2015 Status Report for the Makua and Oahu Implementation Plans

October 2015

Prepared by:
Oahu Army Natural Resources Program
Pacific Cooperative Studies Unit
Schofield Barracks, HI 96857

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF CONTRIBUTORS

Daniel Adamski	Natural Resource Management Coordinator, PCSU
Michelle Akamine	Monitoring Program Specialist, PCSU
Makanani Akiona	Natural Resource Management Technician, PCSU
Jane Beachy	Ecosystem Restoration Program Manager, PCSU
Tyler Bogardus	Small Vertebrate Pest Stabilization Specialist, PCSU
Matthew Burt	Elepaio Stabilization/Ungulate Program Manager , PCSU
Kelly Cloward	Natural Resource Management Technician, PCSU
Vincent Costello	Rare Snail Conservation Specialist, PCSU
Celeste Hanley	Environmental Outreach Specialist, PCSU
Jessica Hawkins	Natural Resource Management Technician, PCSU
Scott Heintzman	Senior Natural Resource Management Specialist, PCSU
Stephanie Joe	Natural Resource Research Specialist, PCSU
Roy Kam	Natural Resource Database Specialist, PCSU
Kapua Kawelo	Biologist, Department of Public Works (DPW) U.S. Army Garrison Hawaii
Matthew Keir	Rare Plant Program Manager, PCSU
Eli Kimmerle	Senior Natural Resource Management Specialist, PCSU
Linda Koch	Natural Resource GIS Specialist, PCSU
Julia Gustine Lee	Senior Ecosystem Restoration Specialist, PCSU
Alex Loomis	Natural Resource Management Technician, PCSU
Karl Magnacca	Entomological Program Specialist, PCSU
Michelle Mansker	Natural Resource Manager, DPW, U.S. Army Garrison Hawaii
Taylor Marsh	Ecosystem Restoration Specialist, PCSU
Taylor McCarthy	Support Operations Supervisor, PCSU
Kahale Pali	Natural Resource Management Coordinator, PCSU
Jobriath Rohrer	Senior Natural Resource Management Coordinator, PCSU
Daniel Sailer	Senior Natural Resource Management Coordinator, PCSU
Adam Smith	Natural Resource Management Technician, PCSU
Clifford Smith	Natural Resource Operations Manager, PCSU
Philip Taylor	Natural Resource Avian Conservation Specialist, PCSU
Jamie Tanino	Rare Invertebrate Conservation Technician, PCSU
Melissa Valdez	Senior Natural Resource Management Specialist, PCSU
Michael Walker	Natural Resource Management Coordinator, PCSU
Lauren Weisenberger	Propagule Management Specialist, PCSU
Kimberly Welch	Environmental Outreach Specialist, PCSU

*Cover photo *Sanicula mariversa* reintroduction, Ohikilolo Ridge, Waianae Mountains, Oahu.

THIS PAGE INTENTIONALLY LEFT BLANK

EXECUTIVE SUMMARY

The Oahu Army Natural Resources Program (OANRP) has 60 personnel on staff, comprised of 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) 2015 were higher than those in FY 2014. During this reporting period, OANRP hired one Ungulate Management Technician and two temporary employees to conduct fence maintenance and ungulate control projects. For FY 2015, OANRP received a total of $7,130,000 to implement Makua Implementation Plan projects and Tier 1 projects from the Oahu Implementation Plan. This included funding for new research initiatives, bat survey equipment, expanded rat control services, funding to partner with the U.S. Department of Agriculture on a pilot rat bait application project and fence materials to support a Waianae Mountains Watershed Partnership fencing initiative. In FY 2015, 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 October 1, 2014 to June 30, 2015 which is only a nine month reporting period. This reporting period shift was made so that this report will be submitted at the end of the current cooperative agreement that ends 30 Sept 2015. PCSU was awarded a new contract with two one-year options which commenced 1 July 2015. This report covers 9 months of Year 11 of the MIP and Year 8 of the OIP. Due to the abbreviated reporting period, this document will be somewhat abbreviated as compared to previous reports. 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 eleventh year of the MIP Addendum (Addendum completed in 2005, original finalized in 2003) and the eighth 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 2015, 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 Army has 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 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 2015 and a Biological Opinion from the USFWS is anticipated by the end of the 2016 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.

Of special interest are access restrictions experienced for Makua Military Reservation during this reporting period. An unexploded ordnance accident occurred within Makua in April 2015. During the investigation and while safety procedures are being reviewed, OANRP have not been able to access field sites within the valley. Naturally, on going projects for stabilization species are being negatively affected by this shut down. OANRP is working with Army Range Division and Safety to regain regular access before the 2015-5016 outplanting season. When access is regained, OANRP will need to spend extra time to catch up on protection measures. For example, OANRP have not cut/sprayed grass at the *Hibiscus brackenridgei* in Lower Ohikilolo since April and it is expected that multiple treatments will be required to reduce fuel to an acceptable level.

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, pesticide storage and gear storage areas. The outreach staff continue to maintain their office at the East Range baseyard because it is a convenient location to rendez-vous for volunteer trips.

Landowner/Agency Communications

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 is working to acquire a right of entry permit with Dole Food Company for *Hibiscus brackenridgei* subsp. *mokuleianus* surveys and monitoring. These parcels are being sold and this access will need to be negotiated with the new landowner. The Army also continues to work cooperatively under an MOU with the U.S. Navy for work in Lualualei Naval Magazine. Lastly, the Army is in the process of renewing an annual right of entry permit to protect Oahu Elepaio on Gill and Olson property 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. In the last year, the State and Army negotiated to extend the term for these permits from one year to three. 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 this fiscal year.

OANRP continues to provide support for partner agencies including the Oahu Invasive Species Committee, Oahu Plant Extinction Prevention Program, 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 Grouop, the Pacific Island Climate Change Cooperative and the Hawaii Conservation Alliance.

Management Unit (MU) Protection

During this reporting period, OANRP completed the northern section of the Helemano to Poamoho (1,700 m) MU fence. Also, OANRP contracted fence construction along the remaining perimeter of Makua Military Reservation along the northern rim. As of 30 June 2015, ~3,300 meters of this section from Kahanahaiki to Kaluakauila management units was complete. Construction on the final remaining ~1,000 m section of this perimeter fence began August 1st, after preparing a new risk assessment for the project. An unexploded ordnance accident in the valley temporarily halted access for all work in the valley. In addition, OANRP secured funding for and purchased fence materials for the Makaleha, Waianae Mountains Watershed Partnership fencing project. Construction of this fence is being funded by the State of Hawaii.

As reported last year, OANRP has transitioned ecosystem management focus to more intensive MU weed control and restoration. The OANRP fence construction program ended with the 2014 calendar year. In 2015, OANRP hired two ungulate management technicians to focus on fence monitoring and maintenance. For more details about OANRP ungulate control see Chapter 1.

In this 9-month reporting period, OANRP spent 4,654 hours controlling weeds across 325.9 ha. Incipient Control Area (ICA) efforts accounted for 254.6 ha of this total which his 75% of the total area over which weeds were controlled. Staff spent 1,537 hours on ICA management and conducted 333 visits to 148 ICAs. The ICA totals represent an increase from previous reporting periods even though this reporting period only covers 9 months. Some of this increase is due to aerial treatment of *Chromolaena odoratum* using helicopters. Weed Control Area (WCA) efforts covered 80.3 ha in 9 months which is an increase from last year's 90 ha in one year. This area increase is may be attributed to the new Ecosystem restoration crew's efforts in sweeping large sections of management units for single species targets such as *Grevillea robusta* and *Toona ciliata*. OANRP conducted control in WCAs for a total of 3,117 hours over 352 visits at 122 WCAs. See Chapter 1 for a comparison to last year's control figures. OANRP has completed a total of 21 Ecosystem Restoration Management Unit Plans (ERMUPs) for the highest priority and largest MUs. Due to the short reporting period, ERMUPs were not prepared to include in this report.

OANRP conducted road and landing zone surveys in order to detect and prevent the spread of any newly introduced invasive species. OANRP submitted 44 introduced 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, two were new naturalization records and one was a range extension. Highlights are covered in Chapter 1.

During this reporting period, the new central vehicle wash facility (CVWF) opened for use. This facility is staffed during regular business hours and will be staffed if units require access during off duty hours. The location of the CVWF is very convenient for use by units occupying Schofield Barracks West and South Ranges. Unfortunately, the Kahuku and East Range washracks were both out of commission for repairs on a few occasions during this reporting periods. More details about vehicle washracks is presented in Chapter 1.

Rodent Control Program

OANRP rat control operations continue to expand the use of the Goodnature® automatic traps to reduce labor expended rebaiting traps. Also, OANRP continue to test new baits in all traps to maximize the persistence and lengthen rebaiting intervals. In addition, the solicitation for rat control services includes expansion of rat control grids to include more traps per grid, to allow for year-round control and to add a new grid in Makaha. A contractor to conduct this work will be selected before the current contract ends in September. During this reporting period, OANRP also secured funding to partner with the U.S. Department of Agriculture, Wildlife Services to study the application of rodenticide to control rat population spikes. This trial will occur in the Kahanahaiki Mangement Unit and based on the results, OANRP will assess the potential application of this tool in other areas to control seasonal spikes. Lastly, included are summaries of two rat control technique research projects that were completed during the reporting period. For more details about the OANRP rodent control program see Chapter 6.

Vegetation Monitoring

During this reporting period, OANRP re-monitored priority MU level plant community health monitoring plots for the Kahanahaiki and Makaha MUs. This included installation of new plots in the Makaha Subunit II management unit. An analysis of both these data sets are included as Appendices 1-3 and 1-4, respectively, to this report. OANRP developed a new vegetation monitoring protocol, which utilizes pole-intercept methods, intended for smaller management units. This methodology will be applied at the Kamaili MU over the course of the next year. OANRP also analyzed *Clidemia hirta* weeding trial plots from the Opaeula Lower I MU and results are included as Appendix ES-3. This reporting period, OANRP continued to support a University of Hawaii research project which is comparing satellite imagery, aerial imagery and gigapan robotic technology (Gigapan) for collecting vegetation monitoring data (Appendix ES-4). OANRP continues to use Gigapan to monitor fountain grass and strawberry guava control efforts and has applied gigapan in partnership with the State of Hawaii to monitor *Angiopteris evecta*.

Fire

During this 9-month reporting period, no fires have occurred outside the Schofield Barracks firebreak road from training nor have any fires occurred at Makua Military Reservation. In May 2015, the Army conducted another successful prescribed burn at Schofield Barracks. The burn reduced fuel within the impact area as planned.

Rare Plant Conservation

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. 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.

OANRP has expanded its slug control program every year since 2010 in protection of rare plants. We now protect 24 PU’s from slugs. In 2014-2015, OANRP controlled slugs within eight Management Units (MUs) across an area equal to 4.26 acres, a 33% increase in area from the previous year (3.2 acres).

As of the end of this reporting period, 47 of 100 MIP PUs (47%) and 3 of 12 (42%) PUs for OIP Tier 1 plant species are at or above the stabilization goal for minimum number of mature plants. Due to the abbreviated reporting period, OANRP has not updated or prepared any new rare plant 5-year plans and instead presents a summary of rare plant management statistics and some critical updates for a select few priority taxa (Chapter 3). All data tables are included on the CDs distributed to IT members. During this reporting period, OANRP outplanted a grand total of 2,136 individuals of MIP and OIP taxa. Specifically, 1,491 individuals of seven Makua taxa, 462 individuals of three OIP taxa and 152 individuals of four taxa shared between both IPs were outplanted. In the last year, OANRP made 287 observations at in situ sites of IP taxa and 286 observations at outplanting sites.

Makua Implementation Plan - Executive Summary - Plants

# of Stable IP Population Units: 47 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 2014	# 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	9	53	0%	0%	No	
		Kahanahaiki to Keawapilau	2	1	1	0	5	8	0%	100%	No	
		Makaha	36	36	0	0	37	75	3%	100%	No	
		Makua	11	11	0	0	16	15	17%	100%	No	
		Alectryon macrococcus var. macrococcus Total:	57	51	6	0	67	151				0 of 4
Cenchrus agrimonioides var. agrimonioides	50											
		Central Ekahanui	257	168	89	0	257	20	76%	100%	Yes	
		Kahanahaiki and Pahole	380	319	61	79	465	276	22%	100%	Yes	
		Makaha and Waianae Kai	299	171	128	5	17	12	50%	97%	Yes	
		Cenchrus agrimonioides var. agrimonioides Total:	936	658	278	84	739	308				3 of 3
Cyanea grimesiana subsp. obatae	100											
		Kaluaa	150	128	22	1	164	0	100%	100%	Yes	
		North branch of South Ekahanui	149	83	66	0	165	5	100%	100%	No	
		Pahole to West Makaleha	111	75	36	0	116	46	58%	100%	No	
		Palikea (South Palawai)	144	108	36	1	147	63	65%	100%	Yes	
		Cyanea grimesiana subsp. obatae Total:	554	394	160	2	592	114				2 of 4
Cyanea longiflora	75											
		Kapuna to West Makaleha	272	28	244	2	141	66	48%	100%	No	
		Makaha and Waianae Kai	317	110	207	0	52	4	27%	100%	Yes	
		Pahole	162	58	104	21	131	114	100%	100%	No	
		Cyanea longiflora Total:	751	196	555	23	324	184				1 of 3
Cyanea superba subsp. superba	50											
		Kahanahaiki	257	58	199	113	304	152	100%	100%	Yes	
		Makaha	199	27	172	246	197	0	N/A	100%	No	
		Manuwai	142	0	142	0	173	0	N/A	100%	No	
		Pahole to Kapuna	166	95	71	4	200	170	N/A	100%	Yes	
		Cyanea superba subsp. superba Total:	764	180	584	363	874	322				2 of 4

Makua Implementation Plan - Executive Summary - Plants

# of Stable IP Population Units: 47 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 2014	# Plant In Original Report	% Completed Genetic Storage Requirement	% of Plants Protected from Ungulates	PU Met Goal?	# PU Met Goal
Cyrtandra dentata	50											
		Kahanahaiki	113	37	76	94	123	97	48%	100%	No	
		Kawaiiki (Koolaus)	84	5	79	0	84	50	0%	0%	No	
		Opaeula (Koolaus)	130	23	107	0	125	26	2%	100%	No	
		Pahole to West Makaleha	1273	603	670	281	1273	300	100%	96%	Yes	
		Cyrtandra dentata Total:	1600	668	932	375	1605	473				1 of 4
Delissea waianaeensis	100											
		Ekahanui	219	196	23	0	195	58	86%	100%	Yes	
		Kahanahaiki to Keawapilau	259	240	19	0	280	34	72%	100%	Yes	
		Kaluaa	739	650	89	6	720	44	70%	100%	Yes	
		Manuwai	132	88	44	0	197	0	N/A	100%	No	
		Delissea waianaeensis Total:	1349	1174	175	6	1392	136				3 of 4
Dubautia herbstobatae	50											
		Makaha	29	28	1	0	29	0	48%	0%	No	
		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:	544	532	12	0	544	2000				2 of 3
Euphorbia celastroides var. kaenana	25											
		East of Alau	23	21	2	0	23	26	71%	0%	No	
		Kaena	1475	579	896	0	1475	300	100%	0%	Yes	
		Makua	85	85	0	0	127	40	100%	100%	Yes	
		Puaakanoa	166	150	16	2	181	157	56%	0%	Yes	
		Euphorbia celastroides var. kaenana Total:	1749	835	914	2	1806	523				3 of 4
Euphorbia herbstii	25											
		Kaluaa	0	0	0	0	0	0	N/A	100%	No	
		Kapuna to Pahole	108	56	52	0	92	170	28%	100%	Yes	
		Manuwai	0	0	0	0	0	0	N/A	100%	No	
		Euphorbia herbstii Total:	108	56	52	0	92	170				1 of 3

Makua Implementation Plan - Executive Summary - Plants

# of Stable IP Population Units: 47 of 101

[shaded] = Ungulate Threat to Taxon within Population Unit

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

Plant Taxon	Target # Matures	Population Unit Name	Total Current Mat.+Imm.	Total Current Mature	Total Current Immature	Total Current Seedling	# Plants In 2014	# 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	129	6	123	0	127	32	29%	100%	No	
		Makaha	65	10	55	0	61	4	45%	40%	No	
		Manuwai	35	0	35	0	29	0	N/A	100%	No	
		Ohikilolo	1	1	0	0	1	3	100%	100%	No	
		Flueggea neowawraea Total:	230	17	213	0	218	39				0 of 4
Gouania vitifolia	50											
		Keaau	55	55	0	0	55	0	62%	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:	55	55	0	0	55	0				1 of 3
Hesperomannia oahuensis	75											
		Haleauau	1	1	0	0	1	0	0%	100%	No	
		Makaha	46	3	43	0	27	13	0%	100%	No	
		Pahole NAR	42	4	38	0	50	8	N/A	100%	No	
		Pualii	73	6	67	0	65	0	N/A	100%	No	
		Hesperomannia oahuensis Total:	162	14	148	0	143	21				0 of 4
Hibiscus brackenridgei subsp. mokuleianus	50											
		Haili to Kawaiu	8	5	3	2	8	4	81%	0%	No	
		Keaau	16	0	16	0	27	0	27%	100%	No	
		Makua	88	80	8	0	99	7	69%	100%	Yes	
		Manuwai	170	160	10	0	198	0	N/A	100%	Yes	
		Hibiscus brackenridgei subsp. mokuleianus Total:	282	245	37	2	332	11				2 of 4
Kadua degeneri subsp. degeneri	50											
		Alaiheihe and Manuwai	148	78	70	2	158	60	65%	95%	Yes	
		Central Makaleha and West Branch of East Makaleha	36	23	13	8	36	47	60%	0%	No	
		Kahanahaiki to Pahole	278	147	131	23	278	161	100%	100%	Yes	
		Outplanting site to be determined	0	0	0	0	0	0	N/A		No	
		Kadua degeneri subsp. degeneri Total:	462	248	214	33	472	268				2 of 4

Makua Implementation Plan - Executive Summary - Plants

# of Stable IP Population Units: 47 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 2014	# Plant In Original Report	% Completed Genetic Storage Requirement	% of Plants Protected from Ungulates	PU Met Goal?	# PU Met Goal
Kadua parvula	50											
		Halona	121	93	28	19	121	64	100%	0%	Yes	
		Ohikilolo	257	100	157	5	257	66	100%	100%	Yes	
		To be determined (Ekahanui?)	0	0	0	0	0	0	N/A		No	
		Kadua parvula Total:	378	193	185	24	378	130				2 of 3
Melanthera tenuifolia	50											
		Kamaileunu and Waianae Kai	1061	815	246	274	1061	880	0%	0%	Yes	
		Mt. Kaala NAR	125	121	4	0	70	250	0%	100%	Yes	
		Ohikilolo	1117	1109	8	0	1117	2009	12%	100%	Yes	
		Melanthera tenuifolia Total:	2303	2045	258	274	2248	3139				3 of 3
Neraudia angulata	100											
		Kaluakauila	134	65	69	0	134	0	N/A	100%	No	
		Makua	126	120	6	0	126	29	42%	100%	Yes	
		Manuwai	199	115	84	0	88	12	50%	100%	Yes	
		Waianae Kai Mauka	16	13	3	0	19	46	56%	100%	No	
		Neraudia angulata Total:	475	313	162	0	367	87				2 of 4
Nototrichium humile	25											
		Kaluakauila	208	160	48	0	159	200	2%	100%	Yes	
		Makua (south side)	53	50	3	0	53	138	0%	100%	Yes	
		Manuwai	115	115	0	0	119	0	N/A	100%	Yes	
		Waianae Kai	270	216	54	0	270	200	4%	88%	Yes	
		Nototrichium humile Total:	646	541	105	0	601	538				4 of 4
Phyllostegia kaalaensis	50											
		Keawapilau to Kapuna	0	0	0	0	0	0	100%	100%	No	
		Makaha	0	0	0	0	1	0	N/A	100%	No	
		Manuwai	0	0	0	0	5	0	N/A	100%	No	
		Pahole	0	0	0	0	0	10	100%	100%	No	
		Phyllostegia kaalaensis Total:	0	0	0	0	6	10				0 of 4
Plantago princeps var. princeps	50											
		Ekahanui	239	48	191	0	204	33	84%	100%	No	
		Halona	11	10	1	0	11	50	100%	0%	No	
		North Mohiakea	51	39	12	0	51	30	38%	100%	No	
		Ohikilolo	0	0	0	0	0	14	71%	100%	No	
		Plantago princeps var. princeps Total:	301	97	204	0	266	127				0 of 4

Makua Implementation Plan - Executive Summary - Plants

# of Stable IP Population Units: 47 of 101

(shading) = 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 2014	# 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	135	122	13	0	136	141	2%	2%	Yes	
		Ohikilolo	1675	85	1590	0	1675	473	0%	100%	Yes	
		Ohikilolo East and West Makaleha	334	4	330	0	334	75	N/A	100%	No	
		Pritchardia kaalae Total:	2144	211	1933	0	2145	689				2 of 3
Sanicula mariversa	100											
		Kamaileunu	413	5	408	135	361	26	100%	100%	No	
		Keaau	43	0	43	0	43	141	60%	100%	No	
		Ohikilolo	216	0	216	200	30	162	36%	100%	No	
		Sanicula mariversa Total:	672	5	667	335	434	329				0 of 3
Schiedea kaalae	50											
		Kaluaa and Waieli	171	166	5	0	206	55	100%	100%	Yes	
		Maakua (Koolaus)	10	10	0	0	10	4	40%	0%	No	
		Pahole	228	83	145	47	132	3	100%	100%	Yes	
		South Ekahanui	428	160	268	12	428	85	74%	100%	Yes	
		Schiedea kaalae Total:	837	419	418	59	776	147				3 of 4
Schiedea nuttallii	50											
		Kahanahaiki to Pahole	220	108	112	58	226	65	95%	100%	Yes	
		Kapuna-Keawapilau Ridge	74	74	0	0	113	4	100%	100%	Yes	
		Makaha	111	68	43	0	57	0	N/A	100%	Yes	
		Schiedea nuttallii Total:	405	250	155	58	396	69				3 of 3
Schiedea obovata	100											
		Kahanahaiki to Pahole	1311	283	1028	210	1961	90	100%	100%	Yes	
		Keawapilau to West Makaleha	584	58	526	67	1419	36	100%	95%	No	
		Makaha	198	146	52	13	226	0	N/A	100%	Yes	
		Schiedea obovata Total:	2093	487	1606	290	3606	126				2 of 3
Tetramolopium filiforme	50											
		Kalena	117	24	93	0	117	0	6%	100%	No	
		Ohikilolo	3858	2394	1464	20	3858	2500	14%	100%	Yes	
		Puhawai	30	21	9	2	85	12	80%	0%	No	
		Waianae Kai	20	20	0	0	38	22	0%	0%	No	
		Tetramolopium filiforme Total:	4025	2459	1566	22	4098	2534				1 of 4

Oahu Implementation Plan - Executive Summary - Plants

# of Stable IP Population Units: 12 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 2014	# 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	164	46	118	5	146	44	18%	100%	No	
		Kaawa to Puulu	91	32	59	0	105	124	0%	59%	No	
		Kahanahaiki	78	72	6	0	29	0	100%	100%	Yes	
		Makaha Makai	225	92	133	0	120	100	100%	75%	Yes	
		Abutilon sandwicense Total:	558	242	316	5	400	268				2 of 4
Cyanea acuminata	50											
		Helemano-Punaluu Summit Ridge to North Kaukonahua	272	130	142	0	375	72	8%	0%	Yes	
		Kaluanui and Maakua	249	123	126	50	221	0	0%	0%	Yes	
		Makaleha to Mohiakea	216	151	65	0	228	118	2%	97%	Yes	
		Cyanea acuminata Total:	737	404	333	50	824	190				3 of 3
Cyanea koolauensis	50											
		Kaipapau, Koloa and Kawainui	119	106	13	0	125	76	0%	84%	Yes	
		Opaeula to Helemano	27	23	4	0	24	13	0%	48%	No	
		Poamoho	39	21	18	0	36	12	0%	0%	No	
		Cyanea koolauensis Total:	185	150	35	0	185	101				1 of 3
Eugenia koolauensis	50											
		Kaunala	59	20	39	27	62	141	18%	95%	No	
		Oio	7	5	2	0	12	74	24%	100%	No	
		Pahipahialua	28	22	6	141	28	291	35%	100%	No	
		Eugenia koolauensis Total:	94	47	47	168	102	506				0 of 3
Gardenia mannii	50											
		Haleauau	69	69	0	0	2	2	50%	100%	Yes	
		Helemano and Poamoho	17	17	0	0	8	18	12%	0%	No	
		Lower Peahinaia	10	9	1	0	10	46	10%	67%	No	
		Gardenia mannii Total:	96	95	1	0	20	66				1 of 3
Hesperomannia swezeyi	25											
		Kamananui to Kaluanui	246	134	112	45	246	99	0%	4%	Yes	
		Kaukonahua	109	55	54	2	128	127	0%	0%	Yes	
		Lower Opaeula	39	18	21	0	27	24	0%	0%	No	
		Hesperomannia swezeyi Total:	394	207	187	47	401	250				2 of 3

Oahu Implementation Plan - Executive Summary - Plants

# of Stable IP Population Units: 12 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 2014	# Plant In Original Report	% Completed Genetic Storage Requirement	% of Plants Protected from Ungulates	PU Met Goal?	# PU Met Goal
Labordia cyrtandrae	50											
		East Makaleha to North Mohiakea	335	295	40	0	340	100	18%	88%	Yes	
		Koloa	81	33	48	0	123	0	N/A	100%	No	
		Labordia cyrtandrae Total:	416	328	88	0	463	100				1 of 2
Phyllostegia hirsuta	100											
		Haleauau to Mohiakea	147	71	76	0	132	18	67%	100%	No	
		Koloa	220	97	123	1	129	0	55%	98%	No	
		Puu Palikea	241	114	127	0	204	0	N/A	100%	Yes	
		Phyllostegia hirsuta Total:	608	282	326	1	465	18				1 of 3
Phyllostegia mollis	100											
		Ekahanui	12	11	1	0	76	35	100%	100%	No	
		Kaluaa	130	88	42	0	191	49	100%	100%	No	
		Pualii	11	11	0	0	33	0	100%	100%	No	
		Phyllostegia mollis Total:	153	110	43	0	300	84				0 of 3
Schiedea trinervis	50											
		Kalena to East Makaleha	647	296	351	377	622	376	100%	89%	Yes	
		Schiedea trinervis Total:	647	296	351	377	622	376				1 of 1
Stenogyne kanehoana	100											
		Haleauau	129	0	129	0	0	1	100%		No	
		Kaluaa	204	26	178	0	222	79	100%	100%	No	
		Makaha	130	0	130	0	156	0	N/A	100%	No	
		Stenogyne kanehoana Total:	463	26	437	0	378	80				0 of 3

Rare Snail Conservation

During this reporting period, OANRP continued to maintain the Kahanahaiki and Puu Hapapa predator exclosures and cooperate with SEPP to maintain the Puu Palikea exclosure. SEPP took over the management of the Poamoho predator exclosure in preparation for their Koolau *Achatinella* reintroductions. OANRP and partners continue to monitor population trends for *Achatinella mustelina* within the Kahanahaiki and Puu Hapapa predator exclosures using timed count monitoring. During this reporting period, OANRP's ecosystem restoration program planted *Achatinella* host plant taxa to increase vegetation cover within the Puu Hapapa predator exclosure, a total of 62 host plants for *Achatinella* were outplanted.

At the request of the U.S. Fish and Wildlife Service, OANRP prepared a Tree Snail Monitoring Overview to provide history and background and justification for the OANRP tree snail monitoring strategy. This overview is meant to build off of the monitoring plans presented in the 2014 *Achatinella mustelina* management plan from last year's annual report. The monitoring strategy has been reviewed and commented on by USFWS staff through the years and the current plan includes resulting changes. If the USFWS has suggestions or recommendations regarding this strategy, OANRP look forward to discussing these and amending the monitoring strategy as appropriate.

Table 4 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. The goal is to achieve 300 total snails across all age classes in each ESU. Populations of *A. mustelina* in the MIP have been genetically assigned to one of six ESUs. Up from last year, 6 of the 8 managed field populations have over 300 snails. The ESU-A snail numbers went up substantially likely due to more intensive surveying in order to translocate snails into the Kahanahaiki exclosure. This increase is a reflection of the cryptic nature of tree snails, there are regularly more in a population than can be counted during any one monitoring event.

Table 4. Makua Implementation Plan –Executive Summary – Snails

Achatinella mustelina Evolutionary Significant Unit (ESU)	Population	2014 Snails # Adult	2014 Snails # Sub-adult	2014 Snails # Juvenile	Total 2015	# Snails in 2014	# Snails in 2003 MIP	# of Snails at University of Hawaii Lab	% of Snails in Population Protected from Ungulates	% of Snails in Population Protected from from Rats	Is Population at Goal?	Overall Populations at Goal for Species
ESU A	Kahanahaiki/ Pahole	171	110	55	336	179	105	3	100%	100%	Yes	*6 of 8*
ESU B	B1: Ohikilolo	266	132	61	459	457	300	0	100%	100%	Yes	
	B2: East Makaleha	235	61	8	304	307	40	11	0%	100%	Yes	
ESU C	Lower Kaala NAR/ Schofield Barracks West Range	235	128	29	392	392	50	9	100%	100%	Yes	
ESU D	D1: North Kaluaa to Schofield Barracks South Range	294	188	49	531	380	86	0	100%	100%	Yes	
	D2: Makaha	155	52	6	213	210	17	1	100%	100%	No	
ESU E	Ekahanui	140	43	9	192	171	12	11	100%	95%	No	
ESU F	Puu Palikea	264	121	73	458	430	40	0	93%	100%	Yes	
Totals					**2,885**	**2,526**	**650**	**36**				***6 of 8***

Rare Vertebrate Management

In 2015, OANRP controlled rats to protect 98 pairs of Oahu Elepaio (*Chasiempis ibidis*). The BO requires the protection of 75 pairs, therefore, OANRP met this requirement. The documented fledgings from managed pairs this year numbered 50 which is down from last year's number. Weather may be the cause of a less productive breeding season this year. This may be the result of numerous high wind events during the nesting season. The number of rats caught was higher at all managed Elepaio sites than in 2014. Based on data from other rodent control projects where tracking tunnels are employed, rat populations spiked in 2015 which may be one explanation for the increase in rats captured. At some sites, such as Schofield, OANRP asked our rat control contractor to reset traps twice during the one week/month of access. Therefore, the increases in rats caught at Schofield must be looked at using rats caught per trap night to determine what this increase can be attributed to. In addition, at Palehua, OANRP converted rat control from a territory based system to trapping in a grid design so the spike in captures here could be due to trap relocation and distributional change rather than rat population increases. OANRP installed automatic traps in Schofield for the 2015 breeding season to compensate for access limitations. OANRP will continue to adapt rodent control approaches in order to maximize protection. The total required access dates were met during the calendar year but were not distributed ideally for Elepaio management. For more information, see the Rare Vertebrate Management Chapter 4.

Over the past year, nene geese (*Branta sandvicensis*) were not observed once in July at Wheeler Army Airfield. The male nene bird died during the past year, therefore, only the family of three, mom and her two offspring were observed. 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 4.

Acoustic monitoring for the Hawaiian hoary bat was expanded this year to include the majority of Army installations on Oahu. A total of 30 detection stations are being monitored for one year by U.S. Geological Survey staff and OANRP. In early September 2015, an official Garrison policy was signed that formalizes a tree cutting moratorium during the bat pupping season each year. This new policy is included as Appendix 4-2. During this reporting period (the month of June), prior to this policy being signed, OANRP was tasked to survey trees for roosting bats that required cutting, pruning or denutting because of safety issues. OANRP conducted five bat surveys to clear trees for removal or pruning, spent 18 of hours was spent by OANRP conducting these surveys. Forty-one trees were surveyed and zero roosting bats were found. OANRP expect that during the next pupping season, emergency tree removal and trimming requests will be drastically reduced. For more information, see the Rare Vertebrate Management Chapter 4.

Insect Mangement

During this reporting period, OANRP focused efforts on regular monitoring of known *Drosophila* populations designated in last year's report at 'manage for stability'. 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 5. Additionally, 75 plants of various native species were planted into Palikea for habitat restoration of the *Drosophila* site. Also, 50 *Urera glabra* were planted at each of four selected *Drosophila montgomeryi* sites. 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 BA.

In anticipation of the likely listing of Hawaiian *Hylaeus* bee taxa as endangered within the next few years, OANRP supported its entomologist's involvement in a pilot reintroduction of *H. anthracinus*. Many of the techniques involved in conducting this project may be applied to listed Oahu *Hylaeus* which may become the Army's responsibility to stabilize. Appendix ES-5 is a summary of the first large reintroduction effort with *Hylaeus* in Hawaii. Lastly, Appendix ES-6 is a discussion of *Megalagrion xanthomelas*, which was recently rediscovered on the grounds of Tripler Army Medical Center.

OANRP was also involved in a cooperative effort during this reporting period to locate a translocation site for *Megalagrion xanthomelas* from Tripler Army Medical Center (TAMC). It is anticipated that this taxon will be listed as an endangered species by Fall of 2016. The intent is to conduct a transloction before it is proposed endangered, Fall 2015, and bureaucratic processess become more onerous. The State of Hawaii has taken the lead on researching species' biology, gathering information and pursuing permission for conducting another trial translocation. The Army is an active participant in these efforts. For a summary of these efforts see Chapter 5.

OANRP is a cooperator in control and detection efforts for coconut rhinoceros beetle (CRB) and the little fire ant (LFA) on Oahu. There are no known breeding population 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 has established an official Garrison policy for preventing the LFA from establishing at Army controlled lands. 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. The new policy is included as Appendix 7-1. This financial hook will hopefully prevent contractors from using contaminated nurseries as plant sources. For more information on these efforts review Chapter 7.

Research

During this reporting period, OANRP funded numerous research projects related to management of MIP and OIP taxa and in house research projects continue. The OANRP Research Specialist conducted a project in support of the upcoming Sluggo© special local needs permit renewal. This research involved quantifying the effect of slug control on the survivial of the endangered plants, *Delissea waianaensis* and *Cyanea superba* ssp. *superba*. Though not statistically significant, higher numbers of *D. waianaensis* seedlings and greater survival of *C. superba* ssp. *superba* were found in the slug control plots. The results of this project are presented in Chapter 7. In addition, the Research Specialist tested three herbicides on large patches of *Blechnum appendiculatum* to identify the most suitable control options. These research results are presented in Chapter 1.

For tree snail management, OANRP continued to fund the captive *Achatinella* propagation program at the University of Hawaii (UH) Tree Snail Laboratory (Lab). Results of this work are included in Appendix ES-7. Also included in Appendix ES-7 are results of reptile and amphibian predator studies conducted in Dr. Brendan Holland's laboratory. In addition, OANRP funded a molecular systematic assessment of *Achatinella mustelina* diet using snail feces and host plant leaves. A summary of research results obtained during this reporting period are included as Appendix ES-8A. Also included as Appendix ES-8B is a draft manuscript summarizing snail feeding preference studies and their relevance to *Achatinella* captive rearing. Lastly, related to tree snails, OANRP funded genetics work to elucidate climate associated adaptations and to relate this information to management of wild field populations. A summary of this work is presented in Appendix ES-9.

In support of the rare plant program, OANRP are also funding a population viability analysis for three IP rare plant taxa using demographic modeling. The project proposal for this work and a summary of work conducted during this reporting period are included as Appendix ES-10. OANRP also conducted a preliminary in-house trial to assess germination rates of seeds from senesced versus fresh *Cyanea superba* subsp. *superba* fruit. The results of this trial have interesting implications on the importance of fruit dispersal for this taxon and are included as Appendix ES-11. In addition, OANRP funded the National Center for Genetic Resource Preservation to conduct research with dessication-sensitive seeds of IP taxa. Lastly, OANRP continue to conduct ground-breaking in-house research on pollination biology, fruit collection, seed viability, germination and storage.

Research funded by OANRP in support of the Ecosystem Management Program included the work of Dr. Paul Krushelnycky, who is studying the impacts of rodents on native arthropods. His research is conducted at two sites within the Waianae Mountains where OANRP maintains large-scale snap trap rat control grids. He published a paper based on the arthropod monitoring conducted in Kahanahaiki and Palikea it can be found at http://manoa.hawaii.edu/hpicesu/DPW/PEC-2015/2015.pdf. A report on this project can be found at Appendix ES-12. In addition, OANRP funded research to determine the importance of mycorrhizal fungi on the successful outplanting of native plants within management units. This research will be continued in the coming year in a trial of pot-bound plants ground in media containing various mixes of soil microbes. A summary of this year's research results are included as Appendix ES-13.

OANRP also funded research regarding the affect of an invasive ant *Solenopsis papuana* on native arthropods. This research will provide insight as to the significance of this particular ant taxon as a limiting factor for endangered *Drosophila*. An update on this project is include as Appendix ES-14.

TABLE OF CONTENTS

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: ECOSYSTEM MANAGEMENT

Notable projects from the 2014-2015 reporting year are discussed in the Project Highlights section of this chapter. This reporting year covers 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. Ungulate control, outreach program, and weed control 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).

1.1 UNGULATE CONTROL PROGRAM

The Oahu Army Natural Resources Program (OANRP) has ended the fence construction phase of its management program and focusing more energy on ecosystem management; redirecting the focus from construction to managing the existing fence units. OANRP has transferred management of some Manage for Stability (MFS) 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 is focusing its 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 fences not being built are listed in the table below.

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

As a result of the refocus of efforts, as of December 31, 2014, OANRP no longer staffs an in-house fencing crew. Rather, OANRP will focus on working within partnerships to contract fence construction projects together (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. OANRP has developed two ungulate management technician positions whose management focus will be fence monitoring/maintenance and ungulate control work. One position has been filled, but we are still looking for a qualified interested person to fill the second.

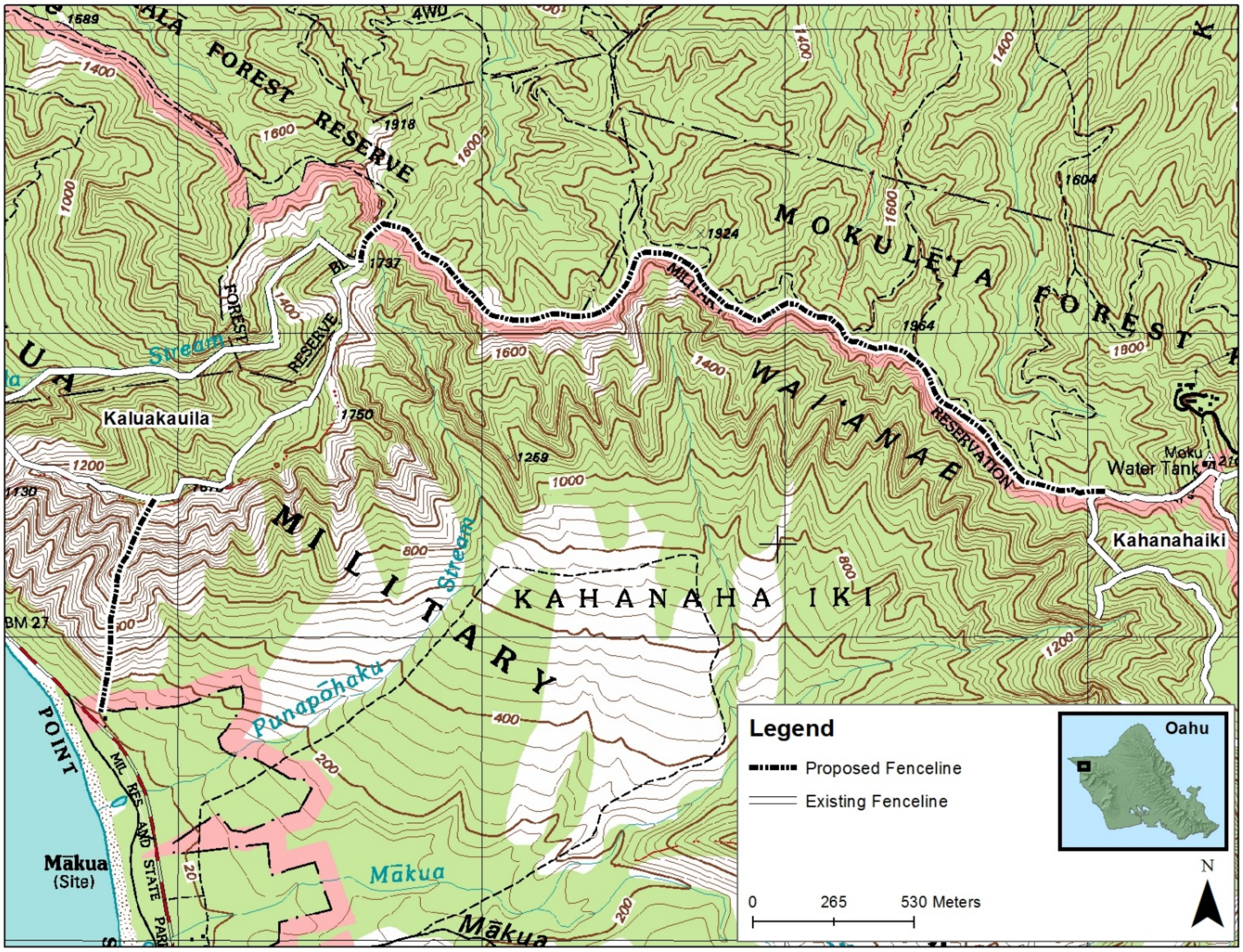


Figure 1.1 Map of fence construction in Northern Waianae's

Summary

- The final project for the OANRP in-house fence crew was to complete the north line of Poamoho (1500m). This section of fence connects to the larger Poamoho Unit (about 640 acres) that the DOFAW Natural Area Reserve System constructed. They were able to finish that project before their last day. They also scoped the strategic section of fence at Ekahanui and determined that the original determination that pigs could not pass through was correct.

- OANRP contracted out the construction of the northern Makua rim fence (Figure 1.1). The contractor completed the section between Kahanahaiki and Kaluakauila (3323 m). In April 2015 there was an accident in Makua where a grass cutting contractor was injured by detonation of UnExploded Ordnance. This resulted in the training area being shut down while an investigation was completed and mitigation measures could be determined so that accidents such as this may be avoided. As of 1 August fence construction was able to begin anew to complete the final section that runs from Kaluakauila to Farrington Highway (1000 m). All totaled, about 4,000 meters of new fencing was built during the reporting year. With the completion of this final section of fencing, all of Makua will be fenced. This will complete the terms and conditions laid out in the 2007 Makua Biological Opinion, ". Construction of an ungulate-proof fence encircling the Makua Military Reservation installation boundary will be completed within three years of the data of completion of this Biological Opinion"

- OANRP is proposing to finish the Northern rim of Makua Valley, replace about 200 m of skirting and 400 m of fencing on the Opaeula/Helemano line and the lowest 2000 m of fencing along the Ohikilolo ridge in Makua by the end of the next reporting period.

- Opaeula Lower I and Makaha Subunit II had pigs breach the perimeter fences. At Opaeula Lower I the fence was reinforced with a mix of skirting and fickle wire, a type of plastic coated chicken wire. Four small pigs were removed using a combination of snares and conibear traps. In Makaha, one pig was able to squeeze into the fence. OANRP first tried to push the animal out a hole in the fence but to no avail. Finally, WMWP came in with a few dogs and removed it very quickly.

- Pig eradication efforts continued in Lihue MU. To date, a total of 537 pigs have been removed. 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 it that much more difficult to capture them. Efforts are focused on increasing coverage in areas minimally covered 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 can only run those traps during the range maintenance week available each month.

OIP/MIP Management Unit Status

The MU status table below shows the current status of all proposed and completed fence units 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, ungulate free, identifies how many acres are protected versus how many were proposed in the Implementation plan, and the year the fence was or is expected for completion. Fences for which a Conservation District Use Permit (CDUP), Cultural 106, MOU, ROE or RA, or a License agreement has been acquired 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 PU's. The MFS PU's are divided by taxa P (Plants), I (Invertebrates) and V (Vertebrates) The table also contains notes which give the highlights and status from 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 Propose	CDUP	106	MOU/ ROE/ RA	Lic. Agr.	# MFS PUs MIP P	MIP I	OIP P	OIP I	OIP V	Notes	Current Threats
ARMY LEASED AND OWNED LANDS																
Kahanahaiki	Kahanahaiki I	Yes	Yes	64/64	1998					9	1	1			Complete and ungulate free	None
	Kahanahaiki II	Yes	Yes	30/30	2013		X								Fence is complete and ungulate free	None
Kaluakauila	Kaluakauila	Yes	Yes	104/104	2002					5					Complete. Fence is in need of some repair but still pig-free.	None
Opaeula Lower	Opaeula Lower	Yes	Yes	26/26	2011	X	X		X	1		1	1		Fence is complete and ungulate free.	None
Ohikilolo	Ohikilolo	Partial	No	3/574	2002 2014		X			14	1				Ohikilolo ridge fence is complete. Six PU fences are also complete and ungulate free. Since July 2006, 20 goats have been able to breach the fence,a couple may still be inside but OANRP have not observed them since they were seen originally. The Northern Makua rim section is almost complete, completing the 2007 BO terms and conditions.	Pig/Goat
Ohikilolo Lower	Ohikilolo Lower	Yes	Yes	70/70	2000					3					This strategic fence is complete. A portion of the fence was repaired after rock-falls.	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																
East Makaleha	East Makaleha	No	No	0/231	Cancelled	X	X			2	1		1		High priority fenceline for WMWP. OANRP may construct PU sized fences for PUs that could not be managed within existing MU fences.	Pigs and Goats
	West of East Makaleha	No	No	0/3	TBD	X									A PU fence has been proposed but is being deferred for now. A partnership fencing effort with the Snail Extinction Prevention Program may be a possibility. Permission from Oahu Branch required.	
Ekahanui	Ekahanui I	Yes	Yes	44/44	2001	X				6	1	2		1	Completed by TNCH and ungulate free.	None
	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
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

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		
	Keaau III	No	No	4/33	2015	X	X	X							Fence being constructed 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
Napepeiauolelo	Napepeiauolelo	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.	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 and NAR staff believes it is ungulate free.	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	Yes	Yes	1/1	2011	X	X	X							Complete. Fence is continuously damaged by rock falls. OANRP is assessed the cost/benefit to maintaining management at this site and decided to move management to Kamaili unit.	None
West Makaleha	West Makaleha	Yes	No	7/11	2001 2016	X	X	X		5					The *Schiedea obovata* and *Cyanea grimesiana* subsp. *obatae* PU fences are complete and pig free. OANRP has proposed to extend *C. grimesiana out to include more Cyrtandra dentate* MFS plants in 2016.	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
	Kamaileunu/ Waianae Kai	No	No	0/1	Cancelled	X			X	4		1			This fence will not be constructed due to the terrain and safety concerns for staff. DLNR is still working on a goat management plan that will include aerial shooting to reduce the population here.	Pigs and Goats
Makaha	Makaha I	Yes	Yes	85/96	2007					8	1				Complete and ungulate free.	None
	Makaha II	Yes	Yes	66/66	2013	X	X		X	5		1			Complete and ungulate free	None
DOLE FOOD COMPANY, INC.																
Alaiheihe and Kaimuhole	Alaiheihe and Kaimuhole	No	No	0/100	Canceled	X				1	0	1			Landowner is unwilling to allow fences built so this fence will not be constructed.	

OIP Management Unit Status

Management Unit	Management Unit Fence	Fenced	Ung Free	Acreage Current/ Proposed	Year Complete or Propose	CDUP	106	MOU/ ROE/ RA	Lic. Agr.	# MFS PUs MIP		OIP			Notes	Current Threats
										P	I	P	I	V		
ARMY LEASED AND MANAGED LANDS																
Kaala-Army	Kaala	Partial	No	183/183	2008		X					4	1		Strategic fences complete. Three pigs were caught in 2014, the first since 2010. A line has been scoped for the Waianae Kai side and 106 surveys complete. OANRP is pursuing construction of this fence.	Pig
Kaunala	Kaunala	Yes	Yes	5/5	2006		X					1			Complete and ungulate free.	None
Kawaiiki I/II	Kawaiiki I/II	No	No	0/11	Cancelled	X			X						There are no tier 1 taxa therefore it will not be built until the Army trains in a way that may impact Tier 2 and 3 taxa.	
Kawailoa	Kawailoa	No	No	0/7	Cancelled	X	X		X			1			Army training does not impact this tier 1 species	
Lihue	Lihue	Yes	No	1800/980	2012		X			3	1	6			Completed. Encompasses six PU fences and original three proposed units. A total of 537 pigs have been removed. There are very few pigs left in unit.	Pig
Poamoho	Poamoho Lower	No	No	0/156	Cancelled	X	X		X			1			Species management be relocated to Poamoho NAR fence.	
	Poamoho Upper	No	No	0/60	Cancelled	X	X		X						There are no tier 1 taxa therefore it will not be built until the Army trains in a way that may impact Tier 2 and 3 taxa.	
Opaeula Lower II	Opaeula Lower II	No	No	0/24	Cancelled	X			X						Army training does not impact this tier 1 species	
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. Contractors are working on completing necessary repairs	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 2015. The Tier 1 taxa *Hesperomannia swezeyi* occurs within this MU.	Pig
	South Kaukonahua II	No	No	0/.5	Cancelled		X								There are no tier 1 taxa therefore it will not be built until the Army trains in a way that may impact Tier 2 and 3 taxa.	
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
Kaipapau	Kaipapau	No	No	0/273	Canceled	X						2			OANRP has shifted PU efforts from Kaipapau to other existing MUs.	Pig
Manana	Manana	No	No	0/19	Cancelled	X	X								OANRP is managing *Labordia cyrtandrae* within the Koloa MU as the wild plant found at Manana died.	Pig

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		
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 that although not highly probable, is possible could breach the unit	Pig
North Kaukonahua	North Kaukonahua	No	No	0/31	Cancelled	X	X	X				1			OANRP is partnering with the State to build a larger unit encompassing large amounts of suitable habitat.	Pig
Poamoho	Poamoho Lower II	Yes	No	5/5	2014	X	X	X				1			OANRP is partnering with the State to build a larger unit encompassing this unit. OANRP is almost completed with construction of the North line.	Pig
	Poamoho Pond	Yes	No	18/18	2014	X	X	X							Included in the Poamoho Natural Area Reserve fence	Pig
	Kaukonahua-Punaluu	No	No	0/2	Cancelled	X	X	X							There are no tier 1 taxa therefore it will not be built until the Army trains in a way that may impact Tier 2 and 3 taxa.	Pig
Wailupe	Wailupe	No	No	0/22	Cancelled	X									There are no tier 1 taxa therefore it will not be built until the Army trains in a way that may impact Tier 2 and 3 taxa.	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.																
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.	Pig
	Waiawa II	No	No	0/136	Cancelled	X			X						Army training does not impact these tier 1, 2 and 3 taxa	Pig
STATE OF HAWAII DEPARTMENT OF TRANSPORTATION																
North Halawa	North Halawa	Partial	No	.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 Schkaa 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	No	No	120/4	2015	X									U.S. Fish and Wildlife Service is building a 120 acre unit at this moment.	Pig

1.2 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.

Highlights from the 2015 reporting year are discussed below. See Appendix 1-1 for photos and examples of outreach materials and articles.

Volunteers

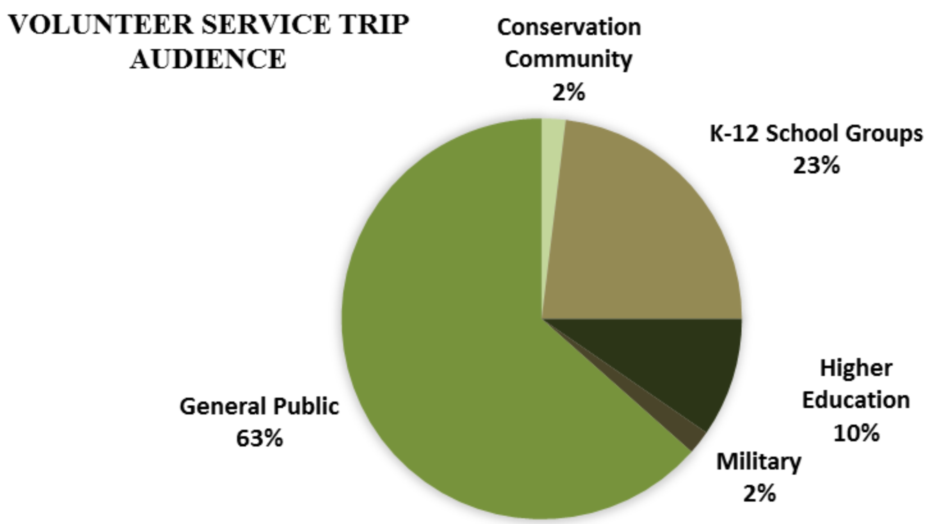
During the reporting period the outreach program continued to coordinate and lead an average of six volunteer trips each month and successfully met volunteer weeding goals. Additional projects at the two OANRP baseyards continue to receive support from a few of the program's most dedicated volunteers.

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. For 2015, only nine months of the year's data have been included, while previous years included 12 months. This reporting period also excludes volunteer hours from the Hawaii Youth Conservation Corps summer program, which will be included in the report for 2016.

Report Year	Total Volunteer Hours for Field Days*	Total Volunteer Hours at Work Site**	Total Volunteer Trips	Total Baseyard Volunteer Hours***
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.*

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.



Outreach staff expanded their weeding efforts by developing additional volunteer projects at appropriate locations within the Palikea, West Makaleha, and Pualii MUs.

The greatest volunteer effort continues to focus on controlling a variety of incipient and invasive weeds at the Kaala MU. A large portion of volunteer time this reporting year has also been spent within the Palikea and Kahanahaiki MUs.

The table below summarizes volunteer service trips by location.

Volunteer service for reporting period 2015

Management Unit	Projects	Management Actions
Kahanahaiki	Invasive weed control	6
	Trail maintenance	1
	Incipient weed control	1
	Revegetation projects	2
Kaala	*Sphagnum* moss control	6
	Other incipient weed control	9
	Invasive weed control	5
	Revegetation projects	3
Makaha I	Invasive weed control	4
	Waianae High School Field Day	1
Palikea	Incipient weed control	5
	Invasive weed control	7
West Makaleha	Invasive weed control	2
Kaluaa	Invasive weed control	6
Pualii	Invasive weed control	3

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

- Maintained a volunteer database of 1,893 total volunteers 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 24, which included the design and construction of a volunteer glove drying rack, bench, interpretive garden improvement and educational signage. The Scouts completed the project on March 28 and volunteered a collective total of 110 hours.

Internships and Temporary Staff

Outreach staff developed internships at OANRP and with cooperating agencies. Outreach staff coordinated the first day of orientation and various trainings for all interns. Field teams coordinated subsequent orientation days in the field.

Internship opportunities provide valuable natural resource management training for the next generation of conservationists and give participants the opportunity to experience terrestrial field work. Bulleted points below highlight outreach staff efforts with the interns and temporary staff.

- Evaluated and scored 36 applicants, interviewed seven applicants and awarded five 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 one applicant, and awarded that individual with a three-month, Pacific Internship Program for Exploring Science (PIPES) internship with OANRP. Intern was tasked with conducting specialized weed control projects under the Ecosystem Restoration Program.

- Hosted a 10-month AmeriCorps intern with OANRP. The intern worked with each of the three natural resource field crews and participated in projects with program specialists.

See Appendix 1-1 for photos of interns and temporary staff.

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:
  - Predator Tracking Game
    - PURPOSE: Inform K-12 students about presence of introduced predators in Hawaii and how OANRP monitors and controls predator activity in MUs
  - Prevent Extinction Color-in Button
    - PURPOSE: Engage K-12 students in conversations about endangered species, specifically Oahu elepaio, mao hau hele (the state flower, *Hibiscus brackenridgei*) and kahuli tree snails.

- Brochures & Flyers:
  - Hawaiian Hoary Bat Brochure
    - PURPOSE: Inform general public about the endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*) and OANRP's management efforts in MUs
- Presentations:
  - Officer-in-Charge/Range-Safety-Officer USAG-HI Range Safety Briefing
    - PURPOSE: Revised Natural Resource Section of the OIC/RSO Range Brief to enable staff from Range Division-Hawaii to give presentation
- Other:
  - Nene Goose Observation Form
    - PURPOSE: To provide USAG-HI (contractors, civilians, enlisted personnel) a means to report Nene geese observations on Oahu to OANRP staff
  - Cover design for OANRP Helicopter Safety and Management Plan

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. Additionally, staff developed a new Range Brief Presentation for Range Safety Officers to give at bimonthly Range Briefs, reducing the presentation load on OANRP staff.

Event	**Description**	**Number of presentations**	**Number of People Served**
Range Brief Presentation: "Environmental Requirements"	A 20-minute brief on natural resource considerations on training lands.	9	509

Environmental Compliance Officer (ECO) training presentation: “Protecting Natural Resources”	A one-hour presentation for the ECO training courses held at Schofield Barracks.	6	169
Training Area Presentation: “Protecting Natural Resources in Makua”	A 15-minute presentation on natural resource considerations at Makua Military Reservation (MMR).	3	218
Total number of people served:			**896**

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. See Appendix 1-1 for photos.

- Total number of outreach activities = 22
- Total number of people served (approximated) = 3,214

Outreach activities for FY 2015

<table>
<tr><th>Event</th><th>Estimated # of People Served</th><th>Audience</th></tr>
<tr><td>Volunteer Appreciation Hike</td><td>4</td><td rowspan="3">general public</td></tr>
<tr><td>Hawaii Invasive Species Awareness Week Kickoff Event</td><td>10</td></tr>
<tr><td>Hawaii Agriculture and Environmental Awareness Day</td><td>100</td></tr>
<tr><td>Leeward Community College STEM Class</td><td>25</td><td rowspan="11">higher education</td></tr>
<tr><td>Windward Community College Botany Class Presentation</td><td>12</td></tr>
<tr><td>University of Hawaii Natural Resource and Environmental Management Presentation</td><td>40</td></tr>
<tr><td>Windward Community College Environmental Science Class Presentation</td><td>8</td></tr>
<tr><td>Hawaii Pacific University Natural Resource Management Class Presentation</td><td>14</td></tr>
<tr><td>Windward Community College Botany Class Presentation</td><td>18</td></tr>
<tr><td>University of Hawaii Geography Club Nursery Tour</td><td>3</td></tr>
<tr><td>University of Hawaii Natural Resource and Environmental Management Presentation</td><td>20</td></tr>
<tr><td>Nonacademic careers in Ecology, Evolution and Conservation Biology: Q&A with State and Federal biologists</td><td>45</td></tr>
<tr><td>Kupu Environmental Fair</td><td>150</td></tr>
<tr><td>Leilehua High School Career Day Presentation</td><td>42</td><td>K-12</td></tr>
</table>

Spot the ant, Stop the ant: Information on two new pests affecting Hawaii, the Coconut Rhinoceros Beetle and the Little Fire Ant	500	military
Nene Brief at Wheeler Army Air Field	10	
Applause for Paws (USAG-HI Pet Awareness Event)	200	
Schofield Fun Fest	800	
Schofield Earth Day	500	
Fort Shafter Earth Day Festival	500	
Hale Kula Elementary "Build a Forest" presentation*	105	
Hale Kula Field Trip to OANRP Baseyard*	100	
Wheeler Intermediate School Career Fair*	63	
Hawaii Botanical Forum Field Trip	10	Conservation community
Total Number of People Served	**3,214**	

**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, one staff presented at the 2015 Pacific Biosecurity conference and four staff presented at the first annual Hawaii Botanical Forum. These and other presentations are listed in the table below. Other conferences fell outside of the reporting period for 2015 and will be included in the 2016 report.

Presentation Title	Format	Author/leader name(s)	Venue	Date
The Distribution of *Solenopsis papuana* in the Waianae & Koolau mountains*	Poster presentation	Ogura-Yamada, C.S. and P.D. Krushelnycky	Pacific Biosecurity: Protecting What Matters Most	1-Apr-15
Sierola (Hymenoptera: Bethylidae) and the evolution of hyperdiverse lineages in Hawaii	Oral presentation	Magnacca, Karl N.		1-Apr-15
Ecology of some of the less-celebrated invasive ants in Hawaiian forests*	Oral presentation	Krushelnycky, Paul D.		1-Apr-15
Considerations for in situ harvesting of fruits of rare plants	Oral presentation	Weisenberger, Lauren	Hawaii Botanical Forum	9-Oct-14
Propagule selection for ex situ storage strategies of rare plants	Oral presentation	Keir, Matthew		9-Oct-14
Rare Taxa Management: Habitat Restoration and Weed Control Issues	Oral presentation	Beachy, Jane		9-Oct-14
Monitoring Protocols and Hawaii Rare Plant Restoration Group Monitoring Forms	Oral presentation	Kawelo, Kapua		9-Oct-14

**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 (see Appendix 1-1 for examples). The table below is a summary of all media and publications relating to OANRP management in 2015.

Media coverage and publications in FY 2015

Title	Author	Publication	Date	Format
Volunteers Help Protect Makua Endangered Plants	Kimberly Welch	Hawaii Army Weekly (http://www.hawaiiarmyweekly.com/2014/10/04/volunteers-help-protect-makua-endangered-plants/)	04-Oct-2014	News article
Remants of populations provide effective source material for reintroduction of an endangered Hawaiian plant, *Schiedea kaalae* (Caryophyllaceae)	Weisenberger, L.†, S.G. Weller and A.K. Sakai	American Journal of Botany 101(11): 1954-1962	24-Oct-14	Scholarly journal article
Youth 'build' a forest, environmental awareness	Celeste Hanley	Hawaii Army Weekly (http://www.hawaiiarmyweekly.com/2015/02/26/youth-build-a-forest-environmental-awareness/)	26-Feb-15	News article
Notes on native and alien Hymenoptera and Diptera (Insecta) from the Hawaiian Islands	Karl Magnacca	Bishop Museum Occasional Papers	11-May-15	Scholarly journal article
Post works to oust pesky coconut rhinoceros beetle	Stephanie Joe	Hawaii Army Weekly (http://www.hawaiiarmyweekly.com/2015/05/14/post-works-to-oust-pesky-coconut-rhinoceros-beetle/)	14-May-15	News article

†*Denotes OANRP staff for co-authored articles*

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.

- Volume 60, Issue 2 – Arthropods
- Volume 60, Issue 3 – Research

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 FY2015 at the end of September 2015, when we report their service hours to the Corporation for National and Community Service. Volunteers who were eligible to receive President's Volunteer Service Award in FY2014 were honored with an 'elepaio interpretive hike at Palehua with OANRP's avian specialist on March 31.

See Appendix 1-1 for photos and samples of outreach materials and articles.

1.3 WEED CONTROL PROGRAM

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 4,654 hours controlling weeds across 325.9 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 five reporting cycles. Note that all other reporting periods were 12 months in length, while only nine months are discussed in this year's report.

Report Year	Effort (hrs)	Area (ha)
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.

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 in 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 about 61 taxa in 235 ICAs, and considers eradication to have been achieved at 9 ICAs.

Of the total 325.9 ha swept, ICA efforts covered 245.6 ha. Staff spent 1,537 hours on ICA management and conducted 333 visits to 148 ICAs. This is the greatest area managed for incipient weeds in a reporting period to date, despite the fact that this period is three months shorter than previous years; see table below. This increase is due to additional focus on conducting sweeps and control for several priority taxa, including *Chromolaena odorata*, *Schizachyrium condensatum*, and *Erythrina poeppigiana*. This year, ICA work accounted for 75% of the total area controlled and 33% 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 (hrs)	Area (ha)
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* ICAs, 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.

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.

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 is *Sphagnum palustre*, which is highly invasive, but is not located in direct proximity to IP taxa. Volunteer time allows staff to focus on *Hedychium gardnerianum*, which directly threatens rare plants and their habitat, while maintaining focus on less immediate threats, including *S. palustre, Juncus effusus*, and *Crocosmia crocosmiiflora*.

The ten MUs where most ICA effort was spent are highlighted in the table below. Note that effort hours do not include travel or trip preparation, or time spent surveying outside of known ICA boundaries to define infestation areas.

2015 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*	66	505.95	As predicted, the majority 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 almost 90% of time spent at KTA. Hours recorded here do not include hours spent by OISC, which are included in Appendix 1-2.
SBE No MU	8	*Buddleja madagascariensis* *Cenchrus setaceus* *Chromolaena odorata* *Heterotheca grandiflora* *Rhodomyrtus tomentosa* *Schizachyrium condensatum* *Smilax bona-nox* *Vitex trifolia*	44	270.8	Most of the effort at SBE this year was used towards surveys and control of *Schizachyrium*. Much of the Range has been surveyed, and it appears that this grass sticks to its preferred open habitat, including heavily used LZs. Control efforts are complicated by LZ maintenance (mowing). The biggest find this year was a small population of 15 *Chromolaena*, discovered while conducting *Schizachyrium* surveys. This appears to be an isolated population, and no plants have been seen since February 2015.
Kaala Army	6	*Anthoxanthum odoratum* *Crocosmia* x *crocosmiiflora* *Festuca arundinacea* *Juncus effusus* *Pterolepis glomerata* *Setaria palmifolia* *Sphagnum palustre*	30	216	Staff work with volunteers to control most of the *Crocosmia, Juncus,* and *Sphagnum* ICAs. *Sphagnum* control efforts in particular have been very successful, and fewer trips are needed to cover the same amount of area. Unfortunately, several new ICAs (*Sphagnum, Pterolepis, Juncus*) were found on the transect trail this year; it is likely these were spread by staff or hikers.

MU	# of Taxa	Taxa List	# of Visits	Effort (hrs)	Comments
Lihue	1	*Erythrina poeppigiana*	5	110.5	The temporary ecosystem restoration crew conducted buffer surveys around this infestation, delimiting the boundaries of the ICA. In addition, crews cleared understory weeds to allow for easier detection of young *Erythrina*. Mature trees continue to be challenging to kill, and require multiple treatments.
Kaala NAR	5	*Crocosmia* x *crocosmiifolia* *Diplazium esculentum* *Juncus effusus* *Pterolepis glomerata* *Sphagnum palustre*	21	88.8	Staff assisted NEPM staff with treatment of *Sphagnum* both along the boardwalk, and in the core of the infestation. Control efforts of *Pterolepis* at the shelter have been successful thus far, with no plants found last year. Volunteers continue to assist with control efforts of *Crocosmia* and *Juncus*.
SBW No MU	1	*Chromolaena odorata*	16	72.5	Control of *Chromolaena* at SBW is a high priority. A combination of ground and aerial treatment was used to cover a large portion of the infestation. Fortunately no new outlier sites were found this year.
Ohikilolo Lower	1	*Cenchrus setaceus*	6	72.2	This year a combination of ground control and aerial sprays were conducted at the *Cenchrus* infestation. Control efforts were hampered by the closure of MMR following a safety incident on the Range. Aerial operations were able to continue, but ground operations have been halted until the Range is reopened.
Palikea	2	*Crocosmia* x *crocosmiiflora* *Dicliptera chinensis*	10	51.6	The majority of time was spent on *Crocosmia* control, and utilized volunteer labor. One new *Dicliptera* location was discovered this year.
Kahanahaiki	7	*Angiopteris evecta* *Dicliptera chinensis* *Ehrharta stipoides* *Elephantopus mollis* *Pterolepis glomerata* *Rubus argutus* *Triumfetta semitriloba*	32	40.73	Control work on *Ehrharta* continues to be the focus at Kahanahaiki, and additional new locations were discovered this year. Seed studies suggest that this taxon does not form a persistent seed bank, suggesting that intensive control may pay off in successful eradication. *Elephantopus* was found for the first time here. A common trailside weed elsewhere on Oahu, staff hope to eradicate it from Kahanahaiki.
Kaluaa and Waieli	8	*Angiopteris evecta* *Arthrostemma ciliatum* *Casuarina equisetifolia* *Clusia rosea*	18	38.15	These numbers include ICA control in both Kaluaa and Waieli MU and Kaluaa No MU. Efforts have been successful at suppressing some ICAs, with no plants found this year at ICAs for

MU	# of Taxa	Taxa List	# of Visits	Effort (hrs)	Comments
		Dovyalis hebecarpa			*Arthrostemma, Casuarina*, *Clusia,* and *Dovyalis*.
		Ehrharta stipoides			
		Morella faya			
		Solanum capsicoides			

The table below highlights the taxa which required the most control effort in the past year.

ICA Target Taxa

Taxa	2015 Effort (hours)	2014 Effort (hours)	Comments
Chromolaena odorata	524.6	418.6	*Chromolaena* continues to be OANRP's top ICA priority. Staff efforts include treatments of hotspots, large sweeps, and aerial spraying; see discussion section 1.8 below. OANRP continued to contract OISC to conduct work across half of the KTA infestation; see Appendix 1-2 for OISC's progress report.
Schizachyrium condensatum	190.95	108	SBE remains the only location on Oahu with *Schizachyrium*. Efforts to fully delimit the boundaries of the infestation continued this year. Areas of likely habitat were identified using GIS imagery and systematically surveyed. Fortunately, few plants were found outside of the known infestation areas, although one new ICA was identified in August 2015. Control efforts are ongoing. Coordination with range maintenance staff will be critical to preventing further spread of this grass.
Sphagnum palustre	186.4	327.75	Due to the success of previous control efforts, there is much less *Sphagnum* on the Army side of the Kaala boardwalk than ever before. Volunteer efforts continue in a narrow, 3m buffer along the boardwalk, and focus on detailed searches for scattered *Sphagnum* florets. Staff began conducting complementary control in the portions of the infestation off the boardwalk, which are difficult to sweep thoroughly with volunteers. In addition, staff spent 63.75 hours conducting *Sphagnum* control in the Kaala NAR.
Crocosmia x *crocosmiiflora*	115.75	167.95	Volunteers conduct the majority of *Crocosmia* control at both Kaala and Palikea. Most effort 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 designed this year, and will be installed in the coming months.
Erythrina poeppigiana	110.5	8.5	With a HPWRA score of 12 (high), this taxon has the potential to become a major threat. It recruits easily, with hundreds of immature plants seen in the field. Staff notes that it grows quickly, and large mature can be difficult to kill. This taxon is known from two locations on OANRP managed lands, both on Schofield Barracks. All effort was spent this year at the site in the Lihue MU, described in the table above. Control work has yet to start on the other site, located between the edge of the training range and a cantonment road. A work order was submitted to DPW to remove the one large mature tree; completion is pending.

Taxa	2015 Effort (hours)	2014 Effort (hours)	Comments
Cenchrus setaceus	75.05	107.05	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. ICAs located at DMR, KTA, and SBE were likely dispersed to these areas via military training. No plants have been seen at three ICAs (DMR, one each at KTA and SBE) for several years, and they have been classified as eradicated. Previous studies by the OANRP seed lab suggest seeds do not persist in the soil for longer than a year and half. The majority of effort (72.2 hours) this year was spent on the MMR infestation at Ohikilolo Lower MU. Aerial sprays and ground sweeps were conducted.
Rhodomyrtus tomentosa	64.13	77.05	*Rhodomyrtus* is known from several OANRP managed areas, including SBE, KTA, and Pahole. At Pahole, no plants have been seen since the initial discovery of this site in 2013. At KTA, no plants have been seen since initial discovery in 2005, although follow-up monitoring efforts occasionally were conducted in an area just south of the known plant site. One additional follow-up visit, targeting the known plant site, will be conducted before declaring the KTA infestation extirpated. The largest infestation is at SBE, which accounts for 62 person hours of control effort. The size of the infestation is the greatest challenge; systematic sweeps must be implemented to make real progress towards eradication. Control efforts thus far have mostly targeted known hotspots.
Melochia umbellata	59.5	91.75	This species, incipient to KTA has been controlled by OANRP since 2002. Last year, staff discovered *Melochia* sprinkled across several kilometers of Kaunala gulch. This discouraging find was somewhat mitigated by later surveys, which indicated that the plants appeared to be clustered into hotspots in the gulch bottom. OANRP strategy currently is to keep plants off roadways, minimizing potential for human-aided spread, and to treat hotspots. One *Melochia* ICA was declared eradication, as no plants had been seen at it for ten years.
Juncus effusus	33.9	41.85	Volunteers conduct the majority of control on this species, which staff only know from Kaala. Since the seeds are long-lived, control will need to continue for years to come.
Pterolepis glomerata	34.45	23.30	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 Kaala and Manuwai. It is suspected *Pterolepis* seeds persist in the soil for many years, requiring constant vigilance to prevent spread and achieve eradication.
Ehrharta stipoides	24.3	28.5	*Ehrharta* continues to spread, with new locations discovered this year at Ekahanui, Kahanahaiki, Ohikilolo, and Pahole, despite efforts to improve sanitation practices. It is likely that *Ehrharta* is much more widespread across the Waianae Mts than originally thought. It thrives in the shade, forming dense mats. Preventing establishments of this taxon in MUs remains a priority. While difficult to ID, the lack of a persistent seed bank suggests this species is locally eradicable. Almost 15 hours alone were spent on control efforts in Kahanahaiki. If intensive efforts at Kahanahaiki pay off in the form of successful eradications, similar efforts may be replicated at other MUs.
Angiopteris evecta	20.67	52.55	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.

Taxa	2015 Effort (hours)	2014 Effort (hours)	Comments
Morella faya	16	15	While widespread in the southern Waianae Mts. around Palikea, *Morella* is a high priority for control anywhere else on the island. No plants were found at ICAs in Makaha or Waieli. One mature plant was found at the ICA just outside of Kaluaa and Waieli, site of a former *Morella* plantation.

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.

This year, WCA efforts covered 80.3 ha. Staff spent 3,117 hours over 352 visits at 122 WCAs. WCA work accounted for 25% of the total area controlled and 67% 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 below compares this report year's efforts to previous report years. Note that only nine months are covered this year, but that previous years cover twelve months each. Area data from 2008 through 2011 was not collected as accurately as current practices and is not presented for comparison.

Report Year	Effort	Visits	Area (ha)
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	

As MU vegetation monitoring results have come in, many of the long-term IP goals across MUs have not yet been met (the IP covers 20 years). However, MU monitoring results may not capture smaller scale responses to weed control effort and various techniques. Staff therefore recognize the importance of also having meaningful short term goals and measures of success paired with effort data (staff time, cost) for various weed control strategies. OANRP should be able to use this information to prioritize projects, strategies, and to progress towards long-term ecosystem restoration goals in order to better balance alien plant control efforts with time needed to control other threats to rare taxa.

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 continues to work towards creating meaningful estimates of effort needed per WCA for select sites in the coming year.

The 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. The primary exception is Ohikilolo Lower, home to two rare IP taxa, and currently closed to management until MMR is reopened following a serious safety incident. Maintaining the fuel reduction areas around the rare taxa is a high priority and requires consistent, large inputs of time. Volunteer weeding efforts contributed a large amount of time to the Kaluaa and Waieli, Makaha, Kahanahaiki, Palikea, West Makaleha, and Pualii North MUs. At Kaluaa and Waieli, Makaha, Kahanahaiki, 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. At Kaala and Lihue, staff target *Hedychium gardnerianum* in native-dominated forest. These targeted sweeps account for most of the acreages swept at these MUs.

IP Management Unit	Area Weeded (ha)	# Visits	Effort (person hours)	Targeted Canopy or Single Taxa Sweeps	Volunteer Projects?
Kaluaa and Waieli	14.63	48	603.00	*Grevillea robusta, Toona ciliata*	Yes
Makaha I and II	6.11	42	337.75	*Grevillea robusta, Toona ciliata*	Yes
Kahanahaiki	2.71	38	302.67	*Grevillea robusta*	Yes
Palikea	1.29	33	281.30	-	Yes
Kaala Army	5.43	22	280.50	*Hedychium gardnerianum*	
Ohikilolo Lower	3.66	13	148.00	-	
Manuwai	10.14	9	144.00	*Grevillea robusta, Toona ciliata, Schefflera actinophylla, Spathodea campanulata*	
Pahole	2.59	21	126.00	-	
West Makaleha	0.59	11	125.25	-	Yes
Kapuna Upper	1.29	22	104.84	-	
Ekahanui	1.79	12	99.25	-	
Koloa	0.82	8	94.50	-	
Lihue	3.02	12	93.50	*Hedychium gardnerianum*	
Pualii North	0.30	6	79.75	-	Yes

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 2014 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).

