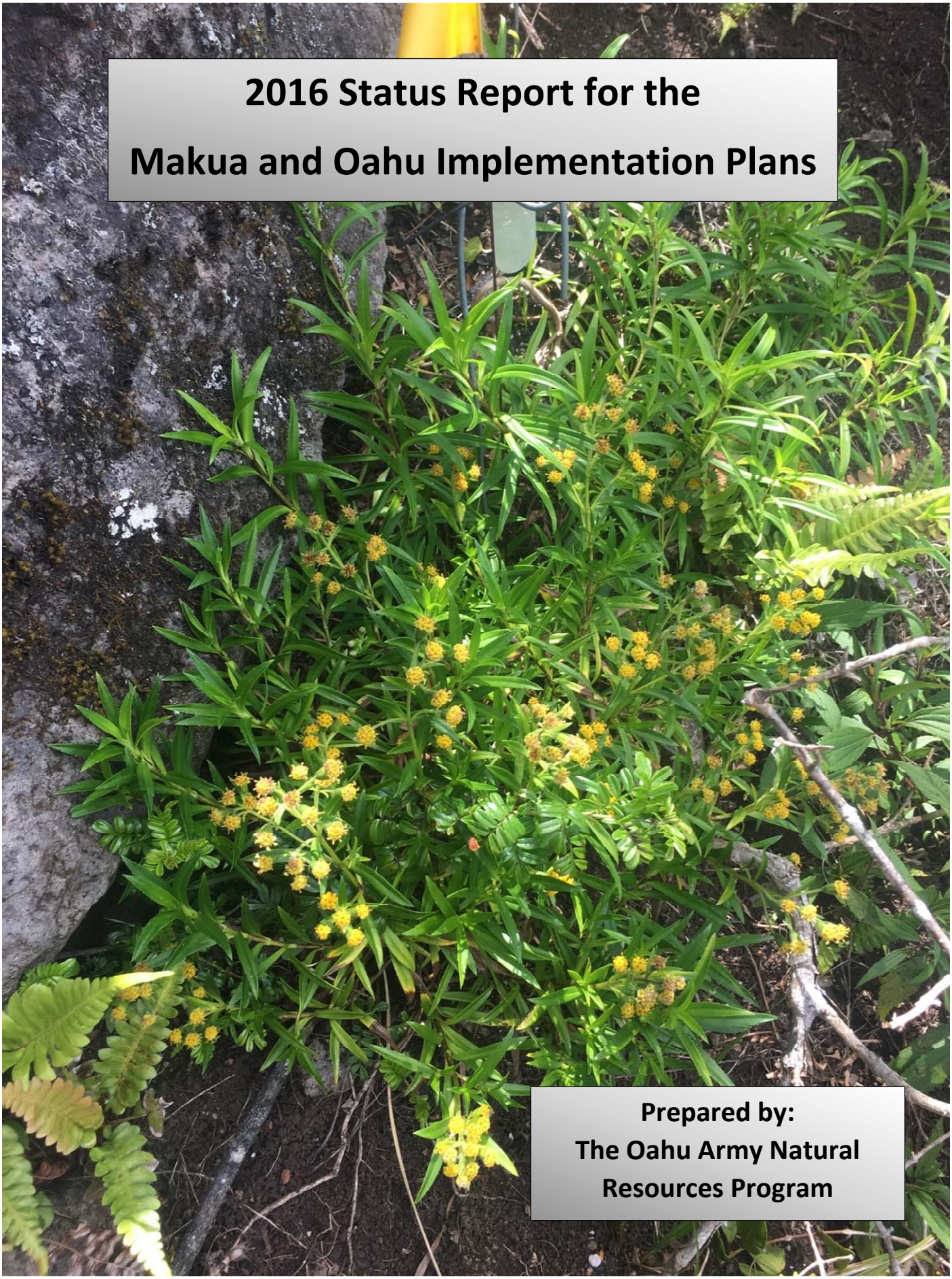
2016 Status Report for the Makua and Oahu Implementation Plans



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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.

Infrastructure

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.

Landowner/Agency Cooperative Agreements and Partnerships

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)

Fire Management

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.*

Outreach Program

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

# 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
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

# 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
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	
		Ohikiiolo	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											
		Halii 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

= 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 Kumakaili	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

= 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											
		Kalpapau, 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	
		Olo	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 Peahinala	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

= 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 Mohlakea	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 Mohlakea	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	
		Puaili	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

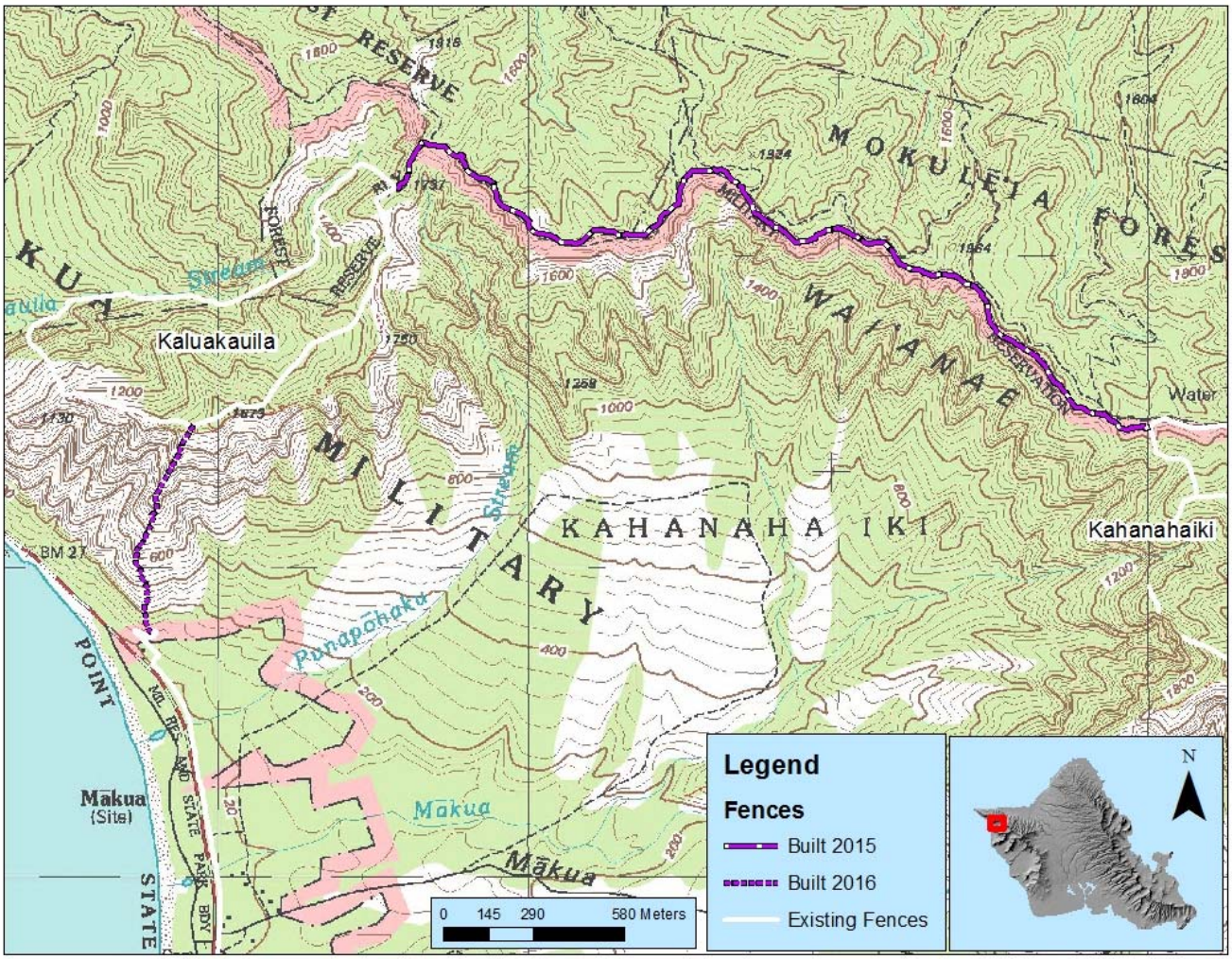


Figure 1: Map of fence construction on the Northern rim of MMR

- 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.

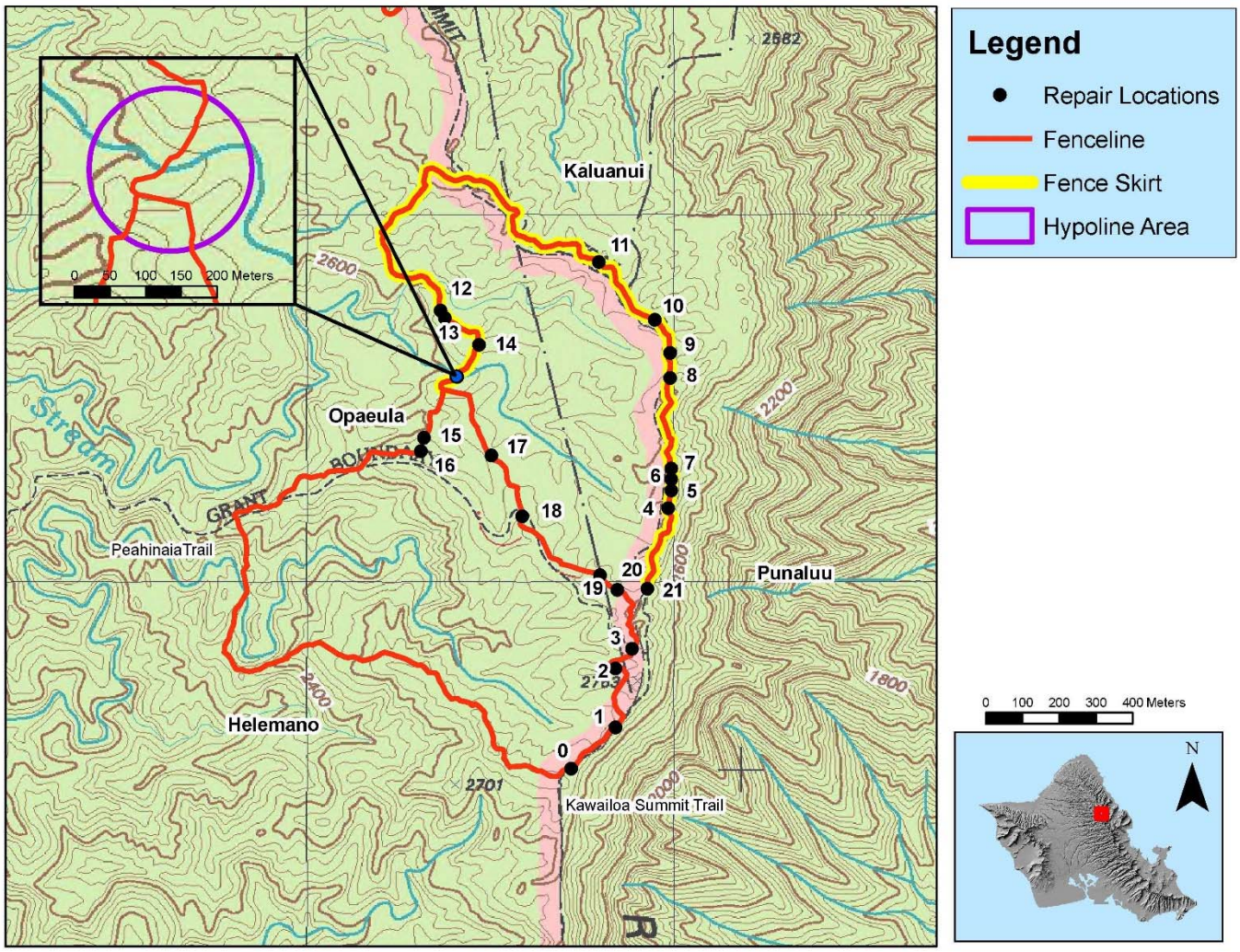


Figure 2: Map of fence repair and skirt replacement at Opaeula/Helemano MU

- 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.

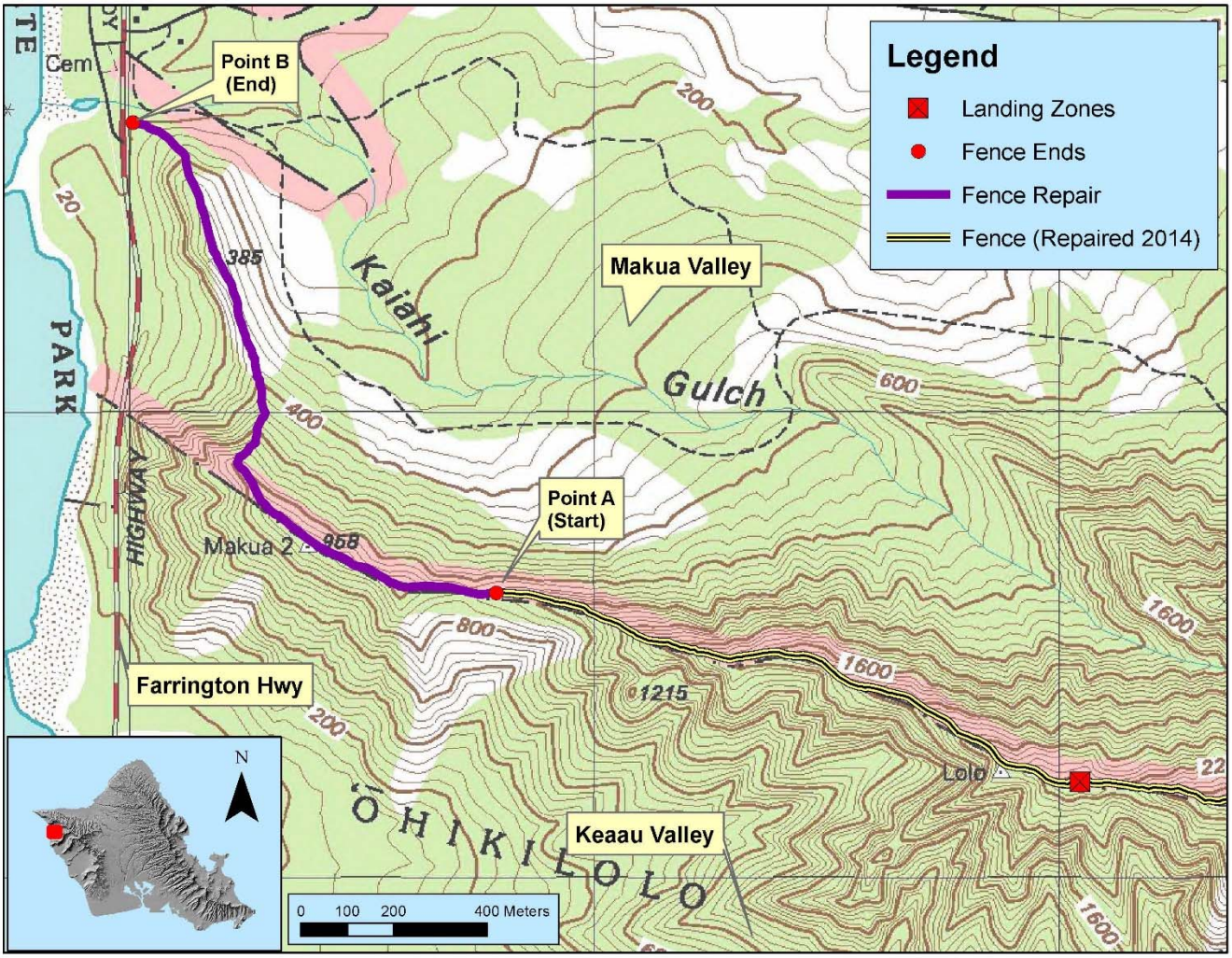


Figure 3: Map of fence replacement on Ohikilolo ridge at MMR

- 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					Notes	Current Threats
										MIP		OIP				
										P	I	P	I	V		
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					Notes	Current Threats
										MIP		OIP				
										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

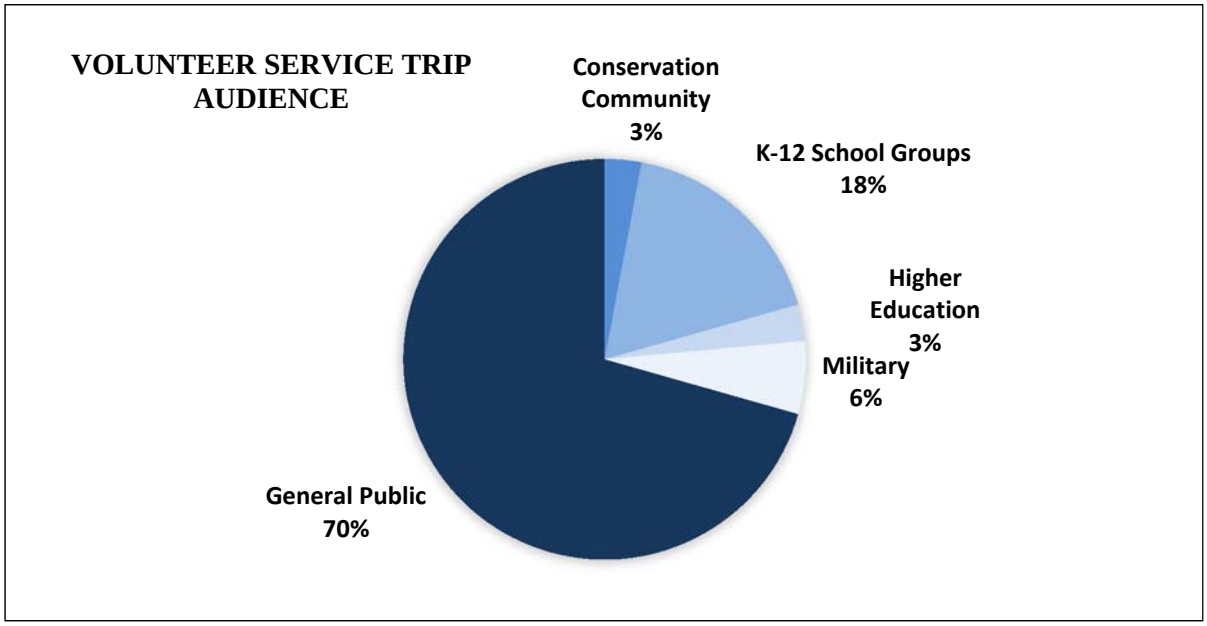
During the reporting period the outreach program continued to coordinate and lead an average of six volunteer trips each month and successfully met volunteer weeding goals. In addition to the ongoing generous support from a few of the program's most dedicated volunteers, baseyard hours increased this 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			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.
		Chromolaena odorata			
		Heterotheca grandiflora			
		Rhodomyrtus tomentosa			
		Schizachyrium condensatum			
		Senecio madagascariensis			
		Smilax bona-nox			
		Vitex trifolia			
Kaala NAR	5	*Crocosmia* x *crocosmiifolia*	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.
		Diplazium esculentum			
		Juncus effusus			
		Pterolepis glomerata			
		Sphagnum palustre			
SBW No MU	2	*Erythrina poepiggiana*	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.
		Chromolaena odorata			

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*	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.
		Sphaeropteris cooperi			
Palikea	3	*Crocosmia* x *crocosmiiflora*	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.
		Dicliptera chinensis			
		Setaria palmifolia			
Manuwai	2	*Dietes iridioides*	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.
		Pterolepis glomerata			
Pahole	6	*Angiopteris evecta*	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
		Axonopus compressus			
		Dicliptera chinensis			

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 m²)*	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 m²)*	**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 m²)*	**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 m²)*	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 m²)*	**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 m²)*	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 m²)*	**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 m²)*	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 m²)*	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 m²)*	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 m²)*	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 m²)*	**3**	**3**	0.04 *(439 m²)*	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 m²)*	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).

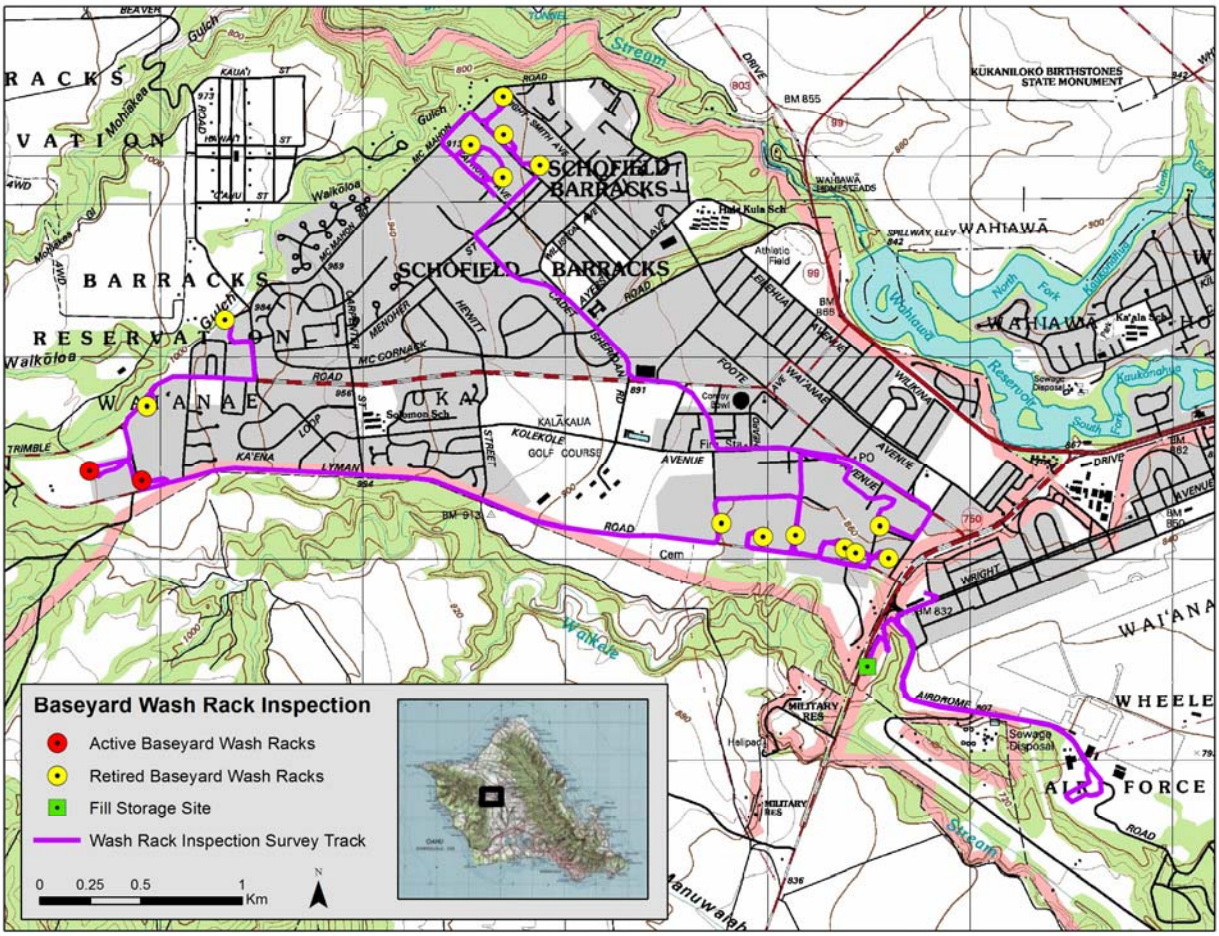
3.4 INVASIVE SPECIES SPREAD PREVENTION ON ARMY TRAINING RANGES

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.

