outside temporary snail enclosure sites at Ekahanui when both sprinklers and shade cloths were functional during drier day times (relative humidity < 90% outside enclosures), and 30 minutes after sprinklers were run.

Relative humidity

Similarly, there were small significant differences in relative humidity inside vs. outside at both sites as well as between sites during the day and night for the entire duration of time in which sprinklers and shade cloths were concurrently functional (Table 3 and Figure 3). Conditions were slightly more humid inside vs. outside at both enclosures during the day (by a mean of 1.2% at Mamane, and 4.1% at Spirizona). Differences inside vs. outside at night were minimal at both sites, as were differences between the enclosures during both day and night, with means no greater than 0.6%. Again, there were more appreciable differences inside vs. outside the enclosures during drier day times (when relative humidity was < 90% outside the enclosures), more humid by a mean of 2.4% at Mamane and 5.5% at Spirizona, as compared with outside conditions (Table 4 and Figure 4). Differences were greater still 30 minutes after the sprinklers were run, more humid by a mean of 5.8% at Mamane, and 13.7% at Spirizona, as compared with outside the enclosures. The most extreme instances of higher humidity inside vs. outside the enclosures 30 minutes after the sprinklers were by 17.4% at Mamane and 35.5% at Spirizona.

Table 3. Relative humidity (%) inside vs. outside snail enclosure sites at Ekahanui during the day and night. P-values derived from Wilcoxon signed rank tests.

		Mamane		Spirizona		Mamane vs. Spirizona (inside)			
		inside	outside	inside	outside	p	Z	n	Mean difference (Mamane-Spirizona)
Day	Median	90.8	88.7	96.3	92.4	0.001	-3.39	221	-0.6
	Minimum	70.7	68.7	65.3	57.9				
	Maximum	100.0	100.0	100.0	100.0				
	p	<0.001		<0.001					
	Z	-9.602		-20.907					
	n	626		923					
	Mean difference (out - in)	-1.2		-4.1					
Night	Median	98.3	99.0	100.0	100.0	<0.001	-8.91	180	-0.5
	Minimum	87.1	87.5	90.4	89.7				
	Maximum	100.0	100.0	100.0	100.0				
	p	<0.001		<0.001					
	Z	-14.582		-14.45					
	n	495		726					
	Mean difference (out - in)	0.4		-0.4					

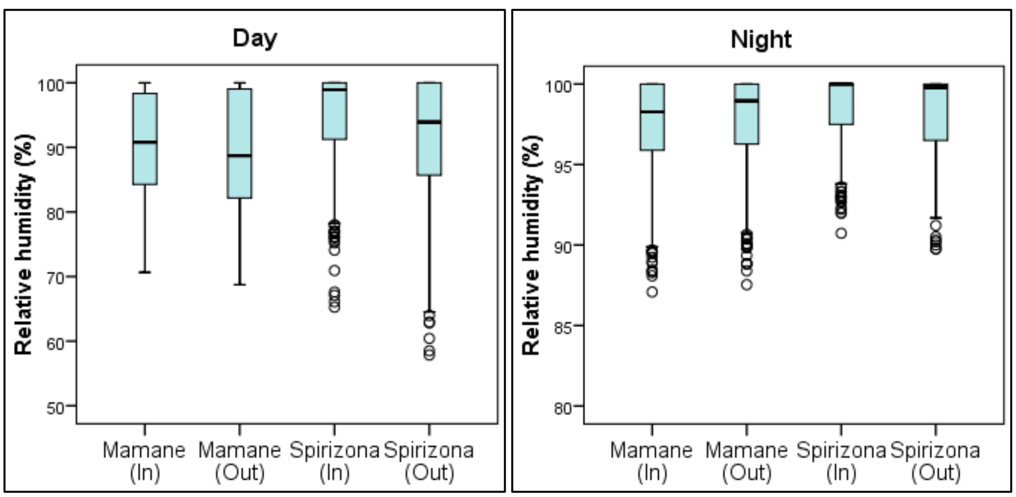


Figure 3. Boxplots of relative humidity inside vs. outside temporary snail enclosure sites at Ekahanui during the day and night for the duration of time in which both sprinklers and shade cloths were functional.

Table 4. Relative humidity (%) inside vs. outside snail enclosure sites at Ekahanui during drier day times (relative humidity < 90% outside enclosures) and 30 minutes after sprinklers were run. P-values derived from Wilcoxon signed rank tests.

	Drier day times				10:30 and 2:30			
	Mamane		Spirizona		Mamane		Spirizona	
	inside	outside	inside	outside	inside	outside	inside	outside
Median	84.7	82.6	87.6	82.5	88.4	83.0	94.8	80.5
Minimum	70.7	68.7	65.3	57.9	74.8	71.1	76.8	57.9
Maximum	98.3	89.9	100.0	90.0	97.7	87.7	100.0	90.0
p	<0.001		<0.001		<0.001		<0.001	
Z	-12.7		-15.0		-4.6		-5.4	
n	334		382		35		40	
Mean difference (out - in)	-2.4		-5.5		-5.8		-13.7	

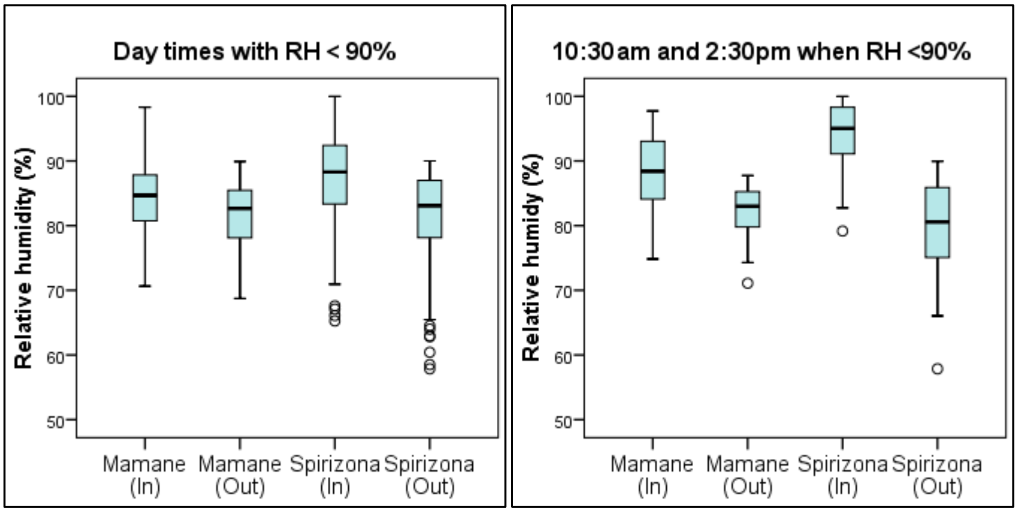


Figure 4. Boxplots of relative humidity inside vs. outside temporary snail enclosure sites at Ekahanui when both sprinklers and shade cloths were functional during drier day times (relative humidity < 90% outside enclosures), and 30 minutes after sprinklers were run.

SUMMARY AND DISCUSSION

The effects of sprinklers and shade cloths on temperature and relative humidity at the Ekahanui temporary snail enclosures, to varying degrees, is apparent when viewed graphically in Figure 5. Slightly cooler conditions, and humidity spikes following the running of the sprinklers, are apparent on the drier days. The small degree of differences in temperature and relative humidity inside vs. outside the enclosures during the day across the entire duration of time in which sprinklers and shade cloths were present is not surprising, given the occurrence of cloudy or rainy conditions at times, when any effects would be overridden, and because the effects associated with the sprinkler occur in a limited window of time. Minimal differences were expected at night. The more marked differences that occurred at drier times and 30 minutes following the running of sprinklers indicate the use of sprinklers and shade cloths likely provide a beneficial cooling and humidifying effect for *A. mustelina* during higher environmental stress conditions.

Sprinkler functionality was inconsistent resulting from a faulty solenoid and water catchment shortages. As of July 6, 2016, sprinklers at both sites were functional and catchment tanks contained enough water for at least a few months. The weekly number of snail deaths declined in the initial weeks following, and it was hoped this decline was in part due to the installation of sprinklers and shade cloths (Figure 6). However, higher than expected mortality resumed in late June through August, particularly at the Mamane enclosure. The addition of a 12:00 PM sprinkler setting may further enhance environmental conditions during what is often the driest and hottest part of the day, and help maintain higher humidity levels throughout the day. While temperature and moisture levels may have contributed to *A. mustelina* mortality at these sites, it should be noted that other unknown causes of mortality may be occurring.

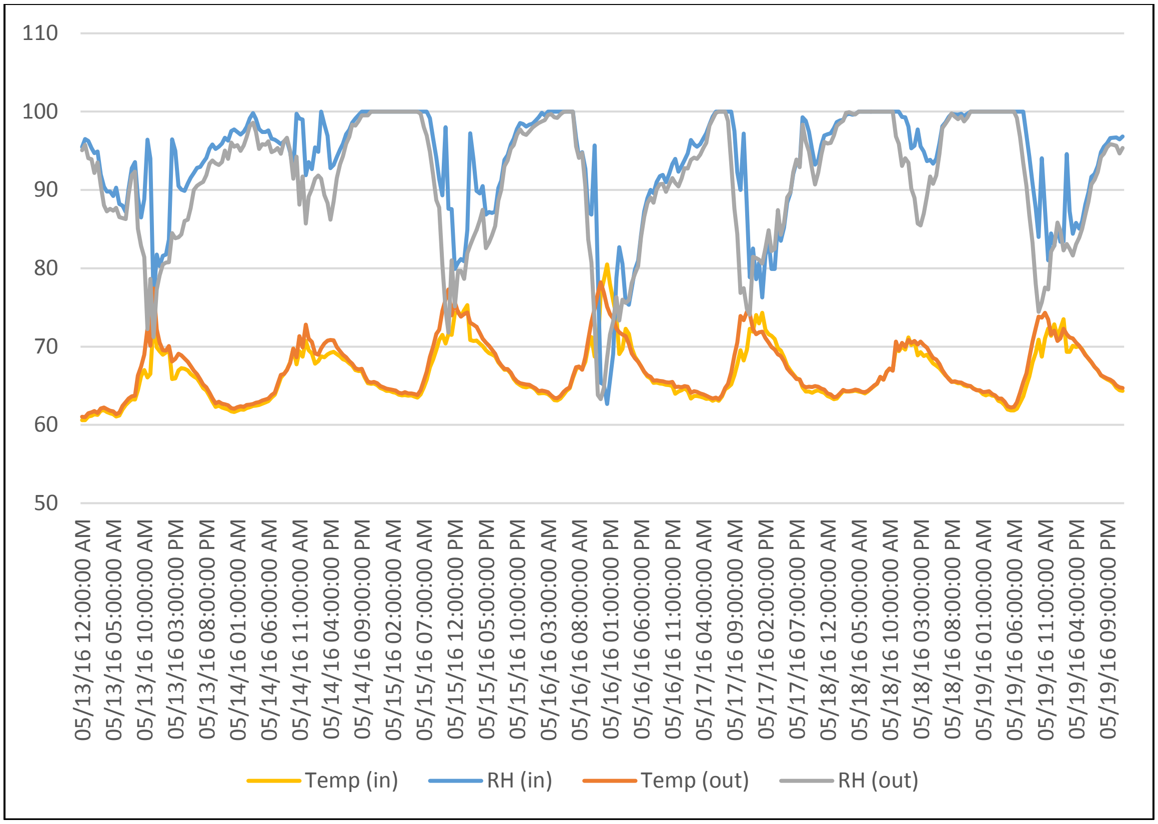


Figure 5. Temperature (°F) and relative humidity (%) at the Spirizona enclosure during one week in May 2016 showing typical diurnal patterns, and relative humidity spikes associated with automated sprinkler settings for 10:00 AM and 2:00 PM inside the enclosure on drier days.

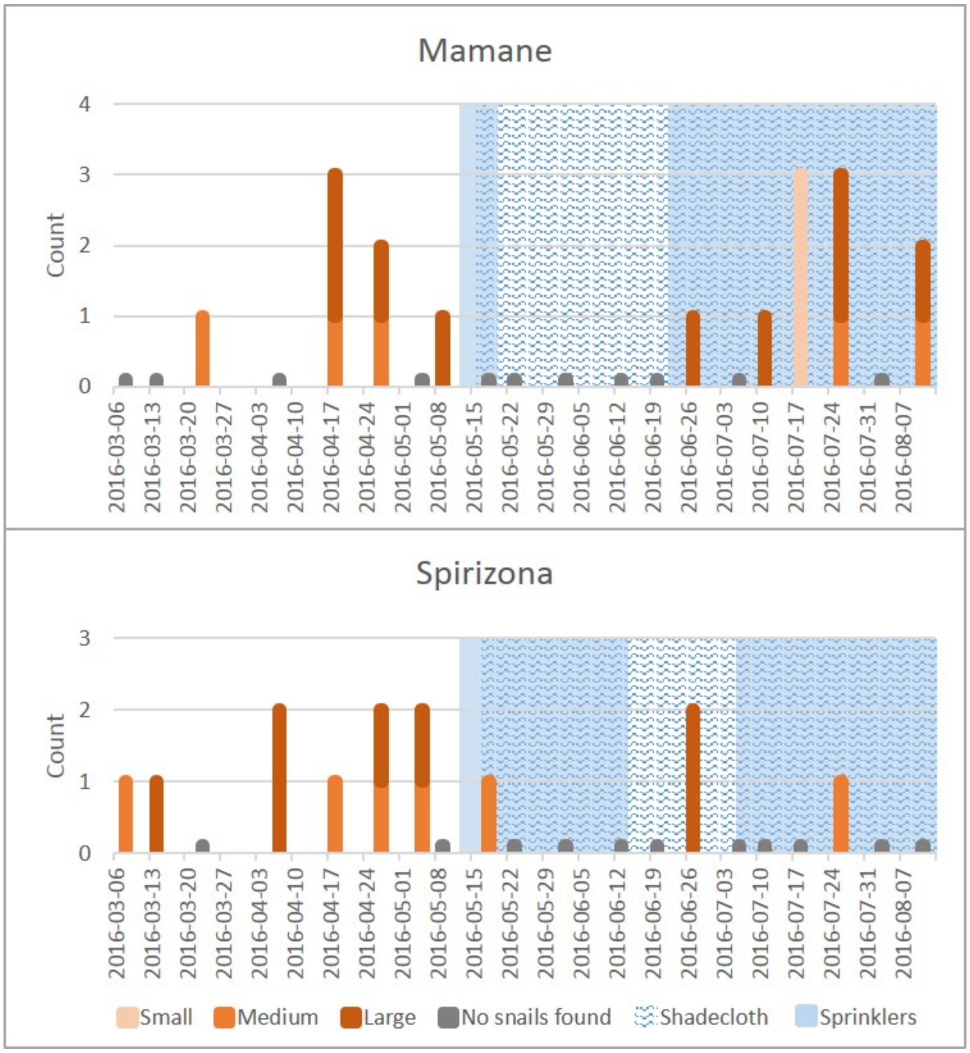


Figure 6. Counts of dead *Achatinella mustelina* shells recovered from the Mamane and Spirizona temporary snail enclosures at Ekahanui between March 8 and August 11, 2016. Shell sizes are indicated by color for small (< 8mm), medium (8-18mm) and large (> 18mm) individuals. Background shading indicates date ranges in which shade cloths (patterned fill) and sprinklers (solid fill) were in use at each enclosure.

Appendix 6-1

Demographic assessment of Oahu Elepaio on Army-managed lands, 1996-2015

Prepared by Dr. Eric VanderWerf, Pacific Rim Conservation

August 2016

INTRODUCTION

Elepaio are territorial, non-migratory monarch flycatchers (Monarchidae) endemic to the Hawaiian Islands of Kaua‘i, O‘ahu, and Hawaii (VanderWerf 1998). The forms on each island were treated as subspecies for many years, but morphological, behavioral, and genetic evidence indicate Elepaio on each island constitute separate species (VanderWerf 2007a, VanderWerf et al. 2009). In July 2010, the American Ornithologists Union officially changed the taxonomy of Elepaio so that each island form is now recognized as a distinct species endemic to that island. The Kaua‘i Elepaio (*Chasiempis sclateri*) and Hawaii Elepaio (*C. sandwichensis*) are fairly common and widespread (Scott et al. 1986), but the O‘ahu Elepaio (*C. ibidis*) is rare and locally distributed (VanderWerf et al 2001, 2013).

Oahu Elepaio have adapted relatively well to disturbed habitats composed of alien plants due to their flexible foraging behavior, broad diet consisting of diverse arthropods, and variable nest placement (Conant 1977; VanderWerf 1993, 1994, 1998; VanderWerf et al. 1997). Despite their adaptability, O‘ahu Elepaio have declined severely in the last few decades and now occupy only 25% of the range occupied in 1975 and less than 4% of the presumed prehistoric range (VanderWerf et al. 2001). The total population was estimated to be approximately 1,980 birds in the 1990s, and the population further declined to an estimated 1,261 birds in 2012, which consisted of 477 breeding pairs and 307 single males (VanderWerf et al. 2013). The current range is about 5,187 ha in size but is fragmented into numerous small populations, many of which are isolated by urban and agricultural development (VanderWerf et al. 2001, 2013). The O‘ahu Elepaio was listed as endangered under the United States Endangered Species Act in April 2000 (USFWS 2000), is listed as endangered by the State of Hawaii, and is considered endangered by the International Union for the Conservation of Nature (Birdlife International 2004).

The primary factors that currently threaten Oahu Elepaio populations are nest predation by alien black rats (*Rattus rattus*) and mosquito-borne diseases (VanderWerf and Smith 2002, USFWS 2006, VanderWerf et al. 2006, VanderWerf 2009). Habitat loss and degradation caused by spread of invasive non-native plants, feral ungulates, and fires are also threats (USFWS 2006, VanderWerf 2009). There is currently no practical method of controlling transmission of mosquito-borne avian diseases in forested environments in Hawaii, but rat control has proven to be an effective method of increasing nesting success and survival of female Elepaio (VanderWerf and Smith 2002, VanderWerf 2009, VanderWerf et al. 2013). Rat control has become the cornerstone of the conservation strategy for the Oahu Elepaio (VanderWerf 2009, VanderWerf et al. 2011).