MU WCA Weed Control Summary, 2013/10/01 through 2014/09/30

Management Unit						2014 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	**0.04** *(369 m^2)*	**1**	**2**	0	0	0	One trip was spent controlling weeds around the remaining, struggling *Eugenia koolauensis* at this site.
Alaiheihe No MU	N/A	9.99	**9.22**	**1**	**9**	2.46	2	3.5	This region includes the Lower Kaala NAR access road. Staff sprayed weeds along the road, and monitored an *Ehrharta stipoides* site at the end of the road.
East Makaleha No MU	N/A	1.21	**0**	**0**	**0**	0.03 *(257 m^2)*	1	1	Last year, weed control was conducted in this area to facilitate ICA work. No similar effort was needed this year.
Ekahanui	87.5	77.91	**1.79**	**12**	**99.25**	1.48	28	119.25	Control efforts focused around rare species sites, particularly reintroduction zones. Low staffing levels on the Ekahanui crew contributed to the decline in effort this year.
Ekahanui No MU	N/A	10.09	**0**	**0**	**0**	0.01 *(117 m^2)*	1	1	Limited weed control is conducted outside the MU.
Haili to Kealia No MU	N/A	0.82	**0.03** *(296 m^2)*	**1**	**1**	0.70	1	1.5	This region encompasses the Kuaokala access road. Staff controlled *Sphaeropteris cooperii* along the road, and will continue to do so opportunistically.
Helemano	60.63	61.86	**0.91**	**2**	**2**	0.49	5	24.5	Helemano is a low priority MU due to the small number of Tier 1 taxa. This, combined with challenging access due to weather led to limited weed control effort in 2015. Staff targeted *Setaria palmifolia* along the fenceline.
Huliwai	0.91	0.20	**0**	**0**	**0**	0.13	1	4	This MU is centered around an *Abutilon sandwicensis* population. Low staffing resulted in no weed control at this site this year.
Huliwai No MU	N/A	9.43	**0**	**0**	**0**	0.41	1	6	Last year, staff conducted one IPA treatment in this area this year, targeting *Grevillea robusta*. No control was performed this year.

Management Unit						2014 Report Year			Comments
	MU area (ha)	Total WCA area (ha)	**Area weeded (ha)**	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Kaala Army	49.02	51.19	**5.43**	**22**	**280.5**	6.55	33	570	*Hedychium gardnerianum* continues to be the primary weed target at Kaala. Staff focused efforts on the lower slopes of Kaala, just above the cliffs ringing the summit. In addition, staff conducting buffer sweeps for *Sphagnum* also treated *Hedychium* along the boardwalk.
Kaala NAR	20.03	4.30	**0**	**0**	**0**	0.01 *(101 m^2)*	1	0.25	No WCA work was conducted in the NAR this year.
Kaena	10.06	3.06	**0**	**0**	**0**	0.92	4	18	Typically, staff continue to focus weed control efforts around *Euphorbia celastroides* var. *kaenana*. Past control efforts were successful in controlling all woody weeds, so additional efforts here were given low priority in the face of severely reduced staffing on the crew assigned to Kaena.
Kaena East of Alau	14.51	0.89	**0**	**0**	**0**	0.27	3	47	Generally, weed control efforts focus on reducing fuel loads around a small population of *E. celastroides* var. *kaenana*. Low staffing levels on the crew assigned to Kaena resulted in no weed control performed this year.
Kahanahaiki	37.7	41.49	**2.71**	**38**	**302.67**	7.22	62	896.9	An exceptionally large amount of area and time were spent at Kahanahaiki last year. This year, efforts focused around rare taxa, on the chipper restoration site, and on two new gulch restoration sites. In addition, targeted sweeps were conducted to remove remaining *Grevillea robusta* from the canopy.
Kaleleiki	0.12	0.80	**0**	**0**	**0**	0.03 *(338 m^2)*	1	2	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.

Management Unit						2014 Report Year			Comments
	MU area (ha)	Total WCA area (ha)	**Area weeded (ha)**	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Kaluaa and Waieli	80.97	82.91	**14.63**	**48**	**603**	6.37	42	436.25	The large increase in area and time spent at Kaluaa are due to additional targeted canopy sweeps (IPA), and increased staff effort around rare taxa sites and the Hapapa snail enclosure.
Kaluaa No MU	N/A	14.23	**1.33**	**4**	**13**	6.45	6	48.5	Limited effort is spent outside of the fenced enclosure. Trail and road maintenance account for the time spent in this area.
Kaluakauila	42.73	9.64	**2.24**	**3**	**31**	1.73	12	102	Control efforts focused on grass control and *L. leucocephala* control around rare taxa. The ridgeline fuelbreak was maintained.
Kamaili	2.57	4.04	**0.17**	**5**	**30**	0.14	4	24	Last year two fences were completed in Kamaili. This year, vegetation monitoring was conducted, and once analysis is complete, weed control efforts will begin. Thus far, efforts have been limited to LZ clearing and habitat improvement around rare taxa.
Kapuna Upper	172.35	179.20	**1.29**	**22**	**104.84**	1.00	22	82	Control efforts continue to focus around rare taxa and reintroductions, particularly preparing rare taxa outplanting sites.
Kaunala	1.98	2.24	**0.06** *(553 m^2)*	**1**	**20**	0.09 *(863 m^2)*	2	28.5	Weed control efforts in this MU were limited due to the poor condition of the remaining *E. koolauensis*. Until an effective strategy to combat *Puccinia* rust is created, OANRP is hesitant to commit resources to habitat restoration.
Keaau and Makaha	1.19	0.18	**0**	**0**	**0**	0.02 *(238 m^2)*	2	3	Minimal effort is needed around this *Sanicula mariversa* site.
Koko Crater No MU	N/A	0.28	**0.23**	**2**	**15.5**	0	0	0	Weed control was conducted around a new living collection site for *Hibiscus brackenridgii* ssp. *mokuleianus* at Koko Crater Botanical Garden

Management Unit						2014 Report Year			Comments
	MU area (ha)	Total WCA area (ha)	**Area weeded (ha)**	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Koloa	71.54	73.16	**0.82**	**8**	**94.5**	1.51	11	154.9	*Psidium cattleianum* is the dominant weed at this MU. Staff continued efforts to systematically control it in the southern end of the exclosure, close to the summit. Efforts also focused around an IP taxa outplanting.
KTA No MU	N/A	1.31	**0.01** *(96 m²)*	**1**	**1**	0	0	0	Minimal weeding was conducted at a *Eugenia koolauensis* site in conjunction with monitoring the remaining *Eugenia.*
Lihue	710.23	714.98	**3.02**	**12**	**93.5**	9.28	17	310.5	Last year, a lot of effort was spent in Lihue controlling *H. gardnerianum*, and maintaining the road, fence, and trail. This year, efforts were focused on habitat improvement around rare taxa, as well as continued *H. gardnerianum* massacres.
Makaha I	34.2	34.32	**5.8**	**34**	**271.75**	2.70	31	406.5	While area swept almost doubled this year, effort did not. The increase in area is primarily due to large scale sweeps for *G. robusta* and *T. ciliata*. 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. Volunteer trips supplement staff efforts here.
Makaha II	26.69	7.19	**0.31**	**8**	**66**	0.29	7	94	Work at Makaha II focused on rare taxa habitat improvement around both wild and reintroduced plants.
Manuwai	122.49	127.43	**10.14**	**9**	**144**	8.18	19	184.5	Effort at Manuwai was split between large landscape sweeps for canopy weeds and focused control around rare taxa sites.
MMR No MU	N/A	21.18	**0.35**	**1**	**5**	1.33	8	132.1	This year, fencing was completed along the Kuaokala road, connecting Kahanahaiki and Kaluakauila. Grass was controlled along the line to facilitate fence checks.
Moanalua No MU	N/A	5.66	**3.31**	**1**	**24**	0	0	0	Grass clearing was conducted along the four wheel drive Moanalua access road.

Management Unit						2014 Report Year			Comments
	MU area (ha)	Total WCA area (ha)	**Area weeded (ha)**	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Nanakuli No MU	N/A	4.00	**0.04** *(381 m²)*	**1**	**3**	0	0	0	This is the Halona ridgeline, between the Palikea and Palikea IV MUs. Staff improved the LZ on this ridge, clearing away some weedy trees.
Ohikilolo	272.79	147.40	**0.04** *(432 m²)*	**3**	**15.5**	6.04	25	295	Efforts at Ohikilolo were severely limited this year. MMR was closed in April due to a safety incident, and has not yet reopened. Work in the Lower Makua portion of the MU is low priority; no trips were conducted while the Range was open. All effort in the Ohikilolo Ridge portion of the MU was targeted around rare taxa sites, particularly a new *Sanicula mariversa* outplanting. In addition, low staffing contributed to the lack of time spent at Ohikilolo Ridge.
Ohikilolo Lower	28.75	4.46	**3.66**	**13**	**148**	4.13	18	218	Maintaining fuel breaks around the rare taxa here continues to be labor-intensive. An experimental outplanting of *Scaevola taccada* was conducted in hopes of creating a green fuelbreak. The closure of MMR hampered monitoring of the trial, although the *Scaevola* are still alive. The range closure also has prevented crews from conducting weed control since April.
Oio	1.33	1.39	**0.09** *(908 m²)*	**1**	**16**	0	0	0	Due to the poor health of the *E. koolauensis* population at this site, no large scale weeding is planned for this site.
Opaeula Lower I	10.15	6.80	**0.27**	**3**	**6.5**	0.36	12	177.5	Last year, weed control efforts in this MU focused on *C. hirta* control at reintroduction sites and across the flat bowl in the center of the MU. This year, follow-up grass control was conducted, as well as minimal woody understory control. The decline in effort can be attributed to low staffing for the crew assigned to this area. Plots examining the optimal interval between weeding events to minimize *C. hirta* recruitment were completed this year. Results will be incorporated in the strategy for the MU.

Management Unit						2014 Report Year			Comments
	MU area (ha)	Total WCA area (ha)	**Area weeded (ha)**	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Pahipahialua	0.6	0.80	**0.03** *(346 m²)*	**1**	**15**	0.23	6	71	Due to the poor prognosis of *E. koolauensis* due to *Puccinia* rust damage, efforts at this MU are limited.
Pahole	88.02	31.50	**2.59**	**21**	**126**	3.80	39	548.25	Weed control effort at Pahole is targeted primarily around rare taxa locations. Last year, an exceptional amount of time was spent at Pahole. The decrease this year can be attributed in part to lower staffing on the crew assigned to Pahole.
Pahole No MU	N/A	11.25	**5.58**	**6**	**36.5**	4.95	4	26.5	Staff continues to control weeds along the Pahole road, around the Nike greenhouse, and at the Nike LZ.
Palawai No MU	N/A	1.43	**0.02** *(215 m²)*	**1**	**0.5**	0.21	3	12	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	10.84	**1.29**	**33**	**281.3**	3.22	45	486.5	Control efforts this year included control around rare taxa sites, grass control along trails and fences, and maintenance around the snail enclosure. Additionally, a restoration project was developed; *S. terebinthifolius* was cleared and a variety of native species, including hosts for *Drosophila* were planted. A volunteer work site was also developed outside the old TNC fence.
Poamoho No MU	N/A	94.67	**0**	**0**	**0**	4.60	1	18	Last year, staff controlled weeds along the Poamoho road.
Puaakanoa	10.7	1.07	**0**	**0**	**0**	0.27	4	40	Fire is a major threat to the MU. Weed control efforts were hampered by the closure of MMR.
Pualii North	7.99	4.52	**0.30**	**6**	**79.75**	0.27	4	10.25	Staff focused control efforts around rare taxa sites and reintroductions, including a new site, which was planted with *Drosophila* host trees. Much of the increase in effort here comes from a new volunteer project.

Management Unit						2014 Report Year			Comments
	MU area (ha)	Total WCA area (ha)	**Area weeded (ha)**	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Puu Kumakalii	5.65	6.12	**0.27**	**1**	**1**	0	0	0	A large infestation of *Ehrharta stipoides* was scoped along the ridgeline. No control has been performed yet.
SBE No MU	N/A	4.16	**0.04** *(439 m²)*	**1**	**4**	0.05 *(547 m²)*	2	1.5	Weeds were cleared at the sediment disposal site, to keep it open for future use by DPW.
SBW No MU	N/A	2.03	**1.28**	**9**	**20.75**	1.34	12	23.5	Control efforts focus on maintaining weed free areas at the West Baseyard, to reduce the potential for staff to act as weed vectors.
Waianae Kai	3.66	1.14	**0.15**	**2**	**5.5**	0.05 *(465 m²)*	2	15	Control efforts focused around rare taxa locations and keeping the fenceline clear of weeds.
Waianae Kai Neraudia Mauka	0.53	2.59	**0.13**	**1**	**6**	0.14	6	29	Control efforts were conducted around rare taxa. Due to the difficulty of maintaining this fence, this MU may not be maintained in future.
Waimanalo to Kaaikukai No MU	N/A	1.28	**0.04** *(390 m²)*	**1**	**12.5**	0	0	0	This area encompasses the Palikea access trail. Last year, one volunteer trip was conducted at a native forest patch midway along the trail.
West Makaleha	38.04	1.49	**0.59**	**11**	**125.25**	0.51	14	174.5	This MU has two widely separated WCAs. No work was needed at the more remote site for years, but on a rare plant monitoring visit this year, staff noted major ingress of understory weeds and performed control. The majority of effort was spent at the other site, nicknamed 3-Points. Control here is targeted around rare taxa sites, along the fence, and a large patch of *Psidium cattleianum*. Volunteers provide much of the labor for the fenceline and *P. cattleianum* work.
West Makaleha No MU	N/A	0.51	**0.12**	**1**	**0.5**	0.09 *(932 m²)*	1	1	Control is conducted as needed to maintain the access trail. Grasses were controlled along the trail this year.
TOTAL	N/A	2,193.22	**80.36**	**352**	**3,117**	90.05	526	5,846	This reporting year covers 9 months, while 2014 covers 12 months.

1.4 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:

- Board of Water Supply (BWS)
- College of Human Resources and Tropical Agriculture (CTAHR). OANRP has worked closely with Dr. James Leary of CTAHR in research on novel weed control techniques.
- Koolau Mountains Watershed Partnership (KMWP)
- Oahu Early Detection (OED). Plant samples submitted to the Bishop Museum Herbarium are identified by Museum and OED staff. Interesting finds are discussed in section 1.7.
- 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.
- Puu Ohulehule Conservancy
- 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)
- Waianae Mountains Watershed Partnership (WMWP)
- Waimea Valley

This year, OANRP participated in a second Weed Workshop, hosted by Waimea Valley and sponsored by KMWP. In addition, OANRP also participated in the first Oahu Weed Working Group Meeting, organized by NEPM. These two complementary events both focus on information, data, and technique sharing among agencies conducting active weed control management work.

1.5 VEGETATION MONITORING

Vegetation monitoring was conducted at the Kahanahaiki and Makaha MUs this year. These studies are described and analyzed in Appendix 1-3 (Vegetation Monitoring at Kahanahaiki, 2015) and 1-4, (Vegetation Monitoring at Makaha Subunits I and II, 2014). 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 Kaluaa and Waieli MUs at the end of this report year. Results are being analyzed and will be presented next year.

1.6 INVASIVE SPECIES SPREAD PREVENTION ON 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

- The Central Vehicle Wash Facility (CVW) opened for use in March 2015. This facility is open daily, and is conveniently located on Schofield Barracks. While units are supposed to schedule the CVW, DPW and others can drop in to use it during regular operation hours, 0800-1600.

Using the CVW, located 5 minutes from the OANRP baseyard

- OANRP, DPW Cultural Resources, and OISC staff attended a short orientation on running the KTA Wash Rack. This orientation means that staff do not need to schedule the wash rack via Range Facility Management Support System (RFMSS), but may simply show up at Range, check out the facility key, and wash vehicles. This reduces the need for Range Control staff to oversee washing operations and allows field crews to work more efficiently.

Receiving orientation to the KTA Wash Rack from Mr. Joe Lee of the Range Division.

- Both the KTA and SBE Wash Racks had mechanical issues, and were not fully operational for part of the year. The SBE Wash Rack was shut down for repairs November 2014, and did not come fully online until March 2015. In May, it was determined that additional repairs are needed to a different portion of the system; these repairs have not been completed and the facility is not fully operational at this time. The KTA Wash Rack was partially operational for most of the year. It was shut down briefly in March for repairs.
- A large, 5,000 soldier training event occurred in March 2015 at KTA. Range staff ensured that planning was done ahead of time to ensure that all vehicles could be washed upon departing the range, as required by policy. Repairs were completed on the KTA Wash Rack and Range staff prepared to keep the wash rack open for several days to accommodate all vehicles. In addition, the SBE Wash Rack was manned on the weekend to accommodate additional vehicles from the training event (normally open only week days), and the CVW also was scheduled for more detailed washing.
- The table below summarizes availability and usage of wash racks during the report year:

Facility	Days Available	Days Scheduled	Days Utilized	Notes
CVW Facility	52	4	1	The CVW opened in March, which accounts in part for the low number of days available. Scheduling the facility in advance is not required. It is unclear if 'days utilized' is tracked via the Range Scheduling office, but the low number shown here doesn't reflect staff observations of activity at the facility.
KTA Wash Rack	273	103	68	Units are required to wash vehicles upon departure from the training range. Last year, KTA was available for use 365 days, was scheduled for use 56 days, and actually utilized 45 days. This year's numbers are an improvement.
SBE Wash Rack	232	102	84	Last year, SBE was available for use 365 days, was scheduled for use 237 days, and actually utilized 199 days. Mechanical problems account for this year's decline. Fortunately, the CVW is now a back-up facility for SBE.

Landing Zones

- Staff reviewed a request to develop a new LZ located near Canon Dam on SBE. There are no sensitive taxa or incipient invasive species near this location. When the LZ is created, it will be added to the annual survey list.
- Staff reviewed the JOTC Land Expansion meeting notes, which discussed 5-10 LZs on the eastern end of Poamoho which are not currently in good repair and cannot be used for training. These LZs may be cleared in future; if so, staff will monitor them annually. No sensitive taxa or incipient invasive taxa are near these sites.
- After observing unauthorized landings on Non-Stop and Hammer LZs last year, staff pursued the issue with Range Scheduling. Investigation revealed that several LZs (Non-Stop, Hammer, Bryan's) were in fact located on private land. All of these LZs were removed from the RFMSS scheduling system. While this may not prevent all landings, it is now clear that these sites are not official training LZs.

Soil/Fill Inspections

- Over the past couple of years, staff noted *Heterotheca grandiflora*, a weed new to Oahu, growing out of sand and sand bags on SBE. Eventually, staff were able to track down the original stockpile of sand located at Area X on Schofield Barracks and conduct a survey there. No *H. grandiflora* or any other concerning incipient invasive species were found at the site. This stockpile site will be monitored periodically to inspect new shipments of sand and gravel.
- Staff reviewed a request to use soil stockpiled on SBS for repair work at SBE. No incipient invasive weeds are know from the soil stockpiles.
- Integrated Training Area Management (ITAM) requested review of a proposal to use soil from the Fort Shafter Flood Mitigation Project for repair work on SBE and SBS. The Federal Biologist conducted a survey of the Fort Shafter site, and no incipient weeds were found. However, there is *Santalum album* (non-native relative to Hawaiian *Santalum,* or Iliahi) found nearby. If the proposal is approved by DPW, fill sites will be monitored for *S. album*.

KTA

- Staff reviewed a Record of Environmental Consideratoin (REC) for vegetation clearing at Radar Hill in KTA. A site visit was conducted with the requesting unit, and all native trees were flagged to avoid accidental removal. A weed control trial is located nearby, but will not be impacted by the clearing.
- 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 is pursuing a variety of actions to curb impacts. These include education, signage, and building a fence around X-Strip LZ.
- In May 2015, ITAM staff reported finding 2.47 miles of unauthorized trails constructed in the D-1 range on the far eastern side of KTA. This area directly abuts private land. The trails appeared to have been made with a small bulldozer, and do not overlap with any trails managed for training by ITAM. The Army may pursue an official investigation into the matter. These trails are concerning for OANRP as they represent another vector/pathway for the spread of *C. odorata*. The dozer trails were surveyed in August.

SBE and SBW

- A REC for removal of *Falcataria molucana* along the California Avenue entrance to SBE, and creation of a gravel parking area at the site was reviewed and approved. This area will be surveyed annually as part of regular SBE road surveys.
- OANRP began coordinating with Range Control and range maintenance contractor General Dynamics Information Technology (GDIT) regarding the presence of *Schizachryium condensatum* on LZs and other actively used maneuver areas on SBE. GDIT regulars mows these open grassy fields, preferred habitat for *S. condensatum*. OANRP reiterated the need to wash all equipment, including mowers and other vehicles, whenever they depart off SBE. A follow-up meeting will be scheduled in the coming year to try to coordinate OANRP surveys around the mowing schedule, and encourage GDIT to assist with control efforts.
- New signs were installed in July at a portion of the SBW *C. odorata* infestation. Staff had observed soldiers training in part of the infestation, in an area not open to training. Metal signs

were placed on the edge of the site, stating that the area was closed to training, and that there are invasive plants in the area.

1.7 WEED SURVEY UPDATES: NEW FINDS

Every year, new alien taxa are detected during directed surveys and incidentally during regular work. During directed surveys, lists of weeds are compiled, and staff considers distribution and invasive potential to determine whether control is warranted. Unknown species are collected and delivered to Oahu Early Detection (OED) and Bishop Museum. Support from these organizations facilitates the prompt identification of unknown species, and aids in determining whether control work is necessary. OANRP supports OED and Bishop Museum financially for identification services. The Hawaii Pacific Weed Risk Assessment (HPWRA) also provides a valuable indicator of invasive potential.

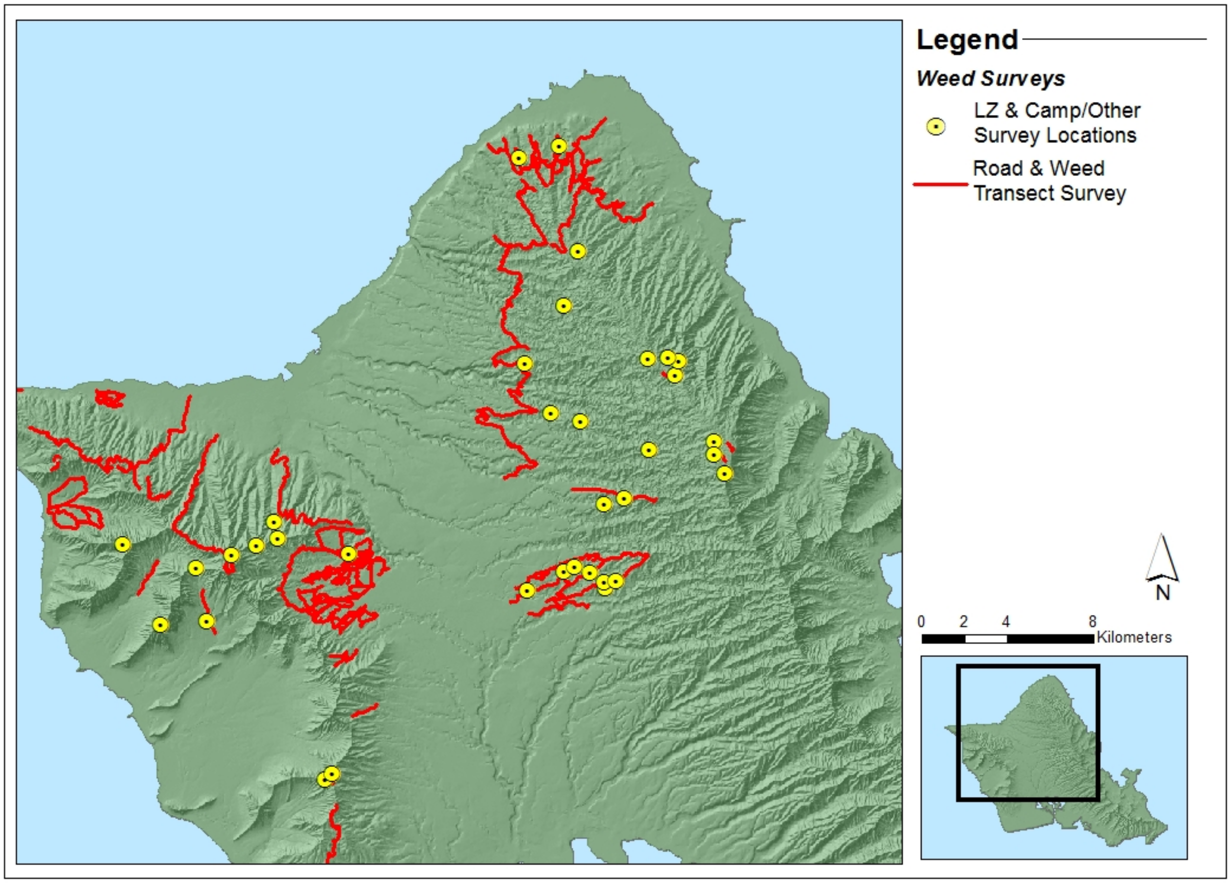
During the reporting period, staff surveyed nearly 350 km of roads and surveyed Landing Zones (LZs) on and off Army Training Ranges. Staff also surveyed at sites and along trails that are potential locations of introduction. Two surveys of this kind were newly added this year: the SBE washrack sediment disposal site, and a storage site for sand and gravel used for training range repairs across Schofield.

This year efforts continued to identify landing zones definitively in use by the Army. Range scheduling reports were used to identify LZs that did not have any reported Army use over the past several years. As it is possible that some landings were unreported, scheduled surveys were only discontinued for those LZs which had both no reported landings and that were identified as overgrown and impossible for Army helicopters to land. However, OANRP will monitor Army LZ use reports, and will stay abreast of LZ improvements to retired LZs, or construction of new LZs so that they may be surveyed in the future.

Summary of Surveys Conducted

Survey Type	Description	# Surveys Conducted this Year
Road Survey	All drivable roads on Army Training Ranges surveyed; Access roads to OANRP Management Units surveyed annually or every other year.	21 road surveys
LZ Survey	All actively used Army LZs surveyed once per year. OANRP LZs surveyed if used within a quarter.	42 surveys on 32 LZs (13 Army LZs, 19 OANRP LZs)
Transect Survey	Surveys conducted annually along access trails to OANRP MUs, and along selected MU fencelines and transects inside MUs.	16 surveys along 15 transects
Camp/Other Survey	Surveys conducted at OANRP campsites and other potential locations of introduction such as washrack sediment disposal sites.	2 surveys

Map of Surveys Conducted in 2015



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 Survey Results

Survey Type	Survey Code	Significant Alien Taxa Seen	Discussion
Road	RS-Kaala-01	*Verbesina encelioides*	Locations of previous observations of this taxa along the Kaala Rd were controlled. Control of this species will continue where seen above the Ranch Gate (2nd gate).
Road	RS-KLOA-01 (Poamoho)	*Vigna hosei*	OED notes that this species was introduced as an agricultural cover crop and was naturalized in surrounding pineapple fields. This observation extends known location. No control planned.
Road	RS-KLOA-08 (Drum Rd)	*Angiopteris evecta*	This invasive fern is widespread across the Koolaus, however only now observed along Drum Road. No control planned.

Survey Type	Survey Code	Significant Alien Taxa Seen	Discussion
Road	RS-KTA-07	*Leptospermum scoparium*	*L. scoparium* is known from several locales in the Northern Koolaus, several of which are in KTA. This find was new to this particular section of Road in KTA. Continued spread of this taxon will be monitored.
Road	RS-KTA-10	*Cleome gynandra*	This ornamental plant is considered widespread by Bishop Museum however no records occur from KTA. No control is planned.
Road	RS-Makaha-01	*Elephantopus mollis*	*E. mollis* is currently controlled as an ICA where it occurs in Management Units (one to date). Its proximity to the Makaha MU will be monitored.
Road	RS-Pahole-01	*Heliocarpus popayanensis*	*H. popayanensis* is not known from any locations in this vicinity. This observation may indicate spread from Central Waianae populations. Control along the Pahole Road will be discussed with State NARs staff, and this species will be targeted if found inside OANRP MUs.
Road	RS-Pahole-01	*Passiflora suberosa*	Known to have high densities in the Southern Waianaes, this taxa appears to be spreading in the Northern Waianaes. OANRP are noting greater frequency during vegetation surveys in Management Units and on more directed surveys. It is controlled during regular weed sweeps in MUs.
Road	RS-SBE-01	*Hyptis capitata*	Bishop records indicate this species is uncommon on Oahu. This observation may indicate further spread. No control planned.
Road	RS-SBE-01	*Cestrum nocturnum*	Part of this survey occurs adjacent to residential gardens. This ornamental may have been noted from a residential fence. It is known to naturalize as observed on Tantalus and would be a target for potential control if found naturalizing in more interior locations of the range. Monitor for now.
Road	RS-SBS-01 & RS-SBS-02 RS-WaiKai	*Dovyalis hebecarpa*	This species was known from the greater South Range area. It was a target on the OED survey list at one point in time. OANRP will continue to monitor any further spread across the range, however control is only currently conducted in Management Units.
Road	RS-SBS-01	*Petrorhagia velutina*	*P. velutina* was collected in 2010 from SBW and was a new island record. This is an expansion from that first detection No control planned.
Road	RS-SBS-02	*Oenothera kunthiana*	This species is a Primrose first collected by OANRP at the Kolekole Quarry in 2008. It was again observed shortly after on an LZ in 2009, and now is documented from SBS. No control planned.
Road	RS-SBW-04	*Tetragonia tetragonioides*	Interesting location occurrence as this species is usually found naturalized in coastal areas or locations where likely planted. No control planned.
Camp/ Other	OS-SBW-03 (Sand pile staging area)	*Albizia adianthifolia*	This taxa was a New State Record when collected in 2011 from Schofield Barracks and is now observed naturalizing across Schofield Barracks. Locations of occurrences will be documented and control of outlier plants on range will be discussed.

Survey Type	Survey Code	Significant Alien Taxa Seen	Discussion
Transect	WT-Kaluaa-01	*Pimenta dioca*	OANRP staff know of locations of this taxon in North Ekahanui and Huliwai Gulches, as well as in Lihue. It is not known from inside the Kaluaa and Waieli fence, however this location on the access trail to the MU will be documented and monitored to prevent further spread into the MU.
Transect	WT-Kaluaa-03	*Drymaria cordata var. pacifica*	This species ran rampant in the Hapapa Snail enclosure after alien canopy removal and heavy staff presence while conducting snail management in the last few years. This new find may represent staff spread of this on to the access trail. No control is planned, however if large patches form along the trail, control should be considered to prevent further spread along additional trails.
Transect	WT-MMR-02	*Vigna sp.*	This year OED staff helped identify several *Vigna* species that were collected from various surveys. Effort should be made during the next survey to collect a sample of this observed *Vigna* so that it can be identified to species.
Transect	WT-Palikea-01	*Crocosmia* X *crocosmiiflora, Cryptomeria japonica, Morella faya, Urochloa maxima*	*C.crocosmiiflora* is controlled inside the Palikea MU as an ICA, and is also controlled along this transect trail at regular intervals to prevent spread along the trail. It is not surprising that plants are observed even with regular control as plants reproduce vegetatively and complete control of 'clumps' via the preferred hand removal technique is not 100% successful, but does inhibit further spread. A large stand of *C. japonica* also occurs inside the MU and is targeted for gradual removal, and a known stand outside the MU that runs along this transect is not targeted for control. *M. faya* is only known as naturalized in this region of the Waianaes. Control efforts inside the Palikea MU are expected to increase this year using the IPA control method. *U. maxima* carries fire well and should be kept off of trails and fencelines.
LZ	LZ-HON-133 (Halona Ridge)	*Morella faya*	As mentioned in previous row, spread of *M. faya* to new areas should be avoided.
LZ	LZ-KLOA-018 (Black)	*Vigna luteola*	Another species of this genus was found on Poamoho Rd this year; both possibly agricultural introductions. No control planned.
LZ	LZ-KTA-016 (X-Strip)	*Paspalum cf. notatum*	This species was submitted to OED for identification and came back with a tentative id of *P. notatum*, a species known as naturalized on other islands, but not yet Oahu. Collection of fertile material will be important in correctly identifying this rhizomatous species.
LZ	LZ-MAK-143 (Burn Site)	*Nephrolepis brownii*	This LZ was the site of a fire in October 2007 and *N. brownii* (a fern) has likely taken advantage of the disturbed area created post fire. It forms dense understory clumps and spreads rapidly; control will be discussed.

Survey Type	Survey Code	Significant Alien Taxa Seen	Discussion
LZ	LZ-SBW-057 (Nalu's)	*Begonia foliosa*	This species occurs in abundance in the gulches at and below Mt. Kaala. This find documents a distant spread from known occurances (over 2 kilometers away from the summit of Kaala). Further spread of this taxa will be monitored, especially paying attention to any documentation of spread into Manuwai MU.
LZ	LZ-WAIKAIFR-110 (North of Puu Kepauula)	*Petrorhagia velutina*	Collected as a New Island Record in 2010 from SBW, observed at SBS this year, and now observed in the Waianae Kai Forest Reserve. No control planned.
Incidental	None (SBE)	*Chromolaena odorata*	Several immature individuals were noted while conducting surveys at SBE for another incipient weed species. This observation documents further spread of this highly invasive species between Army Training Ranges. Plants are aggressively controlled and monitored at the ICA created for this site and plants here are targeted for eradication; additional buffer surveys were conducted and no new plants were identified.
Incidental	Bottom corner of Kahanahaiki MU, just outside fence	*Eucalyptus urophylla*	This species was presumed planted on a Kuaokala Rd offshoot road, but now appears to be naturalizing with smaller size classes present. It is therefore considered a New State Record. No control is planned.
Incidental	None (Lower Peahinaia –Frog Pond)	*Nymphaea sp.*	A plant found growing in a mat type habit in the pond inside the Lower Peahinaia MU (rooted in the mud). Identified by OED as either *N. lotus*, or *N. rubra*. No control planned
Incidental	None (East of Whitmore Village)	*Thysanolaena latifolia*	Found a few 'patches' of overhead plants during a survey to scout potential Army training routes. OED notes that this species was historically known from this region (potentially as naturalized), and the observer for this collection noted that the plants appeared to have been occurrences of naturalization. No control planned.
Incidental	None (Keaau)	*Sideroxylon persimile*	This collection was taken from a single mature individual found in the ranch area in Keaau. It is noted in highest abundance in Makaha Valley, has been documented as naturalizing into Makua Valley, and is present in SBW. Any plants found inside the Keaau MU, and any MU in the Waianae Mts will be targeted for control.
Incidental	WT-Kapuna-01	*Veronica serpyllifolia*	Found along the Mokuleia trail while hiking into managed areas. Two 'patches' were found, one each in Keawapilau and Kapuna Gulches. While found on other islands, no additional locations of its presence has been reported on Oahu. No control planned.
Incidental	None (Palehua area)	*Viola hederacea*	This species is a small herb that was found growing as a mat growing in the middle of a cabin access road off the main Palehua Rd. It has been known from cultivation from other islands, but this observation is a new naturalizing record. No control planned.

1.8 Invasive Species Updates

***Chromolaena odorata*, Devil Weed**

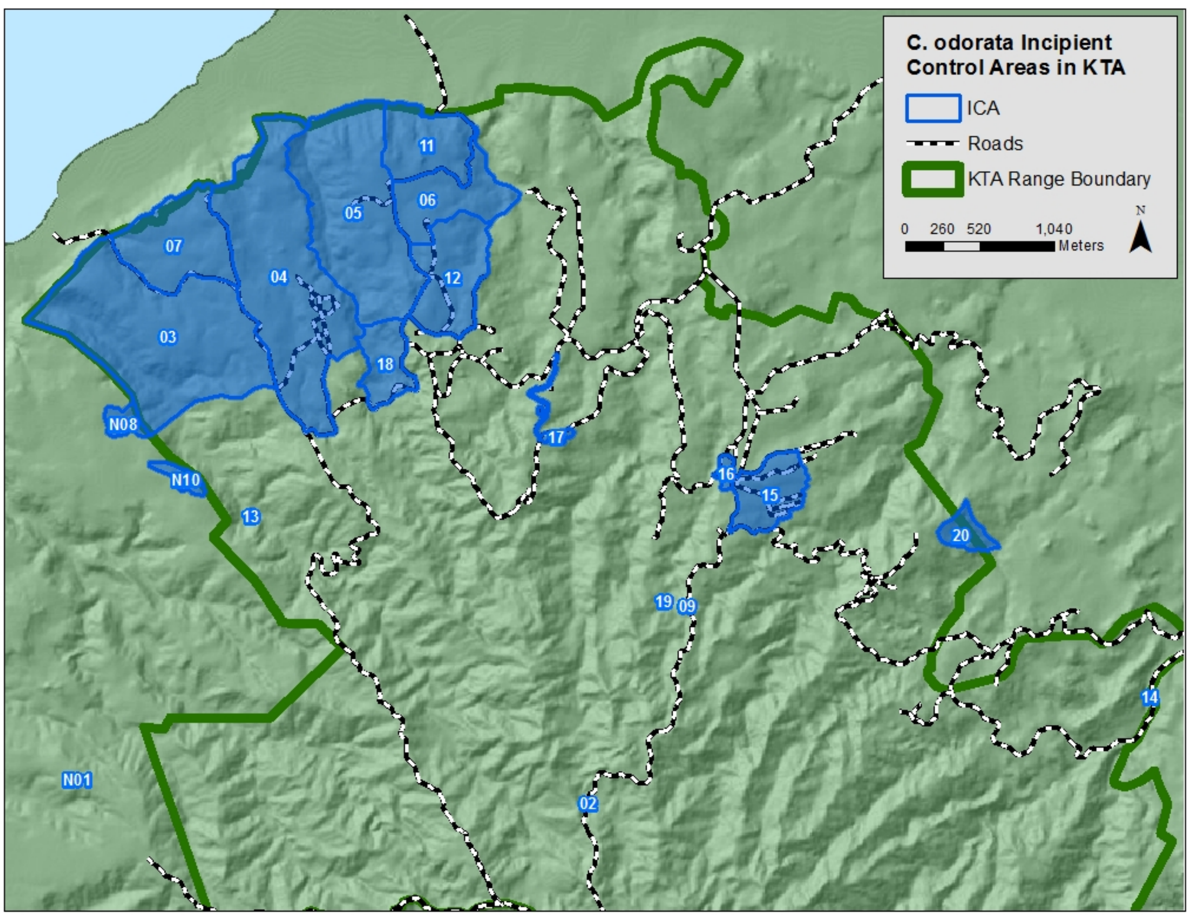
Control of *C. odorata* is a high priority for OANRP. Please see the 2011 Year End Report, Appendix 1-2 to view the draft management plan for *C. odorata* control.

It is clear that a much larger effort is needed if *C. odorata* is to be eliminated from Oahu. New finds at SBE and Aiea this year highlight the ease with which *C. odorata* moves on vehicles and humans. It seems likely that there are other unknown infestations located off Army training facilities; surveys need to be conducted across the island to better understand the scope of the infestation and set realistic goals. The Chromolaena odorata Working Group is one forum for discussing an island-wide control plan.

KTA Update

Control efforts at KTA account for almost 30% of all incipient control time this report year. In addition, OANRP continues to contract OISC to conduct control across almost half of the primary infestation.

C. odorata Incipient Control Areas at KTA



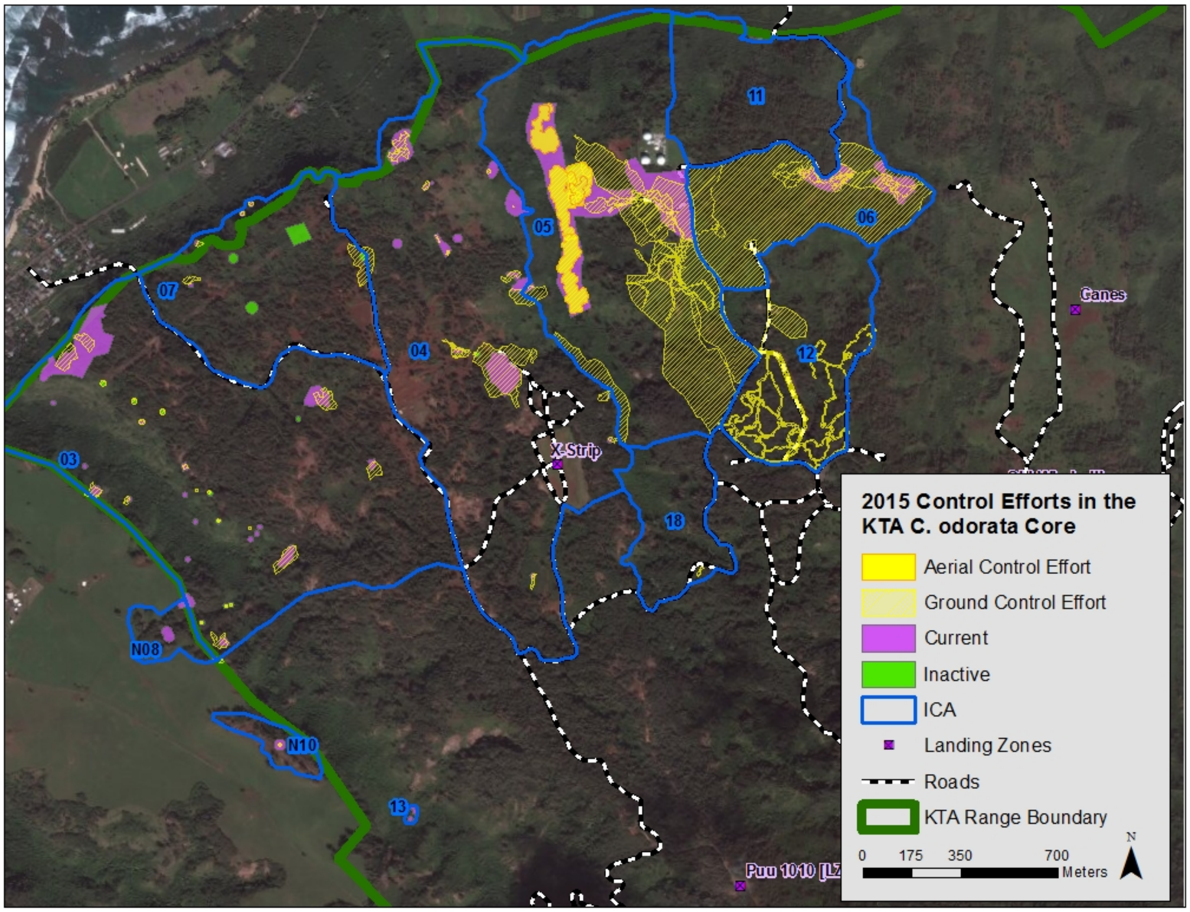
- Surveys resulted in one new ICA being discovered this year, #20. Located in the eastern, Delta Range, this ICA is on the border of the Training Range. Control efforts have not yet begun here.
- All control efforts are summarized in the table below. Each ICA is categorized. ‘Outlier’ ICA are isolated locations of few plants; all are located along roads or trails. ‘OISC Contract’ ICAs are managed by OISC; OANRP only conducts hotspot treatments in these ICAs. The ‘Sweep + Hotspot + Aerial spray’ ICA is the core of the infestation, and many control strategies are employed here. ‘Sweep + Hotspot’ ICAs require thorough ground sweeps, as well as hotspot treatments. ICAs marked as ‘Trails, Roads, Hotspots’ are not swept in their entirety, but rather, only pathways with high potential for dispersal are surveyed.

KTA Control Efforts

ICA	ICA Total Area (ha)	Area Weeded (ha)	Effort (person hours)	# Visits	ICA Type
WaimeaNoMU-ChrOdo-01	64 m^2	64 m^2	1.5	2	Outlier
KTA-ChrOdo-02	328 m^2	328 m^2	3	3	Outlier
KTA-ChrOdo-03	118.32	2.23	60.75	5	OISC Contract
KTA-ChrOdo-04	111.66	4.56	66.7	6	OISC Contract
KTA-ChrOdo-05	89.94	29.49	177	10	Sweep + Hotspot + Aerial spray
KTA-ChrOdo-06	29.32	27.14	92.75	7	Sweep + Hotspot
KTA-ChrOdo-07	40.69	0.73	13.5	2	OISC Contract
AimuuNoMU-ChrOdo-08	4.59	0	0	0	OISC Contract
KTA-ChrOdo-09	78 m^2	78 m^2	2	2	Outlier
AimuuNoMU-ChrOdo-10	3.73	78 m^2	1.5	1	OISC Contract
KTA-ChrOdo-11	27.96	0	0	0	Sweep + Hotspot
KTA-ChrOdo-12	34.69	4.55	12.5	3	Trails, Roads, Hotspots
KTA-ChrOdo-13	0.21	0	0	0	Hotspot
KTA-ChrOdo-14	6 m^2	6 m^2	2.5	2	Outlier
KTA-ChrOdo-15	20.71	1.48	4	2	Trails, Roads, Hotspots
KTA-ChrOdo-16	2.20	0.13	1.5	2	Trails, Roads, Hotspots
KTA-ChrOdo-17	2.70	1.3	2	2	Trails, Roads, Hotspots
KTA-ChrOdo-18	16.43	0.03 (275 m^2)	2.5	2	Trails, Roads, Hotspots
KTA-ChrOdo-19	78 m^2	0	0	0	Outlier
KTA-ChrOdo-20	6.96	0	0	0	Trails, Roads, Hotspots
TOTALS	*510.15*	*71.72*	*443.7*	*51*	

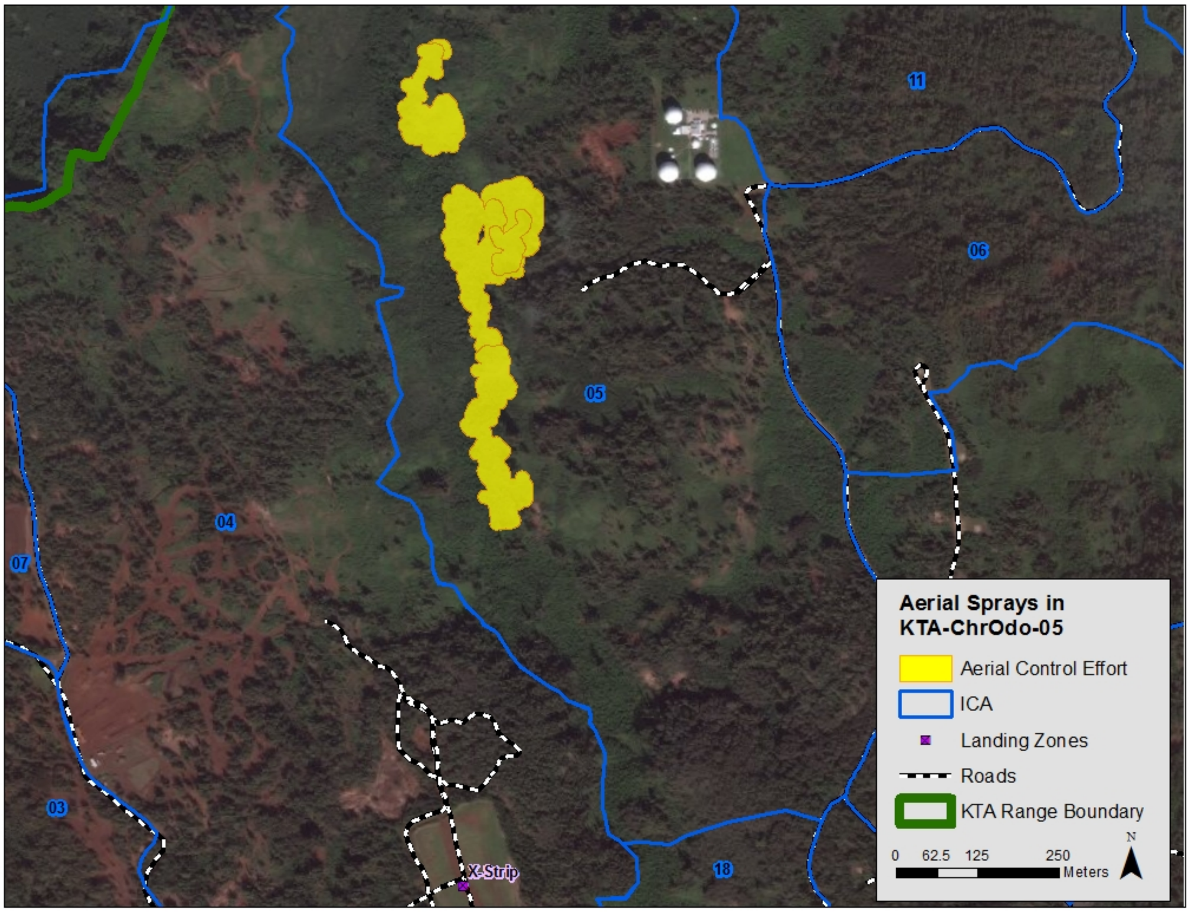
- The majority of effort was spent in ICAs #3, #4, #5, and #6; see map below. These ICAs encompass the primary infestation. All OANRP time spent in #3 and #4 was devoted to controlling designated hotspots. Many of these hotspots were surveyed, and few to no plants remain; these were classified as inactive, and will not receive special treatment trips outside of OISC ground sweeps any more. Lots of active hotspots remain, however, and they will continue to be targeted in the coming year. The majority of time spent in #5 and #6 was devoted to large scale sweeps. ICA #6 was swept in one day with a large crew. Large portions of #5 are not suitable for sweeps due to steep terrain; ground sweep efforts targeted the more gradual slopes. Some hotspot treatment was conducted in #5; these efforts were facilitated by clearing a path through a stand of trees to allow the power sprayer to be driven closer to known hotspots.

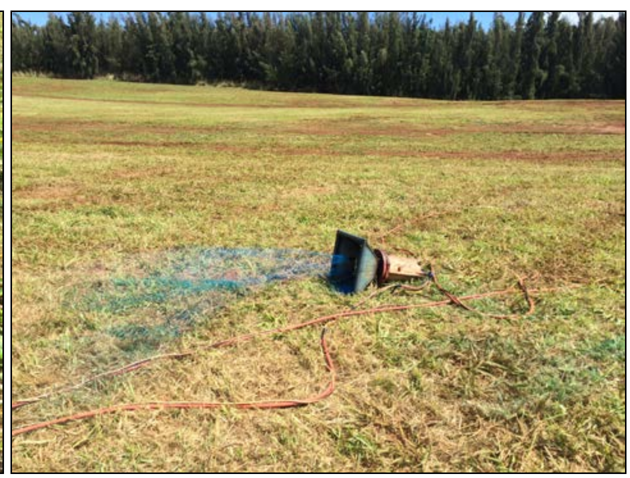
Control Effort in the Primary Infestation at KTA



- Aerial spray treatments finally began at KTA this year. Six were conducted, two in January, one in March, one in June and two in July. Several other trips were scheduled, but cancelled due to high winds. In all, 5.07 ha were treated aerially. The map below highlights aerial control efforts. While aerial sprays are efficient, they are not necessarily as effective as ground-based, high-powered sprays. Walking through one of the aerially treated zones, staff noted both completely dry and dead *C. odorata* plants, as well as plants which were re-sprouting, see photos below. This may be because some plants are sheltered by other vegetation, or do not receive a full dose of herbicide. Multiple aerial treatments may be needed to knock down large infestations to the point where follow-up treatments can be done from the ground.
- Mechanical problems plagued several of the aerial operations. Staff continue to make improvements. One early improvement was to switch from one aerosol type nozzle to an array of drip nozzles which produce a ‘rain’ like spray, see spray ball photos below. As equipment improves, staff hope both efficacy and efficiency are improved.
- While progress is being made at many ICAs, work is overdue at hotspot #s 11, 13, 19 and 20. These will be targeted in the coming year.

OANRP C. odorata Surveys at KTA



Left: array of three 'rain' nozzles. Right: spray ball with 'rain' nozzles being tested prior to flight.

Above: aerial control in progress. Below: close-up of ball sprayer in action.

Above: dead vegetation in the aerial spray area

Left: resprouting *C. odorata* along a trail. Right: dead *C. odorata* in the canopy

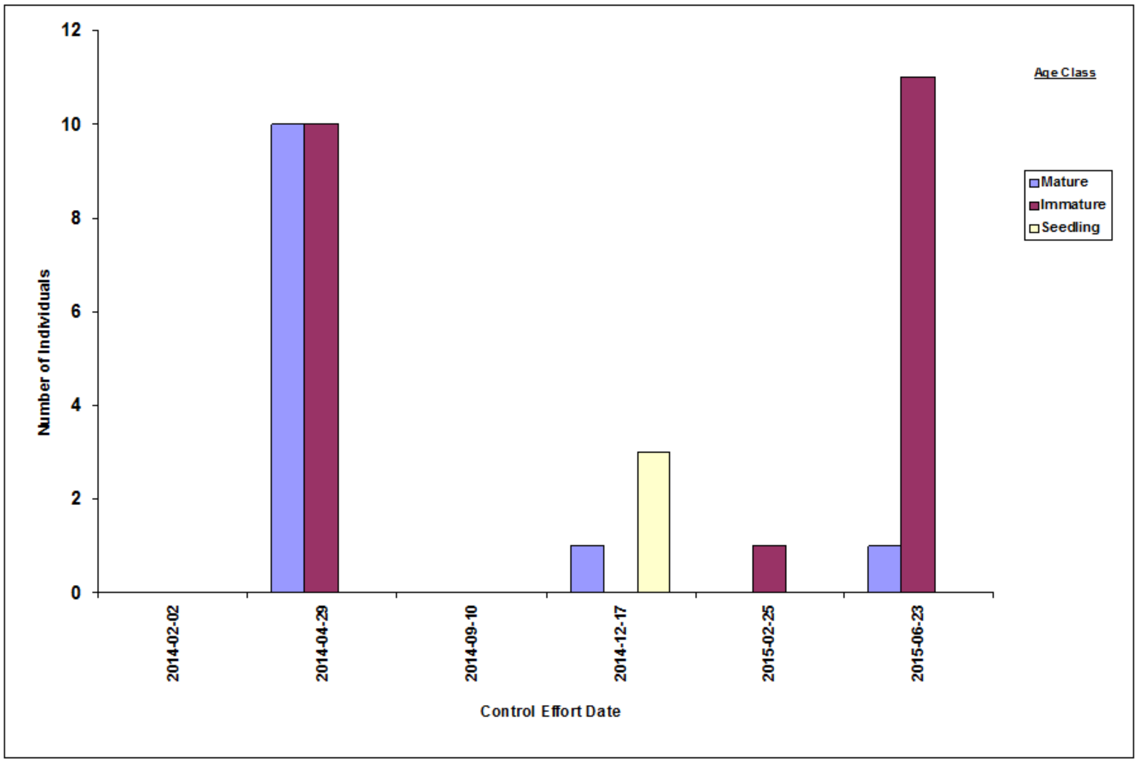
SB Update

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 Schofield in 2015:

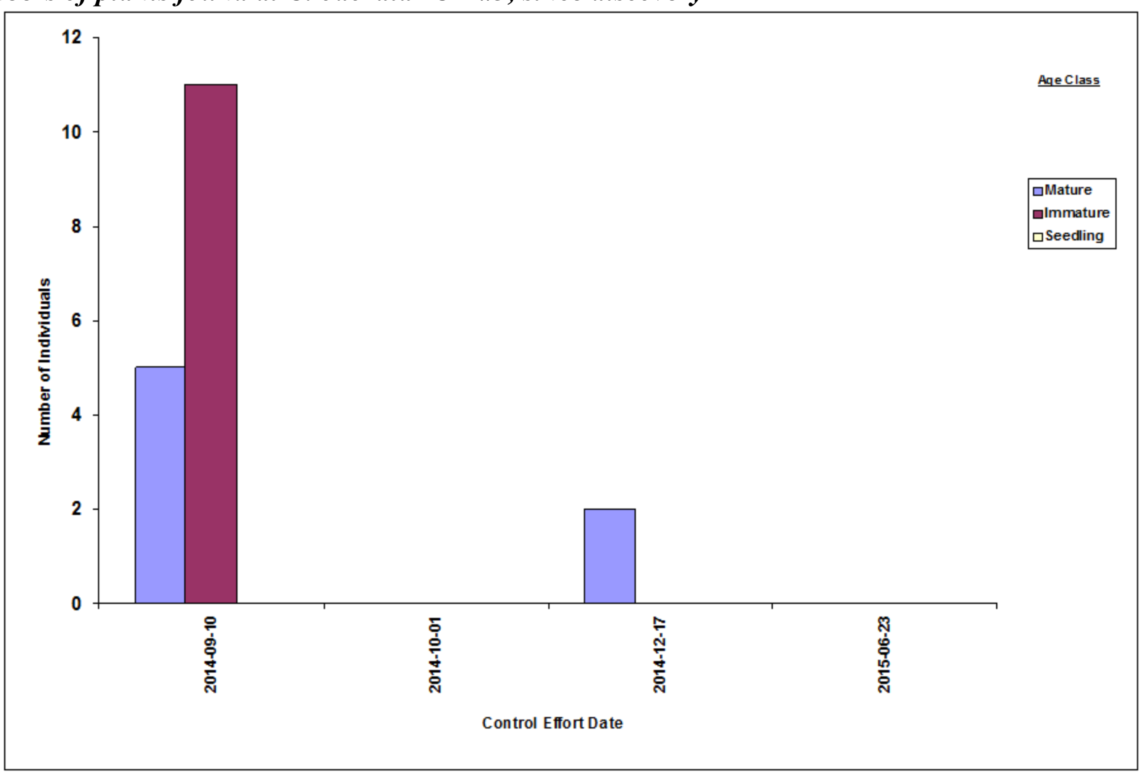
ICA	ICA Total Area (ha)	Area Weeded (ha)	Effort (person hours)	# Visits
SBWNoMU-ChrOdo-01	19.52	1.23	23	5
SBWNoMU-ChrOdo-02	1.11	0.70	5	3
SBWNoMU-ChrOdo-03	0.49	0.49	20	3
SBWNoMU-ChrOdo-04	22.68	3.66	24.5	5

- ICA #1 was split into two sections along the McCarthy Flats Access road. The split facilitates tracking of control efforts. ICA #1 remains the western end of the infestation, and ICA #4 now covers the eastern core of the infestation.
- Control efforts at ICA #1 focused on known hotspots. Surveys last year identified about five hotspots in this ICA. All were monitored and treated this year. Staff control all weeds in the hotspots with non-selective sprays, which suppress all vegetation, making *C. odorata* recruits easier to see, allowing for easier detection of potential UXO.
- ICA #2 is a discrete, outlier infestation. Despite aggressive sprays, staff noted many immature plants this year. In addition, the size of the ICA was increased when plants were found along the adjacent road, in a slightly new area. While overall numbers remain low, and few mature *C. odorata* have been observed since April 2014 (see ICA #2 graph below), it seems apparent that a persistent seed bank must have formed onsite.
- ICA #3 is also a discrete, outlier infestation. Despite very large, mature plants present on site, little recruitment has been observed thus far (see ICA #3 graph below). Much of this site is shaded, which may assist in suppressing recruitment of sun-loving *C. odorata*. Most of the 20 hours spent at this ICA were for delimiting surveys. Both ground and aerial surveys were conducted; fortunately, no additional plants were found.
- Efforts ramped up in the core of the infestation, ICA #4, significantly this year. Staff continued to spray easily accessible portions of the infestation from the ground, but only a small portion of the known plants can be reached in this way. UXO concerns prevent staff from walking through thickly vegetated areas (where the ground is obscured). To reach the rest of the infestation, staff began conducting aerial sprays. Four sprays were conducted, one in June, the rest in July. Note that the July hours are not reflected in the table above. Despite working through equipment challenges, 4.1 ha were treated. The map below shows both ground and aerial control for the past year, including the July sprays. In the coming year, staff hope to complete at least one full aerial treatment of all *C. odorata* patches in the ICA, as well as scout ground access routes into the gulch from the south.

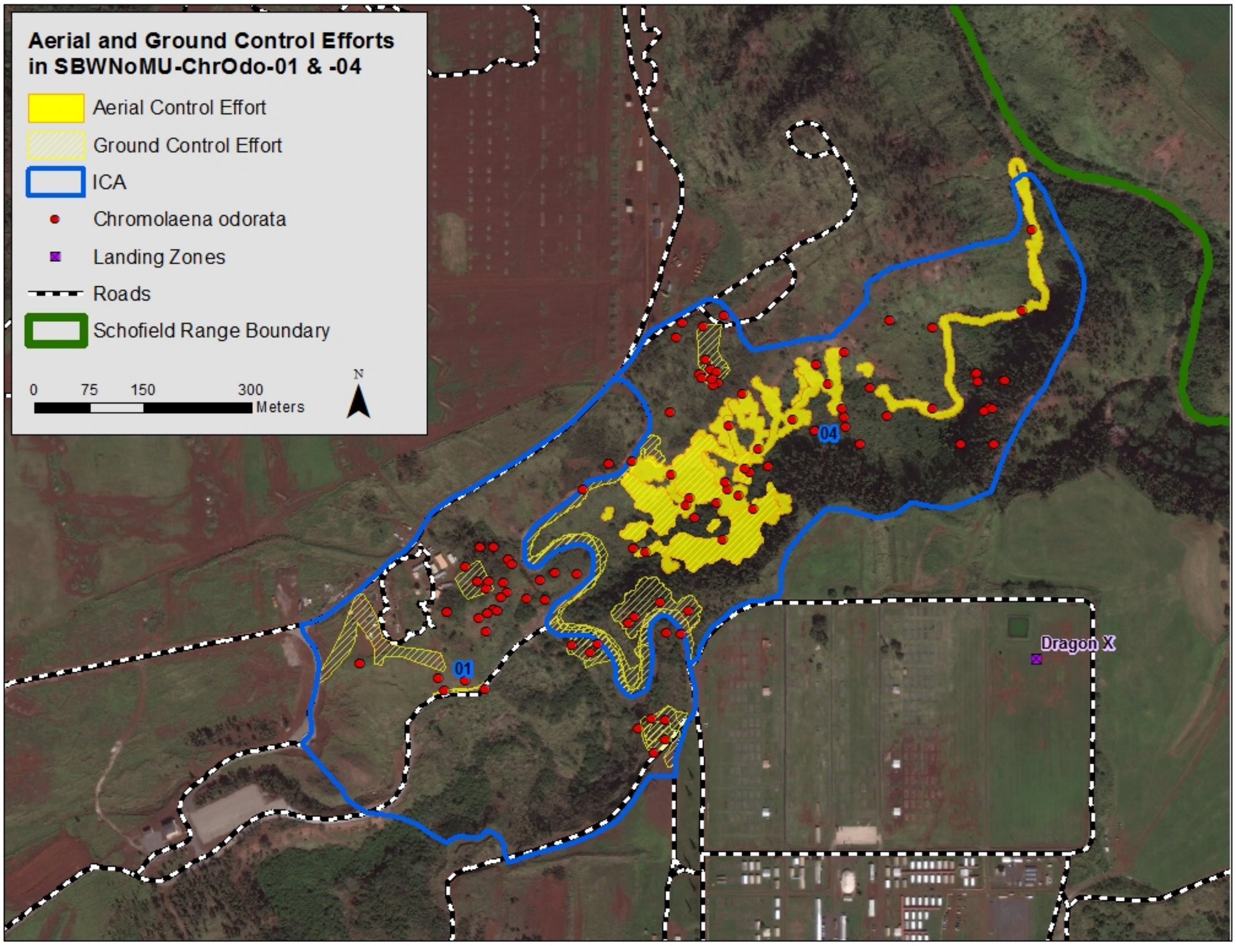
Numbers of plants found at C. odorata ICA #2, since discovery



Numbers of plants found at C. odorata ICA #3, since discovery



***C. odorata* Aerial Sprays and Ground Control at SB**



Looking across the gulch at part of the target aerial spray zone

SBE Discovery and Update

While conducting surveys for another incipient target at SBE, *Schizachyrium condensatum*, staff stumbled upon a small patch of immature *C. odorata*. This find was incredibly discouraging, as it demonstrated that *C. odorata* successfully dispersed to a third Army Training Range. SBE is heavily used, perhaps more so than KTA, so the find wasn't completely surprising. The plants were found at the end of a dirt road, in a clearing next to powerline poles, and there is concern that maintenance of powerline corridors could be yet another potential vector. Staff contacted HECO to discuss *C. odorata*; a meeting planned for earlier in the year was postponed, but is scheduled for the end of 2015.

***C. odorata* Location and Surveys at SBE**

Control efforts are summarized in the table below. Staff completed a 200 m buffer survey around the site, with no new *C. odorata* sites found. Staff added *C. odorata* as a search target while conducting sweeps for *S. condensatum* across all of the heavily used western portion of SBE, and will continue to search for both incipient weeds in the coming year.

ICA	ICA Total Area (ha)	Area Weeded (ha)	Effort (person hours)	# Visits	Total # Plants Found
SBE-ChrOdo-01	0.18	0.14	8.4	3	15 immature (1st visit) 1 mature (2nd visit)

The road the plants were discovered on was surveyed in early 2014. Given the small size and immature status of the plants, it seems likely the infestation was less than a year old. Hopefully this site was caught early, before it could establish a seed bank.

Treated *C. odorata* at SBE

Aiea Discovery

At the end of November, an OANRP staff member hiking on the Aiea Loop Trail was startled to come across a large patch of *C. odorata* on the southeastern portion of the trail. OISC followed up with extensive surveys. The infestation connects with Camp Smith, where multiple trails connect from the facility to the Aiea Loop Trail. These side trails appear to be used by military personnel for physical training. OANRP staff assisted in connecting OISC with MCBH staff, who facilitated access to Camp Smith. OANRP also assisted with treating roadside plants at Camp Smith with the power sprayer.

In the coming year, OANRP will continue to provide support to OISC. This may include flying water to known hotspots, assisting with hotspot treatment with the power sprayer, and following up with Marine/Navy staff to leverage funding for further control.

1.9 NOVEL WEED CONTROL TECHNIQUE DEVELOPMENT

Blechnum appendiculatum Herbicide Control Trials

Background: *Blechnum appendiculatum* (palm fern) is an escaped ornamental fern from Central and South America that spreads by spores and subterranean stolons. It readily invades natural areas forming nearly solid mats on the forest floor where it displaces low-growing plants (Mootoka *et al.* 2003) and has been observed to inhibit seedling recruitment around rare plant species managed by OANRP. The palm fern is a direct competitor for space and nutrients with native ferns such as *Diellia* (Mehltreter *et al.* 2010). In previous field trials good results were achieved by trenching (isolating patches of the fern by cutting the network of stolons around the perimeter of the mat) followed by a foliar application of Garlon 5% G4 in water. DLNR has also had good results with herbicides containing the active ingredient imazapyr; however, they observed it migrated at least a foot from the treatment area thereby risking harm to non-target plants (Hardman, *unpub. data*).

These previous trials suffered from the lack of replication and control groups, so conclusions were limited and often qualitative. We set out to systematically evaluate differences in efficacy between three herbicides with different active ingredients. Though trenching worked in the previous trials, we did not trench in this test because it was labor intensive and we wanted to know whether the herbicides would be effective used alone. All were foliar applications and applied according to label rates (148 ml of herbicide mixture to 1 m^2). The three formulations tested were: Garlon 4 10% (*a.i.* triclopyr) with crop oil, Ranger pro 2% (*a.i.* glyphosate) with water and Polaris 2% (*a.i.* imazapyr) with water. This is the first time OANRP has tested glyphosate for control of this species. I refer to these herbicides by their trade names for the rest of this document (Garlon, Ranger and Polaris).

Research questions

1. Which of three herbicide formulations killed palm fern most rapidly with no trenching?
2. Which of the three herbicides remained effective at suppressing regrowth from rhizomes at 1 year?
3. Does patch size influence herbicide efficacy?

Secondary questions addressed:

4. How far outside of the treated area did herbicides migrate (as indicated by changes in plant vigor outside of the plot)?
5. Were non-target plants adversely impacted by treatment?

Methods: Palm fern patches share rhizomes and resources with neighbors. Treated plants surrounded by untreated plants are therefore expected to be more resistant to herbicide and/or resprout more quickly than those growing in small isolated patches. We controlled for this by arranging plots in a randomized block design, with each of the three herbicide treatments and a control plot replicated within each discreet fern patch (block). In March 2014 we located 10 patches of palm fern in Ekahanaui MU (Figure 1). Within each patch four 1 m^2 plots were established no closer than 1 m to the patch edge and to one another. This meant that the smallest measured 25 m^2 while the remainder varied in size with the largest patch covering an area 100 m^2. Blocks were classified as small (25≥45 m^2), medium (45≥65 m^2) or large (65≥100 m^2). Four blocks were small; four medium, and two were in the largest group. Most patches had dense healthy cover and a one-way ANOVA confirmed no significant difference in cover between blocks ($F_{9,30} = 2.10$, $p = 0.3$).

The response variable was measured in the following manner. At each monitoring event a photo point was taken, the percent cover (dead and alive) of palm fern recorded (mean from two different observers), the presence of dead fern or other plants outside of the plot boundary noted and the presence of any co-occurring species. These data were taken immediately prior to treatment on March 20 (day 0) then at one, two, six and 13 months subsequently. No significant pre-treatment differences in live fern cover (Fig. 2) was evident between herbicide and control groups according to a one-way ANOVA ($F_{3,36} = 0.56$, $p = 0.64$).

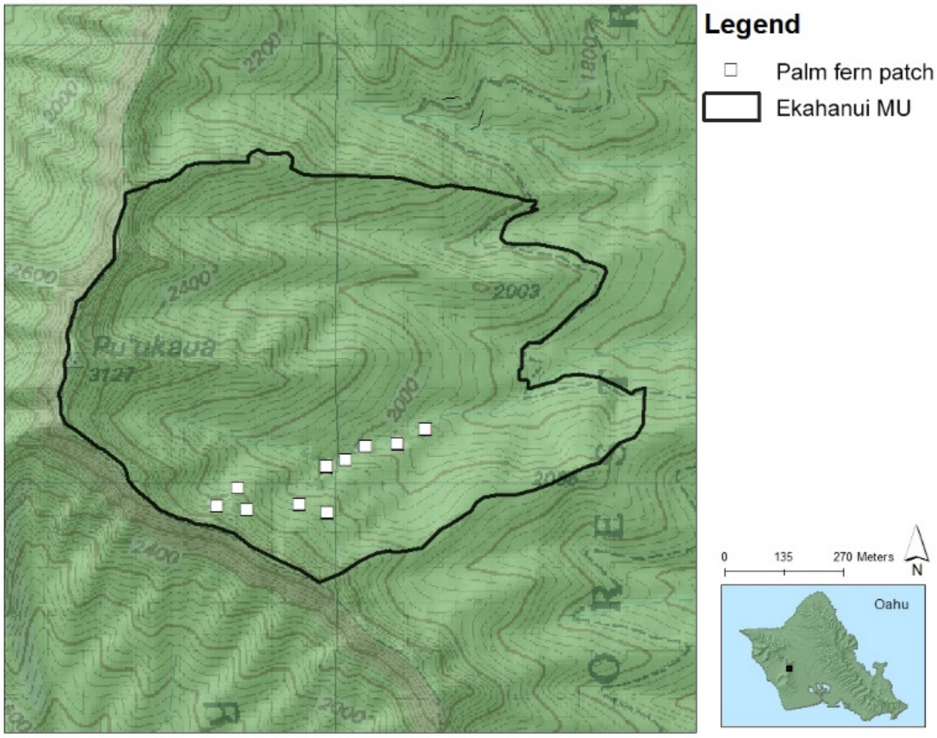


Figure 1. Palm fern patch (block) locations. Three herbicide treatments were repeated within each block.

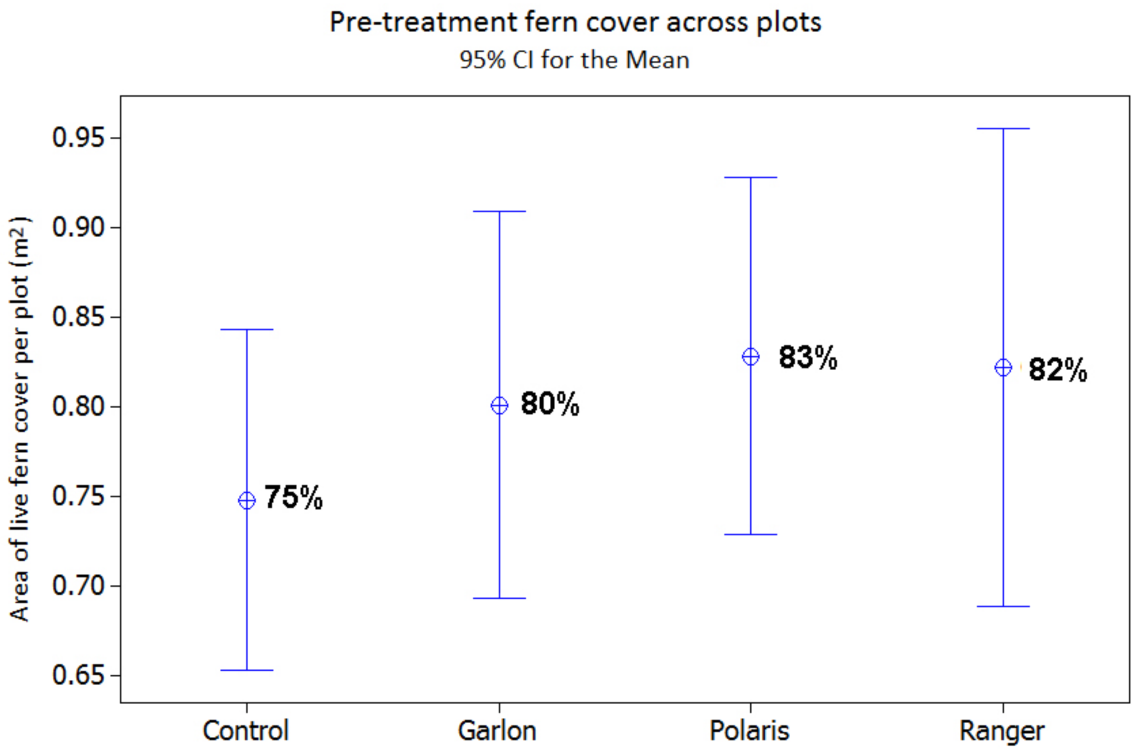


Figure 2. Pre-treatment fern cover shows no significant differences between groups. Mean cover ranged from 75-83%.

Results: Change in live fern cover at each time period was calculated as a percent deviation from pre-treatment values. A positive number indicated an increase; zero equaled to no change and negative values, a reduction in fern cover. All herbicide treatments significantly reduced fern cover over the control group by 2 months and treatments were equally effective at 6 months, however, Polaris had a slower onset (Fig. 3). While Garlon and Ranger immediately reduced fern cover by close to 100%, Polaris needed as least 6 months to catch up with the other two treatments (Fig. 4). The effect of treatment, time, and block (fern patch size) was analyzed using General Linear Model (GLM) and we made post-hoc comparisons between groups using a Tukey's HSD. Fern cover was significantly affected by treatment (GLM, $F_{3,108}$ = 174.81, p = 0.000) but not by block (GLM, $F_{9,108}$ = 0.95, p = 0.498). Reductions in fern cover by treatment and block are shown in Figure 5.

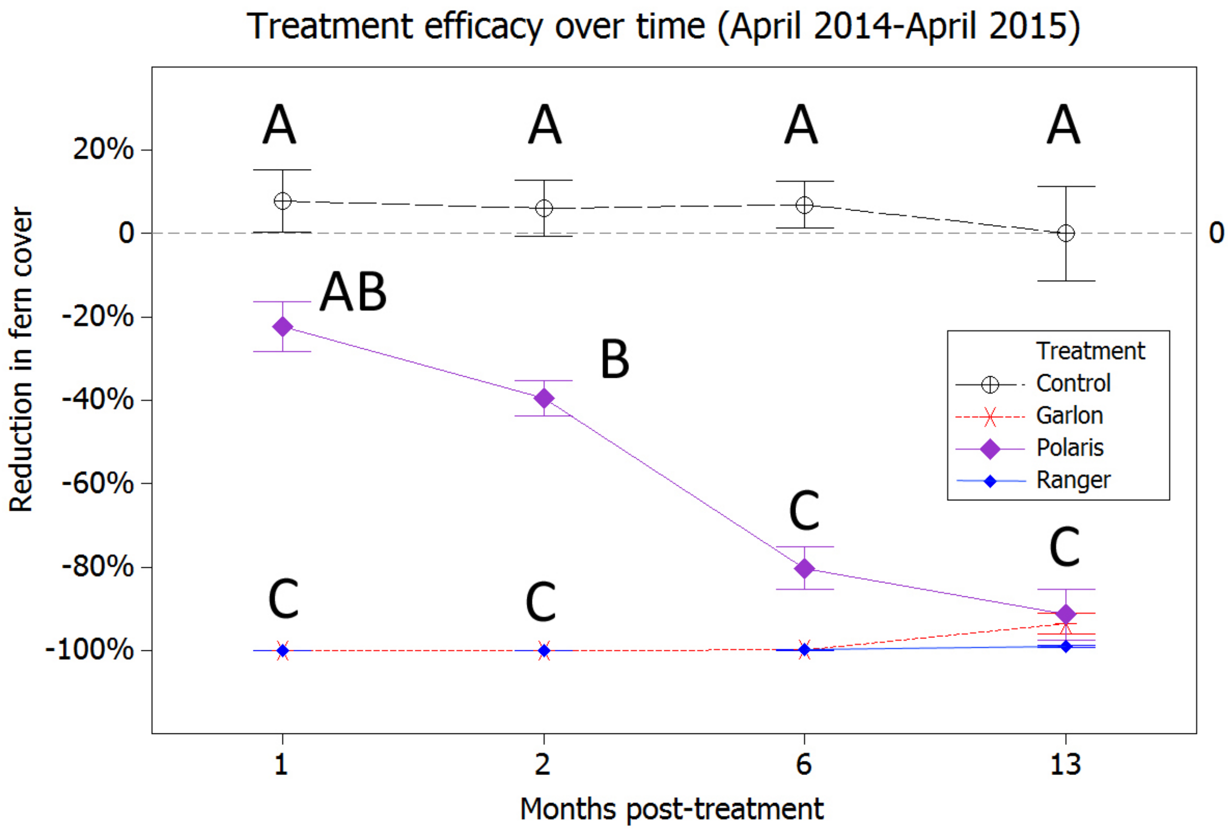


Figure 3. Change in fern cover over time by herbicide treatment. Bars are ± 1 standard error from the mean (SEM). Letters indicate groups which differed significantly from one another according to post-hoc comparisons.