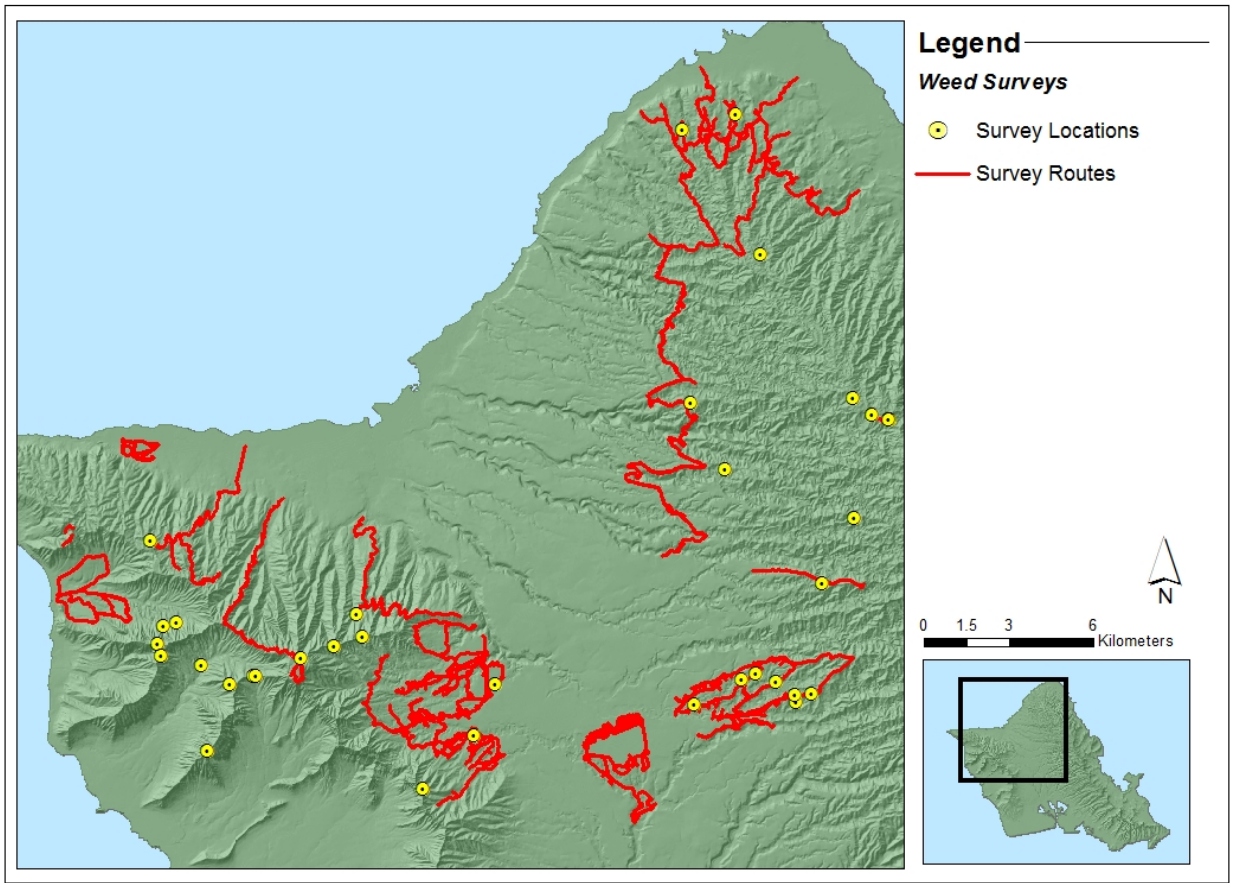
Access to roads throughout Schofield Barracks South Range has been difficult to schedule for the past 5 years, and only a partial survey was conducted the previous report year. OANRP gained access this year to all roads during a Range Maintenance week when no live-fire training was allowed. Continued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

Aerial Spray Equipment

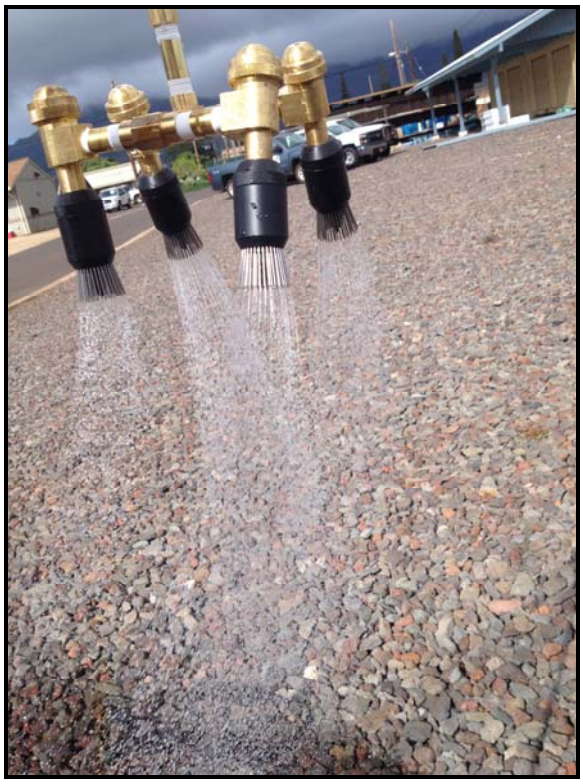
Aerial sprays are an efficient and effective way to control *C. odorata* in challenging terrain, over large areas. Over the past several years, staff worked with several different spray rigs and helicopter companies. Challenges with poorly maintained equipment, finicky parts, and occasionally poor spray 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.

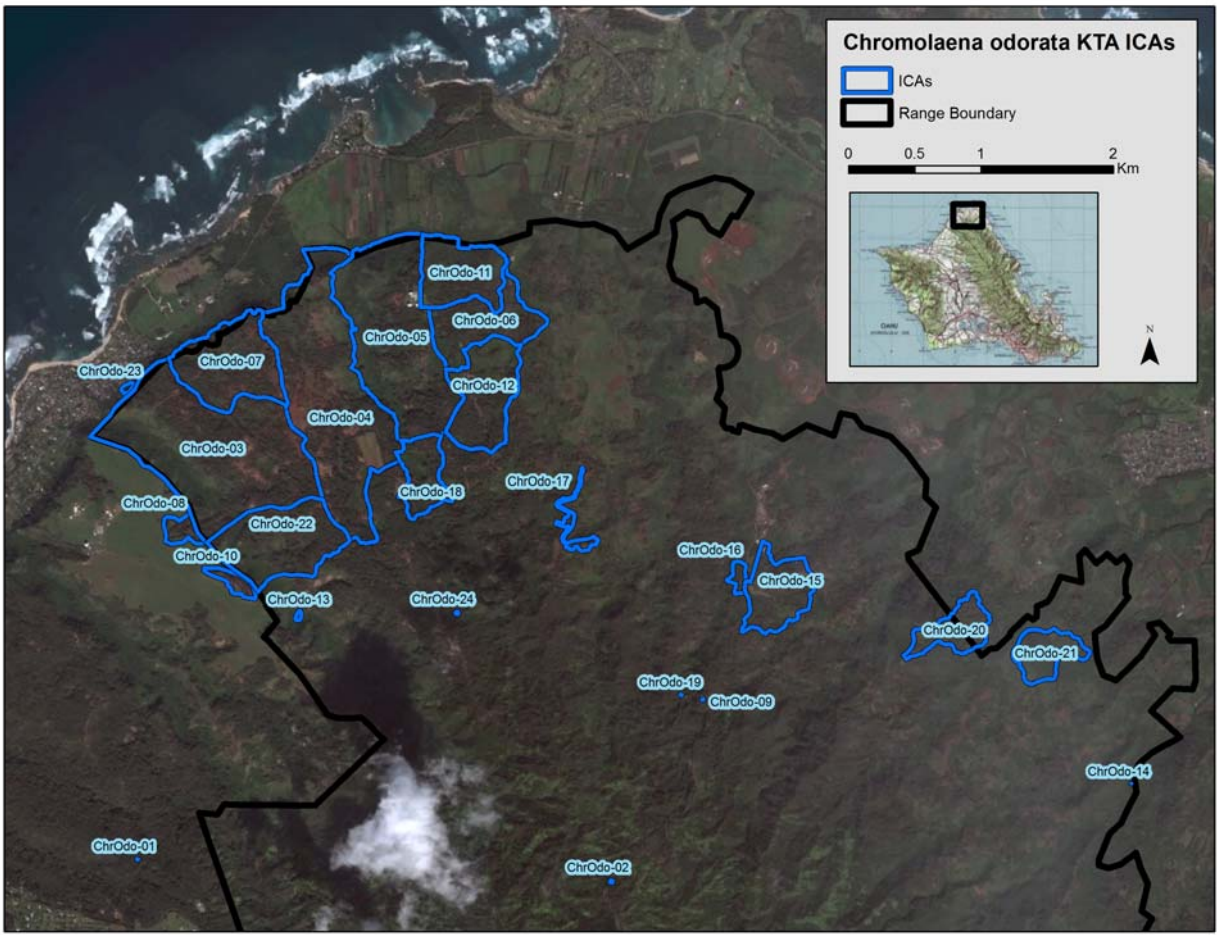
Below right: High quality Accu-Flo™ nozzles create large droplets, reducing potential drift.



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**

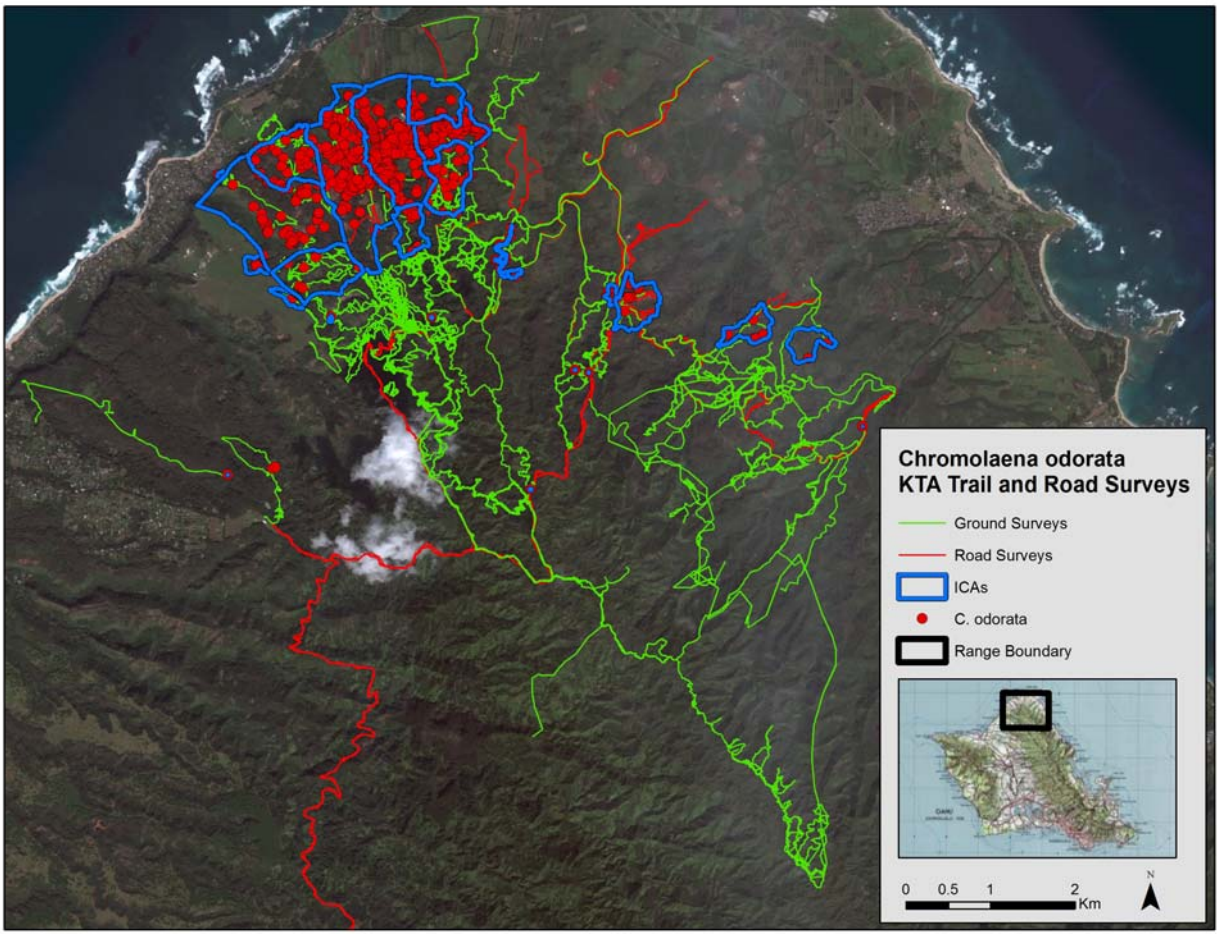


- Over the last few years, staff surveyed almost all of the trails (motocross, Army training, etc.) in KTA; see 'Trail and Road Surveys at KTA' map below. A systematic effort was made to check every loop and side-trail, no matter how convoluted. Since *C. odorata* is known to disperse easily along roads 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.

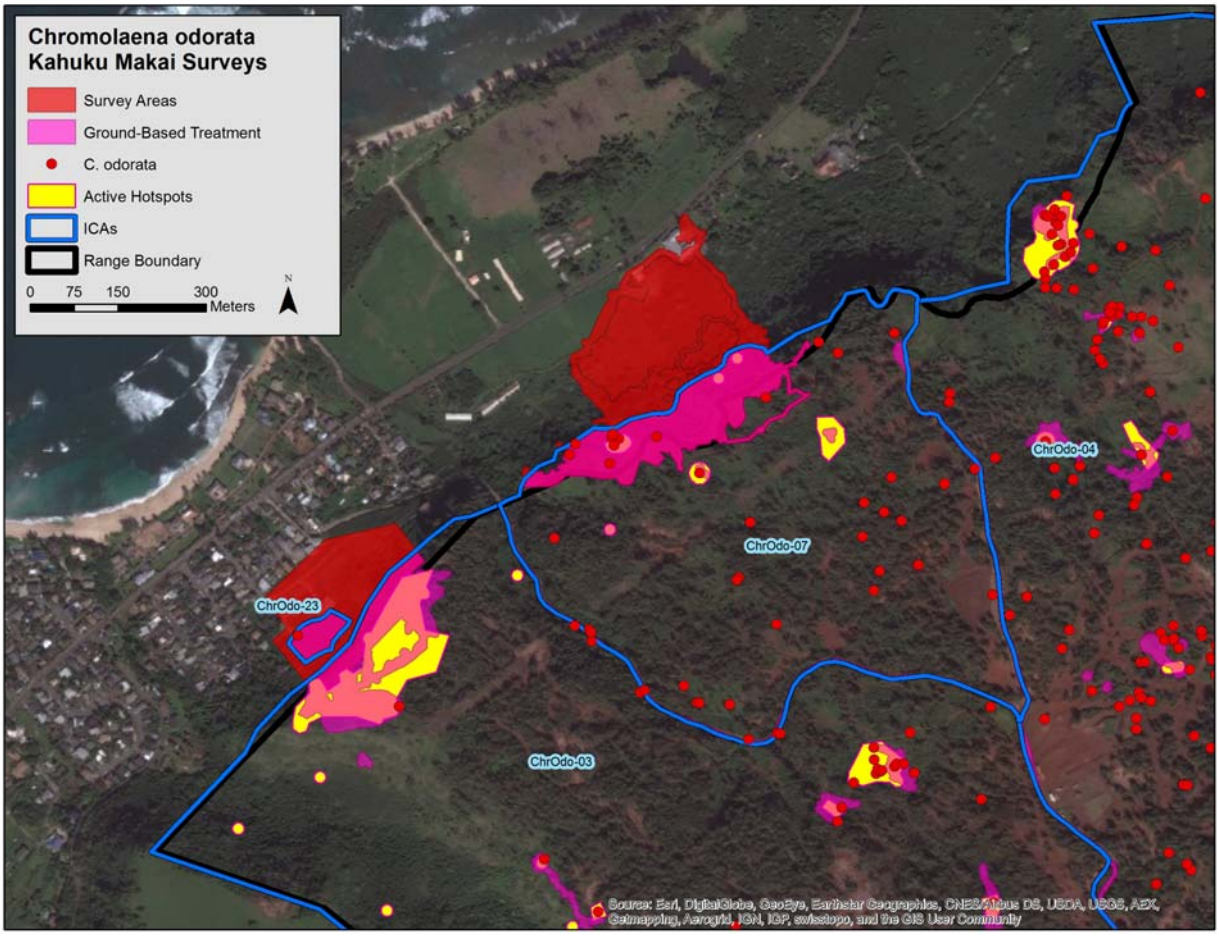
Trail and Road Surveys at KTA



- 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.

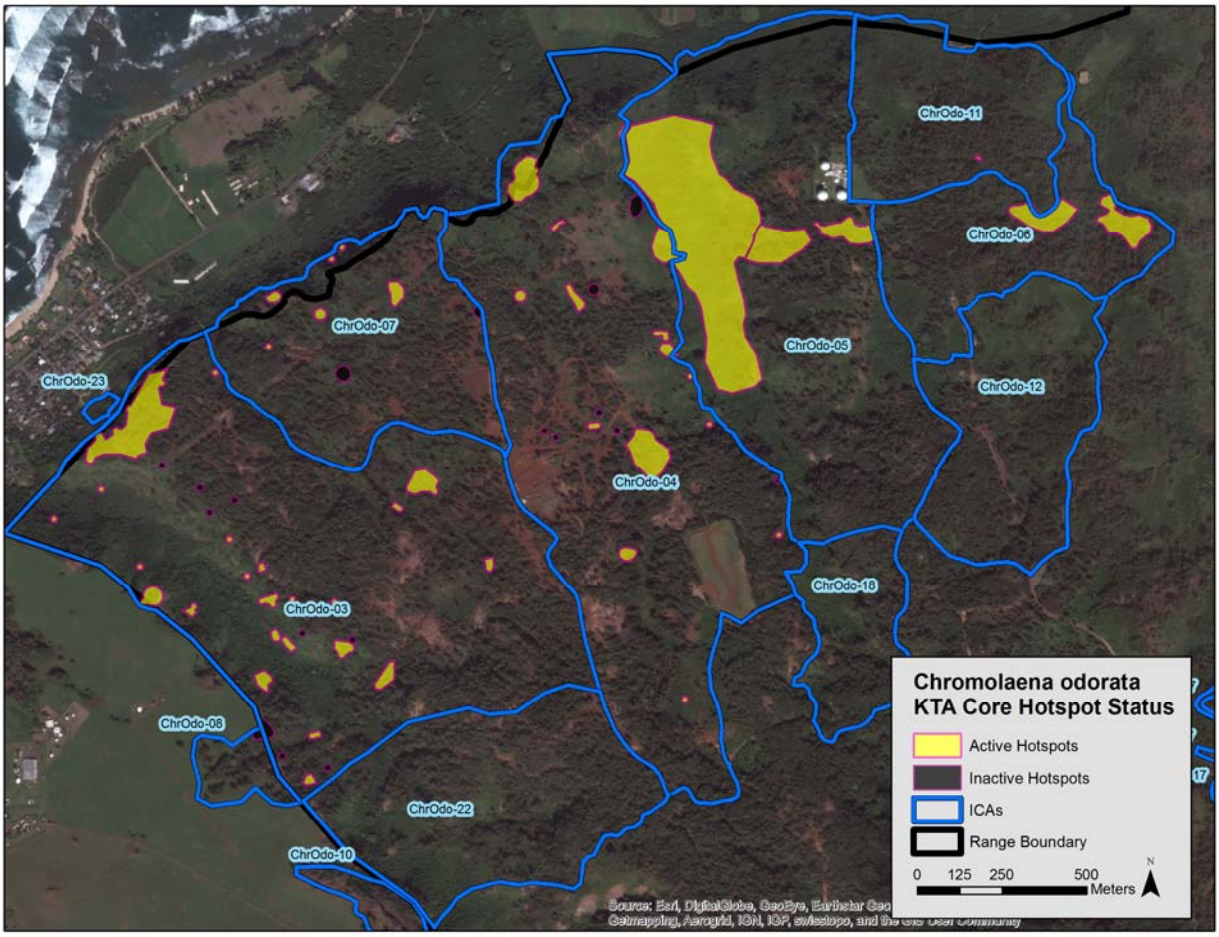
Makai Survey Areas at Kahuku



- 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

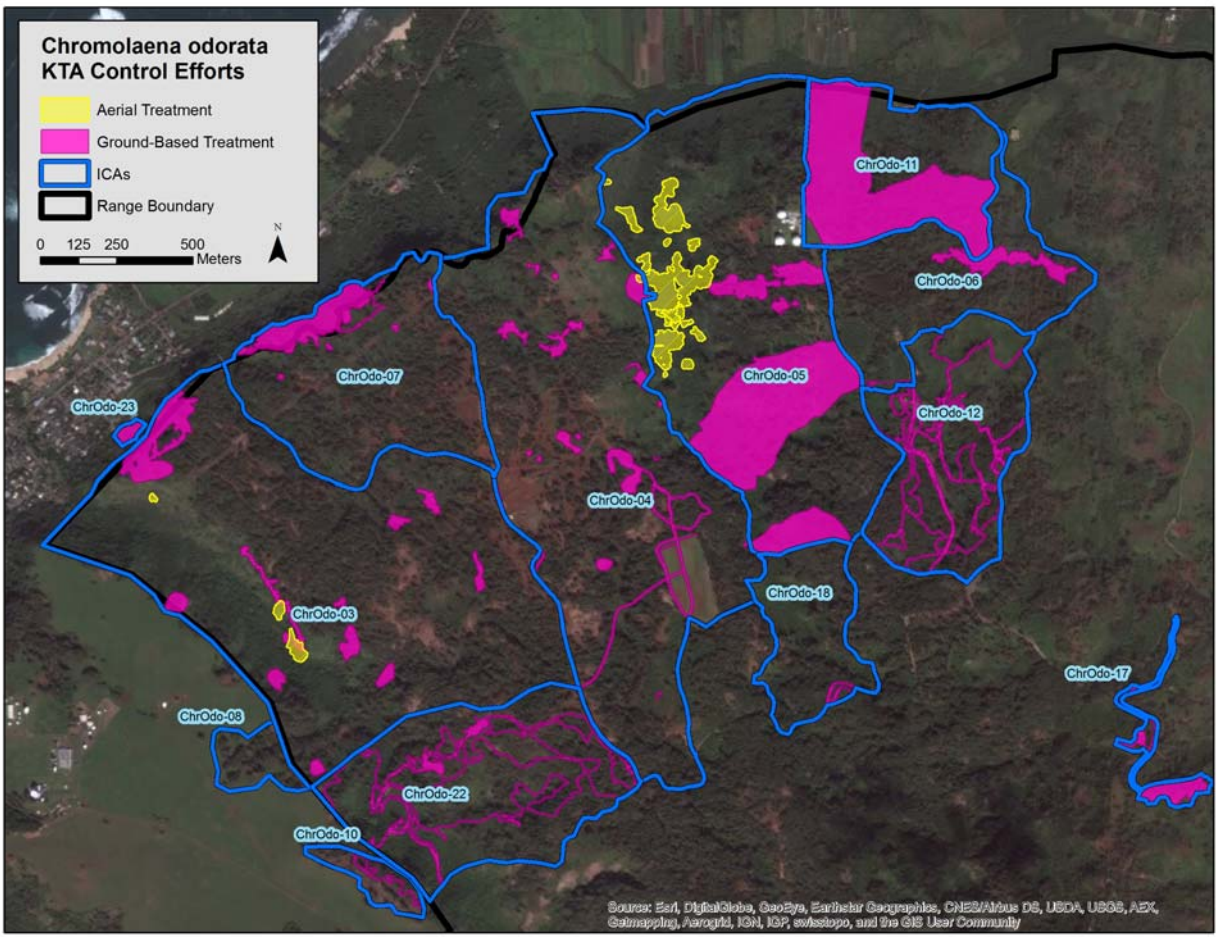
ICA Code	ICA Area (ha)	2016 Report Year			2015 Report Year			2016 # Plants Treated		Total # Plants Treated		Type and Strategy
		Area Weeded (ha)	Effort	# Visits	Area Weeded (ha)	Effort	# Visits	# Mat.	# Imm.	# Mat.	# Imm.	
KTA-ChrOdo-20	14.72	3.07	10.25	4	N/A	N/A	N/A	3	64	3	64	Trails + Roads + Hotspots
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.