The U.S. Army is required to manage 75 breeding pairs of Oahu Elepaio according to the terms of a consultation with the U.S. Fish and Wildlife Service. This management consists primarily of rat control and is conducted by the Oahu Army Natural Resources Program (OANRP). Some of this management occurs on Army lands and some occurs on other lands through cooperative agreements with landowners. The OANRP has controlled rats using traps and diphacinone bait stations at Schofield Barracks West Range and Makua Military Reservation since 1998; in Ekahanui Gulch in collaboration with The Nature Conservancy of Hawaii and the Hawaii Division of Forestry and Wildlife (DOFAW) since 2000; in Makaha Valley in collaboration with the City and County of Honolulu Board of Water Supply from 2004 to 2009; in Moanalua Valley in collaboration with DOFAW since 2005; at Palehua in collaboration with The Nature Conservancy of Hawaii and the Gill Family Trust since 2007; and in Waikane Valley from 2007-2009.

The efficacy of management for the Oahu Elepaio conducted by the OANRP has been assessed previously (VanderWerf et al. 2011). That assessment showed the management was generally effective at helping to increase Oahu Elepaio populations, but also that the efficacy varied among sites. At some sites the management was less effective because the steep terrain limited where rat traps could be placed and because of difficulty in accessing some sites with sufficient regularity to achieve effective rodent control. Management was subsequently discontinued in Waikane Valley and Makaha Valley in 2009. In Makua Valley rats are still controlled but the number of Oahu Elepaio gradually declined until they were gone. Since then the OANRP has focused its efforts on four sites where management has proven to be more cost-effective: Schofield Barracks West Range, Ekahanui, Moanalua Valley, and Palehua.

The purpose of this report is to re-assess the efficacy of management efforts for the Oahu Elepaio by the OANRP in order to ascertain whether the management is still effective and whether any modifications to the management are warranted. This report is divided into several sections, each of which includes a description of the specific methods and results on a particular subject, followed by a section with overall conclusions and recommendations.

Report Outline:

- General methods
- Oahu Elepaio reproduction
  - Fecundity and effect of rat control
  - Nest Success
  - Tree Species
  - Nest height
- Oahu Elepaio survival
  - Effect of rat control
  - Effect of avian poxvirus
- Avian pox virus in Oahu Elepaio
- Oahu Elepaio Population growth and effect of rat control

OVERALL METHODS

Each year the OANRP controls rats to protect Oahu Elepaio and their nests. The methods of rat control have changed over time as different techniques have become available or were limited in their use by regulatory agencies. Methods used to control rats have included snap traps, bait stations, and automated pneumatic traps made by the Goodnature Company. Details of rat control methods, results, and efficacy are presented in the OANRP annual reports.

The response by Oahu Elepaio to rat control is measured each year in several ways: 1) nest success (proportion of nests from which at least one chick is fledged); 2) fecundity (the number of offspring raised by each breeding pair); and 3) Survival of males and females. To facilitate monitoring, Oahu Elepaio in each site have been captured with mist-nets and marked with a unique combination of an aluminum band and three colored plastic bands. Each bird was weighed, measured, inspected for molt, fat, and health, then released unharmed at the site of capture within one hour.

The Army has met the requirement of managing at least 75 Oahu Elepaio breeding pairs every year since the requirement went into effect (2003), and in some years the number of pairs managed has been substantially higher than 75. This variation occurs because not all Elepaio territories are occupied each year and new territories become established, and it is difficult to predict in advance what changes may occur from year to year. In some years the number of pairs managed at Schofield has been low because access to portions of the range has been limited by military training. The number of Elepaio pairs managed by the Army at each site each year is presented in the table below.

Year	Schofield	Ekahanui	Moanalua	Palehua	Total
2005	16	20			36
2006	14	20	22		56
2007	6	18	26	11	61
2008	11	19	25	11	66
2009	14	23	24	15	76
2010	22	30	17	18	87
2011	31	30	16	17	94
2012	28	29	24	16	97
2013	29	36	23	17	105
2014	22	28	22	10	82
2015	26	37	19	15	97
2016	28	35	12	11	86

Each Elepaio territory in each site was visited approximately once a week throughout the nesting season and occasionally at other seasons. During each visit, observers searched for Elepaio by sight and sound, and recorded the band combinations of any birds seen. Observers also searched for and monitored nests during each visit. Most nests were located during the building phase by watching adult Elepaio gather nest material and following them to the nest. Nests were counted as successful if they fledged at least one chick, and nest success was calculated as the successful proportion of nests. Nest success was based only on nests known to have had eggs laid in them, as determined by observations of incubation or by using a pole-mounted mirror to look inside the nest. Some nests were abandoned for unknown reasons before eggs were laid. It is possible that some nests counted as abandoned actually were depredated before incubation was observed, which would cause a slight overestimate of nest success. In a few cases fledglings were produced from nests that were not found, and it is also possible that a few failed nests were not found, but it is unlikely that any fledglings that survived more than a few days were missed. Elepaio fledglings are fed by their parents for 4-6 weeks after they leave the nest, are easy to locate by their persistent begging calls, and may stay on their natal territory for up to 9 months, until evicted by the parents at the start of the next breeding season (VanderWerf 1998).

Some specific data limitations are worth mentioning: 1) This report did not include data from Makaha or Waikane because it was already determined that management was less effective at those site and management was discontinued in 2009 (VanderWerf et al. 2011). 2) Rat control and Elepaio monitoring started in 1996 at some sites, but for some analyses this report used data starting in 2000 because monitoring was less consistent and the sample sizes were small before then. 3) Data from 2010 were not used in this report because the Elepaio monitoring effort was low and the performance was poor that year in three of the four sites (‘Ekahanui, Moanalua, and Palehua). Specifically, in 2010 there were few visits to some Elepaio territories, many nests were not monitored frequently enough to determine their outcome, and very few color-banded Elepaio were resighted. Although data from Schofield Barracks in 2010 were fine, it was necessary to discard the data from all sites in 2010 because of analytical constraints.

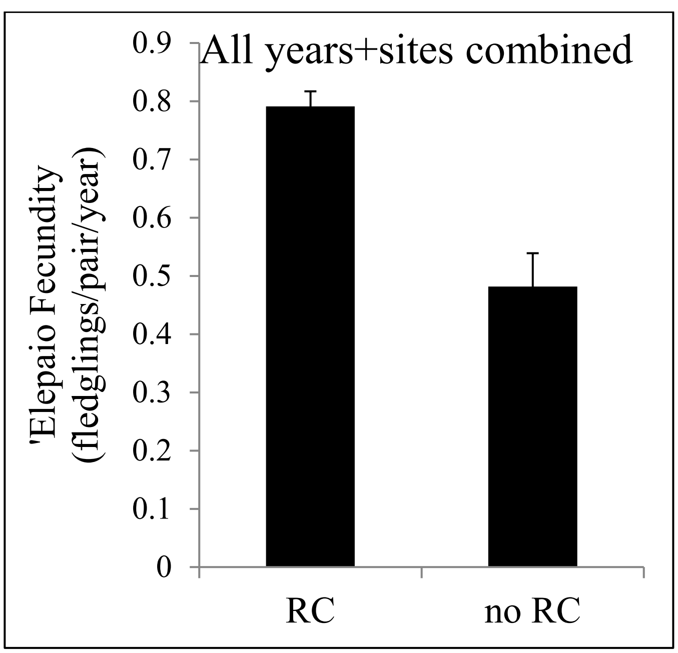
OAHU Elepaio REPRODUCTION

Elepaio Fecundity. An increase in fecundity, measured as the number of fledglings produced per pair each year, was the most dramatic effect of rat control on Oahu Elepaio in previous studies, including those on Army lands (VanderWerf and Smith 2002, VanderWerf 2009, VanderWerf et al. 2011).

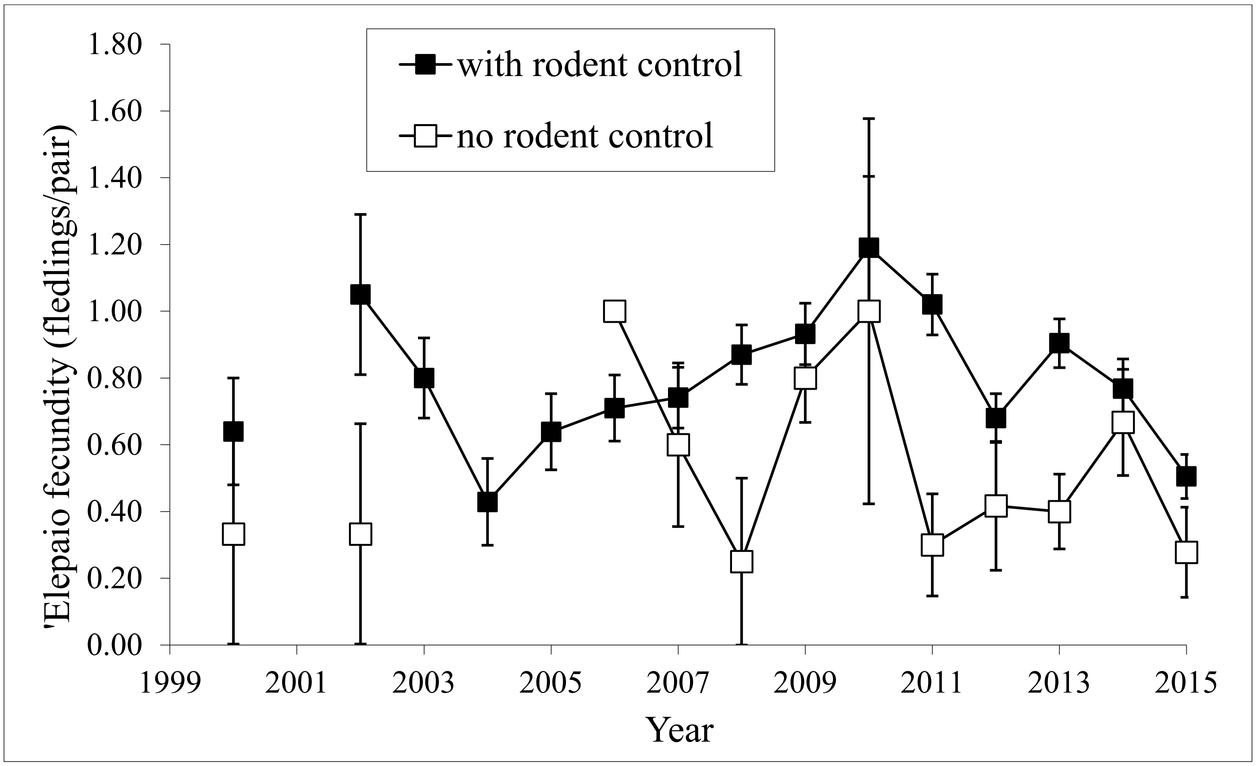
Methods. To investigate factors that affected Oahu Elepaio fecundity, a General Linear Model was used, with number of fledglings as the response variable and rodent control (yes, no), year, and site as factors.

Results. Fecundity was affected significantly by rat control ($F_{1,942} = 21.20$, $p < 0.001$), site ($F_{3,941} = 3.96$, $p = 0.008$), and year ($F_{14,941} = 3.45$, $p < 0.001$). The most important result was that fecundity was 65% higher with rat control at all sites combined, indicating rat control continues to be an effective means of increasing Oahu Elepaio reproduction. There was some variation in fecundity among sites, with highest fecundity at Schofield Barracks West Range (SBW) and the lowest fecundity at Moanalua. The lower fecundity at Moanalua may be related to weather; Storms with strong winds and heavy rain cause nests to fail at all sites, but Moanalua is the wettest site in which Elepaio are managed and more nests there may fail because of severe weather.

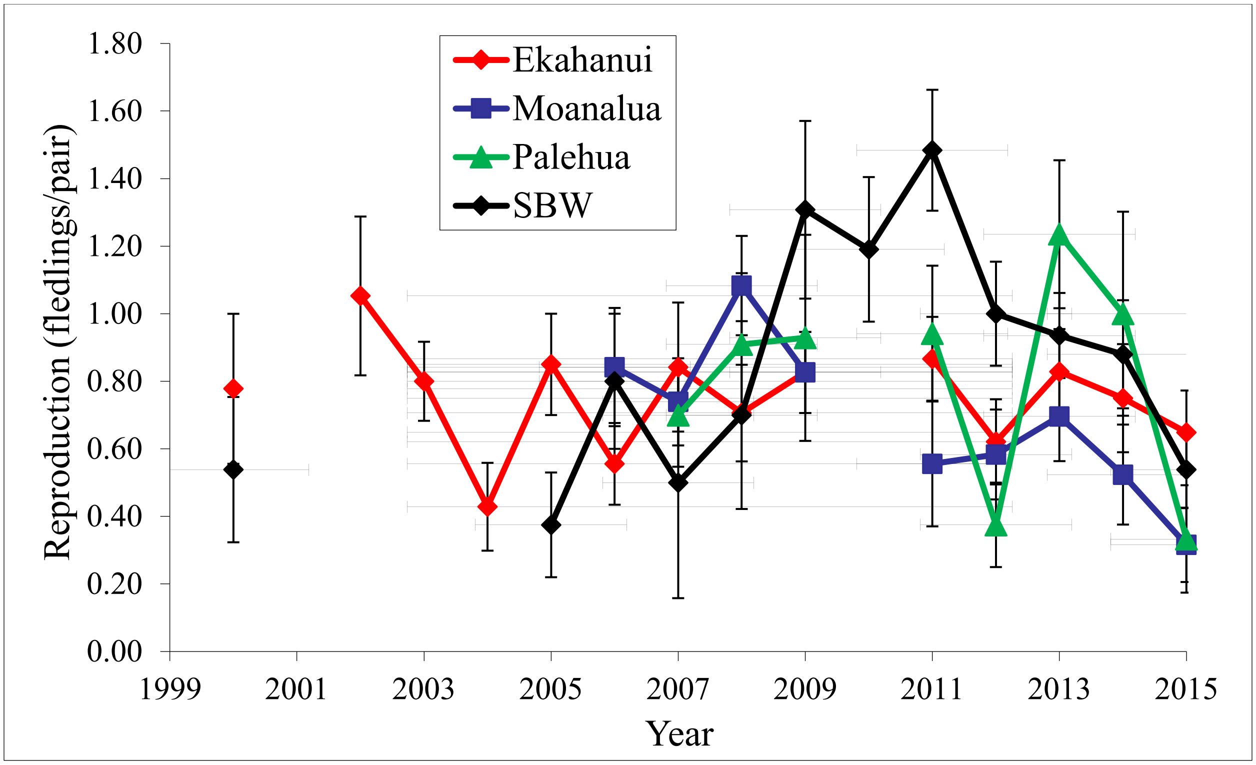
Site	Fecundity with rat control	# pair-years with rat control	Fecundity no rat control	# pair-years no rat control
Ekahanui	0.75±0.04	325	0.40±0.11	20
Moanalua Valley	0.69±0.05	195	0.42±0.11	26
Palehua	0.80±0.08	111	0.50±0.29	4
Schofield Barracks	0.93±0.06	220	0.53±0.08	60
All 4 sites combined	0.79±0.03	851	0.48±0.06	110



There also was significant variation in Oahu Elepaio fecundity among years. This variation is thought to be related to rainfall and consequent availability of insects and other arthropods as prey for Elepaio (VanderWerf 2009). Elepaio reproduction tends to be lower in dry years and higher in wet years. Rat abundance also tends to be higher it wet years, probably also because of increased food availability, so that the effect of rat control on Oahu Elepaio often is strongest in wet years. Rat control on Army lands appeared to be less effective in some years, but sample sizes without rat control were small in some years.



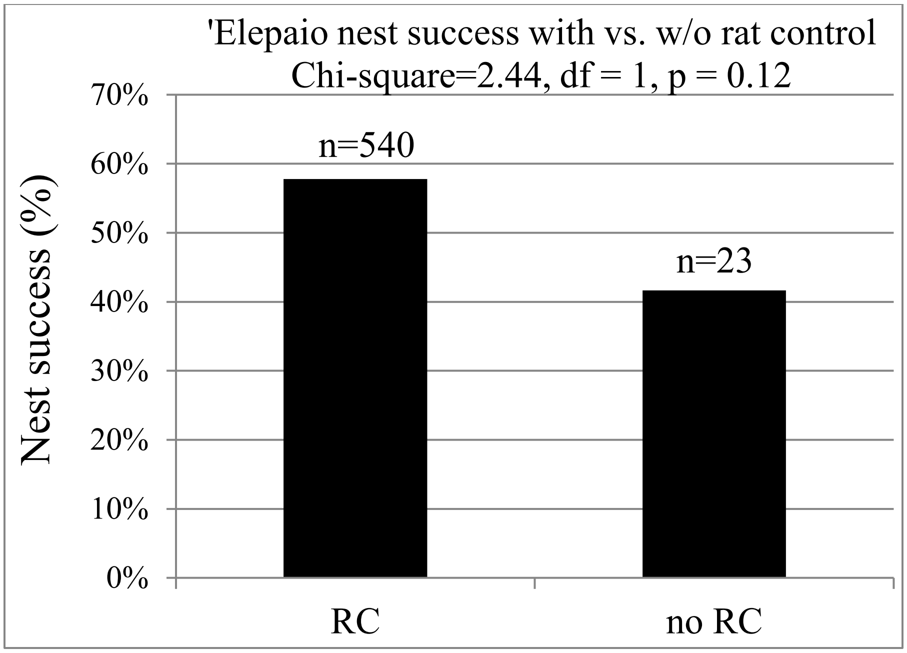
Fecundity also varied substantially among sites, but the pattern among years was not always consistent among sites. For example, fecundity was highest in 2013 and 2014 at Palehua, but in in 2012 and 2015 Palehua had the lowest fecundity. Similarly, Schofield Barracks had exceptionally high fecundity from 2009-2011, but in 2007 and 2008 fecundity at Schofield was lowest. The causes of local variation in fecundity among sites are not well understood but may be related to local variation in rainfall that is difficult to measure.