Figure 4. Photos of representative plots of Polaris vs. Garlon over time. Notice that the Polaris at two months has not yet killed all of the fern, but by 13 months has achieved complete suppression. An asterisk (*) marks a kukui (*Aleurites moluccanus*) tree in the Polaris plot for reference.

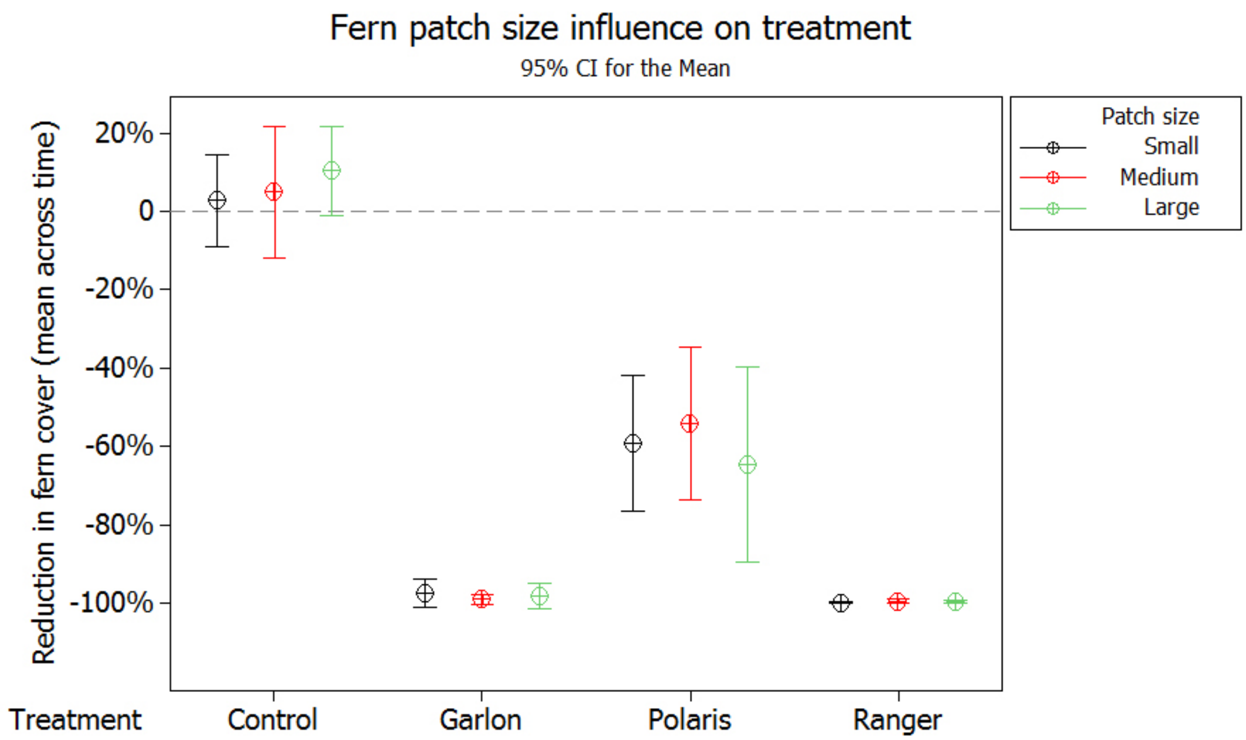


Figure 5. Performance of herbicides within differently sized blocks. This is an average of all times and does not reflect final herbicide efficacy at 13 months. Notice that the herbicides performed similarly despite fern patch size and that larger patch sizes did not confer herbicide resistance.

Neither Garlon or Ranger was observed to migrate outside of the plot (as indicated by dead or dying adjacent plants). Polaris appeared to have a slightly greater influence on nearby vegetation but only at small distances (not exceeding 40 cm from plot boundary). Co-occurring plants within plots did not fare well under any herbicide regimen (Table 1). Not all species occurred in all plots, *Clidemia*, for example only occurred in only two plots and died following treatment. *Passiflora suberosa* died in one of the control plots for unknown reasons.

Table 1. List of co-occuring plants which also died after treatment.

Species	Treatment
Pisonia spp.	Polaris, Garlon, Ranger
Oplismenus hirtellus	Polaris, Garlon, Ranger
Aleurites moluccana	Polaris, Garlon, Ranger
Clidemia hirta	Polaris, Garlon
Passiflora suberosa	Polaris, Garlon, Ranger, Control

Conclusions: Foliar application of any of the three herbicides tested are effective at controlling palm fern for up to 13 months regardless of the size of the patch. Trenching and cutting of stolons is not necessary. Non-target plants will be impacted by treatments so care should be used around native species, especially if they are uncommon. This is the first time Ranger was tested on palm fern and it is an acceptable alternative to Garlon. Both Garlon and Ranger are postemergent systemic (translocated) herbicides that do not persist for a long time in the soil. The half-life for Ranger in soil is 60 days and for Garlon it is about 30 days. Polaris, by contrast, is a preemergent herbicide which suppresses regrowth and new plant regeneration over time. Though slower to take action, it prevents regrowth of plants and is designed to persist in soil for 5 months or longer depending on rainfall. The label also cautions: “untreated trees can .. be affected by root uptake .. through movement into topsoil.. and onto areas where their roots extend.” Thus, Polaris use would not be appropriate in an area where rare plant outplanting is planned within the next 5 months, or where rare native plants may be exposed. It may be appropriate, however in very weedy areas where natives won’t be introduced for one year or more following weed control.

Works Referenced

Mehltreter, K., L.R. Walker, J.M. Sharpe. 2010. Fern Ecology. Cambridge University Press.

Motooka, P., L. Castro, D. Nelson, G. Nagai, and L. Ching. 2003. Weeds of Hawai‘i’s Pastures and Natural Areas; An Identification and Management Guide. College of Tropical Agriculture and Human Resources, University of Hawai‘i at Manoa.

CHAPTER 2: RARE PLANT MANAGEMENT

2.1 PROJECT HIGHLIGHTS

During this reporting period, OANRP outplanted a total of 2,136 individuals of MIP and OIP taxa. Specifically, 1,491 individuals of seven Makua taxa, 462 individuals of three OIP taxa and 152 individuals of four taxa shared between both IPs. In the last year, OANRP made 287 observations at *in situ* sites of IP taxa and 286 observations at outplanting sites. Some of this year's highlights include:

Cyanea grimesiana subsp. *obatae* (MIP & OIP): A 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. OANRP decided to conduct supplemental pollinations and not emasculate flowers at the risk of damaging the flowers and inhibiting fertilization. This technique also allowed for the quantification of pollen limitation by comparing seed set in fruits that receive supplemental pollen to controls (open-pollinated; natural conditions). If methods, however, can be developed to emasculate flowers without negatively impacting pollination, they will allow for certainty that propagules are from hand-pollinations and not from autogamy (flower selfing). Bags were applied to prevent additional pollen deposition on hand-pollinated flowers. Pollen was collected and used within a two week period to reduce artificial selection during storage. Early-life stage fitness measurements include fruit set, seed set, seed weight, seed viability, seed storage potential and seedling survivorship (from germination to the first true leaves). Long-term fitness measurements include nursery success, survival after outplanting, years to maturity, and the number of flowers and fruits produced at the first year of maturity. We could also assess pollen viability from these first flowers by collecting pollen samples. In lieu of measuring later life stages, seeds could be used in seed sow trials to compare fitness via recruitment (dependent on the number of seeds collected per treatment). Methods were approved by OANRP, NARS, and OPEPP staff. This project is ongoing and results will be presented over the next several years.

Eugenia koolauensis (OIP): Collections were made from all known sites in the last year. Vegetative cuttings and small immature plants have been salvaged from every site to secure a nursery living collection of 150 founders. There are now 117 founders represented in the OANRP nursery including 30 small immature plants that were removed from the wild populations. In the coming year, OANRP will complete these collections, replicate the founders and pursue experimental outplantings to investigate feasibility of maintaining an *inter situ* collection.

Gardenia mannii (OIP): Collections were made from 26 founders in the last year to secure a living collection in the OANRP nursery. This collection will be used to produce propagules by vegetatively cloning the trees for outplanting. Efforts are also being made to induce flowering in these collections to begin breeding system research and produce viable seeds for storage and propagation for outplanting. The first outplanting of stock grown from the nursery living collection was conducted in January 2015 in Lihue (SBW). All outplants are still alive and one began to flower shortly after it was planted. These sites will be supplemented with additional male founders from the Koolau Mountain PUs in the coming year because all of the four founders with known sex from the Waianae Mountains are observed to be female (pollen absent; ovules present). There are two founders with unknown sex. All of the six founders in the Koolau Mountains with known sex are believed to be male (pollen present; ovules absent). There are approximately 28 more trees in the Koolau Mountains and 3 from the Waianae Mountains with unknown sex. In the coming year, clones of male trees from the Koolau Mountains will be added to the Lihue PU.

Labordia cyrtandrae (OIP): The outplanting sites at Kaala were monitored in the last year and many of the plants were observed in flower. Staff spent time to hand-pollinate the flowering plants and many were observed producing fruit soon afterwards. This is likely to have increased the amount of seed produced at the site this year. The sites will be monitored for seedlings in the coming year as fruit will not likely mature and dehisce until early 2016. In the coming flowering season, OANRP will investigate whether the outplants are being effectively pollinated and producing viable seeds.

Pritchardia kaalae (MIP): A bulk collection of 200 fruit was scheduled to be made from the large wild population in Makua for testing protocols for storage at the National Center for Genetic Resources Preservation. However, when the plants were visited in Oct. 2014 and again in Feb. 2015, there were not enough mature fruit to make a collection. Rat damage was observed to be more extensive than in previous years and it is also possible that high-wind events limited fruit production during that season. Due to access restrictions into MMR, the site has not been revisited since.

Sanicula mariversa (MIP): The first large-scale outplanting with this taxon occurred in February 2015. The 186 plants were grown for two full seasons before being outplanted in February 2015. Due to access restrictions into MMR, the site has not been monitored since and their fate is unknown.

Stenogyne kanehoana (OIP): The first outplanting of this taxon back into a historic site in SBW occurred in January 2015. Stock grown from the two original wild founders from Kaluaa and Lihue were planted with stock cloned from two seedlings produced via a hand-pollination cross of the two founders. These sites will be supplemented with additional stock in the coming year.

2.2 TAXON STATUS SUMMARY

In the last year, there have been changes in the number of mature plants at 56/131 of the Manage for Stability Population Units managed by OANRP. Table 2.2.1 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. For taxa covered by the Makua Implementation Plan, the largest changes occurred in PU that have been augmented with outplants with a few exceptions. For example, there were notable declines in the number of wild mature plants in the Makua PU of *Euphorbia celastroides* var. *kaenana* and significant declines at smaller PUs of *Alectryon macrococcus* var. *macrococcus*, *Tetramolopium filiforme* and *Hibiscus brackenridgei* subsp. *mokuleianus*. Increases at the *Melanthera tenuifolia* PU at Mt. Kaala NAR, and *Nototrichium humile* were due to more thorough surveys of known sites. For taxa covered by the Oahu Implementation Plan, the largest changes also occurred due to fluctuations in the number of mature outplants, especially for *Phyllostegia hirsuta, Gardenia mannii, Stenogyne kanehoana* and *Abutilon sandwicense*. Otherwise, surveys by OANRP and the Koolau Mountains Watershed Partnership located more wild individuals of *Cyanea acumintata*, *C. koolauensis*, *Gardenia mannii*. More wild plants were observed in flower at known populations of *Abutilon sandwicense* in the last year, causing increases at two MFS PUs. Significant declines continue at PUs of *Eugenia koolauensis*, and fewer *Cyanea acuminata* were observed at the Helemano-Punaluu PU, but otherwise most decreases in OIP taxa occurred at outplantings of *Phyllostegia* sp. The declines observed at these sites were not a surprise, but are a reminder that these PUs may have to be maintained by repeated short-lived outplantings.

Table 2.2.1 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 PUs with DECREASES	Δ Mat	% change	IP	Species and MFS PUs with INCREASES	Δ Mat	% change
MIP	**AleMacMac- Kahanahaiki to Keawapilau**	-3	-100%	OIP	GarMan- Haleauau	67	3350%
MIP	**HibBraMok- Keaau**	-1	-100%	OIP	AbuSan- Kahanahaiki	59	454%
MIP	**VioChaCha- Halona**	-19	-86%	OIP	PhyHir- Koloa	72	288%
OIP	PhyMol- Ekahanui	-65	-86%	OIP	AbuSan- Ekahanui and Huliwai	28	156%
OIP	PhyMol- Pulaii	-22	-67%	OIP	**GarMan- Helemano and Poamoho**	3	113%
MIP	**TetFil- Waianae Kai**	-10	-50%	OIP	SteKan- Haleauau	109	100%
MIP	**EupCelKae- Makua**	-40	-47%	MIP	CenAgrAgr- Makaha and Waianae Kai	161	94%
MIP	**AleMacMac- Makua**	-5	-46%	MIP	CyaLong- Makaha and Waianae Kai	95	86%
MIP	**AleMacMac- Kaluaa to Central Waieli**	-1	-33%	MIP	HesOah- Pualii	5	83%
OIP	PhyMol- Kaluaa	-44	-33%	MIP	**SanMar- Kamaileunu**	4	80%
MIP	SchNut- Kapuna-Keawapilau Ridge	-24	-32%	MIP	TetFil- Puhawai	11	52%
OIP	**CyaAcu- Helemano-Punaluu**	-59	-31%	MIP	HesOah- Pahole NAR	2	50%
OIP	**EugKoo- Oio**	-2	-29%	OIP	LabCyr- Koloa	10	44%
MIP	SchKaa- Pahole	-23	-28%	MIP	**MelTenf- Mt. Kaala NAR**	51	42%
MIP	DelWai- Manuwai	-24	-27%	OIP	**AbuSan- Makaha Makai**	27	42%
MIP	SchObo- Keawapilau to West Makaleha	-14	-24%	MIP	SchObo- Makaha	42	29%
MIP	NerAng- Waianae Kai Mauka	-3	-23%	MIP	NerAng- Manuwai	27	24%
OIP	PhyHir- Haleauau- Mohiakea	-20	-22%	MIP	EupHer- Kapuna to Pahole	13	23%
MIP	**HibBraMok- Haili to Kawaiu**	-1	-20%	OIP	**AbuSan- Kaawa to Puulu**	5	19%
MIP	SchKaa- Kaluaa and Waieli	-32	-19%	MIP	SchObo- Kahanahaiki to Pahole	51	18%
OIP	**SchTri- Kalena to East Makaleha**	-56	-16%	MIP	**NotHum- Kaluakauila**	28	18%
OIP	**HesSwe- Kaukonahua**	-10	-15%	OIP	**CyaKoo- Poamoho**	3	17%
OIP	**EugKoo- Kaunala**	-3	-13%	MIP	SchNut- Makaha	11	16%
MIP	HibBraMok- Makua	-9	-11%	MIP	CyaGriOba- Pahole to West Makaleha	11	15%
MIP	HibBraMok- Manuwai	-13	-8%	MIP	DelWai- Ekahanui	28	14%
MIP	CyaSupSup- Pahole to Kapuna	-7	-7%	MIP	CyaSupSup- Kahanahaiki	8	14%
OIP	SteKan- Kaluaa	-2	-7%	MIP	CyaGriOba- South Ekahanui	11	13%
OIP	**CyaKoo- Kaipapau, Koloa & Kawainui**	-7	-6%	OIP	PhyHir- Puu Palikea	13	13%
MIP	DelWai- Kahanahaiki to Keawapilau	-13	-5%	MIP	KadDegDeg- Alaiheihe and Manuwai	8	10%
MIP	CyaGriOba- Palikea (South Palawai)	-5	-5%	MIP	CyaGriOba- Kaluaa	13	10%
MIP	SchNut- Kahanahaiki to Pahole	-5	-5%	MIP	DelWai- Kaluaa	60	9%
OIP	**CyaAcu- Makaleha to Mohiakea**	-7	-4%	OIP	LabCyr- East makaleha to North Mohiakea	24	9%
MIP	NotHum- Manuwai	-4	-4%	OIP	**CyaAcu- Kaluanui and Maakua**	10	9%
MIP	**AleMacMac- Makaha**	-1	-3%	MIP	**CyrDen- Kahanahaiki**	3	8%
MIP	CenAgrAgr- Kahanahaiki and Pahole	-8	-3%	MIP	CyaLong- Kapuna to West Makaleha	2	7%
MIP	PriKaa- Makaleha to Manuwai	-1	-1%	MIP	**CyaLong- Pahole**	3	5%
				OIP	**CyaKoo- Opaeula to Helemano**	1	5%
				MIP	PlaPriPri- Ekahanui	2	4%

The Taxon Status Summary for each IP taxon is included as Appendix 2-1. The example shown below (Table 2.2.2), 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 2.2.2. 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.

2.3 THREAT CONTROL SUMMARY

The Threat Control Summary for each IP taxon is included as Appendix 2-2. An example shown below (Table 2.3.1), 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. For MIP taxa in the last reporting period, changes in ungulate threat control were due to construction of a new fence at Keaau for *Hibiscus brackenridgei* subsp. *mokuleianus* and a significant reduction in ungulates within the fenced Lihue MU, resulting in a lower threat. The ungulates remaining in the Upper Kapuna MU and the Opaeula MU have been eliminated and a determination was made that ungulates are not a threat to the few *Cyanea longiflora* at the Kapuna to West Makaleha PU that are outside of the fence. It was also determined that ungulates are not a threat to the *Hibiscus brackenridgei* subsp. *mokuleianus* at the Haili to Kawaiu PU or to the *Tetramolopium filiforme* at the Puhawai PU and *Viola chamissoniana* subsp. *chamissoniana* at the Puu Kumakalii PU and Puu Hapapa PU. If ungulate sign is observed near these PUs, the threat will be added and control will be prioritized. Fence construction and ungulate removal is ongoing at the Keaau PU of *Gouania vitifolia* by the Oahu Plant Extinction Prevention Program and the Waianae Mountains Watershed Partnership. The PUs where ungulates remain a threat to MIP taxa are the *Kadua degeneri* subsp. *degeneri* at Central Makaleha and West Branch of East Makaleha, the *Melanthera tenuifolia* at Kamaileunu and Waianae Kai, the *Kadua parvula*, *Plantago princeps* var. *princeps* and *Viola chamissoniana* at Halona, and the *Pritchardia kaalae* in the Makaleha to Manuwai PU. For the OIP MFS PUs in the last year, many pigs have been removed from the within the Lihue MU and the threat was reduced for: *Cyanea acuminata, Gardenia mannii, Labordia cyrtandrae, Phyllostegia hirsuta, Schiedea trinervis,* and *Stenogyne kanehoana*. Additional OIP MFS PUs will be protected from ungulates once they are removed from the recently completed Poamoho MU fence. Other fences being considered by DOFAW for Kaluanui, East Makaleha and Poamoho would protect additional OIP MFS PUs. The PUs where ungulates would remain a threat to OIP taxa are the *Hesperomannia sweezyi* at the Lower Peahinaia PU and the Kaukonahua PU, and the *Cyanea acuminata* at the Helemano-Punaluu Summit Ridge to North Kaukonahua PU.

Weed control continues at most MU. Due to time constraints caused by the reduced reporting period, data for weed control was not analyzed. Over the last reporting period, weed control was conducted at 46/100 MIP MFS PUs. This is a 33% reduction from last year because the reporting period was three months shorter than the previous period and access restrictions in Makua prevented staff from weeding there. Many of the PUs where no weeding was done occur on difficult terrain such as cliffs, or are PUs where outplantings have not yet begun and therefore the sites have not been managed. For OIP taxa, weed control was conducted at 18/31 MFS PUs in the last reporting period. The same number of PUs had weed control in the previous period. Little or no control was conducted around PUs in remote areas such as Opeaula, Helemano, Kaluanui, Kaipapau, Koloa and Kaukonahua. These sites are relatively native-dominated and may not require as much invasive plant management as other PU. Some of these areas are managed by the Koolau Mountains Watershed Partnership which also conducts weed control. Other PUs receiving less OANRP weed control than others are the Kaawa to Puulu PU and Makaha Makai PU of *Abutilon sandwicense* and sites with *Eugenia koolauensis*. The sites with *E. koolauensis* have been a lower priority in the last few years given the overwhelming threat of Myrtle Rust to the remaining plants, however, the habitat is being rapidly degraded and fuel levels are increasing at all sites.

Rat control continued around many PU in the last year. Although rats are considered a potential threat to most IP taxa, they are only 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. Rats are considered a threat to 11 of the 28 taxa in the MIP and are controlled at 15 of the 45 MFS PU with those taxa. Rats are considered a threat to six of the OIP taxa at 17 PUs, but currently are controlled only around the Ekahanui PU of *Phyllostegia mollis*.

Slugs are a threat to seedlings and small immature plants of many native plants. They are noted as a threat to 16 of the 28 MIP taxa and are currently controlled at 10 of the 57 MFS PUs with those taxa. For the nine OIP taxa where slugs are a threat, there are currently 24 MFS PUs, but slugs are not currently controlled at any PUs. Decisions on where to initiate control are based on staff availability and only at sites without native snails that qualify under label restrictions. Future outplantings for IP taxa that may be dependent on slug control will be planned for areas that do not have those restrictions.

Fire is noted to be a threat to all taxa in both IPs. For the purposes of this report, fire is considered to be a threat to 17 of the 100 MFS PUs for MIP taxa. Of those, fuels have been reduced and the threat from wildfire reduced at four PUs in Makua and in Waianae Kai. For the OIP taxa, wildfire is considered to threaten 5 of the 31 MFS PUs. Fuels and the threat of fire has been reduced at the three MFS PUs for *Eugenia koolauensis* and at the Kaawa to Puulu PU of *Abutilon sandwicense*, but not at the Ekahanui and Huliwai PU for *A. sandwicense*. OANRP has continued to contract mowing of fallow agriculture lands along the Kaukonahua Rd. to eliminate fuels and prevent wildfires from moving from that area into the Lower Kaala NAR as one did in 2007. This action partially controls the threat of fire to Genetic Storage PUs of *Hibiscus brackenridgei* subsp. *mokuleianus* and *Eugenia koolauensis*, and to the MFS Kaawa to Puulu PU for *Abutilon sandwicense*.

The Threat Control Summary for each IP taxon is included as Appendix 2-2. An example shown below (Table 2.3.1), 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 2.3.1. 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.

2.4 GENETIC STORAGE SUMMARY

The Genetic Storage Summary for each IP taxon is included as Appendix 2-3. 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. There were 46 PUs where genetic storage collections were already completed as of September 2014. In the year since, collections were completed at an additional 8 PUs. These include *Cyanea grimesiana* subsp. *grimesiana* in Pahole to West Makaleha PU and Kaluaa PU; *Cyrtandra dentata* in Pahole to West Makaleha PU, *Delissea waianaeensis* in Kahanahaiki to Keawapilau PU, *Eugenia koolauensis* in Palikea to Kaimuhole PU, *Nototrichium humile* in Kaimuhole to Palikea Gulch PU, *Phyllostegia hirsuta* in Kaipapau to Kawainui PU, and *Schiedea nuttallii* in Kapuna-Keawapilau Ridge.

Two PU that met the 100% goal due to a decline in the number of founders in the PU were excluded from this list.

When we look at the number of founders that need to be represented, 40% of them are complete and PU average 41% completion. This is an increase from 37% in 2014 (Table 2.4.1). We completed representation of an additional 18 founders this past year, in addition to starting collections of many other founders. In 2014, we averaged 33% completion of collections inside of the Action Area and currently we have completed 36% of the collections. We averaged 47% completion for MIP and MIP/OIP overlap taxa in 2015, up from 44% completion in 2014; OIP taxa average 28% completion in 2015 (up from 24% in 2014). We had 142 out of 228 PU (62%) with some progress towards completion in 2014 and 2015, indicating that we did not complete a collection from a new founder in a new PU this year, despite the fact that new collections were made from new PU (*i.e. Gardenia mannii*). In 2014, we had 49 PU with greater than 90% completion and in 2015 we had 58%. Lastly, on average we have made more progress toward completing collections from MFS PU (52%) than GS PU (31%).

For the second year in a row we were unable to collect *Pritchardia kaalae* fruits from the main population at Ohikilolo to send to the National Center for Genetic Resources Preservation (NCGRP). In 2014, invasive rodents and birds are suspected for removing and destroying fruits so that there were very few mature fruit to collect at a single point in time. At the end of 2014 through the beginning of 2015 we increased rodent control and frequency of monitoring but we have been denied access by the Army for most of 2015 and collections for this year and next year are doubtful due to the rodent control efforts that will be necessary to yield a large number of mature fruits at one time. OANRP currently contracts NCGRP to determine cryopreservation techniques for *P. kaalae* and to create and maintain a genetic storage collection for this species. Fortunately, we were able to collect hundreds of fruit from our living collection of *Eugenia koolauensis* to send to NCGRP to determine cryopreservation techniques.

Table 2.4.1. Summary statistics to indicate progress during the FY2015 in genetic storage collections. There are 228 total PU that require *ex situ* representation via seed banking, tissue culture, or living collections in the Army Nursery.

Completion Summary Statistics	*2014*	*2015*
Average PU Genetic Storage Completion	37%	41%
MIP and MIP/OIP Overlap Species	44%	47%
OIP Species	24%	28%
PU With No Founder Representation	86 (38%)	86 (38%)
PU With >90% Representation	49 (21%)	58 (25%)
PU With ≥75% Representation	60 (26%)	74 (32%)
Additional Founders Represented in FY2015 (# of founders with completed collections)	(1776)	18 (1794)
Comparison of MFS PU : GS PU Completion	48%: 27%	52%: 31%

The Genetic Storage Summary for each IP taxon is included as Appendix 2-3. In the example below (Table 2.4.2), 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 2.4.2. 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.

% 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%.

CHAPTER 3: *ACHATINELLA MUSTELINA* MANAGEMENT

3.1 BACKGROUND

In 2014 OANRP prepared a three year management plan for *Achatinella mustelina* ESUs. This year OANRP reports on ESU highlights of the past year and progress toward the goals set in 2014. The three snail enclosures are working as designed and construction plans are being developed for additional snail enclosures in suitable habitat. Without snail enclosures almost all native snail populations of *A. mustelina* would be headed for extinction.

OANRP have prepared a tree snail monitoring overview which is included as Appendix 3-1. This overview summarizes the history and context that have influenced OANRP's tree snail monitoring schedule, frequency and applied methods. This section was prepared at the request of the USFWS.

Map removed to
protect rare resources

Figure 1. Map of Six ESUs

3.2 ESU-A

Map removed to protect rare resources. Available upon request

Figure 2. Map of ESU-A

3.2.1 Update ESU-A

3.2.1.1 MMR-A, Kahanahaiki Enclosure PU

Monitoring of the *A. mustelina* population within the enclosure has been 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. Current TCM (Timed Count Monitoring) numbers continue to show a stable trend within the enclosure and TCM will continue be conducted quarterly.

Installation of the remote monitoring system has been delayed due to upgrading of the system being conducted by technicians in California. A new remote monitoring system should be set up in the next few months. Additional upgrades to the enclosure were conducted in May, which included further fortification of the buried section of the wall with plastic lumber and wall supports. The database shows that there are approximately 250 snails have been moved inside the enclosure and staff have been able to count 177 of them in a single monitoring event. Not all snails are found on any one monitoring, thus there are many more than 177 inside the enclosure.

Figure 3. Recent enclosure wall upgrades showing plastic lumber at ground level and wall supports on the inside.

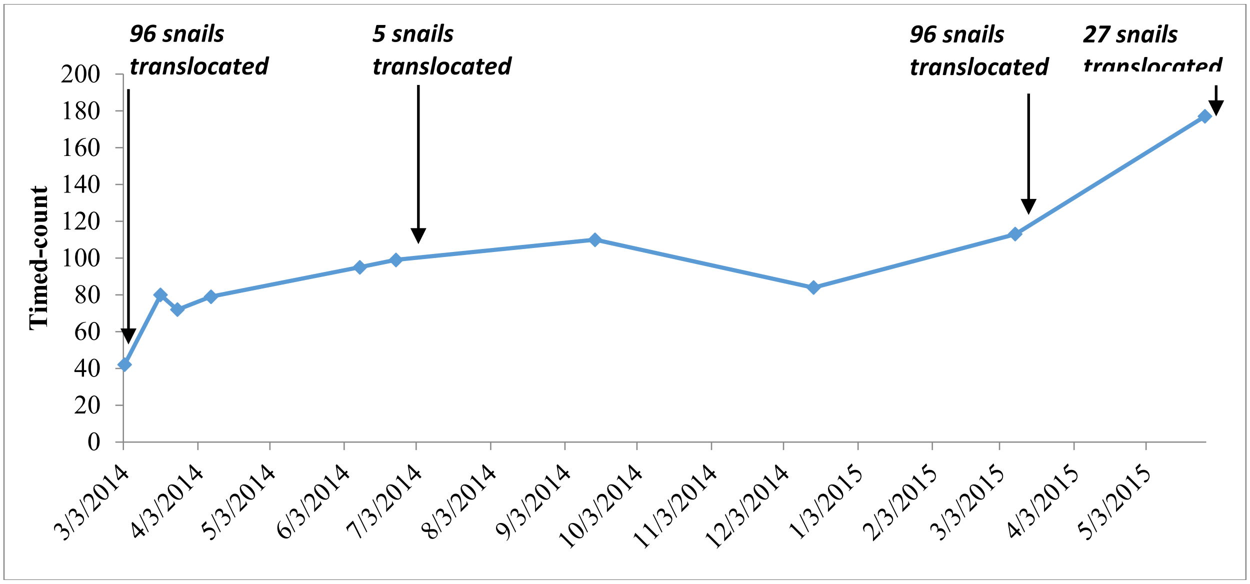


Figure 4. Timed-counts for *A. mustelina* in Kahanahaiki snail enclosure from March 2014 to May 2015.

3.2.1.2 MMR-C, Maile Flats PU

Remaining snails from this population have been and will continue to be collected and placed into the MMR-A enclosure. A total of 12 snails were moved on September 15, 2014, including 1 small, 3 medium, and 8 large snails. Twenty-seven additional snails were translocated into the enclosure on June 27, 2015, including 4 small, 9 medium, and 24 large snails. It is believed that only a small number of snails remain outside the enclosure in Maile Flats.

3.2.1.3 MMR-O, Giant Olopua

The remaining snails in this population were collected and brought into the MMR-A enclosure. On March 9, 2015, 2 small, 3 medium and 4 large for a total of 9 snails were translocated. On June 27, 2015, no snails were found at this site to be translocated.

3.2.1.4 ESU-A, No Management PUs

With a collaborative effort from SEPP and NARS staff, a total of 71, including 12 small, 22 medium and 37 large *A. mustelina* were translocated from No Management PUs into the Kahanahaiki enclosure. On March 19, 2015, 10 snails were translocated from the KAP-A population. A total of 7 snails were translocated from the KAP-C population. Lastly, 54 snails were collected from the PAH-C population and were brought into the MMR-A enclosure. Staff will return to these three sites and continue to search for any remaining snails. See OANRP 2014 Makua and Oahu Implementation Plan Status Report for detailed plans.

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes: Large	Medium	Small	Unk	Threat Control: Ungulate	Weed	Rat	Euglandina rosea	Jackson's Chameleon
Achatinella mustelina												
ESU: A — Pahole to Kahanahaiki												
KAP-A Just below Makua rim on trail above hunter's cabin.	Manage for stability	10 *	2015-03-18	2	5	3	0	Yes	No	Yes	No	No
KAP-B Chaher weeding site	No Management	1	2005-09-27	1	0	0	0	Yes	Yes	No	No	No
KAP-C One Acre Site	Manage for stability	7 *	2015-03-24	2	3	2	0	Yes	Yes	Yes	No	No
LEH-F West Makaleha off of Keawapilau ridge	No Management	1	2005-03-08	1	0	0	0	Yes	No	No	No	No
MMR-A Kahanahaiki Exclosure	Manage for stability	177	2015-05-27	83	64	30	0	Yes	Yes	Yes	Yes	No
MMR-C Maile Flats	Manage for stability	12	2014-09-15	8	3	1	0	Yes	Yes	Yes	No	No
MMR-D Kahanahaiki Gulch	No Management	0	2015-03-11	0	0	0	0	Yes	Yes	No	No	No
MMR-M East Rim 2A ridge	No Management	17	2014-09-17	0	7	10	0	Partial	No	No	No	No
MMR-N Kahanahaiki gulch at Steph Joe's slug boxes	No Management	0	2015-03-11	0	0	0	0	Yes	Yes	No	No	No
MMR-O Giant Olopua	Manage for stability	15	2014-09-15	6	7	2	0	Yes	No	Yes	No	No
PAH-A Cyasup Pahole gulch reintro lower site	No Management	0	2011-07-15	0	0	0	0	Yes	Yes	No	No	No
PAH-B Pahole Exclosure	Manage for stability	61	2015-02-04	37	14	10	0	Yes	Yes	Yes	Yes	No
PAH-C below Pahole snail exclosure	Manage for stability	54 *	2015-04-08	33	14	7	0	Yes	No	Yes	No	No
	ESU Total:	355		173	117	65	0					

*=Total Snails were Trans Located or Reintroduced

= Threat to Taxon at Population Reference Site (shaded)

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.

Figure 5. ESU-A Population Structure Summary

The following spreadsheet shows how many snails have come from which populations.

Taxon Code Pop Ref Site ID	Pop Ref Site Name	Observation Date	Reintro Origin	Reintro Small	Reintro Medium	Reintro Large
AchMus.MMR-A	Kahanahaiki Exclosure	2015-03-19	AchMus.KAP-A	3	5	2
AchMus.MMR-A	Kahanahaiki Exclosure	2015-03-25	AchMus.KAP-C	2	3	2
AchMus.MMR-A	Kahanahaiki Exclosure	2015-04-09	AchMus.PAH-C	7	14	33

Figure 6. Kahanahaiki Translocations 2015

3.2.2 Plans for Next Year

OANRP staff plan to survey the five populations where snails can still be found in ESU-A and move any other located snails into the snail enclosure. Staff are waiting for final support from FWS to also move the remaining snails from MMR-M. Maintenance and monitoring will follow the protocol written in the 2014 report.

3.3 ESU-B

Map removed to protect rare resources. Available upon request

Figure 7. Map of ESU-B1

3.3.1 Update ESU-B1

3.3.1.1 MMR-E, Ohikilolo Mauka PU

This site was last surveyed in 2012. Due to an accident in Makua, access has been denied since April 2015. Staff plan to conduct a current survey when the range is opened up for field work again. The habitat at this site has improved because there has been a considerable amount of weed control performed here.

3.3.1.2 MMR-F, Ohikilolo Makai PU

Due to an accident in Makua, access has been denied since April 2015. A TCM was conducted in 2014 and staff plan to follow-up with another survey in 2016. This site is protected by an extensive rat grid and fortunately, no *Euglandina rosea* have ever been seen in this area. The habitat here is improving due to weed control and outplanting and the snail numbers have been stable.

3.3.1.3 MMR-H, Ohikilolo Koiahi Prikaa Reintro PU

Monitoring of this PU was conducted on October 21, 2014 and April 6, 2015, with 32 and 19 snails observed, respectively. Access for further monitoring has been denied due to the accident in Makua. If the number of observed snails drops to a total of 15 or less, they will be translocated to the MMR-F PU about 700 meters upslope. No fresh ground shells have been observed here during opportunistic surveys.

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												
LEH-L 3 Points	No Management	6	2013-04-30	4	1	1	0	Yes	No	No	No	No
MMR-E Ohikilolo Mauka	Manage for stability	70	2012-05-02	45	6	19	0	Yes	Yes	Yes	No	No
MMR-F Ohikilolo Makai	Manage for stability	357	2014-03-12	204	115	38	0	Yes	Yes	Yes	No	No
MMR-G Ohikilolo Alemac Site	No Management	1	2010-12-02	1	0	0	0	Yes	No	No	No	No
MMR-H Ohikilolo Koiahi Prikaa Reintro Site	Manage for stability	32	2014-10-21	17	11	4	0	Yes	Yes	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	Yes	No	No	No
MMR-K Ctesqu ridge	No Management	3	1998-03-02	0	0	0	3	Partial	Yes	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:	481		278	133	62	8					

Size Class Definitions

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

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

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

Figure 8. ESU-B1 Population Structure Summary

3.3.2 Update ESU-B2

Map removed to protect rare resources. Available upon request

Figure 9. Map of ESU-B2

3.3.2.1 LEH-D, East Branch of East Makaleha Culvert 73 PU

A TCM was conducted on February 23, 2015 with a total of 41 snails observed. These snails could potentially be released into the planned snail enclosure that is being designed for 3 Points in the near future.

3.3.2.2 No Management PUs

OANRP has reached the goal numbers with just the two largest MFS sites; therefore, no effort was made in 2015 to revisit the no management sites to get updated numbers and status. The next survey scheduled for LEH-C is in 2016.

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	46	2009-11-17	38	6	2	0	No	No	No	No	No
LEH-A Central Makaleha (culvert 39)	No Management	63	2011-04-27	37	19	7	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	41	2015-02-23	34	5	2	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
	ESU Total:	538		361	108	35	34					

Size Class Definitions

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

= Threat to Taxon at Population Reference Site

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

Yes=Threat is being controlled at PopRefSite

No=Threat is not being controlled at PopRefSite

Partial=Threat is being partially controlled at PopRefSite

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

Figure 10. ESU-B2 Population Structure Summary

3.3.3 Plans for Next Year

OANRP will pursue building a snail enclosure at 3 Points for ESU-B snails in Makaleha and Ohikilolo. Maintenance and monitoring will follow the protocol written in the 2014 report.

3.4 ESU-C

Map removed to protect rare resources. Available upon request

Figure 11. Map of ESU-C

3.4.1 Update ESU-C

3.4.1.1 SBW-A, North Haleauau-Hame Ridge PU

This site was last surveyed on June 29, 2013 when a total of 80 snails were counted. Since then 23 snails were sampled for genetic analysis with Melissa Price's DNA project. It is difficult to get permission to camp here because the site is behind the live fire ranges. A current survey will be planned for the coming year.

3.4.1.2 SBW-B, North Haleauau One Ridge North of Hame PU

It is difficult to get permission to camp here because the site is behind the live fire ranges. A current survey will be planned for the coming year.

3.4.1.3 SBW-W, Skeet Pass PU

This site continues to impress staff as a rich area for snails. On August 27, 2014 a total of 303 snails were counted here. It is very steep habitat and staff are proposing to build an enclosure on the top of Mt. Kaala where the terrain is flat. Staff will continue to work with USFWS to conduct surveys of the area and study the weather data available. In addition, data loggers have been deployed to better quantify difference between skeet pass and Kaala.

3.4.1.4 No Management PUs

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, staff plan to conduct current surveys and ascertain whether or not there are any snails surviving here. Extensive surveys were conducted in the Lower Kaala NAR sites but no snails were found. In general, these lower elevation areas appear to be drier than the areas where snails survive higher up the ridge.

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes: Large	Medium	Small	Unk	Threat Control: Ungulate	Weed	Rat	Euglandina rosea	Jackson's Chameleon
Achatinella mustelina												
ESU: 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	No	No	No	No
ANU-A Manuwai gulch	No Management	1	2004-06-02	0	1	0	0	No	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	80	2013-06-29	36	39	5	0	Yes	No	Yes	No	No
SBW-B North Haleauau one ridge north of Hame	Manage for stability	9	2009-09-06	9	0	0	0	Yes	No	Yes	No	No
SBW-C North Haleauau just above Pouteria pair territory	No Management	0	2009-09-06	0	0	0	0	Partial	No	No	No	No
SBW-P South Water gulch by Stenogyne kanehoana	No Management	10	2005-01-19	3	7	0	0	Partial	No	No	No	No
SBW-W Skeet Pass	Manage for stability	303	2014-08-27	190	89	24	0	Partial	No	Yes	No	No
SBW-X elepaio #4	No Management	1	2009-11-23	0	1	0	0	Partial	No	Yes	No	No
SBW-Y Elepaio #8	No Management	3	2009-11-23	0	3	0	0	Partial	No	Yes	No	No
SBW-Z Clair's Ridge	No Management	14	2010-06-03	10	4	0	0	Yes	No	No	No	No
	ESU Total:	424		249	146	29	0					

Size Class Definitions

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

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

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

Figure 12. ESU-C Population Structure Summary

3.4.2 Plans for Next Year

OANRP staff will work with FWS and pursue building a temporary snail enclosure on Mt. Kaala. Maintenance and monitoring will follow the protocol written in the 2014 report.

3.5 ESU-D

Map removed to protect rare resources. Available upon request

Figure 13. Map of ESU-D1

3.5.1 Update ESU-D1

3.5.1.1 KAL-G Puu Hapapa Snail Enclosure PU

A total of 531 snails were counted here on January 5, 2015 and 491 on April 15, 2015. At the present time there are approximately 1500 snails inside the enclosure. 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 become bigger. Staff did find two Jackson's chameleons inside the enclosure and it was thought that they might have climbed in when fast growing *Pipturus albidus* trees on the inside and outside bridged. Since then staff have been diligent in trimming the trees along the fence walls and no more Jackson's have been seen inside since.

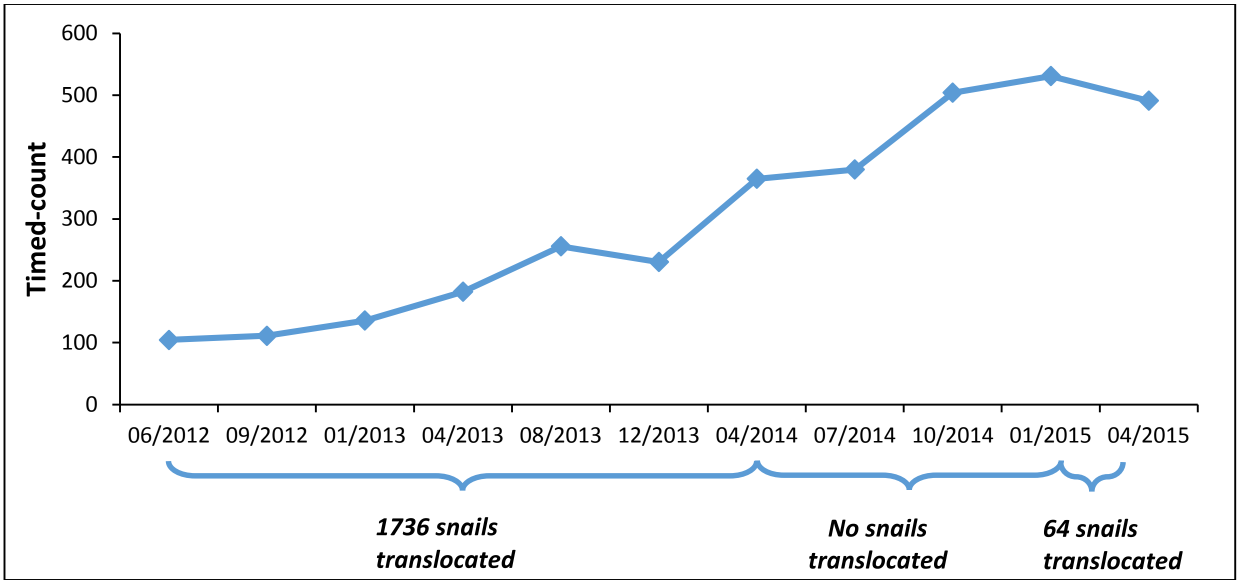


Figure 14. Timed-counts for *A. mustelina* in Hapapa snail enclosure from June 2012 to April 2015.

3.5.1.2 No Management PUs

Many snails have been collected from these populations and released into the snail enclosure. The following spreadsheet shows how many snails have come from which populations.

Taxon Code Pop Ref Site ID	Pop Ref Site Name	Observation Date	Reintro Origin	Reintro Small	Reintro Medium	Reintro Large
AchMus.KAL-G	Puu Hapapa snail enclosure	2015-01-14	AchMus.KAL-B	0	5	7
AchMus.KAL-G	Puu Hapapa snail enclosure	2015-01-14	AchMus.KAL-D	2	5	13
AchMus.KAL-G	Puu Hapapa snail enclosure	2015-01-27	AchMus.KAL-C	0	4	1
AchMus.KAL-G	Puu Hapapa snail enclosure	2015-02-12	AchMus.KAL-B	1	6	6
AchMus.KAL-G	Puu Hapapa snail enclosure	2015-02-12	AchMus.KAL-F	1	5	8

Figure 14. Puu Hapapa Translocations 2015

SEPP has translocated into the snail enclosure 15 adult *Amastra spirizona* from Makaha and they presently number 50+; 18 *Laminella sanguinea* from the Army side of Puu Hapapa; 1 *Amastra intermedia* from Mikilua and 7 from Daniel Chung's captive propagation project and they've produced one offspring; 16 *Cookeconcha* from Puu Hapapa and 1 *Leptachatina* from Mikilua.

Number of Snails Counted

Achatinella mustelina

ESU: D1 North Kaluaa, Waieli, Puu Hapapa, and Schofield Barracks South Range

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes: Large	Medium	Small	Unk	Threat Control: Ungulate	Weed	Rat	Euglandina rosea	Jackson's Chameleon
ELI-A South Waieli Gulch North Branch	No Management	34 *	2014-03-05	22	10	2	0	Yes	No	No	No	No
KAL-A Land of 10,000 snails	No Management	6 *	2014-03-06	5	1	0	0	Yes	Yes	Yes	Partial	No
KAL-B Gulch 1 Kaluaa	No Management	13 *	2015-02-12	6	6	1	0	Yes	No	No	No	No
KAL-C North Kaluaa	No Management	5 *	2015-01-27	1	4	0	0	No	No	No	No	No
KAL-D Gulch 3	No Management	20 *	2015-01-14	13	5	2	0	Yes	Yes	No	No	No
KAL-E Gulch 2	No Management	8	2012-04-16	8	0	0	0	Yes	Yes	No	No	No
KAL-F Central Kaluaa South Branch	No Management	14 *	2015-02-12	8	5	1	0	Yes	Yes	No	No	No
KAL-G Puu Hapapa snail enclosure	Manage for stability	491	2015-04-15	245	203	43	0	Yes	Yes	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	Yes	No	No	No
SBS-B Puu Hapapa	No Management	295 *	2013-12-11	143	99	53	0	No	No	No	No	No
	ESU Total:	886		451	333	102	0					

*=Total Snails were Trans Located or Reintroduced

Size Class Definitions

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

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

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

Figure 15. ESU-D1 Population Structure Summary

3.5.1.3 No Management PUs

Since a lot of these populations are not being managed and have not been recently surveyed, OANRP recommend performing current surveys and moving some of these snails into the Puu Hapapa snail enclosure. All of these snails are part of ESU-D. Although this might conceivably involve moving some snails approximately two to four kilometers, mixing them will help to preserve genetic material, possibly strengthen the existing population, and prevent the non-managed snails from being preyed upon by rats, *E. rosea* and Jackson's chameleons.

Number of Snails Counted

Achatinella mustelina

ESU: D — No Management ESU Sites of Waianae Kai, Kaluaa, Puhawai, SBS, and SBW

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes: Large	Medium	Small	Unk	Threat Control: Ungulate	Weed	Rat	Euglandina rosea	Jackson's Chameleon
PHW-A Lualualei, Puhawai below Tetfil finger	No Management	11	2009-11-05	10	0	1	0	No	No	No	No	No
SBS-C Lower Moho Gulch - Jennifer Crummer's spot	No Management	10	2003-04-16	10	0	0	0	No	No	No	No	No
SBS-D Two gulches west of Moho gulch enclosure	No Management	15	2012-12-19	12	2	1	0	No	No	No	No	No
SBW-AA Mt Kaala below blue trail fence	No Management	12	2012-10-25	7	5	0	0	Yes	No	No	No	No
SBW-BB Below transect 790	No Management	15	2013-10-10	6	5	4	0	Yes	No	No	No	No
SBW-D Kaala-Kalena ridge on "M" in Military	No Management	1	2000-02-18	0	0	0	1	Yes	No	No	No	No
SBW-E Kaala-Kalena ridge between Military and Reservation	No Management	1	2000-02-18	1	0	0	0	Yes	No	No	No	No
SBW-F North Mohiakea Banana Gulch	No Management	4	2006-06-22	3	0	1	0	Yes	No	No	No	No
SBW-G South of Puu Kalena	No Management	0	2003-10-14	0	0	0	0	Yes	No	No	No	No
SBW-H North Branch of South Mohiakea	No Management	10	1999-08-02	10	0	0	0	Yes	No	No	No	No
SBW-I South Mohiakea Sicyos site	No Management	32	2002-08-28	27	3	2	0	Yes	No	No	No	No
SBW-J Zandip site along Kalena-Kumakalii Ridge	No Management	10	2000-05-17	10	0	0	0	Yes	No	No	No	No
SBW-K Kumakalii-Kalena ridge-"TR" gulch on the map by "Wahiawa District"	No Management	47	2009-11-05	30	9	8	0	Yes	No	No	No	No
SBW-L Kalena-Kumakalii Ridge-Dike rock gulch	No Management	43	2009-11-04	22	10	11	0	Yes	No	No	No	No
SBW-M Puu Kumakalii	No Management	23	2009-06-24	17	4	2	0	Yes	No	No	No	No

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes: Large	Medium	Small	Unk	Threat Control: Ungulate	Weed	Rat	Euglandina rosea	Jackson's Chameleon
SBW-N 1st Peak North of Kolekole Pass	No Management	0	2009-06-24	0	0	0	0	No	No	No	No	No
SBW-O North of Puu Kalena Alstri Notch	No Management	7	2000-02-18	2	5	0	0	Yes	No	No	No	No
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 fenceline	No Management	121	2014-09-11	92	25	4	0	Yes	No	No	No	No
SBW-S Upper Banana Gulch	No Management	4	2007-08-29	3	1	0	0	Yes	Yes	Yes	No	No
SBW-T Albizzia Gulch	No Management	33	2009-06-10	25	1	7	0	Yes	Yes	Yes	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:	538		368	114	45	11					

Size Class Definitions

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

= Threat to Taxon at Population Reference Site

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

Yes=Threat is being controlled at PopRefSite

No=Threat is not being controlled at PopRefSite

Partial=Threat is being partially controlled at PopRefSite

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

Figure 16. ESU-D Population Structure Summary

3.5.2 Update ESU-D2

Map removed to protect rare resources. Available upon request

Figure 17. Map of ESU-D2

3.5.2.1 MAK-B Kumaipo Ridge Crest PU

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. OANRP proposes to move this snail to MAK-D where there is a thriving population of 127 snails.

3.5.2.2 MAK-C Near Pinnacle Rocks PU

Some of the trees at this site have also died and the population is struggling. Since the 14 snails are mostly in individual trees the proposal is to move these snails also to the MAK-D site where they will continue to benefit from the expanded rat grid and share the habitat with 127 other snails.

3.5.2.3 MAK-E Ridge East of Cyasup PU

This site had not been surveyed for six years, but on June 17, 2015 a total of 60 snails were counted here. These snails seem to have a more favorable and healthy habitat, consisting mostly of *Nestigis sandwicensis*. The site is protected by the large rat grid and staff will search here for *E. rosea* whenever working in the area.

3.5.2.4 MAK-F Waianae Kai Trail PU

This site was recently surveyed on June 17, 2015. Surveyors had more time available than the previous year and thus covered more ground. A total of 48 snails were counted. This site is further away from the other sites at a higher elevation and because the area is steep it does not lend itself to rat control.

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	No	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	No	Yes	No	No
MAK-E Ridge east of Cyasup exclosure	Manage for stability	60	2015-06-18	47	10	3	0	Yes	Yes	Yes	No	No
MAK-F Waianae Kai trail to Kaala	No Management	48	2015-06-17	36	11	1	0	No	No	No	No	No
	ESU Total:	261		191	63	7	0					

Size Class Definitions

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

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

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

Figure 18. ESU-D2 Population Structure Summary

3.5.3 Plans for Next Year

OANRP staff plan to work with FWS on future translocations into the Puu Hapapa snail enclosure. Maintenance and monitoring will follow the protocol written in the 2014 report.

3.6 ESU-E

Map removed to protect rare resources. Available upon request

Figure 19. Map of ESU-E

3.6.1 Update ESU-E

3.6.1.1 EKA-A Mamane Ridge PU

This site was surveyed on August 27, 2014 and a total of 58 snails were counted. The trees at this site still look healthy but staff have collected more *E. rosea* and it appears that this predator is having a detrimental effect on the snails here. Staff plan to build a temporary enclosure in Ekahanui in October 2015 as a stop gap measure to protect the snails until a larger enclosure can be built.

3.6.1.2 EKA-B Below Tetlep PU

This site was also surveyed on August 27, 2014 and 13 snails were counted. This site is also showing decline and likely also attributed to *E. rosea.* These snails will also be included with snails from other sites and placed in the temporary enclosure.

3.6.1.3 EKA-C Plapri PU

This is the primary site in the entire ESU. Staff worked here with Melissa Price on August 28, 2014 to collect genetic samples for her DNA project. A total of 88 snails were counted here but this site is also in danger of decline because staff have found and controlled *E. rosea* here while surveying. These *A. mustelina* will also be prime candidates for the temporary enclosure.

3.6.1.4 EKA-D Puu Kaua PU

Snails at this site have been in serious decline since a dieback affected most of the *Myrsine lessertiana* trees in the area. *E. rosea* have also been a serious problem here.

3.6.1.5 EKA-H South Ekahanui

This site was last surveyed on May 16, 2013 when a total of 21 snails were counted. The habitat is very steep and requires rope work to locate most of the snails. These snails could benefit from the construction of a temporary enclosure.

3.6.1.6 No Management PUs

These sites are mostly ones with few snails that could benefit greatly by the construction of a temporary predator-free enclosure. These sites are part of the expanded rat grid but do not receive regular *E. rosea* control.

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes: Large	Size Classes: Medium	Size Classes: Small	Size Classes: Unk	Threat Control: Ungulate	Threat Control: Weed	Threat Control: Rat	Threat Control: Euglandina rosea	Threat Control: Jackson's Chameleon
Achatinella mustelina												
ESU: E — Puu Kaua / Ekahanui												
EKA-A Mamane Ridge and Near Plapripri EKA-A	Manage for stability	58	2014-08-27	38	15	5	0	Yes	No	Yes	No	No
EKA-B Below north population of Tetlep. Between Plapri EKA-A, EKA-B and EKA-C	Manage for stability	13	2014-08-27	13	0	0	0	Yes	No	Yes	No	No
EKA-C At Plapripri EKA-C site	Manage for stability	88	2014-08-28	69	18	1	0	Yes	No	Yes	No	No
EKA-D Puu Kaua	Manage for stability	11	2012-07-18	7	4	0	0	Yes	No	No	No	No
EKA-E Amastra site	No Management	8	2014-05-28	6	1	1	0	Yes	No	Yes	No	No
EKA-F from Plapri-C head along blue trail under cliffs mauka	Manage for stability	1	2008-11-03	1	0	0	0	Yes	No	Yes	No	No
EKA-G Cenagr	Manage for stability	0	2013-02-17	0	0	0	0	Yes	Yes	Yes	No	No
EKA-H South Ekahanui North Branch	Manage for stability	21	2013-05-16	12	6	3	0	Yes	No	Yes	No	No
HUL-A North Huliwai south branch	No Management	17	2014-12-16	11	6	0	0	No	No	No	No	No
HUL-B South Huliwai Gulch	No Management	1	2007-06-18	1	0	0	0	No	No	No	No	No
HUL-C Off Ridge Crest South of Puu Kanehoa	No Management	1	2009-06-16	1	0	0	0	No	No	No	No	No
	ESU Total:	219		159	50	10	0					

Size Class Definitions

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

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

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

Figure 20. ESU-E Population Structure Summary

3.6.2 Plans for Next Year

OANRP plan to construct a temporary enclosure in Ekahanui and a permanent one somewhere else. Maintenance and monitoring will follow the protocol written in the 2014 report.

3.7 ESU-F

Map removed to protect rare resources. Available upon request

Figure 21. Map of ESU-F

3.7.1 Update ESU-F

3.7.1.1 KAA-A Mauna Kapu

Due to a decline in both the population of snails and the habitat, a total of 29 snails were moved from this site on July 22, 2015 into the Palikea snail enclosure. OANRP worked together with SEPP on this project and contacted the landowners to receive their support. The snails were all photographed and will be tracked using the "Hotspotter" monitoring technology to determine the relative success of the translocation.

3.7.1.2 PAK-A Puu Palikea Ohia Spot

On April 22, 2015 a total of 23 snails were collected here and moved into the snail enclosure. On June 8, 2015 another 15 snails were placed into the enclosure. This site is situated along side of an eroded area and had been showing signs of decline over the past five years. The site will continue to be monitored for more snails.

3.7.1.3 PAK-C Steps

This site has also been in decline the past three years. On April 21, 2015 a total of 17 snails were collected here and released into the snail enclosure. On June 9, 2015 another seven snails were collected and released into the enclosure.

3.7.1.4 PAK-D Joel's

This site is due for a survey in the upcoming quarter. The last thorough survey was performed here in 2008. Depending on the number of snails found they will either remain at the site or be moved into the snail enclosure.

3.7.1.5 PAK-G Hame

On April 22, 2015 a total of 15 snails were collected here and released into the enclosure. The site will continue to be monitored in case more snails are found.

3.7.1.6 PAK-H Hadfield's

This site will be surveyed in the next quarter and depending on how many snails are found there, they will either remain at the site or be moved into the snail enclosure.

3.7.1.7 PAK-K Pilo

This site will also be surveyed in the next few months and likely these snails will remain here as the previous survey showed 59 snails. The site will be evaluated as a possible site for a new ground shell plot.

3.7.1.8 PAK-L Olapa

This site had 32 snails when it was surveyed in 2008. Depending on the number of snails found and the condition of the habitat, staff will decide whether to leave the snails or move them into the enclosure.

3.7.1.9 PAK-M Middle

This is the largest population in the ESU and had 201 snails in 2012. It is likely that these snails will remain at their present location.

3.7.1.10 PAK-P Enclosure

OANRP staff have translocated snails into the Palikea snail enclosure and will now begin TCM on a quarterly basis. Snails outside the enclosure in small populations will continue to be brought inside for protection from predators.

3.7.1.11 PAK-Q Outside the Enclosure

Snails fouond outside the snail enclosure are being brought inside since the habitat is similar and there are no predators.

3.7.1.12 No Management PUs

These sites have historically had very few snails and the plan is to perform current surveys in these areas and if any remaining snails are found they will be brought into the enclosure.

3.7.2 Plans for Next Year

OANRP staff plan to continue working with FWS to continue translocations of smaller populations. Maintenance and monitoring will follow the protocol written in the 2014 report. Consideration will be given to potential enclosure sites for snails in Ekahanui.

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes: Large	Medium	Small	Unk	Threat Control: Ungulate	Weed	Rat	Euglandina rosea	Jackson's Chameleon
Achatinella mustelina												
ESU: F Puu Palikea												
KAA-A Mauna Kapu (Palehua)	Manage for stability	29 *	2015-07-21	16	11	2	0	No	No	Yes	No	No
PAK-A Puu Palikea-Ohia spot	Manage for stability	15 *	2015-06-08	9	4	2	0	Yes	Yes	Yes	No	No
PAK-B Iele Patch	Manage for stability	2	2014-08-05	2	0	0	0	Yes	Yes	Yes	No	No
PAK-C Steps spot	Manage for stability	7 *	2015-06-09	1	5	1	0	Yes	Yes	Yes	No	No
PAK-E Exogau site	Manage for stability	0	2010-03-04	0	0	0	0	Yes	Yes	Yes	No	No
PAK-F Dodonaea site	Manage for stability	2	2012-03-14	2	0	0	0	Yes	Yes	Yes	No	No
PAK-G Hame and Alani site just above Cyagri fence	Manage for stability	15 *	2015-04-22	7	4	4	0	Yes	Yes	Yes	No	No
PAK-H Mike Hadfield's study site at Puu Palikea	Manage for stability	17	2013-08-12	6	8	3	0	Yes	Yes	Yes	No	No
PAK-K Pilo site	Manage for stability	59	2012-10-24	32	15	12	0	Yes	No	Yes	No	No
PAK-L Olapa site north of Puu Palikea	Manage for stability	15	2011-05-25	12	2	1	0	Yes	Yes	Yes	No	No
PAK-M Middle Site	Manage for stability	201	2012-05-15	109	50	42	0	Yes	No	Yes	No	No
PAK-N Campside of Lobelia Ridge	No Management	1	2015-06-23	0	1	0	0	No	No	No	No	No
PAK-O Below camp fence	No Management	1	2009-09-23	1	0	0	0	No	No	Yes	No	No
PAK-P Palikea snail exclosure	Manage for stability	83	2015-03-04	59	20	4	0	Yes	Yes	Yes	Yes	Yes
PAK-Q outside snail enclosure	Manage for stability	9 *	2015-04-21	6	2	1	0	Yes	Yes	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	Yes	No	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
	ESU Total:	468		271	123	74	0					

*=Total Snails were Trans Located or Reintroduced

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

Size Class Definitions

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

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

Figure 22. ESU-F Population Structure Summary

Taxon Code Pop Ref Site ID	Pop Ref Site Name	Observation Date	Reintro Origin	Reintro Small	Reintro Medium	Reintro Large
AchMus.PAK-P	Palikea snail exclosure	2015-04-22	AchMus.PAK-A	7	5	11
AchMus.PAK-P	Palikea snail exclosure	2015-04-23	AchMus.PAK-G	4	4	7
AchMus.PAK-P	Palikea snail exclosure	2015-04-24	AchMus.PAK-Q	1	2	6
AchMus.PAK-P	Palikea snail exclosure	2015-06-08	AchMus.PAK-A	2	4	9
AchMus.PAK-P	Palikea snail exclosure	2015-06-09	AchMus.PAK-C	1	5	1
AchMus.PAK-P	Palikea snail exclosure	2015-07-22	AchMus.KAA-A	2	11	16

Figure 23. Palikea Translocations 2015

CHAPTER 4: RARE VERTEBRATE MANAGEMENT

4.1 OIP ELEPAIO MANAGEMENT 2015

4.1.1 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.

4.1.2 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, 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 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.

OANRP research specialist, Stephanie Joe, with a subadult Elepaio at Ekahanui.

Rodent Control

This breeding season saw the use 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 snap traps that were 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. Traps at all four sites were checked and re-baited once a week for the first month (December) , then once every two weeks for the rest of the breeding season (January – June). The frequency of re-baiting in December is higher in order to kill as many rodents as possible before Elepaio nesting begins, thus giving the birds the best chance at having successful nests. Due to Army training at SBW the frequency of baiting was less often than the other management units (MUs). This lack of access to the MU compelled the program to deploy 40 automatic traps at paired territories in Banana and North Haleauau gulches to assist the existing small-scale trapping grids. Pono Pacific was contracted to conduct rodent control and monitoring of Elepaio at Moanalua. At SBW, Ekahanui and Palehua, they were contracted to conduct rat control only. OANRP conducted monitoring of birds at SBW, Ekahanui and Palehua. OANRP also assisted in monitoring Elepaio at Moanalua.

4.1.3 Results

With 97 Elepaio pairs managed during the 2015 breeding season, the OANRP fulfilled the required 75 pairs for species management. The results of management conducted for each area during the 2015 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.

Adult Elepaio being released at Palehua. ***Photos by Roy Kikuta***

Schofield Barracks West Range

Schofield Barracks West Range Territory Occupancy Status and Rat Control 2015

Map removed to protect rare resources. Available upon request

Schofield Barracks West Range Site Demographic Data

SBW	2015	2014	2013	2012	2011
Singles	16	17	18	16	15
Pairs	58	57	60	58	56
Pairs with Rat Control	26	22	29	28	31
Active Nests[1]	14	16	18	23	34
Successful Active Nests[2]	8/14=57%	8/16=50%	9/18=50%	16/23=70%	22/34=65%
Unknown Nest Outcome[3]	2	3	0	0	0
Failed Active Nests	4	5	9	7	12
Family Groups Found[4]	5	8	15	11	11
Fledglings Observed[5]	14	20	28	28	46
Fledglings/Managed Pair[6]	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, 57% (8/14) were successful in producing 9 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 5 fledglings were found with five managed pairs where no nesting had been observed (family groups). A total of 14 fledglings were observed in territories benefiting from rodent control management. Another 3 fledglings were observed in territories not protected from rats.

This male from SBW is the oldest living Elepaio in Hawaii. He turned 20 this year! Notice all his white head feathers.

Rodent Control Results

In 2015, the number of rodents caught in snap traps increased from the previous two years. This is likely due to increasing the number of site visits from one to two days of baiting during our four days of SBW access per month. We also deployed 40 automatic traps at paired territories in North Haleauau and Banana gulches to assist the existing small-scale trapping grids. The number of rodents killed in the automatic traps are not displayed in the table below.

Schofield Barracks West Range Rodent Control Data

SBW	# Traps	# Rats in Traps	Rats/Trap
2015	364	1754	4.8
2014	352	931	2.6
2013	372	1176	3.2

Summary

Access in SBW was limited to four days per month in 2015 due to weekly training by the Army. This allows for approximately one day per month of access to each of the three managed gulches in SBW. This significantly reduces the time needed during the breeding season for the OANRP to detect active nests and fledglings. With such restricted access it's also difficult to determine a cause for this decline in breeding activity, though it is suspected to be weather related and/or a shortage in food resources. This decrease in breeding activity is unfortunate, though it's positive to see that the number of resident pairs has remained stable throughout the years.

Recording site-specific vocalizations is an effective technique used to lure territorial Elepaio into mist-nets.

Honouliuli Forest Reserve - Ekahanui

Ekahanui Territory Occupancy Status and Rat Control 2015

Map removed to protect rare resources. Available upon request

Ekahanui Site Demographic Data

EKA	2015	2014	2013	2012	2011
Singles	0	5	1	11	14
Pairs	39	30	39	31	30
Pairs with Rat Control	37	28	36	29	30
Active Nests[1]	23	14	26	21	15
Successful Active Nests[2]	13/23=56%	7/14=50%	17/26=65%	9/21=43%	8/15=53%
Unknown Nest Outcome[3]	5	3	3	0	1
Failed Active Nests	6	6	9	12	6
Family Groups Found[4]	6	12	8	6	15
Fledglings Observed[5]	24	21	29	18	26
Fledglings/Managed Pair[6]	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, 56% (13/23) were successful, producing fifteen fledglings, and 26% (6/23) of active nests failed. Five 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). Nine fledglings were found in six managed pairs where no nesting had been observed (family groups). A total of 24 fledglings were observed in territories benefiting from rodent control management. Another two fledglings were observed in territories not protected from rats.

Adult feeding a rare 3 nestlings at Ekahanui.

Rodent Control Results

The majority of snap traps in the large-scale grid at Ekahanui have now been removed from protective wooden boxes and placed directly onto nearby tree limbs. This has proven to be a more effective method at killing rodents. More traps were also added this season in the upper sections of this MU to benefit both Elepaio and endangered tree snails. The result of these changes is the highest number of rodent kills ever recorded at Ekahanui during an Elepaio breeding season. As with previous years, the status of each snap trap in the grid was checked and re-baited every two weeks during the breeding season.

Ekahanui Rodent Control Data

EKA	# Traps	# Rats in Traps	Rats/Trap
2015	672	1459	2.2
2014	618	1285	2.1
2013	620	774	1.2
2012	619	520	0.8

Summary

It was a positive breeding season at Ekahanui in this year. The MU was just shy of forty pairs with a record 37 of them benefiting from rodent control. The number of active nests was above average with more than half resulting in one or more fledglings. Unfortunately, the number of unknown nest outcomes was above normal, likely contributing to the modest 0.65 fledglings per managed pair. On an interesting note, during the first week in October of 2014 a pair was observed building a nest at Ekahanui. This is the earliest nesting record for Elepaio in the state of Hawaii. This nest resulted in one successful fledgling.

Elepaio nesting in October at Ekahanui.

Palehua

Palehua Territory Occupancy Status and Rat Control 2015

Map removed to protect rare resources. Available upon request

Palehua Site Demographic Data

HUA	2015	2014	2013	2012	2011
Singles	1	2	0	0	0
Pairs	15	11	17	16	17
Pairs with Rat Control	15	10	17	16	17
Active Nests[1]	6	8	16	8	13
Successful Active Nests[2]	3/6=50%	4/8=50%	11/16=69%	3/8=38%	10/13=76%
Unknown Nest Outcome[3]	0	0	0	0	2
Failed Active Nests	3	4	5	5	1
Family Groups Found[4]	1	4	5	3	5
Fledglings Observed[5]	5	10	21	6	16
Fledglings/Managed Pair[6]	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, 50% (3/6) were successful in producing four fledglings, while 50% (3/6) of the nests failed. One fledgling was found with one managed pair where no nesting had been observed (family groups). A total of five fledglings were observed in territories benefiting from rodent control management.

Rodent Control Results

Palehua underwent an alteration to its previous trapping grids this year. The 12 Victor® traps per Elepaio territory were replaced with a large-scale trapping grid similar to what is currently being used at Ekahanui. This increases rodent control protection throughout the entire MU by widening the placement of traps, but unfortunately, does reduce protection within individual Elepaio territories. Staying consistent with previous years, Pono Pacific re-baited all snap traps every two weeks during the breeding season.

Palehua Rodent Control Data

HUA	# Traps	# Rats in Traps	Rats/Trap
2015	170	662	3.9
2014	168	434	2.6
2013	180	393	2.2

Summary

Palehua had another disappointing breeding season this year. Despite a gain of five managed pairs and an increase in the total population of 23%, breeding activity was very low. Only six active nests were observed. This absence of nesting hasn't been seen at Palehua since management began back in 2007/2008. Five fledglings were found, which is the lowest since 2010. An explanation of why 2015 was such an unproductive breeding year is unknown, though weather may have played a role. Cooler spring temperatures may have delayed nesting, as all nests were not found until March and April. Such temperatures combined with storms producing rain and high winds likely discouraged many Palehua pairs from giving nesting a go this year.

Moanalua Valley

Moanalua Territory Occupancy Status and Rat Control 2015

Map removed to protect rare resources. Available upon request

Moanalua Site Demographic Data

MOA	2015	2014	2013	2012	2011
Singles	6	7	14	19	10
Pairs	33	32	33	32	21
Pairs with Rat Control	19	21	23	24	16
Active Nests[1]	7	16	17	15	13
Successful Active Nests[2]	3/7=43%	5/16=31%	14/17=82%	10/15=67%	5/13=38%
Unknown Nest Outcome[3]	1	7	6	2	5
Failed Active Nests	3	6	3	5	3
Family Groups Found[4]	4	4	2	2	3
Fledglings Observed[5]	7	11	17	13	9
Fledglings/Managed Pair[6]	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, 43% (3/7) were successful in producing three fledglings, 43% (3/7) failed. One nest had an unknown outcome (nests with sufficient time gap between visits in which a nest could have fledged with no subsequent detection of a fledgling). Four fledglings were found in four managed pairs where no nesting had been observed (family groups). A total of seven fledglings were observed in territories benefiting from rodent control management.

Rodent Control

Despite fewer snap traps the number of rodents caught this year increased from the previous season. All snap traps from 2013-2015 were checked and re-baited every two weeks during the breeding season.

Moanalua Rodent Control Data

MOA	# Traps	# Rats in Traps	Rats/Trap
2015	252	1293	5.1
2014	288	716	2.5
2013	312	1576	5.1

Summary

Moanalua Valley had another below average breeding season in 2015. Resident pairs tied an all-time high, though just three nests were successful from only seven that were active at 19 managed pairs. Unfavorable weather conditions during the spring likely played a large role in the lack of breeding success at this MU.

Adult Elepaio pair captured in Moanalua. Notice the plumage variation with the male displaying a bit more black below the bill and around the throat.

4.1.4 OIP Summary

Management Action Highlights 2015

- Conducted rodent control in a total of 97 territories with pairs at four management sites.
- A large-scale grid containing 170 Victor® snap traps was deployed at Palehua to ensure rodent protection for all resident pairs.
- 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
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 2016

- 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.
- OANRP will be assisting the Waianae Mountains Watershed Partnership on Gill family property at Palehua to construct a small fenced area that will be used for outreach and education, bringing awareness to the need for protection of Elepaio and other native resources.
- Conduct rodent control and Elepaio monitoring at Ekahanui, SBW, Palehua and Moanalua to meet required 75 managed pairs.

4.1.5 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*.

    [One deceased Oahu Elepaio juvenile was collected this year and turned over to the U.S. Geological Survey. The cause of death could not be determined.]

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.*

[No fires occurred above the firebreak road]

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]

4.2 MIP ELEPAIO MANAGEMENT 2015

4.2.1 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 in this BO was to construct ungulate-proof fencing around Makua Military Reservation and control rodents using aerially broadcast rodenticide when authorized.

4.2.2 Methods/Results

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

Elepaio held in the photographer's grip. This involves holding the top of the bird's legs close to the belly in a scissor-like grip, while pinching the bird's tarsi between the thumb, fore, and middle fingers.

Makua Territory Occupancy Status and Rat Control 2015

Map removed to protect rare resources. Available upon request

Makua Site Demographic Data

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

Due to logistical/weather related complications and restricted access resulting from an incident involving UXO and Makua range personnel our program was not able to conduct surveys in 2015. A breeding pair of Elepaio has not been observed in Makua Valley since the 2009 breeding season.

4.2.3 MIP Summary

Management Actions 2015

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

Management Actions 2016

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

Nests of Oahu Elepaio are constructed using lichens, mosses, moss sporophytes, grasses, leaf skeletons, and spider webs.

4.3 NENE MANAGEMENT 2015

4.3.1 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. The nene were observed once in July 2015. The table and aerial photo below summarize observations through July 16, 2015

Summary of nene observations through Oct 6, 2014

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, one bird could see transmitter.	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.

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 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.

Nene geese at Wheeler Army Airfield.

4.3.2 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 below.

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 Resources Section, immediately when nēnē are observed:

Kapua Kawelo, Biologist **864-1014** Michelle Mansker, Chief **864-1005**

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

Nene goose observation form used to standardize data collection.

4.4 Opeapea Management 2015

4.4.1 Background

OANRP 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 (Fig. 4-1). 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 4-1 OANRP bat survey sites on Army Training lands

4.4.2 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 is from January 2015 to January 2016. Figure 4-2 shows all of the current placement of the bat detectors throughout the island of Oahu. A total of 30 monitoring stations are being run nightly for this study. These data will be used to inform the upcoming consultation with the USFWS.

Map removed to protect rare resources. Available upon request

Figure 4-2: 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 2015 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 acoustical monitoring surveys, thermal imager surveys or a combination of both to determine if bats were utilizing the trees for roosting and if pups were present. Results of all the surveys are listed in Appendix 4-1. A total of five surveys were conducted by OANRP before the end of this reporting period, 18 hours were spend conducting these surveys, 41 trees were surveyed and zero roosting bats were found. 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 4-2.

OANRP has purchased a Fluke 400T and an IR Hunter Mark II thermal imagers to use for detecting possible roosting bat pups. OANRP has been working 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.

CHAPTER 5: *DROSOPHILA* SPECIES MANAGEMENT

5.1 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 restoration of habitat.

5.2 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 16-32 sponges, in groups of four or eight 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 extremely tenuous, as populations may fluctuate not only seasonally but from day to day. However, repeated surveys may 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 sponge 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) were monitored quarterly. Other known populations were visited periodically through the year. 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.

5.3 RESULTS

5.3.1 *Drosophila montgomeryi*

Drosophila montgomeryi is a small yellow-brown species which breeds in rotting bark of *Urera kaalae* and *Urera glabra* (opuhe). It 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 and searching for new sites, but few potential suitable areas have been found. 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.

Map removed to protect rare resources. Available upon request

Figure 1. Distribution of *Drosophila montgomeryi* observations in 2015 and earlier records from 2013-14, with known *Urera* spp. sites and all survey points in the Waianae range.