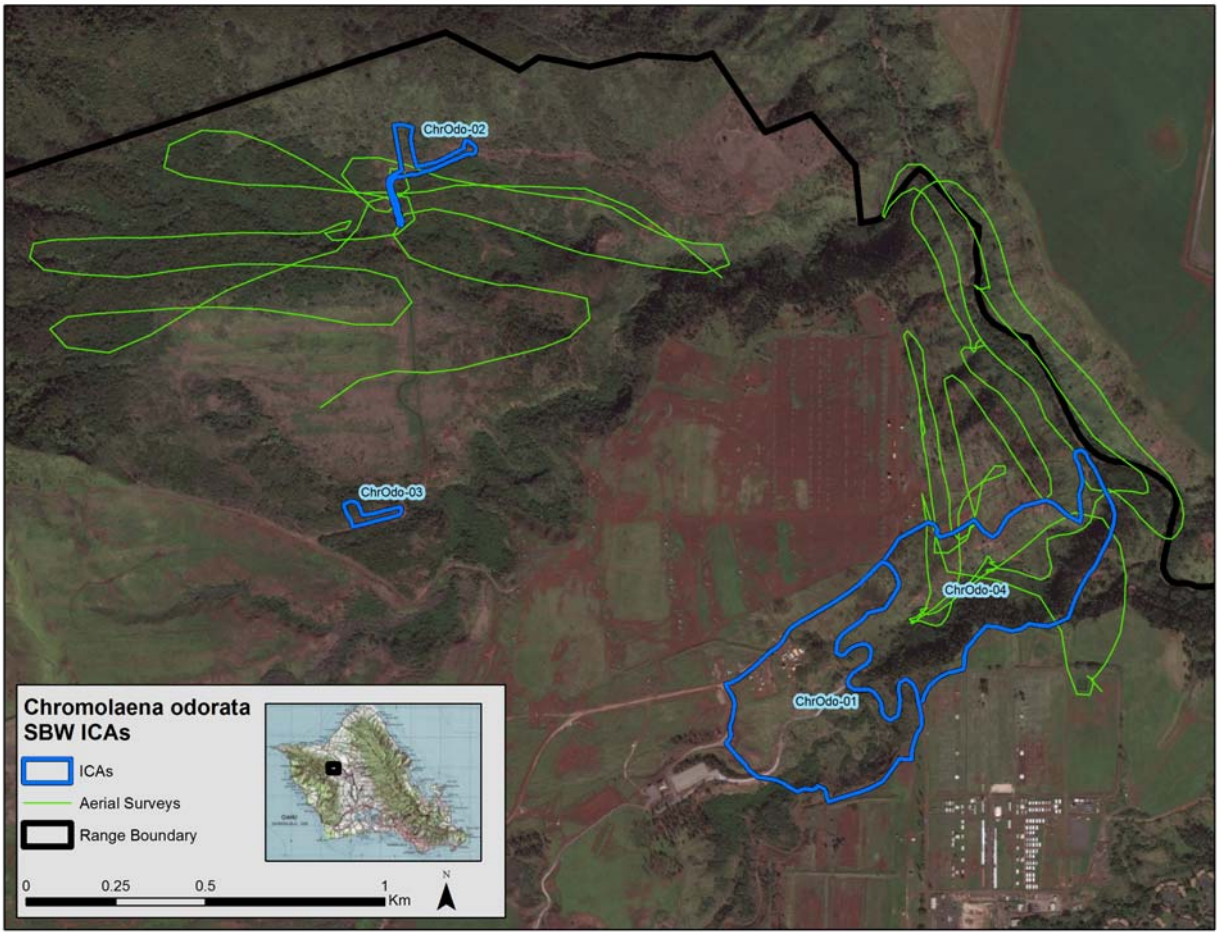
SBW Update

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

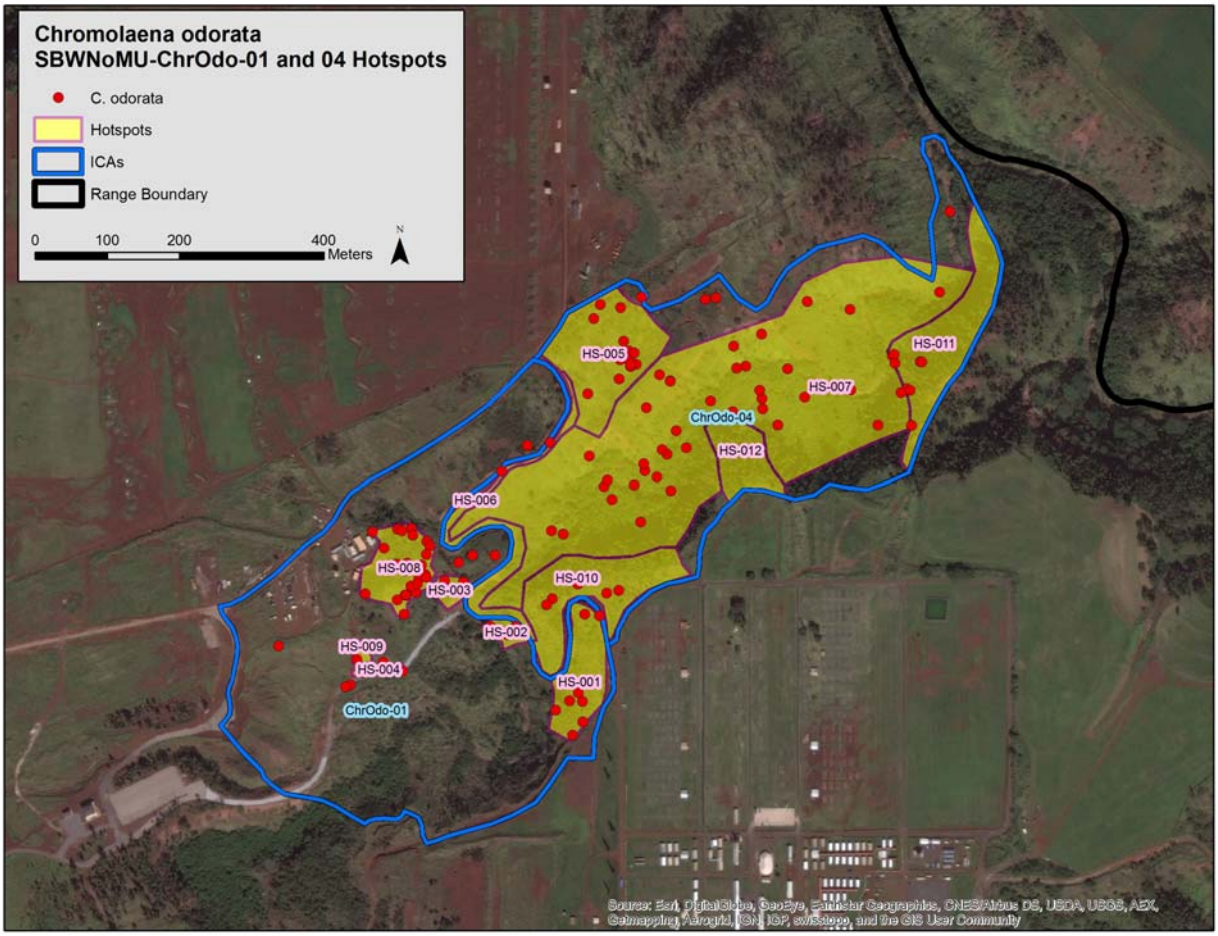
C. odorata Incipient Control Locations and Aerial Surveys at SBW



- 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

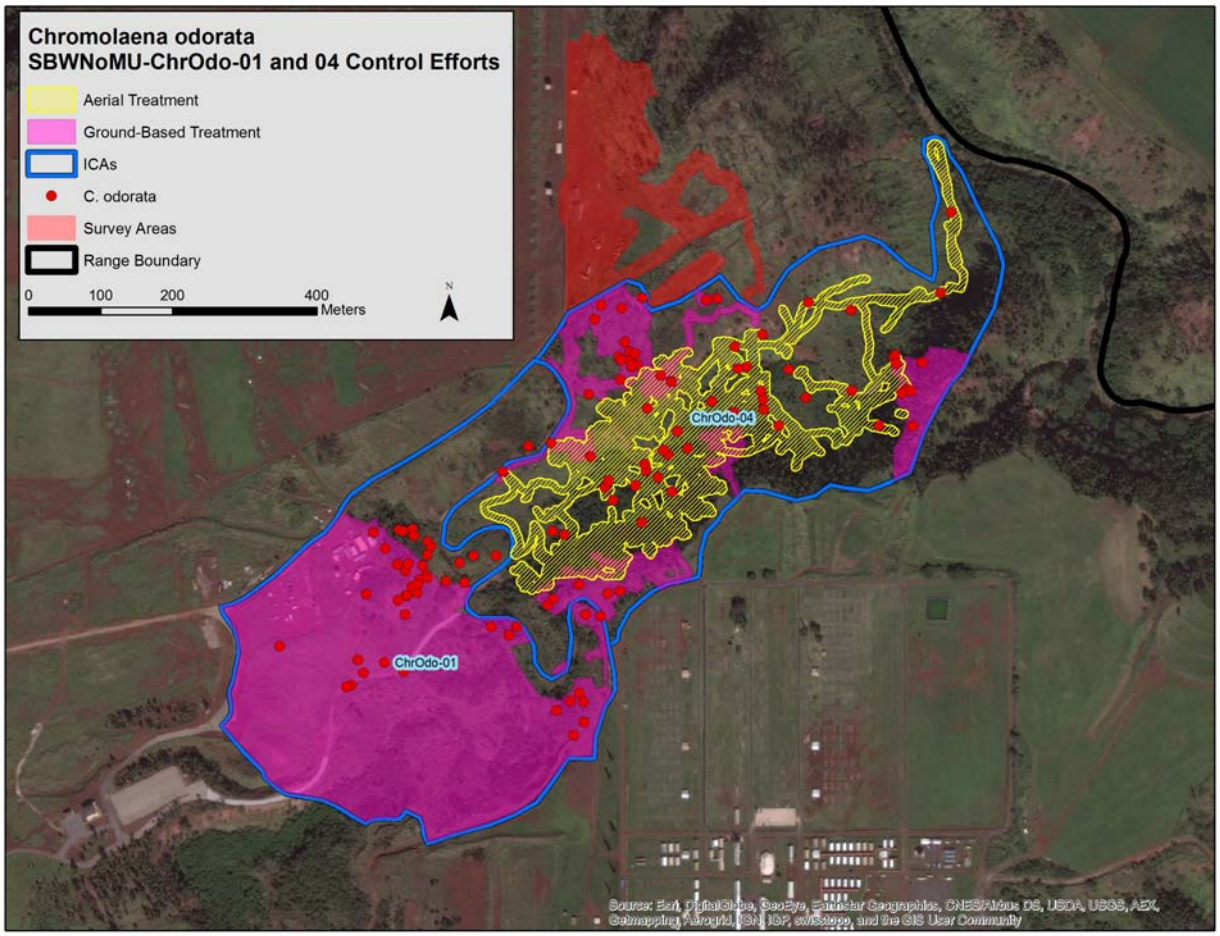


- ICA #2 is a discrete, outlier infestation. This site continues to have a small but persistent population, with 3 mature, 17 immature, and 8 seedling plants controlled this year. A total of 15 mature, 39 immature, and 11 seedlings have been removed since initial discovery in 2014. This suggests a seed 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.

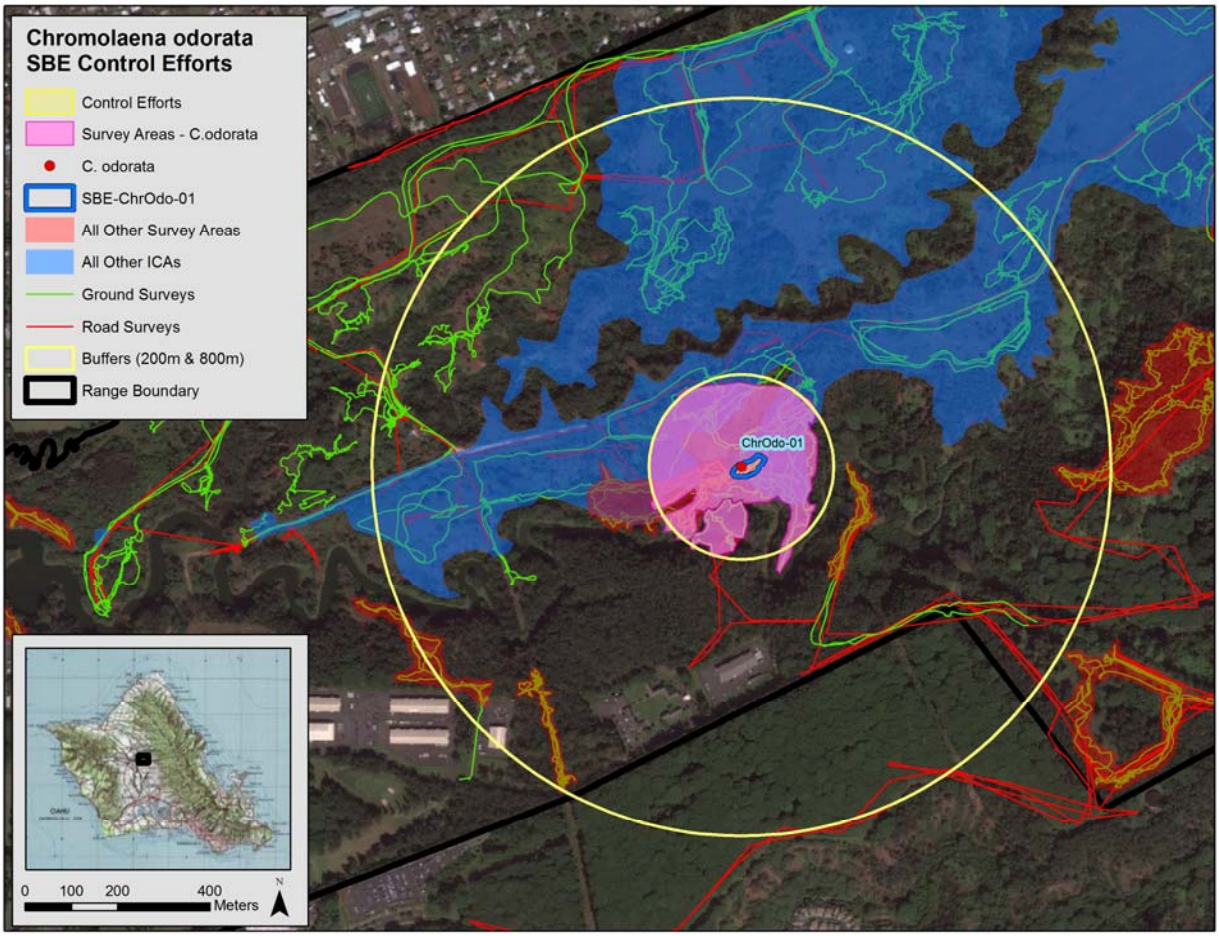
SBE Update

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.

References Cited

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

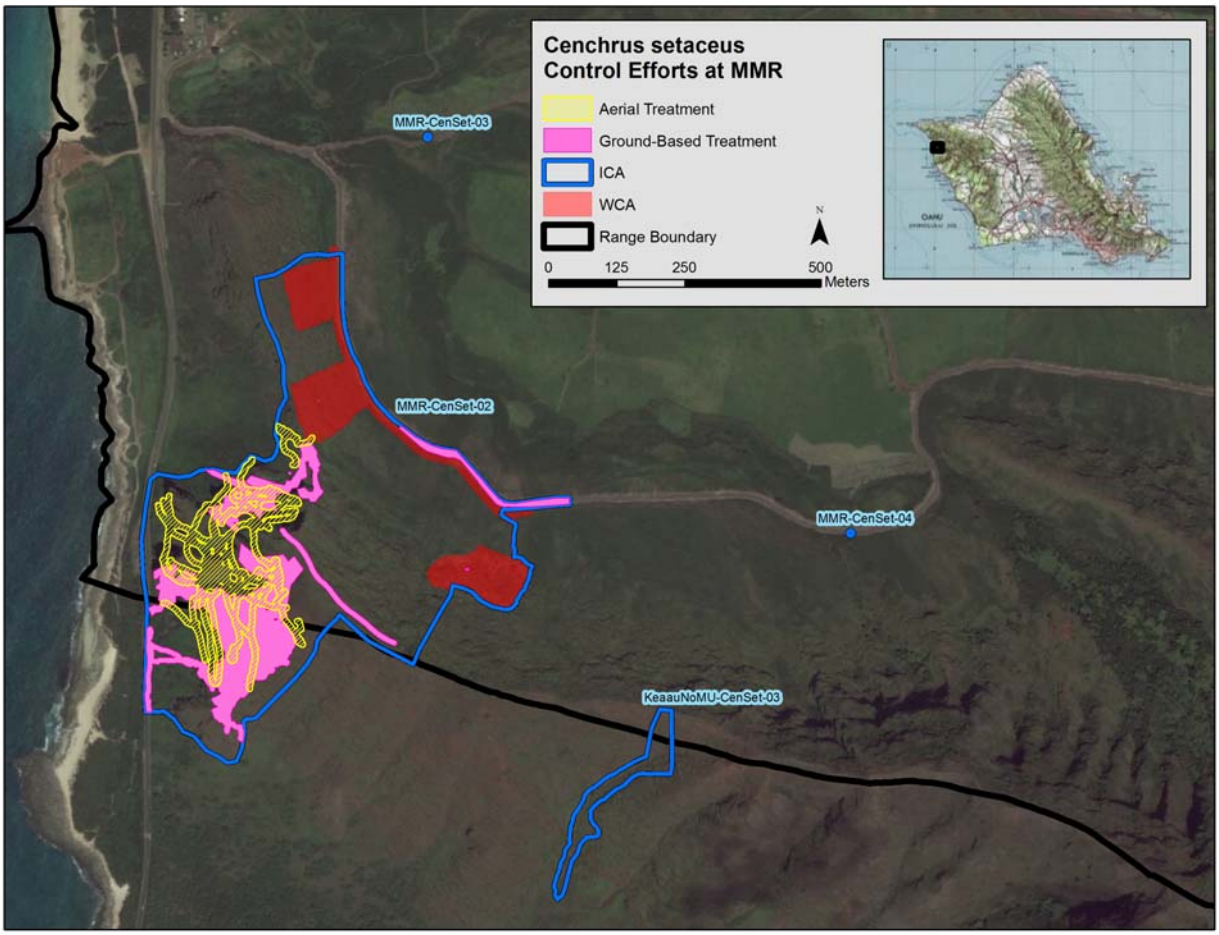
ICA	ICA Total Area (ha)	Area Weeded (ha)	Effort (hours)	# Visits	Comments
KTA-CenSet-02	0.1 (960**m²**)	0.1 (960**m²**)	4	2	Last plants were seen in 2013. This is a small site, with only small numbers found following initial discovery and control of 16 matures and 63 immatures. If no additional plants 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

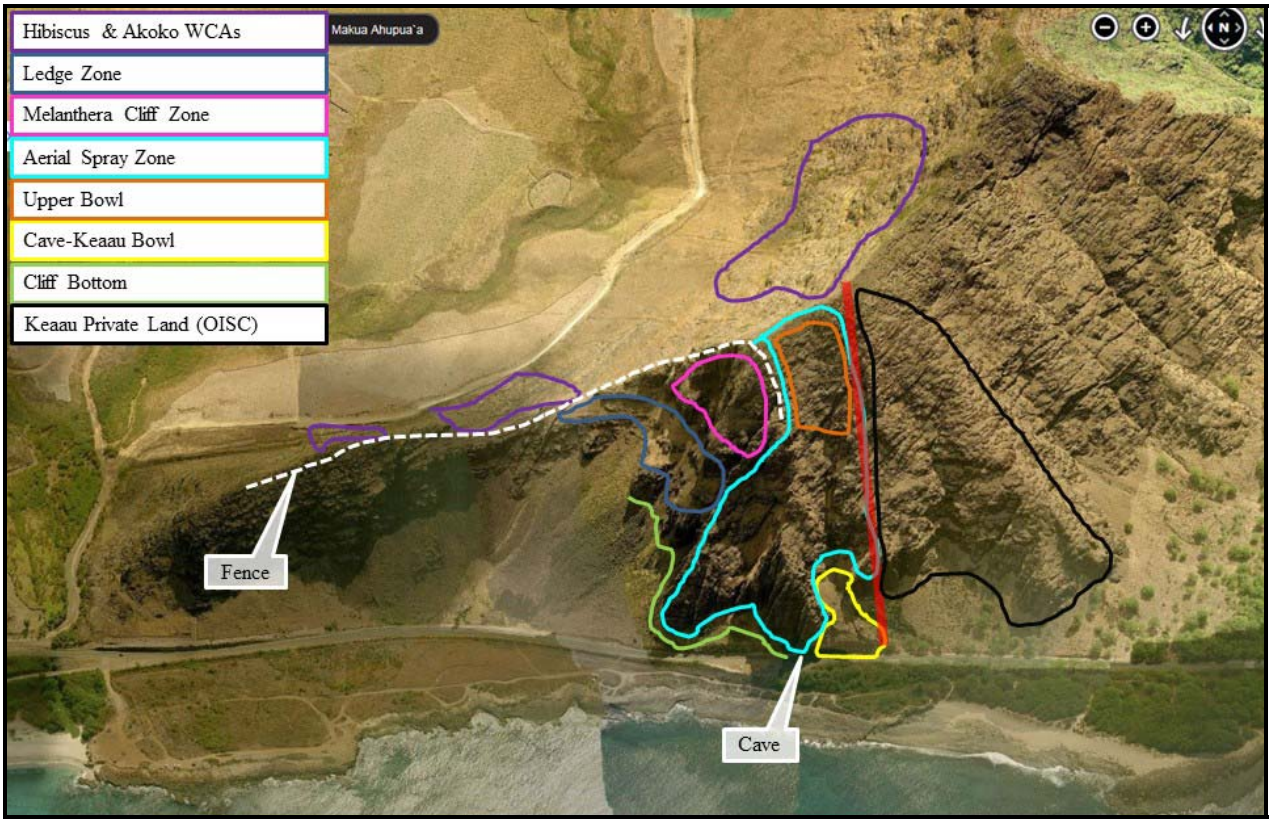


- Unfortunately, two new outlier sites were discovered, ICAs #3 and 4, see map above. Both are located in areas along roads which are regularly mowed and sprayed to reduce fire risk. While discouraging, it is unsurprising that *C. setaceus* is taking advantage of open, disturbed areas. Staff have seen 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:
    - 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



    - 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.
    - 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.

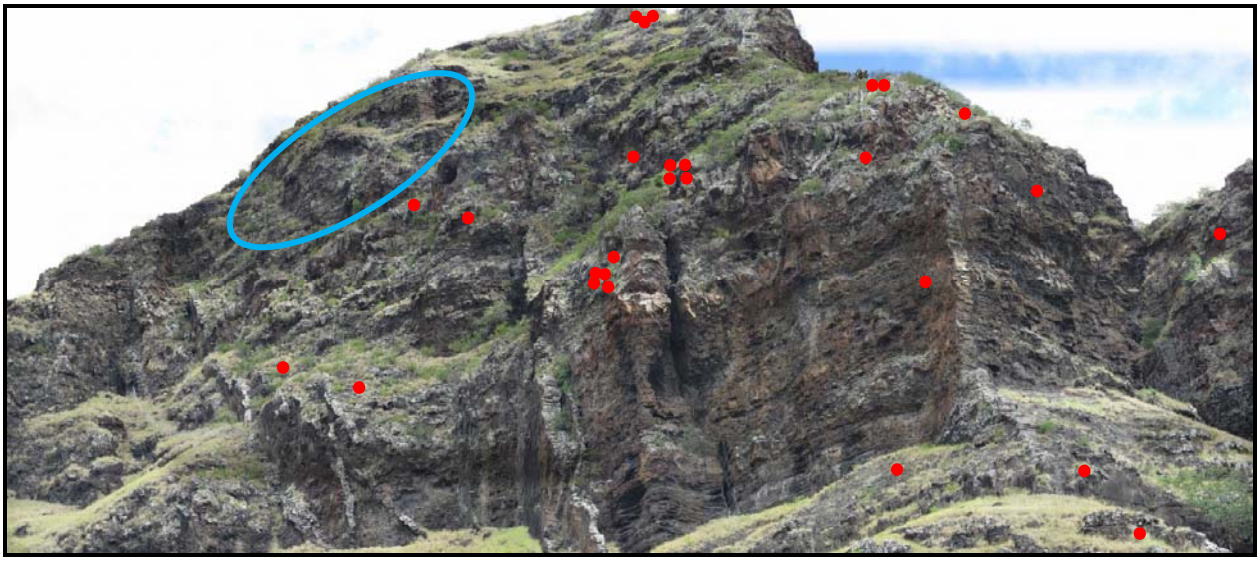
Taking a Gigapan of the *C. setaceus* infestation. The Gigapan unit must be close enough to the target area to zoom in and positively identify *C. setaceus*, but also far enough away to provide a landscape view.