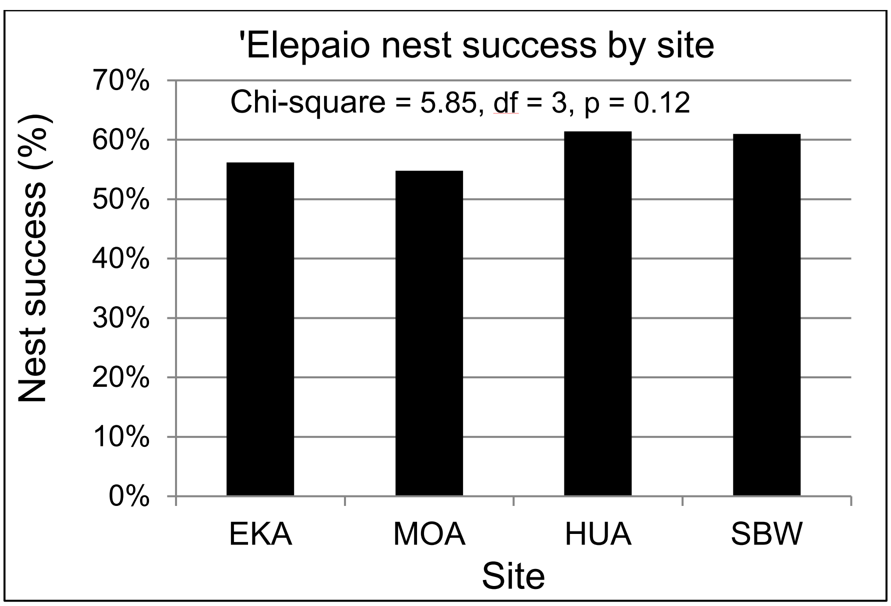
Oahu Elepaio Nest Success. Another pattern that has been observed in Oahu Elepaio as a result of rat control is an increase in nest success (VanderWerf 2009, VanderWerf et al. 2011). This is perhaps the most intuitive benefit of rat control; if rats are removed, fewer Elepaio nests are depredated.

Methods. The success rate of Oahu Elepaio nests with vs. without rat control was tested with a chi-square test. The success rate of nests in the four sites also was tested with a chi-square test.

Results. The success rate of nests with rat control (58%) was not significantly higher than the success rate without rat control (42%; Chi-square = 2.44, df = 1, p = 0.12). However, the lack of statistical significance was caused by a small sample of nests without rat control (n=24). Biologically, this difference is still important. The small sample size is not surprising because rats generally were controlled in most Oahu Elepaio territories that were easily accessible, and less effort was spent in territories without rodent control, so few nests were found.



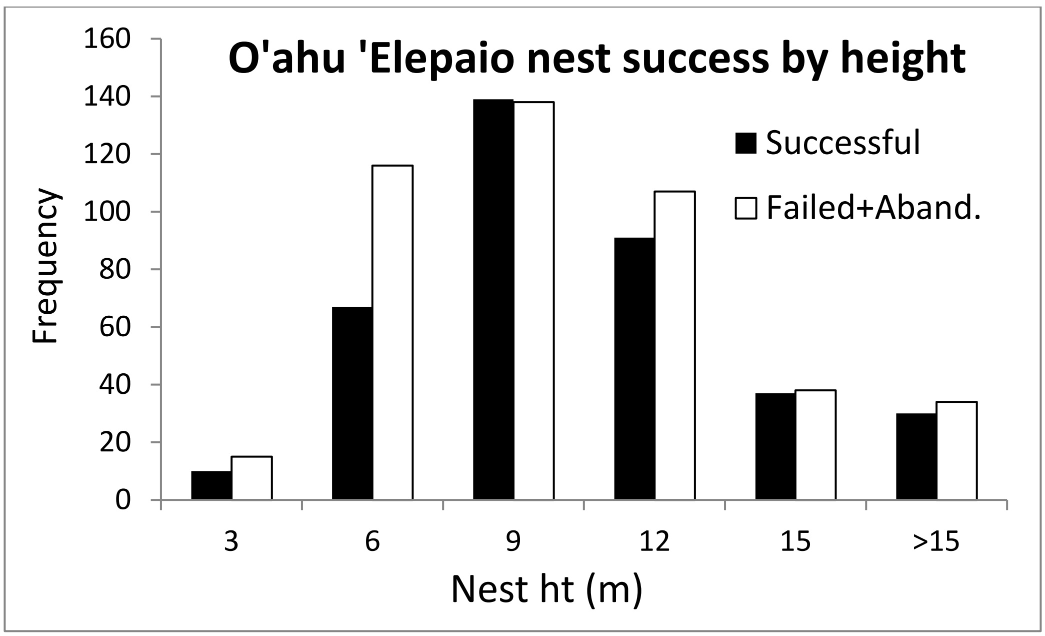
There was some variation in nest success among sites, but the differences were relatively small and were not significant (Chi-square = 5.85, df = 3, p = 0.12). Nest success was slightly lower at Moanalua, possibly as a result of more frequent heavy rain at that site, as mentioned above.



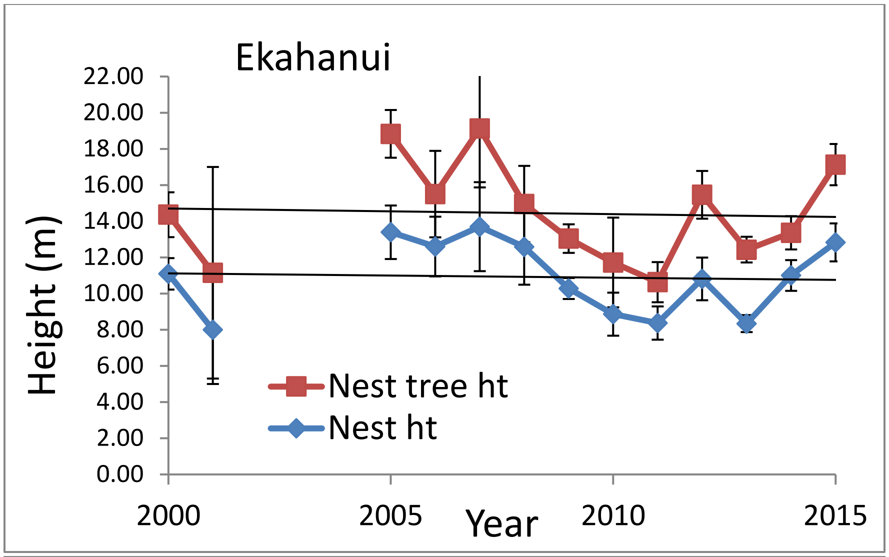
Nest Height. Another interesting and important pattern discovered recently is that Oahu Elepaio in Wailupe Valley in southeastern Oahu are evolving to nest higher off the ground in response to rat predation (VanderWerf 2012). Rats can climb to the top of the tallest tree, but they spend more time closer to the ground and on the ground (Shiels 2010), so lower Elepaio nests are more likely to be depredated by rats. As Elepaio have nested higher, their nest success also has increased. Along with rat control, this natural response may help to ameliorate the effect of rat predation, and it is therefore important to know whether such evolution also is occurring in Elepaio on lands managed by the OANRP.

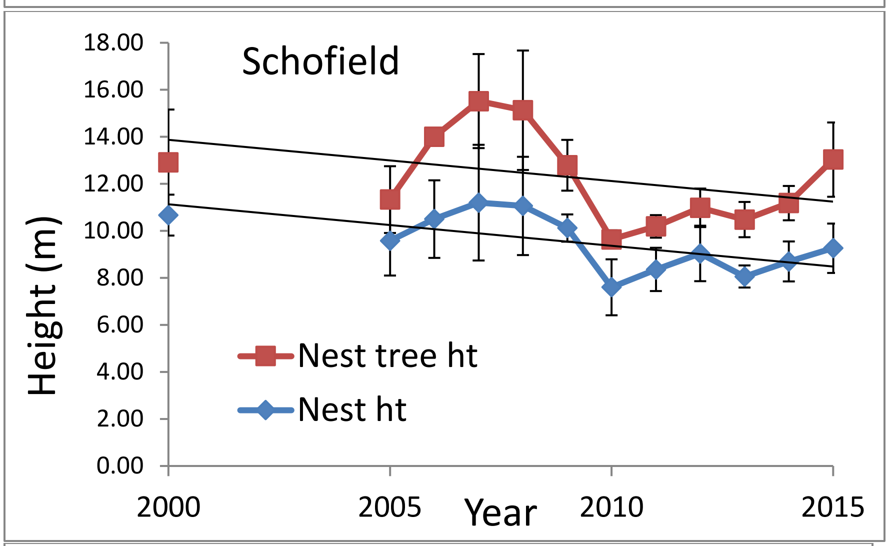
Methods. In order determine whether Oahu Elepaio nest height has changed, the height of each nest was estimated when the nest was found. However, many different observers collected data over the years, some of whom may have had little or no experience estimating heights. There also appeared to be some confusion about use of meters vs. feet; some nest heights reported in the past seemed unreasonably high given the stature of the forest and likely were in feet rather than meters. The effect of nest height on nest success was examined by constructing histograms of successful and failed nests, and testing the proportions with chi-square tests. Elepaio nest success over time was examined using regression, with nest success as the dependent variable and year as the independent variable.

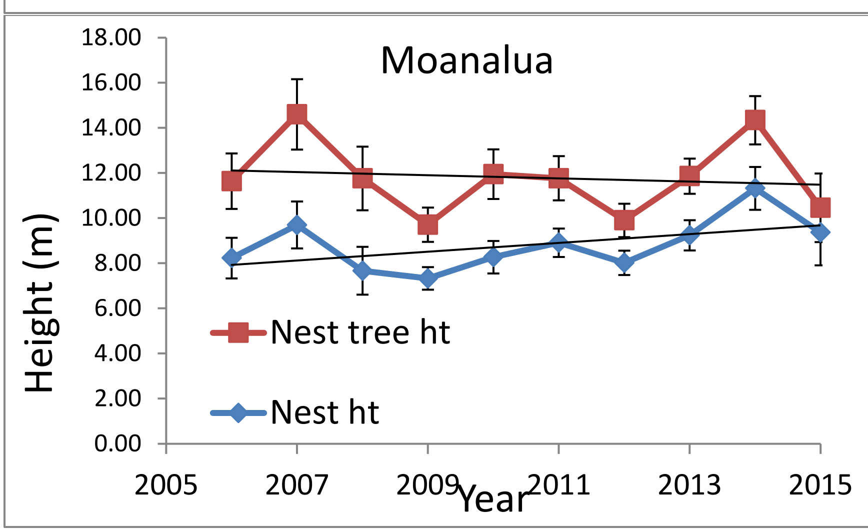
Results. Oahu Elepaio nest success was related to nest height; lower nests <6m high were more likely to fail (Chi-square = 8.07, df = 1, p = 0.004).



There was some evidence that Elepaio nest height has increased over time on lands managed by the OANRP, but the pattern was partially obscured by inconsistency among years in measurement of nest height. Some sites showed an overall downward trend in nest height over time, but as mentioned above, some nests heights in earlier years may have been measured in feet instead of meters, and this information was not recorded. This may have inflated nest height in some early years. However, if only the years since 2010 are considered, when almost all nest height data was collected by a single experienced observer, there was a pattern of increasing nest height at all four sites. This time period is too short to observe a significant trend, but this pattern should be examined again in a few years.


Ekahanui
Height (m)
22.00
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
2000
2005
Year
2010
2015
Nest tree ht
Nest ht


Schofield
Height (m)
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
2000
2005
Year
2010
2015
Nest tree ht
Nest ht


Moanalua
Height (m)
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
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2005
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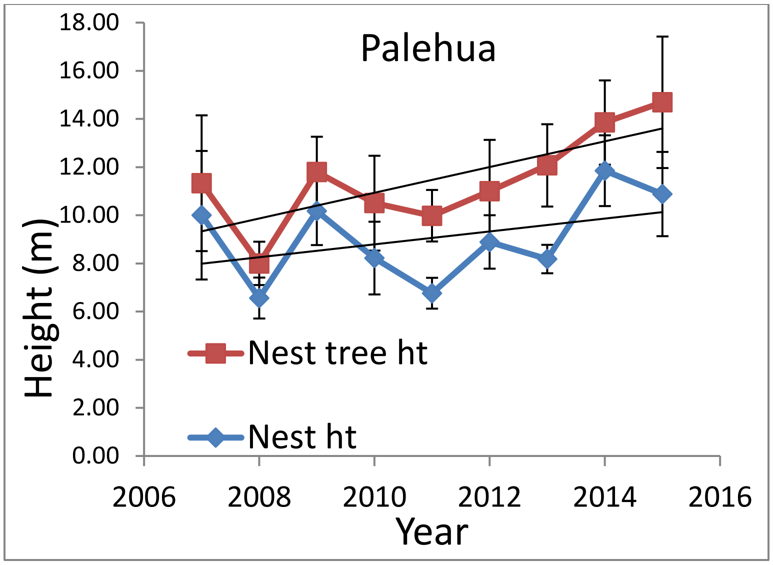
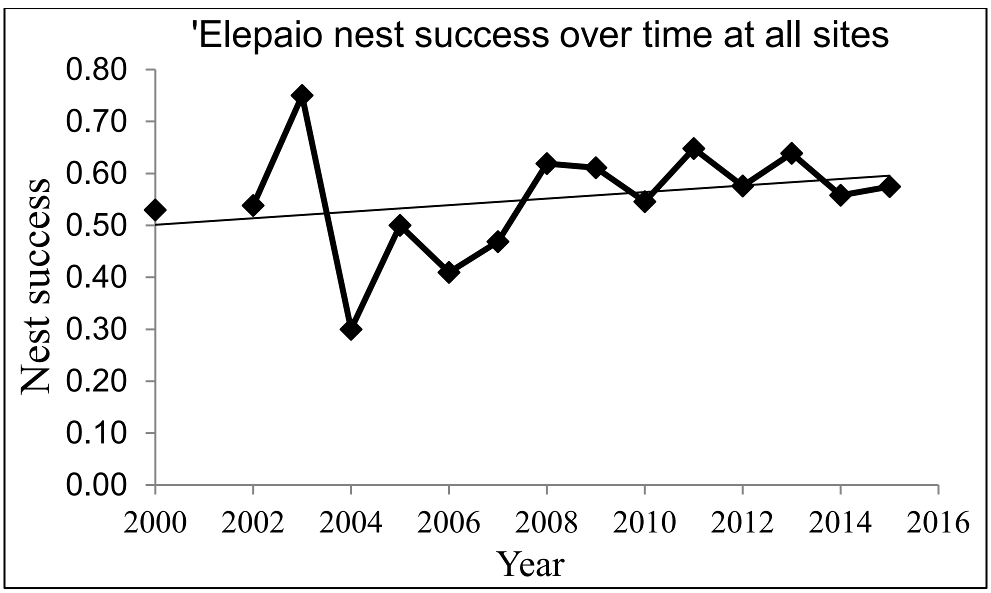
2015
Nest tree ht
Nest ht



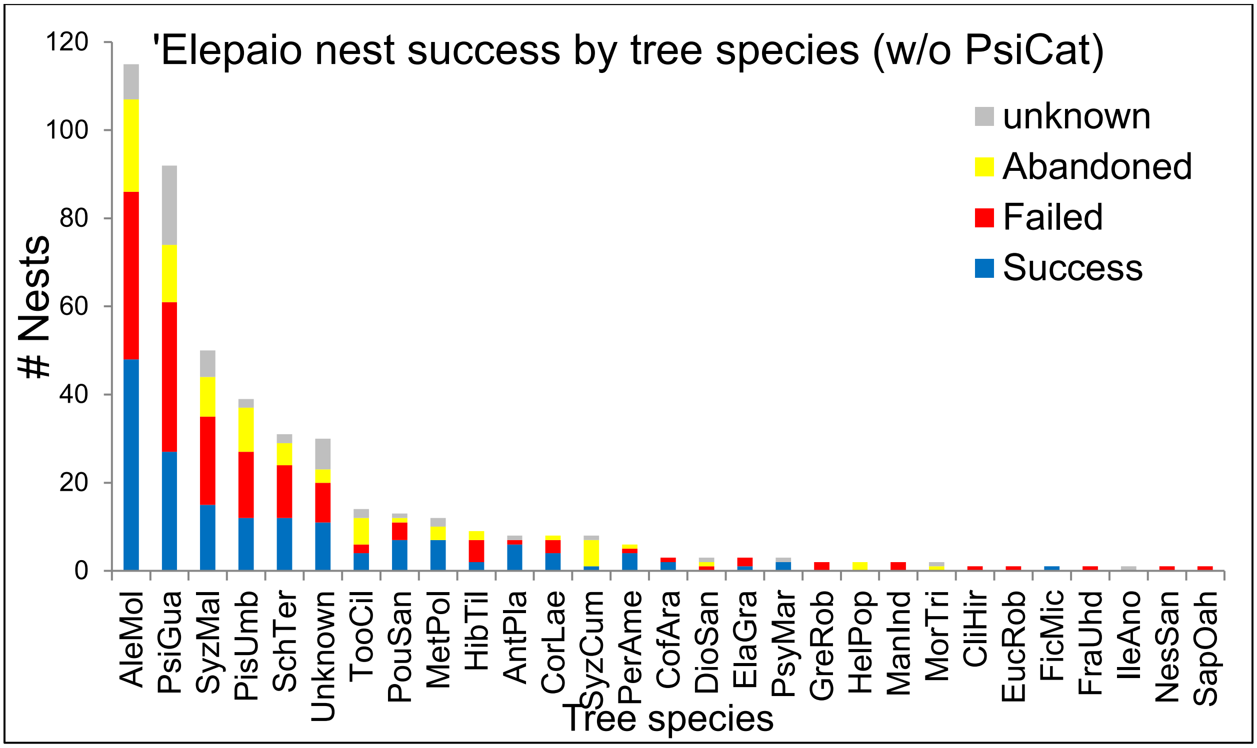
There was some evidence that Elepaio nest success has increased over time on lands managed by the OANRP, but the trend was weak and the pattern was not significant ($F_{1,13} = 1.03$, $p = 0.33$). When years with small sample size (2003, 2004) were excluded trend was stronger but still not quite significant ($F_{1,11} = 3.34$, $p = 0.095$). The increase in nest success over time could be caused by improved rat control methods or increasing nest height.



Oahu Elepaio nest tree species. It has been suggested that Oahu Elepaio suffer from higher rates of nest predation than other Elepaio species because the forest where most remaining Oahu Elepaio occur is dominated by non-native trees that bear fruits or nuts that are attractive to rats (VanderWerf 2009). It is therefore of interest to determine whether nest success of Elepaio differs among tree species, particularly between native and non-native trees and fruiting vs. non-fruiting species.

Methods. Oahu Elepaio nest success was compared in native vs. non-native trees and in fruting vs. non-fruiting trees using chi-square tests. Nests of unknown outcome or that were abandoned before eggs were laid were not included in analyses.

Results. Oahu Elepaio nests on Army-managed lands have been found in at least 30 tree species. By far the most nests (521) were found in non-native strawberry guava (*Psidium cattleianum*).