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. Abundance of *D. montgomeryi* appears to follow a distinct seasonal pattern, increasing dramatically over the winter months to a peak between January and May (Figure 2). This is most likely due to increased rain and treefalls from storms that cause death or branch breakage of *Urera* near monitoring sites. Both the general seasonal pattern and high month-to-month fluctuations were strongly correlated with those of some other species, including the common *D. ambochila*, *D. crucigera*, and *D. inedita*, but not *D. punalua* or the rare *D. divaricata*, suggesting that the effect was independent of at least host plant. There was also no obvious difference in weather or bait quality from high-abundance days that would explain the low numbers.

Pualii

This site was visited for the first time last year, 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 seven *U. kaalae* (all outplanted), and no *U. glabra* (aside from recent outplants), remain at the site; with no reproduction

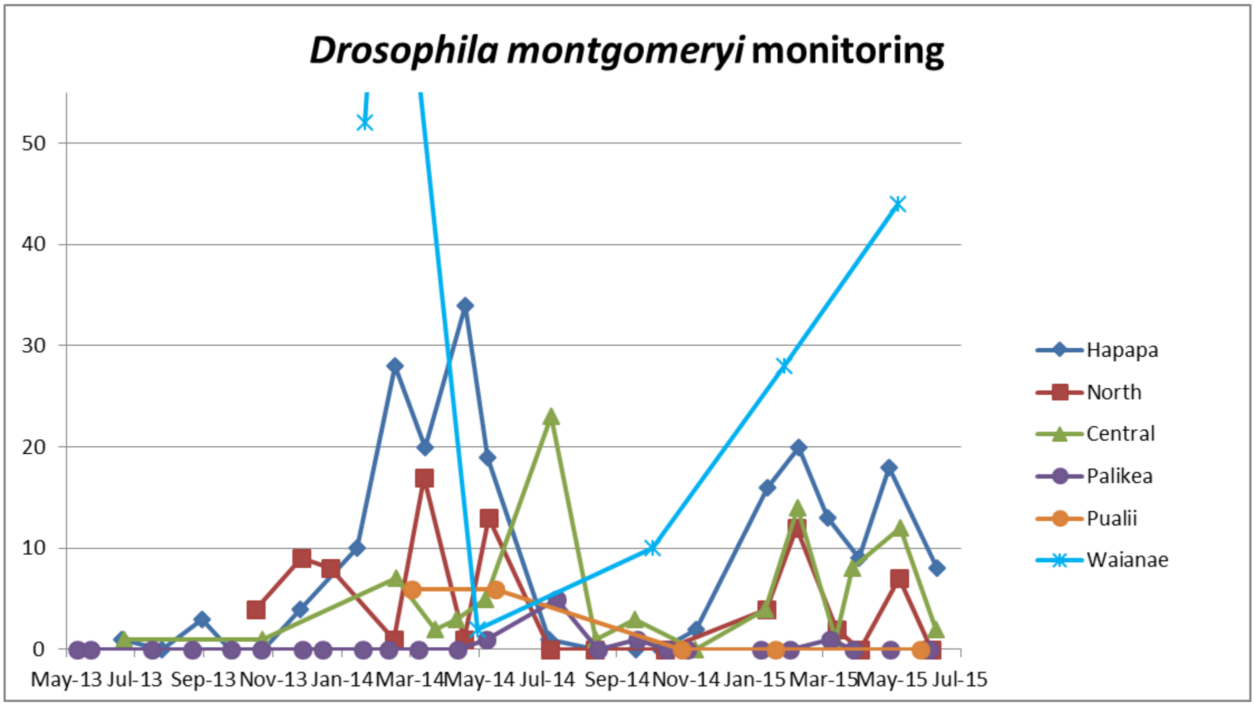


Figure 2. *Drosophila montgomeryi* numbers during monthly monitoring at three sites in Kaluaa PU (Puu Hapapa, North Kaluaa, and Central Kaluaa) and Palikea, and quarterly monitoring at Waianae and Pualii. Y axis is the maximum number observed across the entire site on the survey day (see Survey Methods,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

currently occurring among *U. kaalae*, it will not remain a viable population of *D. montgomeryi* without management intervention. 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 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. 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* is absent, but *U. glabra* has already begun to increase naturally as weed control has reduced alien cover, and outplanting has significantly boosted the population.

Site	Days	Max No.
Kaluaa - Central	7	14
Kaluaa - North	7	12
Puu Hapapa	8	20
Pualii	3	0
Palikea	8	1
Waianae	3	44
Kawaiu	1	0
Makaha	1	0
Pahole	2	0
Ekahanui	1	0

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

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. Only *U. glabra* is present, indicating that *D. montgomeryi* can thrive on it alone (*U. kaalae* was also found in nearby South Kumaipo Gulch as recently as 1995, but no longer occurs in the valley). All are located on or just below steep slopes that are vulnerable to landslides, which may preclude fencing as a matter

Figure 3. Habitat restoration for *D. montgomeryi* at Palikea. Each orange flag marks a *Urera glabra* outplant.

of practicality. The middle gulch, where *D. montgomeryi* has been most abundant and currently the only known site for the critically imperiled *D. kinoole*, is recovering from boulder damage from ongoing severe erosion of the ridge to the north. The fly population has steadily increased since the damage occurred between February and May 2014, although *D. kinoole* has not been seen since then. Unusually, many *D. montgomeryi* at this site are consistently observed resting on branches but few were attracted to baits; counts reflect the total observed. 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.

Lihue

The original rediscovery of *D. montgomeryi* was at Schofield West Range, South Haleauau Gulch near Puu Kalena in 2008. This site was revisited once in late 2013 and again in mid-2014, but none were found. Access is difficult and it is probably still inhabited by the species, given the usual population fluctuations seen at other sites.

Other sites

Five additional sites are currently known for *Urera* in the Waianae range: Kawaiu Gulch, Pahole Gulch, Makaha, Ekahanui, and Palawai. All were surveyed this year (5 survey days) except the last, which was visited once during the 2014 reporting year. No *D. montgomeryi* have been found at any of these so far.

Map removed to protect rare resources. Available upon request

Figure 4. Distribution of *Drosophila substenoptera* observations in 2015 and earlier records from 2013-14.

Habitat restoration

This was the first year of active habitat management for *Drosophila montgomeryi*. Approximately fifty *U. glabra* grown from cuttings were planted at each of North Kaluaa, Central Kaluaa, Pualii, and Palikea between December 2014 and March 2015. Following observations that wild plants tended to be clustered by sex and are probably mostly clones, particular effort was made to ensure that male and female plants were placed close to each other. All sites are exhibiting high survivorship and good growth. Observations of some individuals suggests that pruning of tip shoots may promote extremely vigorous growth of side branches and ultimately larger, more robust trees.

5.3.2 *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* (=*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 4). 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.

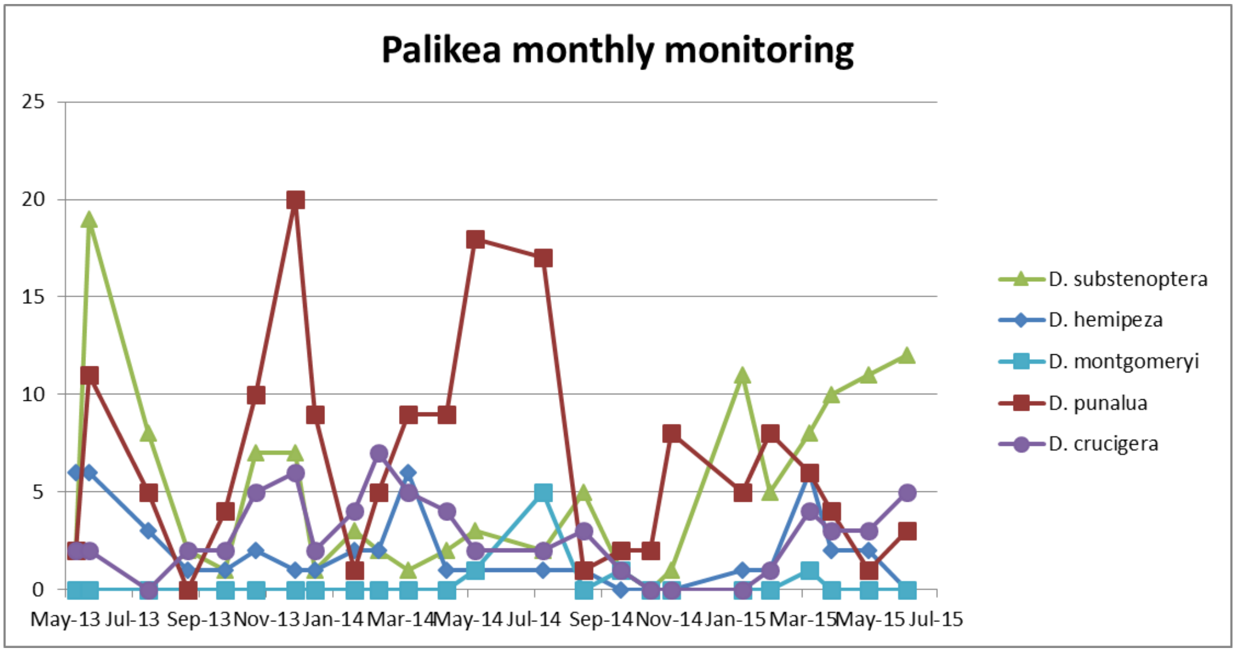


Figure 5. Monthly monitoring results for all species at Palikea, from May 2013 to July 2015.

Waianae Range

Monthly monitoring in the northern portion of Palikea MU has been ongoing since May 2013 (24 survey days total, 8 in the current reporting period). 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. Abundance showed no clear correlation among seasons or across the species found there. (Figure 5). At the Kaala-Kalena PU, one individual was observed along the crestline just north of the South Haleauau "Trinerve Gulch". Near the summit of Kaala, sites on the western, northern, and southeastern faces were surveyed; one individual was found at the first, but none were seen at the others.

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 2015, it was sighted again in the same area. Surveys at Upper Opaeula and Kaluanui did not find any of this species. 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. 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 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.

Site	Days	Max No.
Palikea	8	12
Kaala	5	1
Lihue	1	1
Lower Opaeula	2	1
Upper Opaeula	1	0
Koloa	3	0
Kaluanui	1	0

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

Map removed to protect rare resources. Available upon request

Figure 6. Distribution of *Drosophila obatai* observations in 2015 and earlier records from 2013-14, with known *Chrysodracon* spp. sites and all survey points in the Waianae range.

5.3.3 *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. With the new sites found this year, it is now known from seven sites in four potential PUs, although three of these PUs are within 1,200 m of each other and could potentially form one contiguous population. While it almost certainly was contiguous until recently (possibly up to ~50 years ago), 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.

Surveys for *D. obatai* in 2015 were relatively limited due to a focus on outplanting for *D. montgomeryi* and other projects. *Drosophila obatai* was only found at Manuwai; they were not found at two sites within SBW (the Coffee Gulch and Guava Gulch branches of Pulee Gulch), and one in Central Makaleha had only a single *Chrysodracon* tree and was not suitable habitat. The Makaleha area consists of a series of large, steep valleys with remnant dry and mesic forest that have been little surveyed recently. Future surveys will focus on this area.

Site	Days	Max No.
Manuwai	2	1
Lihue - Pulee	3	0
Central Makaleha	1	0

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

Map removed to protect rare resources. Available upon request

Figure 7. Observations of six non-target rare *Drosophila* species during the 2014 survey season.

5.3.4 Other Rare *Drosophila*

During the course of surveys, six additional rare *Drosophila* were found in management units where *D. montgomeryi* and *D. substenoptera* occur (Figure 7). *Drosophila nigribasis* and *D. oahuensis* were also found on Schofield Barracks.

Non-Target Rare *Drosophila* Observed During Surveys, Oct. 2014–Jul. 2015

Species	Sites	Total Obs.	Max. No.
craddockae	Lower Opaeula	2	1
divaricata	Kaluaa, Ekahanui	25	6
flexipes	Manuwai, Pualii	1	1
hemipeza	Palikea, Hapapa	14	6
nigribasis	Kaala	11	6
oahuensis	Kaala, Kaluanui, Opaeula	12	6

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 during our surveys. Only two were seen, one each at Lower Opaeula and Koloa. The latter is a new site record for the species.

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 and Central Kaluaa in 2015. There were also records from Puu Hapapa and Ekahanui.

Drosophila flexipes breeds in fermenting sap fluxes of *Sapindus oahuensis* (lonomea). Although this tree is relatively common in remnant mesic and dry forest, it often occurs at lower elevations where ants prevent *Drosophila* from persisting. Only one was found in 2015, at Manuwai; it was not seen at Pualii, where it was recorded previously.

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. In 2014, a single individual was found at Puu Hapapa on two separate occasions, the first records of this species outside Palikea since 1974, and two more were seen in 2015. It has been reared from *Cyanea*, *Lobelia*, and *Urera*, all of which are present at both sites.

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. Although most observations this year came from Kaala, many more individuals were seen than previously.

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.

CHAPTER 6: 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 five main sections: Section 6.1 provides an overview of the current rodent control program and discusses recent changes; Section 6.2 discusses recently installed Goodnature® A24 automatic rat trap grids at Kahanahaiki and Ohikilolo; Section 6.3 provides results of an investigation into tracking tunnel data; Section 6.4 discusses on-going trap trials at Palikea and Ekahanui; and Section 6.5 lays out future plans for rat control.

6.1 OANRP RODENT CONTROL PROGRAM SUMMARY

OANRP manages rats threatening some rare species only seasonally (e.g., *Chasiempis ibidis* or Oahu Elepaio during the nesting season), while other species are protected year-round (e.g., *Achatinella mustelina*.). The methods of rodent control that OANRP currently utilizes for rodent control are limited to using kill-traps (Victor® traps, Ka Mate™ traps, and Goodnature® A24 traps) and predator-proof fences.

Rat control in 2015 consisted of deploying small Victor® snap trap and Goodnature® A24 trap grids around resources, maintaining large-scale trapping grids consisting of Victor® or Ka Mate™ traps, and installing and maintaining large-scale trapping grids of Goodnature® A24 traps. More Goodnature® traps will be installed across MUs and around additional population units over the next year. OANRP contracted Pono Pacific to conduct rat control during Elepaio nesting season (December – June) at Ekahanui, Kahanahaiki, Moanalua, Palehua, and Schofield Barracks West Range (SBW). Pono Pacific is also contracted to conduct year round rat control at Ekahanui and Palikea.

In October 2015 a new predator control contract will be awarded for a five year period. Control levels at most sites will increase with number of traps and size of grids. The contractor will also be responsible for checking tracking tunnels at Palikea, Ekahanui, Kahanahaiki, and Makaha. Year round control using A24s will be conducted by the contractor at 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 2015-2016.

MU/Area	Primary Spp. Protected	Control Method	Description	Trap Type	# Traps	Deployment	Check Interval
East Makaleha	*A. mustelina*	Trapping Grid	Two small grids	Victor® w/out boxes	40	Year-round	4-6 weeks
				A24 Automatic traps	20		
Ekahanui† *i*	*A. mustelina*	Trapping Grid	Many small grids	Victor® w/out boxes	47	Year-round	4-6 weeks
				A24 Automatic traps	30		
	C. ibidis	Trapping Grid	Large-scale grid	Victor® w/ & w/out boxes[i]	620	Annual: Dec-June	2 weeks

MU/Area	Primary Spp. Protected	Control Method	Description	Trap Type	# Traps	Deployment	Check Interval
Kahanahaiki †+	*A. mustelina*	Predator-proof fence	Constructed 1998	--	--	Year-round	--
	A. mustelina, Cyanea superba	Trapping Grid	Large-scale grid	A24 Automatic traps	170	Year-round	4 weeks
Kamaohanui	*A. mustelina*	Trapping Grid	One small grid	Ka Mate™	47	Year-round	6 weeks
				A24 Automatic traps	10		
Kapuna	*Hesperomannia oahuensis*	Trapping Grid	Two small grids	A24 Automatic traps	5	Seasonal	6 weeks
	Schiedea nuttallii				4		
Koiahi	*A. mustelina*	Trapping Grid	One small grid	A24 Automatic traps	8	Year-round	6 weeks
Makaha Unit I	*A. mustelina, H. oahuensis, C. superba*	Trapping Grid	Large-scale grid	A24 Automatic traps	110	Year-round	4 weeks
Makaha Unit I	*H. oahuensis*		Two small grids	A24 Automatic traps	13	Seasonal	6 weeks
				Victor® w/out boxes	24		
Makaha Unit II	*Cyanea grimesiana*		Large-scale grid	A24 Automatic traps	80	Year-round	6 weeks
Manuwai	*Delissea waianaeensis*	Trapping Grid	One small grid	Victor® w/out boxes	14	Seasonal	6 weeks
				Ka Mate™	11		
				A24 Automatic traps	8		
Moanalua†	*C. ibidis*	Trapping Grid	Many small grids*	Victor® w/out boxes	300	Annual: Dec-June	2 weeks
Ohikilolo	*A. mustelina, Pritchardia kaalae*	Trapping Grid	Many small grids	Victor® w/ boxes	47	Year-round	6 weeks
				A24 Automatic traps	53		
Palehua†	*C. ibidis*	Trapping Grid	Many small grids*	Victor® w/out boxes	200	Annual: Dec-June	2 weeks
Palikea	*A. mustelina*	Predator Exclosure	Constructed 2012	--	--	Year-round	--
Palikea-Mauna Kapu	*A. mustelina*	Trapping Grid	One small grid	Victor® w/ boxes	15	Year-round	6 weeks
Palikea†	*A. mustelina*	Trapping Grid	Large-scale grid	Ka Mate™	250	Year-round	2 weeks
SBW Haleauau‡†	*A. mustelina*	Trapping Grid	One small grid	Victor® w/out boxes	28	Year-round	6 weeks

MU/Area	Primary Spp. Protected	Control Method	Description	Trap Type	# Traps	Deployment	Check Interval
	H. oahuensis	Trapping Grid	One small grid	Victor® w/out boxes	3	Seasonal	6 weeks
				A24 Automatic traps	3		
	C. ibidis	Trapping Grid	Many small grids*	Victor® w/out boxes	450	Annual: Dec-June	2 weeks
				A24 Automatic traps	50	Annual: Dec-June	4 weeks
W. Makaleha	*C. grimesiana*	Trapping Grid	One small grid	Victor® w/out boxes	28	Year-round	6 weeks
Waianae Kai	*Neraudia angulata*	Trapping Grid	One small grid	Victor® w/out boxes	20	Seasonal	6 weeks
Waieli-Hapapa	*A. mustelina*	Trapping Grid	One small grid	Victor® w/out boxes	35	Year-round	6 weeks
		Predator-proof fence	Constructed 2011	--	--	Year-round	--

* *Each managed Elepaio (*C. ibidis*) territory has 12 traps installed ~12 m apart in trees.*
† *Contracted Pono Pacific to maintain rat grids during Elepaio nesting season.*
‡ *N. Haleauau snail sites are included during Elepaio nesting season.*
i *The majority of traps have been removed from the wooden boxes and placed in trees.*
\+ *Victor® snap traps discontinued to run A24s.*

OANRP is continually researching and reassessing rat control methods to determine the most effective strategies for the protection of natural resources.

6.2 A24 Grid at Kahanahaiki

In 2015, OANRP managed a large scale grid of A24s at the Kahanahaiki Management Unit (MU). This MU has had various rat control conducted in previous years, ranging from small grids of bait stations to large scale Victor® snap trap grids. Kahanahaiki has long been a testing ground for new management techniques and was the first area with ecosystem scale rat control. It was decided to install the A24 grid in Kahanahaiki so that the results could be compared to other rat control strategies used there in the past. Additionally, easy access at this location allows for frequent monitoring and adjustments.

The Kahanahaiki grid is designed for large-scale lethal trapping for rats (*Rattus* spp.) across the MU. The overall goal is to reduce rat activity within an MU to a level that benefits the endangered plants, *A. mustelina* (Oahu tree snail), native insects, and the native ecosystem as a whole.

In 2014, OANRP installed a grid of 119 Goodnature® A24 automatic rat traps across the 26 ha Kahanahaiki MU, equating to 4.6 A24s per ha. The A24 grid was used in 2015 instead of maintaining the prior snap trap grid of 464 Victor® snap traps, equating to 17.8 Victor snaps per ha. The A24 grid was laid out using 50x100m spacing with some traps placed at 25x100m based on prior snap catch data. From past snap catch data we have observed, the gulch area in general accounts for more rat catches than other areas of the MU, so additional traps were placed here based on this information.

A24s were checked monthly, requiring 3 personnel. The A24s were checked for presence of carcasses, re-baited with Goodnature® preservative peanut butter and each CO_2 canister was tested. Due to a limited number of counters, only 17 of the 119 traps were fitted with counters to monitor hits.

A total of 38 tracking tunnels were monitored inside the grid and 24 tunnels were monitored at a nearby site (Kapuna Gulch, within Pahole Natural Area Reserve) as a control with no active trapping being conducted. Tunnels were monitored one month prior to installation of the A24s and then monthly thereafter for both sites. Kahanahaiki has been monitored since 2009 and monitoring results have been included for comparison (Figure 1). Tunnel data show that percent rat activity at the Kapuna site remains high year round, and in the 2014-2015 season, Kahanahaiki was approaching control site levels.

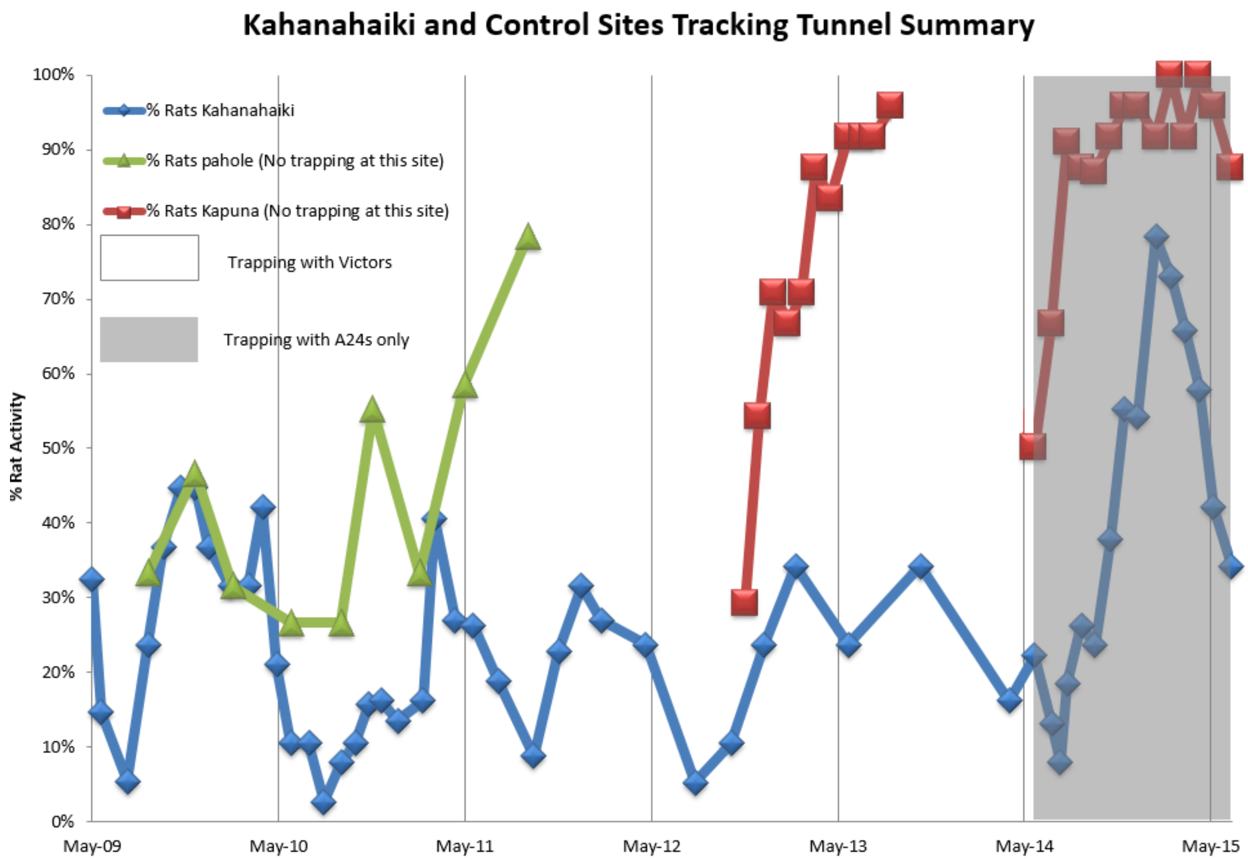


Figure 1. Percent of rat activity each month at Kahanahaiki and two control sites Kapuna and Pahole.

Diphacinone-50 Hand Broadcast Pilot Project

Since 2012, OANRP halted rodenticide use because of a change in the Special Local Needs (SLN) label that makes bait-station application unfeasible in the steep, rugged terrain where the work is conducted. Relying solely on traps has not been effective in keeping populations below the targeted 10% tracking in monitoring tunnels, particularly during the period of peak rat abundance (typically Fall/Winter). In an attempt to combat this problem in Hawaiian habitats, OANRP will make an effort to determine the effectiveness of a “one-time” two-application hand-broadcast (applications spaced approximately 5-7 days apart) and canopy baiting of rodenticide bait (Diphacinone-50) during a period of high rat abundance, October 2015, within Kahanahaiki. The hand broadcast application will involve OANRP staff walking a grid of trails while evenly distributing rodenticide bait; canopy baiting involves placing bait, held in small cloth bags, into trees within the grid. These application methods comply within the

Diphacinone-50 label (EPA Registration No. 56228-35). 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. USDA National Wildlife Research Center (NWRC) will provide the monitoring associated with this study (e.g., bait application according to label, efficacy of this rat-reduction method, and non-target impacts). See Appendix 6-1 for OANRP Diaphacinone-50 Hand Broadcast Study.

Other Management Considerations for 2016

One of the OANRP goals for the A24s is to eventually reduce the trap monitoring interval from monthly to quarterly. Because this is a multi kill trap and costs more than traditional traps, a balance of staff time and trap cost needs to be achieved to meet program objectives. One of the ways to accomplish this is by increasing the bait longevity and attractiveness in the A24s at Kahanahaiki. A study developed to do this involves constructing custom counters that record the date and time of each hit. This will allow us to determine how effective the bait is over a three month period and if the monitoring interval affects number of hits. From bait trials in previous years, we have found that the Goodnature Preservative peanut butter has been more attractive and outlasted all other bait alternatives and thus will be used for the trial.

6.3 COMPLETED TRIALS AT PALIKEA AND EKAHANUI

Although the significant amounts 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. Additionally, it is possible that black rats (*R. rattus*) in Hawaii spend more time in trees than black rats in New Zealand (Peters, pers. comm. 2013). Two questions OANRP asked over the past years is whether or not rat control is improved by housing snap traps inside a protective box (typically placed on the ground) or whether uncovered snap traps mounted directly to trees is more effective. It is thought that perhaps the rats would encounter the traps more easily if they were in trees while the slugs would not encounter them as easily, reducing bait loss. DOC's best practice includes housing Victor® traps inside wooden boxes placed on the ground in order to exclude non-target species, guide target species, prevent accidental triggering, and maintain the integrity of the trap from weather (NZ DOC 2005).

During 2014 a trial was conducted at Ekahanui to assess if putting Victor® traps uncovered in trees is better than putting Victor® traps in trees with two different trap coverings: wooden boxes or greenhouse plant pots. This study also looked at catch of non-targets to determine whether covered traps will catch fewer non-targets relative to uncovered traps while maintaining the same efficacy for rats. The entire Ekahanui grid covers an area of 177 acres (72 ha). The grid consists of 620 Victor® snap traps that are housed in protective wooden boxes on the ground or placed in trees without boxes; there are 225 traps on the perimeter of the MU and 394 traps in the interior of the MU, all spaced 25 meters apart. For this trial, only a subset of traps (150) were used. 80 Victor® traps were placed in trees with no covering, 36 were placed in boxes in trees, and 34 were placed in greenhouse plant pots in trees. Traps were checked every two weeks and catches were recorded.

From July to October, a total of 105 rats were caught using the 3 different treatments. Uncovered traps recorded a higher total number of rat catches than covered traps, but this difference was not statistically significant ($p = 0.8748$). Uncovered traps also caught more birds (*Leiothrix lutea* and *Copsychus malabaricus*) than covered traps, but this difference was not statistically significant ($p = 0.1893$). The different trap covers (wooden boxes and plastic 2 gallon tree pots) did not show a significant difference in the number of rat catches ($p = 0.1613$).

During 2014 a trial was conducted at Palikea to compare two different trap types, Victor® versus Ka Mate™, and to conduct a cost benefit analysis. The Palikea grid covers an area of 21 acres (9 ha). The grid consists of 180 Ka Mate™ traps: there are 98 traps on the perimeter of the MU spaced 12.5 meters apart and 82 traps in the interior of the MU spaced 25 meters apart along trails. Ka Mate™ traps were deployed in order to experiment with that style of trap and compare the trapping efficacy to Victor® snap traps. On June 5, 2014, staff replaced every other Ka Mate™ trap with a Victor® trap uncovered in a tree, for a total of 91 Ka Mate™ and 84 Victor® traps. Both trap types were then baited every two weeks using small pieces of coconut and observations were recorded. Peanut butter was not used for this trial as Ka Mate™ traps require the use of hard bait for proper trap function. Ka Mate™ traps are set by wedging coconut underneath the trigger. The bait is held in place by tension and the trap cannot trigger until the bait is removed. Victor® traps are set by placing the coconut securely on the yellow pan in-between the plastic triangle or by smashing into the little box on the trigger.

A total of 165 rats were caught across both traps during the 4 months of deployment and no differences were observed between trap types ($p = 0.5365$), with Ka Mate™ traps recording a total of 75 catches and Victor® snap traps recording a total of 90 catches. However, the proportion of traps recorded as 'Snapped with no bait' (no rat was caught, but trap was triggered) was marginally higher for Ka Mate™ traps than Victor® traps ($p = 0.0934$). There were no significant differences between trap types in terms of bird catch rates ($p = 0.2697$), with a total of 9 birds caught in the Victor® snap traps and 2 birds in the Ka Mate™ traps.

6.4 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 in combination with traps, such as hand broadcasts of Diphacinone-50. OANRP will use the Diphacinone-50 pilot project findings, counter trials and tracking tunnel results from Kahanahaiki to determine future rat control at other MUs. Over the next year OANRP will utilize all trapping methods in combination at some sites to see if more effective control is achieved.

WORKS CITED

Blackwell, G., M. Potter, J. McLennan. 2002. Rodent density indices from tracking tunnels, snap-traps, and Fenn traps: do they tell the same story? *New Zealand Journal of Ecology* **26**(1): 43-51.

Hill, G. 2011. Personal Communication. Department of Conservation, New Zealand.

Mosher, S.M., J. L. Rohrer, V. Costello, M. D. Burt, M. Keir, J. Beachy. 2010. *Rat control for the protection of endangered birds, plants, and tree snails on the island of Oahu, Hawaii.* Proc. 24th Vertebr. Pest Conf. (R. M. Timm and K. A. Fagerstone, Eds.). Univ. of Calif., Davis. Pp. 14-17.

NZ DOC (New Zealand Department of Conservation). 2005. *Kill trapping for rat control (Current best practice)*. Department of Conservation, Wellington, NZ. (http://www.predatortraps.com/downloads/techniques_rat_trap.doc)

Peters, D. 2013. Personal Communication. National Predator Control, Research, Development and Improvement, Department of Conservation, New Zealand.

Shiels, A. 2010. Ecology and impacts of introduced rodents (Rattus spp. and Mus musculus) in the Hawaiian Islands. Dissertation, Department of Botany, University of Hawaii at Manoa.

CHAPTER 7: 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) Research Specialist which, this year, focused on preparing documents for the five year review of the Sluggo Special Local Needs (SLN) permit by state and federal agencies. This is a molluscicide critical to protecting native plants from slug predation, but which carries a risk of harming non-target native snails if used improperly. We carried out research to determine the effect of slug control on the survival of the endangered plant species: *Delissea waianaeensis* and *Cyanea superba* ssp. *superba* (hereafter referred to as *C. superba*) while monitoring slug numbers in the field. We describe results from that experiment here. We also describe the extent of our on-going slug control program and the plant species protected through these efforts.

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). The status of those efforts are reported here.

We completed work on the control of the invasive moss *Sphagnum palustre*. This work was published as a Pacific Cooperative Studies Unit Technical report: #192. Joe, S.M. 2015. Controlling the invasive moss *Sphagnum palustre* at Ka'ala, Island of O'ahu. 18 pp (http://manoa.hawaii.edu/hpicesu/techrep.htm).

7.1 SUMMARY OF SLUG CONTROL ACTIONS OCTOBER 2014 TO JUNE 2015

Background: Slugs can cause dramatic declines in the survival of rare native Hawaiian plants (Joe & Daehler 2008). Control of slugs using the certified organic molluscicide Sluggo® (registered trademark omitted from the rest of this document) 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 current permit expires in October 2015). This application included research demonstrating the efficacy of Sluggo applied at half the label rate (this is the rate we use currently) and results from rare snail surveys showing no evidence that any were harmed due to slug control. The application is currently under review by HDOA. Whether the SLN is renewed for another five years will determine whether we can continue to protect rare plants from slug depredation.

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. In 2014-2015 we controlled slugs to order to protect eight species in eight Management Units (MUs) across an area equal to 4.26 acres, a 33% increase in area from the previous year (3.2 acres). Rare plant species which received Sluggo treatments at a rate of 1 kg Sluggo per 405 m^2 per month appear in Table 1.

Table 1. List of rare plant species treated monthly with Sluggo. New or expanded areas receiving slug control this year are shown in bold.

MU	Plant species treated (Population Reference Code)	Treatment area (m^2)	Sluggo required per treatment (kg)
Ekahanui	*Cyanea grimesiana* subsp. *obatae* (EKA-C) , *Delissea waianaeensis* (EKA-D), *Phyllostegia mollis* (EKA-D), *Schiedea kaalae* (EKA-D)	4,232	10.4
Palikea	*C. grimesiana* subsp. *obatae* (PAK-A & PAK-B), *C. superba* subsp. *superba* (PAK-A)	2,220 **(+ 706)**	5.4 **(+ 2)**
Kahanahaiki	*C. superba* subsp. *superba* (MMR-E & MMR-H), *S. nuttallii* (MMR-E), *S. obovata* (MMR-C & MMR-G)	1,650	4
Upper Kapuna	*S. kaalae* (KAP-A)	706	2
West Makaleha	*C. longiflora* (LEH-B), *S. obovata* (LEH-A & LEH-C)	1,196	3
Makaha	***C. longiflora* (MAK-B), *C. grimesiana* subsp. *obatae* (MAK-B), *S. obovata* (MAK-A), *S. nuttallii* (MAK-B)**	**2,000**	**4.5**
Kaluaa and Waieli	***D. waianaeensis* (KAL-C), *S. kaalae* (KAL-B)**	**1,600**	**4**
Pahole	*S. nuttallii* (PAH-D & PAH-E), *C. superba* subsp. *superba* (PAH-A)	3,000	7.25

Figure 1. Locations of rare plant species within Management Units (MUs) undergoing slug control.

7.2 *DELISSEA WAIANAEENSIS* & *CYANEA SUPERBA* RESPONSE TO SLUGGO APPLICATION

Background: The purpose of this study was to evaluate whether slug control facilitates seedling emergence and survival (following a seed sow) of *Delissea waianaeensis* and improves survival of *Cyanea superba* seedlings (grown in chamber prior to outplanting) in Ekahanui MU. Natural seedling recruitment from the soil seed bank was also recorded. The soil seed bank did not contain any of the test species. *Cyanea superba* has never been found in this area historically, and the single plot placed in an area with mature *Delissea* has not received seed since June 2014 which is unlikely to be viable. Additionally, we planted *Lactuca sativa* (lettuce) to see whether this highly palatable food would be grazed by slugs. The purpose of the lettuce was to investigate whether slug abundance (as measured with pitfall traps) can be tied to plant herbivory. That data, however, is still under analysis and will not be presented here. The field study began on Feb. 17 and concluded May 28, 2015.

Methods: We established 9 paired plots within Ekahanui MU (Fig. 2). These were circular plots with a total area of 176 m^2. This size was necessary so that the Sluggo treated plots had a sufficient buffer to prevent incursion (determined to be 100 m^2 at West Makaleha if Sluggo was applied every two weeks). At the center of these, we cleared (all plants removed to bare soil) a 1 m^2 area divided into four, 0.25 m^2 quadrants where test species were sown (*D. waianaeensis*) or outplanted (*C. superba* and lettuce) (Fig. 3). There was also a quadrant (referred to as soil seed bank) where natural regeneration of any plants was recorded. All 1 m^2 areas received 1 liter of water on a weekly basis. One plot of each pair was randomly assigned to receive slug control once every two weeks (the 'treatment' group) while the other received no slug control (the 'control' group). Slug abundance was measured using baited pitfall traps (McCoy 1999) consisting of four 9-oz. glass jars per plot, placed in holes so that their openings were level with the soil surface and baited with six oz. of beer (Pabst Blue Ribbon). Traps were oriented within each plot so as to sample as much area as possible (Fig. 3). Plots were at least 10 m away from its pair and 20 m away from the next pair of plots. Not all seed and plants went into plots at the same time. A timeline of these activities appear in Table 2.

Table 2. Timeline of when plants and seed were added to each plot.

Date (M/DD)	Activity	Note
2/17	Five lettuce plants planted in each plot.	Plants were one month old and grown from Manoa lettuce seed in the greenhouse.
2/17	950 *D. waianaeensis* seeds sown into each plot	Seeds were from fruit collected June 2014 from Ekahanui, however, fruit was fermented and it may have made for a poor collection. The fruit was processed and sown nonetheless.
2/24	15-20 *Cyanea superba* seedlings planted into each plot	Plants were two months old and grown in a growth chamber. The number planted varied because some seedlings were destroyed in the transplanting process. Plants were from two founders (MMR-A-3 & MMR-A-4). Care was taken to use the same founders for each plot pair.
3/03	1000 *D. waianaeensis* seeds added to seed sow quadrant	Seeds were from collections made in 2004-2005 from Ekahanui. Initial viability for these batches ranged from 76-94% and viability was not expected to have declined below this range.

Map removed to protect rare resources

Figure 2. Location of the 9 plot pairs.

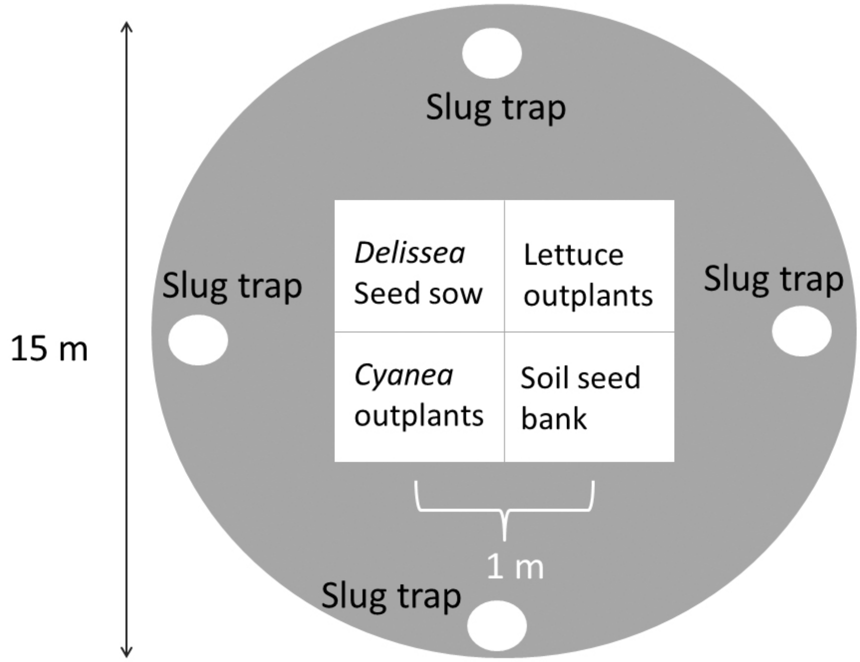


Figure 3. Diagram of a single plot. Objects within the plot are not scaled proportionally to one another. For example, the one meter outplanting area is enlarged relative to the entire plot. Treatment plots receive Sluggo across the entire area shaded in grey. The center 1 m^2 area was watered weekly.

Data collection & Analysis*:* This research was carried out in a paired-plot design. Therefore, control data (from the no Sluggo plot) was subtracted from its treatment plot *pair*. Though there were 18 plots total, there were only nine plot pairs ($n = 9$). Analysis post-treatment relied upon *differences* between the plot pairs at a single monitoring event. A result of 0 indicated no difference between plots, a positive number indicated an increase in the treatment relative to the control and a negative number, the opposite. For *D. waianaeensis* the data collected were a total count of the number of seedlings emerging following a sow of 1,950 seeds (Table 2). Because very young plants can be hard to confirm as being *D. waianaeensis*, this number was equal to the seedlings counted in the sown quadrant minus the number counted in the soil seed bank quadrant from the same plot. *Cyanea superba* survival was calculated as the number of plants alive (at a given time) divided by the original number of plants outplanted multiplied by 100. Regeneration from the soil seed bank was simply a complete count of all plants emerging following clearing of the plot at the start of the study. Slug abundance was calculated as the mean number of slugs from the four pitfall traps within a plot at a single time.

Results & Discussion:

Slug abundance: Slug abundance was significantly higher in the control vs. the treatment plots (General Linear Model (GLM), $F_{1,104} = 46.58$, $p = 0.000$), though not at all time periods (Figure 4). Slugs were most abundant early in the study, becoming steadily scarcer as time progressed. This is not surprising as slug numbers have been observed to decline with declining moisture and increasing temperatures, both of which occur as Hawaii transitions from the wet season (Nov-March) to the dry season (April-October).

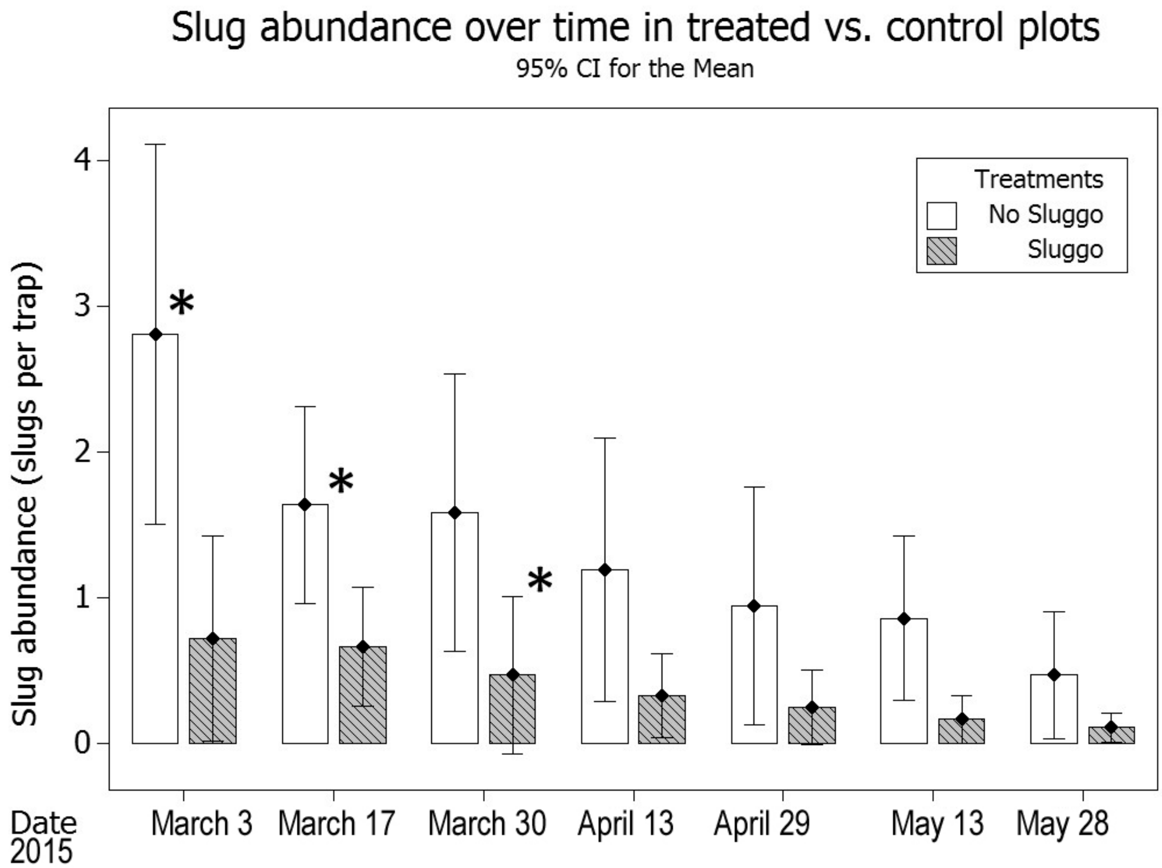


Figure 4. Slug abundance was significantly higher in untreated plots then in the treated plots prior to April 13. Asterisks indicate a significant difference between groups as indicated by post hoc comparisons using a Tukeys HSD.

Delissea waianaeensis* Seed Sow*: Differences in seedling emergence between the plot pairs over time is shown in Figure 5. Notice that the average difference between treatment and control plots begins as positive and declines to zero over time. This suggests that the effects of slug control may have resulted in slightly higher emergence of *D. waianaeensis* early in the season and played little or no role later in the season. Despite this observation, the effect of slug control was not significant when using March data separately (paired-T test, p = 0.09). Indeed, this can be seen in the error surrounding the means in Figure 5. Zero is always included within the error at all times indicating no difference between the treatment and its control pair. Overall, mean seedling emergence from the treated plots was higher: 8.5 seedlings (± 6) vs. 5 (± 2) in the untreated plots (Figure 6) however this effect was not significant and did not endure over the three month period.

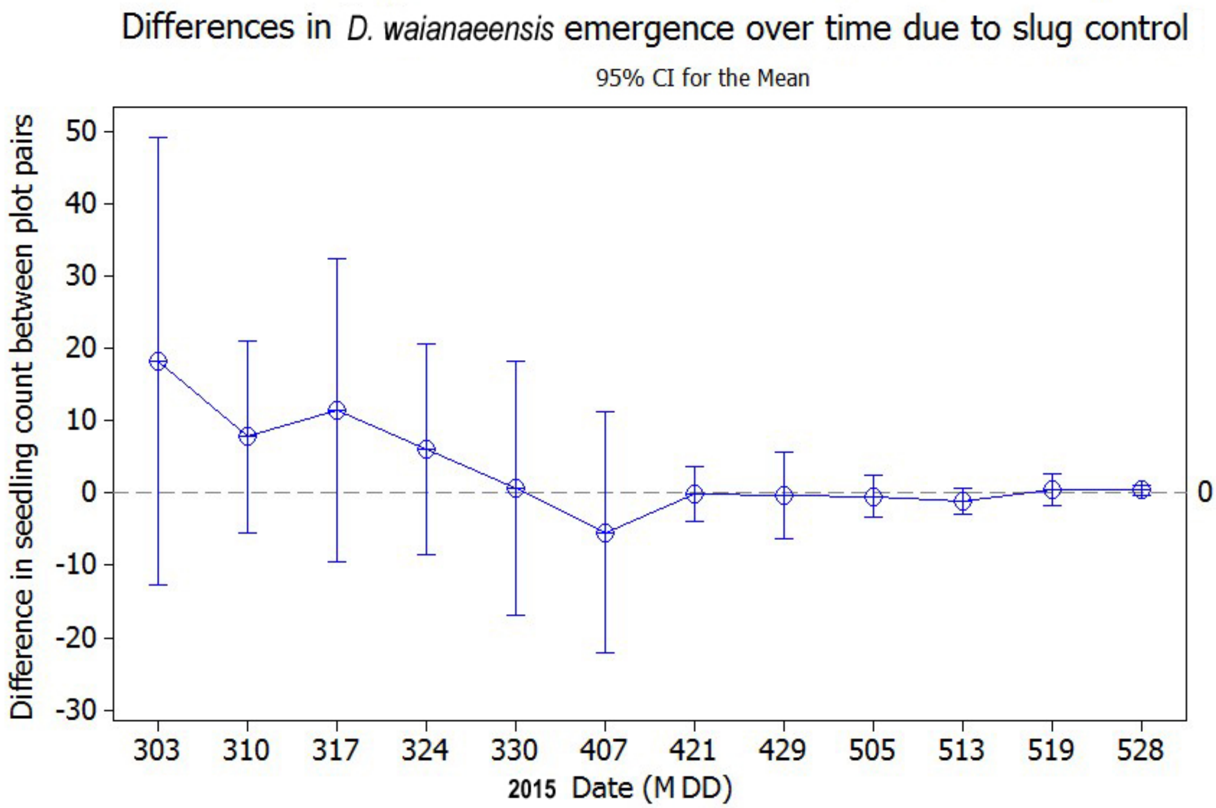


Figure 5. Graph showing a trend slightly positive emergence of plants in the slug control group during March. At no time did the difference between the treatment and control plots deviate significantly from zero.

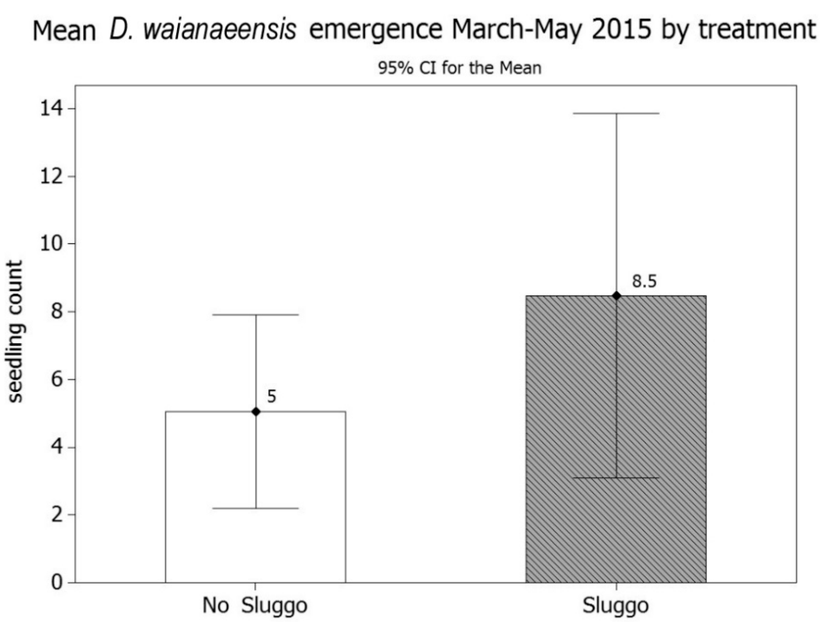


Figure 6. Graph showing the mean seedling emergence from the *D. waianaeensis* seed sow plots. Though the Sluggo treatment showed slightly higher emergence, this was not significant.

***Cyanea superba* Outplanting**: Survival of outplants over time by treatment is shown in Figure 7. Like the *D. waianaeensis,* treatment appeared somewhat effective earlier in the season with both treatments declining to approximately 18% survival by the conclusion of the study. A paired T-test using data from each monitoring event (using a Bonferroni adjustment for multiple comparisons) shows no significant difference between groups overall (p = 0.194).

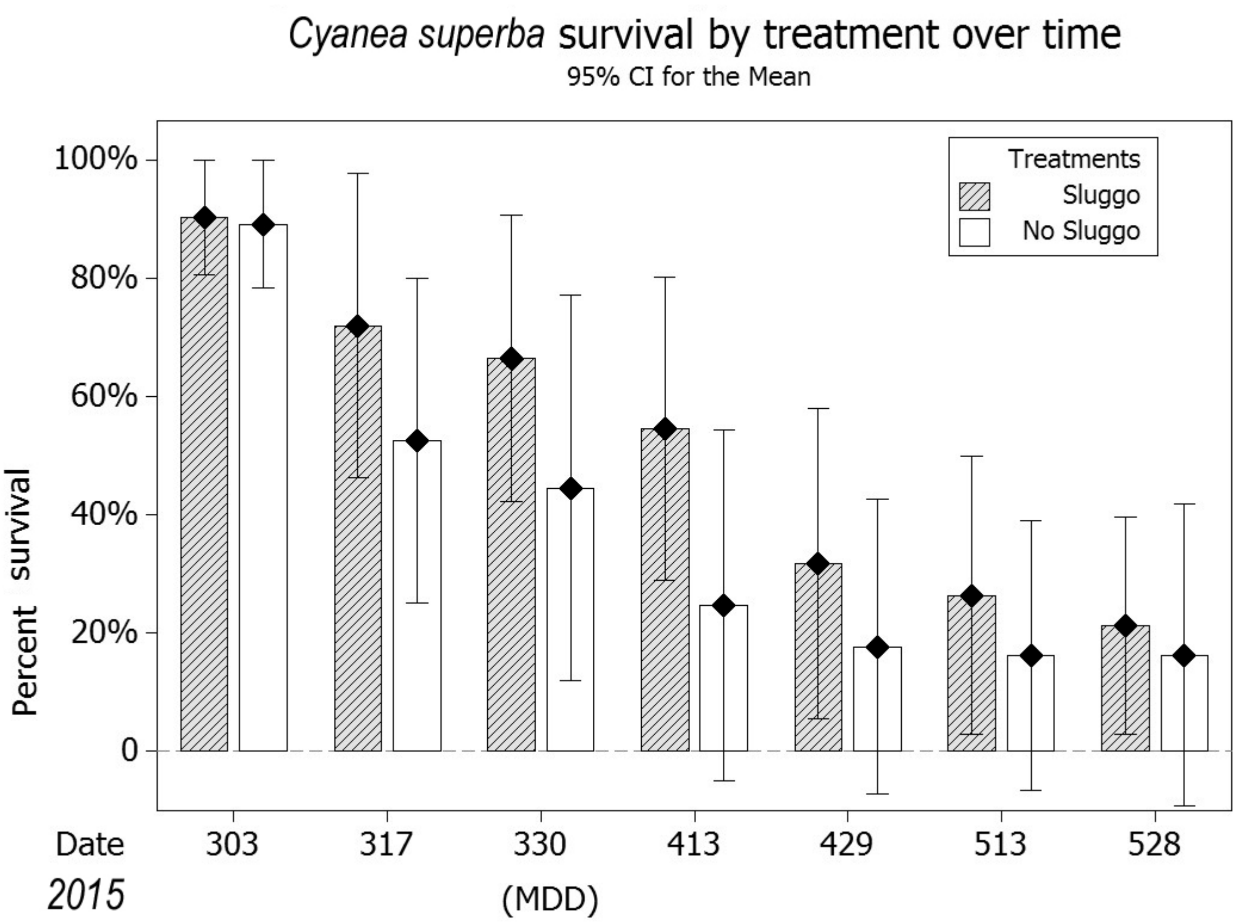


Figure 7. Graph showing survival of *C. superba* outplants in treated and untreated plots. No significant differences in groups were evident.

Soil Seed Bank: Seedling recruitment from the soil seed bank was significantly higher in the treated vs. untreated plots (Fig. 8). Though the species identity of these seedlings were unknown, based on the dominant vegetation in Ekahanaui, it is reasonable to assume the majority are weeds.

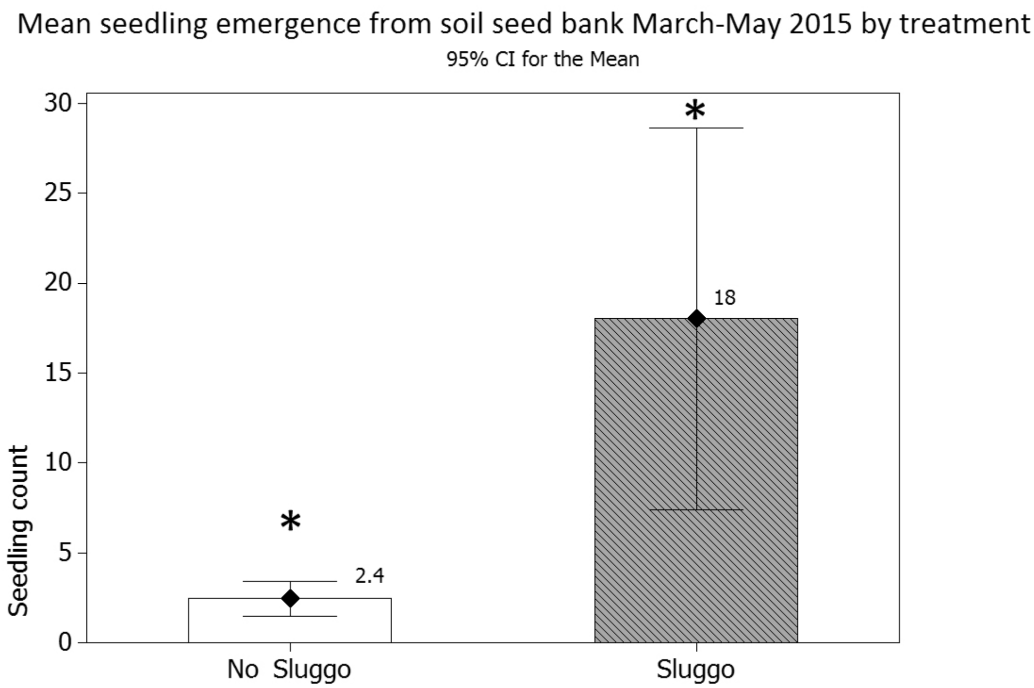


Figure 8. Graph showing significantly higher recruitment of seedlings in the treated plots (T-Test: *T*-Value = -2.92 $p = 0.005$).

Conclusions: Though not significant, slug control generally resulted in positive increases in *D. waianaeensis* seed emergence (Fig. 6) and *C. superba* survival early in the season (Fig. 7). By the conclusion of the study, differences between the treatment and control plots contracted towards zero. This likely occurred because of the slugs were only significantly higher in the control plots in March while conditions dried to the point where plants died. It is likely that any benefits conferred by slug treatment early in the season were negated by drier conditions later. Our finding of significantly greater regeneration of seedlings from the seed bank suggests that slugs are grazing seedling generally and that the number of test seedlings used were too small to see any effect. Additionally, it also could be that the buffer was insuffiecntly large and slugs came into the treatment plots.

Sluggo application significantly depressed slug abundance in treated plots but had less effect as the season progressed (Fig. 4). Again, this is likely due to abiotic conditions.

Regeneration of seed from the existing seed bank increased in the treatment areas. Though most of this regeneration is assumed to be weed species, common, fast growing natives would also benefit from Sluggo application.

7.3 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). These areas include trailheads, cabins and landing zones, where accidental introductions of ants are more likely to occur as well as in areas where rare resources may prove vulnerable to ant attack.

As of the writing of this document, the summer ant survey season is halfway complete. With the exception of the Nike site, Kaluakauila and the OANRP Baseyards, all surveys took place after June 2015 and will be included in next year's report. Included in Table 3 (below) are results from the annual ant surveys. Asterisks indicate new ants found during the most recent survey. Species are considered 'low risk' or 'high risk' according to a Pacific Invasive Ant Key developed by Saurnat (2008).

Management Unit	Ants recorded prior to 2014	Ants recorded October 2014 - June 2015	Action needed?
Pahole mid-elevation nursery (Nike site)	*Solenopsis papuana, S. geminata, Ochetellus glaber, Anoplolepis gracilipes, Cardiocondyla obscurior, Tetramorium bicarinatum*	*Solenopsis papuana, Plagiolepis alluaudi*, Technomyrmex albipes**	No action needed. Following repeated treatments, two high risk species, *Anoplolepis gracilipes* and *S. geminata*, have not been detected since 2013. The two new species detected this year are both low risk species and already widely established
Kaluakauila	*A. gracilipes, Cardiocondyla emeryi, O. glaber, Paratrechina bourbonica, Pl. alluaudi, S. papuana, Pheidole megacephala*	*S. papuana, A. gracilipes, Technomyrmex albipes**	No action needed. New species detected is a low risk species while others are widely established at that location
East and West OANRP baseyards	*A. gracilipes, Pl. alluaudi, Ph. megacephala*	*A. gracilipes, Ph. megacephala*	Species present are widely established, however treatment for both using Terro (for *A. gracilipes*) and Amdro (for *P. megacephala*) took place at regular intervals to keep numbers low

Table 3. List of ant species found in each MU. New records for 2015 are indicated with an asterisk.

Since its first record on Oahu in December 2013, OANRP has been surveying high risk areas to prevent *Wasmannia auropunctata* (the Little Fire Ant or LFA) from establishing on Schofield Army Base. LFA is sampled using vials baited with peanut butter aand left in shady spots on the ground or in trees for at least one hour, then collecting any ants approaching the bait. Wheather conditions must favorable for ant foraging for the survey to be valid (*e.g.* no rain, warm temperatures). With the excpetion that we use vials rather than chopsticks, our methodology follows that reccomended by HDOA in their Spot the Ant, Stop the Ant campaign (http://stoptheant.org/report-little-fire-ants/). No LFA was detected during any of these surveys (Table 4).

A policy for preventing the little fire ant from establishing at Army controlled lands is being routed for signature by the Garrison Commander. Once in place, this policy will require that landscaping plants be sourced from LFA free nurseries and that the responsibility for eradication of LFA, if introduced, is with contractors. This financial hook will hopefully prevent contractors from using contaminated nurseries as plant sources.

Location	Date surveyed	Ants detected
New housing area on junction of Lyman and Iolani Road, Schofield Barracks	March 30, 2015	*Ph. megacephala*
Garden store PX, 903 Cadet Sheridan Road, Schofield Barracks	March 30, 2015	*Ph. megacephala*

Table 4. Results from LFA surveys on Schofield Baseyard.

7.4 COCONUT RHINOCEROS BEETLE (CRB) 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 (Fig. 9). These are placed near palms and at mulch sites and are checked once every two weeks. Lures are replaced every two months. OANRP have maintained these traps since Feb. 2014. No CRB have been detected at any traps during these period. All information is relayed to HDOA and integrated into CRB distribution maps on Oahu.

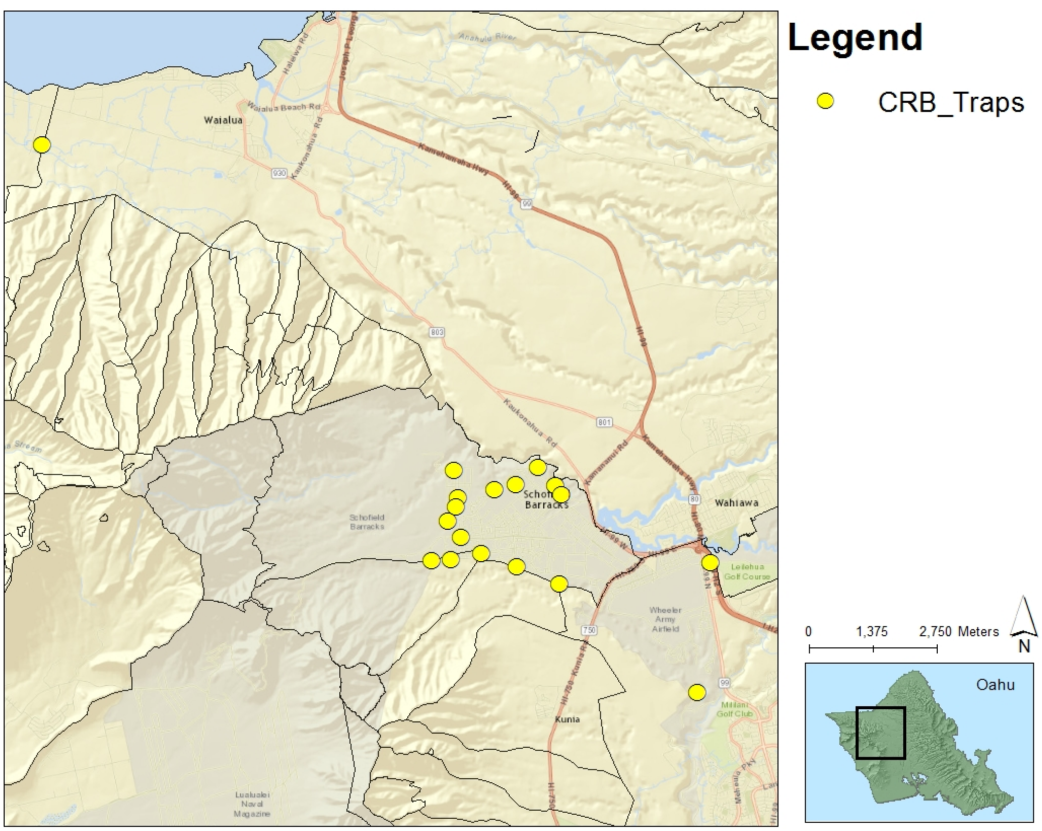


Figure 9. Locations of CRB traps maintained by OANRP.

References

Joe, S. M., and C. C. Daehler. 2008. Invasive slugs as under-appreciated obstacles to rare plant restoration: evidence from the Hawaiian Islands. *Biological Invasions* 10: 245-255

Kawelo, K., S. Ching Harbin, S. Joe, M. Keir and L. Weisenberger. 2012. Unique Reintroduction Considerations in Hawaii. *In* Plant Reintroduction in a Changing Climate. Machinski, J. and K.E. Haskins *Eds*. Island Press

McCoy, K.D. 1999. Sampling terrestrial gastropod communities: using estimates of species richness and diversity to compare two methods. *Malacologia* 41:271–281

Oahu Army Natural Resource Program. 2011. Chapter 5 section 5.4 Ant Control Actions *in* Status Report for the Makua and Oahu Implementation Plans. On-line: http://manoa.hawaii.edu/hpicesu/DPW/2011_YER/default.htm

Oahu Army Natural Resource Program. 2010. Appendix 7-1 Invasive Ant Monitoring Protocol *in* Status Report For the Makua and Oahu Implementation Plans. On-line: http://manoa.hawaii.edu/hpicesu/DPW/2010_YER/default.htm

Sarnat, E.M. 2008. Pacific Invasive Ant (PIA) Key: Identification guide to invasive ants of the Pacific Islands. University of California Davis. On line: http://itp.lucidcentral.org/id/ant/pia/index.html

Appendix ES-1 Spelling of Hawaiian Names

Place name	Hawaiian spelling
Aiea	ʻAiea
Aihualama	ʻAihualama
Aimuu	Aimuu
Alaiheihe	Alaiheihe
Alau	Alau
Ekahanui	ʻĒkahanui
Halawa	Hālawa
Haleauau	Haleʻauʻau
Halona	Hālona
Hawaii	Hawaiʻi
Hawaii loa	Hawaiʻiloa
Helemano/Halemano	Helemano/Halemano
Honolulu	Honolulu
Honouliuli	Honouliuli
Huliwai	Huliwai
Kaaikukai	Kaʻaikūkaʻi
Kaala	Kaʻala
Kaawa	Kaʻawa
Kaena	Kaʻena
Kahaluu	Kahaluʻu
Kahana	Kahana
Kahanahaiki	Kahanahāiki
Kaimuhole	Kaimuhole
Kaipapau	Kaipāpaʻu
Kaiwikoele	Kaiwikōʻele
Kalauao	Kalauao
Kaleleliki	Kaleleiki
Kalena	Kalena
Kaluaa	Kaluaʻā
Kaluakauila	Kaluakauila
Kaluanui	Kaluanui
Kamaileunu	Kamaileʻunu
Kamaili	Kamāʻili
Kamananui	Kamananui
Kapakahi	Kapakahi
Kapuna	Kapuna
Kauai	Kauaʻi
Kauhiuhi	Kauhiuhi
Kaukonahua	Kaukonahua
Kaumoku Nui	Kaumoku Nui
Kaunala	Kaunala
Kawaihapai	Kawaihāpai
Kawaiiki	Kawaiiki
Kawailoa	Kawailoa
Kawainui	Kawainui
Kawaipapa	Kawaipapa
Kawaiu	Kawaiū

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

Puhawai	Pūhāwai
Pukele	Pūkele
Pulee	Puleʻē
Punapohaku	Punapōhaku
Puu Hapapa	Puʻu Hāpapa
Puu Kailio	Puʻu Kaʻīlio
Puu Kanehoa	Puʻu Kānehoa
Puu Kaua	Puʻu Kaua
Puu Kawiwi	Puʻu Kawiwi
Puu Kumakalii	Puʻu Kūmakaliʻi
Puu Pane	Puʻu Pane
Puuhapapa	Puʻu Hāpapa
Puukaaumakua	Puʻu Kaʻaumakua
Puukailio	Puʻu Kaʻīlio
Puukainapuaa	Puʻu Kaʻinapuaʻa
Puukanehoa	Puʻu Kānehoa
Puukaua	Puʻu Kaua
Puukawiwi	Puʻu Kawiwi
Puukeahiakahoe	Puʻu Keahiakahoe
Puukumakalii	Puʻu Kūmakaliʻi
Puulu	Pūʻulu
Puuokona	Puʻu o Kona
Puupane	Puʻu Pane
Waahila	Waʻahila
Wahiawa	Wahiawā
Waialae Nui	Waiʻalae Nui
Waialua	Waialua
Waianae Kai	Waiʻanae Kai
Waiawa	Waiawa
Waieli	Waiʻeli
Waihee	Waiheʻe
Waikane	Waikāne
Wailupe	Wailupe
Waimalu	Waimalu
Waimano	Waimano
Waimea	Waimea
Waimea	Waimea
Wiliwilinui	Wiliwilinui

*Diacriticals unknown

Appendix ES-2

Tutorial: Operating the OANRP Database (Distribute Version)

Overview

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

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

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

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

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

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

Questions may be directed to:

Roy Kam
Natural Resources Database Programmer Specialist
Oahu Army Natural Resources Program
Email: rkam@hawaii.edu

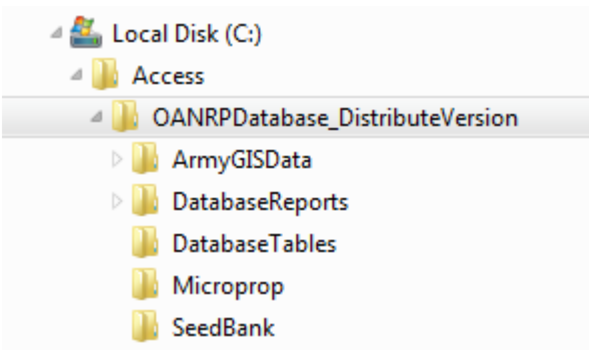
Linda Koch
Natural Resources GIS Specialist
Oahu Army Natural Resources Program
Email: lkoch@hawaii.edu

I. Database Settings

Setting Database Directories and Security Warning

Database directories

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



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

OANRPDatabase_DV.mdb

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

C:\Access\OANRPDatabase_DistributeVersion\ArmyGISData\

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

C:\Access\OANRPDatabase_DistributeVersion\DatabaseTables\OANRPDataTables_DV.mdb

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

C:\Access\OANRPDatabase_DistributeVersion \Microprop\Microprop.mdb

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

C:\Access\OANRPDatabase_DistributeVersion \SeedBank\SeedBankDatabase.mdb

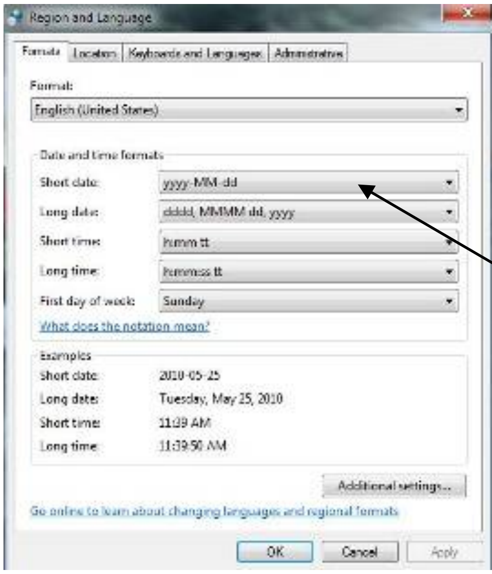
> Army SeedLab Database. Contact Lauren Weisenberger for more information.

C:\Access\ OANRPDatabase_DistributeVersion \TaxaDatabaseReports

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

Setting Default Date Format

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



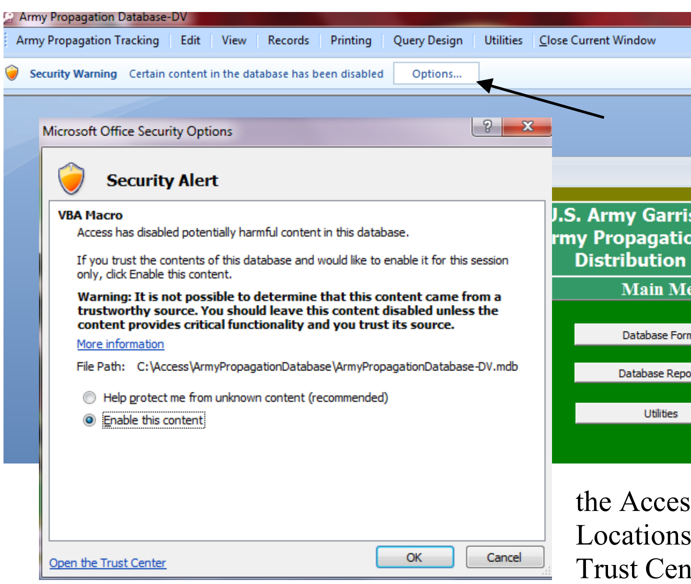
Change to yyyy-MM-dd

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

Security Warning

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

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



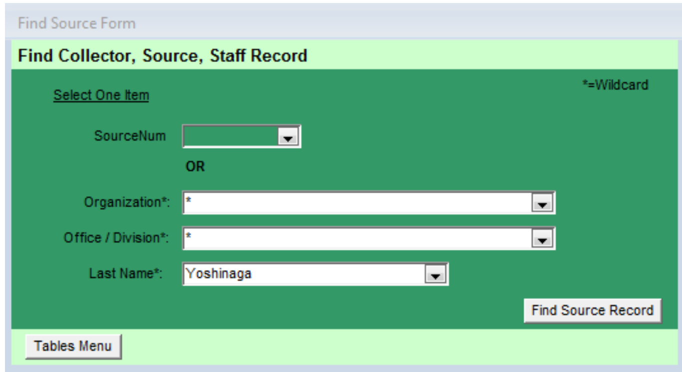
After opening the OANRPDatabase_DV.mdb file in Microsoft Access, click on Options when it appears at the top of your screen.

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

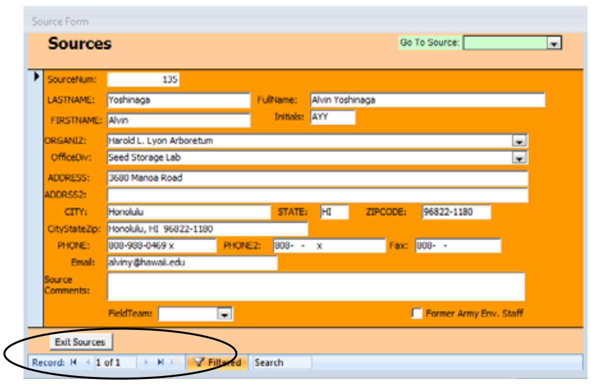
Enabling content will have to be done every time the database file is opened. You may avoid having this Security Warning appear if the Access subdirectory is added to the Trust Center Locations. Contact Roy Kam if you need to establish a Trust Center Location.

Data Search Methods

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

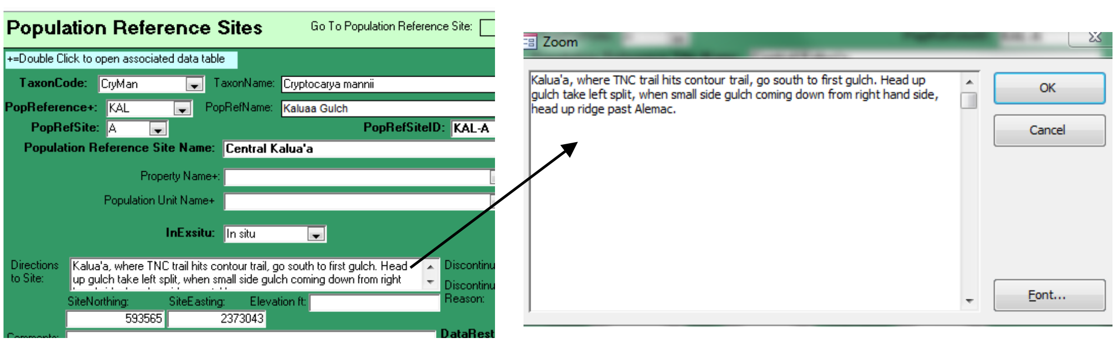


Using the * (asterisk), in a Find Form represents a wild card. Such as Organization *= Search for all Sources with any Organization. In this case, we will just search for the Last Name = Yoshinaga.