- 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.

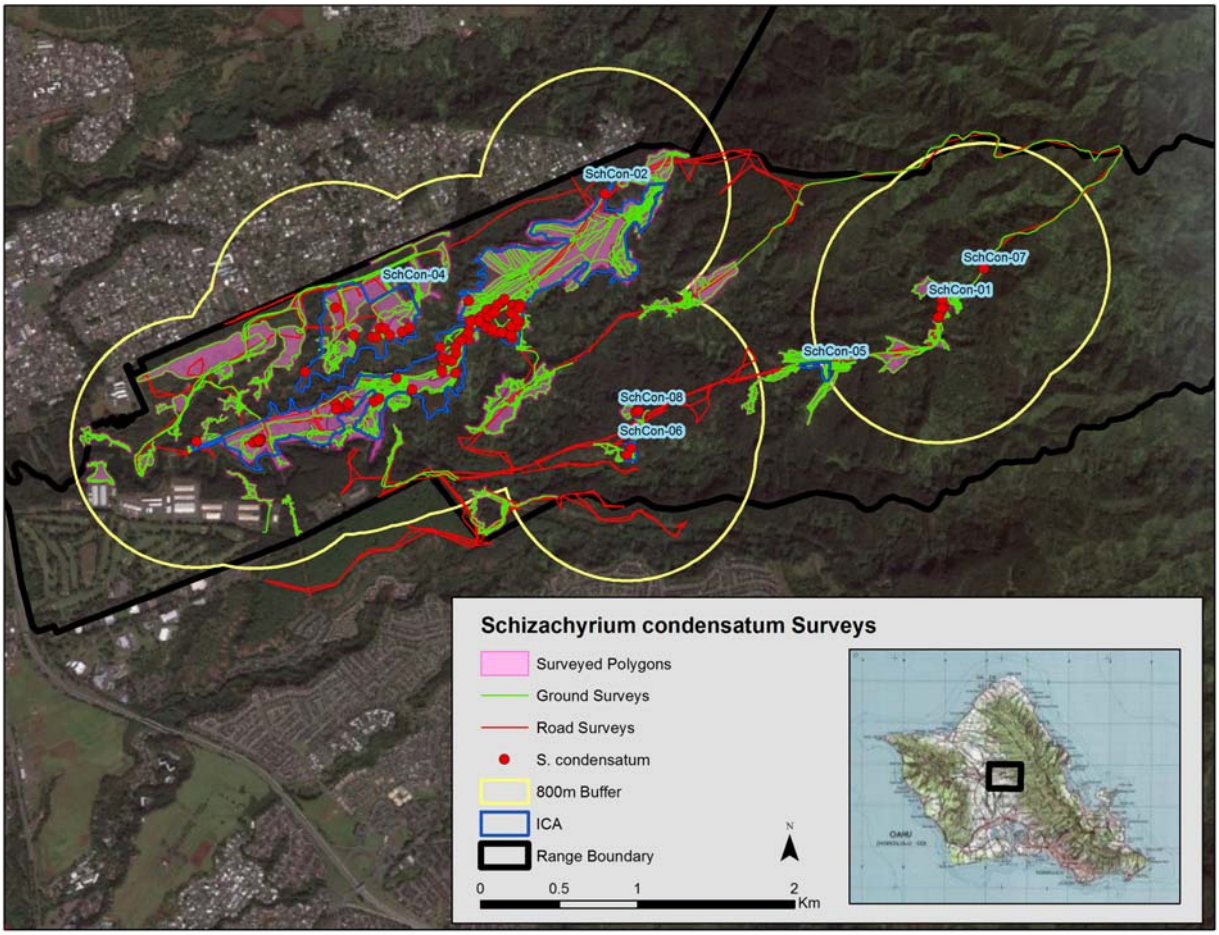
3.8 INVASIVE SPECIES UPDATE: *SCHIZACHYRIUM CONDENSATUM*, BUSH BEARDGRASS

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.

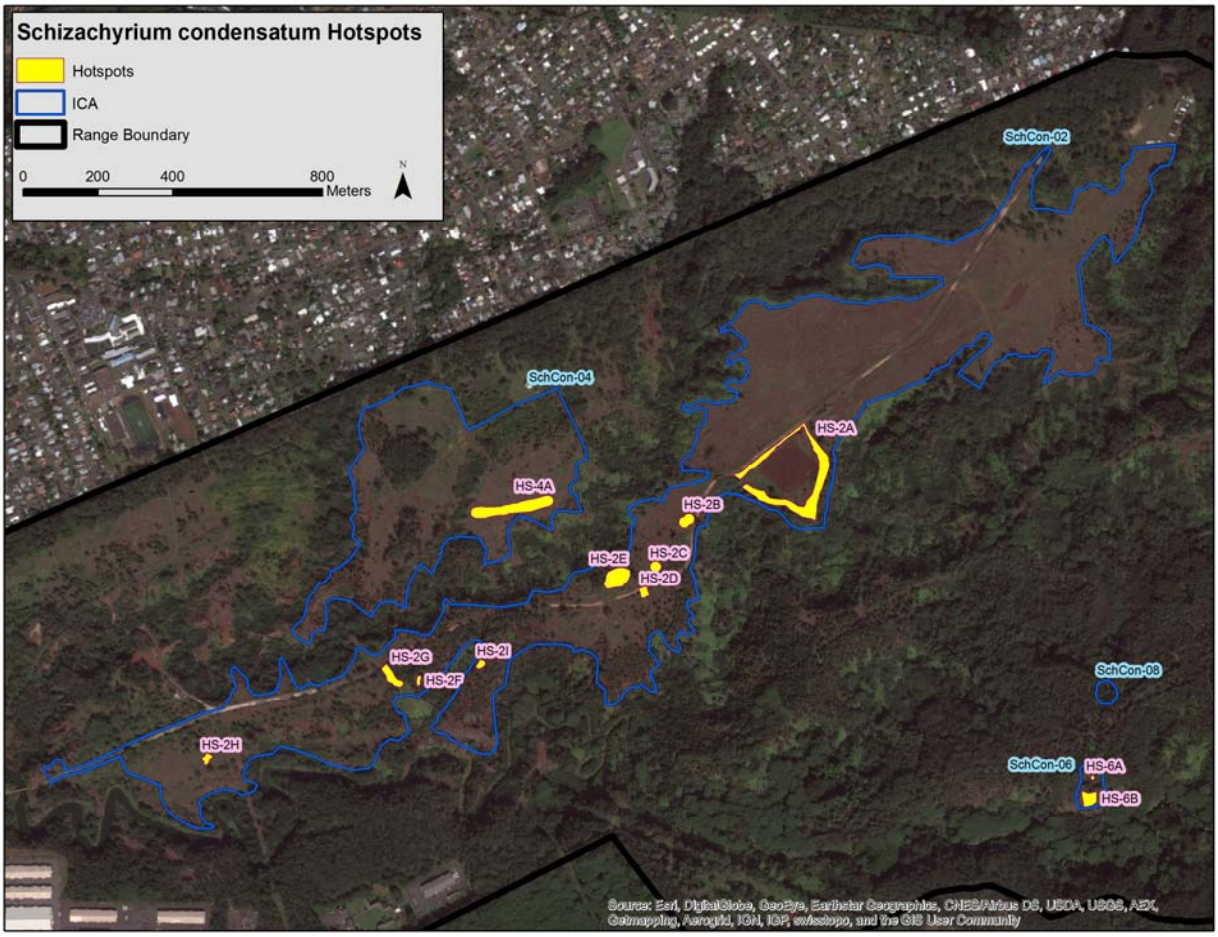
S. condensatum Surveys and Incipient Control Areas at SBE



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 (78**m²**)	0.01 (78**m²**)	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

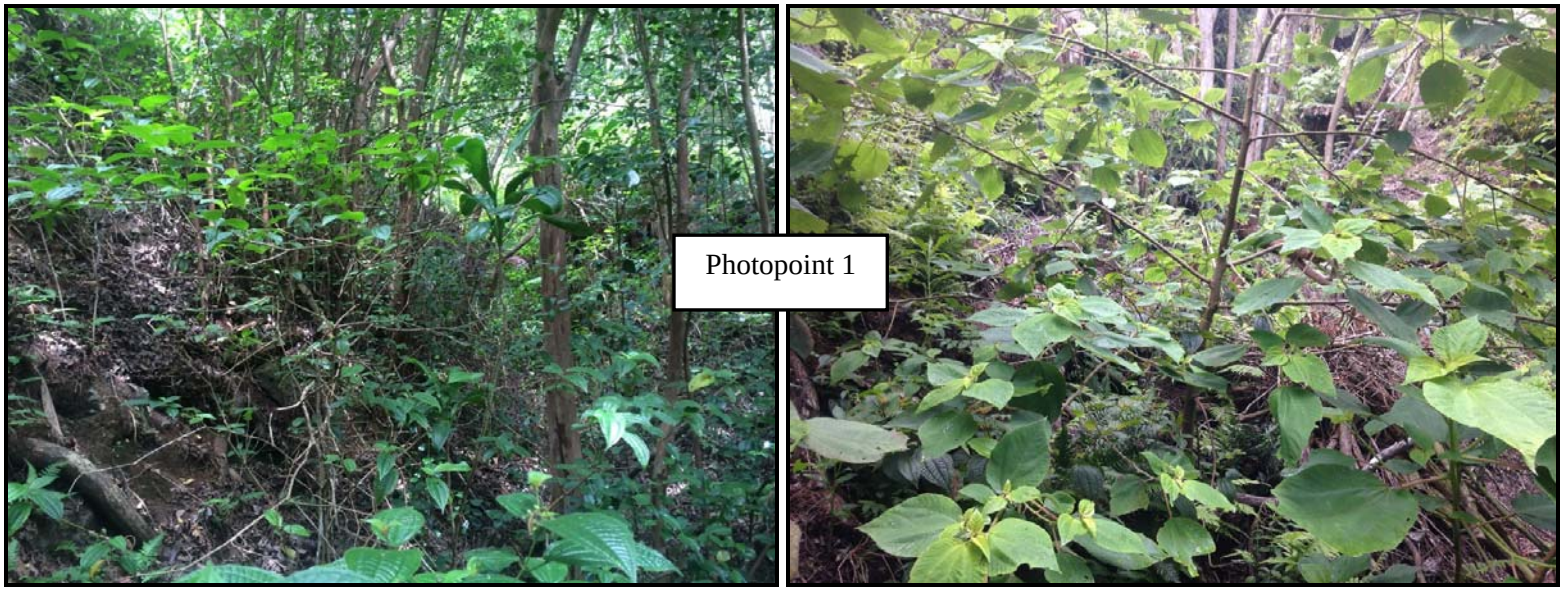
MU	WCA code	Restoration Action	# of plants	Area (m2)	Taxa	Comments
Kaala	Kaala-01	Outplanting	35	86	*Kadua centranthoides*	*K. centranthoides* was planted on the Army side of the boardwalk in an open area where *Juncus effusus* removal is ongoing. This location is particularly wet (isolated patches of 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>

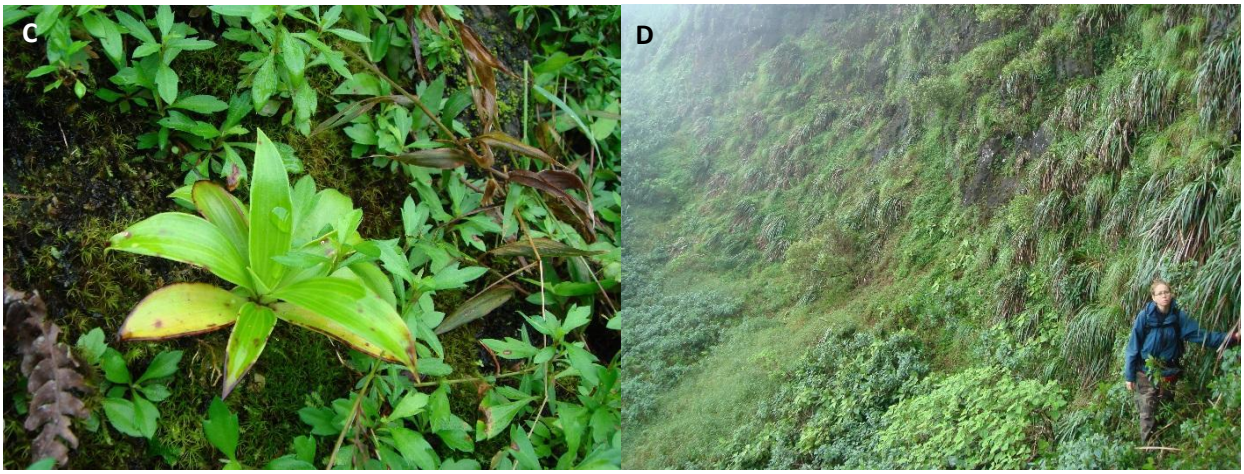


Figure 10: A) Nuuanu (NUU-B), B) Konahuanui (NUU-A) mature plants with ripe infructescences, C) immature plant at Konahuanui, D) habitat at Konahuanui.

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

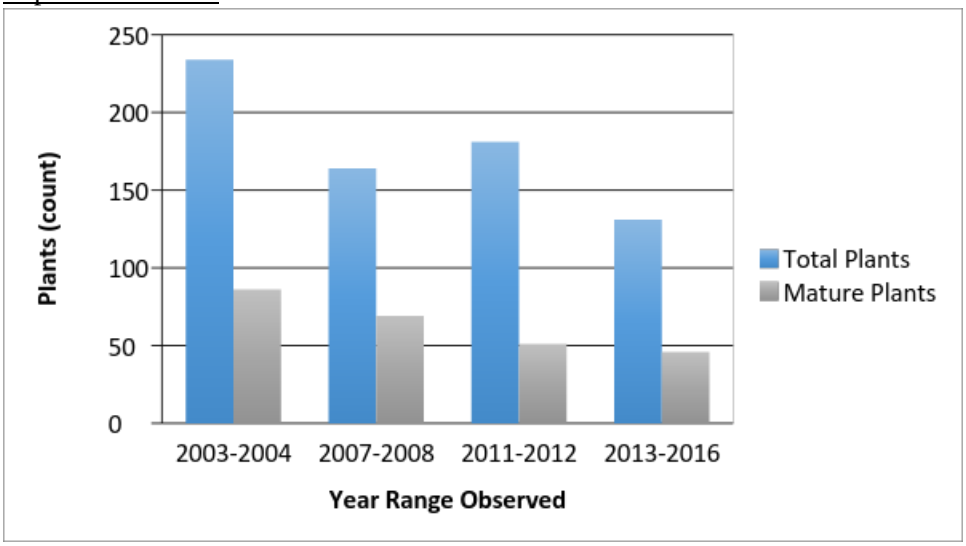


Figure 11: A) Overall counts of total plants and mature plants only for all monitored Waianae Mountain Population Units, excluding reintroductions.

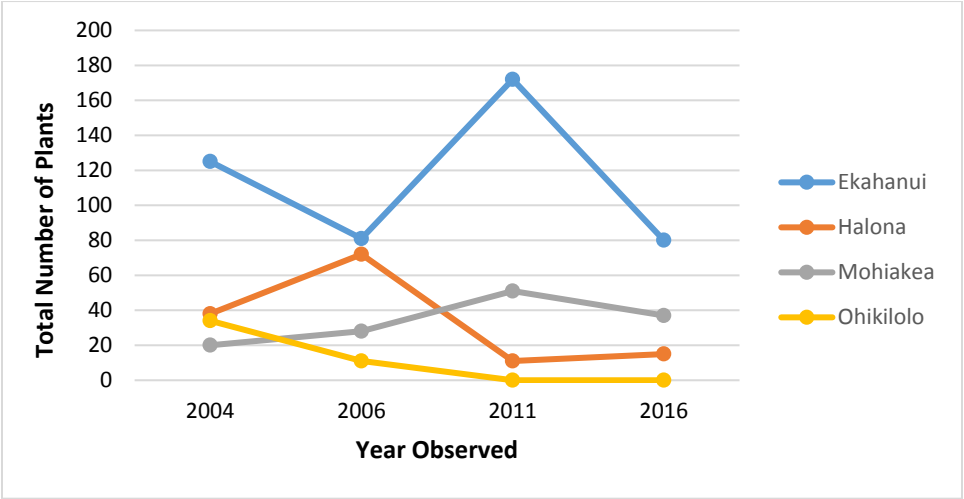


Figure 11: B) Counts for the total number of plants at the four current MFS PU (Waianae Mountains; excluding reintroductions).

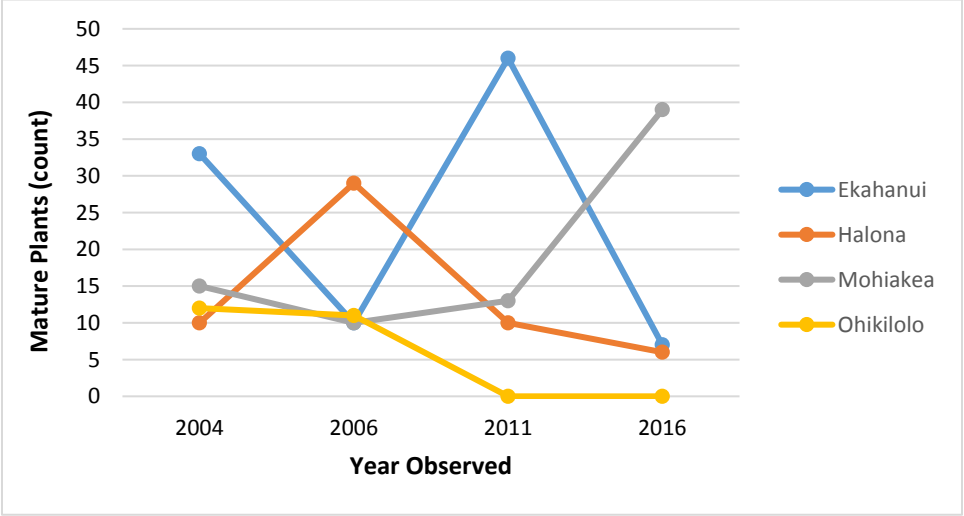


Figure 11: C) Counts of mature plants for the current four MFS PU (Waianae Mountains; excluding reintroductions).

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.

STABILIZATION EFFORTS

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.

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

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

<u>References:</u>

Dunbar-Co, S., A.M. Wieczorek, C.W. Morden. 2008. Molecular Phylogeny and Adaptive Radiation of the Endemic Hawaiian *Plantago* Species (Plantaginaceae). American Journal of Botany 95(10): 1177-1188.

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Wagner, W.L., D.R. Herbst, S.H. Sohmer. 1990. Manual of the Flowering Plants of Hawaii. University of Hawaii Press, Bishop Museum Press: Bishop Museum Special Publication 83. Honolulu.

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).

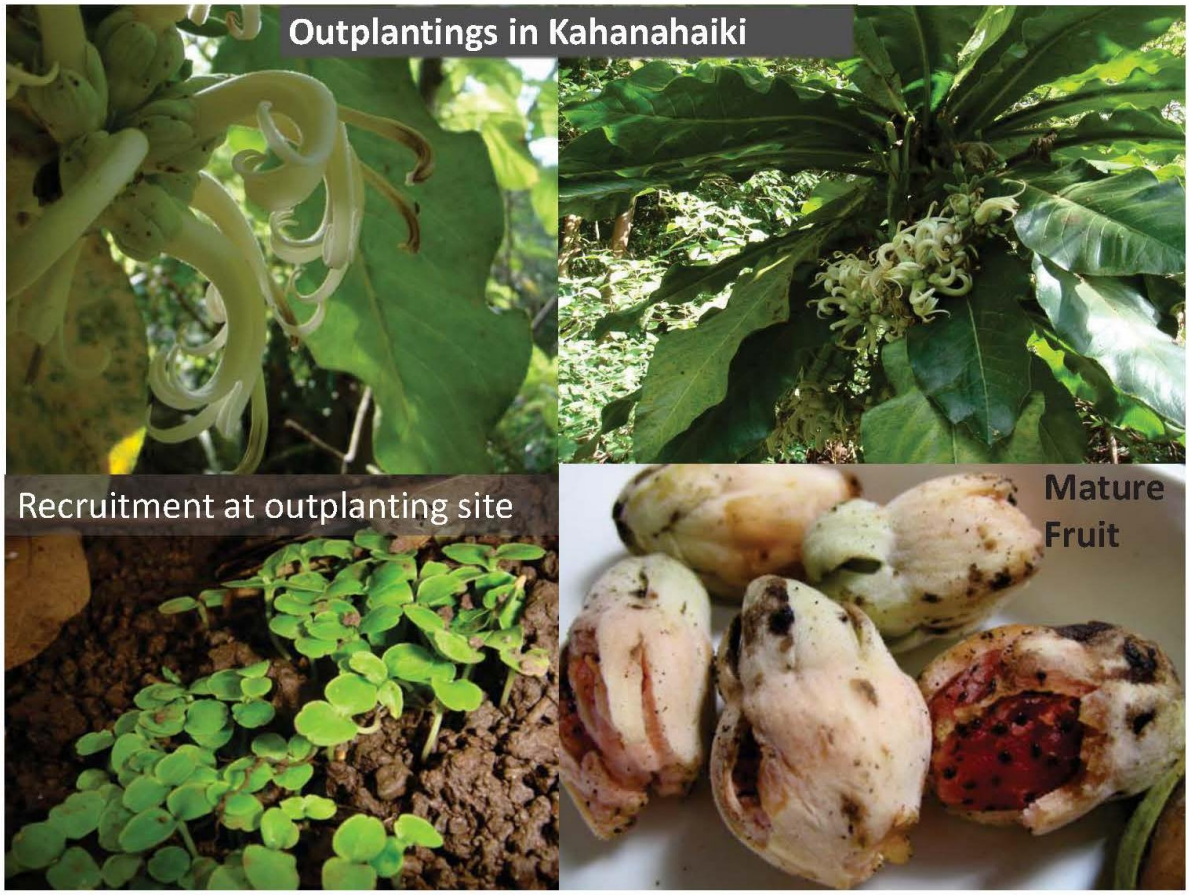
modified from: Makua Implementation Team (MIT). 2003.