Nest success was slightly higher in native tree species (60%) than in non-native tree species (55%), but the difference was not significant (Chi-square = 0.56, df = 1, p = 0.45). However, the samples size of nests in native trees was small (n=57), making it difficult to detect a difference. Among individual native tree species, nest success was 100% in ‘ohia (n=7) and 86% in hame (n=7). There was no difference in nest success in fruiting tree species (55%) vs. non-fruiting species (54%; Chi-square = 0.006, df = 1, p = 0.94), but again the sample of nests in non-fruiting trees was very small (n=24).

OAHU ELEPAIO SURVIVAL

Juveniles. Juvenile survival is one of the most difficult demographic parameters to measure in many bird species, including Elepaio. An estimate of 33% annual survival in juvenile Hawaii Elepaio has been used as a proxy in previous demographic of the Oahu Elepaio, but it would be preferable to use an estimate measured directly in the Oahu Elepaio. A total of 27 juvenile (<6 mo. old) Oahu Elepaio have been banded sites managed by the OANRP. This is too small a sample to employ mark-recapture methods, but a simple estimate of survival can be calculated by enumeration.

Sex of juvenile Oahu Elepaio was determined by behavioral observation (n = 21), either at the time of banding or during subsequent years when the bird was resighted, or by morphometrics (n = 4). Males Elepaio are about 10% larger than females in most body measurements (VanderWerf 1998). Two birds could not be sexed by either method, neither of which was ever seen again. Instead of omitting them, one bird was arbitrarily assigned to each sex for analyses. This resulted in a data set consisting of 11 females and 16 males.

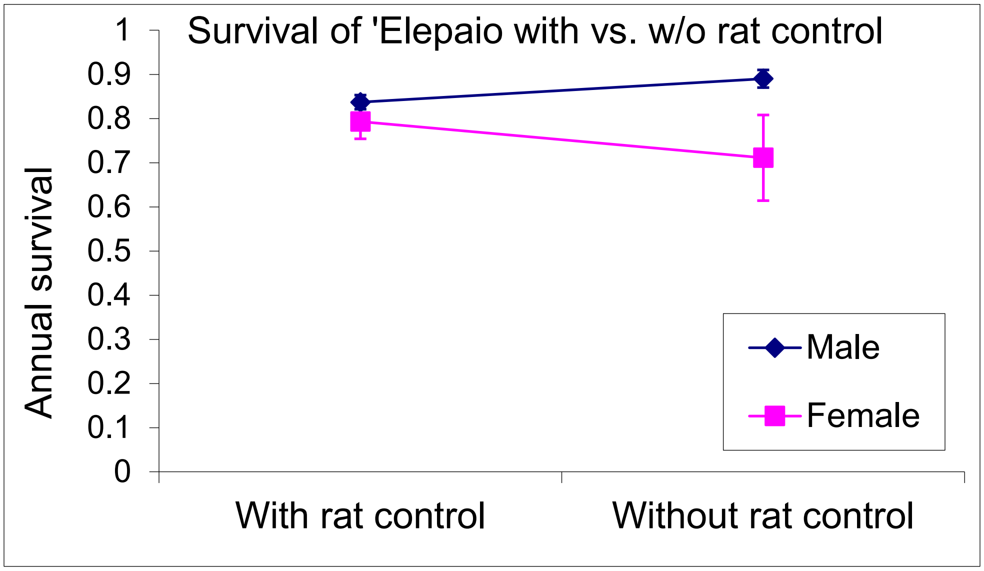
Of the 27 banded juveniles, 19 were seen in at least one subsequent year, of which 8 of 11 were females (73%) ad 12 of 16 (75%) were males. However, most birds were banded in August-October (23), with one bird banded in March, one in July, and two in December, so this does not reflect survival over an entire year and does not include mortality that occurred shortly after fledging, which is when many fledglings probably die.

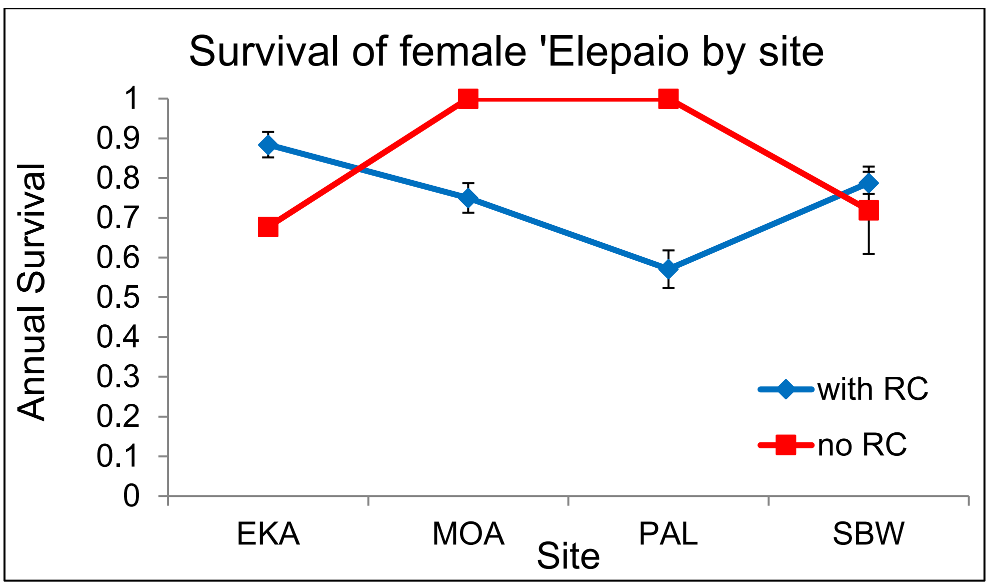
Of three Elepaio banded as nestlings, none were ever seen again. If the birds banded as nestlings are added to the total, then 19 of 30 juveniles have been resighted, or 63%. If it is assumed that this represents survival over half a year, then annual survival of juvenile Oahu Elepaio is 40% (0.63x0.63), which is slightly higher than the estimate in Hawaii Elepaio.

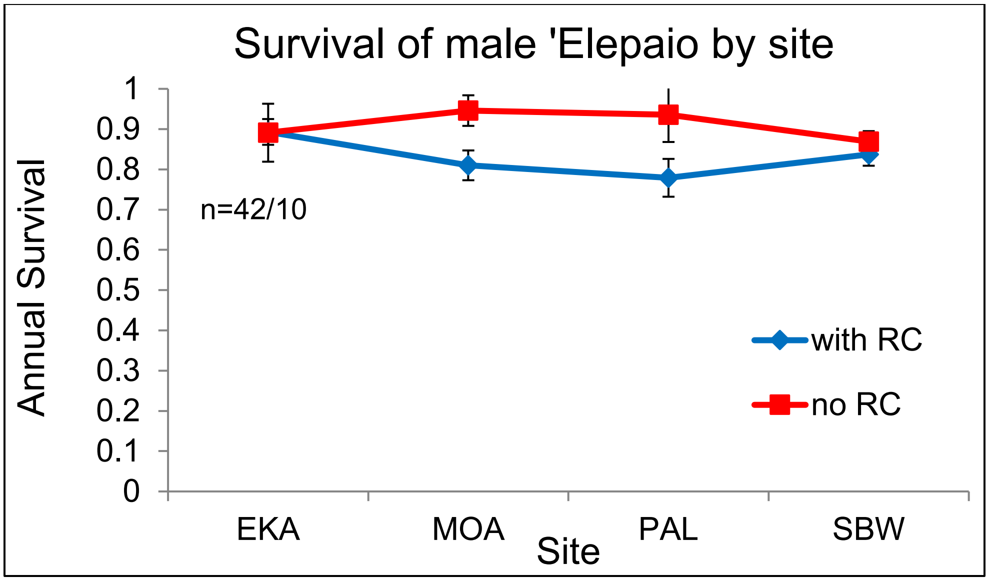
Adult survival. Because Elepaio are long-lived and have relatively low reproductive capacity, adult survival is the most important demographic parameter driving Elepaio population growth (VanderWerf 2008, 2009). Previous analyses have shown that survival of Oahu Elepaio is lower in females than in males, because females are depredated on the nest at night by rats (VanderWerf 2009, VanderWerf et al. 2011). Rat control has been shown to cause an increase in survival of female Oahu Elepaio, which can lead to stabilization of the sex-ratio and population growth (VanderWerf and Smith 2002, VanderWerf 2009).

Methods. Survival of adult Oahu Elepaio was examined using mark-recapture models in program MARK (White and Burnham 1999). An encounter history was created for each bird using the year of initial capture and all recaptures and resightings in subsequent years. Multi-state models were used to generate maximum-likelihood estimates of survival (S) and encounter probability (p) of Elepaio in two states representing rat control (R) and no rat control (N). Transition probabilities (ψ) between these states varied among years but were predetermined by the sites in which rodent control was conducted, so year effects on transition probabilities were included in all models to allow the transitions to vary properly. Elepaio were grouped by sex (male or female) and site (Schofield, Ekahanui, Moanalua, and Palehua). Birds of unknown sex were excluded. The analyses did not include birds banded as juveniles and not seen again, birds thought to be floaters and not territory holders, or birds in territories that were not revisited. This left 256 birds, including 213 males and 43 females. The study encompassed the period from 1996-2015, but 2003 was omitted because the resight effort too low; no banded birds were seen at Ekahanui that year and many were missed at Schofield too.

Results. Survival of female Oahu Elepaio was 8.2% higher with rat control than without (79.3±0.04% vs. 71.1%±0.10). In the 2009 analysis, the difference was 9.9% and both values were a little higher (83.7±0.05% vs. 73.8±0.09%) (VanderWerf et al. 2011). Survival of males was 5.3% lower with rat control than without (83.7%±0.02% vs. 89.0%±0.02%). In 2009 analysis the difference was 2.8% (87.9% vs. 85.1%). It was not possible to examine variation in survival among sites using mark-recapture methods because sample sizes were too small. However, from examining the data, the survival rate of both sexes was somewhat lower at Palehua, especially for females with rat control, which was only 0.57±0.12. Palehua largely accounts for the decline in survival rate since 2009, because rat control at Palehua started in 2007. It also was not possible to examine variation among years because of small samples sizes in some years. If some of the earliest years when sample sizes were smallest were excluded it might be possible to estimate variation for some later years separately.







Avian Pox Virus. Avian pox virus (*Poxvirus avium*) is an arbovirus that occurs virtually worldwide and has been reported in many different bird species (van Riper and Forrester 2007). Prevalence of avian pox virus varies widely depending on a variety of environmental and host-specific factors, and the effect of the disease also varies among bird species. Some species exhibit strong immunity to pox virus and often recover, but species endemic to isolated oceanic islands, such as Hawaiian forest birds, have little immunity and can be crippled or killed by it (van Riper et al. 2002, Atkinson et al. 2005, VanderWerf et al. 2006). Avian pox virus is considered a serious threat to Hawaiian forest birds (USFWS 2006).

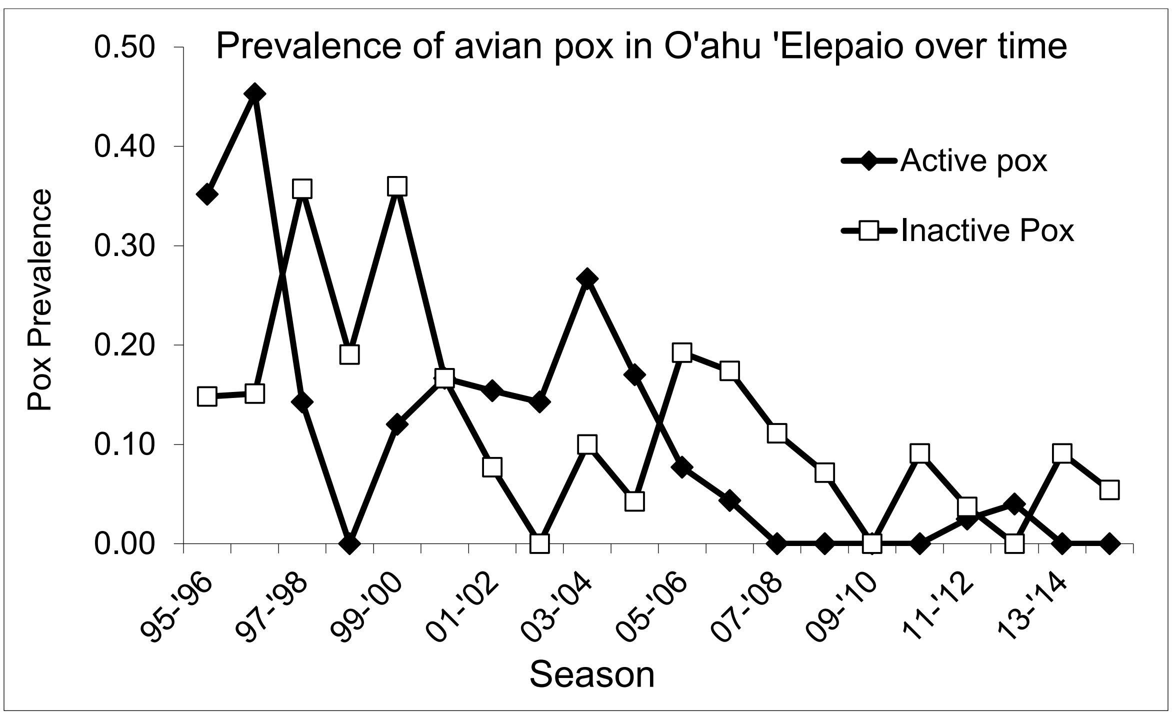
Pox virus infects a bird through a break in un-feathered skin or in the oral or respiratory mucous membranes, and can be transmitted by arthropod bites, contact with a contaminated surface, or aerosol particles (van Riper and Forrester 2007). The principal vector of avian pox virus in Hawaii is the introduced mosquito *Culex quinquefasciatus* (van Riper et al. 2002, Atkinson et al. 2005).

Methods. Prevalence of avian pox virus in Hawaiian forest birds, including the Oahu Elepaio, has been shown to be correlated with rainfall and mosquito abundance (VanderWerf et al. 2006). Because the majority of rainfall in Hawaii typically falls during the winter months, prevalence of pox was compiled over 12 month periods starting in October. Compiling pox prevalence over a calendar year would break the rainy season into two calendar years and could obscure patterns of pox prevalence associated with variation in rainfall.

Elepaio with soft swellings, warty growths, open sores, or crusty scabs on the toes, feet, legs, or face we regarded as having active pox-like lesions. Elepaio with missing or deformed toes or feet were regarded as having healed or inactive pox-like lesions. Elepaio with no visible symptoms were regarded as healthy. Data from five sites (Schofield Barracks, Ekahanui, Moanalua Valley, Palehua, and Makua Valley) were included in analyses. Prevalence of pox virus in Elepaio was measured as the proportion of birds exhibiting visible symptoms. The effect of pox virus on survival of Elepaio was investigated with Program MARK, which was used to generate maximum-likelihood estimates of survival (S) and encounter probability (p) of Elepaio. Elepaio were categorized by pox status at the time of capture (healthy, active pox, inactive or healed pox). It was necessary to combine areas with rat control and without rat control because of small samples sizes in some years. An age-structured parameter index with 2 age-classes was used to simulate survival in first year after capture vs. all subsequent years.

Results. Prevalence of avian pox virus in Oahu Elepaio has declined over time. Prevalence of birds with active pox declined from a peak of 0.47 in 1996 to zero in several recent years (Regression, $R^2 = 53.2\%$, $F_{1,19} = 23.75$, $p < 0.001$). Prevalence of birds with inactive or healed pox declined from a peak of 0.35 in 1997 (Regression, $R^2 = 38.4\%$, $F_{1,19} = 13.49$, $p = 0.002$). Prevalence of active and inactive pox were correlated, but inactive pox lagged 2-4 years behind active pox (lag of 1 year, $r = 0.48$, $p = 0.03$; lag of 2 years, $r = 0.52$, $p = 0.02$; lag of 3 years, $r = 0.71$, $p = 0.001$; lag of 4 years, $r = 0.73$, $p = 0.001$). Peaks in prevalence of inactive pox were a lower than peaks in active pox. The lag between active and inactive pox and the lower prevalence of birds with healed pox both make sense; it takes time for lesions to heal and some birds die.

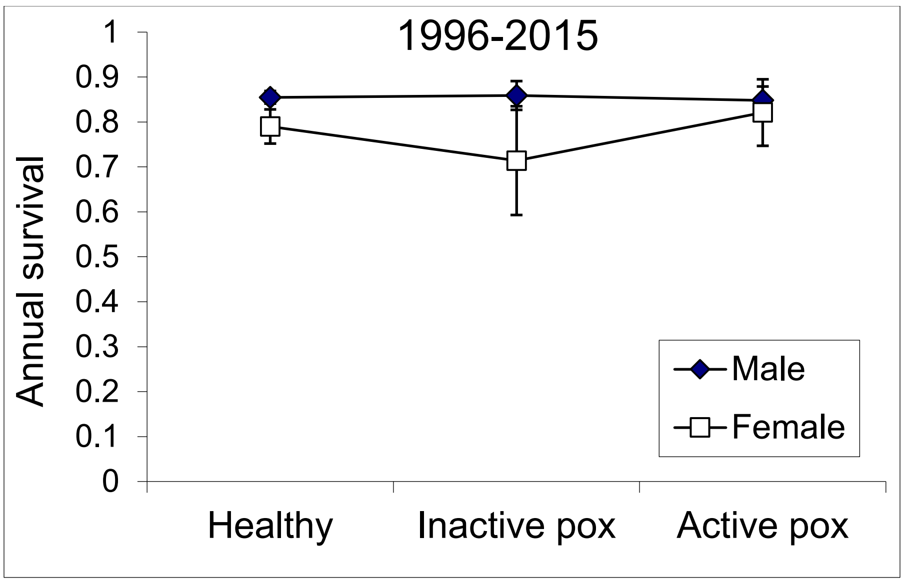
In previous analyses there was a strong relationship between prevalence of pox virus and annual rainfall, with epizootics of pox virus occurring in exceptionally wet years (VanderWerf et al. 2006). It was difficult to examine this relationship using data up to 2015 because it proved difficult to obtain recent rainfall data from locations near the Elepaio study sites. However, pox prevalence was very low in several recent years with high rainfall, so the relationship between pox prevalence and rainfall appears to have weakened or even disappeared altogether.