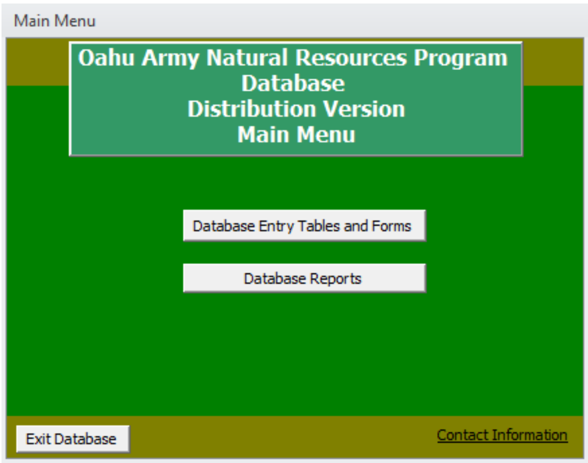


On the bottom of each Data entry form (such as the Sources Form), there are a set of Navigation buttons. These buttons allow you to go to the previous or next record. Pressing the tab or enter keys moves from one data field to another.

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



II. Main Menu



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

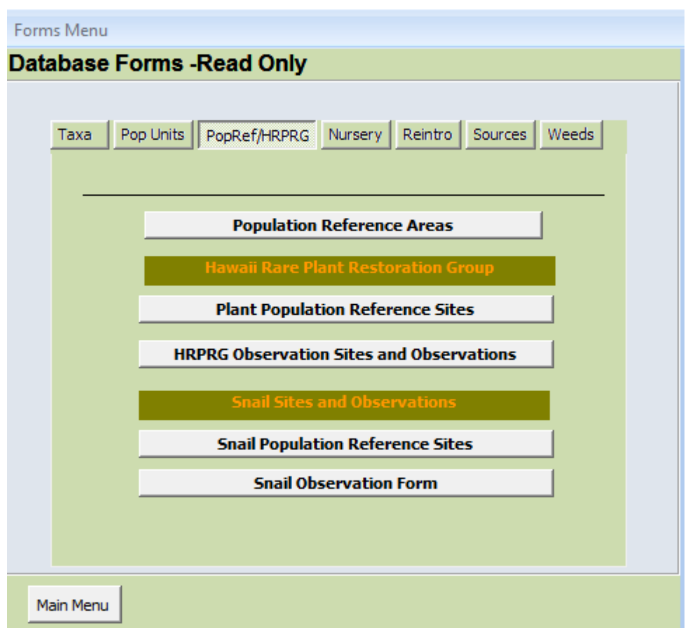
The database is broken up into 2 parts, Database Forms and Database Reports. We will primarily cover the Database reports. Database Forms are self-explanatory and is only for viewing purposes. The forms are provided for detailed review of individual observations. Only pertinent data fields will be discussed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

III. Database Forms

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

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

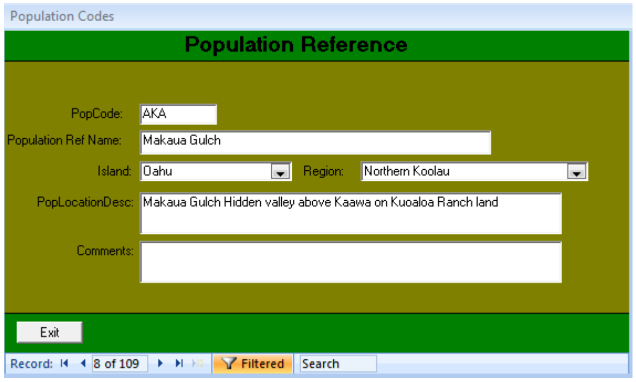
For the purpose of this tutorial, we will discuss forms of the PopRef/HRPRG tab with comprise of the Population Reference and Population Reference Sites. All other sections are supplemental and self-explanatory.



PopRef, Sites, and Observations

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

Population Reference Areas (PopRef)



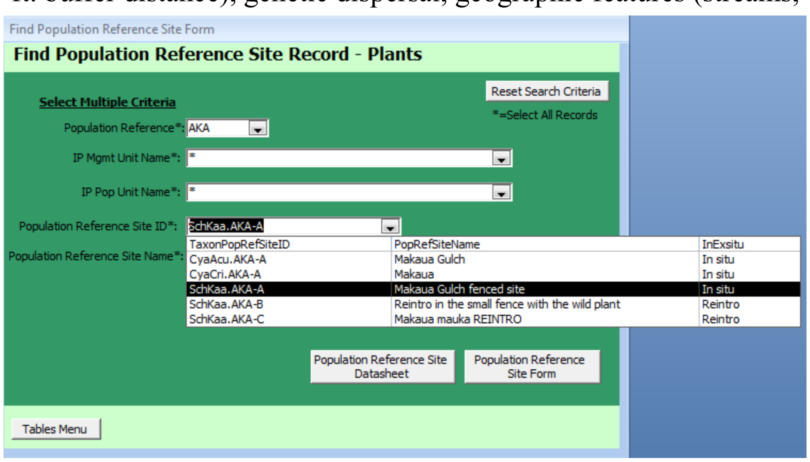
Population Reference, also known as PopRef for short, is a boundary system that allows a consistent identification of plant or animal populations. The PopRef is normally valleys, summits, ahupuaa, bogs, or areas that biologists have continuously acknowledged within observations from past decades.

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

Population Reference Site (PopRefSite)

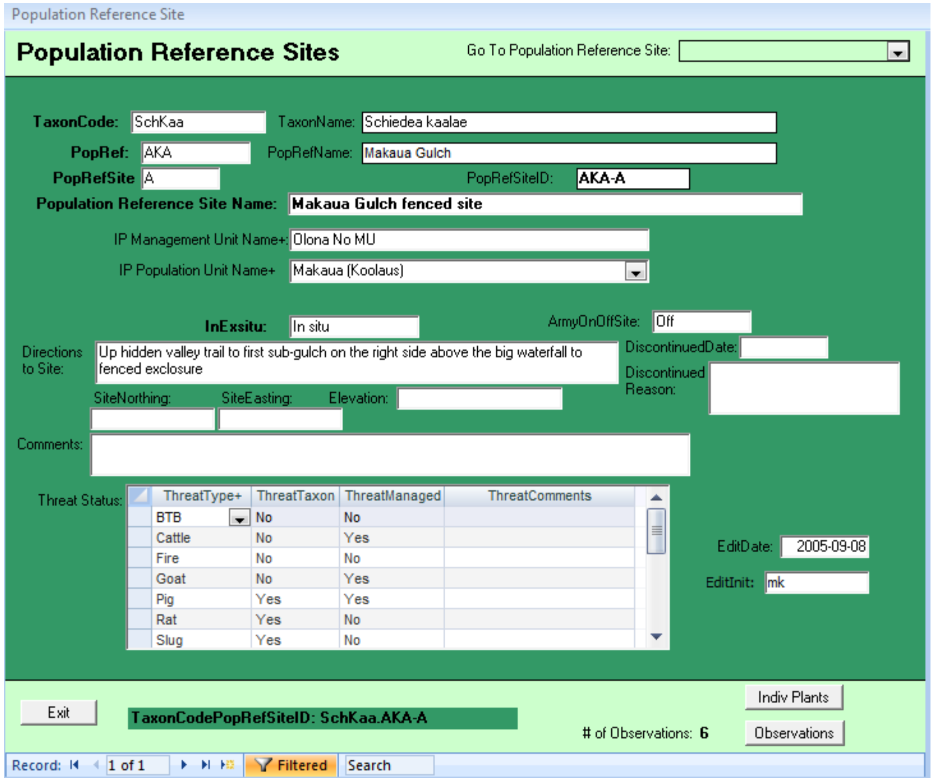
The Population Reference Site (PopRefSite) is the primary data table in establishing plant or animal population sites. The PopRefSite identifies the Population Name, whether it is In situ, Ex situ or Reintro, and provides directions to the site, etc. The PopRefSite is only site information; observation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

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



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

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



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

IP Management Unit Name: Management Unit commonly known from.

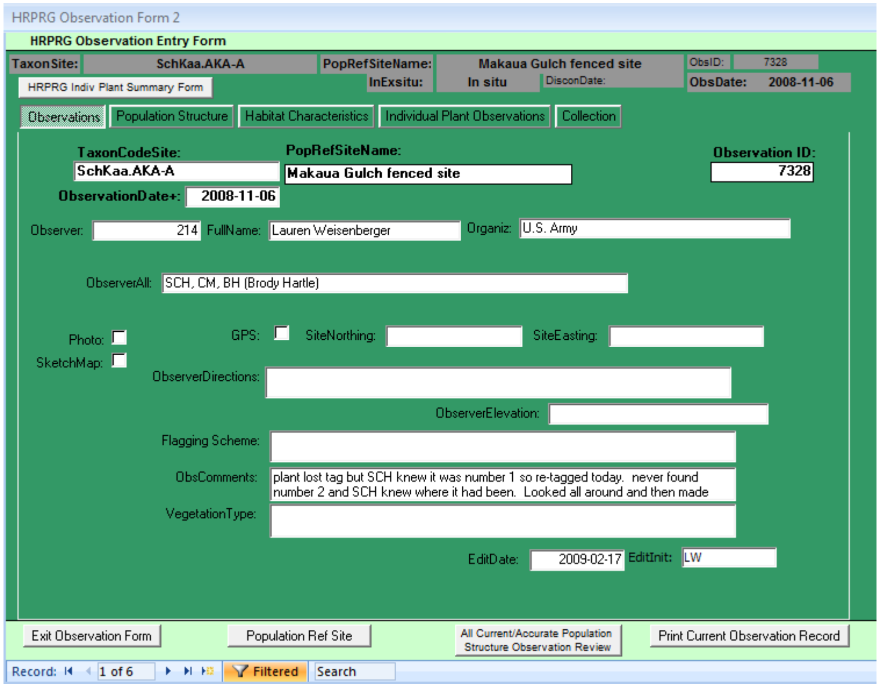
IP Population Unit Name (PopUnit): The PopUnit is used when several PopRefSites need to be tracked together. Such as a taxon with several sites throughout the Northern Waianae Mountains, Northern Waianae could be used as a PopUnit Name.

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

Directions to Site: Detailed directions to locate the population.

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

Observations

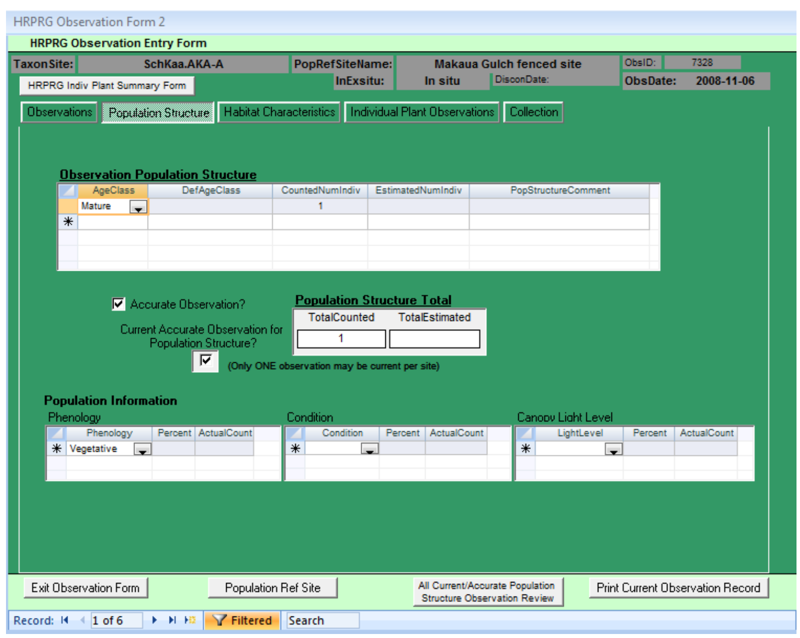


Clicking the Observations button on the bottom of the PopRefSite Form will open up the corresponding Observations.

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

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

Population Structure

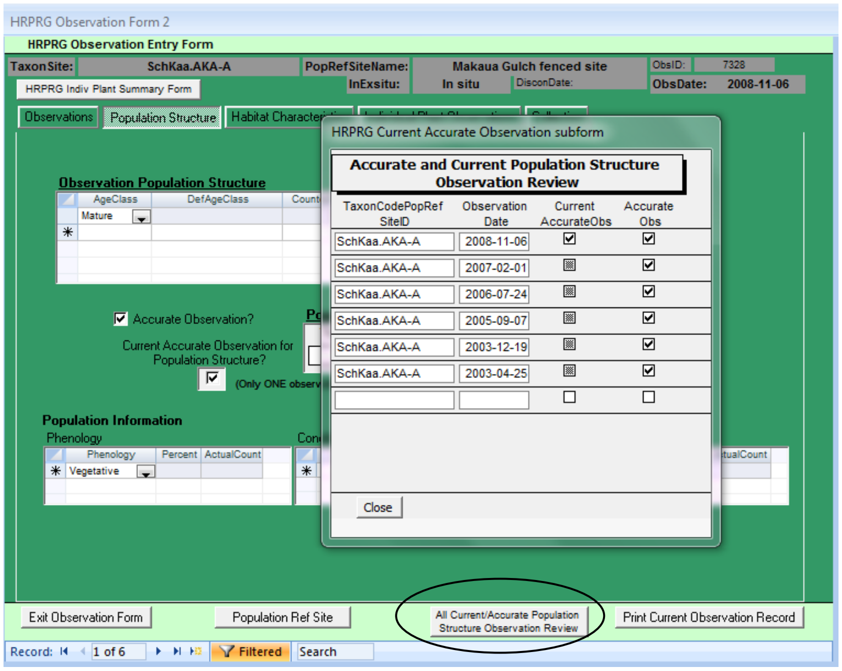


The Population Structure should are always entered for any observations, even if the number of plants observed are incomplete (not all plants observed).

Age Class always is required, where **CountedNumIndiv** (Counted Number of Individuals) is considered a more accurate count of the number of plants. **EstimatedNumIndiv** (Estimated Number of Individuals) may be entered only when the CountedNumIndiv is not entered. EstimatedNumIndiv is used when the number of plants is numerous. EstimatedNumIndiv should not be entered when the number of plants can be counted.

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

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

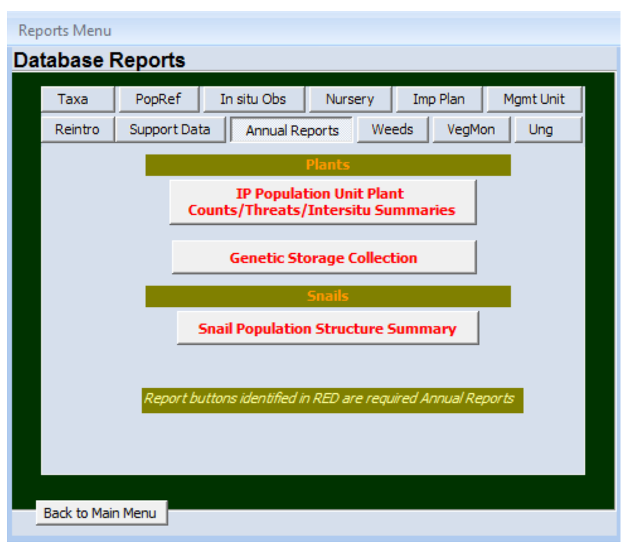


As opposed to the Accurate Observation check box, the **<u>Current Accurate Observation</u>** check off box <u>may only have one observation checked</u>. The Current Accurate represents the population structure that is considered both current and accurate. The most recent observation may not always be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

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

IV. <u>Database Reports</u>

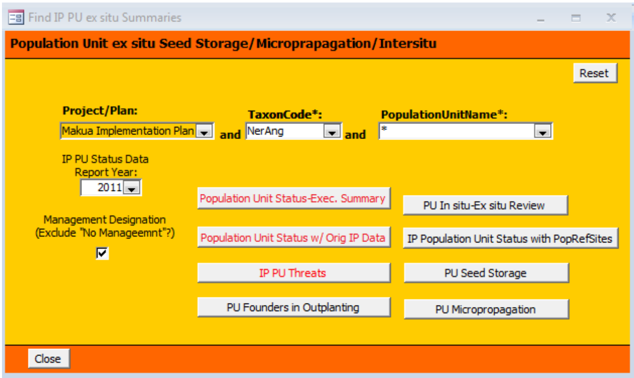
Starting from the Main Menu, click on the Database Reports button. The Database Reports menu provides reports for various sections of the database.



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

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

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



Taxon Status and Threat Summaries

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

Executive Summary

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

Makua Implementation Plan - Executive Summary - Plants

# of Stable IP Population Units: 43 of 100

= Ungulate Threat to Taxon within Population Unit

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

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

Taxon Status Summary

Makua Implementation Plan - Population Unit Status

Action Area: In

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

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

Action Area: Out

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

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2012	Total Immature 2012	Total Seedling 2012	Total Mature Current	Total Immature Current	Total Seedling Current	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Halona	Genetic Storage	15	0	0	30	4	0	**30**	**4**	**0**	30	4	0	0	0	0	2006-05-22	No monitoring in the last year
Leeward Puu Kaua	Genetic Storage	3	0	0	9	0	0	**9**	**0**	**0**	9	0	0	0	0	0	2006-11-21	No monitoring in the last year
Makaha	Genetic Storage	56	14	0	6	7	0	**4**	**2**	**0**	4	2	0	0	0	0	2012-12-18	Thorough monitoring

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

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

Management Designation: For PUs with naturally occurring (*in situ*) plants remaining, the designation is either 'Manage for Stability' or 'Genetic Storage'. Some MFS PUs will be augmented with outplantings to reach stability goals. When reintroductions alone will be used to reach stability, the designation is 'Manage Reintroduction for Stability.' When a reintroduction will be used for producing propagules for genetic storage, the designation is 'Manage Reintroduction for Storage'.

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

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

Total Current Mature, Immature, Seedling: The **SUM** of the *current* numbers of *wild and outplanted* individuals in each PU. This number will be used to determine if each PU has reached stability goals. These last three columns can be compared with the NRS 2010 estimates to see the change observed over the last year.

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

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

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

Population Trend Notes: Comments on the general population trend of each PU is given here. This may include notes on whether the PU was monitored in the last year, a brief discussion of the changes in population numbers from the previous estimates, and some explanation of whether the change is due to new plants being discovered in the same site, a new site being found, reintroductions or augmentations that increased the numbers or fluctuations in the numbers of wild plants. In some cases where the numbers have not changed, NRS has monitored the PU and observed no change. When the PU has not been monitored, the same estimate from the previous year is repeated.

Threat Control Summary

Action Area: In

TaxonName: Cenchrus agrimonioides var. agrimonioides

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	BTB Managed	Slugs Managed	Fire Managed
Kahanahaiki and Pahole	Manage for stability	320	Partial 100%	Partial 86%	Partial 30%	No	No	No
Kuaokala	Genetic Storage	1	No	No	No	No	No	No

Action Area: Out

TaxonName: Cenchrus agrimonioides var. agrimonioides

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

= 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

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

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

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

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

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

Threat control is defined as:
Yes = All sites within the PU have the threat controlled
No = All sites within the PU have no threat control
Partial %= Percent of mature plants in Population Unit that have threat controlled
Partial 100%= All PopRefSites within Population Unit have threat partially controlled
Partial (with no %) = All PopRefSites within Population Unit have threat partially controlled and only immature plants have been observed.

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

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

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

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

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

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

Genetic Storage Summary

Genetic Storage Summary

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

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
127	60	97	6	5	0	59	4	0	0	57	57

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

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

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

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

 # Plants that Met Goal: This column displays the total number of plants in each PU that have met the IP genetic storage goals. As discussed above, a plant is considered to meet the storage goal if it has 50 seeds in storage or three clones in micropropagation or three in a nursery. For some PUs, the number of founders has increased in the last year; therefore, it is feasible that NRS could be farther from reaching collection goals than last year. Also, as seeds age in storage, plants are outplanted, or explants contaminated, this number will drop. In other PUs where collections have been happening for many years, the number of founders represented in genetic storage may exceed the number of plants currently extant in each PU. In some cases, plants that are being grown for reintroductions are also being counted for genetic storage. These plants will eventually leave the greenhouse and the genetic storage goals will be met by retaining clones of all available founders or by securing seeds in storage. This column does not show the total number of seeds in storage; in some cases thousands of seeds have been collected from one plant.

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

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

Snail Population Status Summary

Number of Snails Counted

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes: Large	Medium	Small	Unk	Threat Control: Ungulate	Weed	Rat	Euglandina rosea	Jackson's Chameleon
Achatinella mustelina												
ESU: A Pahole to Kahanahaiki												
MMR-A Kahanahaiki Exclosure	Manage for stability	58	2013-05-13	32	12	14	0	Yes	Yes	Yes	Yes	No
MMR-C Maile Flats	Manage for stability	99	2012-05-17	68	23	8	0	Yes	Yes	Yes	No	No
PAH-B Pahole Exclosure	Manage for stability	42	2013-05-13	24	16	2	0	Yes	Yes	Yes	Yes	No
	ESU Total:	199		124	51	24	0					

Size Class Definitions

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

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

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

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

Population Reference Site: The first column lists the population reference code for each field site. This consists of a three-letter abbreviation for the gulch or area name. For example, MMR stands for Makua Military Reservation. Next, a letter code is applied in alphabetic order according to the order of population discovery. This coding system allows NRS to track each field site as a unique entity. This code is also linked to the Army Natural Resource geodatabase. In addition, the "common name" for the site is listed as this name is often easier to remember than the population reference code.

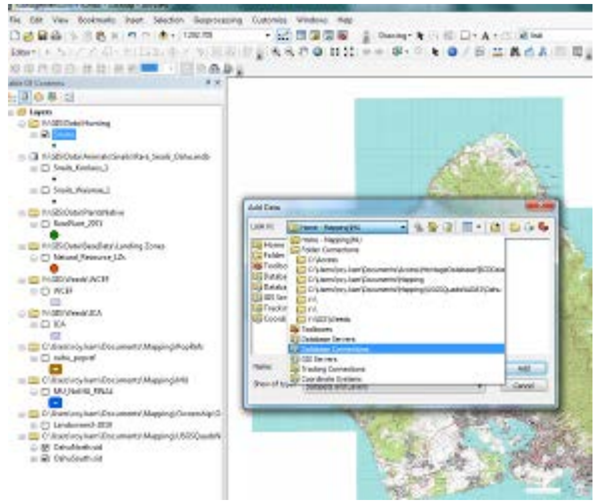
Management Designation: In the next column, the management designation is listed for each field site. The tables used in this report only display the sites chosen for MFS, where NRS is actively conducting management. These sites are generally the most robust sites in terms of snail numbers, habitat quality, and manageability. Other field sites where NRS has observed snails are tracked in the database but under the designation 'no management.' In general, these sites include only a few snails in degraded habitat where management is logistically challenging. The combined total for sites designated as MFS should be a minimum of 300 total snails in order to meet stability requirements.

Population Numbers: The most current and most accurate monitoring data from each field site are used to populate the 'total snails' observed column and the numbers reported by 'size class' columns. In some cases, complete monitoring has not been conducted within this reporting period because of staff time constraints, therefore, older data are used.

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

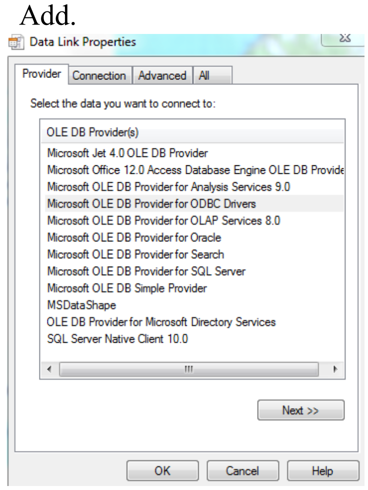
Linking Access Database Query into ArcGIS –Distribution Database Version

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

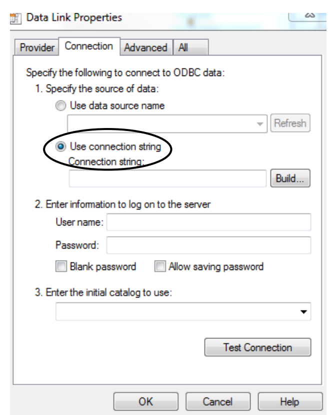


In your ArcGIS Project, make sure you have the Rare Plants or Rare Snails shapefile (or whatever shapefile you are linking) as one of your layers. Click on the Add Button, and choose *Database Connections*.

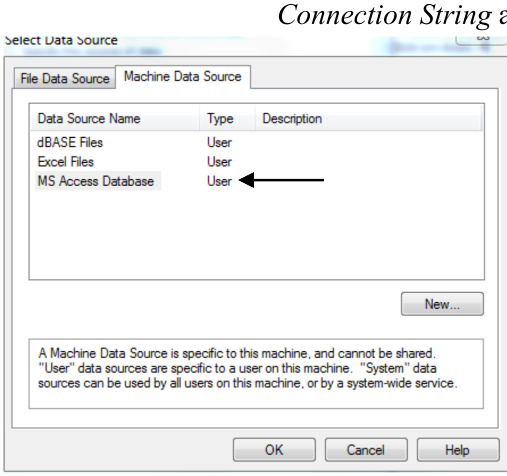
Then select *Add OLE Database Connection*, and click on Add.



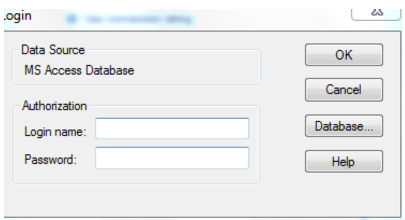
A Data Link Properties window will appear. Select *Microsoft OLE DB Provider for ODBC Drivers*.



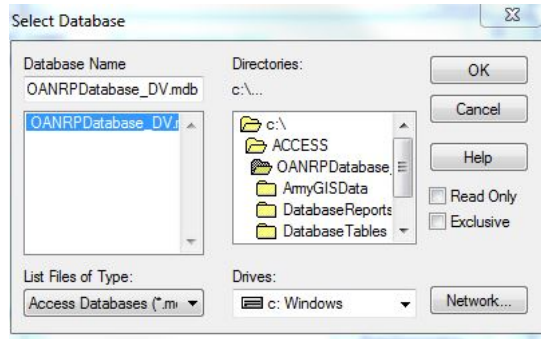
Then in the Data Link Properties window, select the *Connection tab*. Under the Connection Tab, select *Use Connection String* and click on the button *Build*.



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

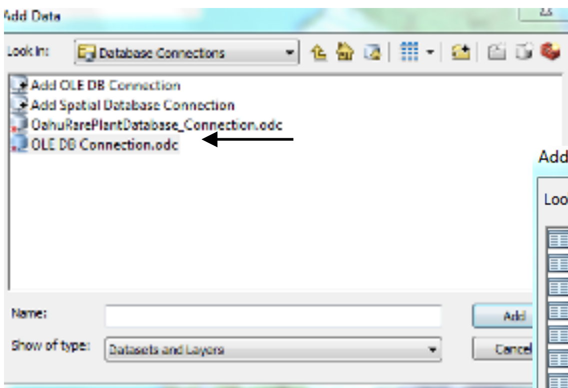


In the Login Window, Click on the *Database* button (leave Login Name and Password blank).

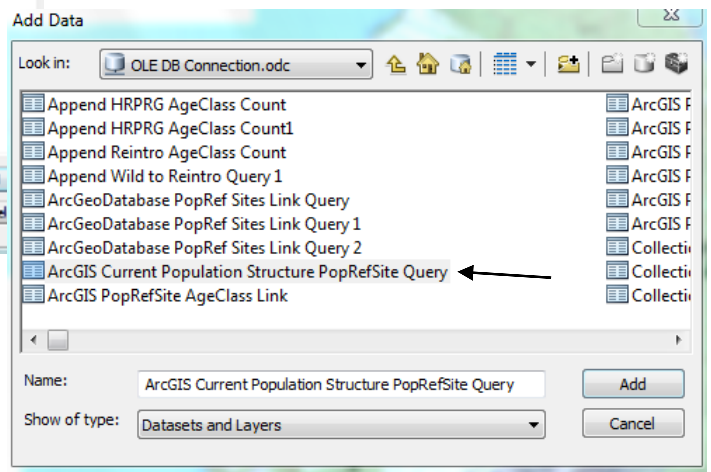


In the Select Database window, change the Drives to C: and browse to C:\Access\OANRPDatabase_DistributeVersion\OANRPDatabase_DV.mdb

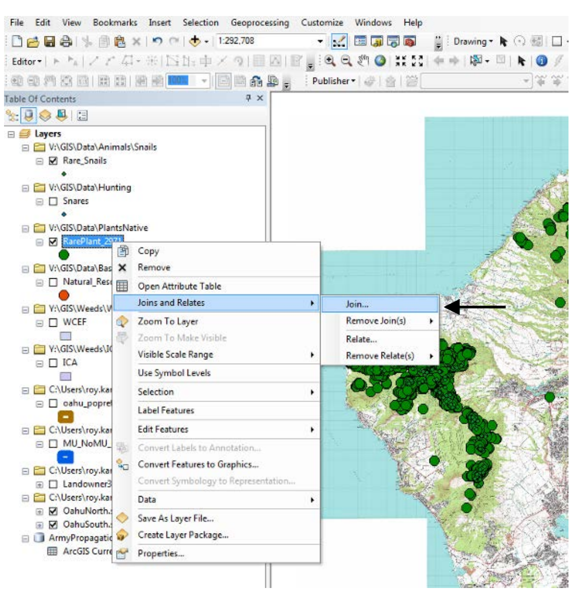
Click Ok to close the windows, until you are back at the Add Data window. You will now see a new OLE DB Connection.odc listed.



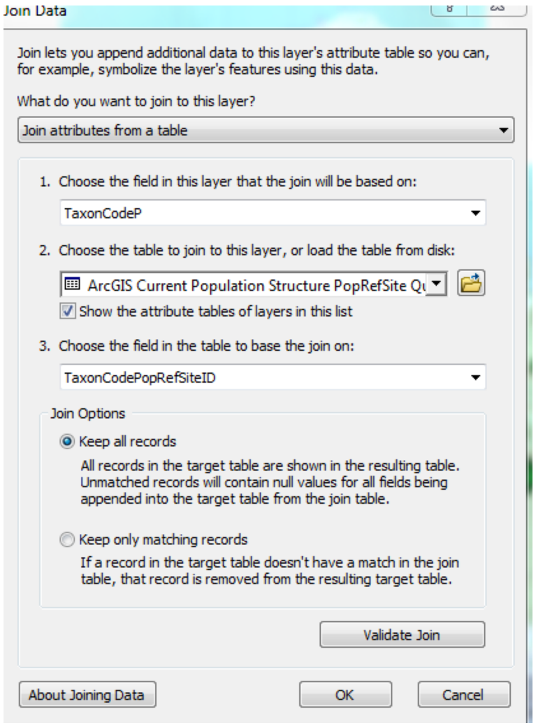
Double click on the OLE DB Connection.odc. The window will then open the Access Database and list all tables and queries.



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



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



The last procedure is to join the Rare Plant shapefile with the Access Query. Select TaxonCodeP from the Rare Plant GIS Shapefile, and TaxonCodePopRefSiteID from the Access database query. The data will now appear together in the Snare shapefile attribute table.

Attribute Table from ArcGIS. Example of Rare Plant shapefile joined to Access Database Query.

← Rare Plants GIS Shapefile table data → Access Database data

RarePlants

OBJ	ID	SPECIES	POPULATION	TaxonCodeP	LOCATION	SOU	FULL_SCIEN	X	Y	NATU	Statu	TaxonCode	PopRefName
1	0	AleMacMac	SBW-A	AleMacMac.SBW-A	Mohiakea gulch	JL	Alectryon macrococcus macrococcus	590515.562	2376426.50004	Yes	E	AleMacMac	Schofield Barracks Mil
2	0	AleMacMac	SBW-C	AleMacMac.SBW-C	Puu Kumakalii	JL	Alectryon macrococcus macrococcus	590981.875	2375960.25005	Yes	E	AleMacMac	Schofield Barracks Mil
3	0	AleMacMac	SBW-D	AleMacMac.SBW-D	Puu Kumakalii	JL	Alectryon macrococcus macrococcus	591323.250	2375402.75002	Yes	E	AleMacMac	Schofield Barracks Mil
4	0	SchTri	ALA-C	SchTri.ALA-C	Kaala	JL	Schiedea trinervis	589030.703	2378443.74343	Yes	E	SchTri	Mt. Kaala NAR
5	0	SchTri	SBW-G	SchTri.SBW-G	Puu Kalena	JL	Schiedea trinervis	589641.375	2376627.49997	Yes	E	SchTri	Schofield Barracks Mil
6	0	CyaAcu	ALA-B	CyaAcu.ALA-B	Kaala	JL	Cyanea acuminata	589083.312	2378560.75002	Yes	E	CyaAcu	Mt. Kaala NAR
7	0	CyaGriOba	SBW-A	CyaGriOba.SBW-A	Kaala 2400'	JL	Cyanea grimesiana obatae	590057.000	2378433.99994	Yes	E	CyaGriOba	Schofield Barracks Mil
8	0	CyaCal	NA	CyaCal.ALA-A	Kaala	JL	Cyanea calycina	588965.812	2378293.99994		E	CyaCal	Mt. Kaala NAR
9	0	CyaCal	NA	CyaCal.ALA-A	Kaala	JL	Cyanea calycina	588996.187	2378697.74996		E	CyaCal	Mt. Kaala NAR
10	0	CyaCal	NA	CyaCal.ALA-A	Kaala	JL	Cyanea calycina	589218.125	2378491.00001		E	CyaCal	Mt. Kaala NAR
11	0	CyaCal	NA	CyaCal.SBW-A	Kaala	JL	Cyanea calycina	589493.687	2377636.75002	Yes	E	CyaCal	Schofield Barracks Mil
12	0	CyaCal	NA	CyaCal.SBW-A	Kaala	JL	Cyanea calycina	589268.312	2377825.24999	Yes	E	CyaCal	Schofield Barracks Mil
13	0	CyaCal	SBW-A	CyaCal.SBW-A	Kaala	JL	Cyanea calycina	588881.999	2378048.50004	Yes	E	CyaCal	Schofield Barracks Mil
14	0	CyaCal	SBW-C	CyaCal.SBW-C	Puu Kalena 2300'	JL	Cyanea calycina	590479.812	2376867.99994	Yes	E	CyaCal	Schofield Barracks Mil
15	0	CyaCal	SBW-C	CyaCal.SBW-C	Puu Kalena 2800'	JL	Cyanea calycina	590307.312	2376571.74996	Yes	E	CyaCal	Schofield Barracks Mil

→ Access Database data joined query →

RarePlants

PopRefName	FedStat	TaxonCodePopRefSit	PopRefSiteName	InExsitu	ObservationDate	AccObs	CurAccObs	Immature	Large	Mature	Medium	
Schofield Barracks Milita	E	AleMacMac.SBW-A	Mohiakea	In situ	2013-05-20	Yes	Yes	<Null>	<Null>	2	<Null>	<
Schofield Barracks Milita	E	AleMacMac.SBW-C	North of Puukumakalii (Dead)	In situ	2012-04-04	Yes	Yes	0	<Null>	0	<Null>	
Schofield Barracks Milita	E	AleMacMac.SBW-D	Southeast of Puukumakalii	In situ	2012-06-27	Yes	Yes	0	<Null>	0	<Null>	
Mt. Kaala NAR	E	SchTri.ALA-C	Lower 2 Poles Ridge	In situ	2002-10-23	Yes	Yes	5	<Null>	5	<Null>	
Schofield Barracks Milita	E	SchTri.SBW-G	Kalena, in notch	In situ	2007-08-20	Yes	Yes	0	<Null>	0	<Null>	
Mt. Kaala NAR	E	CyaAcu.ALA-B	Kaala, one gulch N of Alstri ridge	In situ	2008-03-13	Yes	Yes	<Null>	<Null>	19	<Null>	<
Schofield Barracks Milita	E	CyaGriOba.SBW-A	North Haleauau	In situ	2005-10-03	Yes	Yes	0	<Null>	0	<Null>	
Mt. Kaala NAR	E	CyaCal.ALA-A	Kaala	In situ	2013-06-06	Yes	Yes	<Null>	<Null>	3	<Null>	<
Mt. Kaala NAR	E	CyaCal.ALA-A	Kaala	In situ	2013-06-06	Yes	Yes	<Null>	<Null>	3	<Null>	<
Mt. Kaala NAR	E	CyaCal.ALA-A	Kaala	In situ	2013-06-06	Yes	Yes	<Null>	<Null>	3	<Null>	<
Schofield Barracks Milita	E	CyaCal.SBW-A	North Haleauau, Below ALA-O populati	In situ	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<
Schofield Barracks Milita	E	CyaCal.SBW-A	North Haleauau, Below ALA-O populati	In situ	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<
Schofield Barracks Milita	E	CyaCal.SBW-A	North Haleauau, Below ALA-O populati	In situ	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<
Schofield Barracks Milita	E	CyaCal.SBW-C	Kaala-Kalena	In situ	2006-10-25	Yes	Yes	<Null>	<Null>	1	<Null>	<
Schofield Barracks Milita	E	CyaCal.SBW-C	Kaala-Kalena	In situ	2006-10-25	Yes	Yes	<Null>	<Null>	1	<Null>	<
<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<

OAHU ARMY NATURAL RESOURCES PROGRAM
MONITORING PROGRAM

RESULTS OF A WEEDING TRIAL AT LOWER OPAEULA MANAGEMENT UNIT

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

INTRODUCTION

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

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

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

METHODOLOGY

Study site

Opaeula Lower is a 25-acre MU located in the northern Koolau Mountain Range, on the island of Oahu. The plant community is classified as a montane wet forest and the habitat is predominantly native. The annual precipitation averages 3816 millimeters (mm) (Giambelluca 2013) and elevation ranges between 1920-2260 feet. The vegetation is comprised of a mixture of native and introduced species. The dominant native species in the canopy include *Acacia koa, Metrosideros* spp., *Syzygium sandwicense, Cheirodendron* spp.*, Cibotium* spp, *Ilex anomala*, *Psychotria* spp., and *Melicope* spp.. The most common native species in the understory include *Dicranopteris linearis, Freycinetia arborea, Alyxia stellata, Melicope* spp., *Psychotria* spp., and *Cibotium chamissoi*. The dominant introduced species in the canopy is *Psidium cattleianum*, while those most prevalent in the understory include *C. hirta, Lantana camara, Sphaeropteris cooperii, Citharexylum caudatum, Rubus rosifolius, Paspalum conjugatum, Blechnum appendiculatum, Erechtites valerianafolia, Urochloa maxima* and *Setaria palmifolia*. During plot monitoring in 2013 and 2014, 48 taxa (65% native) were identified in the understory and canopy (Table 1).

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

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

Field Methods

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

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

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

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

To determine if canopy changes occur in response to understory weeding within 18 months, and to assess if differences in light availability between plots should be taken into account when interpreting the trial results, data was also collected on canopy percent cover (using point intercept) and light penetration to the forest understory strata (using photography). Canopy vegetation (> 2 m AGL) intercepted by laser (using a laser pointer aimed 180° from the forest floor) at 2 points spaced 2.5 m apart along each of 10 transects spaced 2 m apart (n = 20 points) was recorded. Hemispheric photographs were taken of the canopy at the same locations. Photographs were taken at breast height, aimed 180° from the forest floor.

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

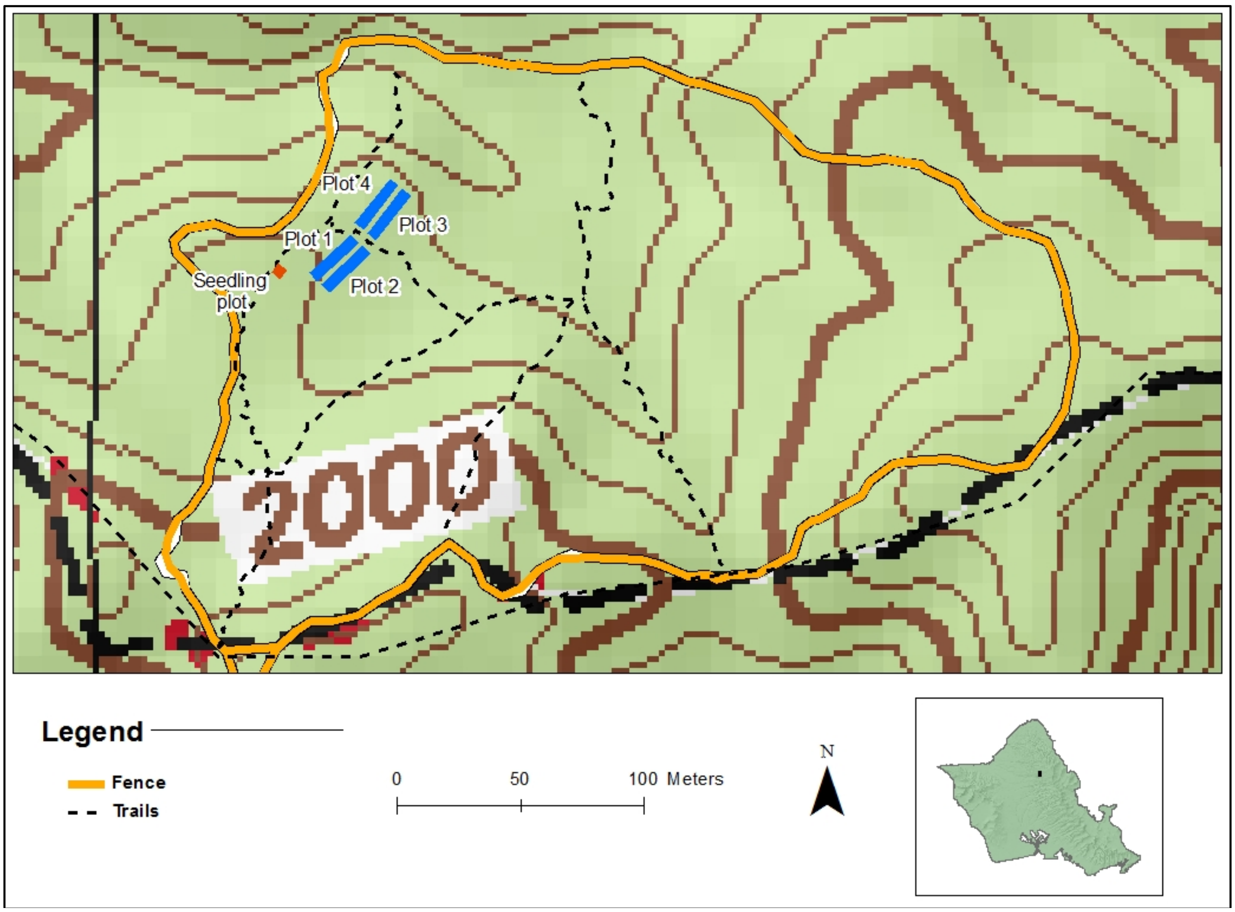


Figure 1. Locations of study plots at Lower Opaeula Management Unit

Data Analysis

Chi-square and Fisher's exact tests were performed using point intercept data to examine change in understory and canopy cover within plots over time, and differences between plots at the end of the trial. Cover is described as very low to very high (Table 2). Within plot differences in species richness over time were analyzed using t-tests. Differences in species richness between plots at the end of the trial were analyzed using ANOVA with Tukey's post-hoc comparisons. Gap Light Analyzer (GLA), Version 2.0 software (Frazer et al. 1999) was used to analyze percent canopy openness, using the hemispheric canopy photographs taken within each plot. Differences in canopy openness at the end of the trial were analyzed using ANOVA with Tukey's post-hoc comparisons.

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

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

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

RESULTS

Understory percent cover

Non-Native

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

At the end of the trial, *C. hirta* cover differed significantly among all plots ($p < 0.001$), ranging from very low (Plot 3), to moderately low (Plot 2), to moderate (Plot 4) to high (Plot 1) in relation to the time elapsed since the last weeding effort (6, 12, and 18 months prior for Plots 3, 2 and 4, respectively, and Plot 1 never weeded). Total weed cover differed among plots except for Plots 2 and 3, ranging from moderate/moderately high (Plots 2 and 3), to high (Plot 4), to very high (Plot 1) ($p < 0.001$), also in relation to time since weeding last occurred. Total weed cover excluding *C. hirta* differed among plots with the exception of plots 3 and 4, ranging from moderately low (Plot1) to moderate (Plot 2) to moderately high/moderate (Plots 3 and 4) ($p < 0.001$).

Native

There was a significant increase in native cover (from low to moderate) for the plots weeded twice (Plots 2 and 3), but no change in the control plot (Plot 1 - moderately low cover) or in the plot weeded only at month 0 (Plot 3 - low cover). Though initially absent in all plots, by the end of the trial, *Acacia koa* recruitment was present in all plots at very low cover, representing a very small but marginally significant increase in Plot 2 (weeded at months 0 and 6) and Plot 4 (weeded at month 0). *Cibotium chamissoi* was present in very low cover in all plots initially, and had a very small but significant increase (to low cover) at the control plot, and a larger increase in the plots weeded twice (to low/moderately low cover), but no difference in the plot weeded once. *Nephrolepis exaltata* subsp. *hawaiiensis* was also present in very low cover initially in all plots, and had a significant increase (to low cover) in Plot 2 (weeded at months 0 and 6), but not in any other plots.

Non-vegetated

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

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

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

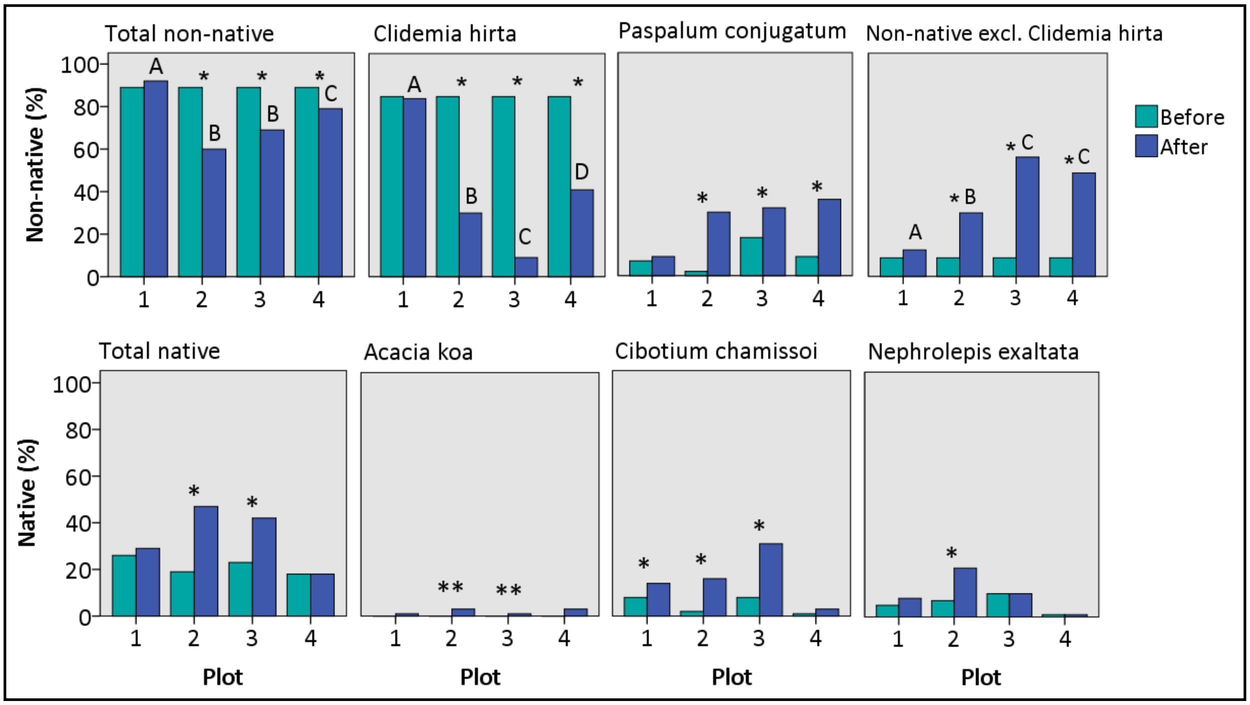


Figure 2. Percent cover of native and non-native understory at the start (before) and end (after) of the trial 18 later, among plots weeded at months 0 and 6 (Plot 2), at months 0 and 12 (Plot 3), at month 0 (Plot 4), and not weeded (Plot 1 - control). Initial data for non-native taxa except for *Paspalum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

Photopoints

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

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

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

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

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

Understory species richness

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

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

	P*	
Plot	Non-native	Native
1	0.689	0.907
2	0.081	0.116
3	**< 0.001**↑	0.057↑
4	**0.001**↑	0.101

*Significance derived from t tests.

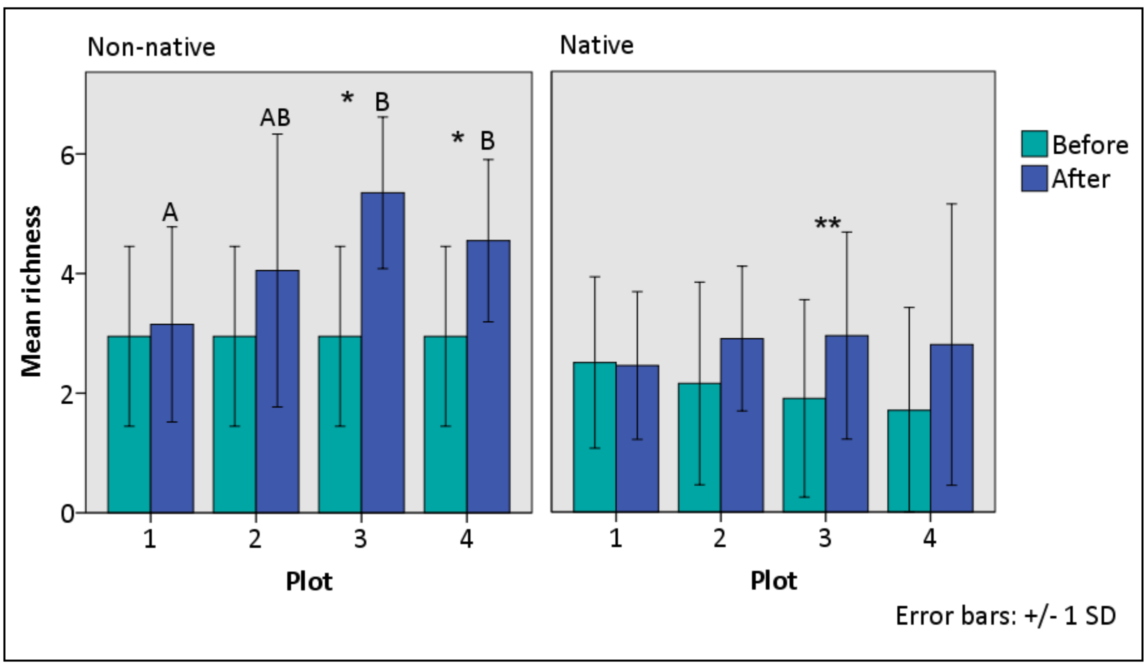


Figure 7. Bar graphs of mean non-native and native species richness among quadrats (n = 20) at the start (before) and end (after) of the trial 18 later, among plots weeded at months 0 and 6 (Plot 2), at months 0 and 12 (Plot 3), at month 0 (Plot 4), and not weeded (Plot 1 - control). Initial data for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

Maturation time

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

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

Cibotium chamissoi, and uprooted *Metrosideros polymorpha* tree.

Canopy percent cover and openness

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

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

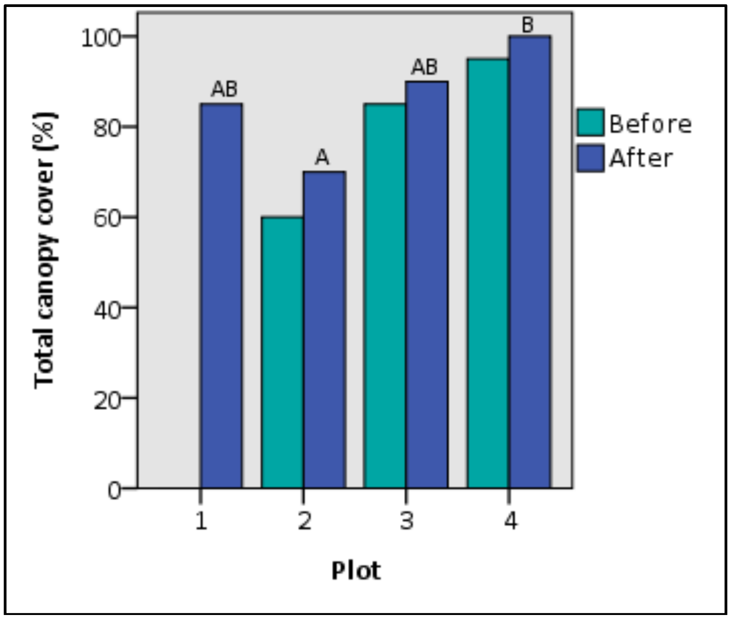


Figure 9. Bar graph of total canopy percent cover (n = 20) before and 18 months after plots were weeded at months 0 and 6 (Plot 2), at months 0 and 12 (Plot 3), at month 0 (Plot 4), and not weeded (control – Plot 1). Initial data for the control plot (not weeded) was not recorded. Letters denote significant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

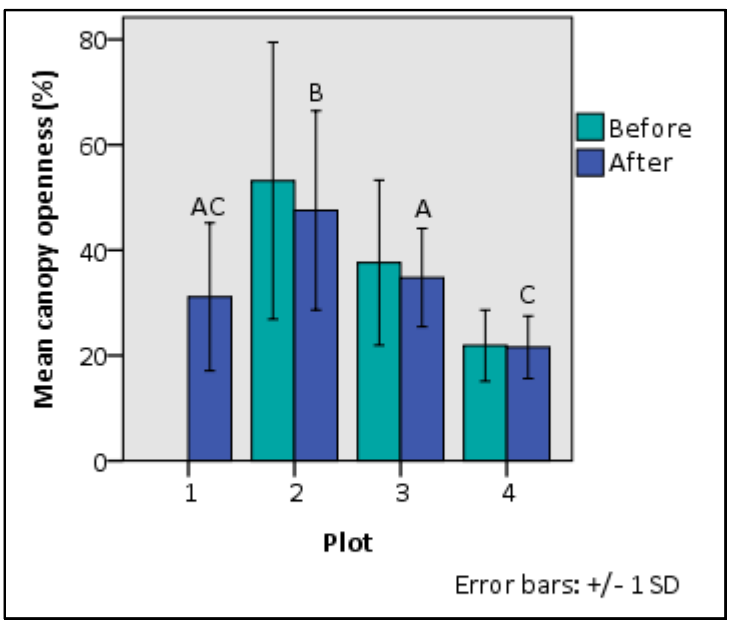


Figure 10. Bar graph of mean percent canopy openness (n = 20) before and 18 months after plots were weeded at months 0 and 6 (Plot 2), at months 0 and 12 (Plot 3), at month 0 (Plot 4), and not weeded (control – Plot 1). Initial data for the control plot was not recorded. Letters denote significant differences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

DISCUSSION

Understory cover

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

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

Photopoints

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

Species richness

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

Maturation time

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

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

Canopy cover and light availability

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

RECOMMENDATIONS

- Re-weeding should occur within 6 to 12 months, in order to allow native cover to expand, and prevent weed cover from returning to near prior levels. Because change is slow in unweeded areas, it is not urgent to weed expansively across the MU in the immediate future, particularly if re-weeding within the recommended time interval is not feasible for all weeded areas.

- Weeding of *C. hirta*-dominated areas should focus first in areas with high canopy cover, as young plants will likely grow and mature less quickly.

- Weeding should be paired with grass control, to prevent expansion of non-native grasses, and possibly allow for further expansion of native cover.

- Because *C. hirta*-dominated areas are partially replaced by other weed taxa, care should be taken to ensure that more problematic weeds do not become established.

- Clearcutting *P. cattleianum* in this area is not advised unless there are resources to follow up and prevent *C. hirta* from becoming established. Or, *P. cattleianum* removal should be limited to the understory only, and limit all canopy removal.

- If there is an impetus to deplete the *C. hirta* seed bank, weeding should occur more frequently than 6 months, particularly in areas with greater light availability. Additionally, weeding must be ongoing, as *C. hirta* forms a long lived seed bank (Brooks and Setter, 2012). However, such a high frequency of weeding will limit the total area that is feasible to weed. Additionally, there will likely be a continual influx of *C. hirta* seeds from the surrounding areas. Depletion of the *C. hirta* seed bank is likely an impractical endeavor.

- Further investigations of the effects of light availability on *C. hirta* growth should be done.

- While this trial provided useful information for *C. hirta*-dominated understory at Lower Opaeula, expectations for similar results in other locations should be applied cautiously.

REFERENCES

Brooks, S. J., and S. D. Setter. 2012. Soil seed bank longevity information for weed eradication target species. *Pak. J. Weed Sci. Res*., 18: 73-83.

Frazer, G. W., C. D. Canham, and K. P. Lertzman. 1999. Gap Light Analyzer (GLA), Version 2.0: Imaging software to extract canopy structure and gap light transmission indices from true-colour fisheye photographs, users manual and program documentation. Copyright © 1999: Simon Fraser University, Burnaby, British Columbia, and the Institute of Ecosystem Studies, Millbrook, New York.

Giambelluca, T. W., Q. Chen, A. G. Frazier, J. P. Price, Y. -L. Chen, P. -S. Chu, J. K. Eischeid, and D. M. Delparte. 2013. Online Rainfall Atlas of Hawaiʻi. *Bull. Amer. Meteor. Soc.* 94, 313-316, doi: 10.1175/BAMS-D-11-00228.1.

Annual Progress Report for "Kahanahaiki Vegetation Mapping Analysis"
Project Update: October 1, 2014 – September 30th, 2015

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

William Weaver wweaver@hawaii.edu
Dr. Tomoaki Miura tomoakim@hawaii.edu
Department of Natural Resources and Environmental Management
University of Hawaii at Manoa

Summary

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

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

Study Site

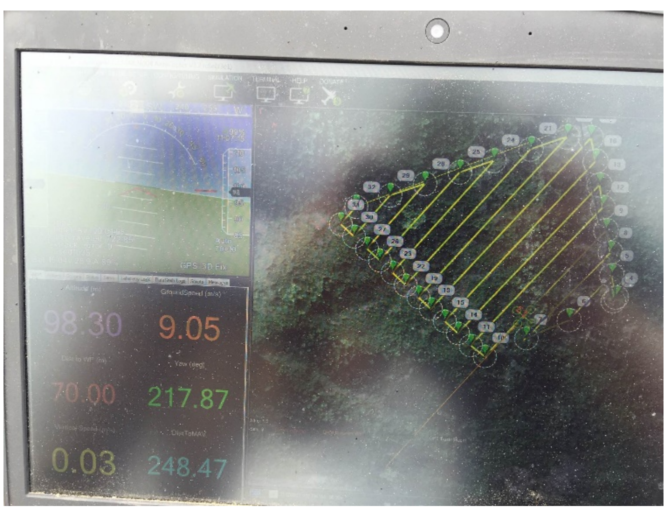
A site visit was conducted in Makaha Valley in early April and it became clear that the site is too remote for the scope of the project. Kahanahaiki in upper Makua Valley was chosen as an alternative study location and was approved by OANRP staff.

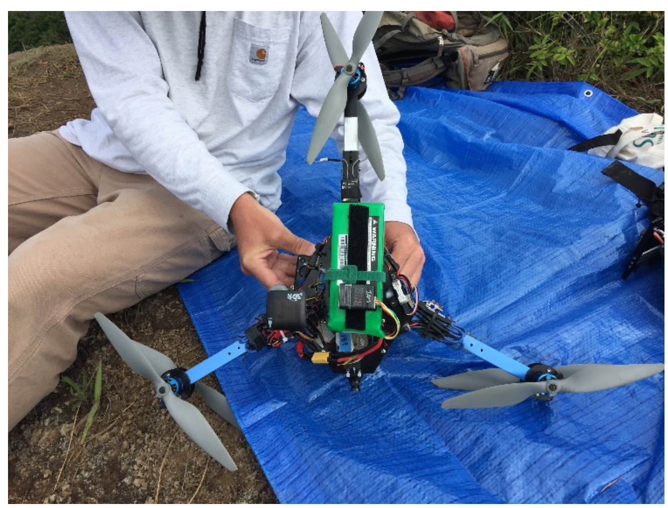
High Resolution Aerial

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

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

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





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

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

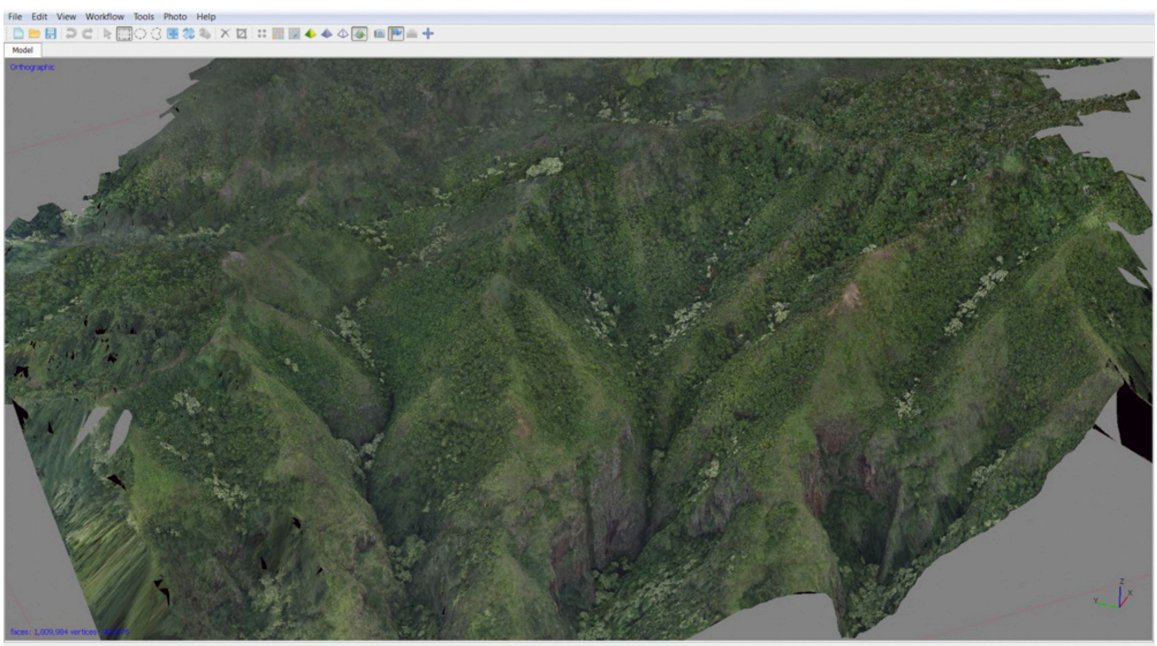


Figure 3: Screenshot of the 3D image data product of Kahanahaiki subunit II looking east.

Figure 4: Sample image tile of Kahanahaiki subunit II.

World View 3 Satellite Imagery

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

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

Gigapan

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

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

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

Other Work

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

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

Appendix 1.

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

William Weaver

Geography 762

Spring 2015

Term Project Paper

Abstract

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

Introduction

The Hawaiian Islands are a prime example of ecological diversity and host an array of unique and rare species that have evolved within a myriad of environments (Gon, 2003; Sailer, 2003). A key ecosystem within the islands is the mesic forest, an area found in coastal, lowland, and montane areas of Hawaii that receives 1200 mm to 1500 mm rainfall annually (Wagner et al., 1998; Sailer, 2003). Although wet forests are credited with capturing the bulk of rain water, mesic forests significantly supplement groundwater recharge and buffer wet forested areas from degradation by land use change, ungulate damage, and fires (Sailer, 2003; Juvik and Juvik, 1998).

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

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

New technology is changing the face of vegetation mapping and its efficacy in the form of remote sensing and GIS. Analysis of remote imagery can provide accurate and timely assessments of vegetation on a large scale at a set point in time (Bunting and Lucas, 2006). Remote imagery can easily be replicated and can provide an accurate visual key of an area (Bunting and Lucas, 2006).

Object of Study

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

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

Study Site

Upper Makaha valley is located on the leeward side of the Northern Waianae Mountain Range of Oahu. It is owned by the Honolulu Board of Water Supply (BWS) and is one of their key watersheds. Makaha valley has a diverse history of land management and some of the land use practices within the valley continue to have impacts on the forest community to this day (OANRP et al., 2010). Maintaining and improving the function of this watershed is of utmost importance for groundwater recharge and protected habitat of endangered native plants and animals (Townscape, 2009). Vegetation communities within Makaha valley have been described by Harmon (2006) and Suzuki (2006), who utilized fine resolution satellite imagery to document the highly invasive *P. cattleianum* throughout much of the valley. Native to Brazil, *P. cattleianum* was first introduced to Hawaii in 1825 and is now a dominant component of many Hawaiian environments from sea level to 1300m (Smith, 1985; Takahashi et al., 2010). Remnant native forest tree species including *Metrosideros polymorpha*, *Acacia koa*, and *Diospyros sandwicensis* are found within a portion of the upper Makaha valley (Harman, 2006). The most intact native areas within the valley were fenced with the recent completion of two subunits. Subunit I is about 85 acres and subunit II is about 35 acres in size (see Figure 1). Ground vegetation monitoring in subunit II was conducted in 2014 with the use of belt transects and survey plots (Oahu Army Natural Resource Program status report, 2014).

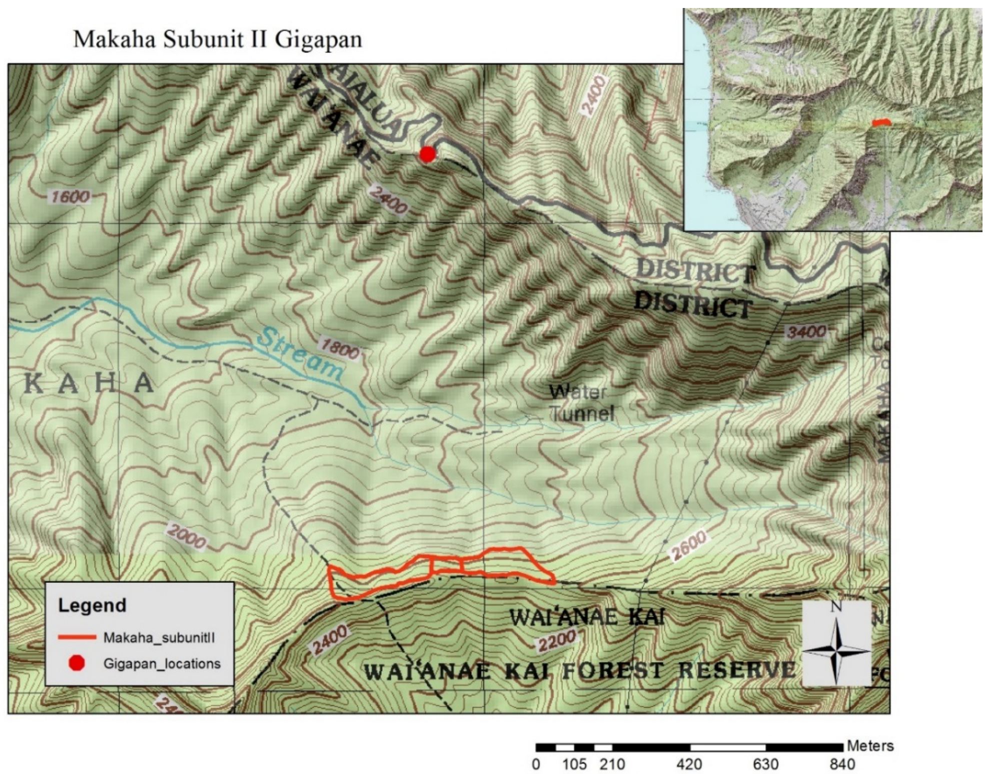


Figure 1. Topographic map portraying the back of Makaha Valley with Subunit II and the Gigapan location on the Ka'ala road.

<u>Object Based Image Analysis</u>

Traditionally, aerial photography has been used to obtain very fine (<1m) spatial resolution, however other platforms are becoming available (Bunting and Lucas, 2006). The advancement of hyperspectral satellite sensors has lent the opportunity for many studies of digital image analysis. The pixel based image analysis was the accepted methodology since the launch of Landsat-1 in 1972 (Blaschke et al. 2014). However there are limitations to this pixel based approach. Blaschke et al. (2014) point out, that once the spatial resolution is finer than the object of interest, objects are made up of multiple pixels so focus should be on the patterns that are created. A per-pixel approach with new high resolution sensors may decrease the accuracy of within class spectral variability (Blaschke et al. 2014, Hay et. al. 1996). Research in the 2000s started developing object based image analysis focusing on the color, tone, texture, patterns, shape, shadow and context of groups of pixel objects; development of these techniques represents a new paradigm in image analysis (Blaschke et al. 2014).

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

<u>Gigapan System</u>

Little work has been done mapping vegetation with the Gigapan system. This project will represent the first attempt to couple the Gigapan system with a laser rangefinder GPS and run through object based classification vegetation analysis. The Gigapan robotic unit allows a user to capture very high resolution digital images (<1cm) with billions of pixels (gigapan.com, Sargent et al. 2010, Stock et al., 2010). The technology utilized by the Gigapan robotic unit was developed by Carnegie Mellon for the Mars Rovers, Spirit and Opportunity to capture images of the red planet (gigapan.com). It is gaining use by researchers across many other fields of science to capture site information from geology to ecology to complement field work (Sargent R., Bartley C., Dille, P., Keller, J., Nourbakhsh, LeGrand, R., 2010). The TruePulse 360R is a laser rangefinder that can link to a GPS to obtain GPS offsets from up to 1,000m from its target location for non-reflective surfaces and 2,000m for reflective surfaces. The laser rangefinder will be mounted on the camera via the hotshoe and fired at each image location in the Gigapan mosaic allowing for georeferencing of the Gigapan mosaic.

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

Methods

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

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

Image post processing was conducted with Adobe LightRoom 5.0. A 10% level increase was applied to contrast, vibrance, clarity, saturation, sharpening and noise reduction of each image. The gigapixel panorama of the study site was put together using GigaPan Stitch 2.3.0307. Visual classification of a subset of the image was undertaken to be used for the classification accuracy assessment using visual cues, such as canopy shape, canopy size, canopy color, texture, bark and stem color and relationship to other objects (Jensen, 2007) (See Table 1). The Gigapan image was imported into ArcMap 10.1 and a subset of the panorama was selected and delineated by a polygon feature class. Ten vegetation species classes were identified by zooming and exploring the image and delineating polygon shapes, each with a separate feature class.

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

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

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

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

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

Results

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

GSD=distance/focal length x CCD pixel size

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

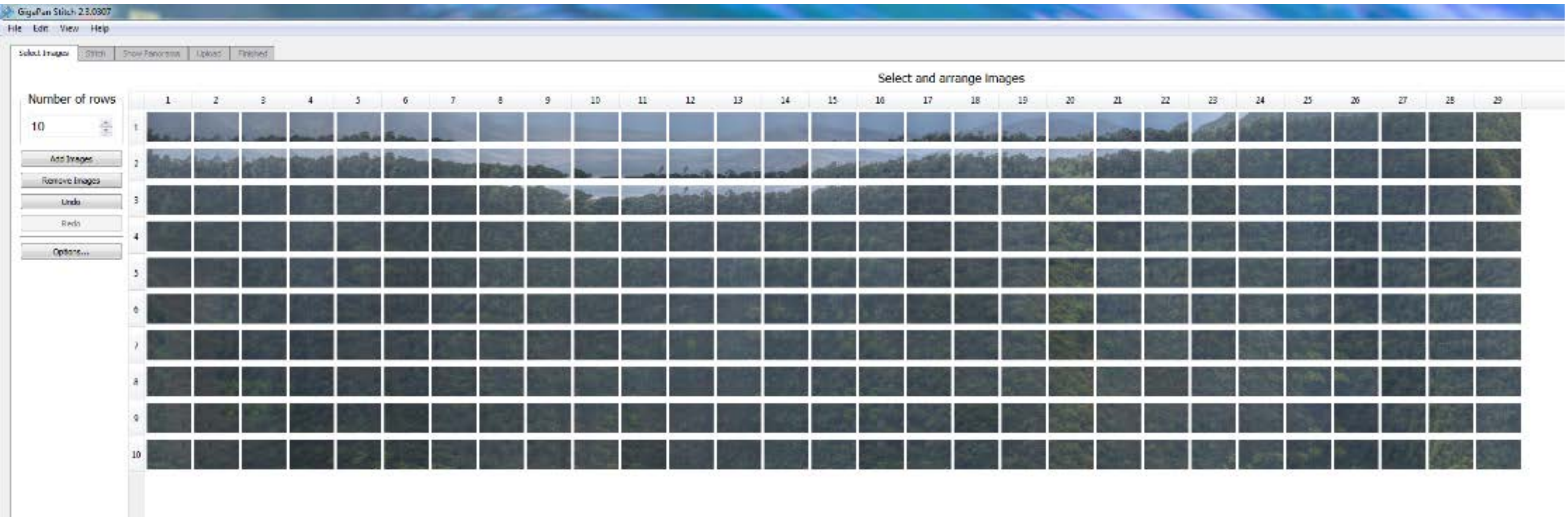


Figure 3. Individual 290 images prior to the stitching process

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

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

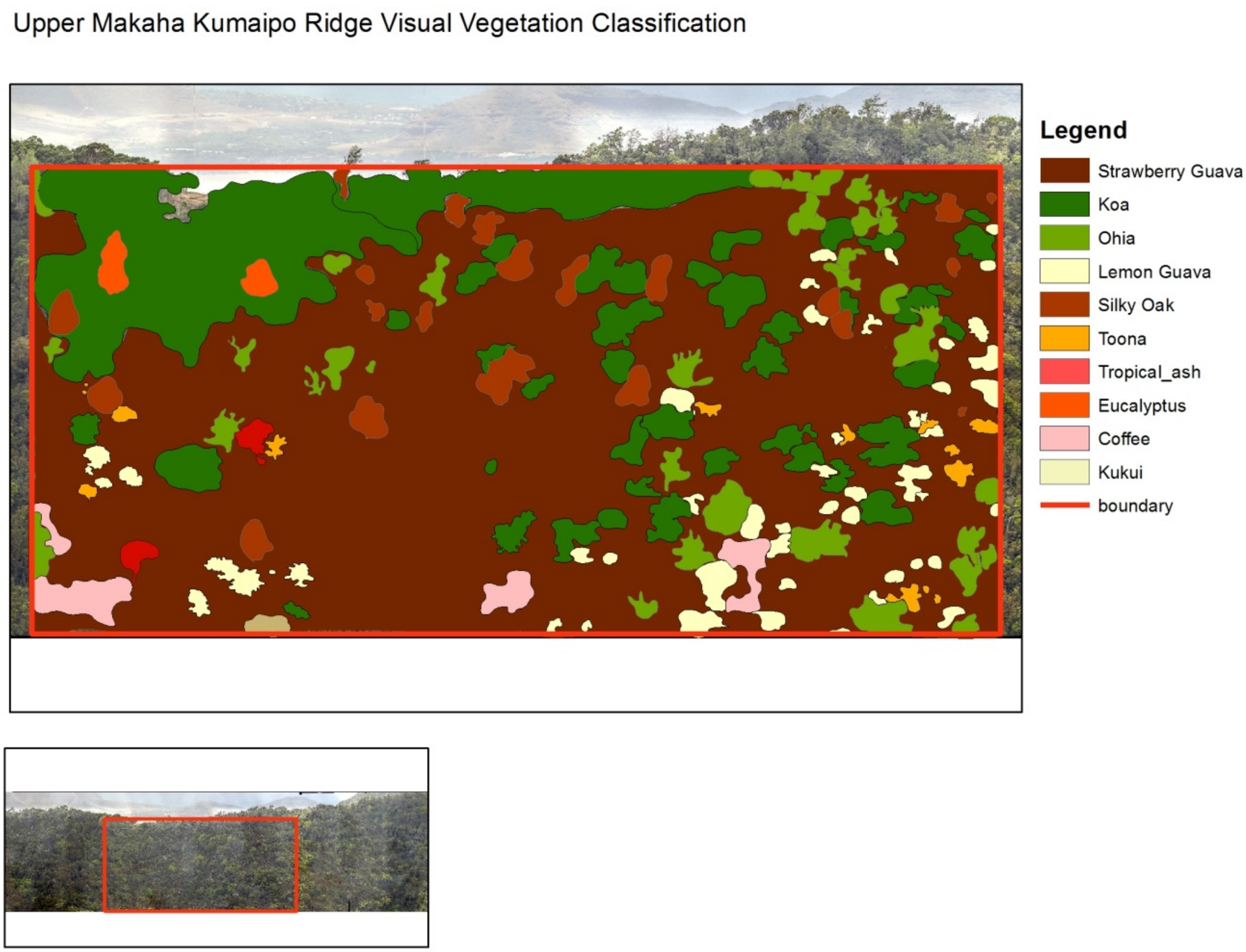


Figure 5. The classification of 10 species by visual classification in ArcMap 10.1

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

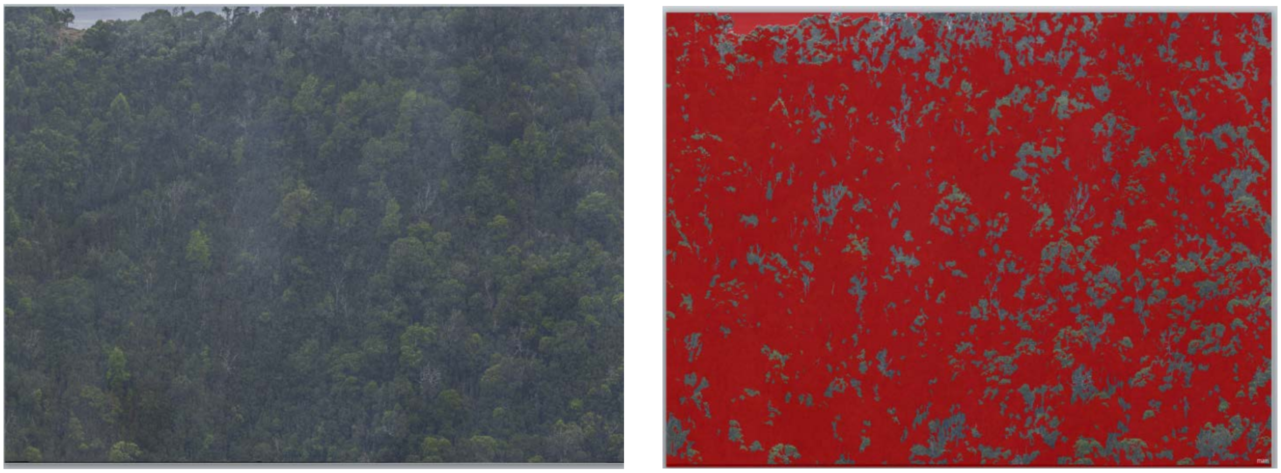


Figure 6. The subset image selected from the panorama for object based classification and the result of the supervised classification process to classify Strawberry Guava in eCognition with Guava as the red color.