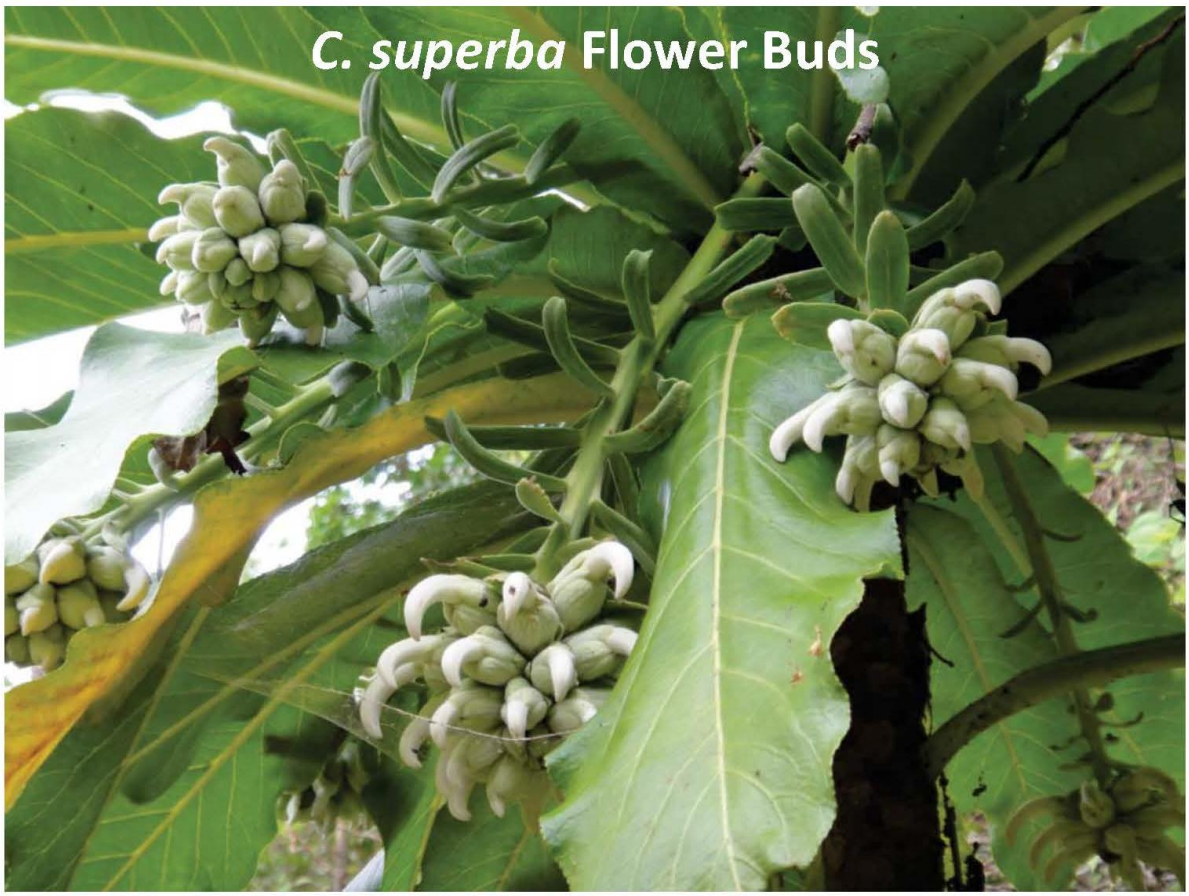
Reproductive Biology Table

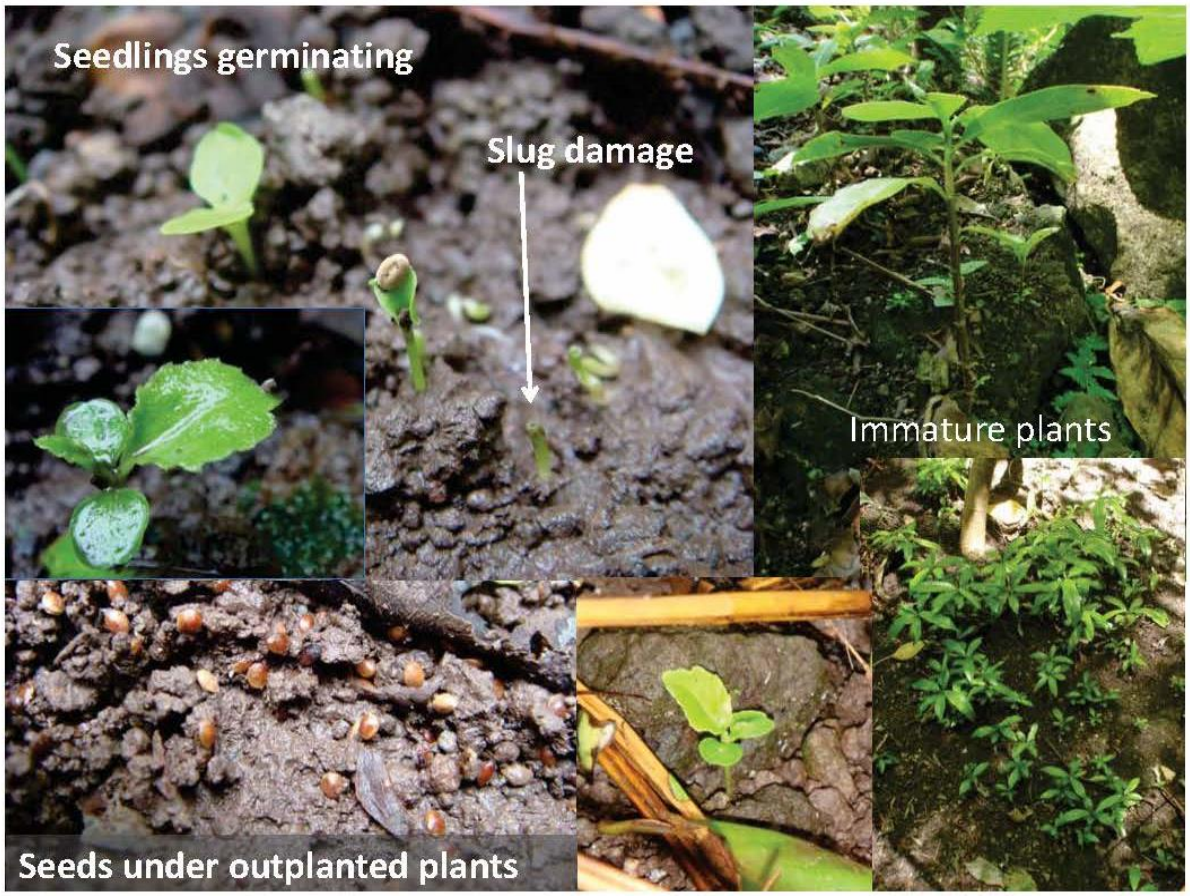
	Observed Phenology			Reproductive Biology		Seeds	
Population Unit	Flower	Immature Fruit	Mature Fruit	Breeding System	Suspected Pollinator	Average # Per Fruit	Dormancy
ALL	Sept-Oct	Oct-Jan	Oct-Jan	Hermaph-roditic	Bird*	112 ± 80	Not Dormant

*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.**

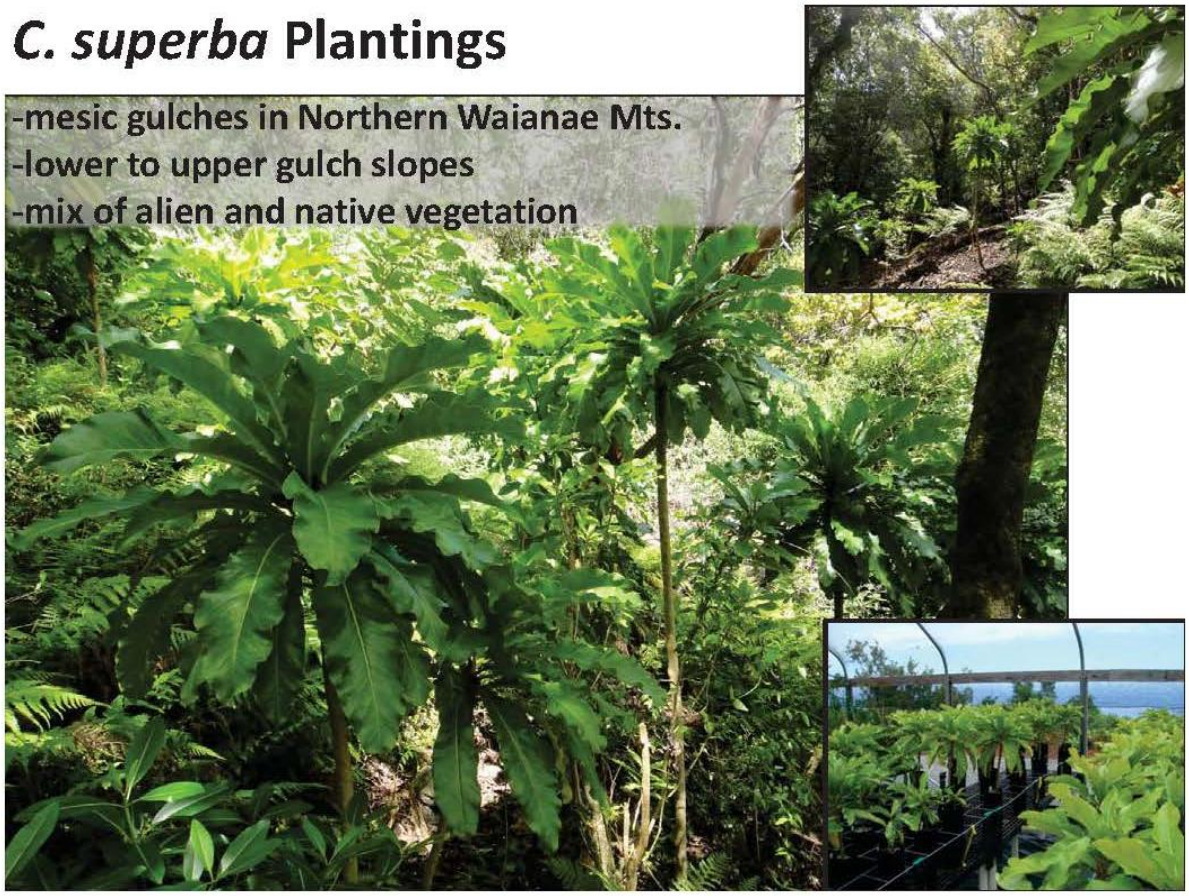
Selected Historic Collections of *C. superba* subsp. *superba*

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

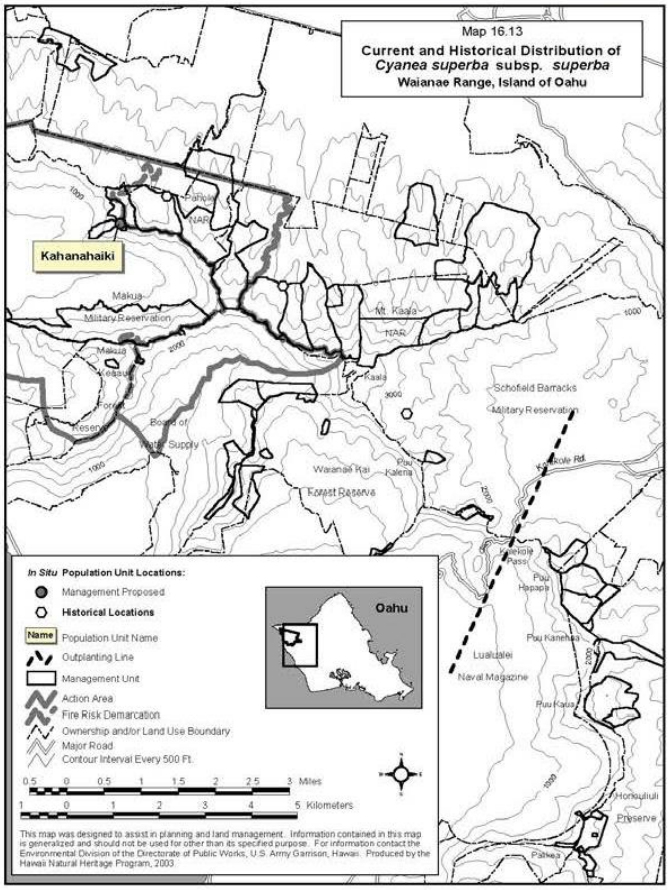


Outplanting considerations:

"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

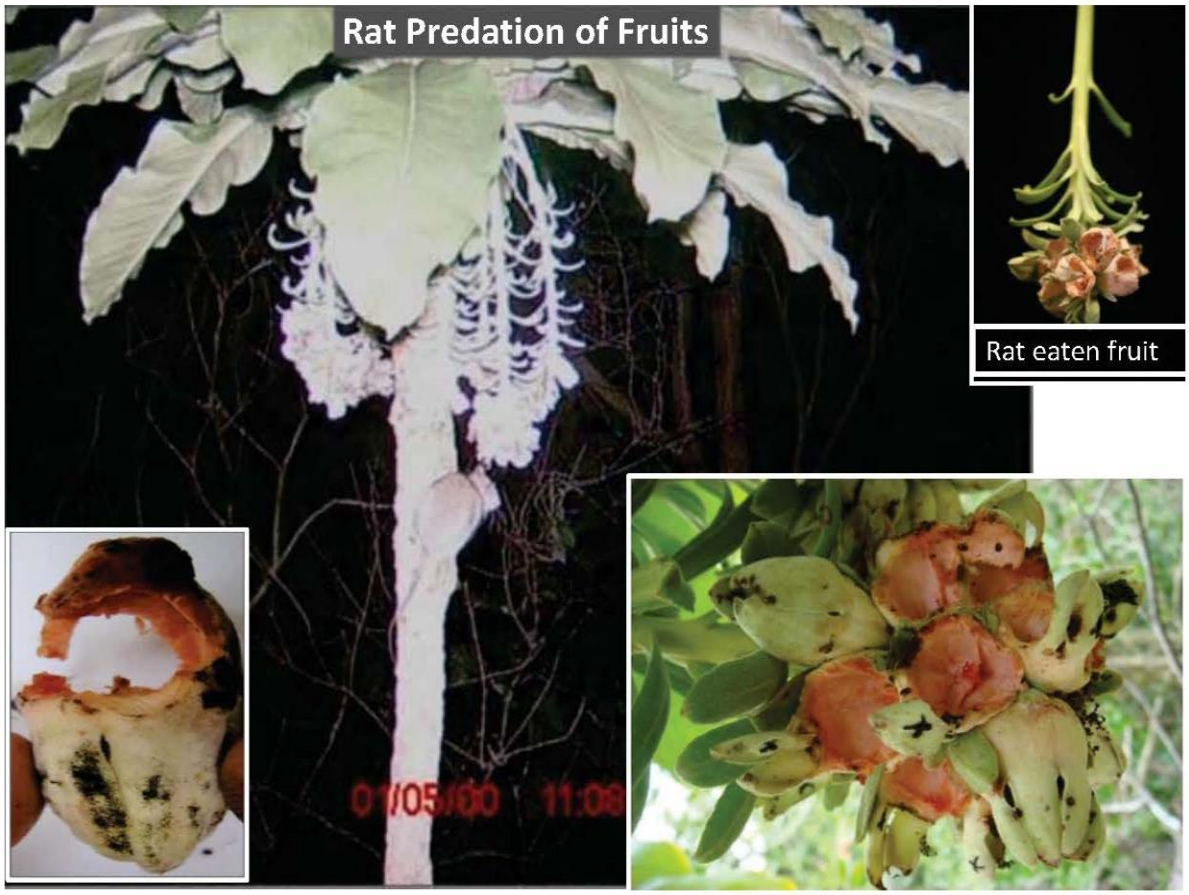
THREATS

- 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.

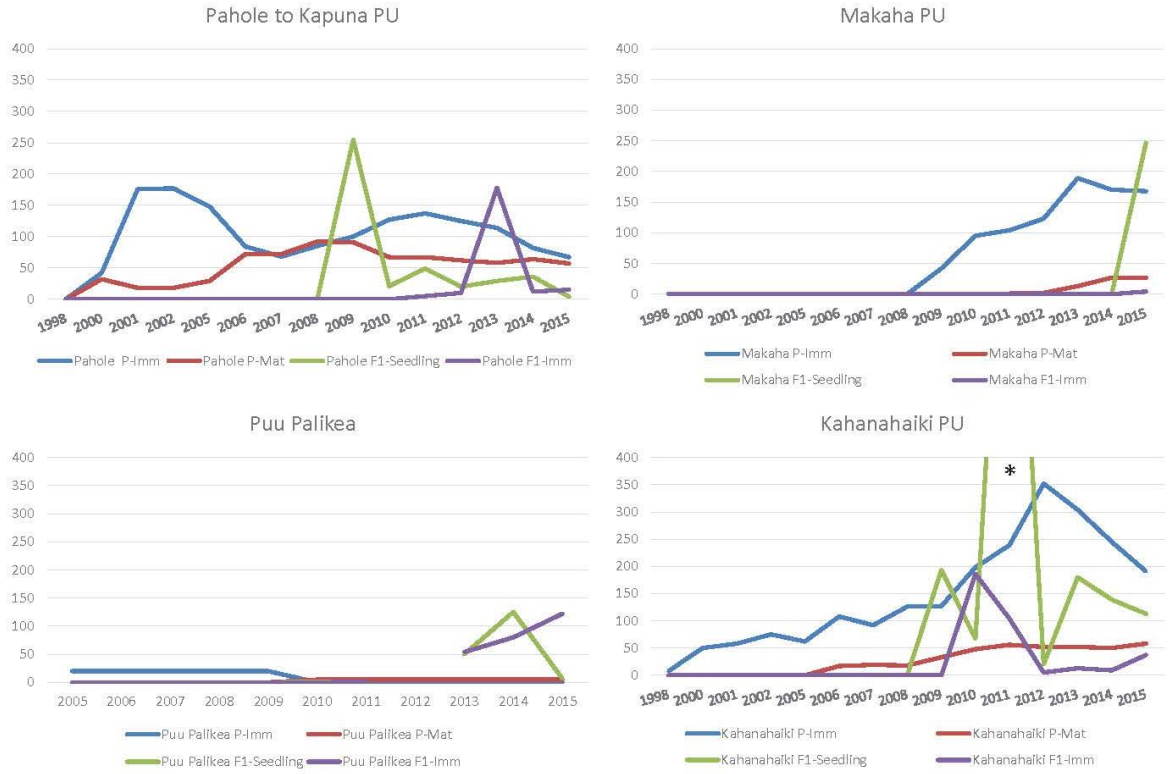
Genetic Storage Plan Comments:

- 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

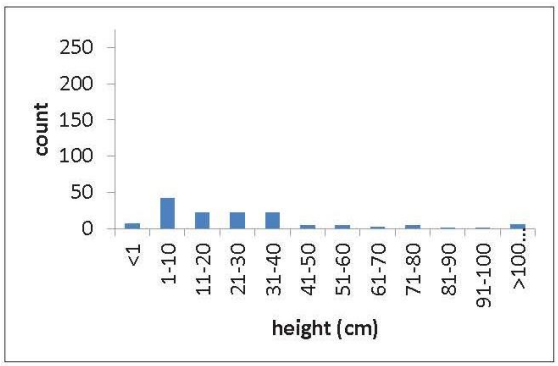
Counts of F1 plants in relation to numbers of outplants*

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

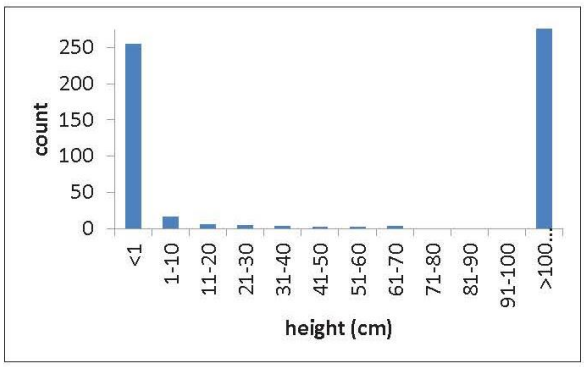
*Outplant data sourced from 2014 monitoring, as not all population reference sites were monitored in 2015. Anecdotally, seedlings at Makaha are now predominantly >1cm.

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

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

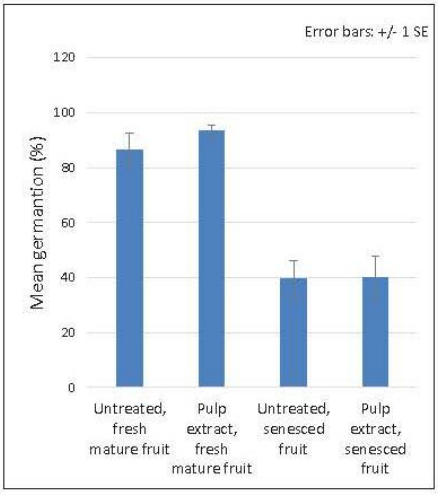
- As stated in the MIP, and with additional information gathered on this taxon and other species of *Cyanea*, inbreeding depression is a concern in this species due to:
  - Presumed bird-pollinated outcrossing species with no observations of pollination (except insect floral visitation); suggests high 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).

Germination Trial

- 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.

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

Size Class Definitions

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

*=Total Snails were Trans Located or Reintroduced

= Threat to Taxon at Population Reference Site

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

Yes=Threat is being controlled at PopRefSite

No=Threat is not being controlled at PopRefSite

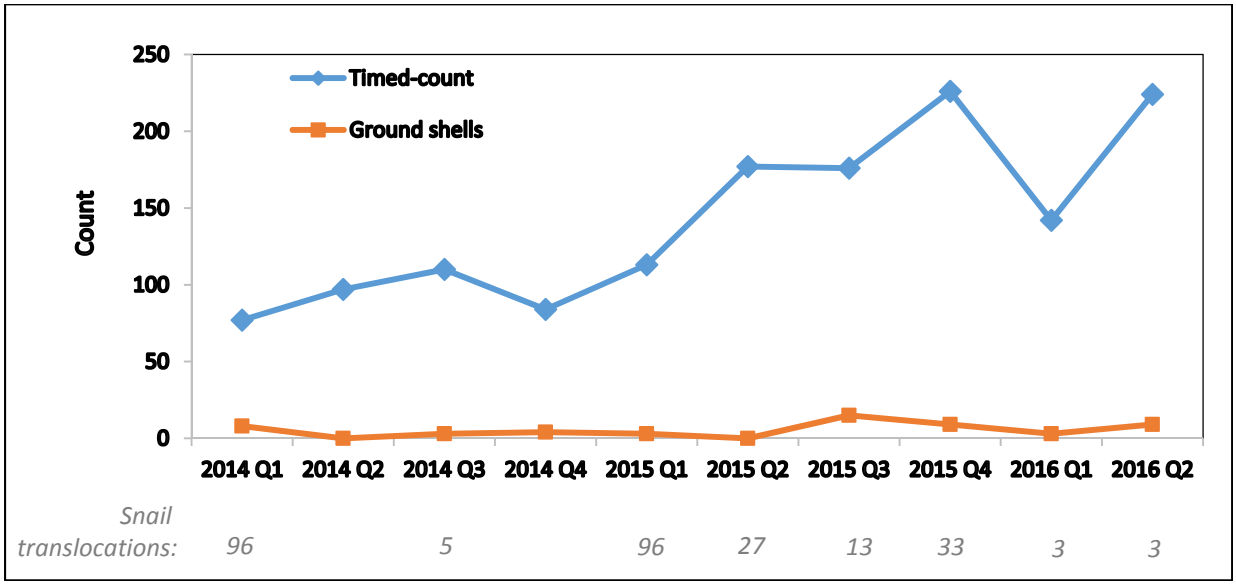
Partial=Threat is being partially controlled at PopRefSite

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.

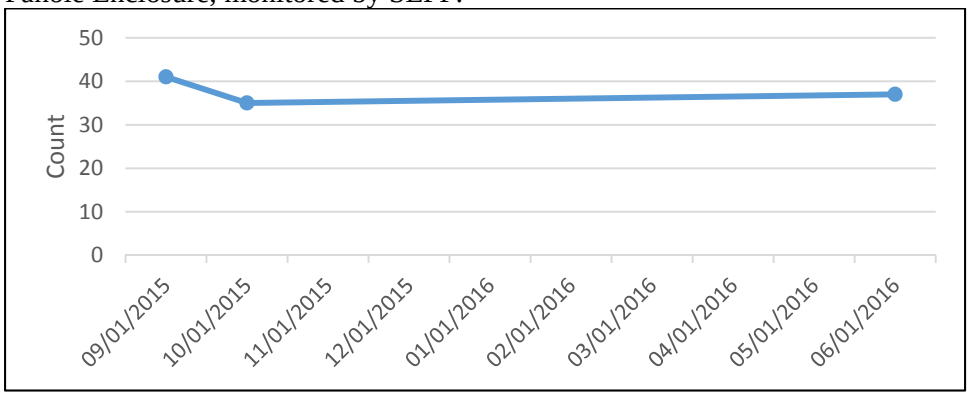
Figure 3: Quarterly timed-counts and ground shell counts for *A. mustelina* in the Kahanahiki snail enclosure from the first quarter of 2014 to the second quarter of 2016, with numbers of snails translocated into the enclosure over time.