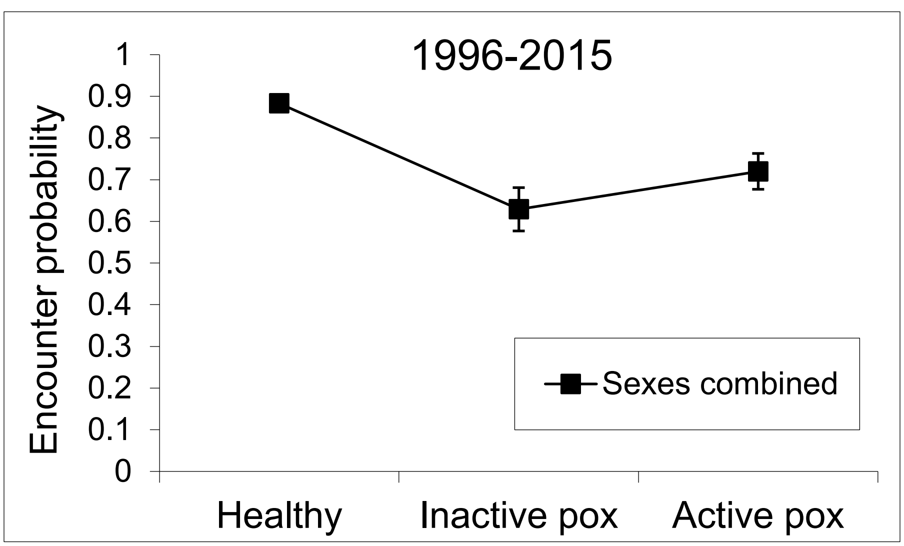


In analyses that included data up to 2009, survival of Oahu Elepaio was lower in birds with active pox than in birds with healed pox or healthy birds (VanderWerf et al. 2011), but in analyses that included data up to 2015 survival did not differ among pox categories. Instead, encounter probability differed among pox categories and was lower in birds with active pox (0.720±0.043) and inactive pox (0.629±0.052) than in healthy birds (0.883±0.015). This means that birds with pox were likely less to be seen, even if they were still alive. Several birds that had not been seen for several years and were presumed to be dead have been seen again since 2009.

Survival was a little lower in females than in males because small sample sizes made it necessary to combine areas with and without rat control, and females experienced higher mortality than males without rat control.

There are two possible explanations for the change in effect of pox virus on survival of Oahu Elepaio: 1) Elepaio have evolved a tolerance to pox and survival of infected birds really has increased. There was other evidence supporting this argument in the form of decreasing pox prevalence over time. 2) The effect of pox on survival was overestimated before. Some birds with active pox that previously were presumed to be dead have been seen again after several years, accounting for the lower encounter probability. Although mortality from pox may be somewhat lower than previously estimated, pox virus may still affect Elepaio by limiting their ability to reproduce. Most of the Elepaio that reappeared after several years absence were relocated in different territories, and it is likely they were weakened by pox and were no longer able to defend their territory and mate against rivals, and lived as floaters until they recovered and were able to regain a territory and mate.



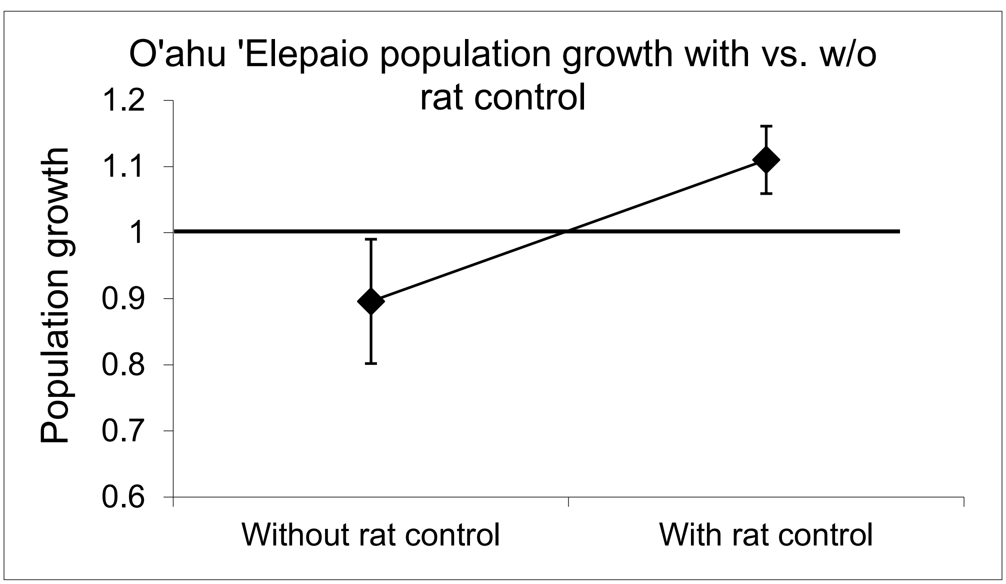


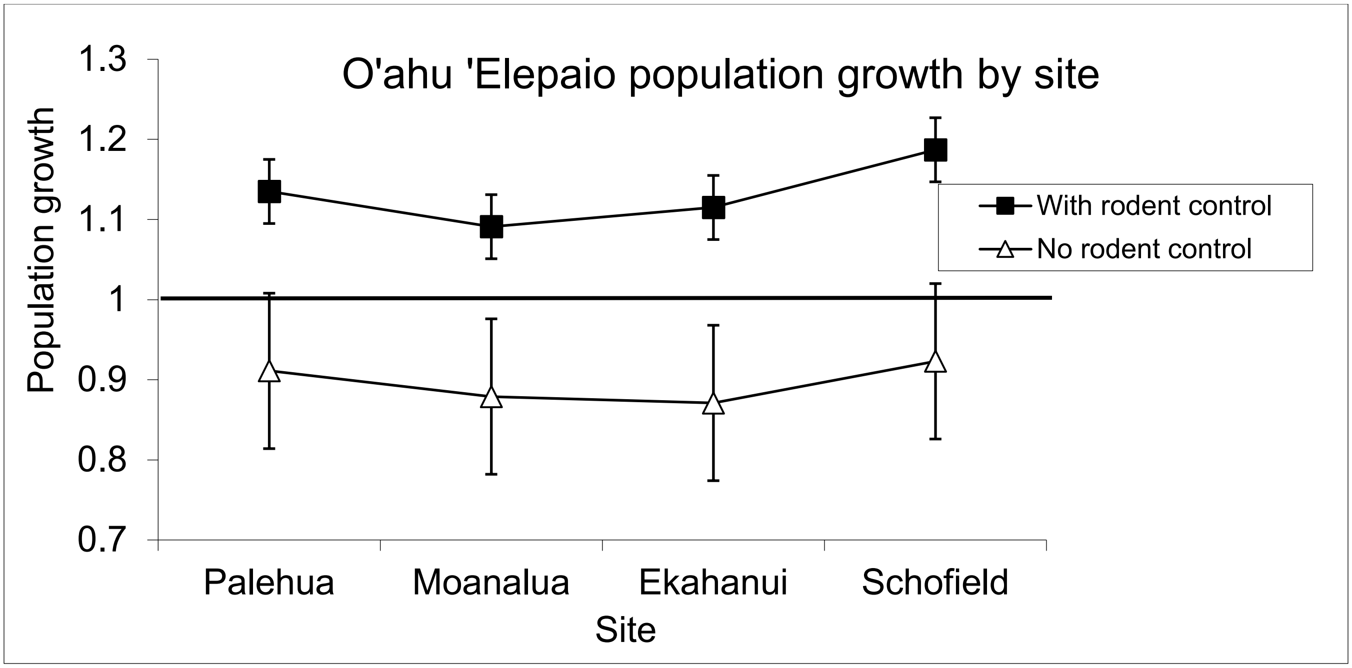
OAHU ELEPAIO POPULATION GROWTH

The Oahu Elepaio population growth rate, indicated by the Greek letter lambda, was calculated using data on survival and reproduction each year. The population growth rate was calculated in order to provide a single measure of the effect of management to facilitate comparisons among sites and years.

Methods. The population growth rate was calculated with the following equation: lambda = female survival + (fecundity x juvenile survival). Survival of females only was used because it was lower than survival of males and was thus the limiting demographic factor. A value of 0.40 was used for juvenile survival at all sites based on results of current analyses. In previous analyses a value from Hawaii Elepaio of 0.33 was used (VanderWerf et al. 2011). Values of lambda >1.0 indicate population growth, values <1.0 indicate population decline.

Results. The Oahu Elepaio population growth rate was higher with rat control (1.11±0.05) than without rat control (0.90±0.09). Rat control thus resulted in a 21% increase in Oahu Elepaio population growth. Population growth differed slightly among the sites, probably because of a combination of intrinsic factors characteristic of each site and the efficacy of rat control at each site. Because values of lambda <1.0 indicate decline, these results also demonstrates that without the management conducted by the OANRP these Elepaio populations would be declining or perhaps even extirpated by now. Population growth was lowest at Moanalua because fecundity was slightly lower, possibly related to higher rainfall at that site. Similarly, population growth was highest at Schofield Barracks because fecundity was highest there. It should be remembered, however, that the population growth rates were calculated using a single measure of female survival from all sites combined because of small samples sizes. Survival of females at Palehua may have been somewhat lower than at other sites, which would cause a correspondingly lower measure of population growth.





OVERALL CONCLUSIONS AND RECOMMENDATIONS

- Rat control continues to be an effective management tool for protecting Oahu Elepaio and their nests.
- Management of Oahu Elepaio was generally effective at all four study sites: Schofield Barracks, Ekahanui, Moanalua, and Palehua.
- The importance of avian pox virus as a threat to the Oahu Elepaio appears to have declined over time. Compared to results of previous analyses, the prevalence of pox in Oahu Elepaio has declined and the effect of pox on survival has diminished, though pox still may hinder reproduction in infected individuals.
- Elepaio in sites managed by the OANRP may be evolving to nest higher in trees, as they have elsewhere on Oahu, but the pattern was obscured by inconsistencies in data collection among different observers. Data quality has improved since 2010 after a single experienced observer began collecting all data on nest height and success.
- Management conducted by the OANRP has prevented the decline and perhaps the extirpation of four important Oahu Elepaio ‘populations.
- The Army has exceeded their requirement to manage 75 breeding pairs of Oahu Elepaio each year.

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Hawaiian Hoary Bat

Thermal IR and Acoustic Monitoring Project for Trimming of Trees and Woody Brush at Hale Kula Elementary School on 16 June 2016

Survey Goals

Establish whether or not Hawaiian Hoary bats (*Lasiurus cinereus semotus*) are roosting with pups in multiple trees species and woody brush along the HV power line corridor located behind of Hale Kula School. The utility lines are already being impacted by some of the branches. If bats present, discuss with regulatory agency possible mitigation measures to continue project or postpone removal of trees until pupping season is completed.

Survey Map

Figure 1. Map of the Hale Kula Elementary School project site which Hawaiian Hoary bat surveys were conducted. Red star indicates location of the site.

Figure 2. Map of project site with tree locations

Survey

Methods

Visual and acoustic surveys for bats were conducted on 16 June 2016, the day of the scheduled tree trimming. A Fluke Ti400 thermal imager was employed to scan the trees for any roosting bats to confirm no presence. OANRP also employed the hand held Wildlife Acoustics Echo Meter Touch attached to an IPad as a way to scan the area for any possible bats returning to a roost within close proximity. This tool has the ability to listen to bats in real time, GPS tracks and tags all recordings with location information and has full color spectrograms. Scanning commenced from 05:15-06:30 from the ground from different angles and locations.

Results and Discussion

The visual thermal IR and acoustic surveys detected no bats at all. Multiple species of birds were observed with the thermal IR, with visual confirmation, in and around the area. It was determined that there would be No Effect to bats if the trees were removed and the corridor cleared.

Recommendations

Work with DPW to better monitor the contractors work so that trees that need trimming are not missed prior to the pupping season.

Hawaiian Hoary Bat

Thermal IR and Acoustic Monitoring Project for Tree Trimming along powerlines at Fort Shafter's Palm Circle on 18 June 2016

Survey Goals

Establish whether or not Hawaiian Hoary bats (*Lasiurus cinereus semotus*) are roosting with pups on two Pink and White Shower trees (*Cassia javonica*), three Chinese banyon trees (*Ficus microcarpa*), five ear pod trees (*Enterolobium cyclocarpum*) and eight Monkey pod trees (*Samanea saman*) that require trimming as they are encroaching on power lines. If bats present, discuss with regulatory agency possible mitigation measures to continue project or postpone removal of trees until pupping season is completed.

Survey Map

Figure 1. Map of the SB Credit Union and Warrior Transition Battalion project site which Fluke thermal imager surveys. Red dot indicates location of the site.

Figure 2. Map of palm locations

Survey Methods

Visual and acoustic surveys for bats were conducted on 18 June 2016, the day of the scheduled tree trimming. A Fluke Ti400 thermal imager was employed to scan the trees for any roosting bats as well to confirm no presence. OANRP also employed the hand held Wildlife Acoustics Echo Meter Touch attached to an IPad as a way to scan the area for any possible bats returning to a roost within close proximity. This tool has the ability to listen to bats in real time, GPS tracks and tags all recordings with location information and has full color spectrograms. Scanning commenced from 05:00-06:30 from the ground from different angles and locations.

Results and Discussion

The visual thermal IR survey detected no bats at all. Multiple species of birds were observed with the thermal IR, with visual confirmation, in and around the area. It was determined that there would be No Effect to bats if the trees were removed.

Recommendations

Work with DPW to better monitor the contractors work so that trees that need trimming are not missed prior to the pupping season.

Appendix 6-4

Hawaiian Hoary Bat

Thermal IR and Acoustic Monitoring Project for Tree Trimming of Eucalyptus robusta at Wheeler Elementary School on 25 June 2016

Survey Goals

Establish whether or not Hawaiian Hoary bats (*Lasiurus cinereus semotus*) are roosting with pups in *Eucalyptus robusta* trees that require trimming as they are interfering with the airspace view of the runway's air traffic control tower. The Airfield Manager wants the trees pruned to a height of probably 30-40 feet to get the proper view. If bats present, discuss with regulatory agency possible mitigation measures to continue project or postpone removal of trees until pupping season is completed.

Survey Map

Map removed to protect rare resources

Figure 1. Map of the Wheeler Elementary School project site which Hawaiian Hoary bat surveys were conducted. Red dot indicates location of the site.

(15) Eucalyptus tree removals proposed :

NOTE:

<u>Tree approximate heights</u>

1- Tree# 40= --------------- 50′
2- Tree# 39= --------------- 80′
3- Tree# 38= --------------- 70′
4- Tree# 36= --------------- 70′
5- Tree# 35= --------------- 75′
6- Tree# 34= --------------- 70′
7- Tree# 33= --------------- 15′
8- Tree# 32= --------------- 8′
9- Tree# 31= --------------- 55′
10- Tree# 30= ------------- 55′
11- Tree# 29= ------------- 50′
12- Tree# 28= ------------- 55′
13- Tree# 27= ------------- 55′
14- Tree# 26= ------------- 55′
15- Tree# 23= ------------- 55′

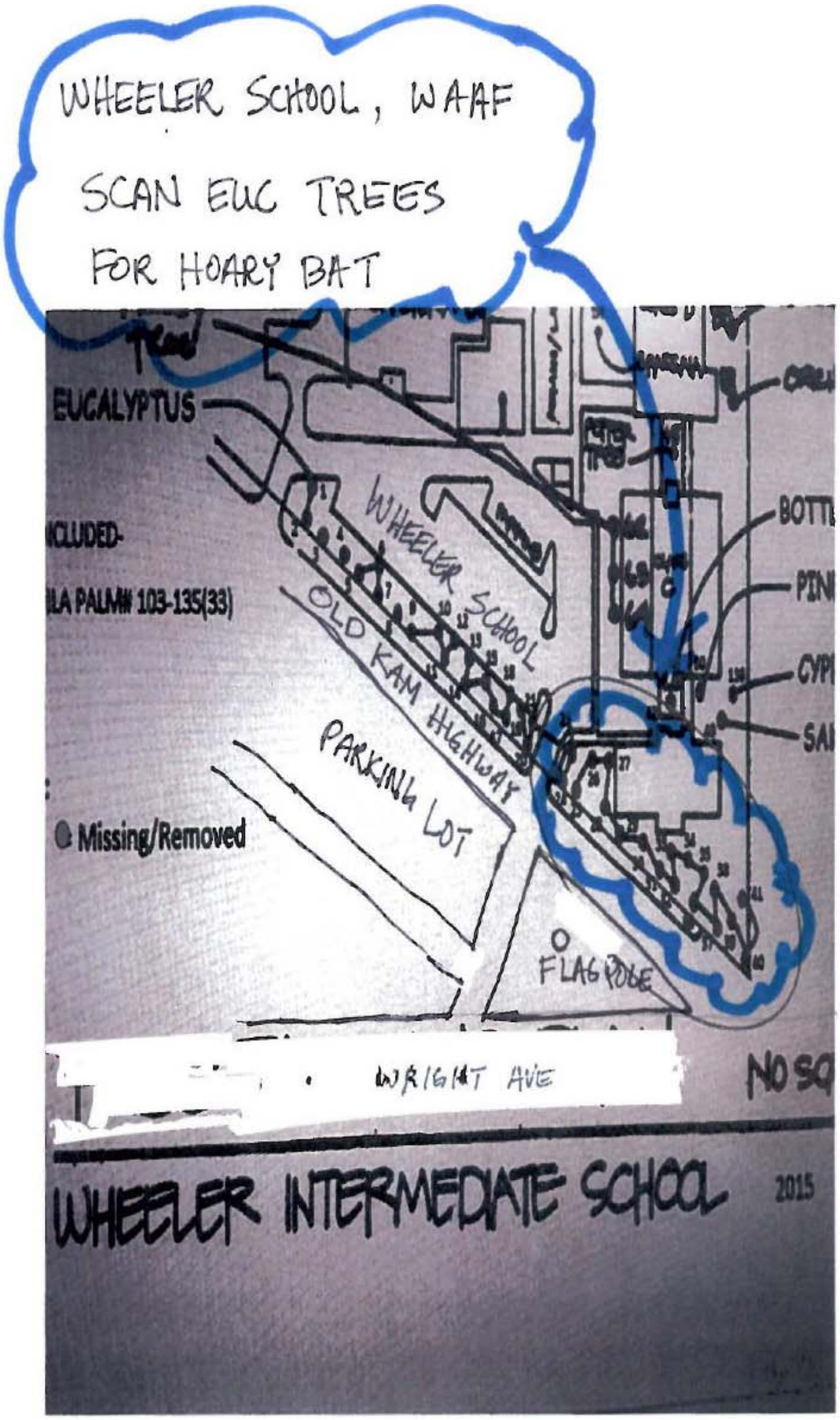

Figure 2. Map of *Eucalyptus* locations

Survey

Methods

Visual and acoustic surveys for bats were conducted on 25 June 2016, the day of the scheduled tree trimming. A Fluke Ti400 thermal imager was employed to scan the trees for any roosting bats to confirm no presence. OANRP also employed the hand held Wildlife Acoustics Echo Meter Touch attached to an IPad as a way to scan the area for any possible bats returning to a roost within close proximity. This tool has the ability to listen to bats in real time, GPS tracks and tags all recordings with location information and has full color spectrograms. Scanning commenced from 05:00-06:30 from the ground from different angles and locations.