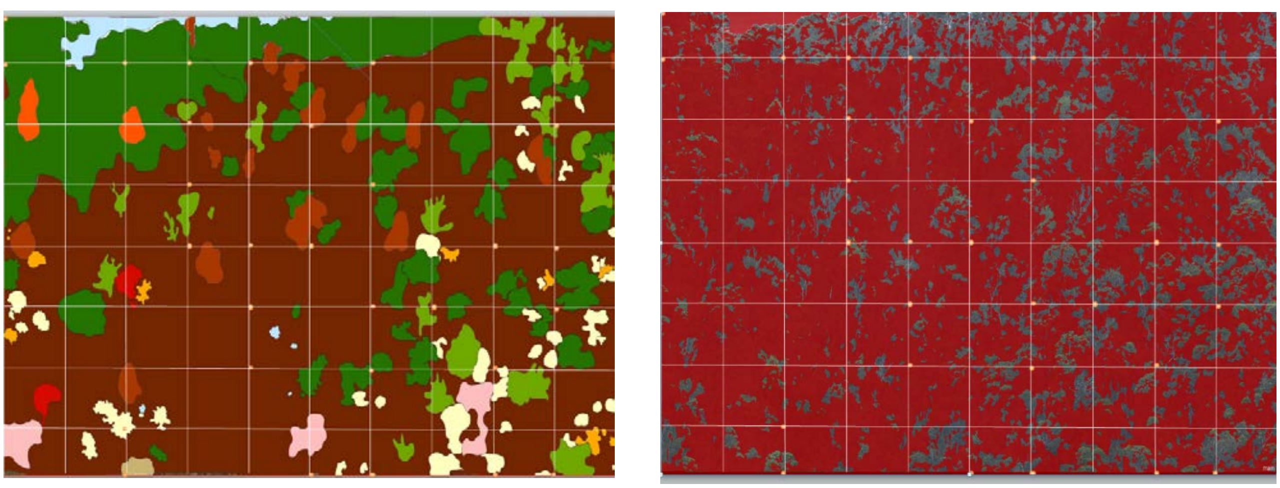


Figure 7. Grid overlay and random points used for the accuracy assessment of the image set

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

Table 2. The accuracy matrix of assessment results.

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

Discussion

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

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

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

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

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

Conclusion

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

References

Ambagis, Stephen., 2015. personal communication

Blaschke, T., 2010. Object based image analysis for remote sensing: ISPRS Journal of Photogrammetry and Remote Sensing, v. 65, p. 2-16

Blaschke, T., Hay, G. J., Kelly, M., Lang, S., Hofmann, P., Addink, E., . . . Tiede, D. 2014. Geographic Object-Based Image Analysis - Towards a new paradigm. Isprs Journal of Photogrammetry and Remote Sensing, 87, 180-191. doi: 10.1016/j.isprsjprs.2013.09.014

Bunting, P., Lucas R., 2006. The delineation of tree crowns in Australian mixed species forest using hyperspectral Compact Airborne Spectrographic Imager (CASI) data. Remote Sensing of Environment (2006) 230–248

Chen, Qi., 2015. personal communication

D'iorio, M., Jupiter, S.D., Cochran, S. and, Potts D.S., 2007. Optimizing Remote Sensing and GIS Tools for Mapping and Managing the Distribution of an Invasive Mangrove (Rhizophora mangle) on South Molokai, Hawaii Marine Geodesy, 30: 125–144

GigaPan Systems LLC customer support personal comm. 2014.

GigaPan Systems User's Manual, 2014.

Hay, G.J., Niemann, K.O., McLean, G., 1996. An Object-Specific Image-Texture Analysis of H-Resolution Forest Imagery. Remote Sensing of Environment 55, 108–122.

Jacobi, J. D., 2015, personal communication

Jacobi, J. D., and Ambagis, Stephen., 2013, Vegetation Map of the Watersheds Between Kawela and Kamalo Gulches, Island of Moloka'I, Hawai'i. p. 1-22

Jacobi, J. D. 2008. Biological Resource Mapping. Pages 200-210 in D. Mueller-Dombois, K. W. Bridges, and C. C. Daehler, editors. Biodiversity Assessment of Tropical Island Ecosystems: PABITRA Manual for Interactive Ecology and Management. Bishop Museum Press, Honolulu, HI.

GigaPan Systems LLC customer support personal comm. 2014

GigaPan Systems User's Manual, 2014

www.gigapan.com, 2013

Gon et al. 2001. Makua Implementation Plan

Makua Implementation Team et al. 2003

Miura, Tomoaki, 2014. Personal Communication.

Oahu Implementation Team et al. 2008. OANRP Year End Report

Oahu Army Natural Resources Program, Makua and Oahu Implementation Plan Status Report. 2010:153-185.

Mimi D'iorio, Stacy D. Jupiter , Susan A. Cochran & Donald C. Potts (2007) Optimizing Remote Sensing and GIS Tools for Mapping and Managing the Distribution of an Invasive Mangrove (Rhizophora mangle) on South Molokai, Hawaii Marine Geodesy, 30: 125–144

Jensen, John. R., 2007. Remote Sensing of the environment: an earth perspective Pierson, Prentice Hall, 2nd edition. Pp. 450-456

Mair, A., Fares, A. and Elkadi, A.I. 2006. Evaluation of the Effect of Groundwater Extraction and Long-Term Weather Patterns on the Kahanahaiki Valley's Streamflow. JAWRA Sustainable Watershed Special Issue, 43(1): 148-159.

Gon, S.O. III. 2003. Think Mauka. In: Stewart, F., Wanger, J., Pope, B. Wao Akua. Division of Forestry and Wildlife, Department of Land and Natural Resources, Honolulu. HI. Pp. 9-10.

Sailer, Daniel, K. 2003. I Ho'ola I Ka Nahele: To heal a forest, a mesic forest restoration guide for Hawaii, The Nature Conservancy of Hawaii. Retrieved from: http://manoa.hawaii.edu/hpicesu/DPW/SAILER_2006/v01-08.pdf.

Bunting, P., Lucas R., 2006. The delineation of tree crowns in Australian mixed species forest using hyperspectral Compact Airborne Spectrographic Imager (CASI) data. Remote Sensing of Environment (2006) 230–248

Rapinel, S., Clement, B., Magnanon, S., Sellin, V., & Hubert-Moy, L. 2014. Identification and mapping of natural vegetation on a coastal site using a Worldview-2 satellite image. Journal of Environmental Management, 144, 236-246. doi: 10.1016/j.jenvman.2014.05.027

Russell G. Congalton, 1991. A Review of Assessing the Accuracy of Classifications of Remotely Sensed Data. Remote Sensing of the Environmnet 37:35-46

Takahashi, M., Giambelluca, T. W., Mudd, R. G., DeLay, J. K., Nullet, M. A. and Asner, G. P. 2011., Rainfall partitioning and cloud water interception in native forest and invaded forest in Hawai'i Volcanoes National Park. Hydrol. Process. 25: 448–464.

Townscape, Inc., 2009. Waianae watershed management plan. Honolulu Board of Water Supply. Retrieved from: http://www.boardofwatersupply.com/cssweb/print.cfm?sid=1614

Suzuki, T. 2006. Spectral separability among invasive and native plant species for satellite image analysis. M.S. Thesis. University of Hawaii at Manoa. p.80.

APPENDIX ES-5: *HYLAEUS ANTHRACINUS* REINTRODUCTION

ES-5.1 BACKGROUND

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

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

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

ES-5.2 METHODS

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

Table 1. Release site characteristics.

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

Map removed to protect rare resources. Available upon request

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

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

ES-5.3 RESULTS

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

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

ES-5.4 CONCLUSIONS

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

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

ES-5.5 REFERENCES

Daly, H.V., Magnacca, K.N., 2003. Insects of Hawaii vol. 17. Hawaiian *Hylaeus (Nesoprosopis)* Bees (Hymenoptera: Apoidea). University of Hawaii Press, Honolulu.

Magnacca, K.N., 2007a. Conservation status of the native bees of Hawaii, *Hylaeus (Nesoprosopis)* (Hymenoptera: Apoidea). Pac. Sci. 61, 173-190.

Magnacca, K.N., 2007b. New records of *Hylaeus (Nesoprosopis)* and *Ceratina* bees in Hawaiʻi. Bishop Mus. Occ. Papers 96, 44–45.

Magnacca, K.N., Brown, M.J.F., 2010. Mitochondrial heteroplasmy and DNA barcoding in Hawaiian *Hylaeus* bees (Hymenoptera: Colletidae). BMC Evolutionary Biology 10, 174.

U.S. Fish and Wildlife Service, 2011. Endangered and threatened wildlife and plants; 12-month finding on five petitions to list seven species of Hawaiian yellow-faced bees as endangered. Fed. Reg. 76, 55170–55203.

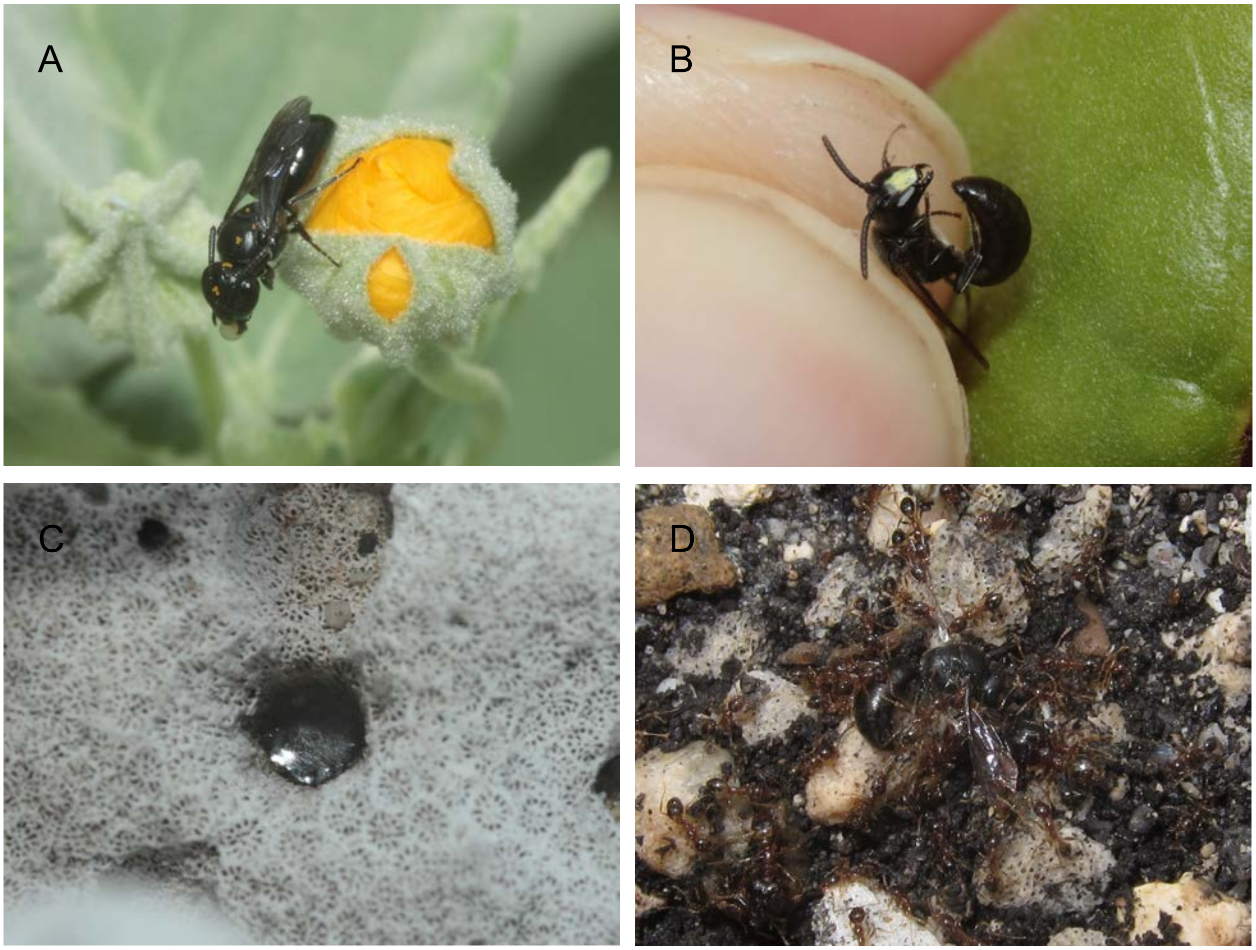


Figure 2. *Hylaeus anthracinus* at Puuhonua O Honaunau NHP. (A) female on *Sida*, concentrating a drop of nectar. (B) Male caught flying around *Scaevola*. (C) Nest entrance in coral rock sealed with cellophane-like secretion. (D) Attacked by *Pheidole megacephala* at the royal grounds site.

APPENDIX ES-6: *MEGALAGRION XANTHOMELAS* CONSERVATION

ES-6.1 BACKGROUND

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

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

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

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

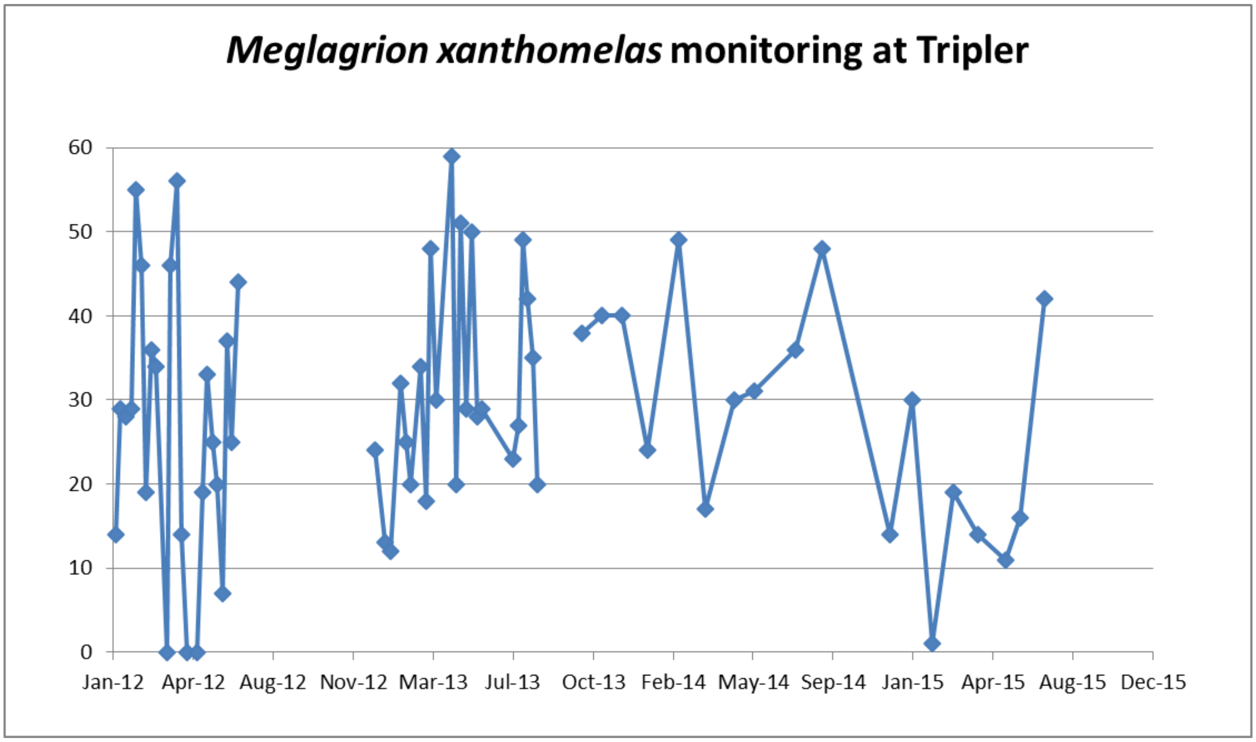


Figure 2. *Megalagrion xanthomelas* observations at TAMC over time.

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

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

ES-6.2 RESULTS

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

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

Map removed to protect rare resources. Available upon request

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

Table 1. Site characteristics.

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

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

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

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

Punanaula spring on the west side of Waianae Valley produces a small permanent stream that flows for a relatively short distance, and has only small wrinkled frogs present. However, it too is likely to be restored to taro production, and the area of available habitat is extremely small. Honua Stream on the east side is much larger but flows through a steep area, resulting in a high flow rate. While no predators were observed, it appears to flow continuously to low elevations so frogs may be present.

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

ES-6.3 CONCLUSIONS

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

The ideal site, where predators are not present or could be eliminated, would be something similar to the pre-disturbance state of the Tripler stream – a spring-fed stream that originates in a relatively dry lowland area, flows a relatively short distance, and then usually dries up before connecting to any permanent water body. It would be extremely surprising if there were no other examples on Oahu, but we have been unable to find any. This may be due in part to the long history of hydrological alteration, including stream diversion and tunnel boring that has lowered perched aquifers.

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

Hawaiian Tree Snail Conservation Laboratory
Pacific Biosciences Research Center

PI: Brenden Holland
Annual Report – October 2015

TREE SNAIL PROPAGATION SUMMARY

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

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

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

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

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

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

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

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

There is a long-standing plan to release a subsample of the total 227 *Achatinella lila* currently housed in the lab, into a recently constructed predator exclusion fence in the central Koolau Mountains at a site called Poamoho. This translocation effort has been delayed due first to climatic conditions leading to complete destruction, due to high wind velocity, of the first steel walled structure. The structure was then completely redesigned and replaced with a wooden version by OANRP staff. Currently the fence structure itself is intake and completed, but the persistence of predatory rodents (rats) in the interior, and uncertainty as to whether rats are able to gain access from outside of the fence has delayed this action.

Chamber temperature calibrations

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

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

New Tree Snail Population Data Entry System

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

HAWAIIAN SNAIL PREDATOR STUDIES

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

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

1.) The first detection of impacts on endemic fauna, including the Oahu tree snail *Achatinella mustelina* (Holland, Costello & Montgomery 2010).

2.) Impact projections, estimates and overall threat assessment via gut content analyses and ingestion frequency (Chiaverano & Holland 2014).

3.) We have characterized movement behavior and establishment of home range in various forest habitats (Chiaverano, Wright & Holland 2014) using radio-transmitter tracking studies in the field.

4.) We discovered consistent, statistically significant differences in head morphology (size) and invertebrate prey utilization among different Hawaiian islands correlated with differences in bite force due to diet differences and rainfall (Van Kleeck, Chiaverano & Holland in press, summarized below).

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

A) Chameleon dissection results:

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

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

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

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

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

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

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

C) Improving Chameleon Detection Methods

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

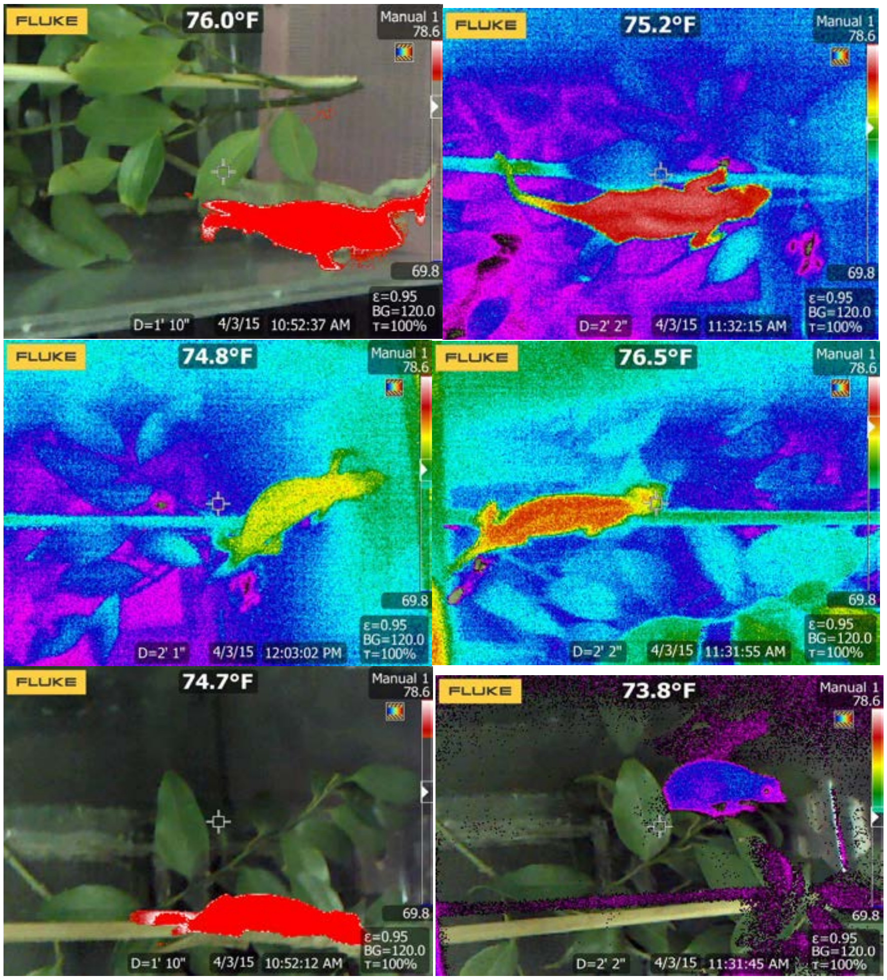


Figure C-1. Thermal images recorded with Fluke technology in the laboratory, when chameleon body temperature differs even by less than one degree from ambient or background temp, this technology is a substantial help in detecting chameleons in the tree. The question we now have is, how frequently does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

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

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

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

Spatial distribution of different environmental factors results in distinct selective pressures on functionally important anatomical characters, such as head size in reptiles. We proposed that, following several dozen generations of reproductive isolation in different environments, head differentiation may be evident among island populations. In order to address this hypothesis we collected morphological data using four size-standardized skull measurements in chameleons from three islands (Hawaii, Maui and Oahu) and tested for correlation among these measurements and environmental factors, such as rainfall and exploited arthropod prey hardness (based on prey type) from gut content data. Our objectives were to 1) quantify the extent of intra-specific skull size variation within and among multiple populations of *T.j. xantholophus* from three islands and 2) conduct and evaluate correlation analyses of morphometric patterns and potential environmental drivers of phenotypic variation in this species.

Results

Head morphology comparison among islands - ANOVA detected no significant differences in SVL among islands (*ANOVA*: $F_{(2,312)} = 0.46$, p= 0.63), but indicated significant differences in PC1 among islands (*ANOVA*: $F_{(2,312)} = 5.7$, p= 0.02). Chameleons from Oahu had significantly smaller heads than those of their counterparts from Hawaii (*Tukey's*, $p < 0.001$), while no significant differences in head size were detected between Maui and other islands (*Tukey's*, $p > 0.05$).

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

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

Relative head size of Jackson's chameleons was significantly smaller at high rainfall locations on Oahu and Maui. Although rainfall is not likely to directly impinge on morphological variation, ecological factors correlated with rainfall, such as resource availability and quality, may drive variation in functional features such as head size, among others. For example, prey type and availability have been shown to vary with precipitation levels, and food abundance has been shown to be higher with higher rainfall in a seasonal tropical ecosystem. Arthropods are the main food source for Jackson's chameleons in the Hawaiian Islands, and these taxa tend to have thickened cuticles in more arid environments to counteract desiccation, while in wetter environments arthropods had thinner cuticles, and softer body types. Higher rainfall has been shown to translate to increased availability of softer prey, requiring relatively lower bite force and smaller predator head size. In fact Measey et al. (2011) showed that Cape dwarf chameleons exhibited a preference for smaller, softer arthropod prey where available.

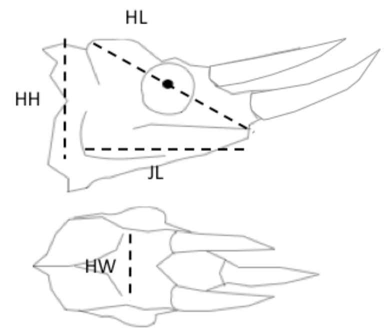


Figure D-1. Dotted lines show measurements recorded from the heads of each individual *T. j. xantholophus*: head length (HL), head height (HH), jaw length (JL) and head width (HW). Male chameleon depicted (three prominent horns shown).

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

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

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

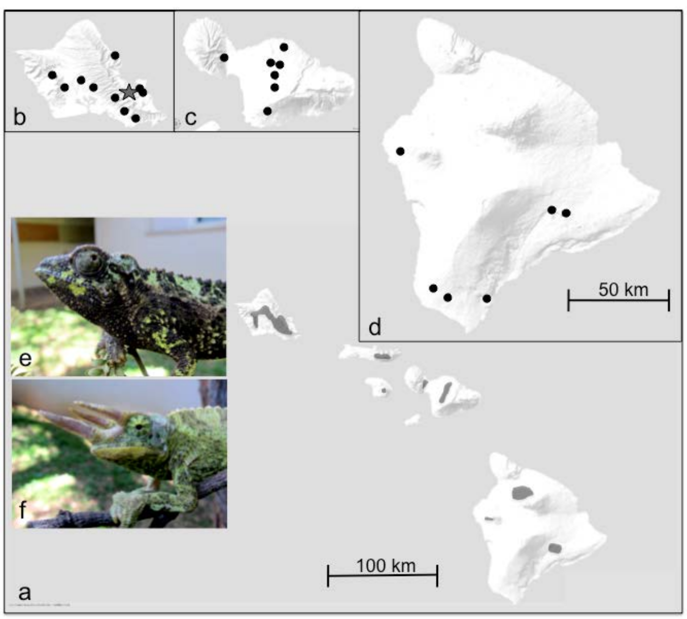


Figure D-2. Distribution of *Trioceros jacksonii xantholophus* in Hawaii, based on museum collections, live specimens captured for this study. a.) Map of known distributions main islands. Collection localities are indicated by black dots on the islands b.) Oahu, c.) Maui, and d.) Hawaii. This species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

(References and reprints available on request)

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

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

Introduction

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

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

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

Methods

Data collection

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

Data analysis

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

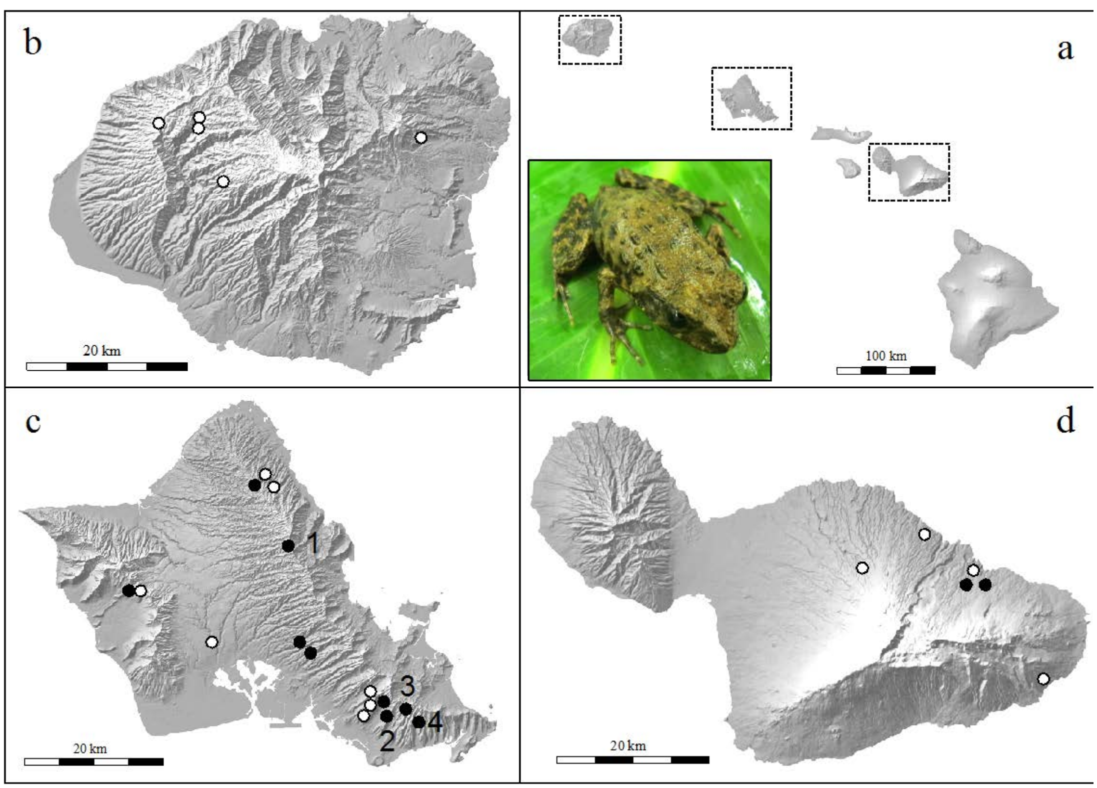


Figure E-1. Map of collection localities; a) Hawaiian Islands, inset photo of *Glandirana rugosa*, b) Kauai, c) Oahu and d) Maui. Closed circles are sites where gut contents were collected, open circles represent collection localities where only size and reproductive data were collected. Numbers (1-4)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

Results

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

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

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

Historical release date and current status, i.e. whether established, eradicated, or unknown, for all herpetofaunal taxa (total 43 species) was compiled and summarized for the Hawaiian Islands (Table E-1). Of the two anuran species that were intentionally released as attempted biocontrol in the late 1800's, *Bufo americanus* and *G. rugosa*, only the wrinkled frog remains, although additional releases of this species are also documented as occurring subsequent to the initial release (Bryan 1932). Total releases by group are 14 species of frogs and toads (Anura), 22 lizards (Squamata), and seven turtles (Testudines). Of the total 43 species released in Hawaii, four are currently of uncertain status, in some cases still periodically observed and occasionally documented but not unambiguously naturalized. A total of 26 herpetofaunal taxa are currently established in the Hawaiian Islands.

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

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

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

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

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

Discussion

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

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

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

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

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

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

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

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

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

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

Impact and threat assessment studies of invasive herpetofaunal species in Hawaii remain few relative to the numerous (26) known established predatory amphibians and reptiles in the islands. Likewise there is a need for additional studies of native and endemic invertebrate diversity, ecosystem services, and changes in areas where new predatory species are established. Studies of declines in native biodiversity are useful, but do not address indirect effects of loss of invertebrate taxa in terms of ecosystem processes such as pollination, leaf litter breakdown, and nutrient cycling. Only once changes in native community structure, alteration of ecosystems and ecology of invasive species are reconciled, can we begin to effectively address the loss of native biodiversity by counteracting the spread and controlling the activity of nonnative lineages. Further in-depth assessment of impacts on endemic ecosystems are warranted to improve our ability to manage and ultimately restore diverse island ecosystems.

Acknowledgements

For help with collection of specimens we thank Vince Costello at the Oahu Army Natural Resource Program. We thank Luc LeBlanc at the University of Hawaii Insect Museum, Thomas Arthur Hooper Smith, University of Hawaii Department of Zoology, and Jesse Eiben University of Hawaii, Hilo, for aid in identification. We also thank the National Parks Service and Molly Hagemann at the Bernice P. Bishop Museum for use of museum collections. Collections were conducted under Hawaii Department of Land and Natural Resources collection Permit #EX 12-22.

(References and reprints available on request)

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

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

Molecular assessment of wild *Achatinella mustelina* diet

Annual Report - September, 2015

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

Status of the Project and Personnel

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

Food Similarity Between Proposed Donor and Enclosure Snail Sites

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

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

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

Snail Food "Farming" for Improved Captive Breeding

Previous work (see Annual Report 2014 and attached manuscript draft) demonstrated that the diet of captive snails differs from that of snails in the wild. We propose an experiment to test whether and how to cultivate preferred snail food on more accessible and convenient host plants and locations. Using a controlled experiment in a growth chamber we plan to assess the extent to which plant identity, community membership, environment and leaf surface pre-treatments enable cultivation of target snail food fungi. Results from this experiment should provide insight into captive breeding programs proposed by SEP and other stake-holders, as well as potential site remediation for future translocations in the field.

Snail Transplant Studies

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

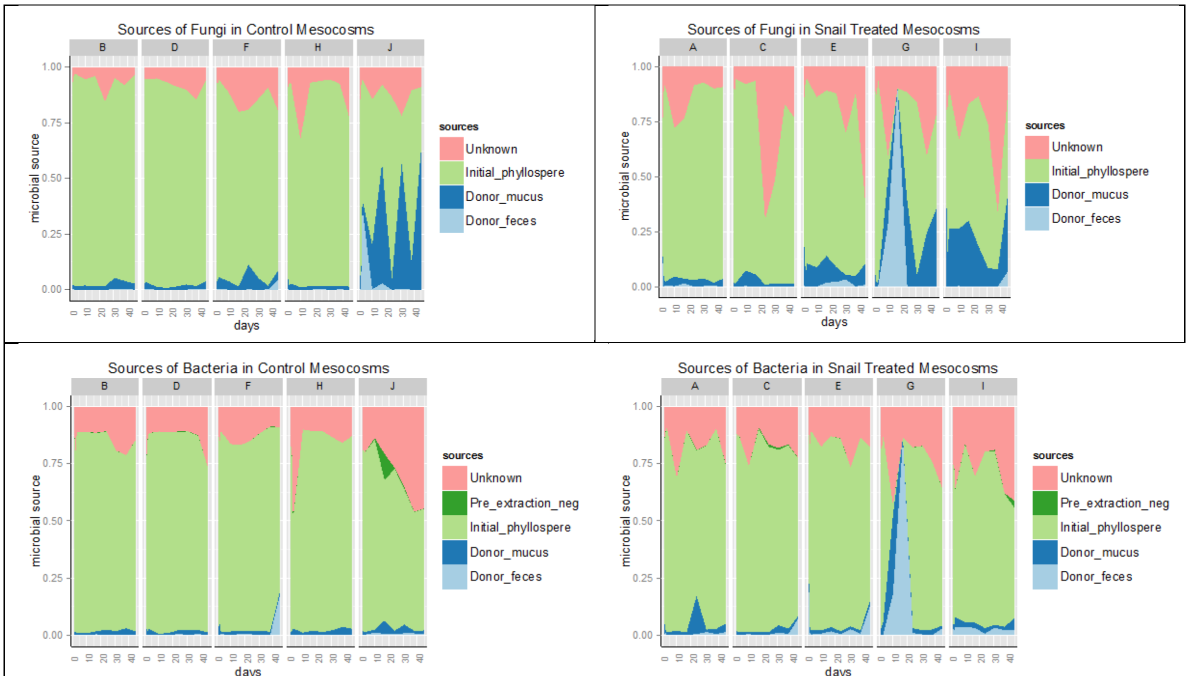


Figure 1. “Source” of microbial community composition on leaves. Clockwise from upper left: Fungal No-Snail, Fungal Snail, Bacteria No-Snail, Bacteria Snail. “Unknown” contribution to community composition is presumed to be aerial deposition from the environment.

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

Results

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

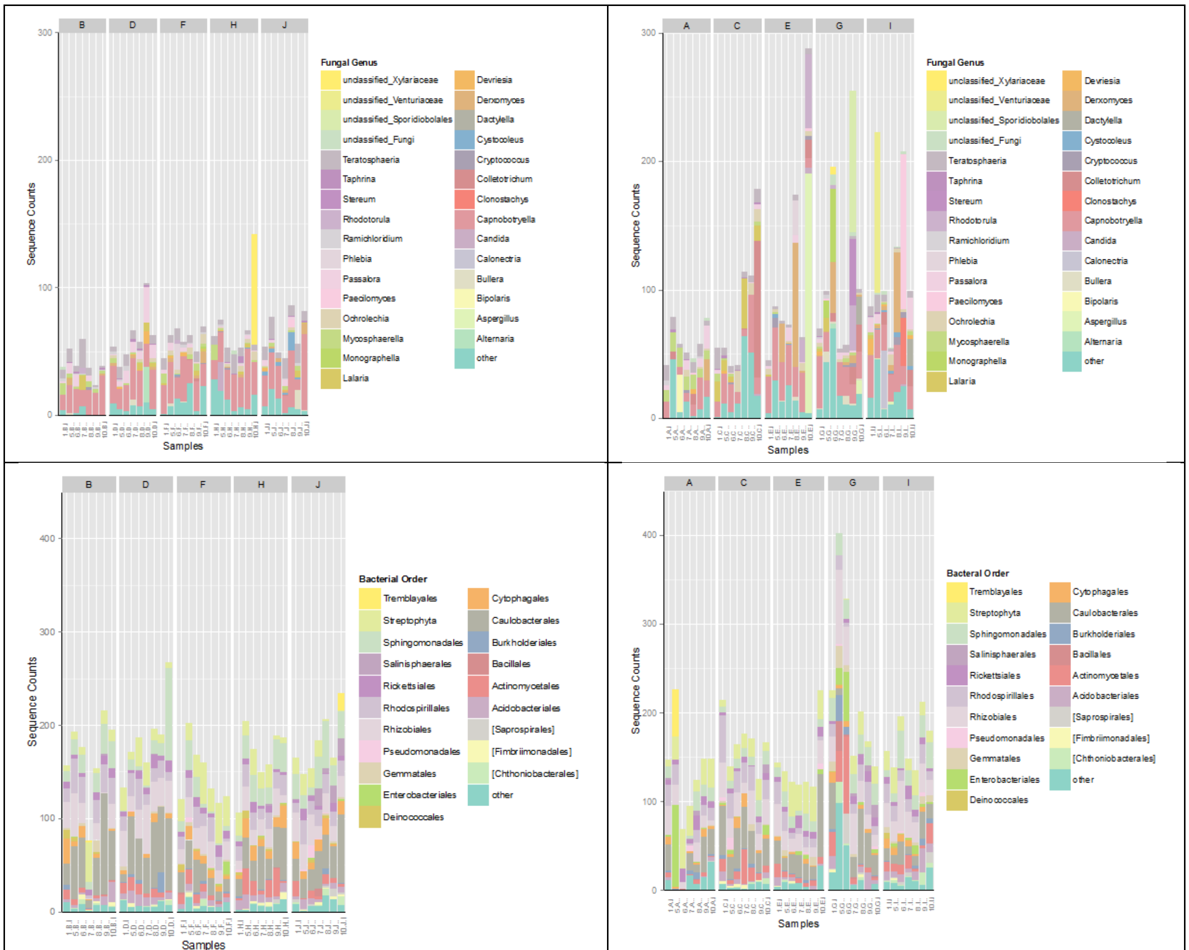


Figure 2. Microbial community composition on leaves. Clockwise from upper left: Fungal No-Snail, Fungal Snail, Bacteria No-Snail, Bacteria Snail. Notice that control leaves (left columns) are much more homogenous than those containing snails (right columns), particularly fungal communities.

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

Significance

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

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

Snail Feeding Trials

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

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

O'Rorke, Holland, Cobian, Gaughen, Amend

Abstract

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

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

Richard O'Rorke[1], Brenden S Holland[2], Gerry M Cobian[1], Kapono Gaughen[1], Anthony S Amend[1]

[1] Department of Botany, University of Hawaii at Manoa, Honolulu, HI 96822, USA
[2] Center for Conservation Research & Training, Pacific Biosciences Research Center, University of Hawaii, Honolulu HI 98822 USA

Abstract

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

Introduction

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

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

To determine whether the *Cladosporium* isolate that is used to supplement the *ex situ* snail diet is a large component of their diet we sequenced fungal DNA from their feces. This also enabled us to determine the degree to which *ex situ* diet overlaps that of the wild populations. We also determined whether snails prefer particular diet items by conducting feeding trials in which isolated fungus and bacteria strains were offered to the tree snail *Auriculella diaphana*. This snail was used as a model for *Achatinella* because although it is of conservation concern, it is more fecund and is not listed as endangered. *Auriculella* are an excellent surrogate for *Achatinella* because they are often sympatric and cohabit the same leaves (Pilsbry et al. 1912) and the dietary remnants in the fecal contents of sympatric *Auriculella* and *Achatinella* are similar, even when sampled almost a year apart (O'Rorke et al. 2014). In addition, both species are members of endemic Hawaiian subfamilies of achatinellid tree snails, the Auriculellinae and the Achaintellinae, which are phylogenetically closely related sister groups (Holland & Hadfield 2004).

Methods

Snails and microbial isolates

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

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

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

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

Determining food preferences of tree snails

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

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

Results

Diversity of the *ex situ* diet

A total of 619,996 high quality DNA sequence reads were obtained from the 1/10th Illumina Miseq run of ITS1-barcoding genes amplified from feces from the HTSCL (NCBI SRA accession XXXXXXXX). The diversity of food items in the *ex situ* facility was 0.700 ± 0.042 (S.E.M) and is significantly lower than that observed in snail feces sampled from the wild 0.914 ± 0.010 (S.E.M) W=747 and $p=9.1 \times 10^{-9}$. Differences were driven by a single OTU: "OTU_1" which dominated the dataset and accounted for 38.6% of the reads (Figure 2A). In comparison OTU_1 accounted for only 1.33% DNA sequence reads of wild snails (Figure 2B). DNA of OTU_1 was 100% identical to the *Cladosporium* species that is used to supplement the diet of snails in culture.

Feeding trials

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

Discussion

Ex situ diet

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

Feeding trials

Despite the superficial appearance that snails are indiscriminant feeders, we found that snails have significant food preferences. This result is similar to the discovery that aquatic snails are selective feeders despite the apparent evidence that they indiscriminately grazed periphyton (Brönmark 1989). Oahu tree snails were long believed to eat fungus. The basis for this determination, however, relied on microscopic analysis of fecal pellets (Pilsbry et al. 1912) in which fungi are more easily observed than smaller microbes. We found that classifying the snails as mycophagous is justified, because snails tended to avoid most bacteria tested. The bacteria, *Micrococcus* and *Microbacterium* were occasionally consumed and can be considered as "not repellent" if not attractive to snails (Figure 3). Both of these isolates are pigmented and belong to clades that do occur in the phyllosphere where pigments act as photo-protectants (Vorholt 2012), so it is plausible that snails do graze on these taxa in the wild. Of the fungi offered to snails, they preferred the dark pigmented *Cladosporium* and *Botryosphaeria*, which are common colonists of leaves (Baker et al. 1979; Denman et al. 2003; van Niekerk et al. 2004), over either the *Cordyceps* or *Annulohypoxylon*. These less preferred fungi are both typical members of a wild fungal assemblage but are not direct colonists of leaf surfaces, as *Cordyceps* are typically invertebrate pathogens and *Annulohypoxylon* are pathogens of fungus. These data therefore suggest that tree snails do have a preference for particular microbes. There is no literature on how tree snails acquire preferences for foods, however studies of other pulmonate molluscs indicate that they can be conditioned to prefer food but also physiologically respond to particular components of food (Sahley et al. 1992; Desbuquois & Daguzan 2004). It is plausible that these particular snails preferred *Cladosporium* and *Botryosphaeria* because they had encountered them before.

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

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

Consuming carbohydrate rich media

A surprising result from the feeding trials was that snails preferred the control “PDA medium only” treatment over any treatment containing a microbial isolate on the PDA (Fig 2). PDA is the medium used to grow the *Cladosporium* food that is used for *ex situ* culture and is a very simple and high calorie medium that contains only potato extract and glucose (i.e., a western “junk food” diet). This suggests that the current method of supplementing the *ex situ* diet with fungus on PDA should be re-evaluated, especially because the cultured fungus comprises such a high percentage of the snail diet (Figure 2). [Here might be a place to mention *Partula* culture, since they are provided with a dietary supplement that is high in carbohydrate.]

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

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

Conclusion

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

Acknowledgements
We are grateful for the assistance of Susan Alford and Leah Tooman in the field and lab. This project was funded through the U.S. Army cooperative agreement W9126G-11-2-0066 with Pacific Cooperative Studies Unit, University of Hawaii through the Pacific International Center for High Technology Research

References

Aebischer, N.J., Robertson, P.A. & Kenward, R.E. (1993). Compositional Analysis of Habitat Use From Animal Radio-Tracking Data. *Ecology*, 74, 1313.

Baker, G.E., Dunn, P.H. & Sakai, W.S. (1979). Fungus communities associated with leaf surfaces of endemic vascular plants in Hawaii. *Mycologia*, 71, 272–292.

Bishop, N.A. & Guarente, L. (2007). Genetic links between diet and lifespan: shared mechanisms from yeast to humans. *Nature Rev Gen*, 8, 835–844.

Brönmark, C. (1989). Interactions between epiphytes, macrophytes and freshwater snails: a review. *Journal of Molluscan Studies*, 55, 299–311.

Calenge, C. (2006). The package "adehabitat" for the R software: A tool for the analysis of space and habitat use by animals. *Ecological Modelling*.

Caporaso, J.G., Kuczynski, J., Stombaugh, J., Bittinger, K., Bushman, F.D., Costello, E.K., Fierer, N., Peña, A.G., Goodrich, J.K., Gordon, J.I., Huttley, G.A., Kelley, S.T., Knights, D., Koenig, J.E., Ley, R.E., Lozupone, C.A., McDonald, D., Muegge, B.D., Pirrung, M., Reeder, J., Sevinsky, J.R., Turnbaugh, P.J., Walters, W.A., Widmann, J., Yatsunenko, T., Zaneveld, J. & Knight, R. (2010). QIIME allows analysis of high-throughput community sequencing data. *Nat Methods*, 7, 335–336.

Caporaso, J. G., Lauber, C. L., Walters, W. A., Berg-Lyons, D., Huntley, J., Fierer, N., et al. (2012). Ultra-high-throughput microbial community analysis on the Illumina HiSeq and MiSeq platforms. *The ISME Journal*, *6*(8), 1621–1624.

Gardes, M., & Bruns, T. D. (1993). ITS primers with enhanced specificity for basidiomycetes--application to the identification of mycorrhizae and rusts. *Molecular Ecology*, *2*(2), 113–118.

Denman, S., Crous, P.W., Groenewald, J.Z.E., Slippers, B., Wingfield, B.D. & Wingfield, M.J. (2003). Circumscription of Botryosphaeria species associated with Proteaceae based on morphology and DNA sequence data. *Mycologia*, 95, 294–307.

Desbuquois, C. & Daguzan, J. (2004). The influence of ingestive conditioning on food choices in the land snail *Helix aspersa* Müller. *Journal of Molluscan Studies Studies*, 61, 353–360.

Edgar, R.C. (2013). UPARSE: highly accurate OTU sequences from microbial amplicon reads. *Nat Methods*, 10, 996–998.

Ewen, J. G., Walker, L., Canessa, S., and Groombridge, J. J. 2014. Improving supplementary feeding in species conservation. Conservation Biology, 29: 341–349.

Gardes, M., & Bruns, T. D. (1993). ITS primers with enhanced specificity for basidiomycetes--application to the identification of mycorrhizae and rusts. *Molecular Ecology*, *2*(2), 113–118.

Guarente, L. & Kenyon, C. (2000). Genetic pathways that regulate ageing in model organisms. *Nature*, 408, 255–262.
Hadfield, M.G., Holland, B.S. & Olival, K.J. (2004). Contributions of ex situ propagation and molecular genetics to conservation of Hawaiian tree snails. In: *Experimental Approaches to Conservation Biology.* University of California Press, Berkeley, pp. 16–34.
Holland, B.S. & Cowie, R.H. (2009). Land snail models in island biogeography: a tale of two snails. *Am. Malacol. Bull.*, 27, 59–68.
Holland, B.S. & Hadfield, M.G. (2004) Origin and diversification of the endemic Hawaiian tree snails (Achatinellinae: Achatinellidae) based on molecular evidence. *Mol. Phylog. Evol.*, 32, 588-600.
Kobayashi, S.R. & Hadfield, M.G. (1996). An experimental study of growth and reproduction in the Hawaiian tree snails *Achatinella mustelina* and *Partulina redfieldii* (Achatinellinae). *Pacific Science*, 50, 339–354.
Manly, B.F., McDonald, L.L., Thomas, D.L., McDonald, T.L. & Erickson, W.P. (2002). *Resource selection by animals*. Second. Kluwer Academic Publishers, New York.
Martínez-Abraín, A., and Oro, D. 2013. Preventing the development of dogmatic approaches in conservation biology: A review. Biological Conservation, 159: 539–547..
Meyer, W.M., Gary, D.T., Yeung, N.W., Dirks, C., Leung, K., Leon, J.A., Ressler, D.T., Curry, P.A. & Hayes, K.A. (2014). Native arboreal land snails in the Mt Kaala Natural Area Reserve, Oahu, Hawaii, have similar plant preferences: implications for conservation. *Journal of Molluscan Studies*, eyu065.
O'Rorke, R., Cobian, G.M., Holland, B.S., Price, M.R., Costello, V. & Amend, A.S. (2014). Dining local: the microbial diet of a snail that grazes microbial communities is geographically structured. *Environ. Microb*.
Pilsbry, H.A., Hyatt, A. & Cooke, C.M. (1912). *Achatinellidae*. The Conchological Department, Academy of Natural sciences, Philadelphia.
Price, M.R., O'Rorke, R., Amend, A.S. & Hadfield, M.G. (*in review*). Characterization of a Snail-Plant-Epiphyte System in Native Hawaiian Forest.
Sahley, C.L., Martin, K.A. & Gelperin, A. (1992). Odors can induce feeding motor responses in the terrestrial mollusc *Limax maximus*. *Behav. Neurosci.*, 106, 563–568.
Savage, R.E. (1931). The relation between the feeding of the herring off the east coast of England and the plankton of the surrounding waters. *Fishery Investigation, Ministry of Agriculture, Food and Fisheries, Series 2*, 1–88.
Smith, D.P. & Peay, K.G. (2014). Sequence depth, not PCR replication, improves ecological inference from next generation DNA sequencing. *PLoS ONE*, 9, e90234.
Soininen, E. M., Ravolainen, V. T., Bråthen, K. A., Yoccoz, N. G., Gielly, L., and Ims, R. A. 2013. Arctic Small Rodents Have Diverse Diets and Flexible Food Selection. PLoS ONE, 8: e68128.
Stamps, J.A. & Swaisgood, R.R. (2007). Someplace like home: experience, habitat selection and conservation biology. *Applied Animal Behaviour Science*, 102, 392–409.
Stanislawski, E. & Becker, W. (1979). Influences of semi-synthetic diets, starvation and infection with *Schistosoma mansoni* (trematoda) on the metabolism of *Biomphalaria glabrata* (gastropoda). *Comp Biochem Physiol A*

Comp Physiol, 63, 527–533.
USFWS (1981) Endangered and threatened wildlife and plants; listing the Hawaiian (Oahu) tree snails of the genus Achatinella as endangered species. [Prepared by the U. S. Department of the Interior, U.S. Fish and Wildlife Service]. Federal Register, 46, 3178–3182.
USFWS (1993). *Recovery Plan. O'ahu Tree Snails of the Genus Achatinella*. U. S. Department of the Interior, U. S. Fish and Wildlife Service, Portland, Oregon.
van Niekerk, J.M., Crous, P.W., Groenewald, J.Z.E., Fourie, P.H. & Halleen, F. (2004). DNA phylogeny, morphology and pathogenicity of Botryosphaeria species on grapevines. *Mycologia*, 96, 781–798.
Vorholt, J.A. (2012). Microbial life in the phyllosphere. *Nat. Rev. Microbiol.*, 10, 828–840.
Zhang, J., Kobert, K., Flouri, T. & Stamatakis, A. (2013). PEAR: a fast and accurate Illumina Paired-End reAd mergeR. *Bioinformatics*, 30, 614–620.

Figures and Tables

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

Table 1

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

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

Table 2

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

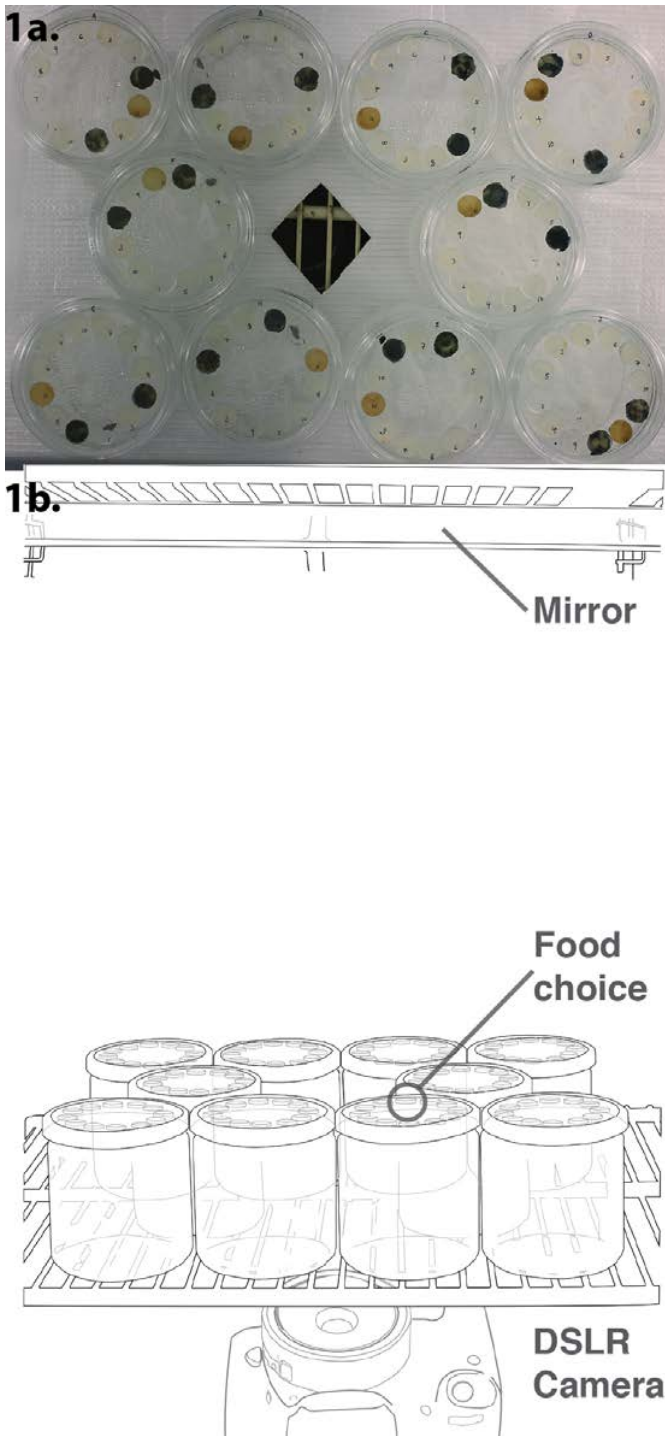


Figure 1. Experimental setup used to determine if snails do have feeding preferences. Snails were fasted for 12 hours and then an individual snail was placed into one of each of ten jars. Twelve different food choices were placed around the perimeter of the underside of the lid of each jar. A digital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

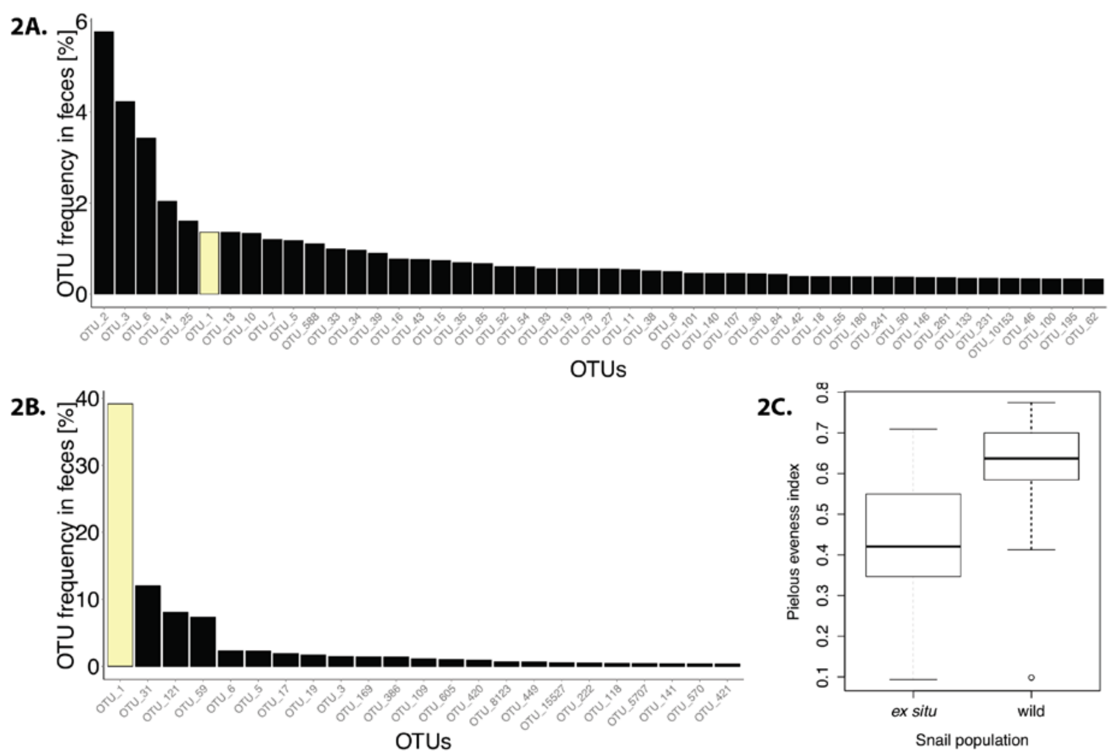


Figure 2. Ranked abundance of fungal OTUs from DNA sequences obtained from feces of a) wild and b) *ex situ* cultured snails and the c) evenness of food composition in diet (note the difference in scale). (2A) Wild populations of *Achatinella mustelina* have a diverse diet with no diet items dominating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

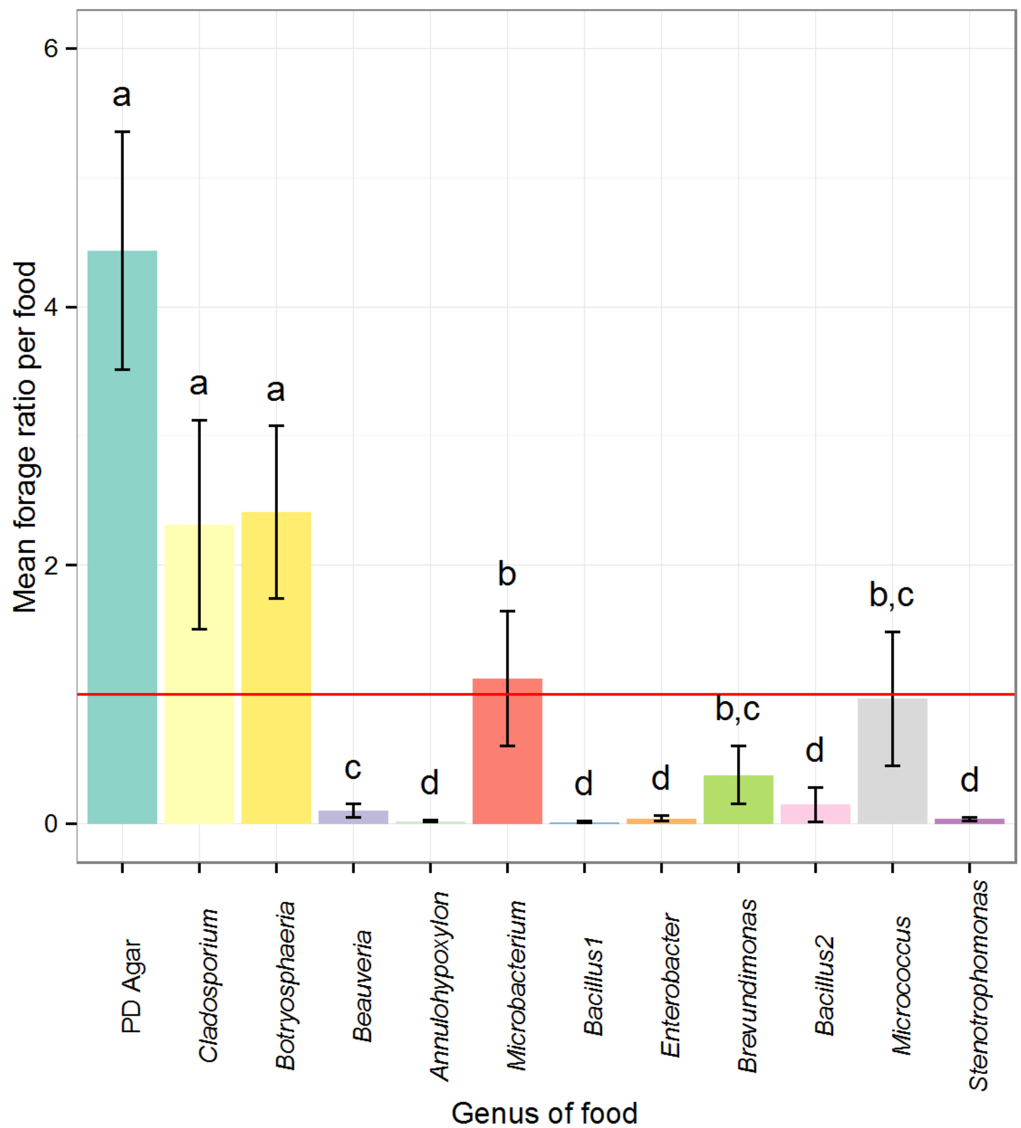


Figure 3. Feeding preferences of snails. A forage ratio above one (the red line) indicates a favored resource and less than one is an avoided item. The "food" offered to snails was an agar only control, then four fungi and the seven samples to the right of the graph are bacteria, Labels above bars are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

OANRP Final Quarter Report, 2015

Dr. Michael Hadfield & Dr. Melissa Price

Adaptive Genetics of Hawaiian Tree Snails & Climate Change

Accomplishments

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

Forecast

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

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

Lalasia Bialic-Murphy[1], Orou G. Gaoue[1,2]

[1] Department of Botany, University of Hawai‘i at Manoa 3190 Maile Way, St. John 101, Honolulu, Hawai‘i 96822, USA; [2] Universite de Parakou, BP 123, Parakou, Benin.

Abstract

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

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

Introduction

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

Tropical islands are biodiversity hotspots and, unfortunately, have some of the highest rates of extinction and species endangerment. For these reasons, tropical island ecosystems are often ranked as high conservation priority (Mittermeier et al. 1998; Myers et al. 2000). The high rates of extinction and species endangerment on islands are due, in part, to the sheer number of localized endemic species (Brigham & Schwartz 2003; Gilpin & Soule 1986; Menges 1990; Shaffer 1981). As a consequence of their limited ranges, island endemic plants are typically adapted to narrow ecological niches (Lesica et al. 2006), making them more sensitive to changing environmental conditions, relative to common widespread species. As a consequence, even small-scale changes in the environmental may have a disproportionally large effect on the population persistence of island plants. Thus, to effectively manage endangered species in an island context, it is critical to understand how changing environmental conditions influence population persistence (Mittermeier et al. 1998; Myers et al. 2000). Surprisingly, the demographic consequence of plant interactions with environmental stressors is rarely studied for localized island endemic species (Krushelnycky et al. 2013; Simmons et al. 2012).

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

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

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

Materials and methods

Study species

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

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

Study site and management history

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

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

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

Demography data and projection matrix model

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

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

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

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

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

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

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

Simulating the effects of microhabitat heterogeneity and frugivory

To simulate the effects of microhabitat heterogeneity and seed consumption by red-billed leiothrix on the dynamics of the *C. dentata* population, we constructed three additional matrices **B**, **C**, and **D** by modifying matrix **A,** discussed above. Frugivory by red-billed leiothrix and the availability of optimal microhabitat impacted the mature to seedling transition φ_m of matrix **A** (see sections: Results, *Microhabitat heterogeneity and frugivory by non-native avifauna)*. Thus, to construct matrix **B**, which captures the removal of frugivory, we increased the φ_m element of matrix **A** by the percentage of fruits consumed by red-billed leiothrix at our field site. To construct matrix **C,** which represents suboptimal microhabitat, we decreased the φ_m element of matrix **B** by the difference in seedling establishment between the optimal and suboptimal microhabitat. Lastly, to construct matrix **D**, which simulates the influence of both stressors (i.e., frugivory and suboptimal microhabitat), we decreased φ_m of matrix **A** by the percent difference in seedling establishment between the optimal and suboptimal microhabitat.

Frugivory by red-billed leiothrix

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

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

Microhabitat heterogeneity

Preliminary observations suggested that *C. dentata* recruit preferentially on rocky outcrops (L. Bialic-Murphy, *unpublished data*). To determine if microhabitat heterogeneity influence vital rates and population dynamics of *C. dentata*, we first classified microhabitats as optimal (i.e., rocky outcrops) and suboptimal (i.e., soil). Then, we collected additional field data to determine the probability of survival, growth, and fertility in these two microhabitats. To quantify potential differences in survival and growth for each life stages by microhabitat, we recorded the rooting substrate for each tagged plants from 2010–2014. To evaluate the effect of microhabitat on seedling establishment, we first quantified the proportion of the study site that was covered by each microhabitat classification by installing ten 1m x 1m quadrats directly underneath randomly selected mature plants. For each quadrat, we recorded the total number of seedlings established and visually estimated the percent cover of rocky outcrops covered by moss and soil. These data were then used to calculate the expected and observed seedling establishment rates by microhabitat. We assumed the percentage of total seedlings that established on each microhabitat classification would be equal to the percent cover by microhabitat, if there were no difference in microhabitat suitability. The difference in the expected and observed establishment rates of seedling by microhabitat were used to create matrices $\mathbf{C}$ and $\mathbf{D}$.

Stochastic long-term population dynamics

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

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

where $\mathbf{X}(t)$ is a random population projection selected at given time *t* from a pool of four yearly matrix transitions (2010–2011, 2011–2012, 2012–2013, and 2013–2014) for the correspondent scenario (**A**, **B**, $\mathbf{C}$, and **D**). The yearly matrices had an equal probability of being selected each iteration. We assumed the time-varying model followed an identically independent distribution (*i.i.d*). For each scenario, we calculated the stochastic growth rate (λ_s) with 95% confidence intervals by simulation using 10,000 iterations, following Tuljapurkar et al. (2003):

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

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

Stochastic short-term population dynamics

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

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

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

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

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

Results

Frugivory by red-billed leiothrix and microhabitat heterogeneity

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

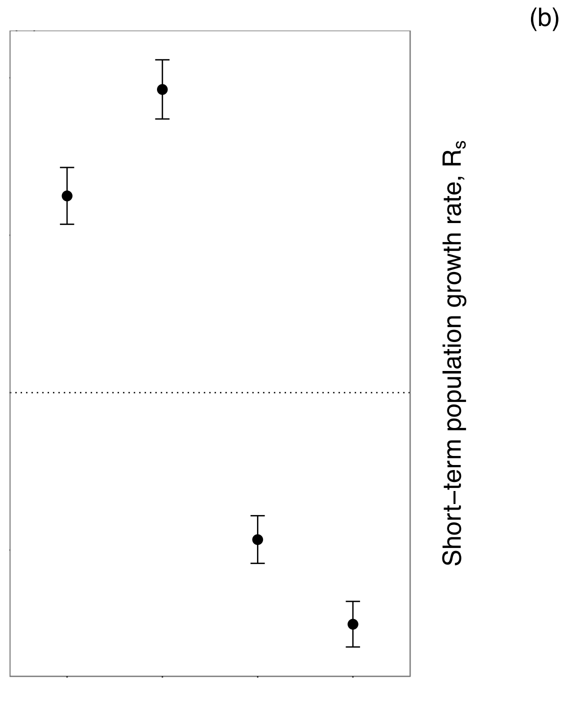


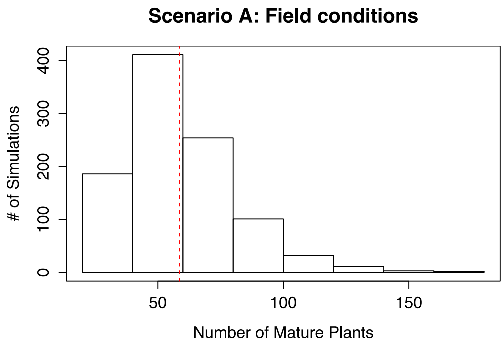
Figure 2: Stochastic short (R_s) and long-term (λ_s) population growth rates of *C. dentata* with 95% confidence intervals. Scenario **A** = Field conditions, **B** = No frugivory, **C** = Suboptimal microhabitat, **D** = Frugivory and suboptimal microhabitat.

Stochastic long-term population growth rates

The stochastic growth rate of the *C. dentata* population, based on field conditions (matrix **A**), was positive (λ_s = 1.032, 95% CI [1.028–1.037]), indicating a moderately growing population in the long-term (Figure 2a). Removal of frugivory by red-billed leiothrix, scenario (**B**), increased the stochastic population growth rate by 1.7% (λ_s = 1.049, 95% CI [1.045–1.055]), relative to scenario **A** (Figure 2a). Under suboptimal microhabitat conditions, scenario (**C**), the population growth rate shifted from positive to negative (λ_s = 0.976, 95% CI [0.971–0.979]). The combined influence of both stressors (scenario **D**) decreased the stochastic population growth rate (λ_s = 0. 963, 95% CI [0.960–0.967]) and led to a declining population trajectory (Figure 2a).

Stochastic short-term population growth rates

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



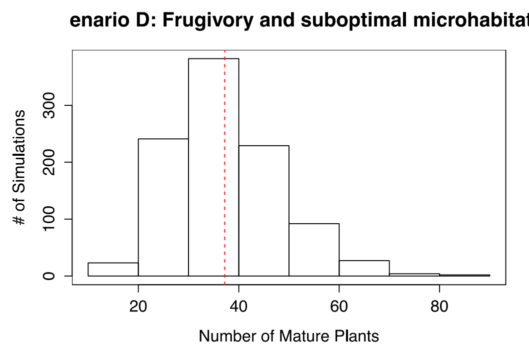


Figure 3: The projected number of mature *C. dentata* plants in 10 years for each scenario (**A, B, C,** and **D)**. Red dash line indicates mean number of mature plants.

Stochastic short and long-term elasticity

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

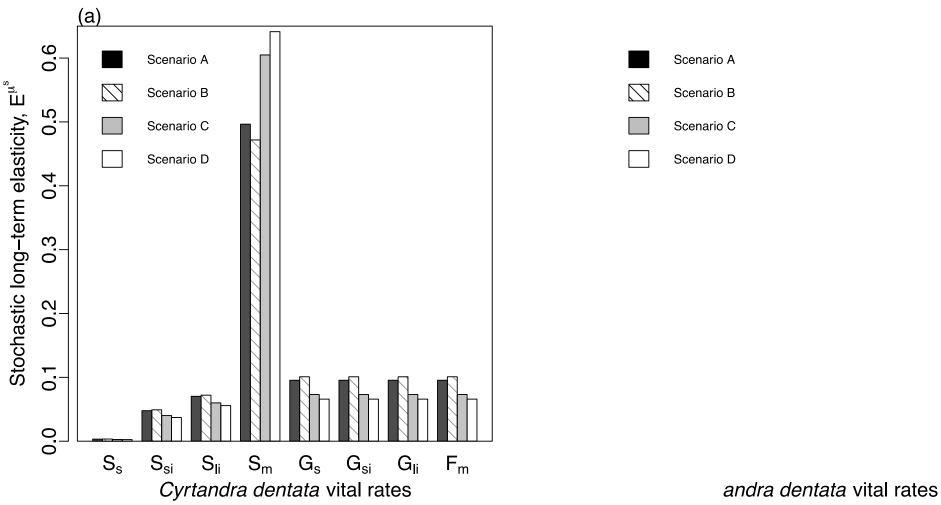


Figure 4: Stochastic elasticities of *C. dentata* (a) long- and (b) short-term growth rates to perturbation of mean vital rates. The vital rates are survival (S), growth (G), and fertility (F) and the life stages are seedling (*s*), small immature (*si*), large immature (*li*), and mature (*m*). Scenario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

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

Discussion

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

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

For long-lived species, it is expected that later life stages will have a larger impact than earlier life stages on the long-term population growth rate (Haridas & Gerber 2010; Silvertown et al. 1993). The importance of later life stages on population dynamics of long-lived species is commonly explained by life history strategy. High survival of mature plants can insulate long-lived species from environmental variability and thus is the most important vital rate for maintaining population persistence in the long-term. However, recent research suggests that long-term elasticity does not always adequately describe the importance of life stages and associated vital rate in the short-term (Haridas & Gerber 2010; Haridas & Tuljapurkar 2007). In some scenarios, earlier life stages disproportionally contributed to the short-term population growth rate of long-lived species, relative to later life stages (Gaoue 2015; Haridas & Gerber 2010; Haridas & Tuljapurkar 2007; McMahon & Metcalf 2008). Consistent with these studies, we also found a shift in the short and long-term elasticity patterns of the *C. dentata* population growth rate to perturbation of vital rates. *Cyrtandra dentata* long-term stochastic elasticity was dominated by the survival of mature plants. However, in the short-term, the establishment of *C. dentata* seedlings had the greatest influence on the population growth rate, followed by the growth of seedlings to the small immature life stage. These results have several management implications for *C. dentata*. First, with high mature plant survival (81% – 97%), there is likely little that can be done to improve that vital rate. However, the importance of mature plants on the long-term population growth rate emphasizes the gravity of maintaining high survival of matures over time. Secondly, management actions that increase seedling establishment would have the greatest positive impact on the population growth rate in the short-term.

Demographic studies tend to focus on population growth rate. However, restoration practitioners often use predefined populations size thresholds to evaluate rare plant recovery and risk of extinction (IUCN 2001; USFWS 1998). Two numerical benchmark goals that have been proposed as general rules of thumb to prevent imminent population extinction are a minimum of 25 matures (Shaffer 1981) and 50 matures (Franklin 1980; Hartl & Clark 1998; Shaffer 1981; Soulé & Wilcox 1980). For *C. dentata*, there was high confidence that the *C. dentata* population would be > 25 mature plants in the short-term (i.e., 10 years). Furthermore, for scenario **A** and **B** there was high confidence that the population would reach a minimum of > 50 in the short-term. Recently, Frankham et al. (2014) proposed a revision of the minimum number of individuals to use as the short-term restoration goal, arguing that >100 reproductive individual is needed to maintain genetic diversity in the short-term. Conversely, other recent studies suggest that the number of matures needed to maintain a population is context specific and there is no general rule of thumb (Brook et al. 2006; Traill et al. 2007).

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

Literature cited

Alvarez-Buylla, E., R. Garcia-Barrios, C. Lara-Moreno, and M. Martínez-Ramos. 1996. Demographic and genetic models in conservation biology: applications and perspectives for tropical rain forest tree species. Annual Review of Ecology and Systematics:387-421.

Brigham, C. A., and M. W. Schwartz 2003. Population viability in plants: conservation, management, and modeling of rare plants. Springer.

Brook, B. W., L. W. Traill, and C. J. Bradshaw. 2006. Minimum viable population sizes and global extinction risk are unrelated. Ecol Lett **9**:375-382.

Brys, R., H. Jacquemyn, P. Endels, G. De Blust, and M. Hermy. 2005. Effect of habitat deterioration on population dynamics and extinction risks in a previously common perennial. Conservation Biology **19**:1633-1643.