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				Threat Control				
				Large	Medium	Small	Unk	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

= 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

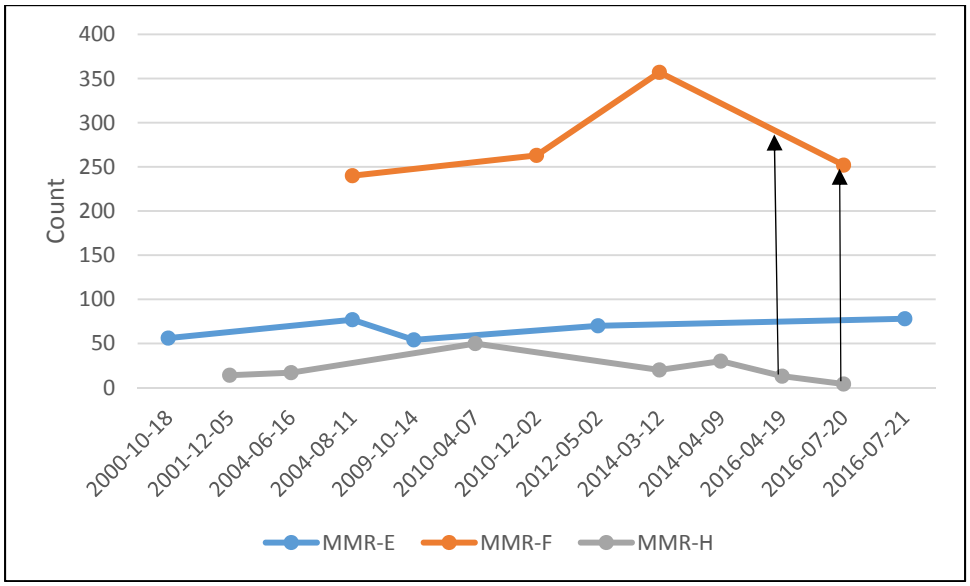
SizeClass	DefSizeClass
Large	>18 mm
Medium	8-18 mm
Small	< 8 mm

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

= 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.

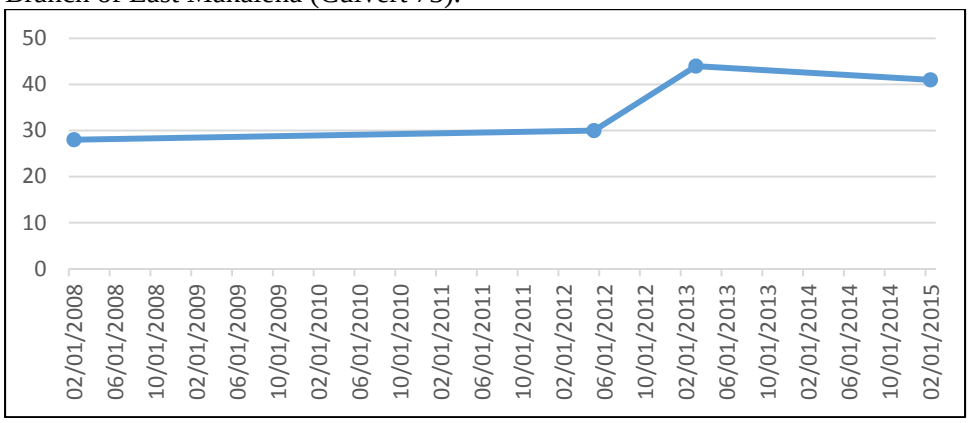
5.3.3.1 LEH-C East Branch of East Makaleha Culvert 69 PRS

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

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

= 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

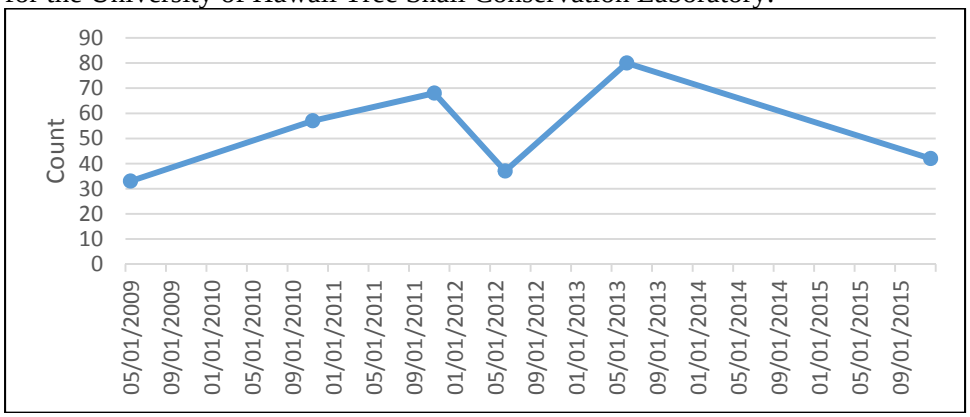
Partial=Threat is being partially controlled at PopRefSite

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					

Size Class Definitions

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

*=Total Snails were Trans Located or Reintroduced

= Threat to Taxon at Population Reference Site

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

Yes=Threat is being controlled at PopRefSite

No=Threat is not being controlled at PopRefSite

Partial=Threat is being partially controlled at PopRefSite

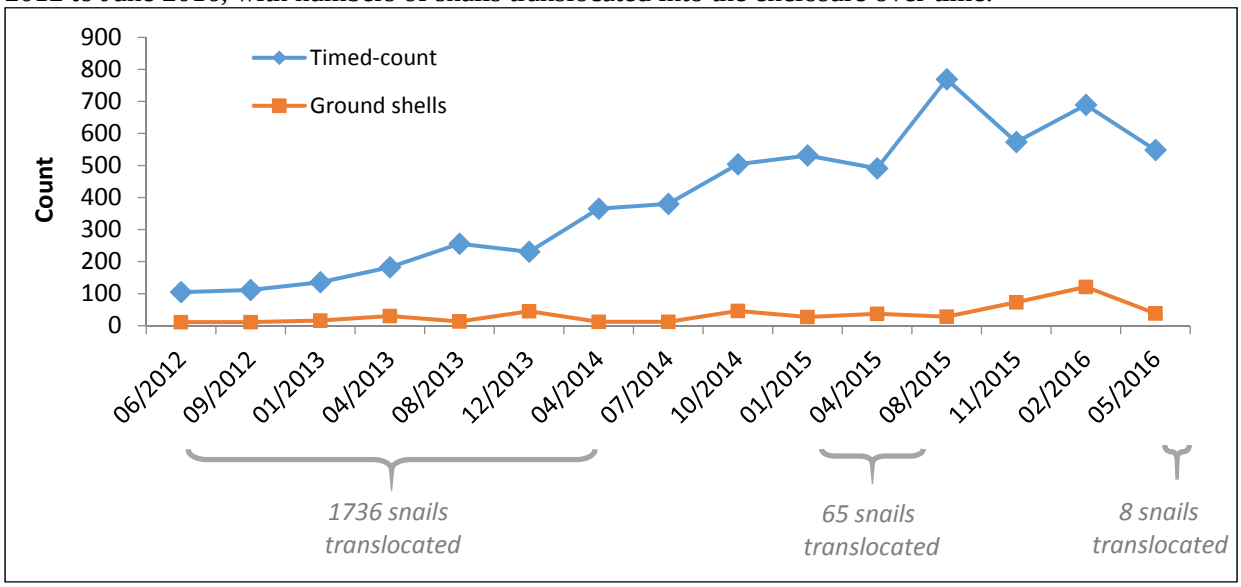
Table shows the number of snails, size classes, and threats to the snails in the ESU sites. Yes = threat is being controlled; In some cases the threat may be present but not actively preying on A. mustelina.

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

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
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

= 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				Threat Control				
				Large	Medium	Small	Unk	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					

*=Total Snails were Trans Located or Reintroduced

= Threat to Taxon at Population Reference Site

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

Yes=Threat is being controlled at PopRefSite

No=Threat is not being controlled at PopRefSite

Partial=Threat is being partially controlled at PopRefSite

Size Class Definitions

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

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

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 Tetiep. 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					

Size Class Definitions

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

*=Total Snails were Trans Located or Reintroduced

= Threat to Taxon at Population Reference Site

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

Yes=Threat is being controlled at PopRefSite

No=Threat is not being controlled at PopRefSite

Partial=Threat is being partially controlled at PopRefSite

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.

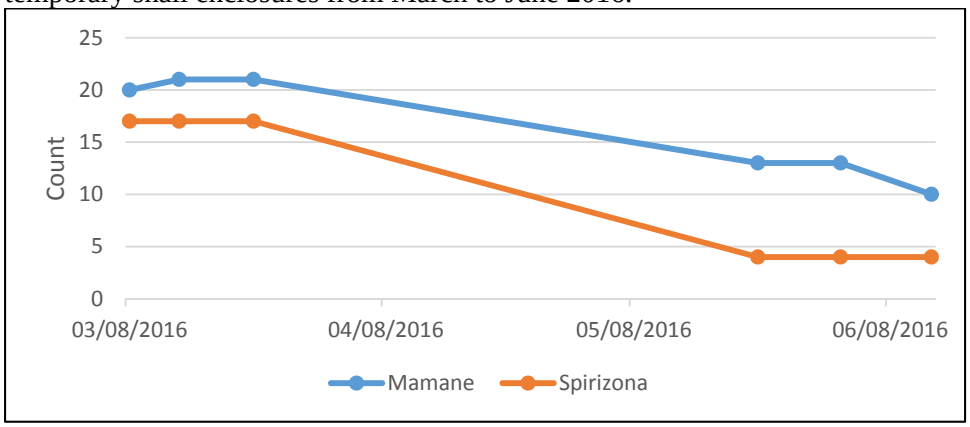
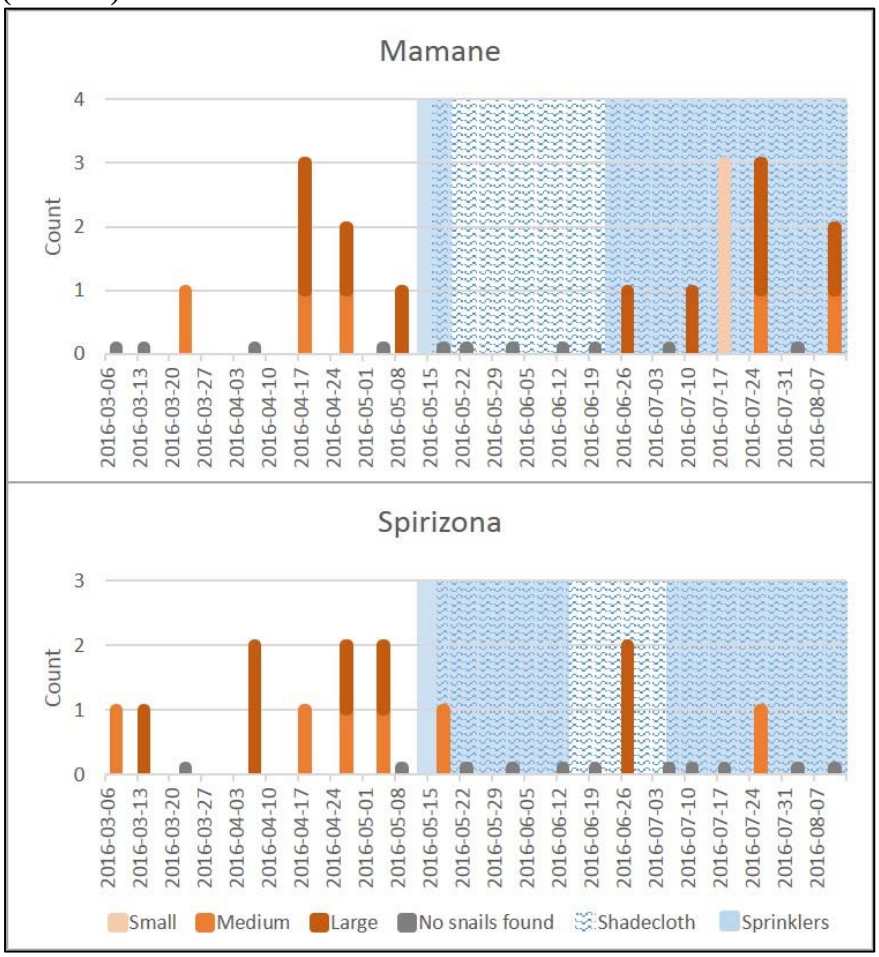


Figure 18: Counts of *Achatinella mustelina* ground shells recovered from the EKA-M Mamane and EKA-S Spirizona temporary snail enclosures between March 8 and August 11, 2016. Shell sizes are indicated by color for small (<8mm), medium (8-18mm) and large (>18mm) individuals. Background shading indicates 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				Threat Control				
				Large	Medium	Small	Unk	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 lele 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				Threat Control				
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina rosea	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

= 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.

5.7.1.1 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.

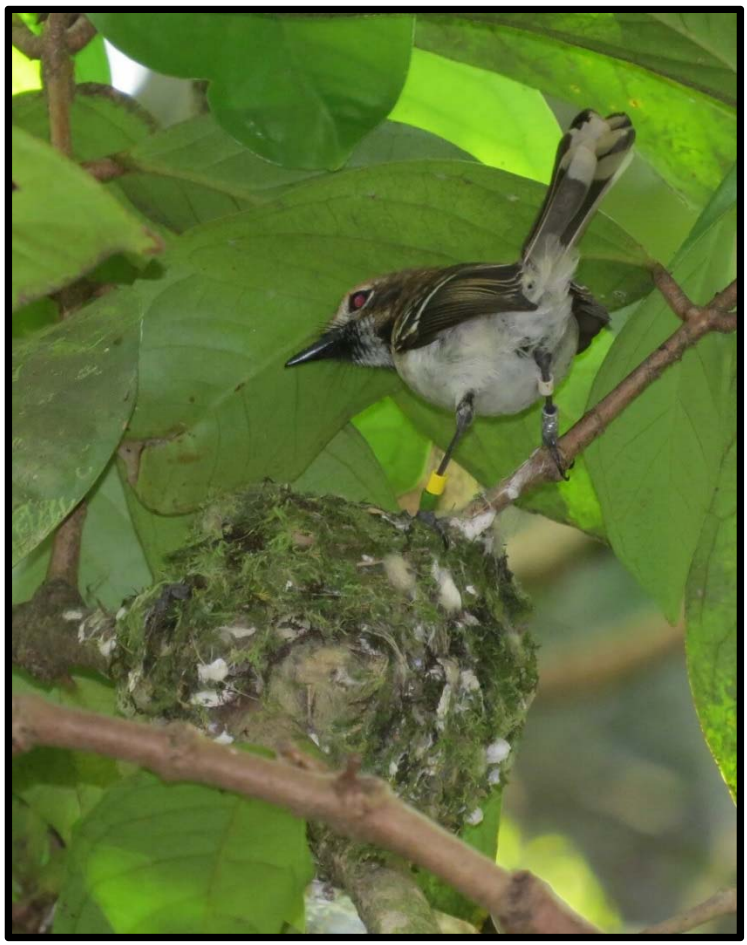


Figure 3: A banded Elepaio comes in to feed small nestlings. A bird is identified by its band combination, which is read top to bottom, left leg first then right leg. In this case, it would be yellow/green, white/aluminum or YGWA.

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.

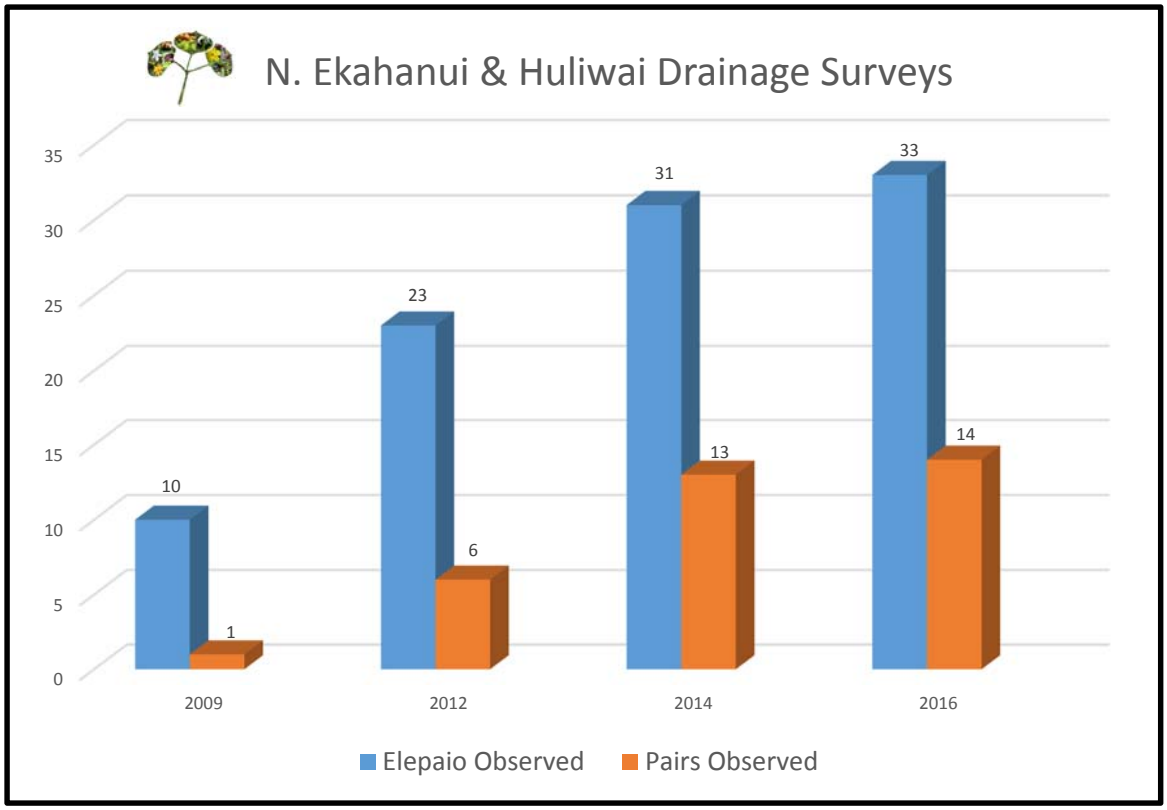


Figure 5: Results of surveys conducted in non-managed drainages north of Ekahanui.

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.

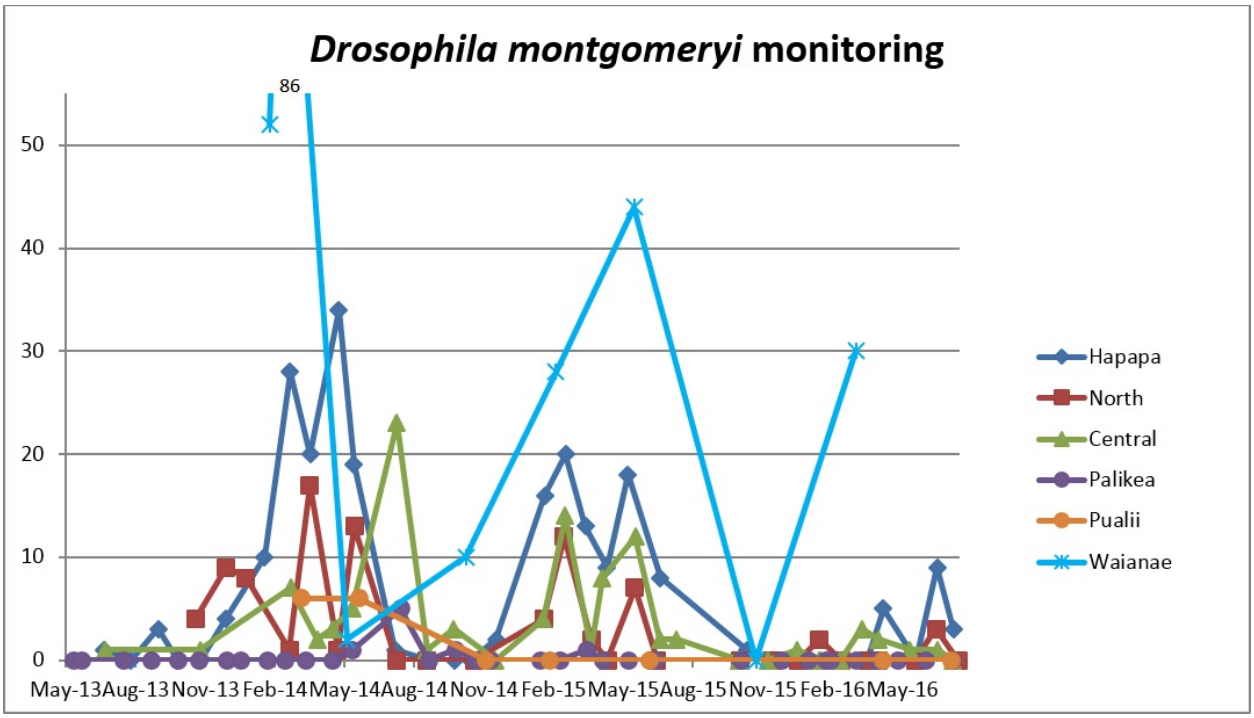


Figure 2: *Drosophila montgomeryi* numbers during monthly monitoring at three sites in Kaluaa PU (Puu Hapapa, North Kaluaa, and Central Kaluaa) and Palikea, and quarterly monitoring at Waianae and Pualii. Y axis is the maximum number observed across the entire site on the survey day (see Survey Methods,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

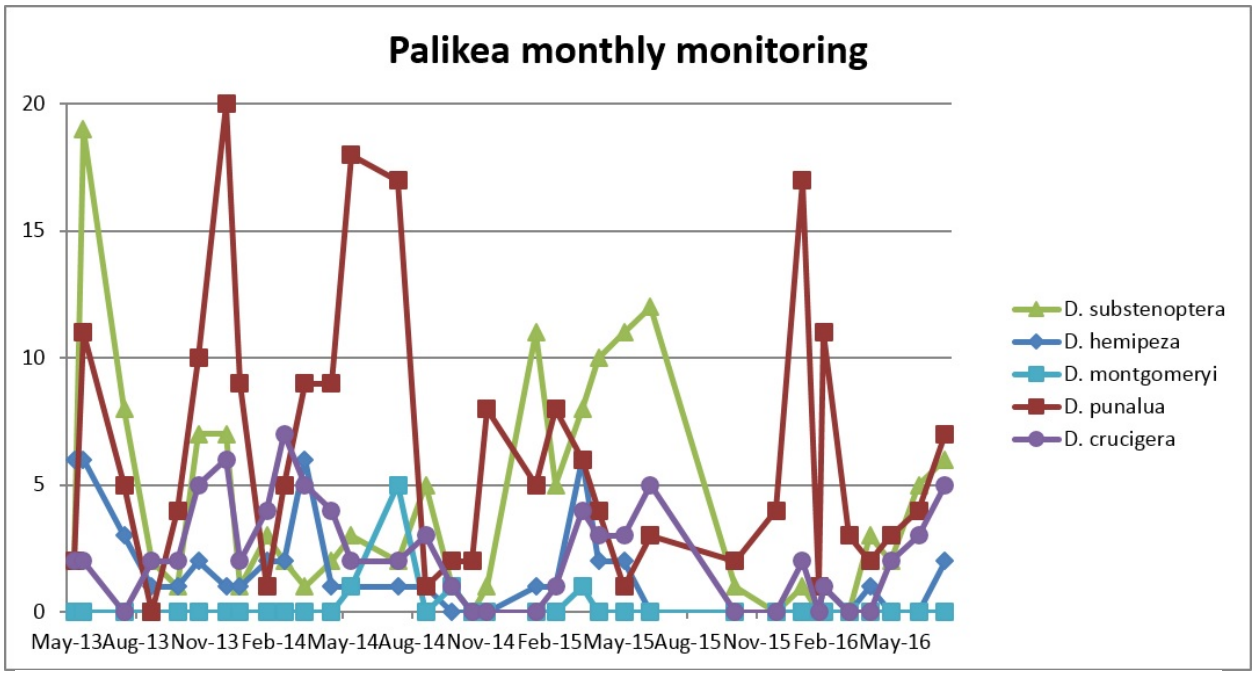


Figure 6: Monthly monitoring results for all species at Palikea, from May 2013 to July 2015.