Results and Discussion

The visual thermal IR and acoustic surveys detected no bats at all. Multiple species of birds were observed with the thermal IR, with visual confirmation, in and around the area. It was determined that there would be No Effect to bats if the trees were removed.

Recommendations

Work with DPW to better monitor the contractors work so that trees that need trimming are not missed prior to the pupping season.

Appendix 6-5

Hawaiian Hoary Bat

Thermal IR and Acoustic Monitoring Project for Trimming of Trees at Leilehua Golf Course on 27 June 2016

Survey Goals

Establish whether or not Hawaiian Hoary bats (*Lasiurus cinereus semotus*) are roosting with pups in multiple trees species along the HV power line corridor located at the Leilehua Golf Course. The utility lines run along the fairway from Tee #1 to Tee #2. If bats present, discuss with regulatory agency possible mitigation measures to continue project or postpone removal of trees until pupping season is completed.

Survey Map

Figure 1. Map of the Leilehua project site which Hawaiian Hoary bat surveys were conducted. Red dot indicates location of the site.

Map removed to protect rare resources

Figure 2. Map 1 of project site with tree locations

Map removed to protect rare resources

Figure 3. Map 2 of project site with tree locations

Figure 4. Map 3 of project site with tree locations

Survey

Methods

Visual and acoustic surveys for bats were conducted on 27 June 2016, the day of the scheduled tree trimming. A Fluke Ti400 thermal imager was employed to scan the trees for any roosting bats to confirm no presence. OANRP also employed the hand held Wildlife Acoustics Echo Meter Touch attached to an IPad as a way to scan the area for any possible bats returning to a roost within close proximity. This tool has the ability to listen to bats in real time, GPS tracks and tags all recordings with location information and has full color spectrograms. Scanning commenced from 04:30-07:30 from the ground from different angles and locations.

Results and Discussion

The visual thermal IR and acoustic surveys detected no bats at all. Multiple species of birds were observed with the thermal IR, with visual confirmation, in and around the area. It was determined that there would be No Effect to bats if the trees were removed and the corridor cleared.

Recommendations

Work with DPW to better monitor the contractors work so that trees that need trimming are not missed prior to the pupping season.

Hawaiian Hoary Bat

Thermal IR for Tree Trimming/Removal at Schofield Barracks East Range on 05 July 2016

Survey Goals

Establish whether or not Hawaiian Hoary bats (*Lasiurus cinereus semotus*) are roosting with pups in multiple tree species that require trimming as they are interfering with the Approach-Departure Zone of Wheeler Army Airfield. Army Wildland Fire Company has offered to remove *Eucalyptus* spp. (10), *Albizia* spp. (3), *Lagerstroemia speciosa* (5), *Trema orientalis* (3), *Schinus terebinthifolius* (5), *Casuarina equisetifolia* (6), *Macaranga* spp. (6) and *Grevillea robusta* (2) at no cost, as a training exercise. If bats are present, discuss with regulatory agency possible mitigation measures to continue project or postpone removal of trees until pupping season is completed.

Survey Map

Map removed to protect rare resources

Figure 1. Map of the Schofield Barracks East Range project site which Hawaiian Hoary bat surveys were conducted. Red star indicates location of the site.

Figure 2. Map of tree removal location shaded in red

Survey

Methods

Visual and acoustic surveys for bats were conducted on 05 July 2016, the day of the scheduled tree trimming. A Fluke Ti400 thermal imager was employed to scan the trees for any roosting bats to confirm no presence. OANRP also employed the hand held Wildlife Acoustics Echo Meter Touch attached to an IPad as a way to scan the area for any possible bats returning to a roost within close proximity. This tool has the ability to listen to bats in real time, GPS tracks and tags all recordings with location information and has full color spectrograms. Scanning commenced from 05:00-06:30 from the ground from different angles and locations.

Results and Discussion

The visual thermal IR and acoustic surveys detected no bats at all. Multiple species of birds were observed with the thermal IR, with visual confirmation, in and around the area. It was determined that there would be No Effect to bats if the trees were removed.

Recommendations

Work with DPW to better monitor the contractors work so that trees that need trimming are not missed prior to the pupping season.

Appendix 6-7

Hawaiian Hoary Bat

Thermal IR for Tree Trimming/Removal at Fort Shafter Flats on 18 August 2016

Survey Goals

Establish whether or not Hawaiian Hoary bats (*Lasiurus cinereus semotus*) are roosting with pups in a single tree located on a construction at the Fort Shafter Flats. If bats are present, discuss with regulatory agency possible mitigation measures to continue project or postpone removal of trees until pupping season is completed.

Survey Map

Figure 1. Map of the Fort Shafter Flats project site which Hawaiian Hoary bat surveys were conducted. Red dot indicates location of the site.

Map removed to protect rare resources

Figure 2. Map of tree removal location

Survey

Methods

Visual and acoustic surveys for bats were conducted on 18 August 2016, the day of the scheduled tree trimming. A Fluke Ti400 thermal imager was employed to scan the trees for any roosting bats to confirm no presence. OANRP also employed the hand held Wildlife Acoustics Echo Meter Touch attached to an IPad as a way to scan the area for any possible bats returning to a roost within close proximity. This tool has the ability to listen to bats in real time, GPS tracks and tags all recordings with location information and has full color spectrograms. Scanning commenced from 05:00-06:30 from the ground from different angles and locations.

Results and Discussion

The visual thermal IR and acoustic surveys detected no bats at all. Multiple species of birds were observed with the thermal IR, with visual confirmation, in and around the area. It was determined that there would be No Effect to bats if the trees were removed.

Recommendations

Work with DPW to better monitor the contractors work so that trees that need trimming are not missed prior to the pupping season.

DEPARTMENT OF THE ARMY
US ARMY INSTALLATION MANAGEMENT COMMAND, PACIFIC REGION
HEADQUARTERS, UNITED STATES ARMY GARRISON, HAWAII
745 WRIGHT AVENUE, BUILDING 107, WHEELER ARMY AIRFIELD
SCHOFIELD BARRACKS, HAWAII 96857-5000

REPLY TO
ATTENTION OF

IMHW-ZA

MEMORANDUM FOR All Military Personnel, Contractors and Department of Defense Civilian Employees within United States Army Garrison, Hawaii (USAG-HI) Installations

SUBJECT: Policy Memorandum 72, Tree Cutting Moratorium

1. References.

a. Army Regulation (AR) 200-1, Environmental Protection and Enhancement, 13 December 2007.

b. Federal Endangered Species Act (1973).

2. Applicability. This policy applies to all Soldiers, civilians, family members, contractors, and other personnel who work on, reside on, or visit any U.S. Army installation, facility, or work site on the Island of Oahu.

3. Policy.

a. In February, 2014, the Natural Resource Program (NRP) discovered the presence of the Federally listed endangered species, Hawaiian Hoary Bat, *Lasiurus cinereus* semotus, at Schofield Barracks West Range. In addition, the NRP discovered the presence of the bat in Schofield Barracks East Range in Spring 2013. Bats have also been found by the US Geological Survey in numerous locations on Oahu spanning from Waikiki to Ford Island to the Waianae Moiuntains to the North Shore of Oahu. For this reason, bats are now considered to be ubiquitous on Oahu.

b. The Army is required to consult with the US Fish and Wildlife Service (USFWS) anytime an action may affect a listed threatened or endangered species or their critical habitat. In the meantime, the Army must practice avoidance.

c. The NRP is in the process of preparing a formal consultation package for the USFWS. Until a Biological Opinion is received from the USFWS, the following measures must be followed to maintain compliance with the Federal Endangered Species Act (1973):

(1) During the bat pupping season, 1 June to 15 September, there shall be no cutting or trimming of any tree over 15 feet tall.

(2) If a tree falls on it's own that is over 15 feet tall, the Army may remove the tree.

(3) In case of an emergency situation, for example, a tree larger than 15 feet tall is threatening a power line, the staff must contact the Natural Resource Program for guidance, prior to cutting the tree.

(4) This policy applies to all Army installations on the island of Oahu, including housing. The policy pertains to cantonement as well as the actual training areas.

(5) This policy is in place until further notice.

4. Proponent. The proponent for administration of the Tree Cutting Moratorium is DPW, Environmental Division, at 655-9189.

RICHARD A. FROMM
COL, AD
Commanding

OANRP Diphacinone-50 Hand Broadcast Study

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EXECUTIVE SUMMARY

The Army is required to stabilize populations of endangered species and their habitat as per Biological Opinions issued by the U.S. Fish and Wildlife Service. Introduced rats (*Rattus* spp.)_are one of the largest threats to endangered plants, snails and birds. Oahu Army Natural Resources Program (OANRP) has been engaged in rodent control since 1995 using various techniques including snap traps, automatic traps, rodenticide applied in bait stations and physical barriers. Since 2012, OANRP halted rodenticide use because of a change in the Special Local Needs (SLN) label that makes bait-station application unfeasible in the steep, rugged terrain where the work is conducted. Relying solely on traps has not been effective in keeping populations below the targeted 10% tracking in monitoring tunnels, particularly during the period of peak rat abundance (typically Fall/Winter). In attempt to combat this problem in Hawaiian habitats, OANRP would like to determine the effectiveness of a "one-time" two-application hand-broadcast (applications spaced approximately 5-7 days apart) and canopy baiting of rodenticide bait (Diphacinone-50) during a period of high rat abundance within Kahanahaiki Management Unit (a fenced Unit where ungulates are excluded) in the Waianae Mountains. Hand broadcast application will involve OANRP staff walking a grid of trails while evenly distributing rodenticide bait; canopy baiting involves placing bait, held in small cloth bags, into trees within the grid. These application methods comply within the Diphacinone-50 label (EPA Registration No. 56228-35). Hand broadcast method of rat control was assessed in the Programmatic Environmental Assessment for the Final Implementation Plan for Oahu Training Areas, March 2010, FNSI June 2010. USDA National Wildlife Research Center (NWRC) will provide the monitoring associated with this study (e.g., bait application according to label, efficacy of this rat-reduction method, and non-target impacts).

1. INTRODUCTION to Project Plan

This is the project plan to study a hand broadcast and canopy baiting application of Diaphacinone-50 for control of *Rattus* spp. at Kahanahaiki Management Unit, northern Waianae Mountains, Oahu. The project plan includes two parts: 1) the operational plan, and 2) the monitoring plan (inserted as an Appendix to this document; NWRC Study Protocol QA-2523). This project plan was written collaboratively by Oahu Army Natural Resources Program (OANRP), with funding from the Army, and the USDA APHIS Wildlife Services (WS), and USDA APHIS WS National Wildlife Research Center (NWRC). The OANRP will lead in the operation, particularly bait application, whereas WS/NWRC will provide project oversight and will lead in the monitoring of this study.

2. GOAL, OBJECTIVES and OUTCOMES

2.1. Goal

The goal of this project is:

"To study if a hand broadcast and canopy baiting application of Diphacinone-50 in combination with a grid of mechanical traps (already in operation) has a seasonal knockdown effect on the rat population at Kahanahaiki (ideally <10% tracking activity through the winter)."

2.2. Objectives and Outcomes

Objectives	Outcomes
1. To determine if a 2-application hand broadcast of Diphacinone-50 is an effective method for seasonal knockdown of *Rattus* spp. at Kahanahaiki	1.1 Reduction of rat activity (ideally <10% measured by tracking tunnels, corriflute tabs and GoodNature chew cards), and >80% local mortality of rats (using fates of rats with radio collars).
2. Study non-target effects	2.1 Gain information on non-target effects (carcasses searches, tests of diphacinone residues through food web)
3. Use results to make management decisions and develop protocols for other MU's	3.1 Determine if seasonal hand broadcast is a safe and effective option for seasonal control of rats.
	3.2 Staff will have skills and knowledge to undertake other hand broadcast operations at other Management Units (MUs).

3. THE SITE, TARGET SPECIES, and NEED for SUPPLEMENTAL RAT CONTROL USING SEASONAL BAIT APPLICATION

3.1. The Site and Rat Management History

The Kahanahaiki Management Unit (MU) is located at 500-660 m elevation in the Waianae mountain range (21^{o} 32' N, 158^{o} 11' W), within the Makua Military Reservation (MMR), on Oahu, Hawaii (Figure 1). The rat control area within the MU is approximately 70 acres and is fenced to exclude ungulates. Overall, the north and east aspects are relatively native while the south and west exposures are dominated by weeds. Kahanahaiki is home to many rare taxa, including plants and snails; 12 plant species and two animals are listed as endangered (Joe and Daehler 2008). Non-native rodents are ubiquitous at Kahanahaiki, including black rats (*Rattus rattus*), Pacific rats (*R. exulans*), and house mice (*Mus musculus*); black rats are numerically dominant, outnumbering Pacific rats by >10-fold (Shiels 2010). Negative impacts of each of these three rodent species at Kahanahaiki has been reported to span native plants, insects, snails, and birds (Meyer and Shiels 2009; Shiels et al. 2013). One endangered plant, *Cyanea superba*, is highly vulnerable to black rat predation, and large-scale and intensive snap-trapping at Kahanahaiki reduced seed predation by rats from 47% to just 4% in one season (Pender et al. 2013). Several additional native plants receive high predation by black rats at Kahanahaiki (Shiels and Drake 2011), implying that these native forests may potentially experience a shift in species composition attributable to invasive rats (particularly black rats).

The U.S. Army is required to stabilize populations of endangered species and their habitat as per Biological Opinions issued by the U.S. Fish and Wildlife Service. Due to the large negative effects of introduced rats on natural resources at Kahanahaiki, Oahu Army Natural Resources Program (OANRP) has been engaged in rodent control since 1995 using various techniques including snap traps, automatic traps, rodenticide applied in bait stations and physical barriers. Due to the high habitat quality and small size of the Kahanahaiki, a large scale Victor Snap grid of 402 traps was installed in May 2009 for Kahanahaiki-wide protection (Figure 1). In general, these traps were re-baited twice per month. After a general knock-down in the rat population in 2009, much fluctuation had occurred and the targeted levels of rat suppression were not always being met with the large-scale snap-trapping (Pender et al. 2013); this resulted in noticeable losses of native and endangered seeds and predation of native snails by rats.

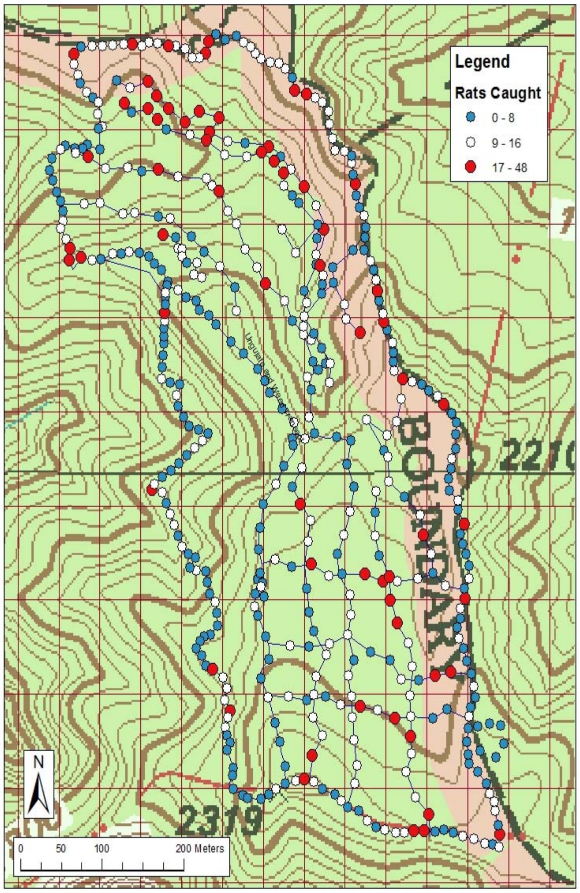

Figure 1. Map of Kahanahaiki snap-trap grid displaying total rat catches (2009-2014).

OANRP rat-control tools became more limited in 2012, which was when OANRP halted rodenticide use because of a change in the Special Local Needs (SLN) label that made bait-station application unfeasible in the steep, rugged terrain where the work (at the MU and elsewhere) is conducted. During a trial in 2012 and 2013, Goodnature A24 rat + stoat traps (Goodnature Limited, Wellington, NZ), which are self-resetting traps that can fire 24 times with one CO_2 cartridge, were shown to be effective in controlling rat activity at a nearby site, Pahole gulch. Because of these results a grid of A24s was installed at Kahanahaiki and snap-traps were discontinued. In July 2014, 83 Goodnature A24s were installed on existing trails at a spacing of approximately 50 x 100 meters. In December 2014, an additional 36 A24s were installed within the gulch area to achieve a device spacing of 25 x 100meters (Figure 2).

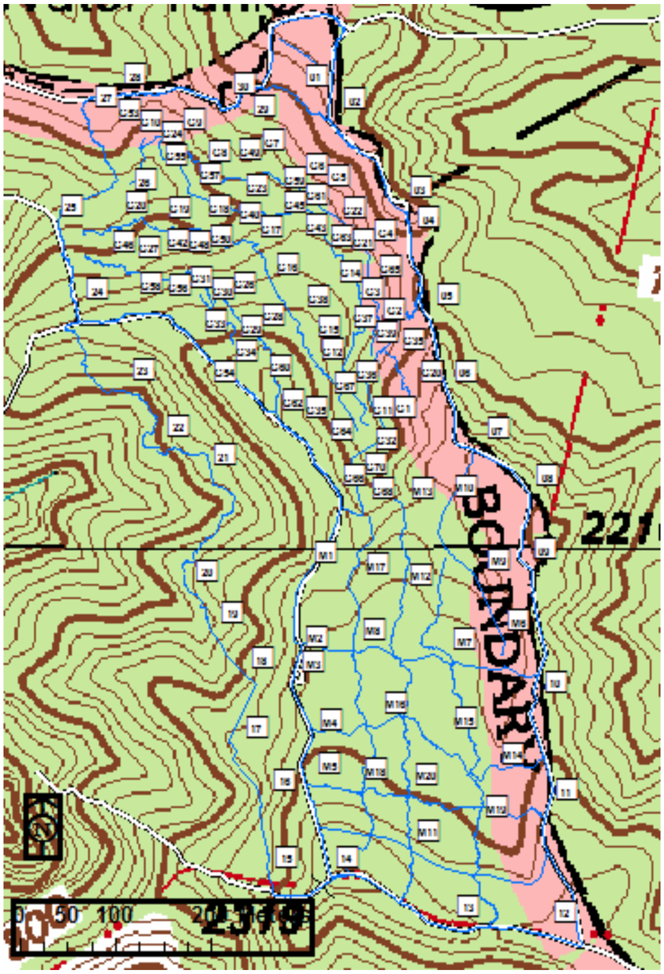

Figure 2. Map of Kahanahaiki Goodnature A-24 trap grid.