Busby, P. E., P. Vitousek, and R. Dirzo. 2010. Prevalence of tree regeneration by sprouting and seeding along a rainfall gradient in Hawai'i. Biotropica **42**:80-86.

Caswell, H. 2001. Matrix population models: construction, analysis, and interpretation, 2001. Sinauer, Sunderland.

Cole, R. J., C. M. Litton, M. J. Koontz, and R. K. Loh. 2012. Vegetation Recovery 16 Years after Feral Pig Removal from a Wet Hawaiian Forest. Biotropica **44**:463-471.

Colling, G., and D. Matthies. 2006. Effects of habitat deterioration on population dynamics and extinction risk of an endangered, long ‐ lived perennial herb (Scorzonera humilis). Journal of Ecology **94**:959-972.

Crone, E. E., E. S. Menges, M. M. Ellis, T. Bell, P. Bierzychudek, J. Ehrlen, T. N. Kaye, T. M. Knight, P. Lesica, W. F. Morris, G. Oostermeijer, P. F. Quintana-Ascencio, A. Stanley, T. Ticktin, T. Valverde, and J. L. Williams. 2011. How do plant ecologists use matrix population models? Ecol Lett **14**:1-8.

Dahlgren, J. P., and J. Ehrlén. 2009. Linking environmental variation to population dynamics of a forest herb. Journal of Ecology **97**:666-674.

Denslow, J. S. 1980. Gap partitioning among tropical rainforest trees. Biotropica.

Dostálek, T., and Z. Münzbergová. 2013. Comparative population biology of critically endangered Dracocephalum austriacum (Lamiaceae) in two distant regions. Folia Geobotanica **48**:75-93.

Ellis, M. M., C. W. Weekley, and E. S. Menges. 2007. Evaluating stability in Ziziphus celata.

Eriksson, O., and J. Ehrlen. 1992. Seed and microsite limitation of recruitment in plant-populations Oecologia **91**:360-364.

Fetcher, N., B. R. Strain, and S. F. Oberbauer. 1983. Effects of light regime on the growth, leaf morphology, and water relations of seedlings of two species of tropical trees. Oecologia **58**:314-319.

Frankham, R., C. J. Bradshaw, and B. W. Brook. 2014. Genetics in conservation management: revised recommendations for the 50/500 rules, Red List criteria and population viability analyses. Biological Conservation **170**:56-63.

Franklin, I. R. 1980. Evolutionary change in small populations. Conservation biology: an evolutionary-ecological perspective:135-149.

Gaoue, O. G. 2015. Transient dynamics reveal the importance of early life survival to the response of a tropical plant to harvest. Journal of Applied Ecology.

García, M. B. 2003. Demographic viability of a relict population of the critically endangered plant Borderea chouardii. Conservation Biology **17**:1672-1680.

Gillespie, R. G., and D. A. Clague 2009. Encyclopedia of islands. Univ of California Press.

Gilpin, M. E., and M. E. Soule 1986. Minimum viable population: Processes of species extinction. Sinauer Associates, Inc, Sunderland, Massachusetts.

Godínez-Alvarez, H., and P. Jordano. 2007. An empirical approach to analysing the demographic consequences of seed dispersal by frugivores. Seed dispersal: theory and its application in a changing world:391-406.

Godínez-Alvarez, H., A. Valiente-Banuet, and A. Rojas-Martínez. 2002. The role of seed dispersers in the population dynamics of the columnar cactus Neobuxbaumia tetetzo. Ecology **83**:2617-2629.

Haridas, C. V., and L. R. Gerber. 2010. Short-and long-term population response to changes in vital rates: implications for population viability analysis. Ecological Applications **20**:783-788.

Haridas, C. V., and S. Tuljapurkar. 2007. Time, transients and elasticity. Ecology Letters **10**:1143-1153.

Harper, J. L. 1977. Population biology of plants. Population biology of plants.

Hartl, D. L., and A. G. Clark. 1998. Principles of population genetics.

IUCN 2001. IUCN Red List Categories and Criteria. IUCN.

Kellner, J. R., G. P. Asner, K. M. Kinney, S. R. Loarie, D. E. Knapp, T. Kennedy-Bowdoin, E. J. Questad, S. Cordell, and J. M. Thaxton. 2011. Remote analysis of biological invasion and the impact of enemy release. Ecological Applications **21**:2094-2104.

Krushelnycky, P. D., L. L. Loope, T. W. Giambelluca, F. Starr, K. Starr, D. R. Drake, A. D. Taylor, and R. H. Robichaux. 2013. Climate ‐ associated population declines reverse recovery and threaten future of an iconic high ‐ elevation plant. Global change biology **19**:911-922.

Loayza, A. P., and T. Knight. 2010. Seed dispersal by pulp consumers, not “legitimate” seed dispersers, increases Guettarda viburnoides population growth. Ecology **91**:2684-2695.

Loh, R. K., and J. T. Tunison. 1999. Vegetation recovery following pig removal in'Ola'a-Koa Rainforest Unit, Hawaii Volcanoes National Park.

Male, T. D., S. G. Fancy, and C. J. Ralph 1998. Red-billed leiothrix. Birds of North America, Incorporated.

Marrero-Gómez, M. V., J. G. B. Oostermeijer, E. Carqué-Álamo, and Á. Bañares-Baudet. 2007. Population viability of the narrow endemic Helianthemum juliae (CISTACEAE) in relation to climate variability. Biological conservation **136**:552-562.

McMahon, S. M., and C. J. E. Metcalf. 2008. Transient sensitivities of non-indigenous shrub species indicate complicated invasion dynamics. Biological Invasions **10**:833-846.

Menges, E. S. 1990. Population viability analysis for an endangered plant. Conservation biology **4**:52-62.

Menges, E. S. 2000. Applications of population viability analyses in plant conservation. Ecological Bulletins:73-84.

Meyer, J.-Y., and J.-F. Butaud. 2009. The impacts of rats on the endangered native flora of French Polynesia (Pacific Islands): drivers of plant extinction or coup de grâce species? Biological Invasions **11**:1569-1585.

Minden, V., J. Jacobi, S. Porembski, and H. Boehmer. 2010. Effects of invasive alien kahili ginger (Hedychium gardnerianum) on native plant species regeneration in a Hawaiian rainforest. Applied Vegetation Science **13**:5-14.

Mittermeier, R. A., N. Myers, J. B. Thomsen, G. A. Da Fonseca, and S. Olivieri. 1998. Biodiversity hotspots and major tropical wilderness areas: approaches to setting conservation priorities. Conservation biology **12**:516-520.

Morris, W. F., P. L. Bloch, B. R. Hudgens, L. C. Moyle, and J. R. Stinchcombe. 2002. Population viability analysis in endangered species recovery plans: past use and future improvements. Ecological Applications **12**:708-712.

Morris, W. F., and D. F. Doak 2002. Quantitative conservation biology. Sinauer Associates Sunderland, Massachusetts, USA.

Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. Da Fonseca, and J. Kent. 2000. Biodiversity hotspots for conservation priorities. Nature **403**:853-858.

OANRP. 2009. Status reprot for the Makua and Oahu Implementation Plans. Pacific Cooperative Studies Unit, Honolulu, Hawaii.

Ostertag, R., S. Cordell, J. Michaud, T. C. Cole, J. R. Schulten, K. M. Publico, and J. H. Enoka. 2009. Ecosystem and restoration consequences of invasive woody species removal in Hawaiian lowland wet forest. Ecosystems **12**:503-515.

Pender, R. J., A. B. Shiels, L. Bialic-Murphy, and S. M. Mosher. 2013. Large-scale rodent control reduces pre-and post-dispersal seed predation of the endangered Hawaiian lobeliad, Cyanea superba subsp. superba (Campanulaceae). Biological invasions **15**:213-223.

Ren, H., Q. Zhang, Z. Wang, Q. Guo, J. Wang, N. Liu, and K. Liang. 2010. Community ecology knowledge for conservation through possible re-introduction: a case study of a rare plant Primulina tabacum Hance in China. Plant Species Biol **25**:43-50.

Shaffer, M. L. 1981. Minimum population sizes for species conservation. BioScience **31**:131-134.

Shiels, A. B., and D. R. Drake. 2011. Are introduced rats (Rattus rattus) both seed predators and dispersers in Hawaii? Biological Invasions **13**:883-894.

Silvertown, J., M. Franco, I. Pisanty, and A. Mendoza. 1993. Comparative plant demography--relative importance of life-cycle components to the finite rate of increase in woody and herbaceous perennials. Journal of Ecology **81**:465-476.

Simmons, C. L., T. D. Auld, I. Hutton, W. J. Baker, and A. Shapcott. 2012. Will climate change, genetic and demographic variation or rat predation pose the greatest risk for persistence of an altitudinally distributed island endemic? Biology **1**:736-765.

Soulé, M. E., and B. Wilcox 1980. Conservation biology: an evolutionary ecological perspectives. Sinauer Associates.

Souther, S., and J. B. McGraw. 2014. Synergistic effects of climate change and harvest on extinction risk of American ginseng. Ecological Applications.

Traill, L. W., C. J. Bradshaw, and B. W. Brook. 2007. Minimum viable population size: a meta-analysis of 30 years of published estimates. Biological conservation **139**:159-166.

Tuljapurkar, S., C. C. Horvitz, and J. B. Pascarella. 2003. The many growth rates and elasticities of populations in random environments. The American Naturalist **162**:489-502.

USFWS. 1998. Recovery Plan for Oahu Plants in U. S. F. a. W. Service, editor, Portland, OR.

USFWS. 2012. Endangered species http://www.fws.gov/pacificislands/species.html, Portland, OR.

Vitousek, P. M. 1996. Biological invasions and ecosystem processes: towards an integration of population biology and ecosystem studies. Pages 183-191. Ecosystem Management. Springer.

Wilcove, D. S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. 1998. Quantifying threats to imperiled species in the United States. BioScience:607-615.

OAHU ARMY NATURAL RESOURCES PROGRAM
MONITORING PROGRAM

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

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

Introduction

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

Methods

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

Map removed to protect rare resources. Available upon request

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

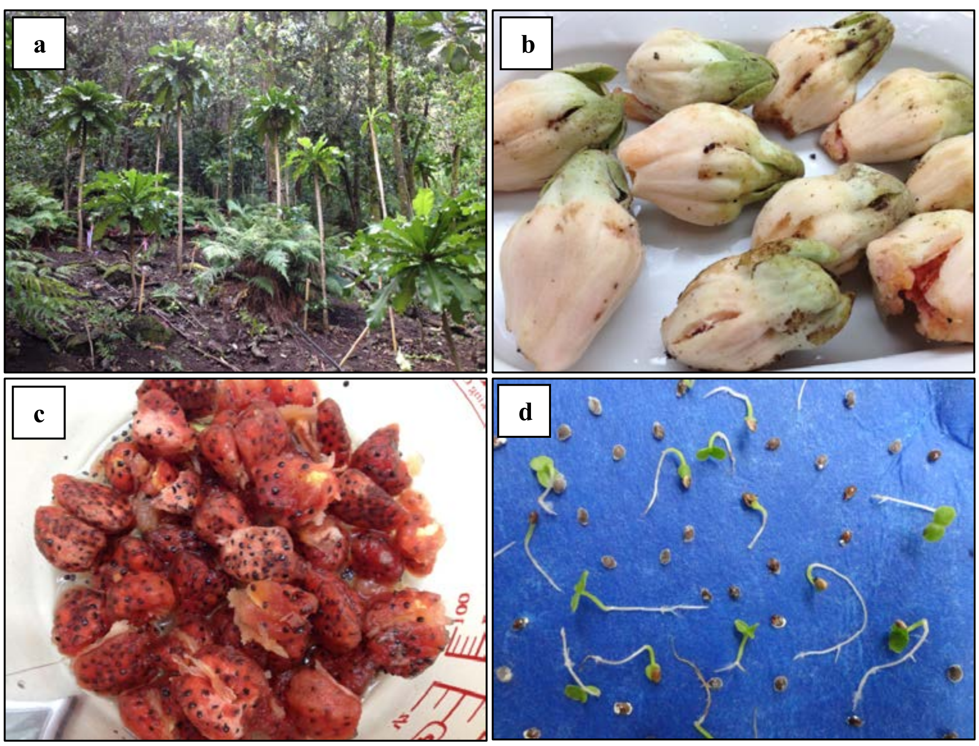


Figure 2. *Cyanea superba* subsp. *superba*. a) fruiting plants at the Makaha reintroduction site, b) fresh mature fruit, c) seeds embedded in fruit pulp, and d) seeds germinating on filter paper.

Results and Discussion

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

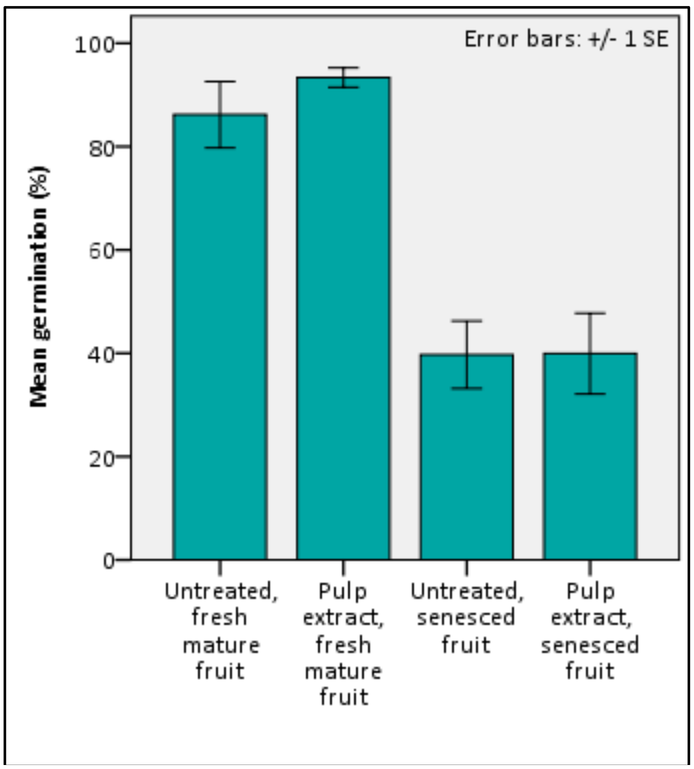


Figure 3. Seed viability from senesced and fresh mature fruits, with and without fruit pulp extract ($n = 10$).

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

The results of this laboratory trial may help partially explain some of the population dynamics observed at reintroduction sites. The limited recruitment observed at Kahanahaiki (despite large numbers of mature plants, extensive rat control, and prolific production of viable seed), may be influenced by a lack of dispersers. Recruitment at this location is primarily located below mature plants. Fruit that is not predated by rats is likely senescing, falling to the ground and having little to no recruitment. By comparison, at Palikea, recruitment occurs distant from the few mature plants present. This area has a more diverse avifauna, which may be effectively dispersing seeds.

Future Directions

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

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

References

Pender, R. J., A. B. Shiels, L. Bialic-Murphy, S. M. Mosher. 2013. Large-scale rodent control reduces pre- and post-dispersal seed predation of the endangered Hawaiian lobeliad, *Cyanea superba* subsp. *superba* (Campanulaceae). Biological Invasions 15:213-223.

Oahu Army Natural Resources Program. 2015a. Oahu Army Natural Resources Program Rare Plant Database.

-----. 2015b. Oahu Army Natural Resources Program Seedbank Database.

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

Annual Statement of Work, September 2015

Dr. Paul Krushelnycky
Dept. of Plant and Environmental Protection Sciences
University of Hawaii
3050 Maile Way, Gilmore 310
Honolulu, HI 96822
Phone: 808-956-8261
Email: pauldk@hawaii.edu

Background

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

FY15 progress

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

Results to date

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

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

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

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

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

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

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

Future plans

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

Appendix ES-12

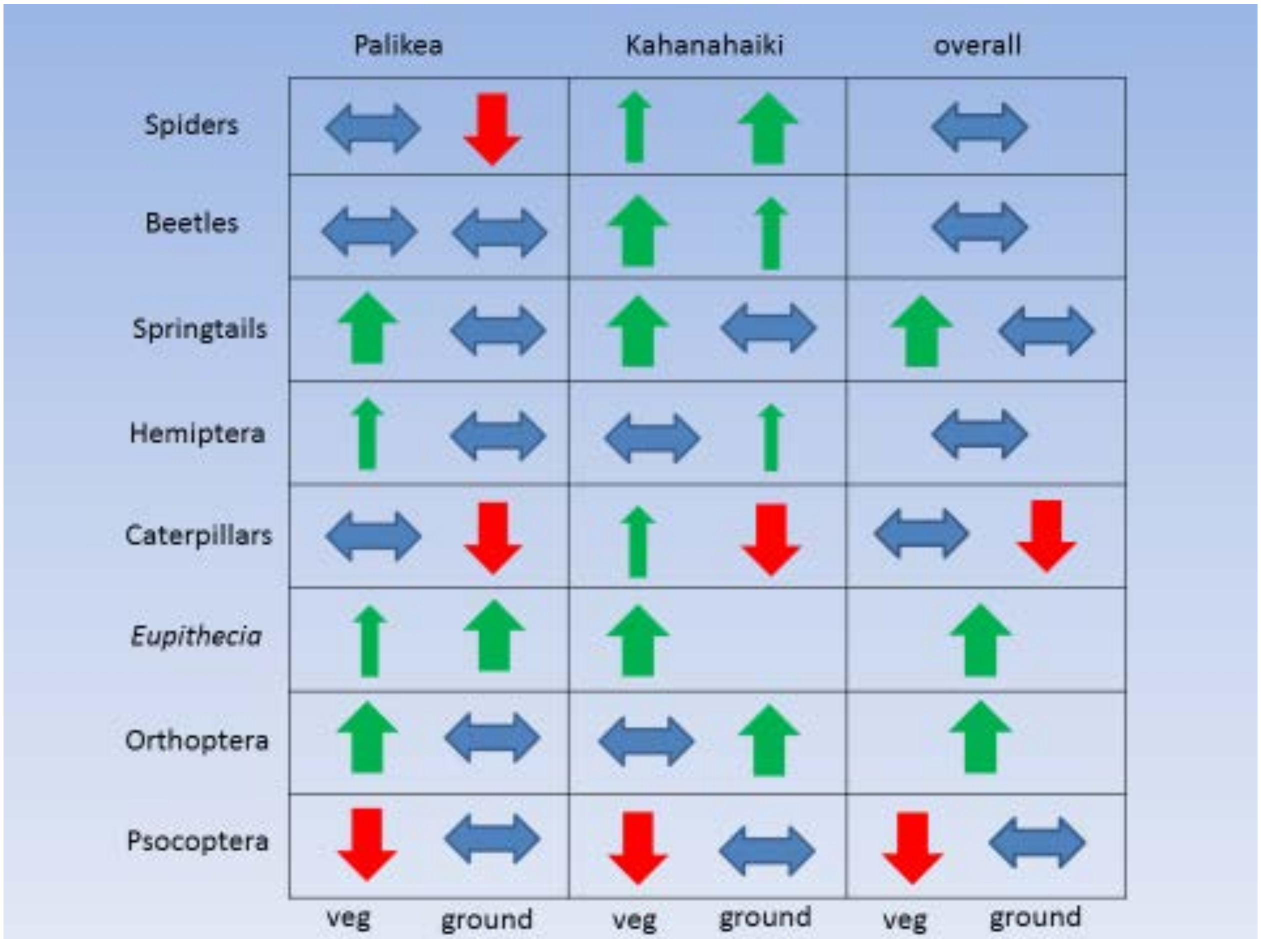


Figure 1. Summary of changes in abundance in rodent-trapping areas relative to adjacent untrapped areas at each site, for select arthropod groups. Taxonomic groups not shown exhibited less consistent changes in abundance. Green arrows indicate general trends of increases in abundance after trapping,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

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

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

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

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

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

Summary of progress on Mycorrhiza project

PIs: Prof. Nicole Hynson and Postdoc Jeremy Hayward

Summary

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

Progress

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

Summary of Results

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

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

Outlook

Our results suggest that restoration of plant communities may benefit from increasing AMF richness at outplanting sites. We suggest that one means of accomplishing this may be to pre-inoculate greenhouse-grown seedlings destined for outplanting with AMF prior to introducing them into the field.

Appendix 1: Methodological details.

Field methods

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

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

Molecular methods

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

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

Appendix 2: Detailed results and analyses

We identified our 182 AMF species as belonging to three orders and seven families. Considering presence/absence data, AM fungal communities in our sampled plots do not vary significantly with invaded/uninvaded status when stratified by sampling region (Kahanahaiki, Manuwai and Palikea, P=.71) in a permutation-based ANOVA (ADONIS test, 10000 permutations). The overwhelming majority of OTUs (158 of 182 total) were detected at least once in both native-dominated and invaded habitats. However, AM fungal communities in our plots do very significantly by sampling region (ADONIS, R^2=.28, P<.001). Considering only contrasts within individual watersheds, invaded/uninvaded status does not predict the composition of plot community composition, considering either individual OTUs or AMF families (P-values all > 0.5). Indicator species analysis suggests that none of the 182 OTUs detected in this study possess significant indicator value for either native-dominated or invaded plots (minimum P-value =0.056).

To test differences in species richness (as opposed to species identities or community composition) with invaded / uninvaded status of our plots, we implemented Bayesian regression models relating the area sampled to richness in those areas. These models allowed us to leverage the statistical power of linear modeling and to extrapolate richnesses between sampled spatial scales. We implemented these models in the Bayesian modeling language JAGS. These models suggest lower richness in invaded plots than uninvaded plots (P = .007).

Appendix 3: Locations of our plots

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

ASSESSMENT OF EFFECTS OF SOLENOPSIS PAPUANA ON ARTHROPODS IN OAHU FORESTS

Annual Statement of Work, September 2015

Dr. Paul Krushelnycky
Dept. of Plant and Environmental Protection Sciences
University of Hawaii
3050 Maile Way, Gilmore 310
Honolulu, HI 96822
Phone: 808-956-8261
Fax: 808-956-2428
Email: pauldk@hawaii.edu

Background

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

FY15 progress and results

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

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

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

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

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

Initial tests of pesticidal bait efficacy indicated that of the two most attractive baits, Siesta was relatively ineffective in controlling *S. papuana*, most likely because of the bait's rapid activity: large numbers of dead ants were typically found in Siesta bait stations within a few hours, which may limit sharing of the bait throughout *S. papuana* colonies. In contrast, Amdro was found to be effective both when broadcast and when presented within bait stations. This result is now being tested more formally in a series of replicated plots at Pahole NAR, in which efficacy of Amdro is being compared with Siesta. Per HDOA consultation, these tests do not exceed the minimum area threshold that necessitates an Experimental Use Permit. So far, after one month, Amdro bait has resulted in substantially greater reduction in ant numbers compared to Siesta (Figure 1). The initial bait efficacy tests also provided important information on the spatial scale of control. The range of effectiveness of baits (Amdro) for suppressing *S. papuana* appears to be only approximately 1-2 meters, whether Amdro is broadcast or presented in stations. This is again likely due to the short foraging range and generally low level of activity in this species.

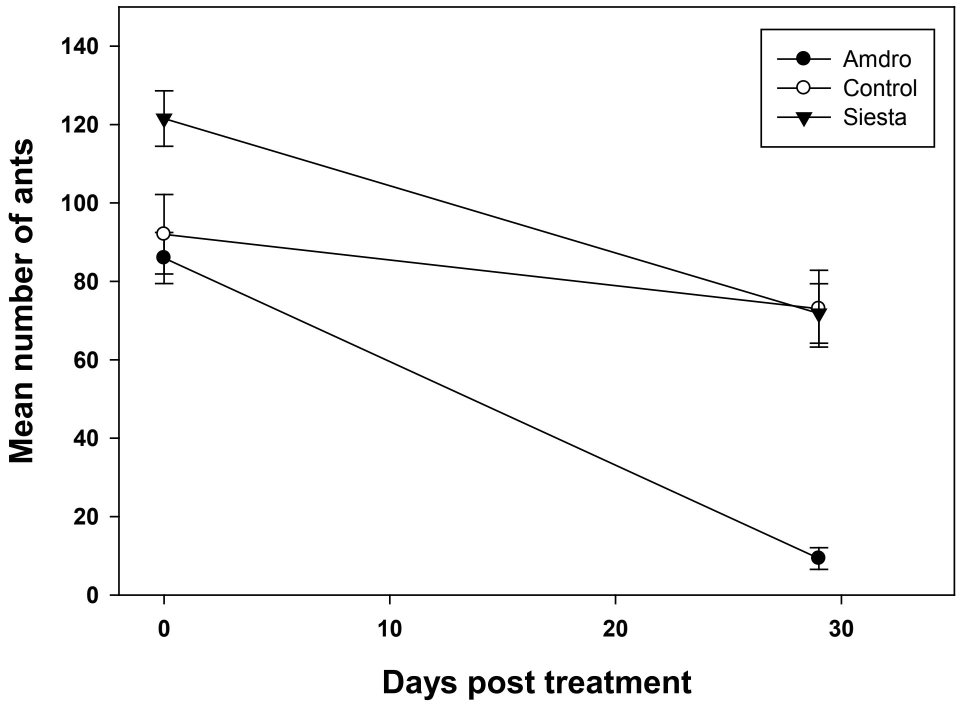


Figure 1. Mean number of ants at peanut butter baits cards in plots treated with Amdro ant bait, Siesta ant bait, and no ant bait (control), after approximately one month. Each treatment group replicated with three plots at Pahole NAR.

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

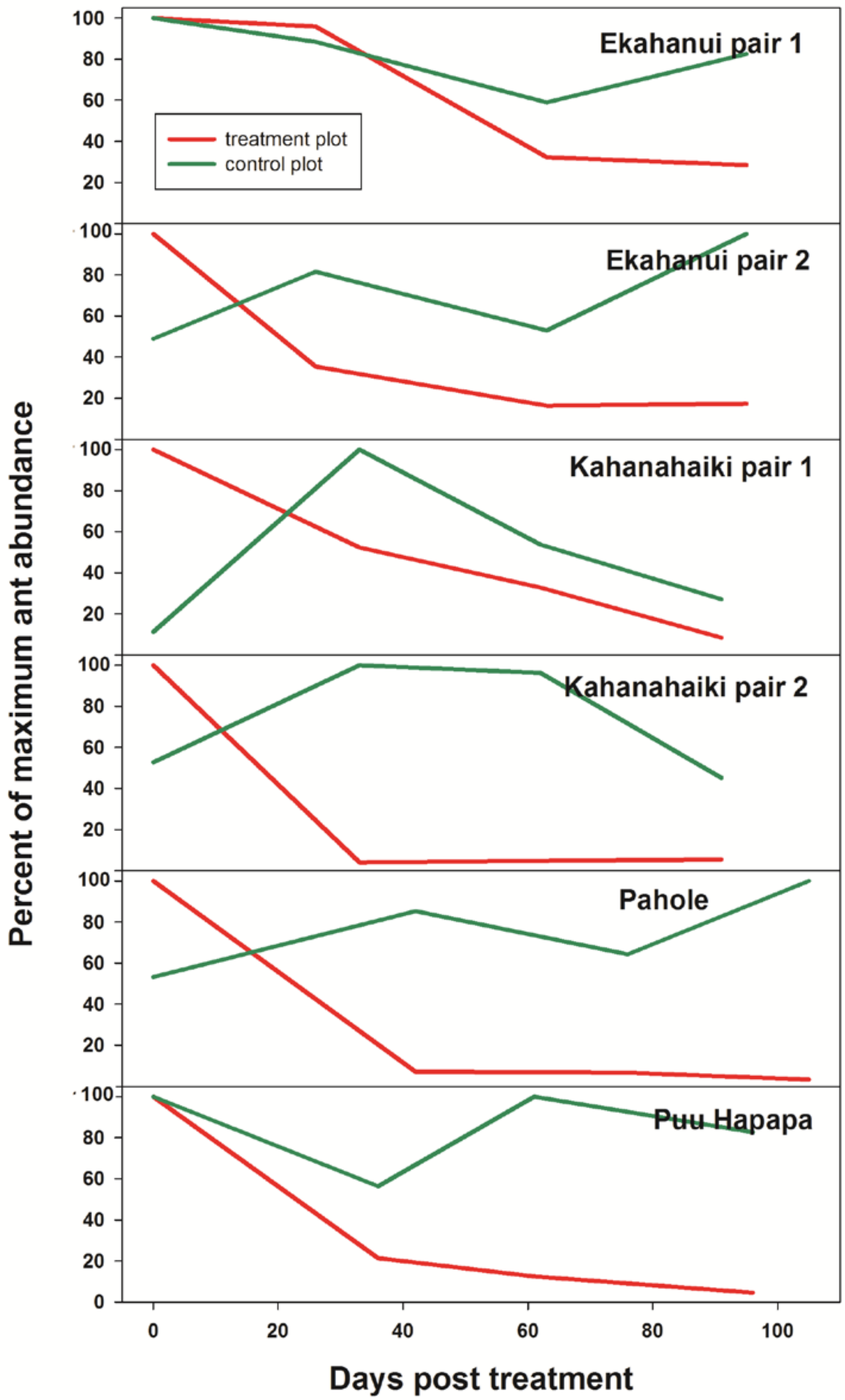


Figure 2. Changes in ant abundances over time in treatment and control plot pairs. Abundances expressed as percentage of the maximum recorded abundances in each plot.

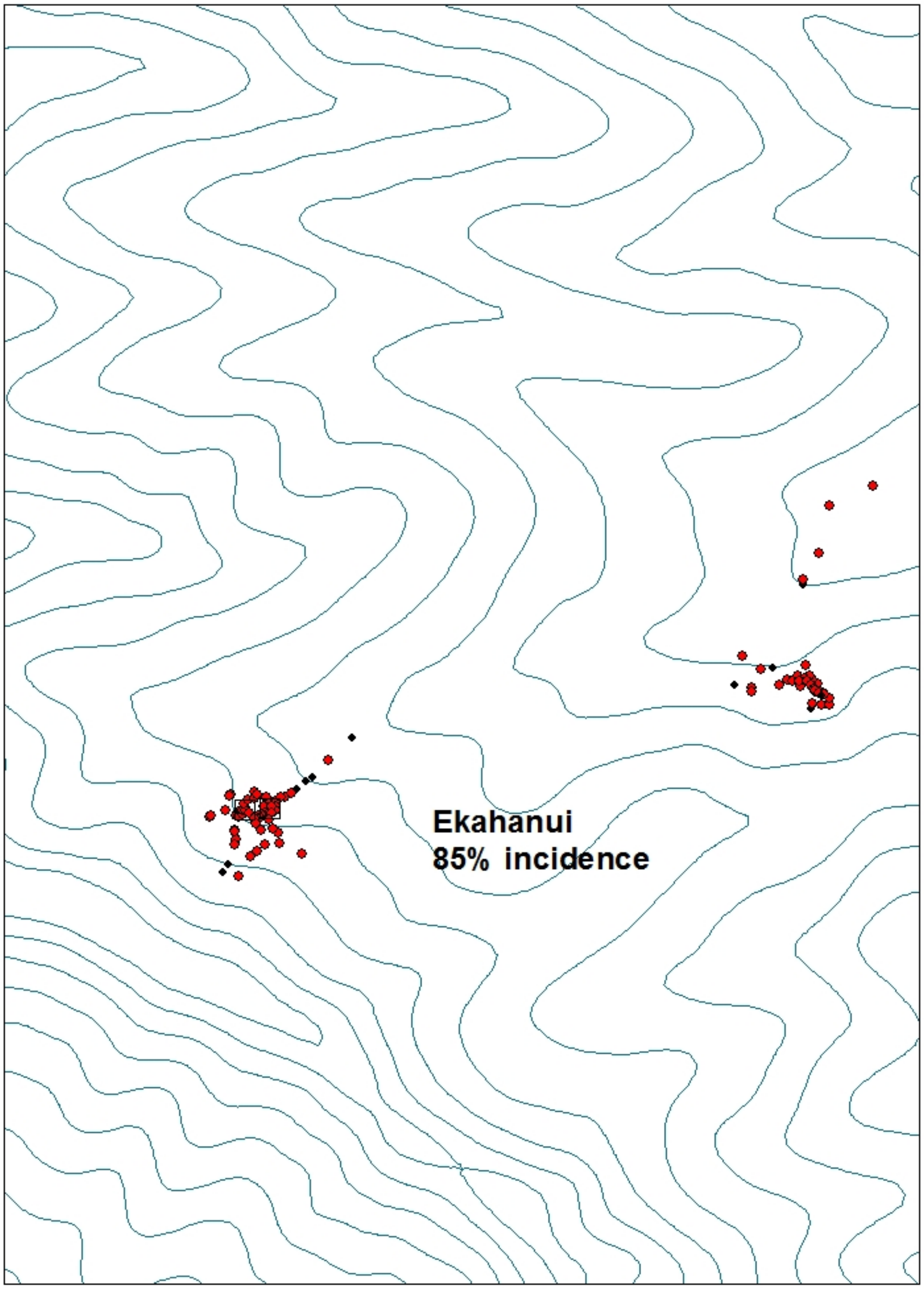
From 4/19/15-5/7/15, pre-treatment arthropod sampling was conducted in all 12 plots. This included five pitfall traps per plot (open for seven days each), five leaf litter samples per plot, and four vegetation sweeping samples per plot. Most of these 168 samples have been sorted to order, and lower-level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

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

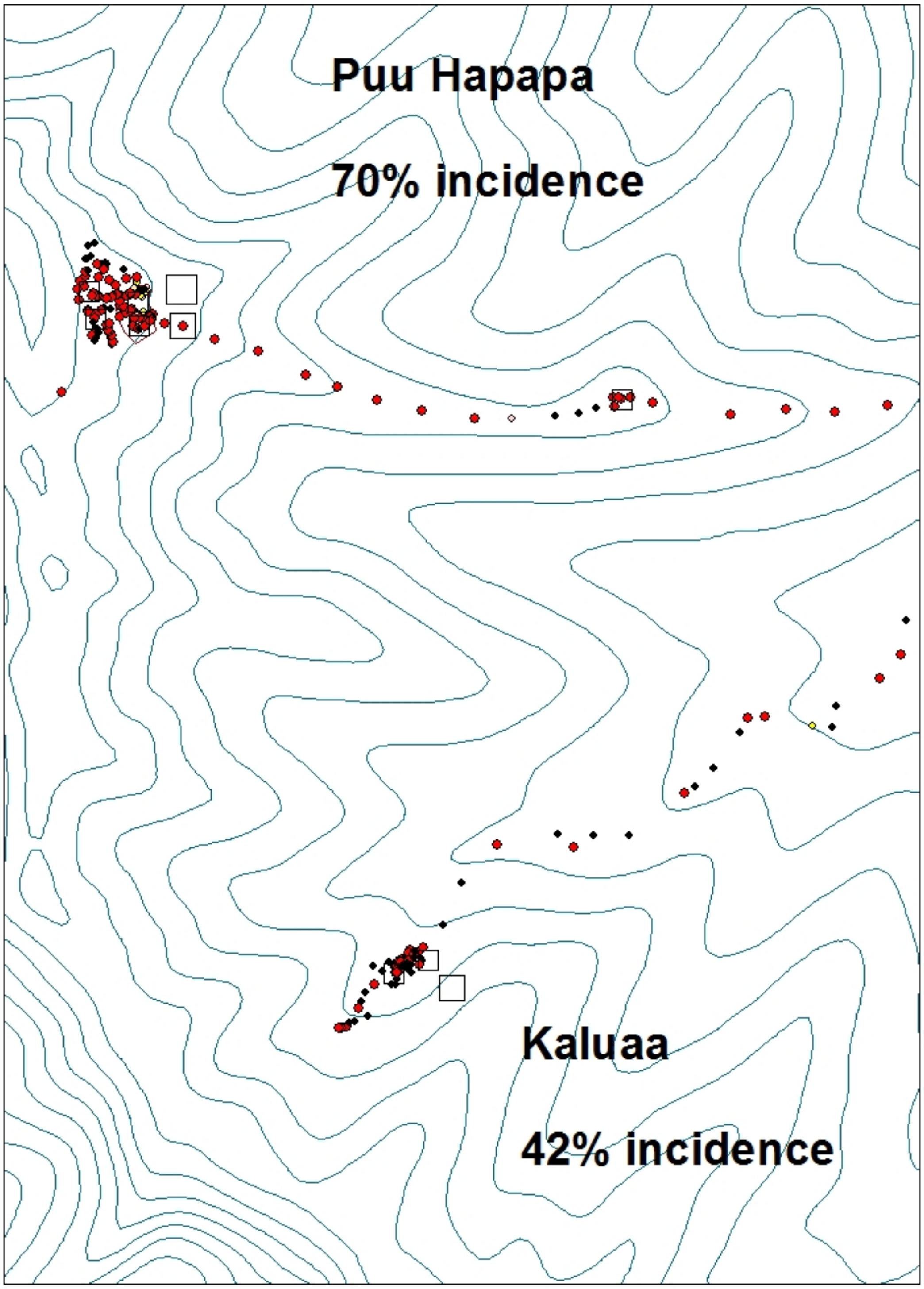
<u>FY16 plans</u>

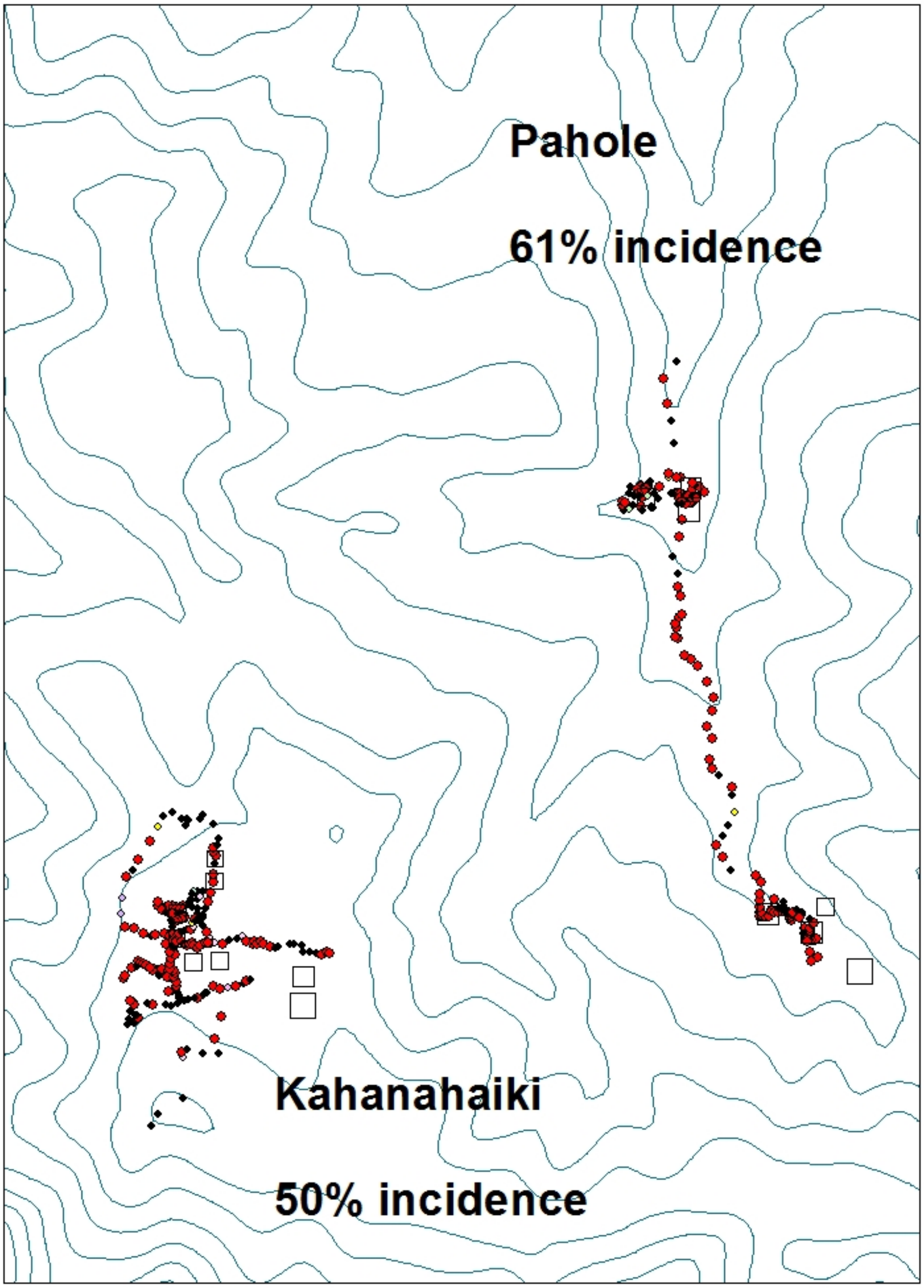
In the second year of this project, we will complete the field efficacy test comparing Amdro and Siesta ant baits at Pahole. We will continue suppressing ants and monitoring their numbers in the treatment field plots by visiting the plots about every 4-6 weeks to replace Amdro bait in the bait stations,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

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

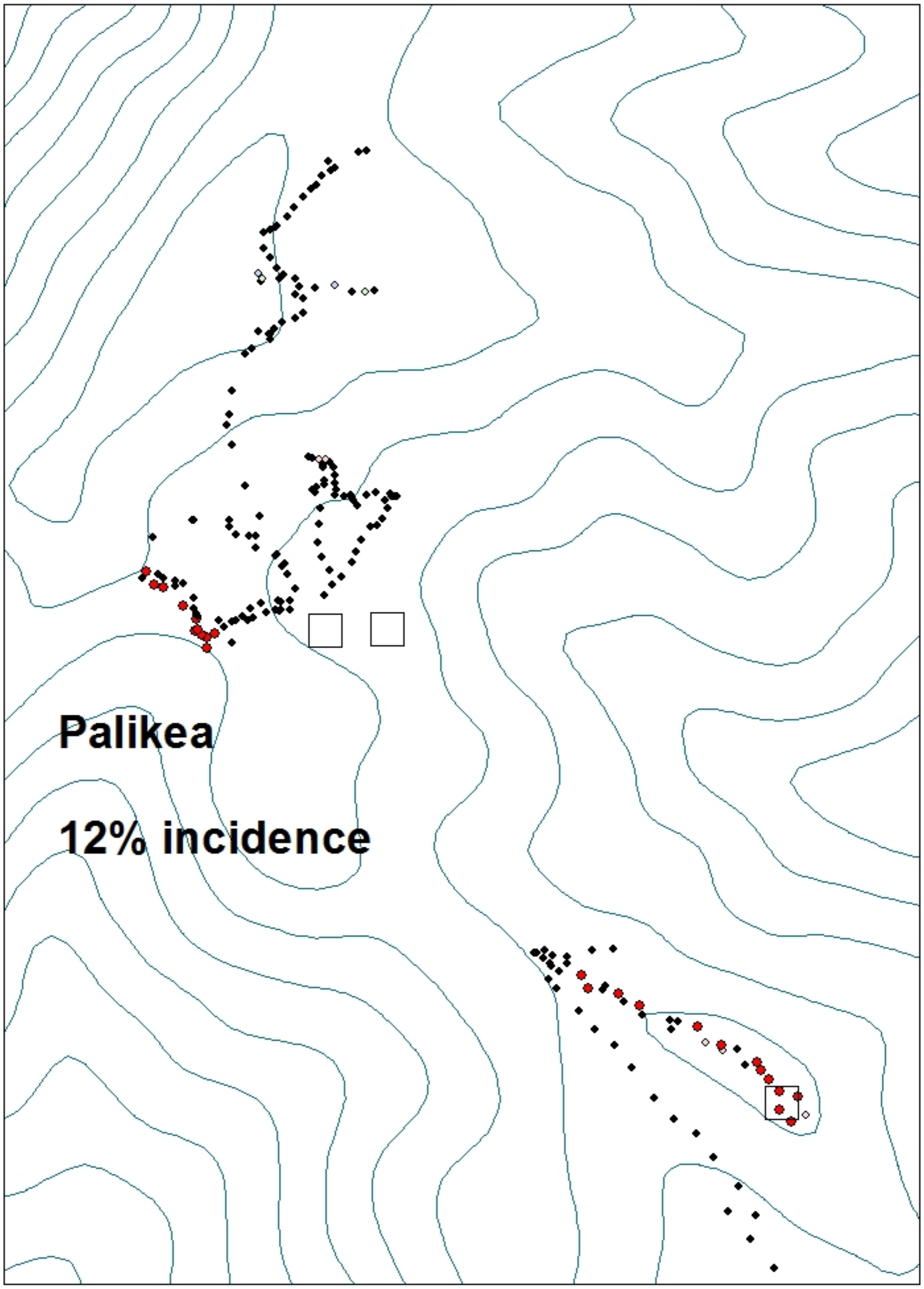


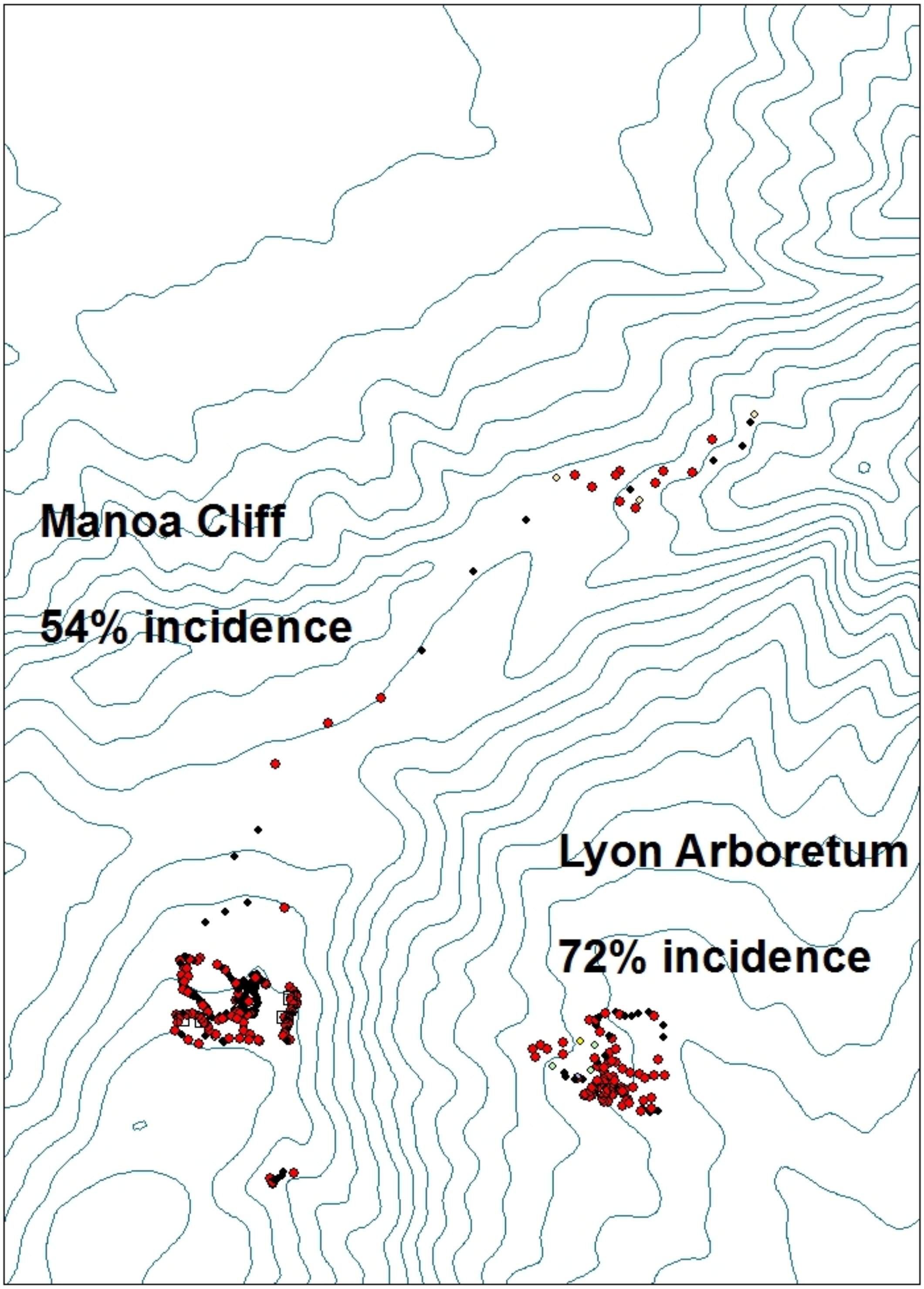
Areas surveyed at Ekahanui are 2D site and Palai Gulch.


Puu Hapapa
70% incidence
Kaluaa
42% incidence



Pahole
61% incidence
Kahanahaiki
50% incidence


Palikea
12% incidence


Manoa Cliff
54% incidence
Lyon Arboretum
72% incidence

Appendix 1-1
Environmental Outreach 2015

VOLUNTEER TRIP PHOTOS:

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

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

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

INTERNSHIPS AND TEMPORARY STAFF:

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

OUTREACH EVENTS:

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

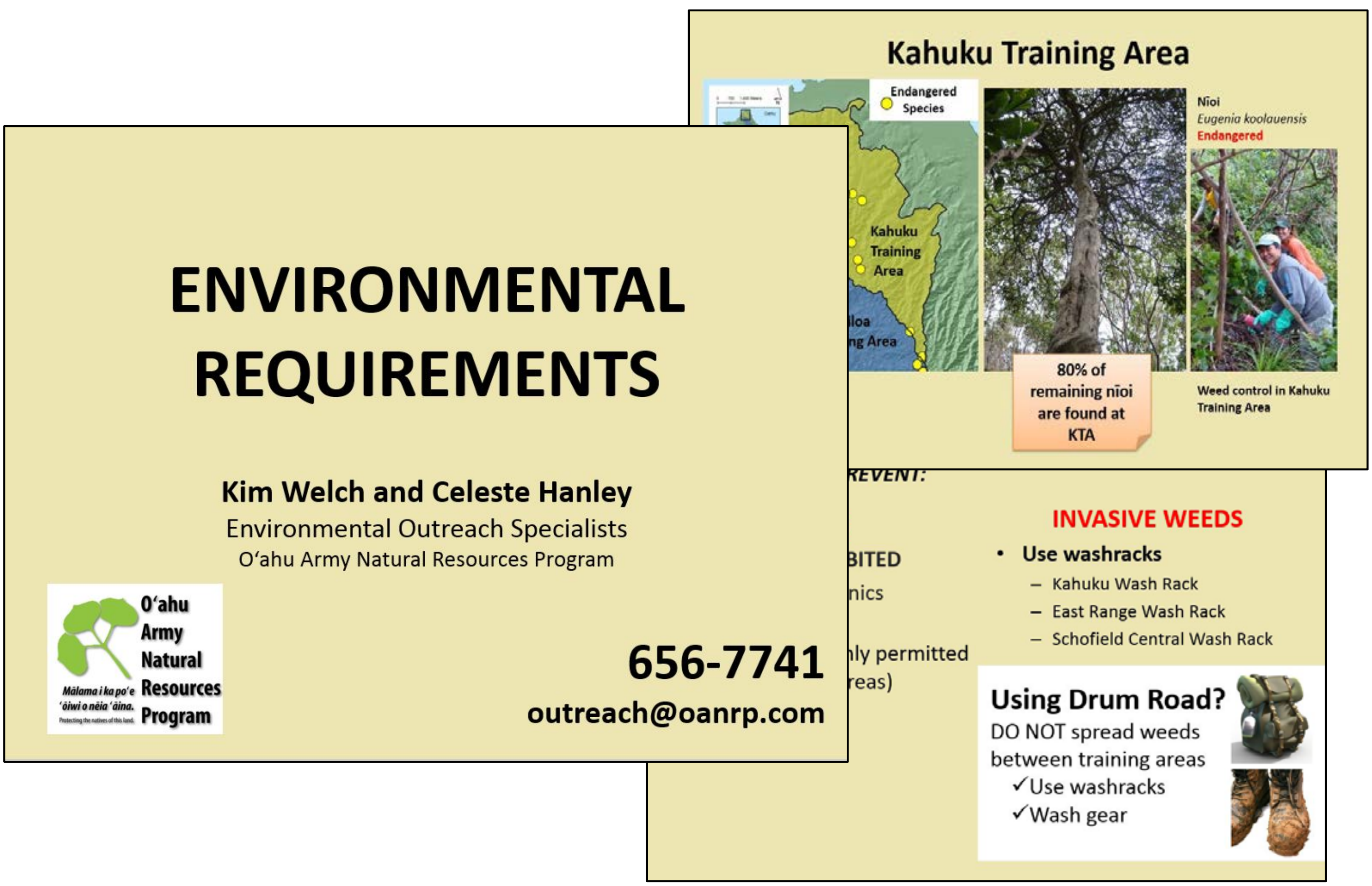
Right: AmeriCorps intern Noweo Kai and volunteer Elizabeth Leaver help elementary school students "build" a native Hawaiian forest at Hawaii Agriculture and Environmental Awareness Day at the Pearl City Urban Garden Center.

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

EDUCATIONAL MATERIALS:

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

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



PUBLIC RELATIONS:

Volunteers help protect Makua endangered plants

haw | October 4, 2014 | 0 Comments

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

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

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

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

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

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

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

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

Youth 'build' a forest, environmental awareness

haw | February 26, 2015 | 0 Comments

enter in Pearl City on Feb. 13. The display,
ian forest, was created by the Oahu Army
nmental Awareness Day. (Photo by Celeste

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

Post works to oust pesky coconut rhinoceros beetle

haw | May 14, 2015 | 0 Comments

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

Stephanie Joe
O'ahu Army Natural Resources Program
Directorate of Public Works
U.S. Army Garrison-Hawaii

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

Both are major pests that can hurt our native ecosystems and agriculture, and affect our households. Thanks to the cooperation between the Oahu Army Natural Resource Program and Patrick Ching, an agronomist with the Directorate of Public Works, Schofield Barracks remains free of these incipient pests.

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

Cover and excerpts from the Ecosystem Management Program bulletins.

DROSOPH

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

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

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

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

O'AHU INVASIVE SPECIES COMMITTEE

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

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

Summary of Project Objectives

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

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

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

The FY2015 survey and control plan is to:

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

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

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

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

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

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

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

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

CHALLENGES

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

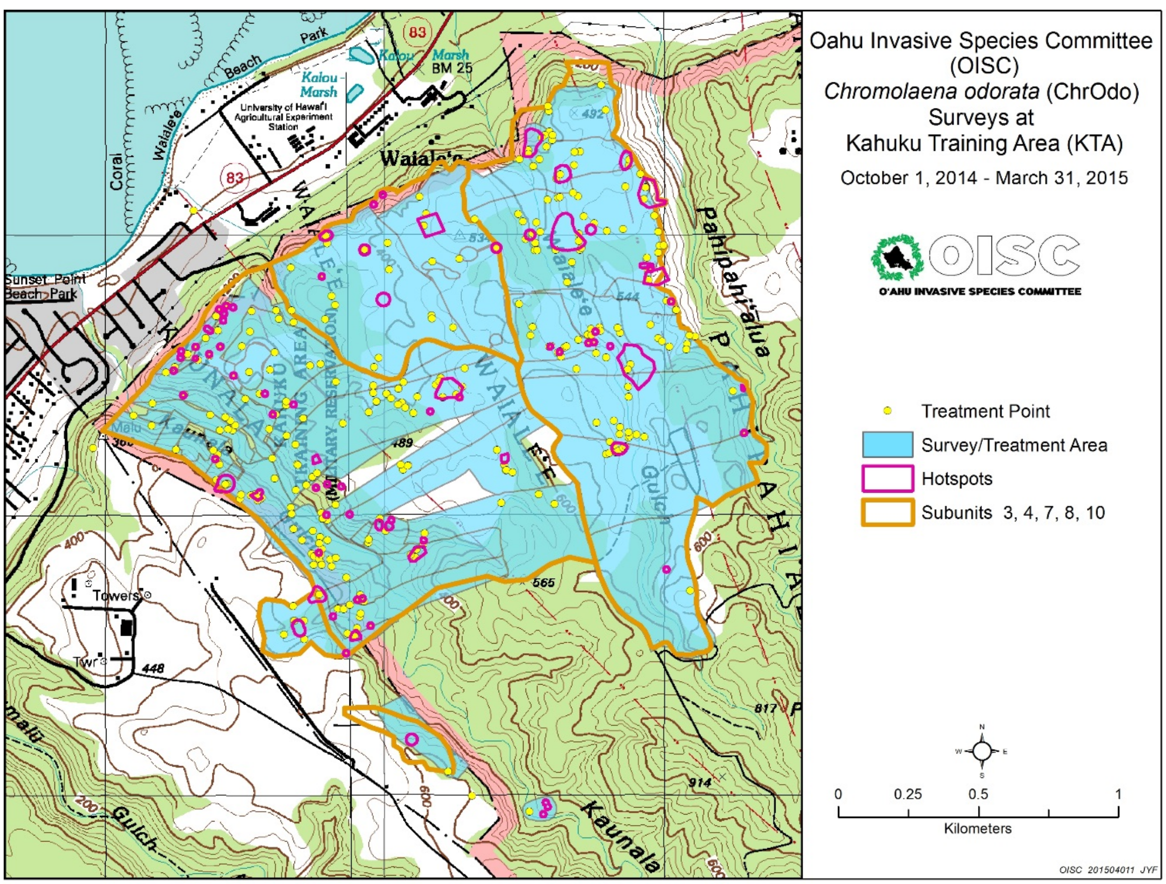
Surveys through guinea grass have a low confidence level because it is difficult to see even a short distance to the next crewmember. Guinea grass also presents a safety hazard because it obscures the steep drop-offs and cliffs common in the area. As a result, OISC crews are treading more carefully and covering less acres per hour.

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

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

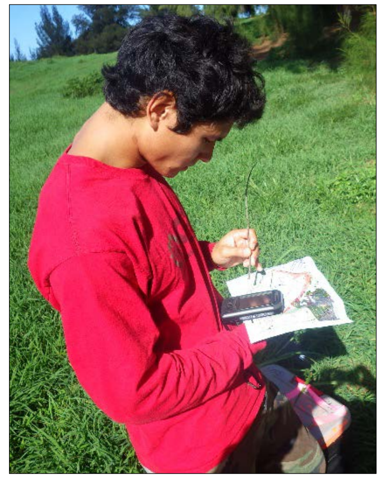
Location	Acres Surveyed	Mature Plants Treated	Immature Plants Treated	Total Plants Treated	Effort (Hours)
KTA Subunits 3, 4, 7, 8, 10	767	316	1,533	1,849	1,449

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



DATA MANAGEMENT

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



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

PUBLIC EDUCATION & OUTREACH

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

OTHER

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

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

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

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

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

COMPLIANCE

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

OAHU ARMY NATURAL RESOURCES PROGRAM
MONITORING PROGRAM

VEGETATION MONITORING AT KAHANAHAIKI MANAGAMENT UNIT, 2015

INTRODUCTION

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

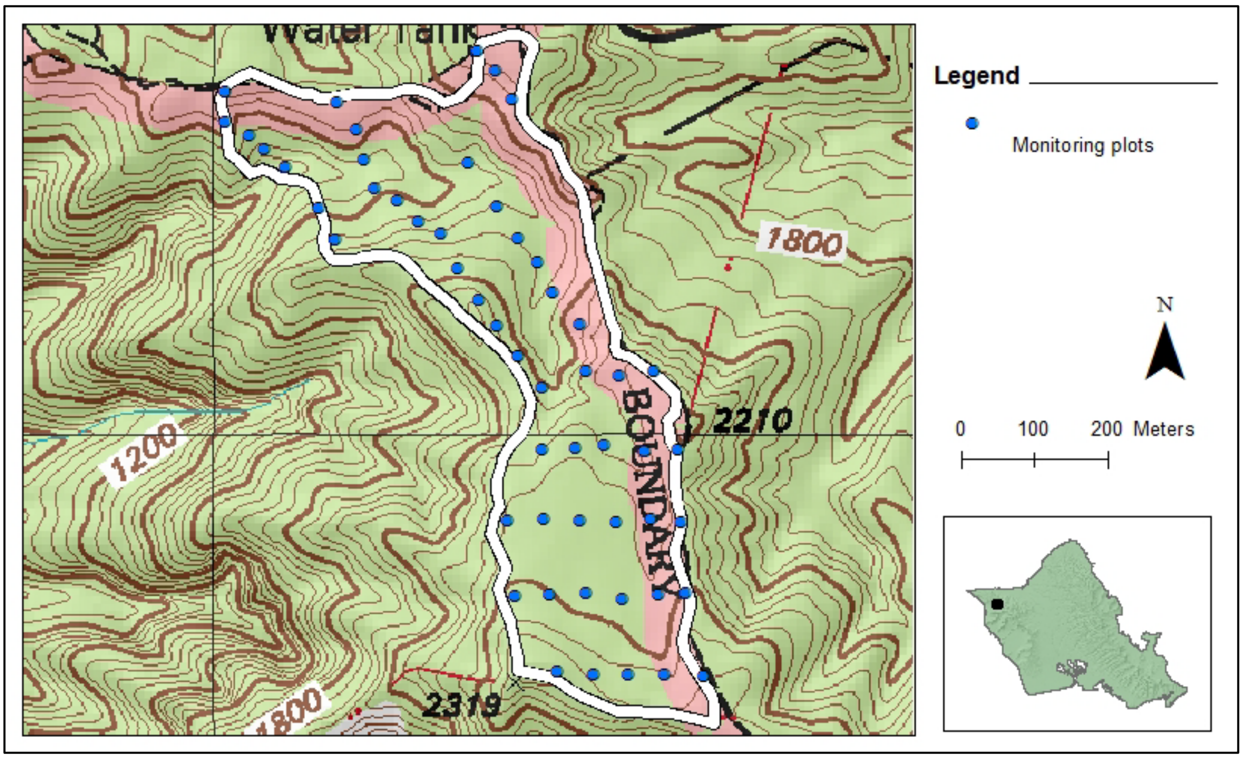


Figure 1. Kahanahaiki Subunit I vegetation monitoring plot locations.

METHODS

In June 2015, 53 plots were monitored along nine transects in Kahanahaiki Management Unit, Subunit I. Transects were spaced 100 meters (m) apart, and plots measuring 5 x 10 m were located every 50 m along transects. Understory [occurring from 0 – 2 m above ground level (AGL), including low branches from canopy species] and canopy (occurring > 2 m AGL, including epiphytes) vegetation was recorded by percent cover for all non-native and native species present, summary percent cover by vegetation type (shrub, fern, grass/sedge) in the understory, overall summary percent cover of non-native and native vegetation in the understory and canopy, as well as bare ground (non-vegetated below 25 centimeters AGL). Bare ground was not clearly defined in 2009, and was not recorded in 2012. Recruitment (defined as seedlings or saplings < 2 m AGL) data for tree species was recorded in 2015, but not documented previously. With the exception of tree recruitment and bare ground, monitoring results were compared with data from both 2009 and 2012. Based on MIP recommendations, $\alpha = 0.05$ was used for significance determinations, and only cover changes ≥ 10% were recognized. Additional methodology information is detailed in Monitoring Protocol 1.2.1 (OANRP 2008). All analyses were performed in IBM SPSS Statistics Version 20. These included either Friedman's test with pot-hoc Bonferroni adjusted pairwise comparisons or Wilcoxon signed rank test for cover data, Mann-Whitney test of cover in plots with > 50% vs. < 50% non-native canopy, repeated measures ANOVA with post-hoc Bonferroni adjusted pairwise comparisons for species richness data, McNemar's test for frequency data, regression analyses for time spent weeding in association with cover change, and t tests for cover change in plots within vs. outside weed control areas.

RESULTS

Understory and canopy cover categories

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

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

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

	2009	2012	2015	p	X^2	years that differed significantly	p (post-hoc**)	Management objective currently met?
Understory								
Native shrubs	8.00	15.00	8.00	< 0.001*↑	20.672	2009 vs. 2012 2009 vs. 2015	0.007↑ 0.007↑	
Native ferns	8.00	2.00	8.00	0.105*	4.500	NA		
Native grasses	0.00	0.00	0.00	0.544*	1.217	NA		
Total native understory	15.00	25.00	25.00	0.157*	3.705			No
Non-native shrubs	15.00	25.00	25.00	**< 0.001***↑	28.573	2009 vs. 2015 2012 vs. 2015	**< 0.001**↑ 0.005↑	
Non-native ferns	0.00	0.00	0.00	0.010*↑	9.155	NA		
Non-native grasses	0.00	0.00	2.00	< 0.00*↑1	25.650	2012 vs. 2015	0.002↑	
Total non-native understory	25.00	25.00	35.00	**< 0.001***↑	31.207	2009 vs. 2015 2012 vs. 2015	**< 0.001**↑ **< 0.001**↑	Yes, but getting worse
Bare ground	45.00	N/A	55.00	**0.020*****↑				
Canopy								
Native canopy	15.00	15.00	15.00	0.042*↑	6.347	NA		No
Non-native canopy	45.00	55.00	55.00	**0.002***↑	12.296	2009 vs. 2015	**0.017**↑	No
Total canopy	65.00	95.00	95.00	**< 0.001***↑	34.228	2009 vs. 2012 2009 vs. 2015	**< 0.001**↑ **< 0.001**↑	

* from Friedman's test, aymptotic significance
**from post-hoc pairwise comparisons with Bonferroni adjustment
*** from Wilcoxon signed-rank test

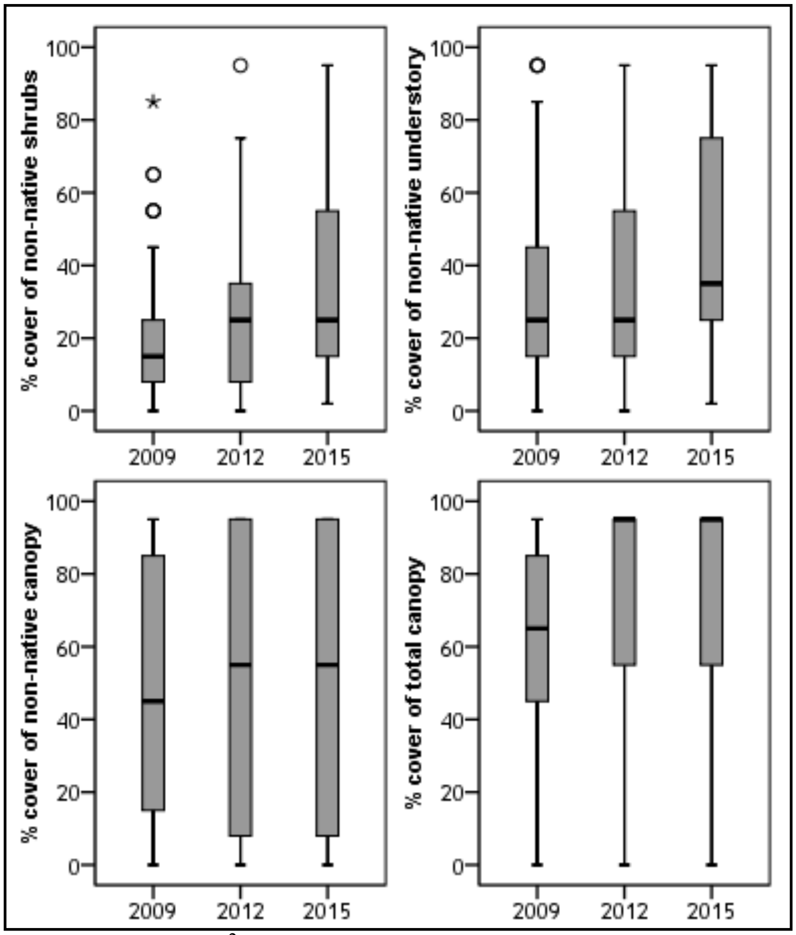


Figure 2. Boxplots[2] for vegetation categories with significant, and ≥ 10%, change in percent cover between years 2009 and 2015.

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

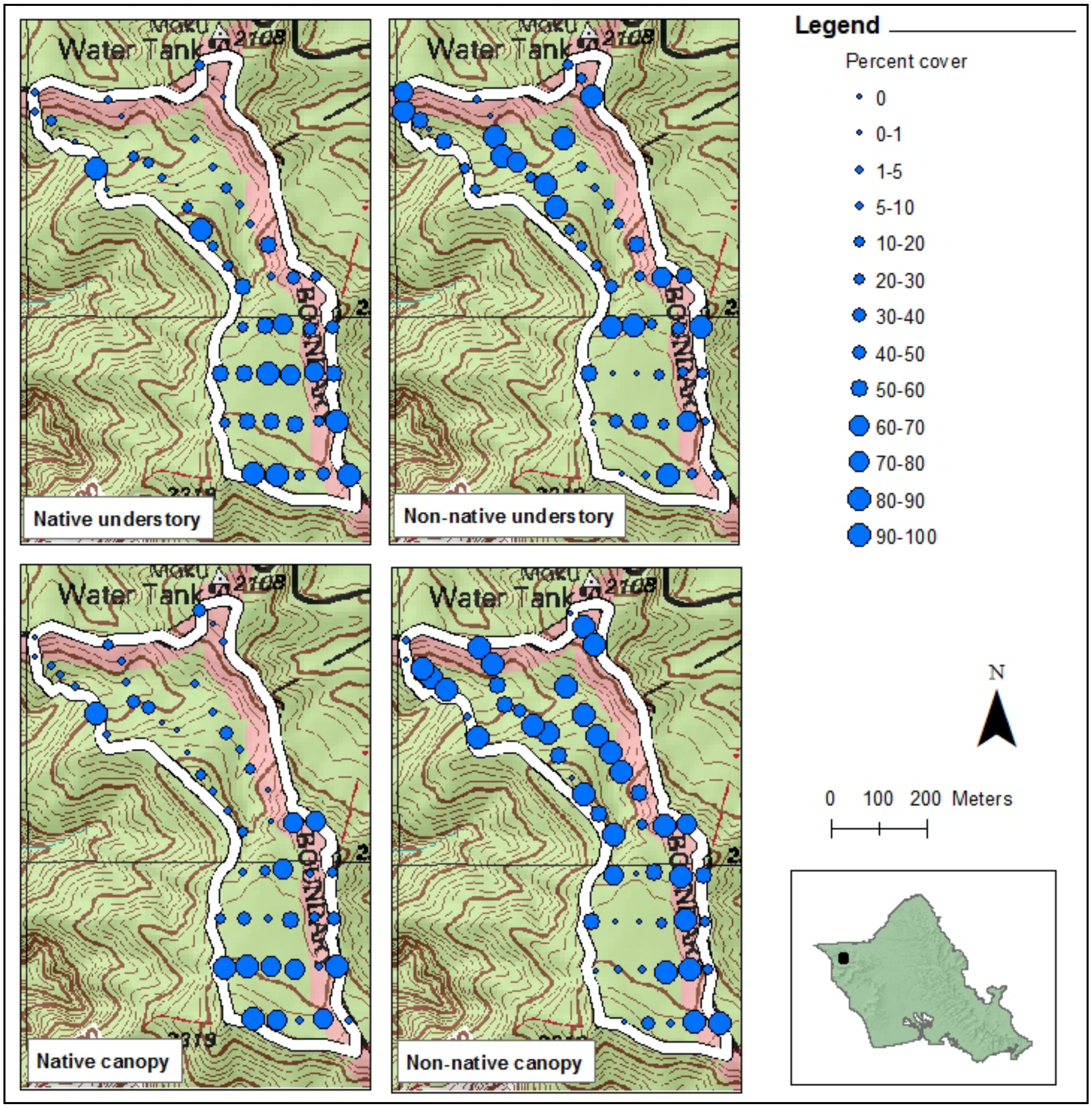


Figure 3. Locations of low to high percent cover of native and non-native understory and canopy vegetation among monitored plots at Kahanahaiki Subunit I in 2015. Larger circles denote higher percent cover, while smaller circles represent lower percent cover.

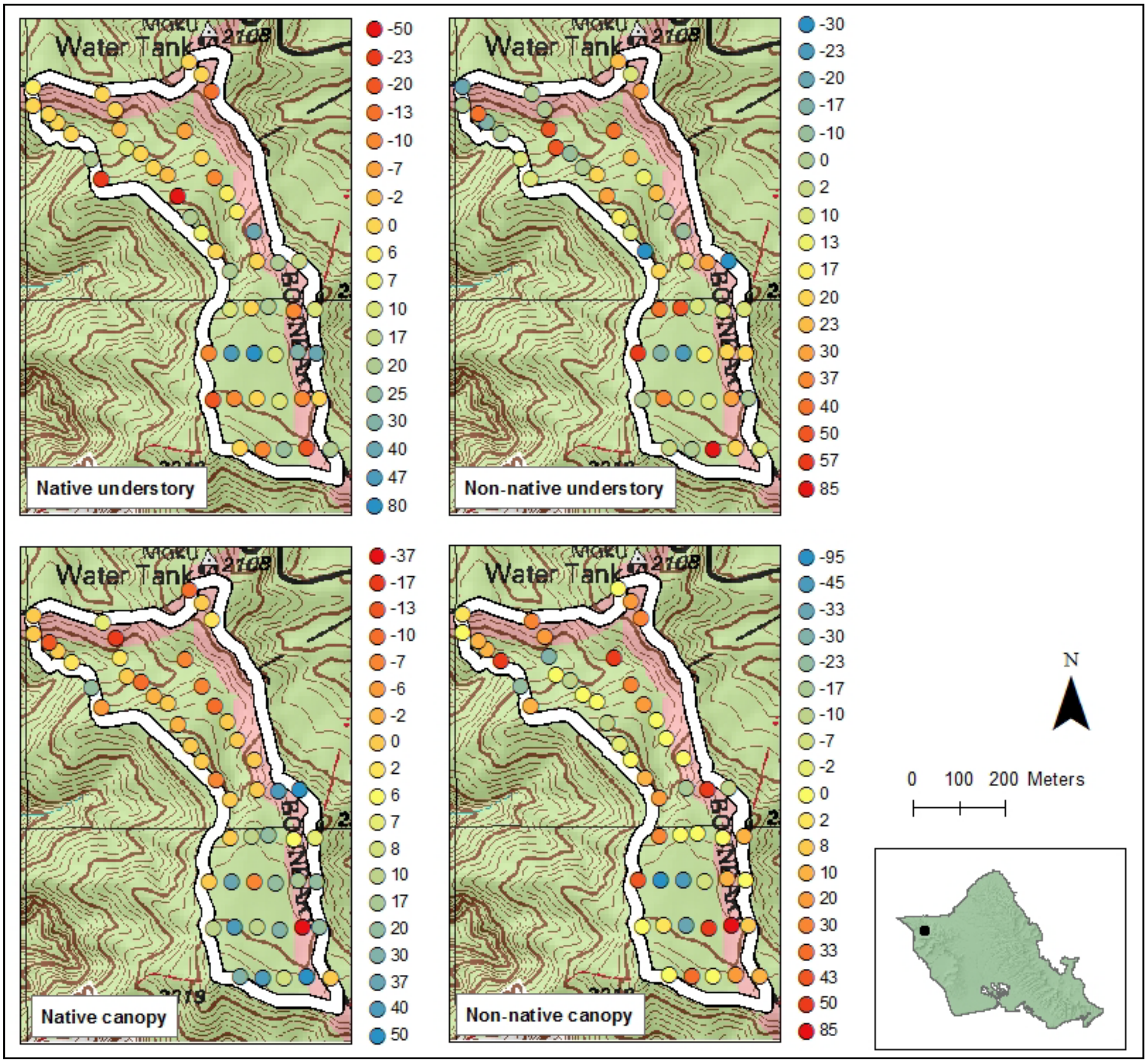


Figure 4. Locations of change in native and non-native percent cover for the understory and canopy (from 2009 to 2015) vegetation in monitored plots in Kahanahaiki Subunit I. Color gradients are inverted for native and non-native vegetation, such that blue indicates beneficial change, red depicts worsening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

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

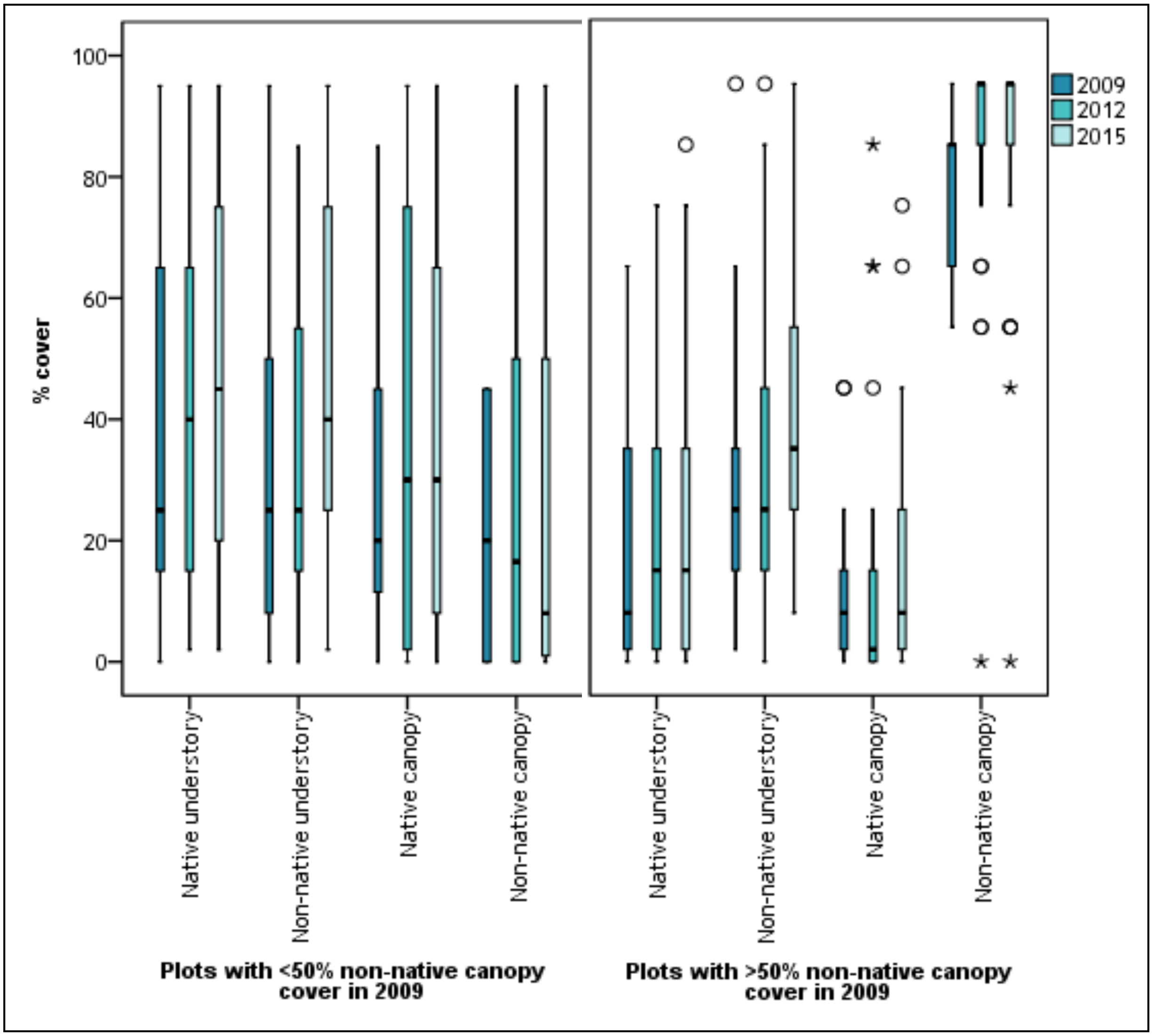


Figure 5. Boxplot of percent cover of native and non-native understory and canopy in 2009, 2012, and 2015, among plots with < 50% and > 50% non-native canopy in 2009.