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).

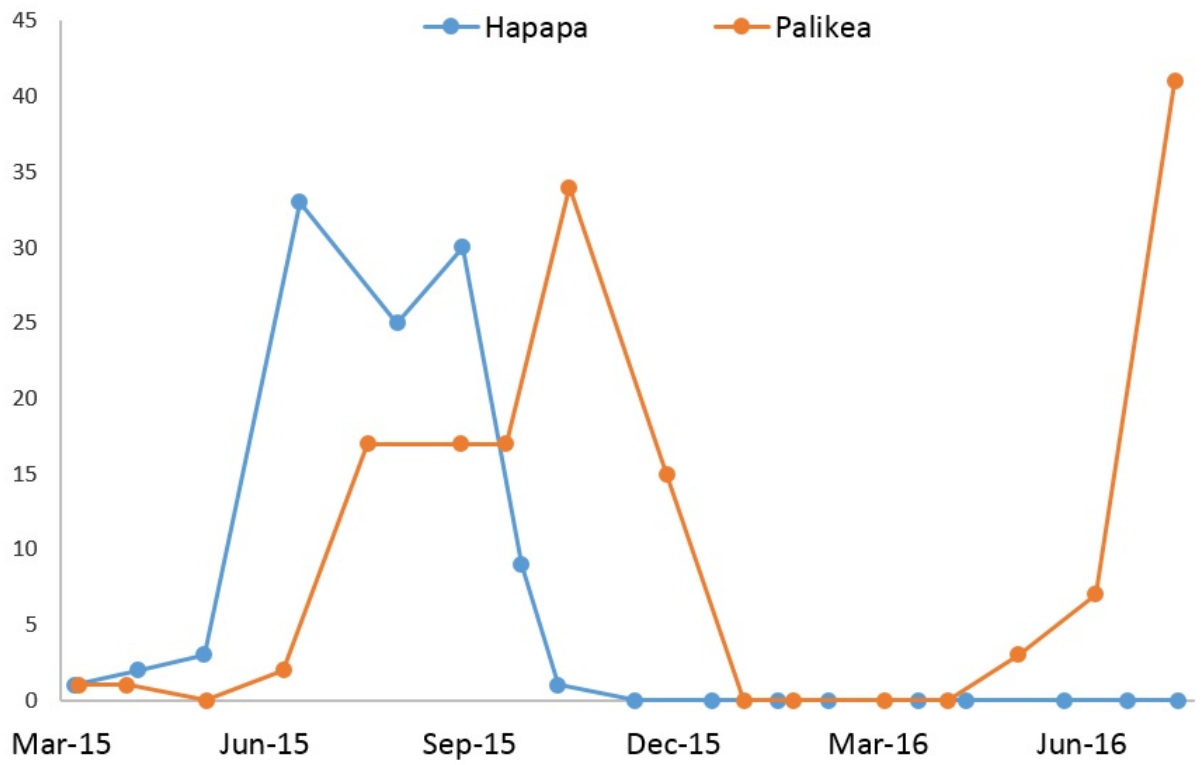


Figure 8: *Vespula pensylvanica* numbers at Palikea and Puu Hapapa (monthly total across 10 traps at each site).

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.

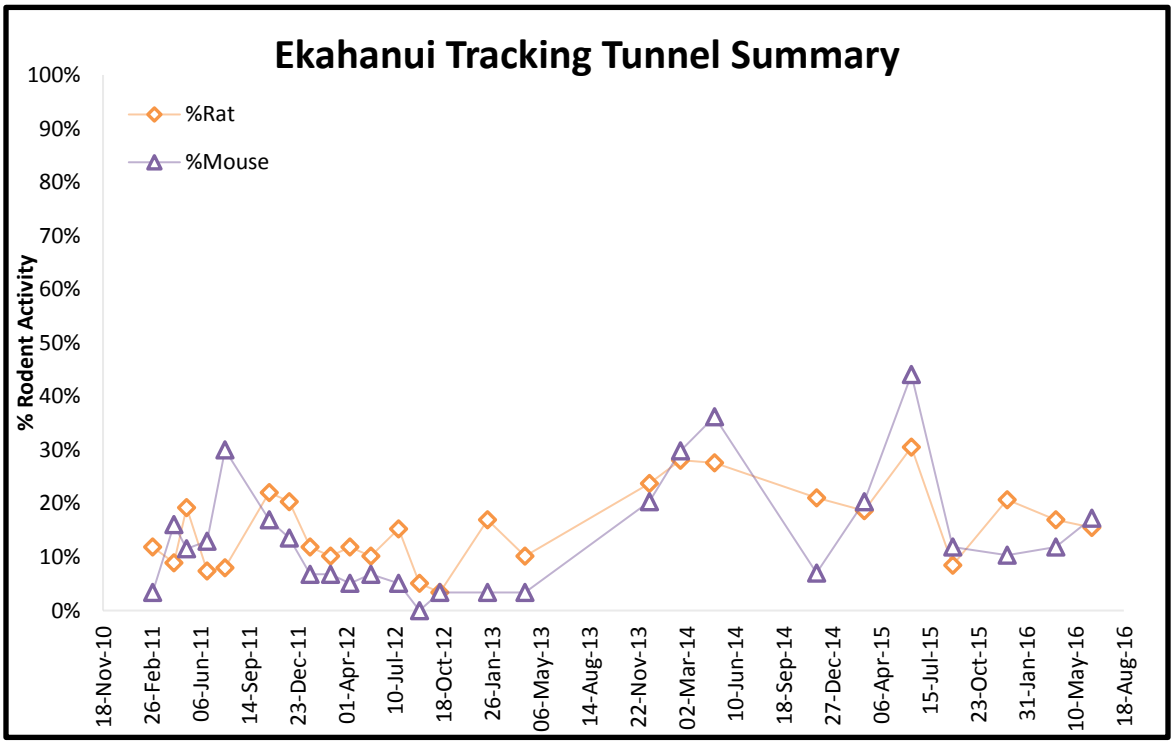


Figure 1: Percent of rodent activity at Ekahanui.

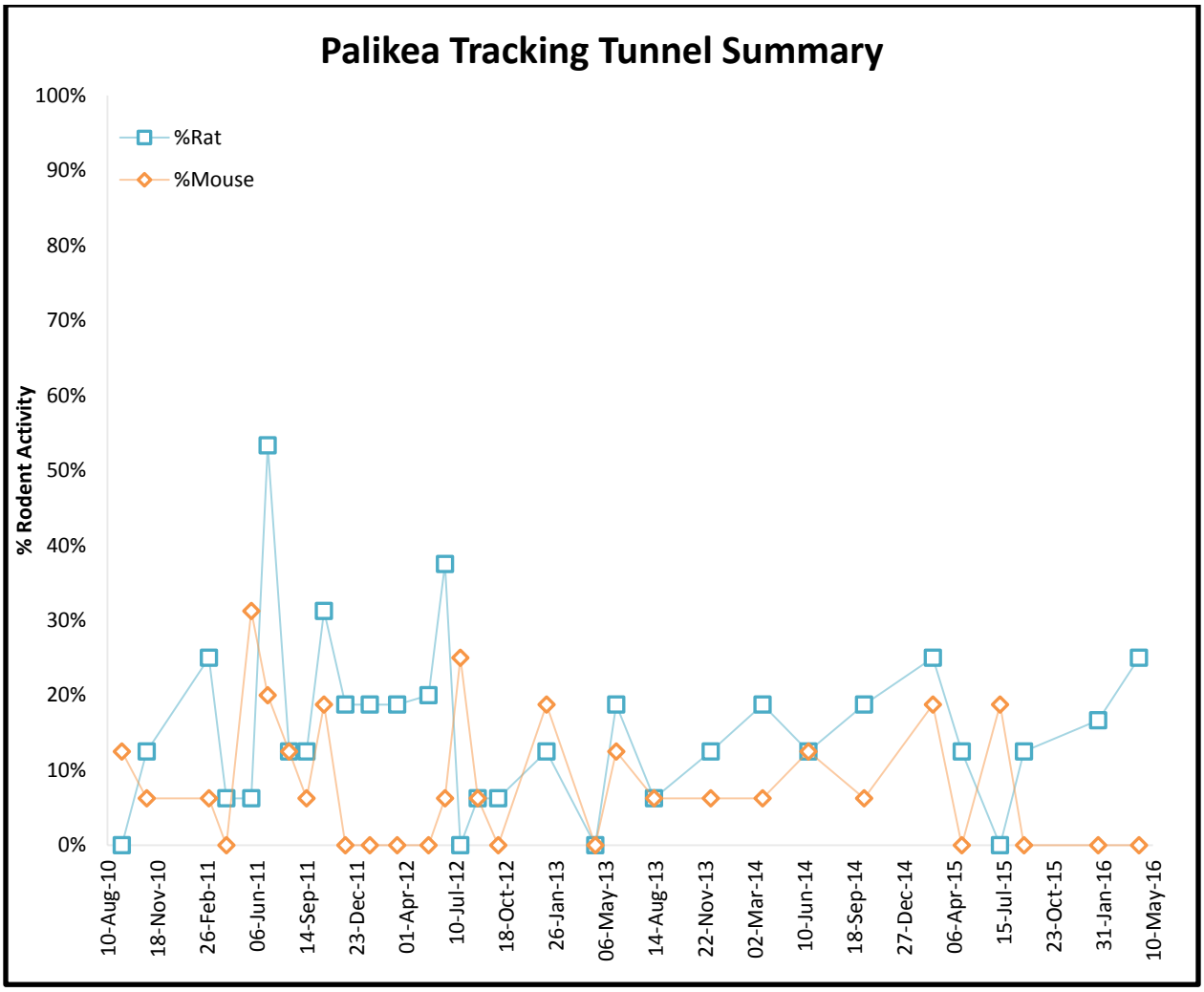


Figure 2: Percent of rodent activity at Palikea.

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.

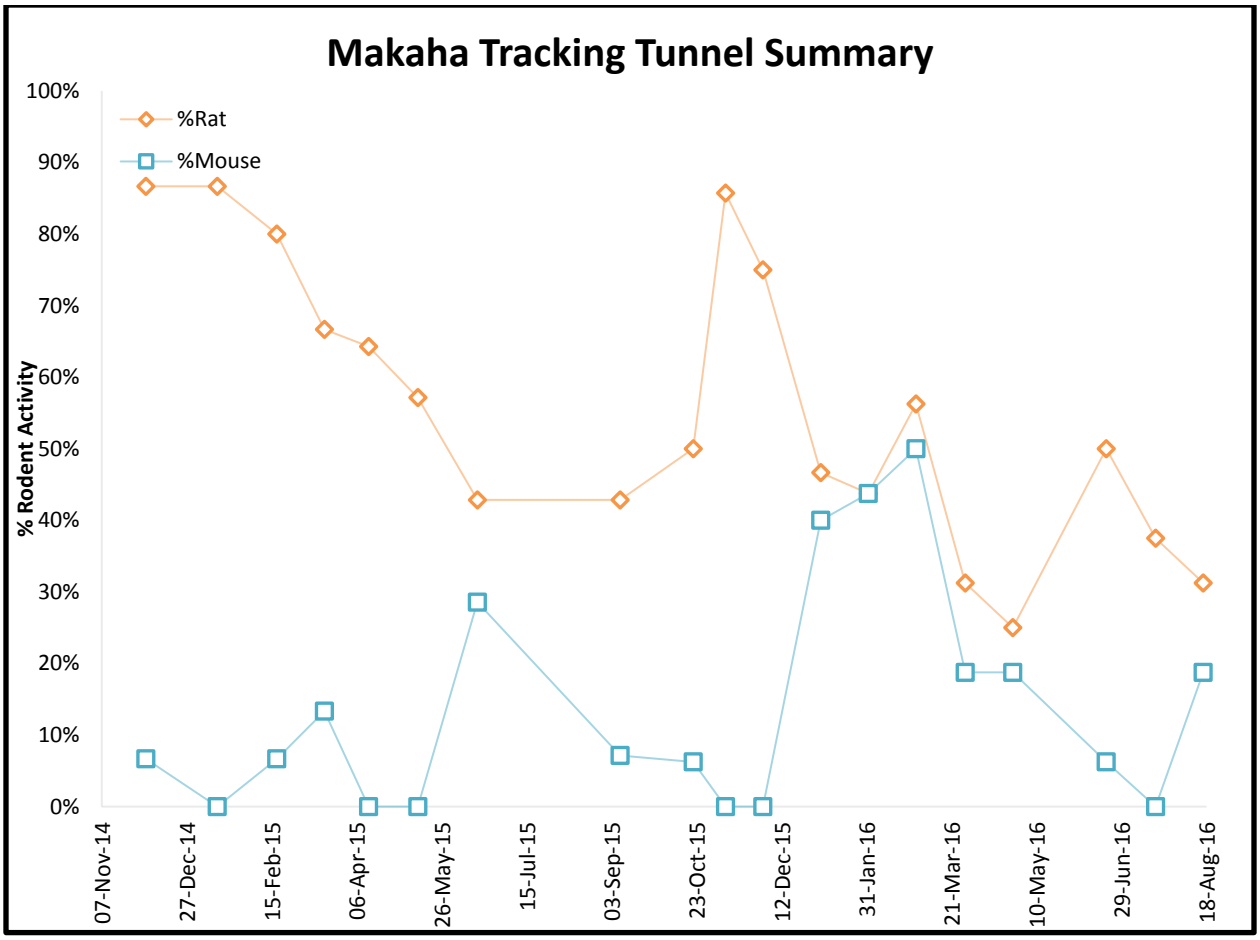


Figure 3: Percent of rodent activity at Makaha.

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.

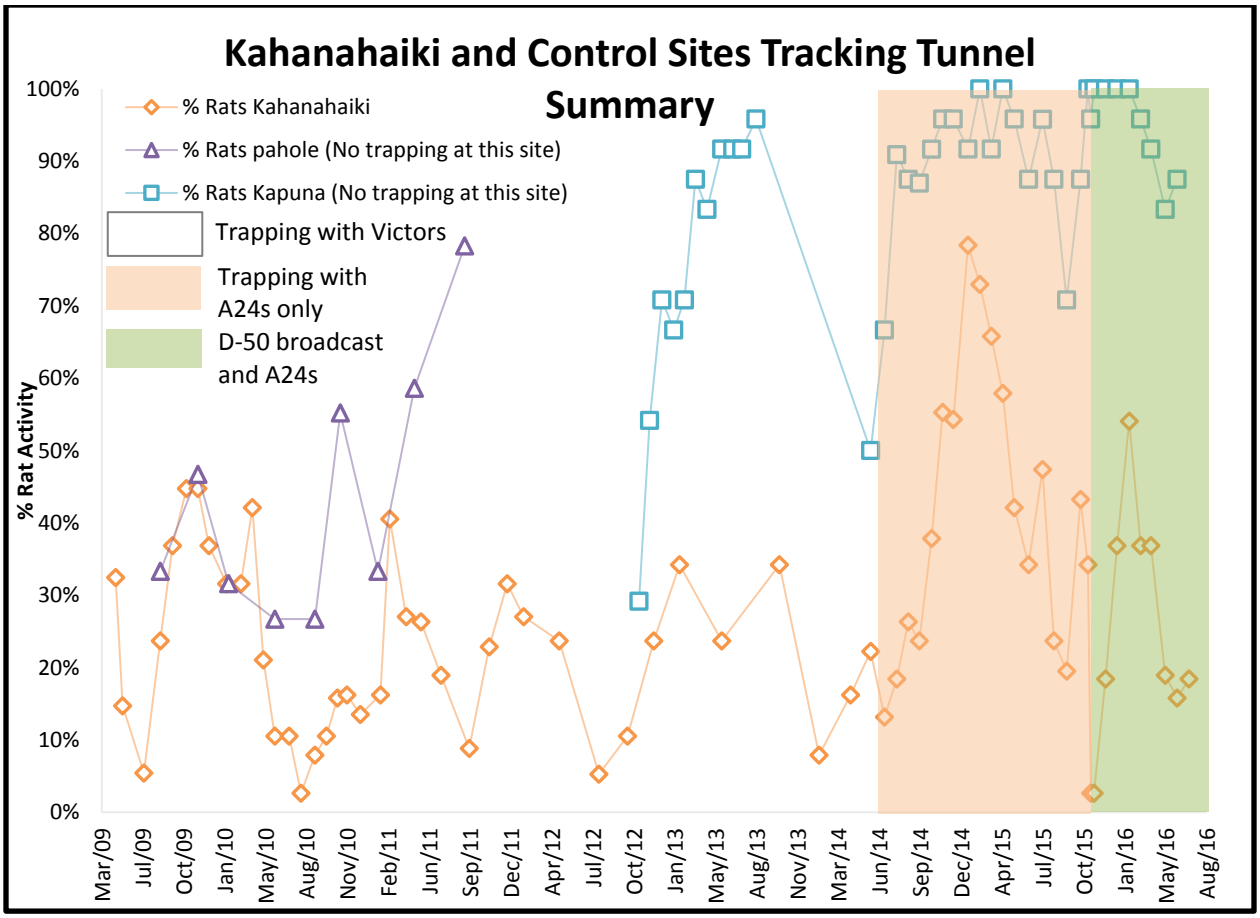


Figure 5: Percent of rat activity each month at Kahanahaiki and two control sites Kapuna and Pahole.

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.

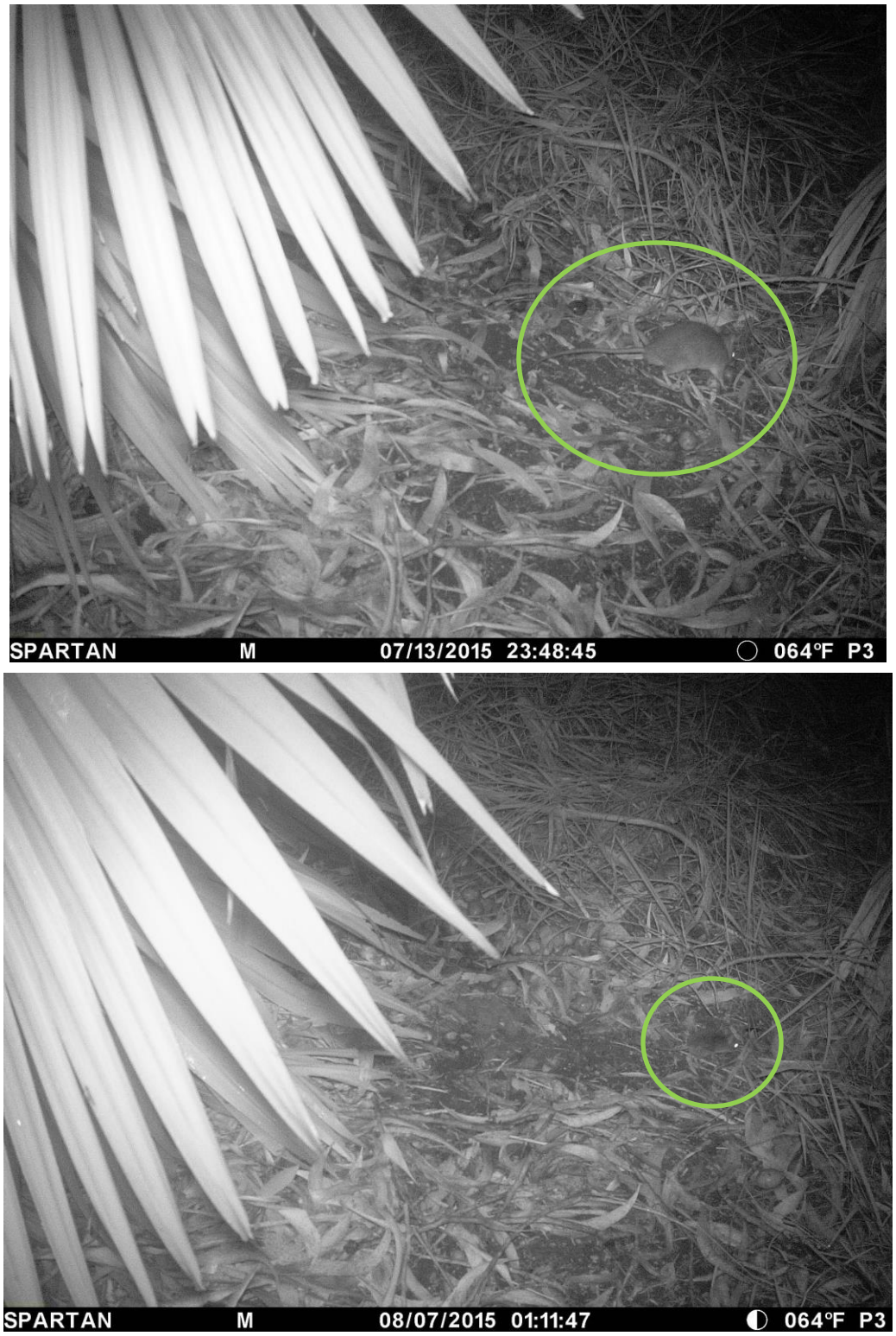


Figure 10: Picture on top of *R. rattus* taking *P. kaalae* fruit, and picture on bottom of *M. musculus* possibly taking *P. kaalae* fruit.

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.

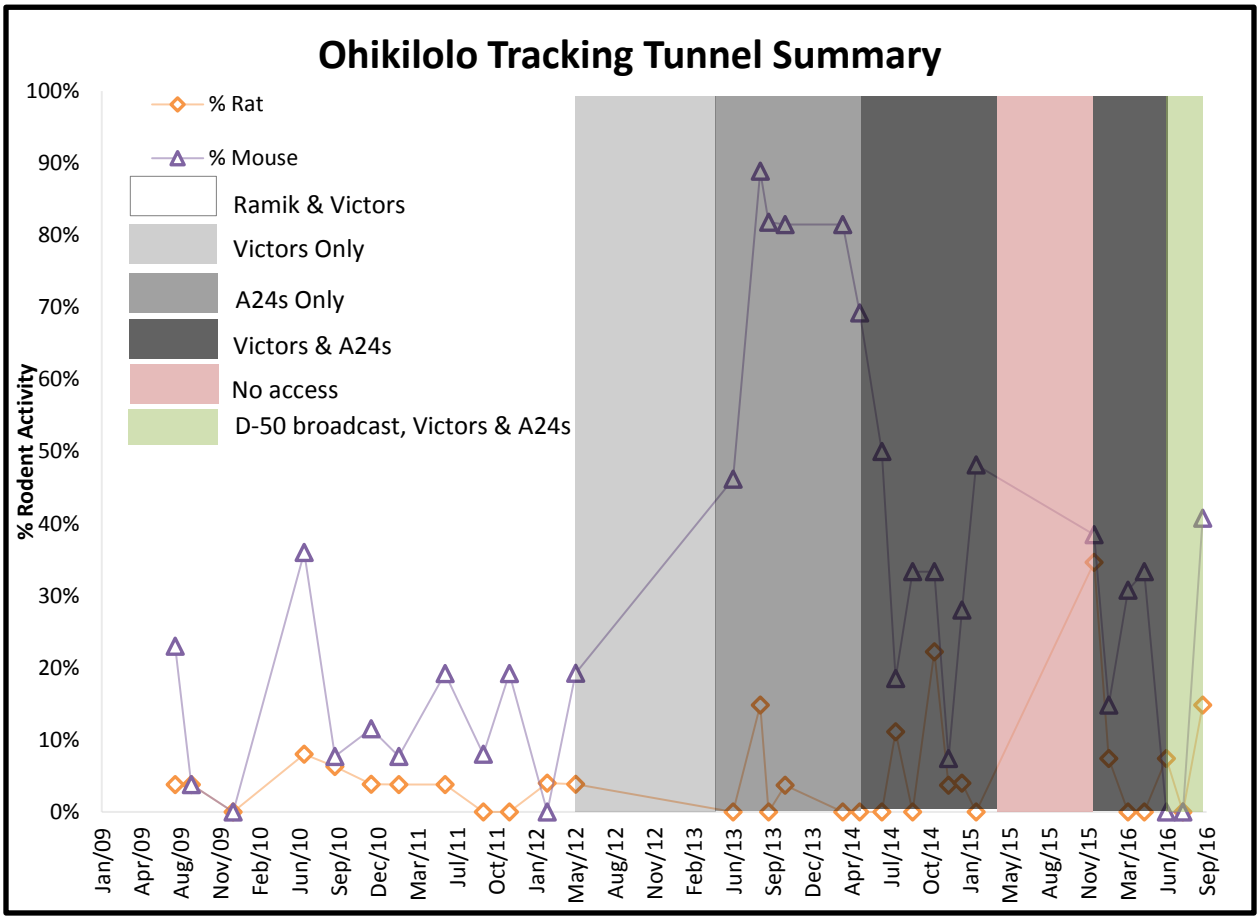


Figure 11: Percent of rodent activity at Ohikilolo.