Monitoring of rat activity at Kahanahaiki as well as a control site via tracking tunnels was implemented to determine efficacy of trapping devices. The management objectives for this MU articulate that there should be less than 10% activity levels in rat tracking tunnels. An acceptable level of rat activity, which promotes stable or increasing native/endangered snail (*Achatinella mustelina*) and plant (*Cyanea. superba* subsp. *superba*) populations, has not been clearly identified. It could be very low, less than 2%, or very high, 40%; in New Zealand, studies have shown that rat activity levels of 10% are low enough to maintain certain rare bird populations (Innes et al. 1999). A 10% activity level may also be the most achievable level using a large scale trapping grid. Results of the past six years of monitoring of the snap-trap grid (May 2009-April 2014) and the subsequent A-24 grid (May 2014 to present) show seasonal winter spikes of rat activity up to 78.4% (Figure 3). Thererfore, relying solely on traps (snap-traps or A24s) has not been effective in keeping populations below the targeted 10% tracking in monitoring tunnels, particularly during the period of peak rat abundance (typically Fall/Winter; Figure 3). The goal of this project will be to reduce the rat population (and therefore tracking) at Kahanahaiki during the seasonal peaks (roughly November-February; Figure 3).

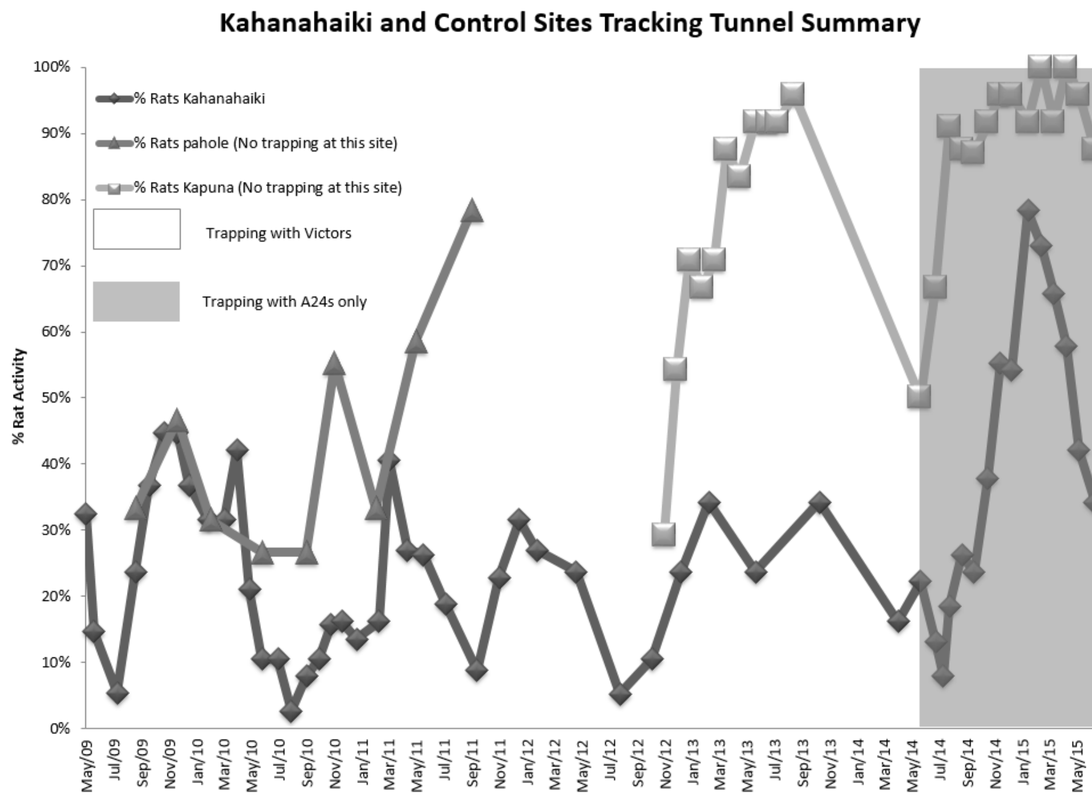

Figure 3. Percent rat activity (based on tracking tunnels) at Kahanahaiki (the rat-trapping site), and two sites where no rat trapping occurs (Pahole and Kapuna). The shaded area from May 2014-May 2015 is when only A24 traps were used at the rat-trapping site; whereas the non-shaded (May 2009-April 2014) was when only Victor snap-traps were used at the rat-trapping site.

Upon recent assessment of OANRP rat control at Kahanahaiki, and the conclusion that it is not meeting targeted rat suppression (i.e., tracking tunnels are rarely <10%), three rat control techniques were considered at Kahanahaiki:

1. A seasonal Hand Broadcast and Canopy Baiting Application of Diphacinone-50 over the Kahanahaiki along a pre-established grid of trails, with the continuation of mechanical trapping.
2. Continuous bait stations filled with Ramik rodenticide, and set in accordance with the SLN.
3. Exclusive use of mechanical traps placed along a grid of trails.

- **Technique 1 – Hand Broadcast and Canopy Baiting Application:** This method may be considered the most appropriate option and be the most efficient and effective way of adequately controlling the seasonal spike in rat activity within the MU. This method allows for greater bait interaction than bait boxes (bait boxes deter some individauls from entry; Recht 1988), thus potentially a better control method for suppressing rat populations. In addition to the hand broadcast, we will also be employing canopy bags to increase our effectiveness in targeting any rats that favor the arboreal habitat. Through several tracking methods, Shiels (2010) found that rats at Kahanahaiki frequent the arboreal, ground, and underground (burrowing) habitats. Mechanical traps would be used prior to, during, and after the broadcast to provide year round control. In addition, traps would only be required to be deployed at densities adequate to control moderate to low levels of rats as the combination approach will be used during the high spikes.

- **Technique 2 – Use of Bait Stations of Ramik:** This technique has been considered but it has been determined that it is not possible to adhere to the 225m buffer requirement in the SLN given the location of resources to be protected and the surrounding cliffs and steep terrain.
- **Technique 3** – **Exclusive Use of Mechanical Traps:** This has been the only method used at this site for the past six years. Tracking tunnel data shows that this method alone is not adequate to meet management goals at the current trap density.

4. Methods for the Hand Broadcast and Canopy Bait Application

Establishment of baiting transects

Trails that have already been established at Kahanahaiki for snap-trapping (Figure 1) and A24s (Figure 2) will be used as baiting transects in this study. These trails (transects) are generally <50 meters apart. Spreading bait along and adjacent to these transects will generally leave <30 meters between baits, which should minimize chances that a given rat will not interact with bait based on rat home range sizes at Kahanahaiki (average of 4 ha for black rats, and 1.8 ha for Pacific rats; Shiels 2010), as well as linear distance moved in a night from point of capture (black rat: mean 20 m, maximum 30 m; Pacific rats: mean 25 m, maximum 40 m; Shiels 2010). Installing additional trails for this two-bait application study is not warranted given the significant disturbance to the fragile habitat and native/rare species that is caused by installing trails.

Applicator training

All OANRP staff (~40 personnel) are certified for applying diphacinone rodenticide (i.e., a license to "purchase and use restricted pesticides" issued as the "State of Hawaii, Dept. of Agriculture, Division of Plant Industry, CERTIFICATION FOR COMMERCIAL APPLICATORS OF RESTRICTED PESTICIDES"). There are 7-10 OANRP personnel anticipated to be applying the bait for this study. In addition to each of the personnel being licensed to apply/use restricted pesticides, they will get additional training in advance of the applications that will clarify methodological details specific to application and bait distribution pattern (see below) within Kahanahaiki forest. Included in this training will be throwing dog-food pellets (a surrogate to Diphacinone-50 bait) on flat ground that has markings out to 10 m; such calibration for each personnel will help ensure even spread of bait in the field at the proper application rate (i.e., according to the Diphacinone-50 label; see below).

Bait staging

Once bait arrives in Hawaii, it will be stored according to the label and in a cool dry place. Because of the difficulty of navigating the terrain at Kahanahaiki, bait caches will be established prior to the beginning of the study. Bait will be flown by helicopter on-site ~1-7 days prior to the initial hand broadcast application. These bait caches (stockpile locations) will consist of metal trash cans with locking lids filled with the bait in original closed container, providing tamper resistant storage. Locations will be selected to allow the applicators to carry 13.8 kg of bait before arriving at the next station. We estimate approximately 14 stations will be needed. GIS will be used to identify the areas to place bait stockpile locations.

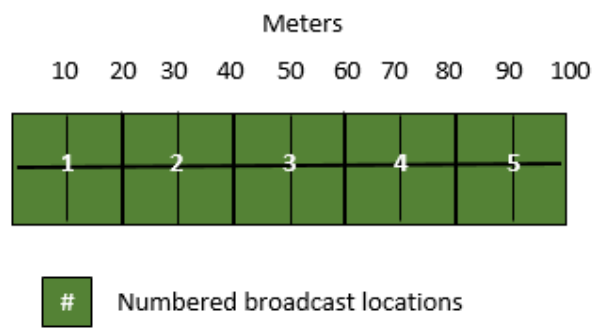

Figure 4. Example of how bait will be stockpiled in "broadcast locations". At each broadcast station, bait will be distributed in all directions within a 20 meter square (530 g of bait at odd numbered stations and 439 g of bait for even numbered stations).

Bait application

All application amounts will be according to the label (Diphacinone 50: Conservation, EPA Reg. No.: 56228-35, State of Hawaii Lic. No. 8600.1). For ground broadcast the rate is 11.1 to 13.8 kg bait/ha per treatment for the first treatment, and no more than 13.8 kg/ha for the second treatment. At Kahanahaiki, bait will be spread 10 meters in all directions at "broadcast locations", every 20 meters along the trails (Figure 4). This will make for continuous baiting in a 10 m distance from each side of the trail throughout the trail system (Figure 5). At all "broadcast locations" 495 g of bait will be distributed equally in all directions within a 20 meter square, making the application rate to the ground for all locations 12.375 kg/ha. To ensure equal amounts of bait being distributed at each broadcast location, staff will have a plastic container/scoop that measures out the appropriate amount to be broadcasted. Staff will then reach into the container with a gloved hand and hand broadcast the bait as equally as possible throughout the area.

At all even numbered "broadcast locations" a canopy bag containing 113 g of bait will tied onto a tree (see below). Thus, the application rate of bait at even stations to the ground (12.375 kg/ha) is combined with canopy (1.356 kg/ha) is 13.731kg/ha (i.e., under the maximum "Aerial and Ground Broadcast" rate according to label).

Using the 10 meter buffer this will equal 25 broadcast locations or 500 meters of trail per/ha. The total area of the trails with a 10 meter buffer on each side equals 14.16 ha. For this area we will be broadcasting to the ground at a rate of 12.375 kg/ha for a total of 175.23 kg, and hanging canopy bags at every other broadcast location (the evens) for a total of 19.20 kg.

In some areas there are cliffs and terrain that do not allow for the addition of trails, however because of the steepness it is possible for applicators to broadcast much farther than 10 meters from the already established trails. This area is in green (Figure 5) and contributes 6.11 ha. Special instructions on how much additional bait to broadcast in the green areas will be provided to the staff that will apply the bait. In these areas canopy bags will not be used so the application rate will be the label maximum of 13.8 kg/ha for a total of 84.32 kg.

We will also be using 22 g of bait at 90 bait availability monitoring plots for a total of 1.98 kg.

Although the entire fenced unit of Kahanahaiki is approximately 36 ha, the total area to be broadcasted equals 20.27 ha. When all methods are combined a total amount of 280.73 kg of bait will be needed per broadcast. Because two broadcasts will occur, 561.46kg or 1237.81lbs of total bait will be needed.

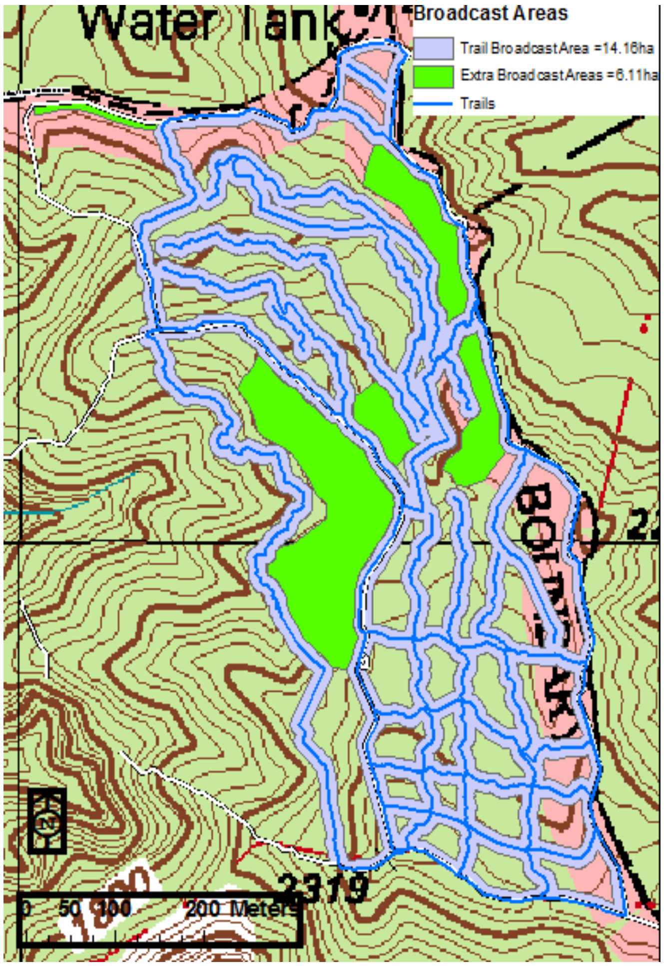

Figure 5. Map of Kahanahaiki with 10 meter buffers (light blue) associated with trails (dark blue) and extra broadcast areas (green). Although the entire fenced unit of Kahanahaiki is approximately 36 ha, the total area to be broadcasted (blue+green) equals 20.27 ha.

The label recommends the addition of canopy baiting in areas where sufficient food and cover are available to harbour populations of rodents in canopies of trees and shrubs. According to the label 113 g to 200 g of bait should be placed in each cloth bag (Figure 6). At all even numbered "broadcast locations" (Figure 6) a canopy bag containing 113 g of bait will be placed in the canopy. This amount and spacing is according to the label; the label states that canopy bags should be placed at intervals of 50 m or less. The bags will be tied to the trees at < 3 m height (target of 2-3 m height, based on Shiels (2010) average black rat activity above ground of 2.8 m, Pacific rat is 0.3 m).

Figure 6. Example of cloth canopy bags that will be used for canopy baiting.

Timing of Operation

We plan to conduct broadcast applications in October 2015. This timing coincides with the disappearance of strawberry guava (*Psidium cattleianum*) fruit, which is one of the major food sources for rats at Kahanahaiki (Shiels 2010; Shiels and Drake 2011). Strawberry guava fruiting normally occurs June-September (peaking in July/August), and September/October is generally the beginning of increased rodent activity measured in the tracking tunnels (Figure 3).

Signage

Warning signs will be posted along the fence line and on the trail leading to Kahanahaiki (Figure 7). Signs will include the date of the broadcast and they will remain on site for 2 months following the first bait application.

CAUTION

THIS AREA HAS BEEN BAITED WITH DIPHACINONE POISION TO CONTROL RODENTS

HAZARD TO HUMANS AND DOMESTIC ANIMALS

IF YOU HAVE QUESTIONS
PLEASE CONTACT THE ARMY'S
ENVIRONMENTAL DIVISION AT (808) 655-9191

Figure 7. Warning sign that will be posted along the trails leading to Kahanahaiki, and the fence line that surrounds Kahanahaiki.

5.Monitoring Efforts

As stated in the Introduction, OANRP will be conducting (taking lead on) the operational aspects of this study that are outlined above, whereas WS/NWRC will lead in the monitoring of this study. For objectivity and best practice procedures, the agency leading the operational aspects of the study should be different than those leading in the monitoring (Pitt et al. 2015). A detailed Monitoring Plan can be found in Appendix 1, which also constitutes the WS/NWRC study protocol (QA-2523). A summary of the main aspects of the Monitoring Plan are briefly listed below, but refer to the full monitoring plan in Appendix 1 for full details.

Monitoring for this study will include the following:

1) Abidance by the Diphacinone-50 label's application rate. NWRC/WS staff will measure bait densities in established plots throughout Kahanahaiki to ensure bait was applied to the site at a rate of no greater than 13.8 kg/ha per application.
2) Bait fate will be monitored by revisiting plots at set intervals after each bait application and bait densities will be measured. Motion cameras will also monitor subsets of bait to determine the types of animals consuming or removing bait.
3) Rodent monitoring will occur before, during, and after hand broadcast by use of rodent tracking tunnels (ink cards baited and inserted into tunnels to establish rodent activity based on foot-tracks), as well as chew cards and tabs. Such monitoring will occur at Kahanahaiki, and a nearby site (Kapuna) that does not have any rodent control. OANRP staff will help collect the tracking and chew cards and tabs and give them to NWRC/WS at the end of the day for NWRC/WS analysis. These monitoring techniques will help to assess the efficacy of the rodenticide application on the rat population.
4) Rodent fates will be assessed by attaching radio-collars to a subset of rats and mice captured prior to the bait application. These individuals will be followed in the subsequent days/weeks following the bait applications in order to assess the proportion of collared rodents in the study area that did not survive the effects of rodenticide baiting. Rodent carcass searches will also be conducted before, during, and after bait application.
5) Non-target effects. As will any project that uses toxicant bait, we expect that there will be some negative effects to non-target organisms (see Pitt et al. 2015). Justification for proceeding with such a control tool that harms some non-target species is that the longer-term effects of a reduced rat population will provide greater benefit to the native species and habitat that goes beyond the number (and types) of non-target mortalities. There are no expected negative impacts to threatened or endangered species as a result of this hand broadcast. There are expected non-target impacts and this study will monitor those (see monitoring section for more information; Appendix 1). These impacts would include some species being affected by eating the bait directly or consuming any animal that has consumed the toxicant. Briefly, in our non-target monitoring at Kahanahaiki, we will: 1) conduct carcass searches before, during, and after bait application, and 2) assess the levels of diphacinone

residue in the food web by sampling (pre- and post-bait application), game birds, lizards, and invertebrates (slugs and insects).

Rodent monitoring

Three monitoring methods will be used to track the % change of rodent activity before, during, and after the hand broadcast (Figure 8). Chew cards and corriflute chew tabs will be left out for 3 nights while tracking tunnel cards will be left out for 1 night.

Figure 8. Tracking tunnel, GoodNature Chew card, and Corriflute chew tab.

At Kahanahaiki we will use 42 tracking tunnels, 38 GoodNature Chew cards, and 38 corriflute chew tabs (Figure 9). 38 Tracking tunnels are currently being monitored on site however for this project an additional four will be added to cover the Unit II line.

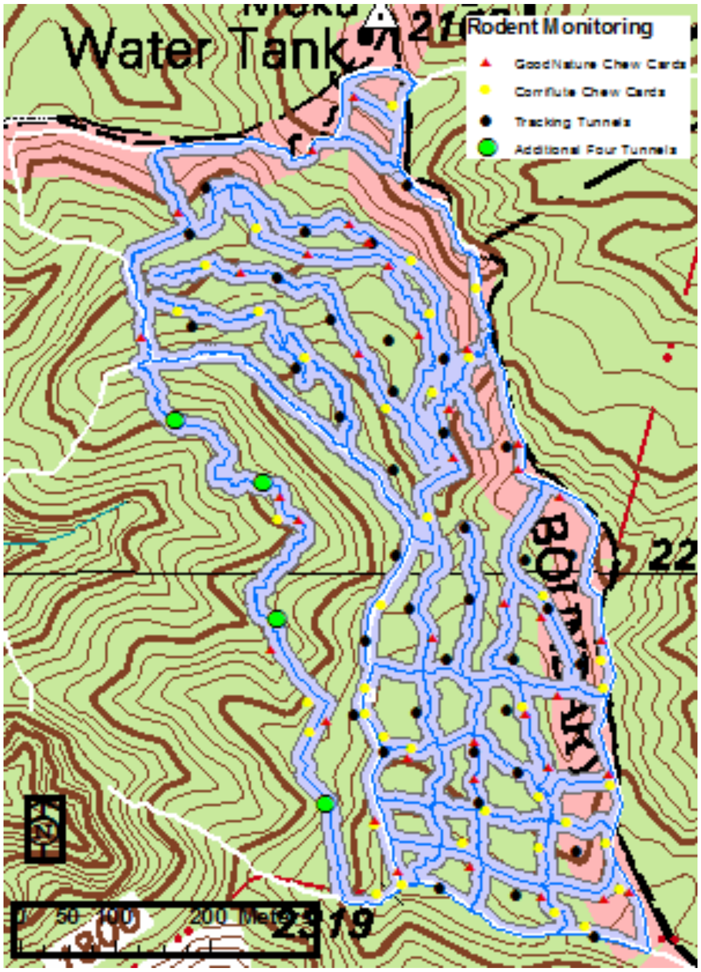

Figure 9. Locations of three rodent monitoring methods at Kahanahaiki.

Monitoring at a control site will also be conducted on the same schedule as the study site. The control site will include 24 tracking tunnels, 24 Good Nature Chew cards, and 24 corriflute chew tabs (Figure 10).

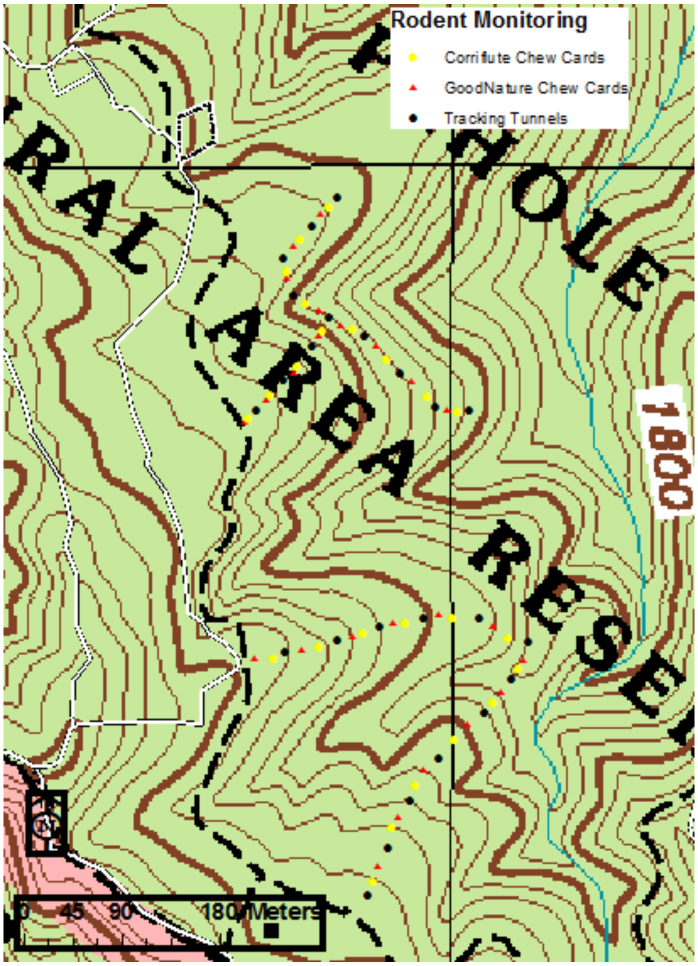

Figure 10. Rodent monitoring device locations at the control site Kapuna.

All three rodent monitoring methods will be initiated one month before the 1st hand broadcast and be used for the duration of the project. Rodent monitoring will be done on the following schedule:

1. 1 month prior to the 1st broadcast
2. The day before the 1st broadcast
3. The day before the 2nd broadcast
4. 7 days after the 2nd broadcast
5. 21 days after the 2nd broadcast
6. 7 weeks after the 2nd broadcast
7. Monthly thereafter with the method deemed most sensitive

Bait availability monitoring

Bait availability monitoring will be initiated on the day of the 1st hand broadcast and continue for 14 days. We don't have plans of doing pre broadcast bait availability monitoring with a non-toxic bait as we will be applying the recommended amount on the label 11.1 to 13.8kg/ha. We have established 90, 1-meter square monitoring plots within the broadcast area using ArcGIS random point generator (Figure 11).

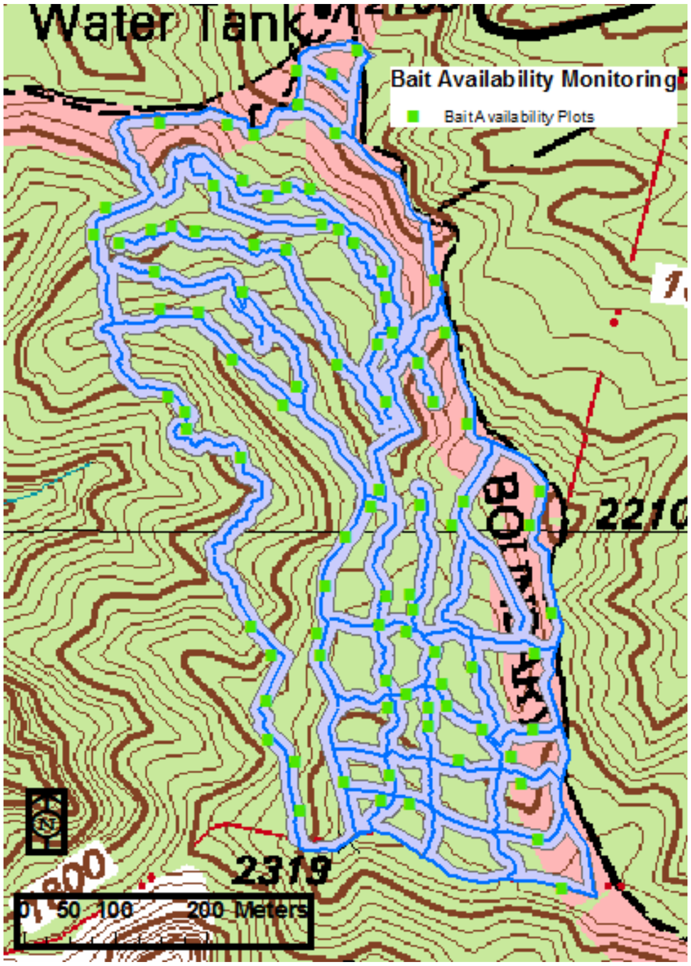

Figure 11. Bait availability monitoring plot locations.

Plots will be denoted with pin flags at each corner. Due to the low amount of bait that could be hand broadcasted into a 1meter plot, assuming that a completely equal distribution of pellets will result in ~2.5 pellets per monitoring plot, twenty pellets (.022kg) will be manually placed in a regular pattern within each plot (Figure 12).

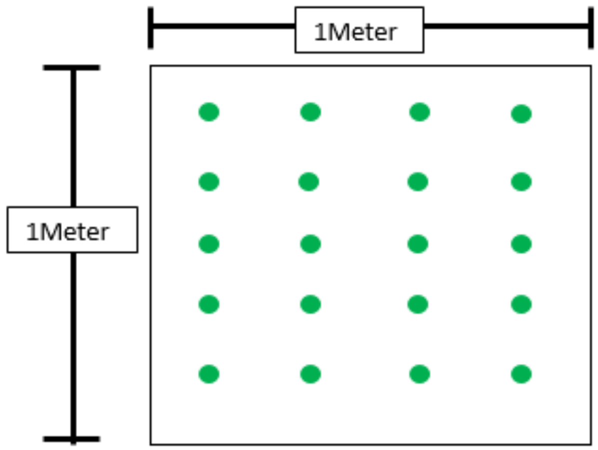

Figure 12. Example of distribution of baits within bait availability monitoring plot.

This bait will be subtracted from the bait broadcasted from the odd numbered locations. Any bait from the hand broadcast that is found in the plots before the twenty baits are manually placed will be broadcasted out of the plot. These procedures will be followed for the 2nd broadcast as well.

During the monitoring period all bait within the plots will be counted and recorded, any partial pellet will be recorded to the nearest 25%. Any pellets that appear to be wet or mouldy will be recorded and noted (Figure 13). Monitoring will begin on the first day soon after the pellets have been broadcasted to obtain an accurate baseline. Plots will then be read daily for 14 days from the first broadcast.

Bait availability monitoring form

Date:

Observer:

Plot #	**# Of Good Bait (to nearest .25)**	**# Of Wet/Moldy Bait**	**Comments**
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Figure 13. Example of Bait availability monitoring form

The monitoring team will also be visually inspecting the canopy bags for signs of take. All canopy bags will be checked daily for 14 days from the first broadcast. An approximation of % bait remaining will be recorded as well as any signs of take or disturbance (Figure 14).

Canopy Bag monitoring form

Date:

Observer:

Bag #	~% Bait Remaining	Comments
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Figure 14. Example of Canopy monitoring form.

Monitoring the area for dead animals

The label states that "For all methods of baiting, monitor the baited area periodically and, using gloves, collect and dispose of any dead animals and spilled bait properly. Dead animals and spilled bait may be buried on site if the depth of burial makes excavation by non-target animals extremely unlikely." The crew responsible for bait availability monitoring will also be responsible for searching all trails for any dead animals and will dispose them according to the label. A gps point, species, sex and condition will be recorded for all carcasses found. Training will be given to staff on properly identifying and recording this information.

Issues with the proposed method

There are no expected negative impacts to threatened or endangered species as a result of this hand broadcast. There are expected non-target impacts and this study will monitor those, see monitoring section for more info. These impacts would include some species being affected by eating the bait directly or consuming any animal that has consumed the toxin.

6. PROJECT TIMELINE

Table 1. Project Milestones

Milestone	Date	Responsible

Operational Planning Stage		
Site Visit	5/14/15	OANRP/USDA
Complete Project Plan	July/August	OANRP/USDA
Order bait	August	USDA
Implementation Stage - pre-operation phase		
Trails and pickup stations	August	OANRP
Establish bait availability plots	August	OANRP/USDA
Conduct pre-broadcast non-target monitoring	September	OANRP/USDA
Attach radio collars to a subset of rats and mice	September	USDA
Conduct pre-broadcast %rat activity monitoring	September	OANRP/USDA
Implementation Stage – Operational phase		
Conduct Hand Broadcast	October	OANRP
Conduct associated monitoring activities including non-target effects	October	USDA
Sustaining the Project Stage		

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OANRP Rodent Standard Operating Procedures

The “rat way”

A24 Setting Instructions

Installation:

- Find a straight tree with a clear footing. Can be set up to a 45 degree angle only if no straight trees can be found.
- Set on up-slope side of tree
- Bottom of bracket should be 10-12cm from the ground. May need to clear dirt on upslope side to allow for clearance of the co2 canister.

Trap checking routine:

- Look for any carcasses. (record)
- If counter present press button firmly once to display number of strikes. (record)
- Remove trap from mounting bracket.
- If bracket is becoming too tight, loosen screws a couple of turns. Do this when needed or during 6 month co2 change.
- Unscrew lid.
- Unscrew bait bottle.
- Test trigger from top of trap (record pass/fail).
- Clean all old bait and mold from bottle and smear below mounting bracket.
- Apply new bait to bottle. Ensure bait is squeezed through the plastic screen on the bottle. The plastic screen needs to be present, if not replace bait bottle with one that has. (record)
- Smear small amount of fresh bait below bracket.
- Screw bait bottle back into trap.
- Screw lid back on.
- Change co2 if it was empty or if it is the 6 month Co2 change. *Note: you do not need to trigger the trap again.
- Click trap back onto mounting bracket.
- Reset counter if present by depressing the button for ~5 seconds.

Every 6 months:

- Ensure flagging is maintained and trap number is visible.
- Remove trap from mounting bracket, loosen screws on brackets if needed.
- Drain co2 from trap and trigger until safe.
- Use alcohol wipes and clean inside of trap, trigger, bait bottle and bracket.
- Replace co2, then click trap back onto mounting bracket
- Do this to all traps within the grid generally in January and June.

If you get familiar with this routine you will be checking traps the “rat way” in no time. Please be sure to follow these guidelines, this will not only standardize the way in which we check traps it will allow us to monitor efficacy better.

Kamate Snap Trap Protocol

Installation on trees:

- In the field locate a horizontal or 45 degree branch
- Place the trap with the trigger facing the trunk of the tree (not the canopy).
- Use two screws to secure the trap to the tree (can also use parachute cord if screws are not wanted)
- If only vertical trees are present the trap should be mounted with the trigger ~12cm from the ground, facing down.
- Gps, number and flag location

Baiting and checking:

- Record observations (take ~10 seconds to search for hair on the trap)
- Trigger trap if set (this allows for the tension to be observed)
- Clean any old bait, hair, deep rust or debris off of the trap with a wire brush
- Ensure trap is secured, re-tie parachute cord or adjust screws if necessary
- Make sure red safety tabs are in place and disabled after setting trap
- Bait the trap with fresh coconut, ensure coconut is not set too far behind trigger

Trap maintenance:

- Replace traps when needed
- During the 3rd quarter check the screws and further inspect the springs for signs of damage, replace if needed

Victor Snap Trap Protocol

Installation in box:

- Transport boxes into the field and place on trails where flat
- Place the operator end towards the trail for ease of checking
- Secure with metal rod (optional)
- Gps, number and flag location

Installation on trees:

- At the shop drill two holes in the top half of the trap to use for securing via screws
- In the field locate a horizontal or 45 degree branch
- Place the trap with the yellow tab facing the trunk of the tree (not the canopy).
- Use two screws to secure the trap to the tree (can also use parachute cord if screws are not wanted)
- If only vertical trees are present the trap should be mounted with the yellow tab ~12cm from the ground, facing down.
- Gps, number and flag location

Baiting and checking:

- Record observations (take ~10 seconds to search for hair on the trap)
- Trigger trap if set (this allows for the tension to be observed)
- Clean any old bait, hair, deep rust or debris off of the trap with a wire brush
- Ensure trap is secured, re-tie parachute cord or adjust screws if necessary
- Bait the tab with peanut butter (~12cm X 12cm X 30cm)
- Set the trap to the “S” setting (S refers to sensitive, F refers to firm)
- Ensure that the tab is not set too high
- Brand new traps can be set to the “F” setting for the first couple of checks and the tab can be set a little higher to ensure traps aren’t being set off due to weather

Annual Trap maintenance:

- All victor snap traps will be removed from the field annually for maintenance during the 3rd quarter
- Bring the correct amount of traps to the field to replace the ones that are being pulled
- Clear all rat trails, re-fresh flagging, update map and forms
- At the shop remove all yellow tabs and place in buckets of cleaning solution and water. Scrub all tabs until clean. Dry tabs
- Use a pressure washer or hose to clean wooden traps free of debris and hair. Dry traps, discard badly chewed or broken tabs.
- Dip traps in linseed oil and set on plywood stacked at an angle to dry.
- Replace yellow tab and wrap parachute cord around the trap

Trap is ready to store until re-deployment!

Tracking Tunnel Protocol

Installation: To be done 1 month prior to setting first tracking cards

- Carry tunnels into the field un-assembled for ease of transportation
- Assemble tunnel
- Find a flat location along trail
- Place tunnel with longer sides on top to act as rain shields
- Use two metal U-wires to firmly stabilize the tunnel
- Gps, number, and flag the location.
- Pre-bait with “quarter” size peanut butter directly in the middle on the inside of the tunnel

Set out tracking cards on the first day:

- Record date, observer, and tunnel number on the card
- Place a “quarter” size amount of peanut butter directly in the middle of the ink on the card.
- Place in tunnel making sure card is flat and at the bottom of tunnel

Retrieve tracking cards the day after setting them:

- Bring gallon size Ziploc to place cards in
- Remove card from the tunnel taking care not to touch the tracking surface of the card
- Remove any bait from the card with a stick or gloved finger
- Fold the card and place in gallon Ziploc bag.

Recording data:

- At the office record onto a data sheet presence of tracks for each species (one card can have multiple species).