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

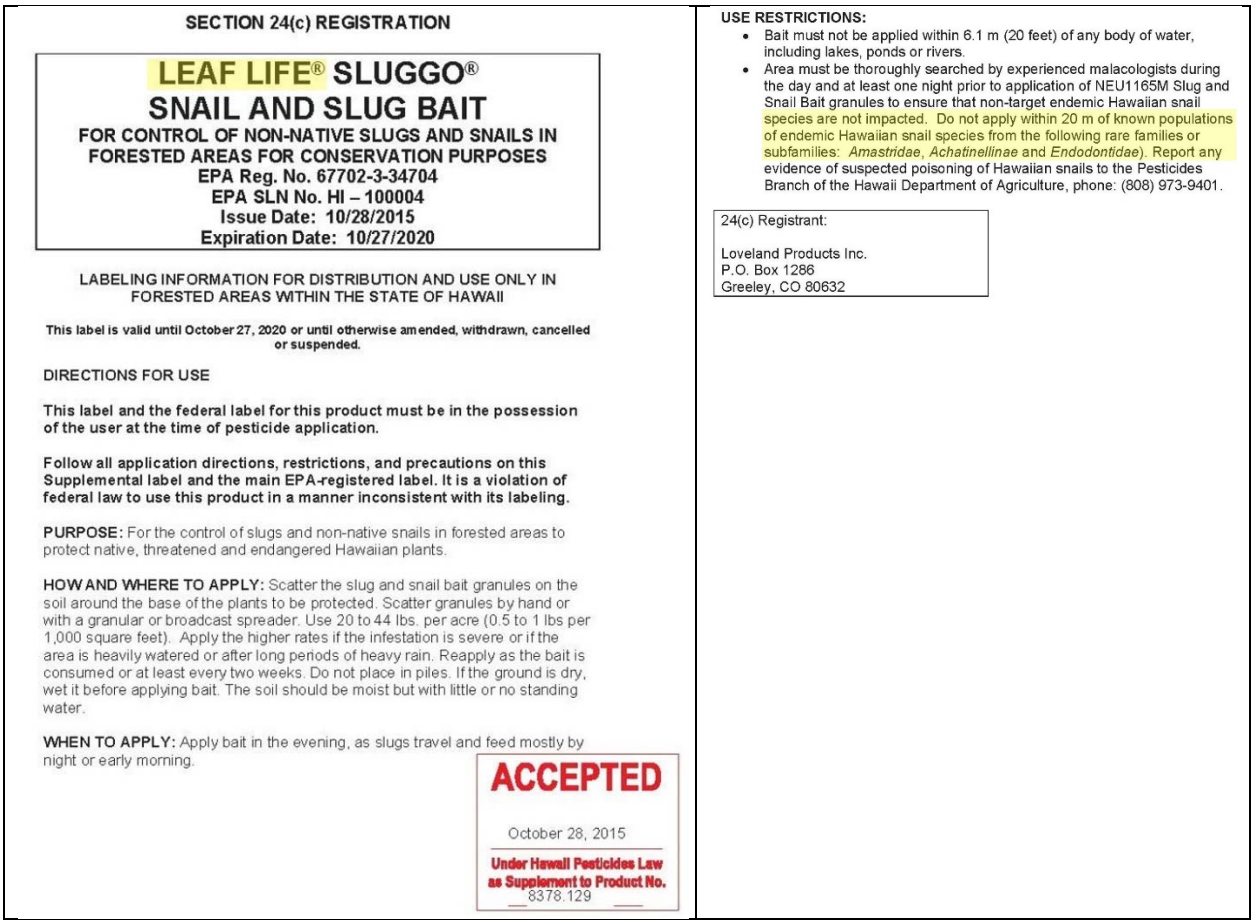
This chapter describes the status and outcome of actions carried out under the direction of the Oahu Army Natural Resource Program (OANRP) Alien Invertebrate Control & Research Specialist which, this year, included the successful renewal of a Special Local Needs (SLN) permit for the use of Sluggo in 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)**

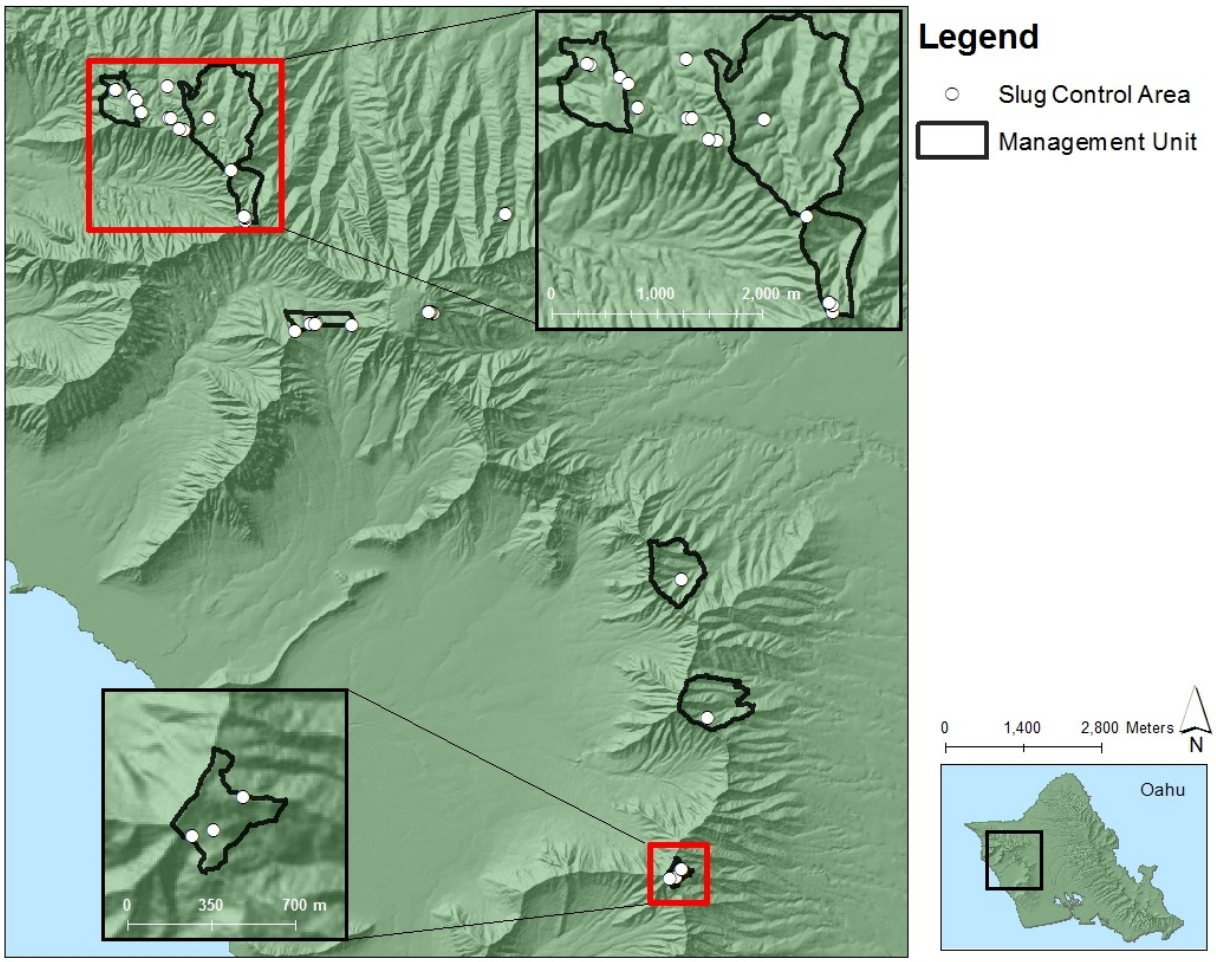


Figure 2: Locations of rare plant species within Managament Units (MUs) undergoing slug control in the Waianae Mountains. A single slug control site in the Koolau Mountains (Opaeula Lower) is not shown.

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.

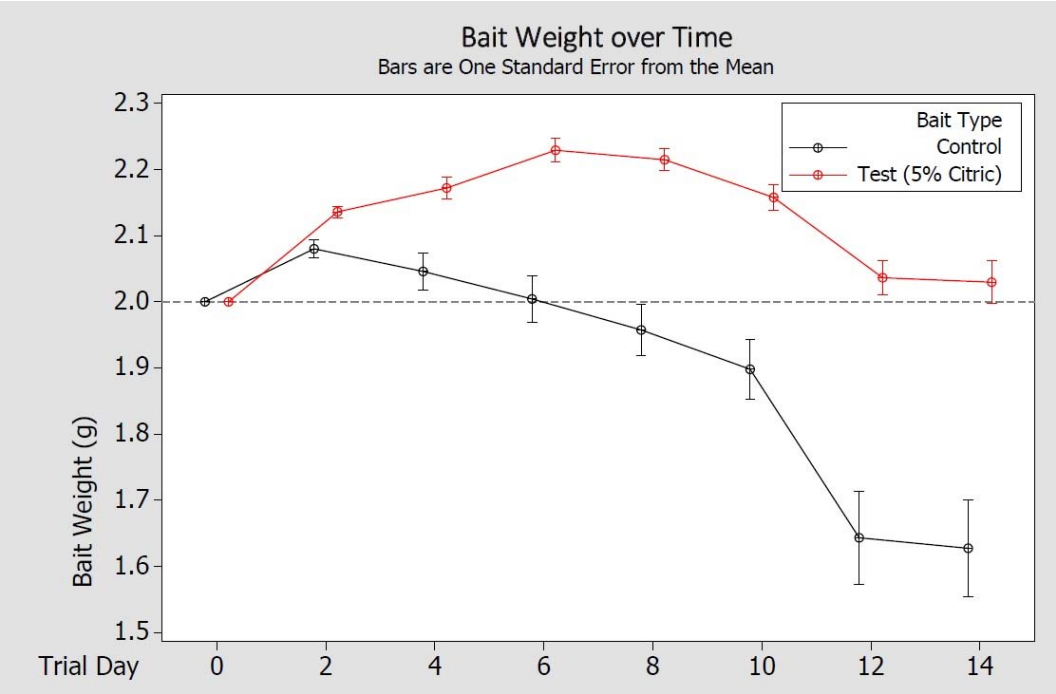


Figure 4: Weight (g) of the test and control bait over two weeks. The dotted line indicates the initial weight of the bait on day 0 of the trial (2 g). By the final day of the trial, the test bait did not differ significantly from 0 indicating it was not consumed by slugs.

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.

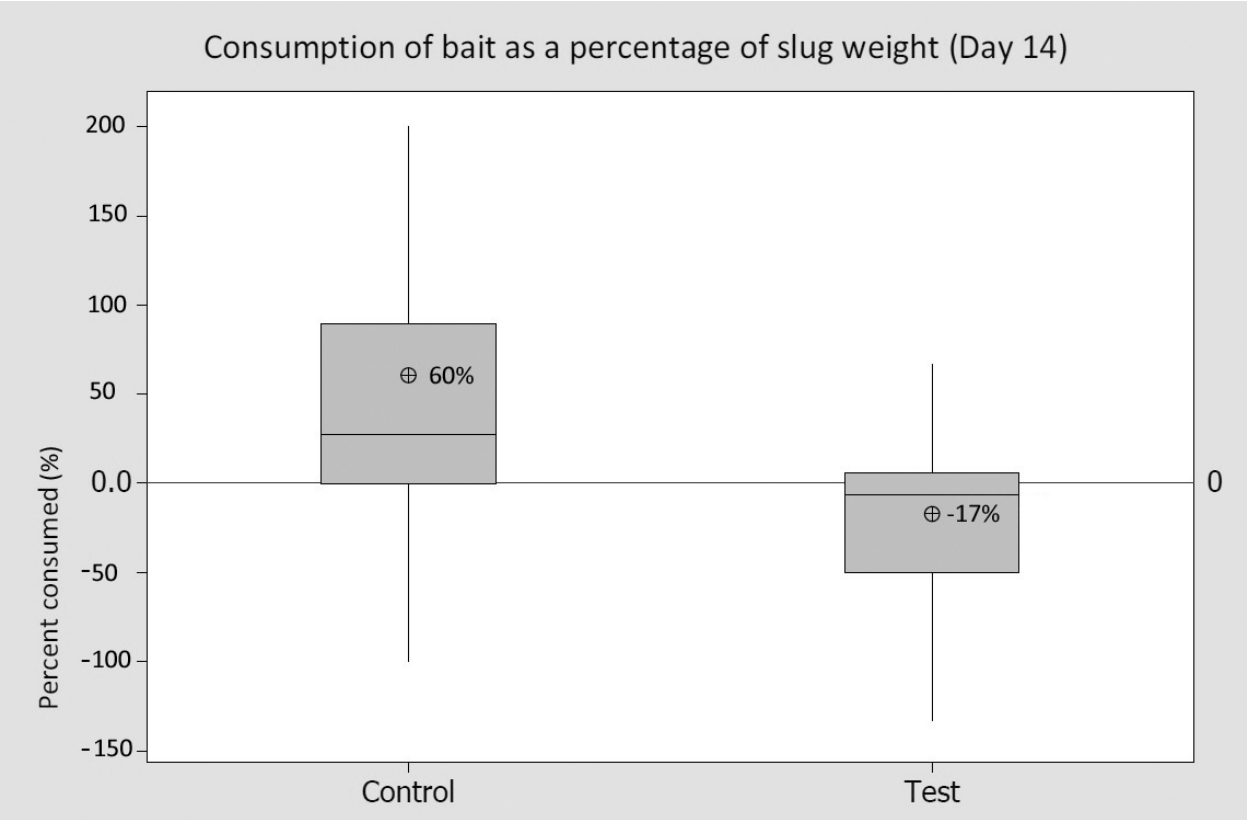


Figure 5: Boxplot showing consumption of control and test baits as a proportion of slug body weight.

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.

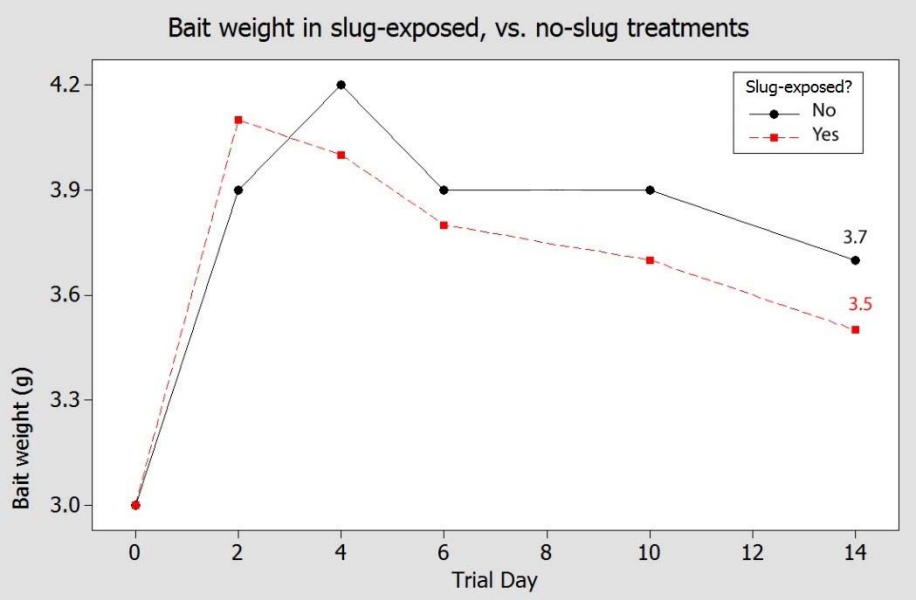


Figure 7: Mean weight of both bait types over time.

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).

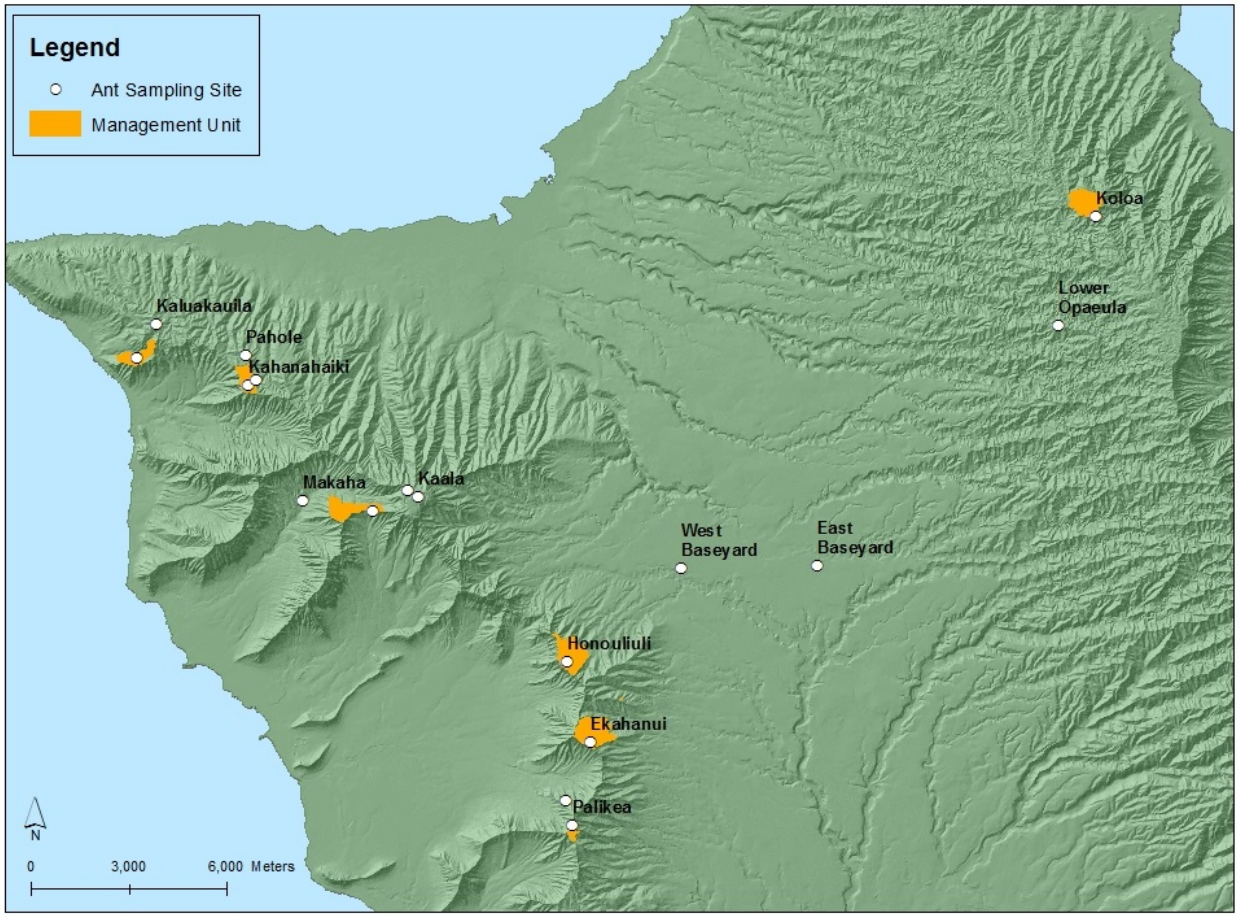


Figure 9: Location of Management Units and ant sampling sites.

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.

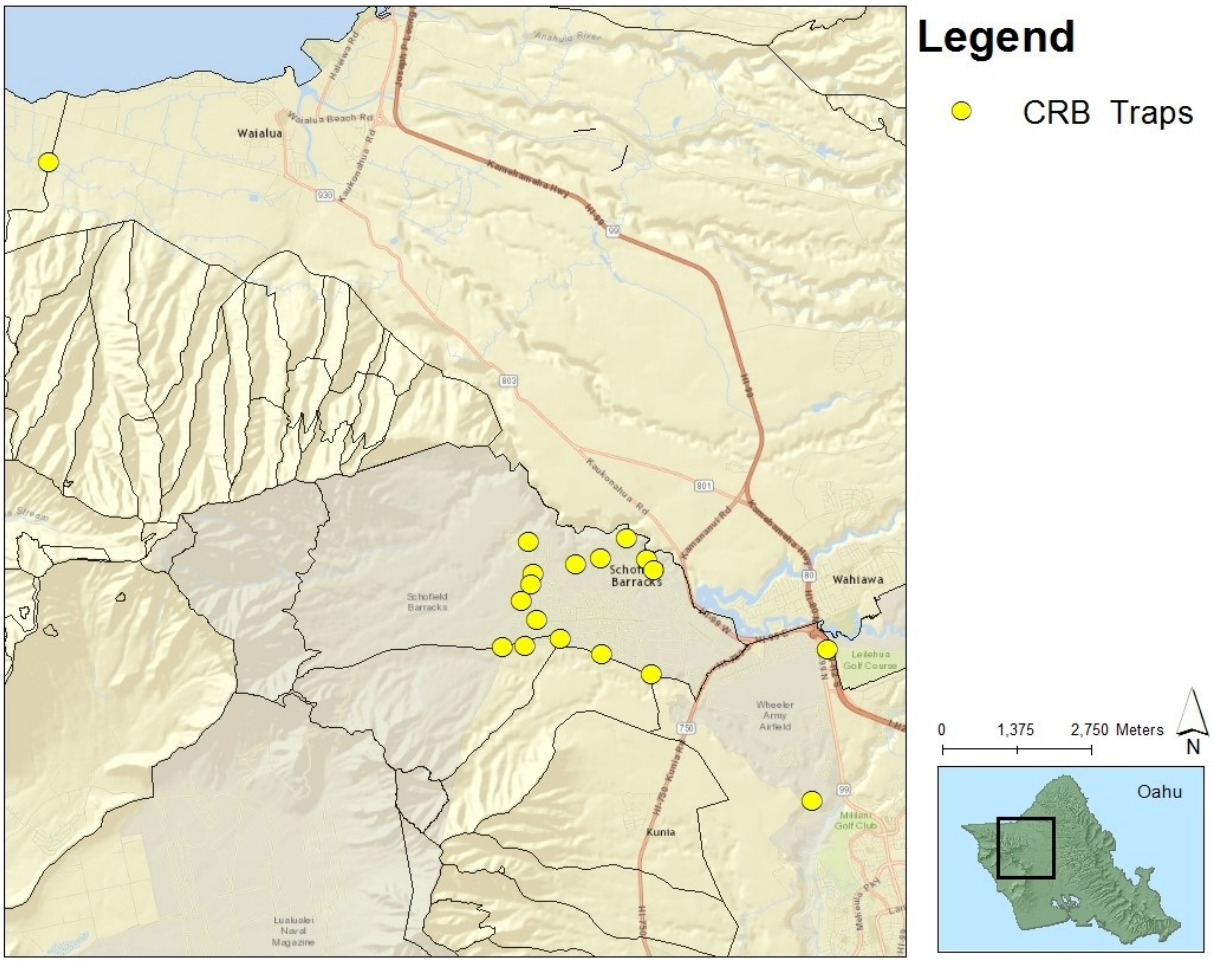


Figure 10: Locations of CRB traps maintained by OANRP.

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