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

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

*from Friedman's test

**post-hoc comparison with Bonferroni adjustment

Species richness

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

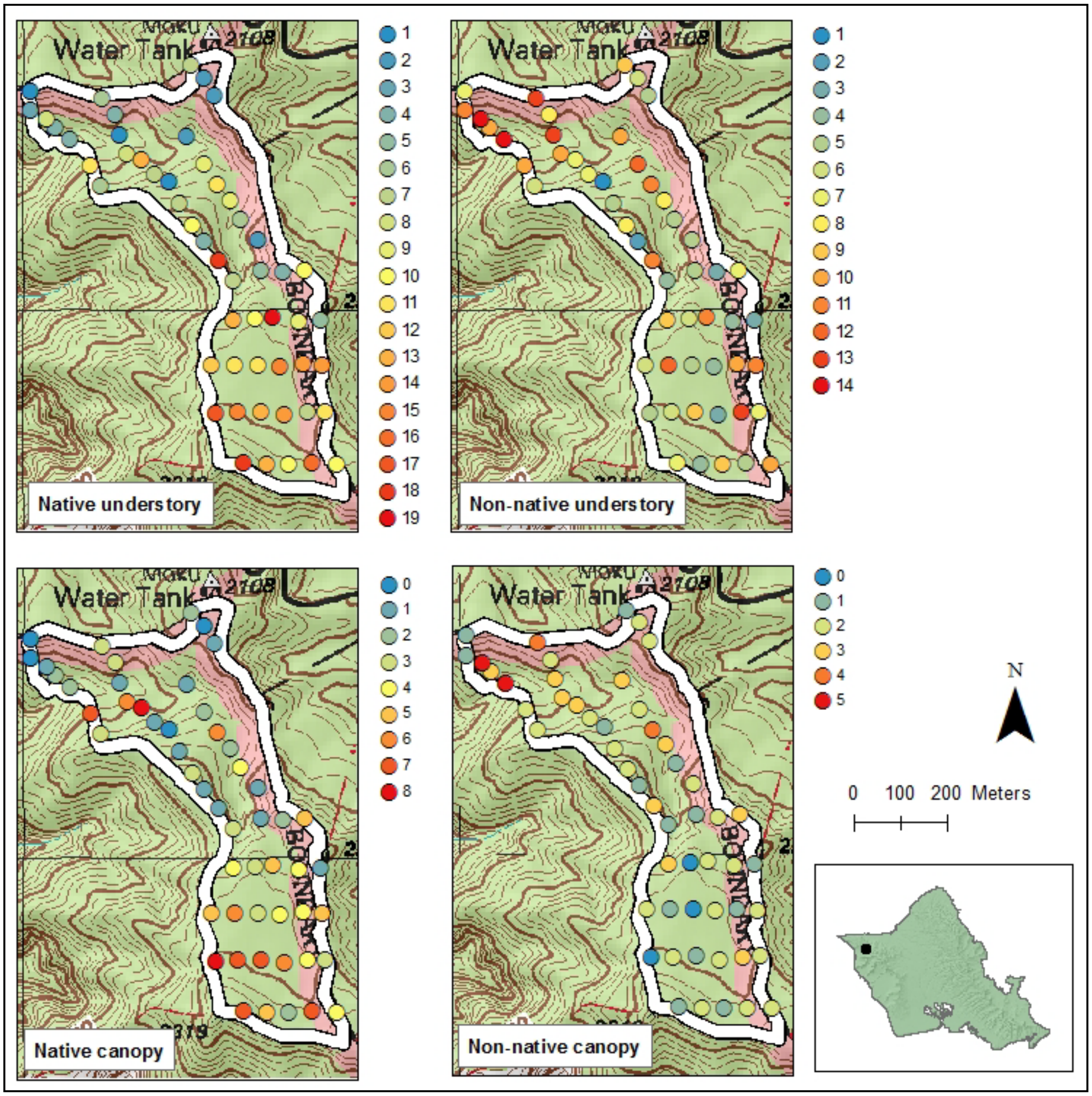


Figure 6. Locations of low to high species richness among plots in the native and non-native understory and canopy in Kahanahaiki Subunit I, 2015. Color gradients of blue to red indicate low to high values, respectively, of the number of species occurring in plots (i.e., blue indicates low diversity,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

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

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

*derived from repeated measures ANOVA
**derived from post-hoc comparison with Bonferroni correction
***Greenhouse-Geisser correction applied

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

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

Species frequency

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

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

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

Table 6. Species with significant frequency change at Kahanahaiki between 2009 and 2015. Only taxa with at least 10% change in frequency were analyzed. Frequency values represent the proportion of plots in which species are present (n = 53). Native species are in boldface. P-values obtained from McNemar's test with exact significance. Arrows indicate increase (↑) or decrease (↓) in frequency.

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

Species cover

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

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

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

*derived from Friedman's test

**post-hoc comparison with Bonferroni adjustment

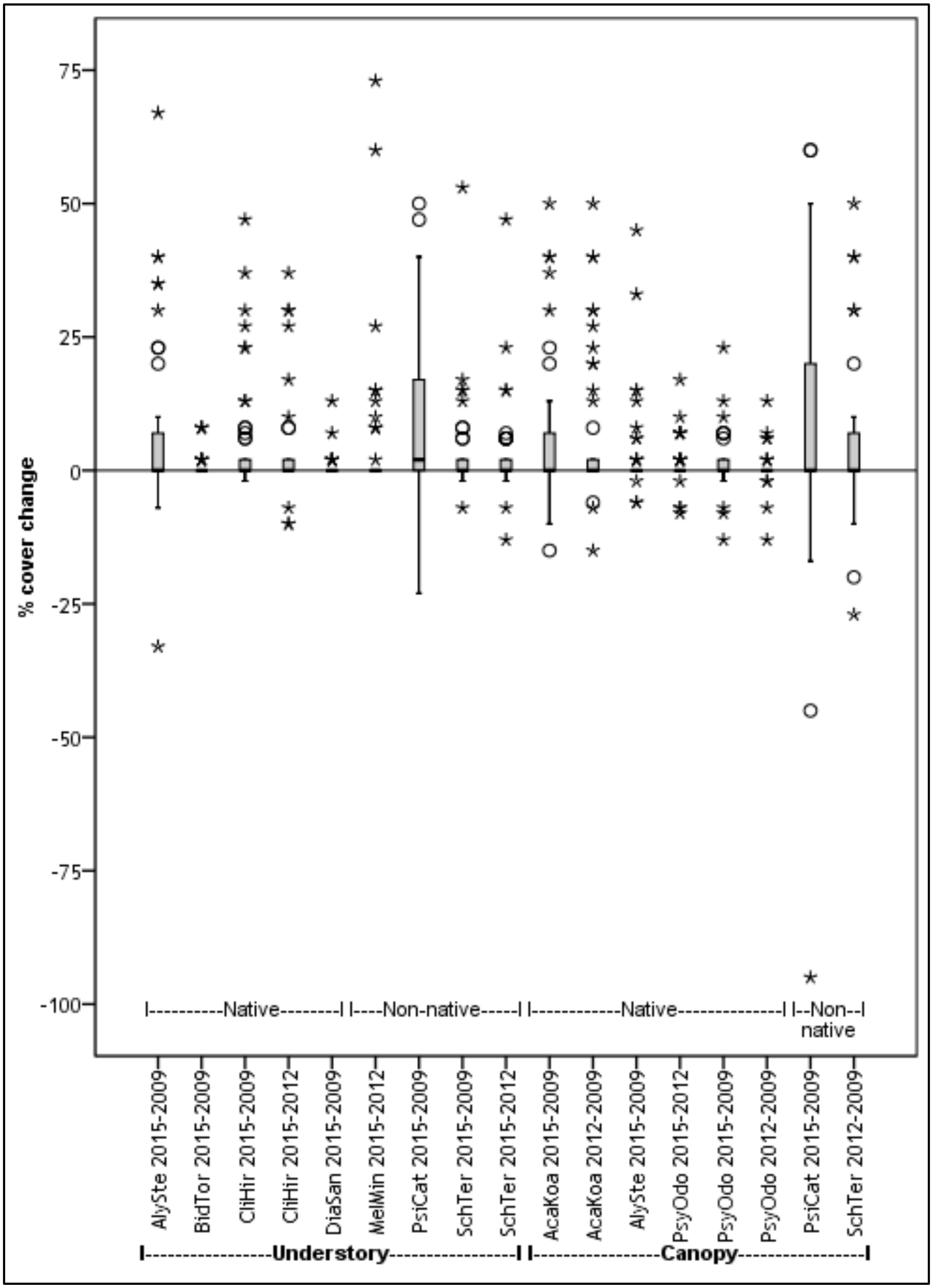


Figure 7. Boxplots of percent cover change between 2009 and 2015 at Kahanahaiki MU, for species with significant changes in cover. Values > 0 represent increased cover in plots, while those < 0 represent decreased cover.

Canopy replacement

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

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

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

Weed control

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

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

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

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

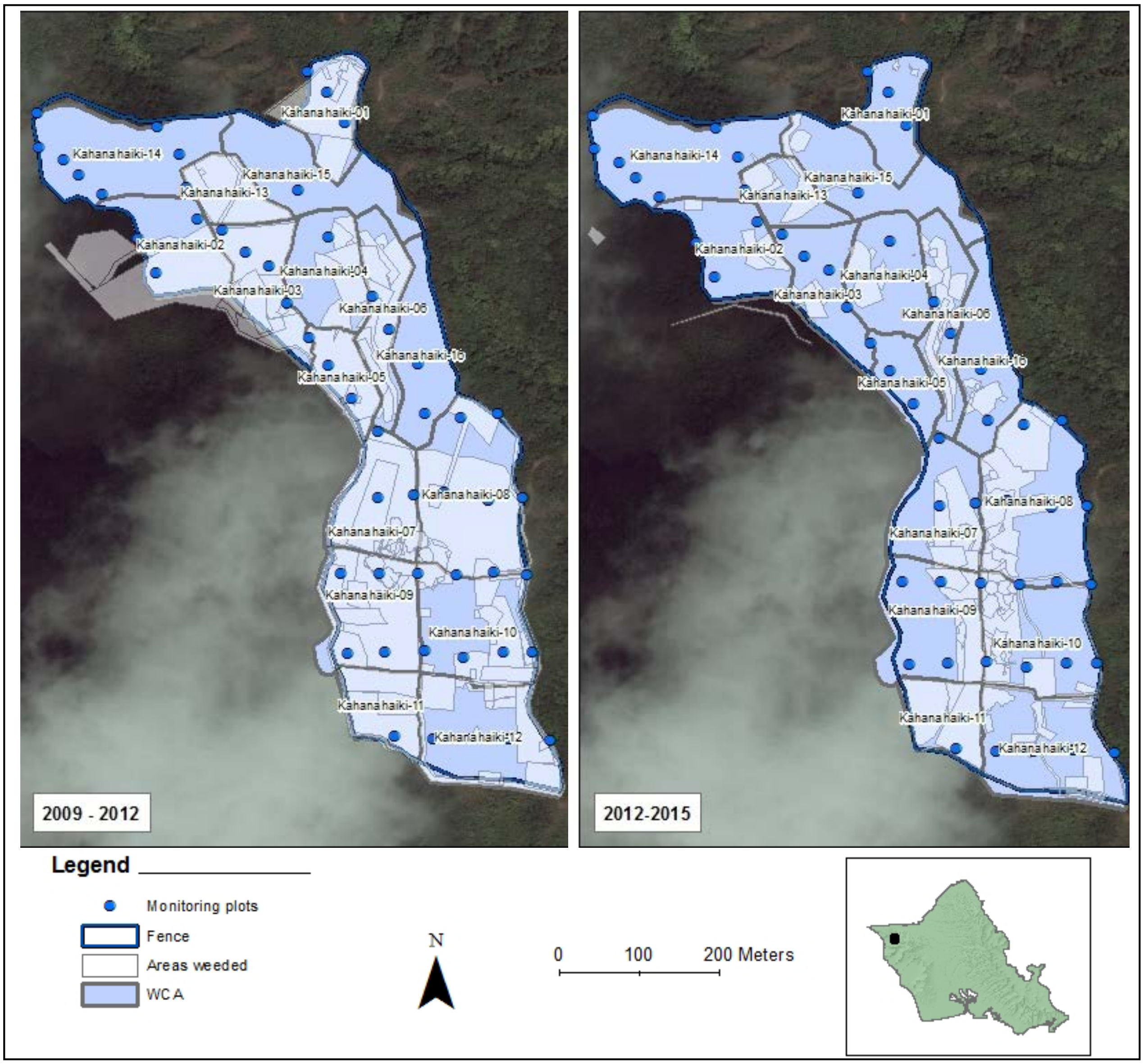


Figure 8. Locations of vegetation monitoring plots at Kahanahaiki Subunit I in relation to weed control areas (WCA) and areas weeded between the 2009-2012 and 2012-2015 monitoring intervals.

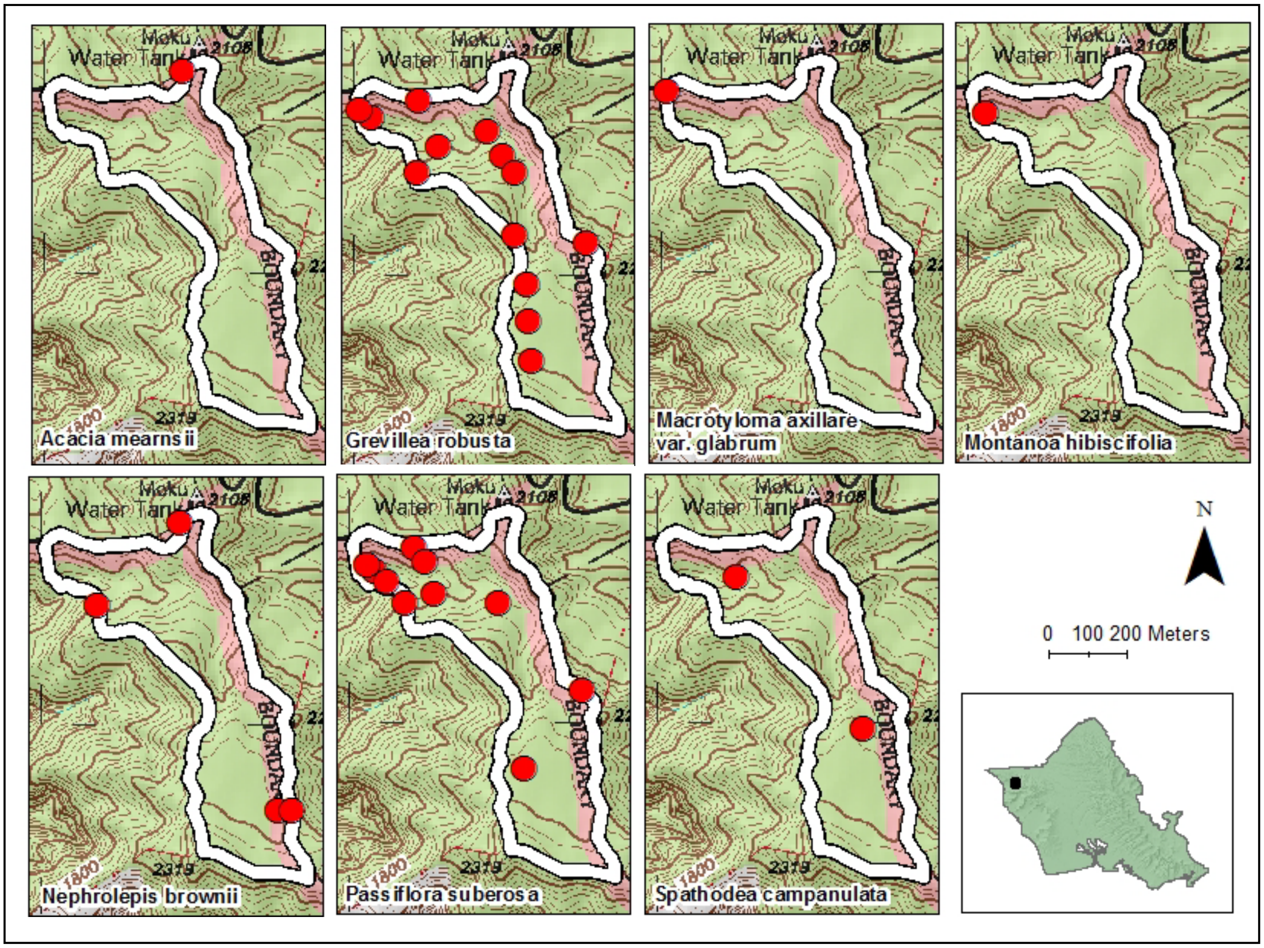


Figure 9. Locations of target taxa among plots in Kahanahaiki Subunit I in 2015.

SUMMARY AND DISCUSSION

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

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

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

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

RECOMMENDATIONS

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

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

REFERENCES

Cole, R. J. and C. M. Litton. 2014. Vegetation response to removal of non-native feral pigs from Hawaiian tropical montane wet forest. Biological Invasions 16:125–140.

Oahu Army Natural Resource Program. 2008. Appendix 2.0 MIP/OIP Belt Plot Sampling Monitoring Protocol *in* 2008 Status Report for the Makua Implementation Plan.

-----. 2009. Chapter 1.4.4 Kahanahaiki Ecosystem Restoration Management Plan *in* 2009 Status Report for the Makua and Oahu Implementation Plans.

-----. 2012. Chapter 1.1.4 Vegetation Monitoring: Kahanahaiki Three-Year Analysis *in* 2012 Status Report for the Makua and Oahu Implementation Plans.

Weller, S. G., R. J. Cabin, D. H. Lorence, S. Perlman, K. Wood, T. Flynn, and A. K. Sakai. 2011. Alien Plant Invasions, Introduced Ungulates, and Alternative States in a Mesic Forest in Hawaii. Restoration Ecology 19: 671–680.

OAHU ARMY NATURAL RESOURCES PROGRAM
MONITORING PROGRAM

VEGETATION MONITORING AT MAKAHA SUBUNITS I AND II, 2014

INTRODUCTION

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

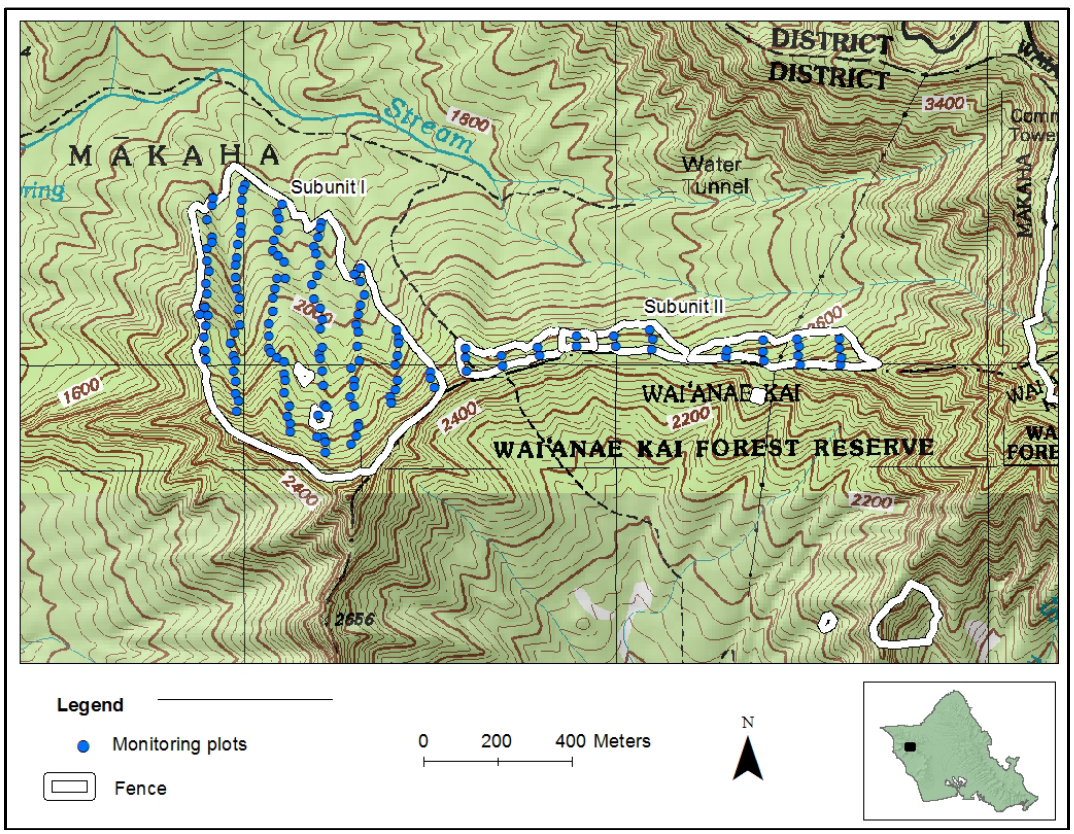


Figure 1. Makaha MU vegetation monitoring plot locations, 2014

METHODS

In August and September 2014, 121 plots were monitored along seven transects in Subunit I, and 27 plots were monitored along ten transects in Subunit II. Transects were spaced 200 meters (m) apart, and plots measuring 5 x 10 m were located every 30 m along transects. The Subunit I plots were also monitored in 2009 (OANRP 2010). Subunit II plots were newly established in 2014. Understory [occurring from 0 – 2 m above ground level (AGL), including low branches from canopy species] and canopy (occurring > 2 m AGL, including epiphytes) vegetation was recorded by percent cover for all non-native and native species present. Summary percent cover by vegetation type (shrub, fern, grass/sedge) in the understory, overall summary percent cover of non-native and native vegetation in the understory and canopy, and bare ground, were also documented. Understory recruitment (defined as seedlings or saplings < 2 m AGL) data for tree species was recorded in 2014, but not documented previously. Monitoring results for Subunit I were compared with data from 2009. Subunit I and II data were combined in the summary results for 2014, as these areas are nearly contiguous, separated by less than 100 m. Based on MIP recommendations, $\alpha = 0.05$ was used for significance determinations, and only cover changes ≥ 10% were recognized. Additional methodology information is detailed in Monitoring Protocol 1.2.1 (OANRP 2008). All analyses were performed in IBM SPSS Statistics Version 20. These included Wilcoxon signed-rank tests for cover data, paired t tests for species richness data, McNemar's test for frequency data, regression analyses for time spent weeding in association with cover change, and t tests for cover change in plots within vs. outside weed control areas.

RESULTS

Understory and canopy cover categories

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

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

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

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

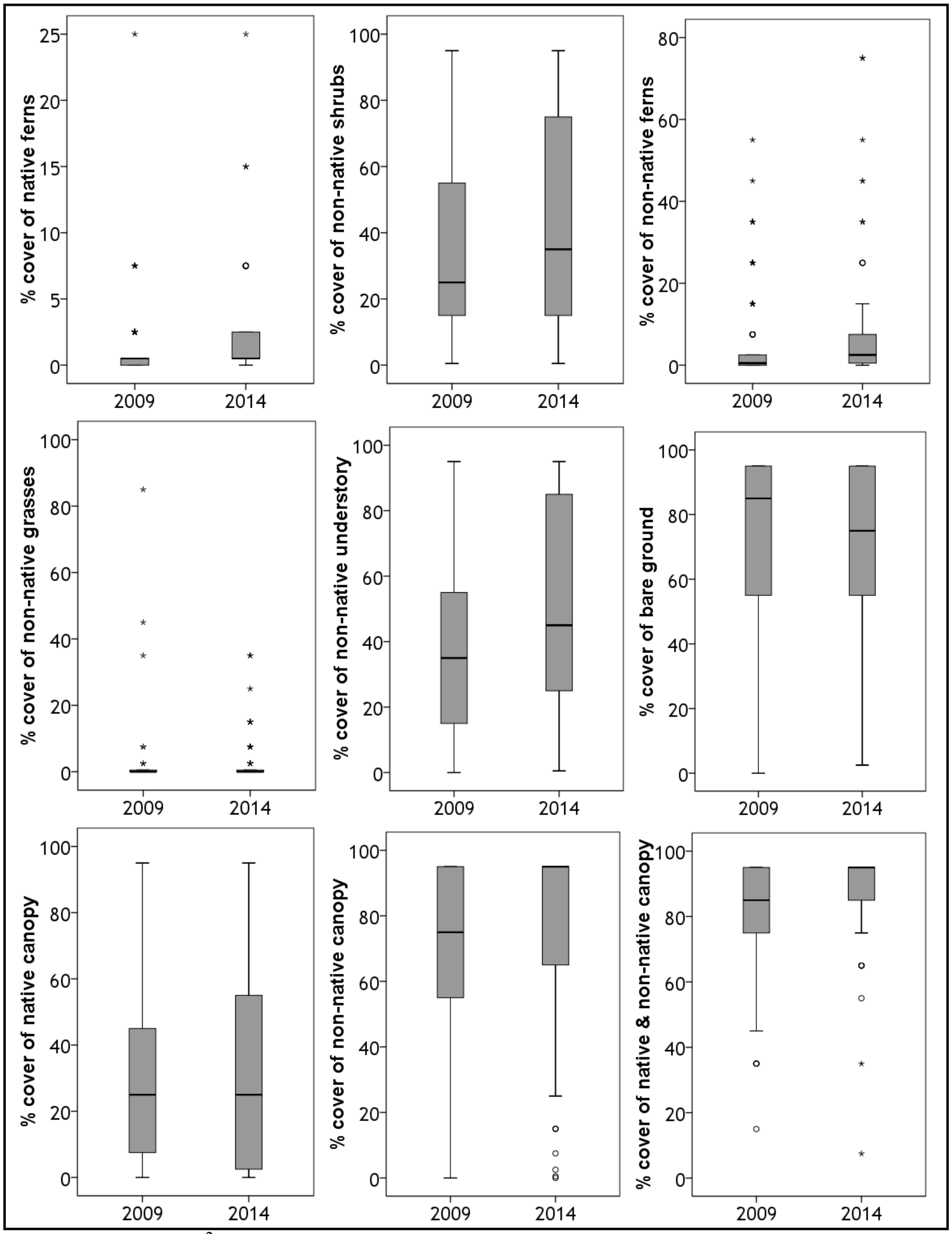


Figure 2. Boxplots[2] for vegetation categories with significant (or marginally significant) change in percent cover between years 2009 and 2014 in Makaha Subunit I.

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

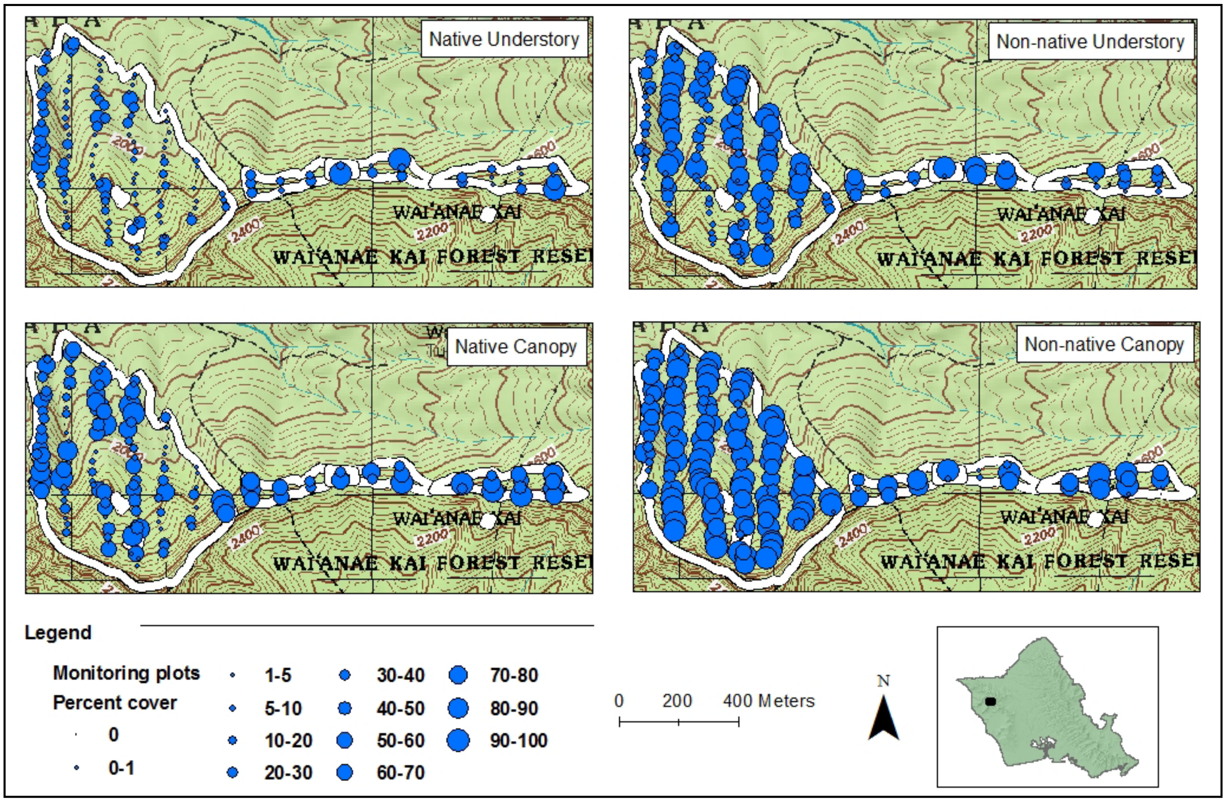


Figure 3. Locations of low to high percent cover of native and non-native understory and canopy vegetation among monitored plots at Makaha in 2014. Larger circles denote higher percent cover, while smaller circles represent lower percent cover.

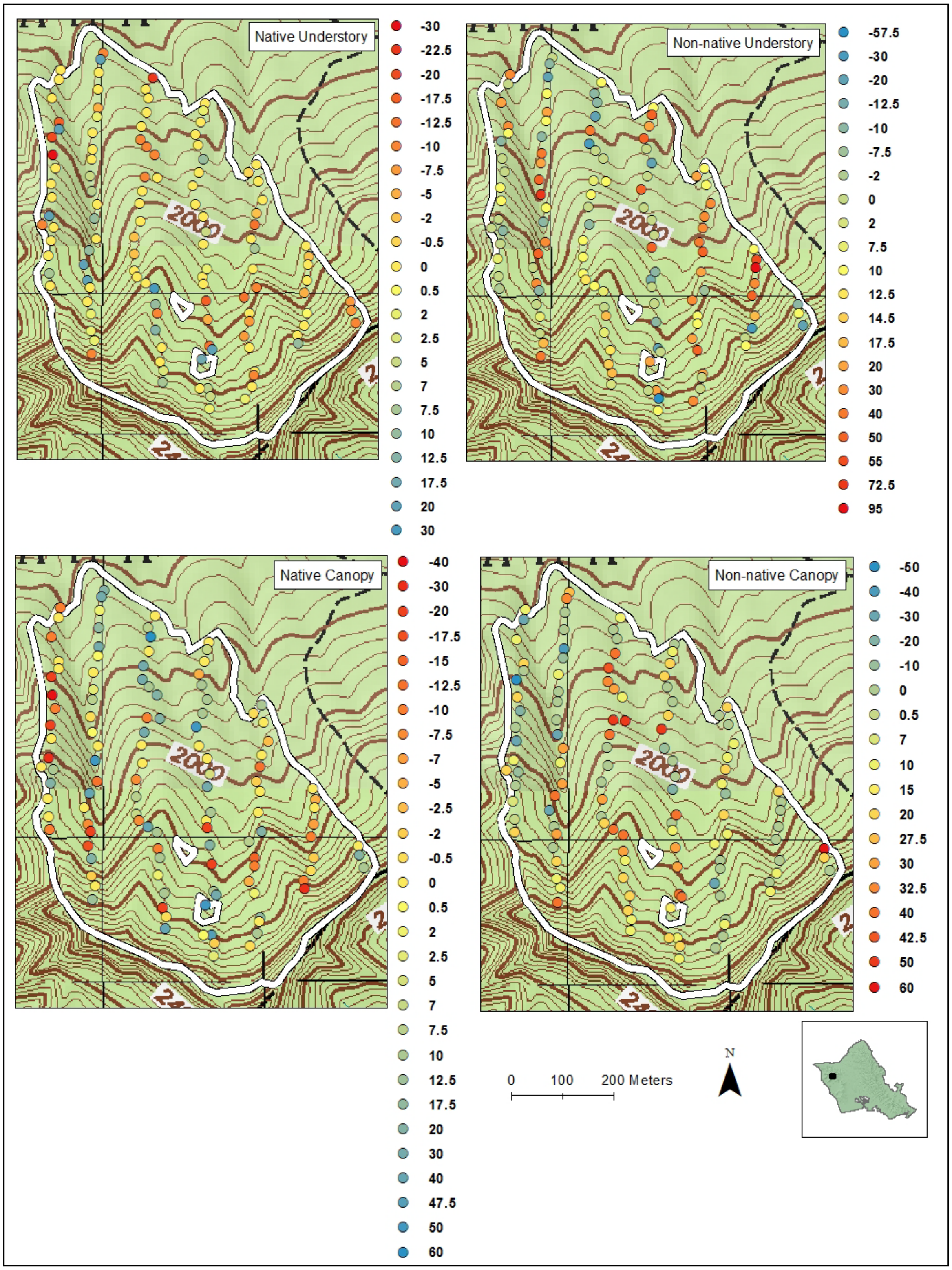


Figure 4. Locations of change in native and non-native percent cover for the understory and canopy (from 2009 to 2014) vegetation in monitored plots in Mahaka Subunit I between 2009 and 2014. Color gradients are inverted for native and non-native vegetation, such that blue indicates beneficial change,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

Species richness

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

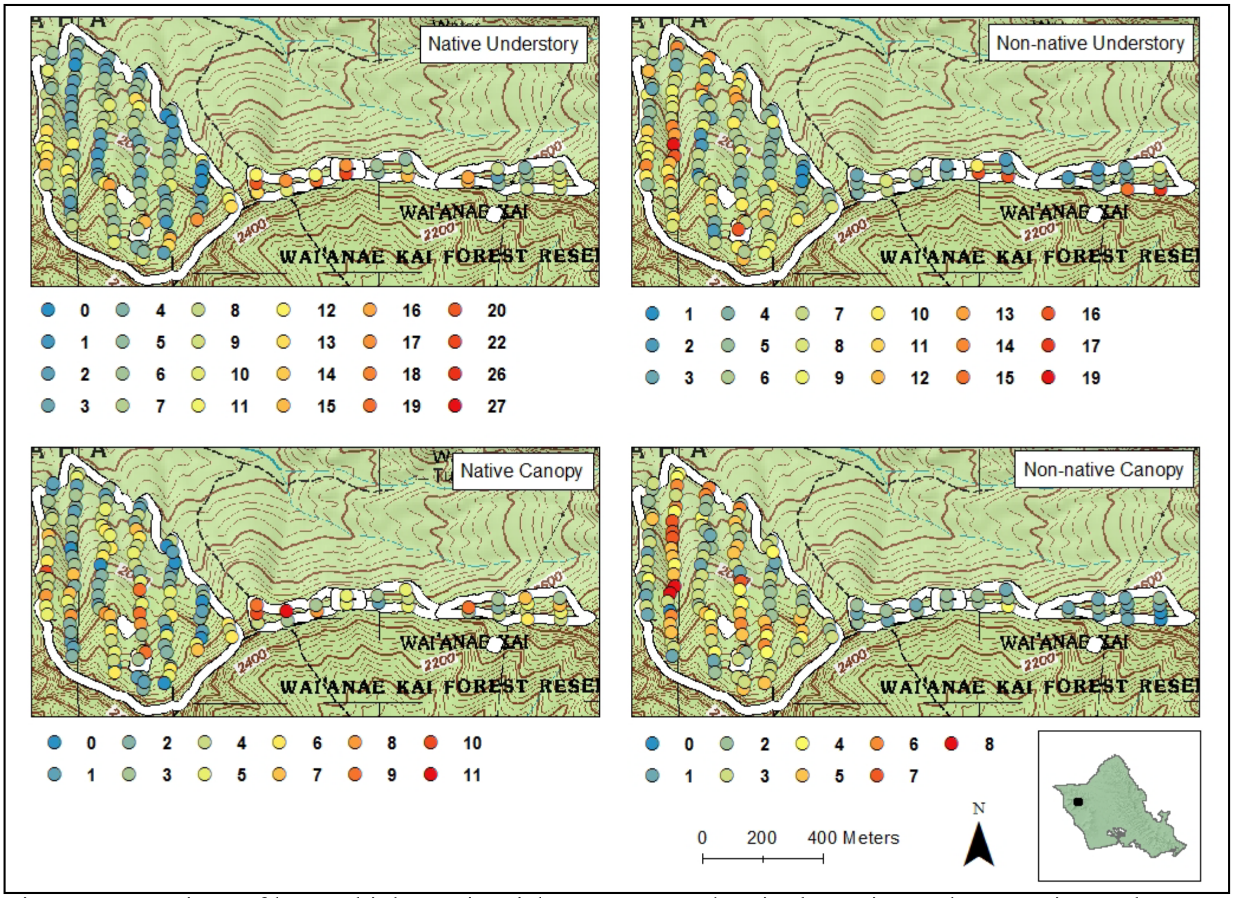


Figure 5. Locations of low to high species richness among plots in the native and non-native understory and canopy in Makaha, 2014. Color gradients of blue to red indicate low to high values, respectively, of the number of species occurring in plots (i.e., blue indicates low diversity, while red indicates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

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

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

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

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

Species frequency

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

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

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

Table 4, continued.

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

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

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

[a]Exact significance. [b]Asymptotic significance.

Species cover

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

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

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

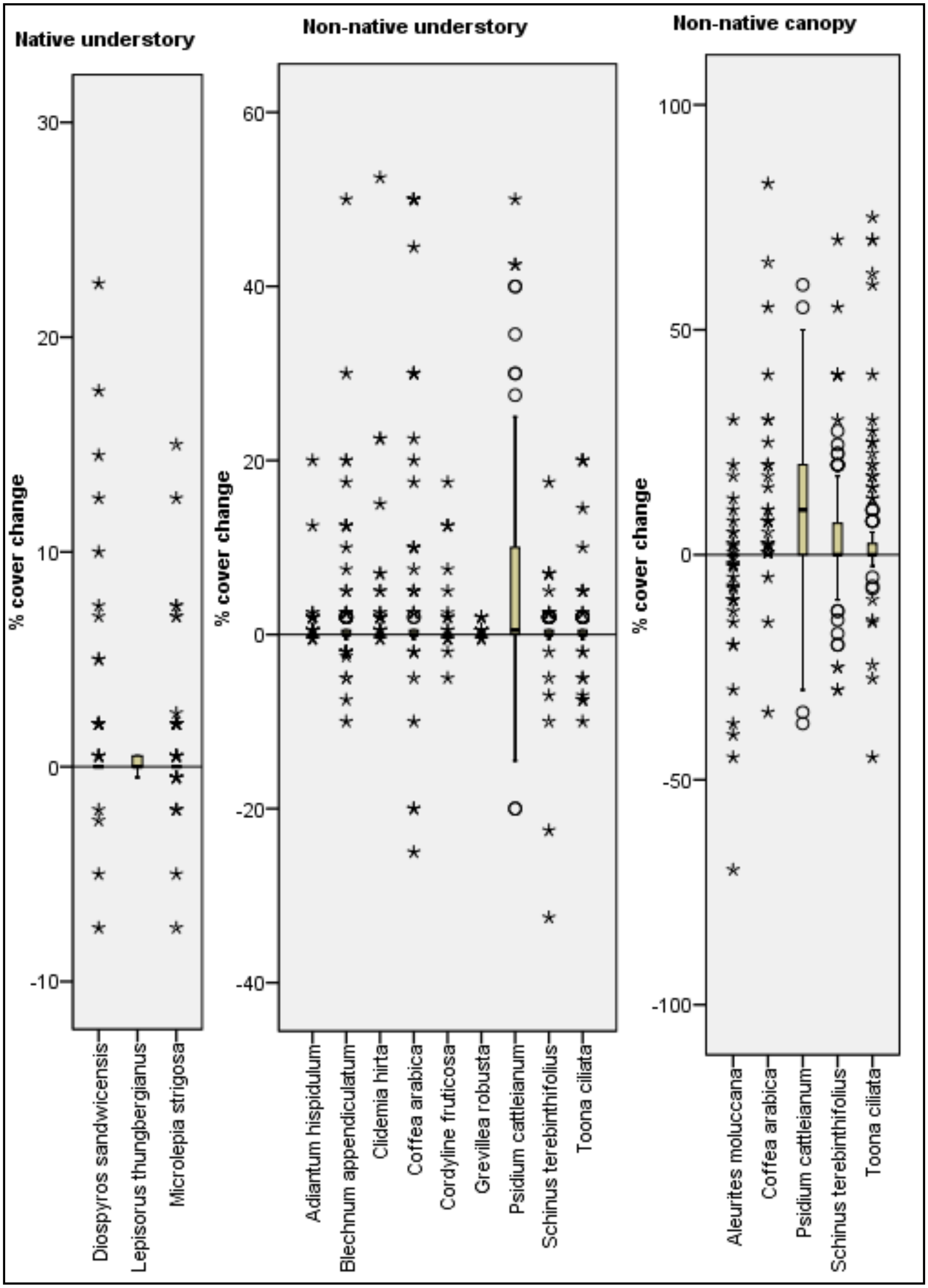


Figure 6. Boxplots of percent cover change between 2009 and 2014 at Makaha Subunit I, for species with significant changes in cover. Values > 0 represent increased cover in plots, while those < 0 represent decreased cover.

Canopy replacement

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

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

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

Weed control

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

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

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

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

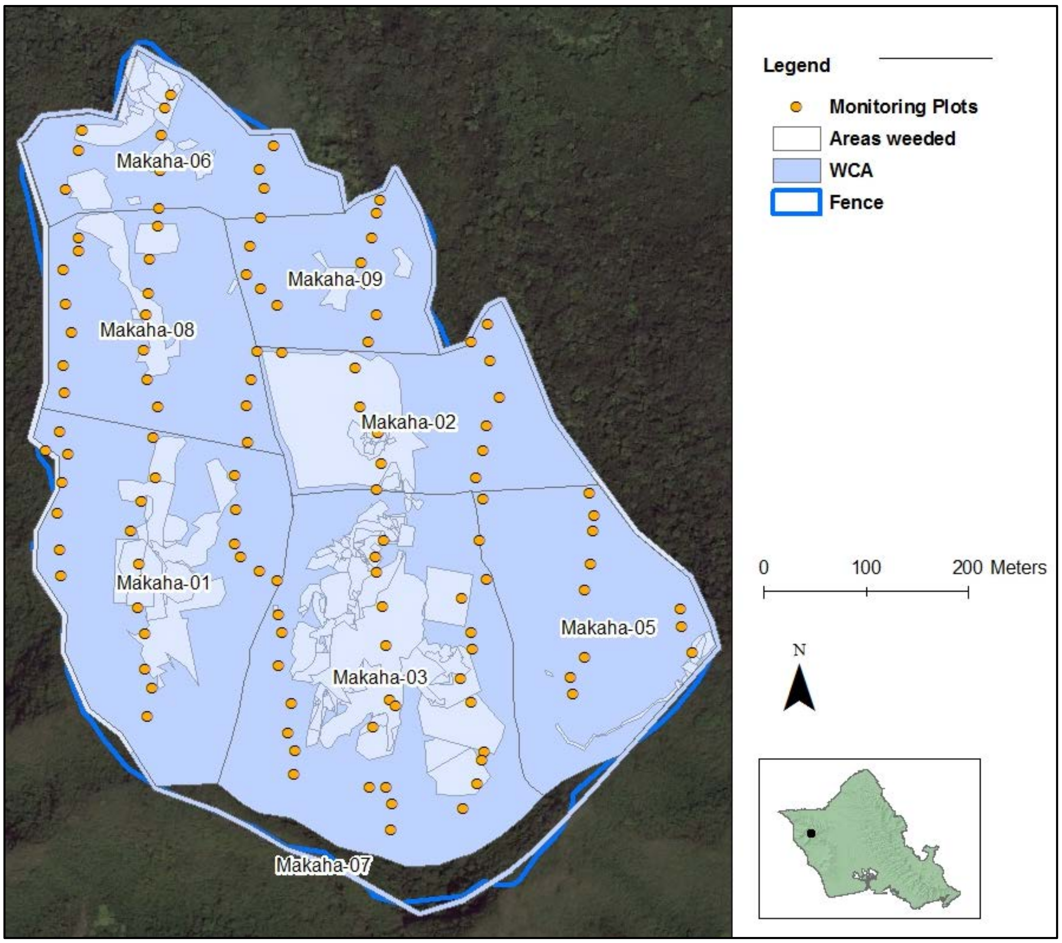


Figure 7. Locations of vegetation monitoring plots at Makaha Subunit I in relation to weed control areas (WCA) and areas weeded between the 2009 and 2014 monitoring intervals.

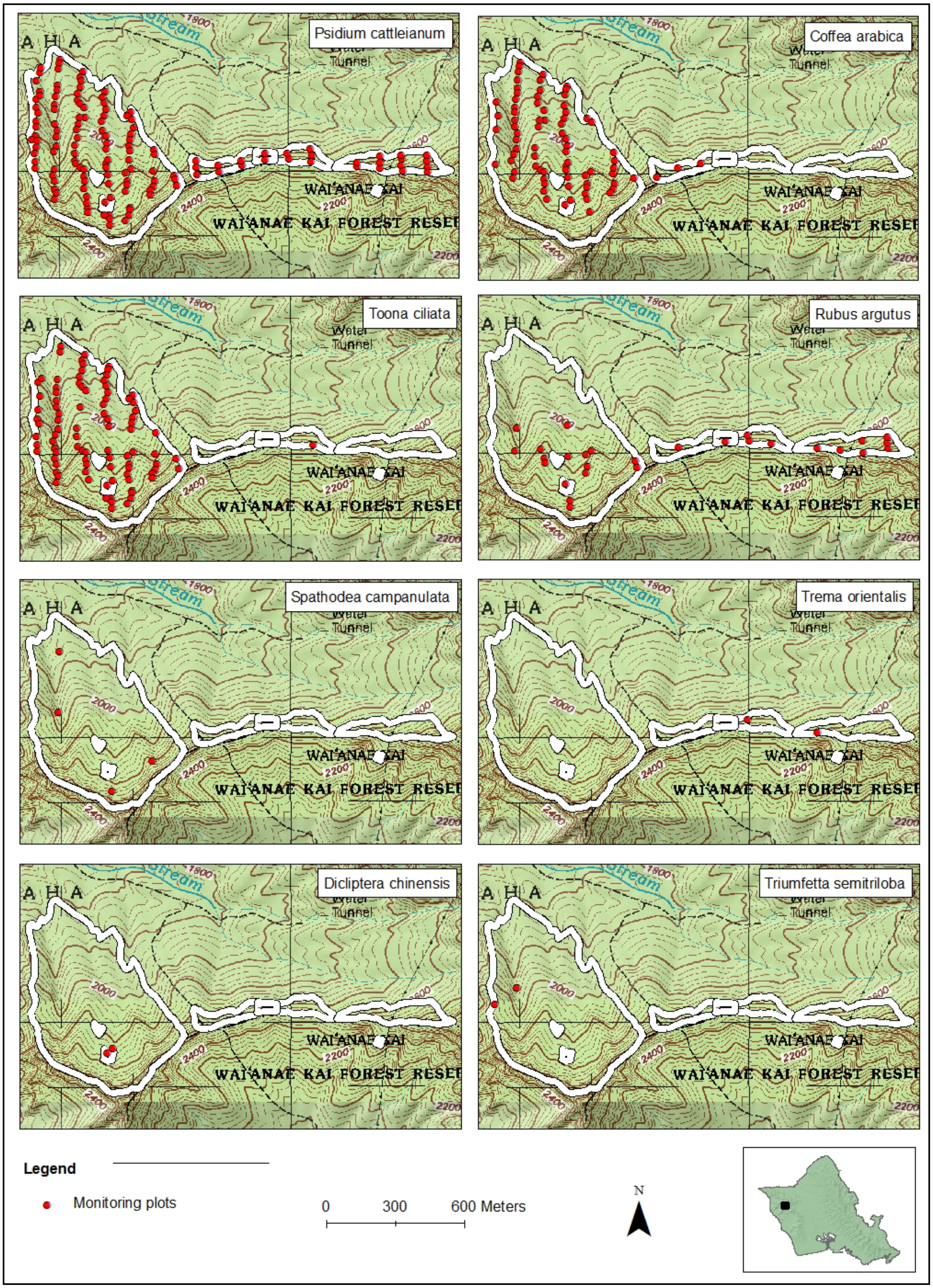


Figure 8. Locations of target taxa in the understory and/or canopy among plots in Makaha Subunit I and II in 2014.

SUMMARY AND DISCUSSION

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

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

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

RECOMMENDATIONS

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

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

REFERENCES

Cole, R. J. and C. M. Litton. 2014. Vegetation response to removal of non-native feral pigs from Hawaiian tropical montane wet forest. Biological Invasions 16:125–140.

Oahu Army Natural Resource Program. 2008. Appendix 2.0 MIP/OIP Belt Plot Sampling Monitoring Protocol *in* 2008 Status Report for the Makua Implementation Plan.

-----. 2010. Chapter 1.3.4 Makaha Ecosystem Restoration Management Plan *in* 2010 Status Report for the Makua and Oahu Implementation Plans.

Weller, S. G., R. J. Cabin, D. H. Lorence, S. Perlman, K. Wood, T. Flynn, and A. K. Sakai. 2011. Alien Plant Invasions, Introduced Ungulates, and Alternative States in a Mesic Forest in Hawaii. Restoration Ecology 19: 671–680.

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Abutilon sandwicense

Target # of Matures: 50

MFS PU Met Goal: 2 of 4

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

Oahu Implementation Plan - Population Unit Status

Action Area: Out

TaxonName: Abutilon sandwicense

Target # of Matures: 50

MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
East Makaleha	Genetic Storage	2	2	40	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0	2013-09-10	No monitoring in the last year
Ekahanui and Huliwai	Manage for stability	14	30	0	18	128	0	**46**	**118**	**5**	5	15	5	41	103	0	2015-07-14	Many of the outplants were observed to have matured in the last year and more outplants were added to the site
Halona	Genetic Storage	0	0	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0		No monitoring in the last year
Makaha Makai	Manage for stability	73	27	6	65	55	0	**92**	**133**	**0**	92	133	0	0	0	0	2015-07-08	A thorough census of the known area found more plants
Makaha Mauka	Genetic Storage	5	58	4	10	51	0	**13**	**1**	**0**	13	1	0	0	0	0	2015-07-09	A thorough census of the known area found fewer plants
Nanakuli	Genetic Storage	0	0	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0		No monitoring in the last year
North Mikilua	Genetic Storage	2	39	0	9	11	0	**9**	**11**	**0**	9	11	0	0	0	0	2012-07-19	No monitoring in the last year
South Mikilua	Genetic Storage	0	0	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0		No monitoring in the last year
Waianae Kai	Genetic Storage	2	0	0	1	0	0	**0**	**0**	**0**	0	0	0	0	0	0	2015-07-09	The last wild plant died in the last year
West Makaleha	Genetic Storage	0	2	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0	2012-09-17	No monitoring in the last year
	Out Total:	98	158	50	103	245	0	**160**	**263**	**5**	119	160	5	41	103	0		
	Total for Taxon:	135	250	66	144	346	10	**265**	**335**	**15**	152	219	15	113	116	0		

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Alectryon macrococcus var. macrococcus

Target # of Matures: 50   # MFS PU Met Goal: 0 of 4

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

Action Area: Out

TaxonName: Alectryon macrococcus var. macrococcus

Target # of Matures: 50   # MFS PU Met Goal: 0 of 4

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

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Cenchrus agrimonioides var. agrimonioides

Target # of Matures: 50

MFS PU Met Goal: 3 of 3

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

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Cyanea acuminata

Target # of Matures: 50 # MFS PU Met Goal: 3 of 3

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

Action Area: Out

TaxonName: Cyanea acuminata

Target # of Matures: 50 # MFS PU Met Goal: 3 of 3

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

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Cyanea grimesiana subsp. obatae

Target # of Matures: 100 # MFS PU Met Goal: 2 of 4

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

Action Area: Out

TaxonName: Cyanea grimesiana subsp. obatae

Target # of Matures: 100 # MFS PU Met Goal: 2 of 4

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

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Cyanea koolauensis

Target # of Matures: 50

MFS PU Met Goal: 1 of 3

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

Action Area: Out

TaxonName: Cyanea koolauensis

Target # of Matures: 50 # MFS PU Met Goal: 1 of 3

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

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Cyanea longiflora

Target # of Matures: 75 # MFS PU Met Goal: 1 of 3

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

Action Area: Out

TaxonName: Cyanea longiflora

Target # of Matures: 75 # MFS PU Met Goal: 1 of 3

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

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Cyanea superba subsp. superba

Target # of Matures: 50 # MFS PU Met Goal: 2 of 4

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

Action Area: Out

TaxonName: Cyanea superba subsp. superba

Target # of Matures: 50 # MFS PU Met Goal: 2 of 4

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

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Cyrtandra dentata

Target # of Matures: 50 # MFS PU Met Goal: 1 of 4

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

Action Area: Out

TaxonName: Cyrtandra dentata

Target # of Matures: 50 # MFS PU Met Goal: 1 of 4

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

Action Area: In

TaxonName: Delissea waianaeensis

Target # of Matures: 100 | # MFS PU Met Goal: 3 of 4

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

Makua Implementation Plan - Population Unit Status

Action Area: Out

TaxonName: *Delissea waianaeensis*

Target # of Matures: 100 # MFS PU Met Goal: 3 of 4

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

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Dubautia herbstobatae

Target # of Matures: 50 | # MFS PU Met Goal: 2 of 3

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

Action Area: Out

TaxonName: Dubautia herbstobatae

Target # of Matures: 50 | # MFS PU Met Goal: 2 of 3

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

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Eugenia koolauensis

Target # of Matures: 50

MFS PU Met Goal: 0 of 3

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

Oahu Implementation Plan - Population Unit Status

Action Area: Out

TaxonName: Eugenia koolauensis

Target # of Matures: 50 | # MFS PU Met Goal: 0 of 3

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

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Euphorbia celastroides var. kaenana

Target # of Matures: 25 # MFS PU Met Goal: 3 of 4

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

Action Area: Out

TaxonName: Euphorbia celastroides var. kaenana

Target # of Matures: 25 # MFS PU Met Goal: 3 of 4

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

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Euphorbia herbstii

Target # of Matures: 25   # MFS PU Met Goal: 1 of 3

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

Action Area: Out

TaxonName: Euphorbia herbstii

Target # of Matures: 25   # MFS PU Met Goal: 1 of 3

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

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Flueggea neowawraea

Target # of Matures: 50 | # MFS PU Met Goal: 0 of 4

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

Action Area: Out

TaxonName: Flueggea neowawraea

Target # of Matures: 50 | # MFS PU Met Goal: 0 of 4

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

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Gardenia mannii

Target # of Matures: 50 # MFS PU Met Goal: 1 of 3

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

Oahu Implementation Plan - Population Unit Status

Action Area: Out

TaxonName: Gardenia mannii

Target # of Matures: 50 # MFS PU Met Goal: 1 of 3

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

Action Area: In

TaxonName: Gouania vitifolia

Target # of Matures: 50   # MFS PU Met Goal: 1 of 3

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

Action Area: Out

TaxonName: Gouania vitifolia

Target # of Matures: 50   # MFS PU Met Goal: 1 of 3

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

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Hesperomannia oahuensis

Target # of Matures: 75 | # MFS PU Met Goal: 0 of 4

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

Action Area: Out

TaxonName: Hesperomannia oahuensis

Target # of Matures: 75 | # MFS PU Met Goal: 0 of 4

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

Action Area: In

TaxonName: Hesperomannia swezeyi

Target # of Matures: 25 # MFS PU Met Goal: 2 of 3

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

Action Area: Out

TaxonName: Hesperomannia swezeyi

Target # of Matures: 25 # MFS PU Met Goal: 2 of 3

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

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Hibiscus brackenridgei subsp. mokuleianus

Target # of Matures: 50 # MFS PU Met Goal: 2 of 4

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

Action Area: Out

TaxonName: Hibiscus brackenridgei subsp. mokuleianus

Target # of Matures: 50 # MFS PU Met Goal: 2 of 4

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

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Kadua degeneri subsp. degeneri

Target # of Matures: 50 | # MFS PU Met Goal: 2 of 4

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

Action Area: Out

TaxonName: Kadua degeneri subsp. degeneri

Target # of Matures: 50 | # MFS PU Met Goal: 2 of 4

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

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Kadua parvula

Target # of Matures: 50   # MFS PU Met Goal: 2 of 3

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

Action Area: Out

TaxonName: Kadua parvula

Target # of Matures: 50   # MFS PU Met Goal: 2 of 3

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

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Labordia cyrtandrae

Target # of Matures: 50 # MFS PU Met Goal: 1 of 2

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

Action Area: Out

TaxonName: Labordia cyrtandrae

Target # of Matures: 50 # MFS PU Met Goal: 1 of 2

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

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Melanthera tenuifolia

Target # of Matures: 50 | # MFS PU Met Goal: 3 of 3

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

Action Area: Out

TaxonName: Melanthera tenuifolia

Target # of Matures: 50 | # MFS PU Met Goal: 3 of 3

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

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Neraudia angulata

Target # of Matures: 100   # MFS PU Met Goal: 2 of 4

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

Action Area: Out

TaxonName: Neraudia angulata

Target # of Matures: 100   # MFS PU Met Goal: 2 of 4

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

Total for Taxon:	141	39	22	350	84	0	**423**	**180**	**0**	93	21	0	330	159	0

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Nototrichium humile

Target # of Matures: 25

MFS PU Met Goal: 4 of 4

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

Makua Implementation Plan - Population Unit Status

Action Area: Out

TaxonName: Nototrichium humile

Target # of Matures: 25 | # MFS PU Met Goal: 4 of 4

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

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Phyllostegia hirsuta

Target # of Matures: 100 # MFS PU Met Goal: 1 of 3

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

Oahu Implementation Plan - Population Unit Status

Action Area: Out

TaxonName: Phyllostegia hirsuta

Target # of Matures: 100 # MFS PU Met Goal: 1 of 3

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

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Phyllostegia kaalaensis

Target # of Matures: 50 # MFS PU Met Goal: 0 of 4

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

Action Area: Out

TaxonName: Phyllostegia kaalaensis

Target # of Matures: 50 # MFS PU Met Goal: 0 of 4

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

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Phyllostegia mollis

Target # of Matures: 100 # MFS PU Met Goal: 0 of 3

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

Action Area: Out

TaxonName: Phyllostegia mollis

Target # of Matures: 100 # MFS PU Met Goal: 0 of 3

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

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Plantago princeps var. princeps

Target # of Matures: 50   # MFS PU Met Goal: 0 of 4

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

Action Area: Out

TaxonName: Plantago princeps var. princeps

Target # of Matures: 50   # MFS PU Met Goal: 0 of 4

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

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Pritchardia kaalae

Target # of Matures: 25 # MFS PU Met Goal: 2 of 3

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

Action Area: Out

TaxonName: Pritchardia kaalae

Target # of Matures: 25 # MFS PU Met Goal: 2 of 3

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

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Sanicula mariversa

Target # of Matures: 100   # MFS PU Met Goal: 0 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Keaau	Manage for stability	16	125	0	0	43	0	**0**	**43**	**0**	0	43	0	0	0	0	2014-04-22	No monitoring in the last year
Ohikilolo	Manage for stability	34	128	0	0	30	200	**0**	**216**	**200**	0	30	200	0	186	0	2015-02-12	Plants were added to the new outplanting site
	In Total:	50	253	0	0	73	200	**0**	**259**	**200**	0	73	200	0	186	0		

Action Area: Out

TaxonName: Sanicula mariversa

Target # of Matures: 100   # MFS PU Met Goal: 0 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kamaileunu	Manage for stability	26	0	0	1	360	14	**5**	**408**	**135**	5	408	135	0	0	0	2015-03-18	A thorough census of the known area found more plants
Puu Kawiwi	Genetic Storage	2	0	0	0	8	0	**0**	**8**	**0**	0	8	0	0	0	0	2014-04-28	No monitoring in the last year
	Out Total:	28	0	0	1	368	14	**5**	**416**	**135**	5	416	135	0	0	0		
	Total for Taxon:	78	253	0	1	441	214	**5**	**675**	**335**	5	489	335	0	186	0		

Action Area: In

TaxonName: Schiedea kaalae

Target # of Matures: 50   # MFS PU Met Goal: 3 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Pahole	Manage for stability	3	0	0	106	26	200	**83**	**145**	**47**	2	0	0	81	145	47	2015-04-06	Many of the outplants died, but new immature plants are becoming established and seedlings are still present
In Total:		3	0	0	106	26	200	**83**	**145**	**47**	2	0	0	81	145	47		

Action Area: Out

TaxonName: Schiedea kaalae

Target # of Matures: 50   # MFS PU Met Goal: 3 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kahana	Genetic Storage	0	0	0	8	0	2	**8**	**0**	**2**	5	0	1	3	0	1	2012-08-09	No monitoring in the last year
Kaluaa and Waieli	Manage for stability	2	53	0	198	8	0	**166**	**5**	**0**	0	0	0	166	5	0	2015-01-22	Thorough monitoring in the last year showed a decline as many of the outplants died
Maakua (Koolaus)	Manage for stability	4	0	0	10	0	0	**10**	**0**	**0**	10	0	0	0	0	0	2008-07-02	The sites were visited, but not thoroughly counted in the last year
Makaua (Koolaus)	Genetic Storage	2	0	0	85	0	0	**85**	**0**	**0**	1	0	0	84	0	0	2012-02-29	No monitoring in the last year
North Palawai	Genetic Storage	1	0	0	0	0	0	**0**	**0**	**0**	0	0	0	0	0	0	2011-04-18	No monitoring in the last year
South Ekahanui	Manage for stability	10	75	0	160	268	12	**160**	**268**	**12**	9	2	0	151	266	12	2015-04-15	The sites were visited, but not thoroughly counted in the last year
Out Total:		19	128	0	461	276	14	**429**	**273**	**14**	25	2	1	404	271	13		
Total for Taxon:		22	128	0	567	302	214	**512**	**418**	**61**	27	2	1	485	416	60		

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Schiedea nuttallii

Target # of Matures: 50 # MFS PU Met Goal: 3 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kahanahaiki to Pahole	Manage for stability	48	17	0	113	113	58	**108**	**112**	**58**	6	0	0	102	112	58	2015-04-06	Small changes were noted during monitoring in the last year
Kapuna-Keawapilau Ridge	Manage for stability	3	1	0	98	15	0	**74**	**0**	**0**	0	0	0	74	0	0	2015-04-21	Thorough monitoring in the last year showed a decline as more of the outplants died. Several were predated by rodents in the last year
	In Total:	51	18	0	211	128	58	**182**	**112**	**58**	6	0	0	176	112	58		

Action Area: Out

TaxonName: Schiedea nuttallii

Target # of Matures: 50 # MFS PU Met Goal: 3 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Makaha	Manage reintroduction for stability	0	0	0	57	0	0	**68**	**43**	**0**	0	0	0	68	43	0	2015-05-12	More plants were added to the outplanting site though many were injured by rodents
	Out Total:	0	0	0	57	0	0	**68**	**43**	**0**	0	0	0	68	43	0		
	Total for Taxon:	51	18	0	268	128	58	**250**	**155**	**58**	6	0	0	244	155	58		

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Schiedea obovata

Target # of Matures: 100 | # MFS PU Met Goal: 2 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kahanahaiki to Pahole	Manage for stability	65	25	0	232	1729	2729	**283**	**1028**	**210**	0	0	0	283	1028	210	2015-09-02	Small changes were noted during monitoring in the last year and fewer seedlings were observed
Keawapilau to West Makaleha	Manage for stability	24	12	0	72	1347	2160	**58**	**526**	**67**	12	524	67	46	2	0	2015-06-22	Thorough monitoring in the last year showed a decline from the previous year
	In Total:	89	37	0	304	3076	4889	**341**	**1554**	**277**	12	524	67	329	1030	210		

Action Area: Out

TaxonName: Schiedea obovata

Target # of Matures: 100 | # MFS PU Met Goal: 2 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Makaha	Manage reintroduction for stability	0	0	0	104	122	0	**146**	**52**	**13**	0	0	0	146	52	13	2015-05-12	Many of the outplants were observed to have matured in the last year and seedlings were observed at this outplanting site
	Out Total:	0	0	0	104	122	0	**146**	**52**	**13**	0	0	0	146	52	13		
	Total for Taxon:	89	37	0	408	3198	4889	**487**	**1606**	**290**	12	524	67	475	1082	223		

Action Area: In

TaxonName: Schiedea trinervis

Target # of Matures: 50

MFS PU Met Goal: 1 of 1

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kalena to East Makaleha	Manage for stability	180	196	318	352	270	333	**296**	**351**	**377**	296	351	377	0	0	0	2015-08-04	Population counts were revised after updating old observations and finding a few new sites
	In Total:	180	196	318	352	270	333	**296**	**351**	**377**	296	351	377	0	0	0		
	Total for Taxon:	180	196	318	352	270	333	**296**	**351**	**377**	296	351	377	0	0	0		

Oahu Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Stenogyne kanehoana

Target # of Matures: 100 # MFS PU Met Goal: 0 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Haleauau	Manage reintroduction for stability	1	0	0	0	0	0	**0**	**129**	**0**	0	0	0	0	129	0	2015-08-26	Plants were added to the new outplanting site
	In Total:	1	0	0	0	0	0	**0**	**129**	**0**	0	0	0	0	129	0		

Action Area: Out

TaxonName: Stenogyne kanehoana

Target # of Matures: 100 # MFS PU Met Goal: 0 of 3

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kaluaa	Manage reintroduction for stability	0	79	0	28	194	0	**26**	**178**	**0**	0	0	0	26	178	0	2015-03-23	Thorough monitoring in the last year showed a decline
Makaha	Manage reintroduction for stability				0	156	0	**0**	**130**	**0**	0	0	0	0	130	0	2015-06-03	Thorough monitoring in the last year showed a decline as some of the outplants were observed to have died
	Out Total:	0	79	0	28	350	0	**26**	**308**	**0**	0	0	0	26	308	0		
	Total for Taxon:	1	79	0	28	350	0	**26**	**437**	**0**	0	0	0	26	437	0		

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Tetramolopium filiforme

Target # of Matures: 50   # MFS PU Met Goal: 1 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Kahanahaiki	Genetic Storage	50	0	0	40	0	0	**40**	**0**	**0**	40	0	0	0	0	0	2006-10-04	The sites were visited, but not thoroughly counted in the last year
Kalena	Manage for stability				24	93	0	**24**	**93**	**0**	24	93	0	0	0	0	2013-05-21	No monitoring in the last year
Keaau	Genetic Storage	25	0	0	30	41	17	**30**	**41**	**17**	30	41	17	0	0	0	2005-11-07	No monitoring in the last year
Makaha/Ohikilolo Ridge	Genetic Storage				300	0	0	**300**	**0**	**0**	300	0	0	0	0	0	1998-01-01	No monitoring in the last year
Ohikilolo	Manage for stability	2500	0	0	2394	1464	20	**2394**	**1464**	**20**	2394	1464	20	0	0	0	2014-07-23	The sites were visited, but not thoroughly counted in the last year
Puhawai	Manage for stability	6	6	0	10	75	3	**21**	**9**	**2**	0	0	0	21	9	2	2015-06-24	Small changes were noted during monitoring in the last year and several of the new plants matured. Most outplants are now dead at this site, but seedlings are still observed
	In Total:	2581	6	0	2798	1673	40	**2809**	**1607**	**39**	2788	1598	37	21	9	2		

Action Area: Out

TaxonName: Tetramolopium filiforme

Target # of Matures: 50   # MFS PU Met Goal: 1 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Waianae Kai	Manage for stability	20	2	0	30	8	1	**20**	**0**	**0**	20	0	0	0	0	0	2015-06-24	Thorough monitoring in the last year showed a decline
	Out Total:	20	2	0	30	8	1	**20**	**0**	**0**	20	0	0	0	0	0		
	Total for Taxon:	2601	8	0	2828	1681	41	**2829**	**1607**	**39**	2808	1598	37	21	9	2		

Makua Implementation Plan - Population Unit Status

Action Area: In

TaxonName: Viola chamissoniana subsp. chamissoniana

Target # of Matures: 50 # MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Keaau	Genetic Storage	40	10	0	40	10	0	**40**	**10**	**0**	40	10	0	0	0	0	2002-06-04	No monitoring in the last year
Makaha/Ohikilolo Ridge	Genetic Storage	250	0	0	7	0	0	**7**	**0**	**0**	7	0	0	0	0	0	2000-04-24	No monitoring in the last year
Ohikilolo	Manage for stability				386	25	1	**386**	**25**	**1**	386	25	1	0	0	0	2013-09-04	No monitoring in the last year
Puu Kumakalii	Manage for stability	19	1	0	44	0	0	**44**	**0**	**0**	44	0	0	0	0	0	2004-10-21	The sites were visited, but not thoroughly counted in the last year
	In Total:	309	11	0	477	35	1	**477**	**35**	**1**	477	35	1	0	0	0		

Action Area: Out

TaxonName: Viola chamissoniana subsp. chamissoniana

Target # of Matures: 50 # MFS PU Met Goal: 2 of 4

Population Unit Name	Management Designation	Total Mature Original IP	Total Imm Original IP	Total Seedling Original IP	Total Mature 2014	Total Immature 2014	Total Seedling 2014	**Total Mature Current**	**Total Immature Current**	**Total Seedling Current**	Wild Mature Current	Wild Immature Current	Wild Seedling Current	Outplanted Mature Current	Outplanted Immature Current	Outplanted Seedling Current	PU LastObs Date	Population Trend Notes
Halona	Manage for stability	3	0	0	41	3	0	**22**	**5**	**0**	22	5	0	0	0	0	2013-12-03	No monitoring in the last year
Kamaileunu	Genetic Storage	38	0	0	35	0	0	**35**	**0**	**0**	35	0	0	0	0	0	2000-05-23	No monitoring in the last year
Makaha	Manage for stability	50	0	0	68	11	0	**68**	**11**	**0**	68	11	0	0	0	0	2014-05-14	No monitoring in the last year
Makaleha	Genetic Storage				34	1	0	**18**	**9**	**0**	18	9	0	0	0	0	2015-06-03	Thorough monitoring in the last year showed a decline
Puu Hapapa	Genetic Storage	10	3	0	7	2	0	**7**	**2**	**0**	7	2	0	0	0	0	2013-12-05	No monitoring in the last year
	Out Total:	101	3	0	185	17	0	**150**	**27**	**0**	150	27	0	0	0	0		
	Total for Taxon:	410	14	0	662	52	1	**627**	**62**	**1**	627	62	1	0	0	0		

Threat Control Summary

Action Area: In

TaxonName: Abutilon sandwicense

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kaawa to Puulu	Manage for stability	32	Partial 59%	Partial 0%	No	No	Partial 100%
Kahanahaiki	Manage reintroduction for stability	72	Yes	Partial 100%	No	No	No
Kaluakauila	Manage reintroduction for storage	0	Yes	No	No	No	No
Keaau	Genetic Storage	1	No	No	No	No	No

Action Area: Out

TaxonName: Abutilon sandwicense

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
East Makaleha	Genetic Storage	0	No	No	No	No	No
Ekahanui and Huliwai	Manage for stability	46	Yes	Partial 93%	No	No	No
Makaha Makai	Manage for stability	92	Partial 75%	No	No	No	No
Makaha Mauka	Genetic Storage	13	No	No	No	No	No
North Mikilua	Genetic Storage	9	Yes	No	No	No	No
Waianae Kai	Genetic Storage	0	Partial	No	No	No	Partial
West Makaleha	Genetic Storage	0	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Alectryon macrococcus var. macrococcus

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki to Keawapilau	Manage for stability	1	Yes	Partial 0%	Partial 0%	No	No
Makua	Manage for stability	11	Partial 100%	No	No	No	No
South Mohiakea	Genetic Storage	2	Yes	No	No	No	No
West Makaleha	Genetic Storage	13	No	No	No	No	No

Action Area: Out

TaxonName: Alectryon macrococcus var. macrococcus

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Central Kaluaa to Central Waieli	Manage for stability	3	Partial 0%	Partial 0%	No	No	No
Makaha	Manage for stability	36	Yes	Partial 97%	No	No	No
Waianae Kai	Genetic Storage	1	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Cenchrus agrimonioides var. agrimonioides

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

Action Area: Out

TaxonName: Cenchrus agrimonioides var. agrimonioides

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

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Cyanea acuminata

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Helemano-Punaluu Summit Ridge to North Kaukonahua	Manage for stability	130	No	No	No	No	No
Kahana and South Kaukonahua	Genetic Storage	2	No	No	No	No	No
Makaleha to Mohiakea	Manage for stability	151	Partial 97%	Partial 2%	No	No	No

Action Area: Out

TaxonName: Cyanea acuminata

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahana and Makaua	Genetic Storage	11	No	No	No	No	No
Kaipapau and Koloa	Genetic Storage	70	Partial 0%	No	No	No	No
Kaluanui and Maakua	Manage for stability	123	No	No	No	No	No
Puukeahiakahoe	Genetic Storage	3	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Cyanea grimesiana subsp. obatae

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Pahole to West Makaleha	Manage for stability	75	Yes	Partial 65%	Partial 35%	Partial 35%	No

Action Area: Out

TaxonName: Cyanea grimesiana subsp. obatae

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kaluaa	Manage for stability	128	Yes	Partial 100%	No	No	No
Makaha	Genetic Storage	4	Yes	No	Yes	Yes	No
North branch of South Ekahanui	Manage reintroduction for stability	83	Yes	Partial 100%	Yes	Yes	No
Palikea (South Palawai)	Manage for stability	108	Yes	Yes	Yes	Yes	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Cyanea koolauensis

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kaipapau, Koloa and Kawainui	Manage for stability	106	Partial 84%	Partial 2%	No	No	No
Kamananui-Kawainui Ridge	Genetic Storage	6	No	No	No	No	No
Kaukonahua	Genetic Storage	8	No	No	No	No	No
Kawaiiki	Genetic Storage	4	No	No	No	No	No
Lower Opaeula	Genetic Storage	1	No	No	No	No	No
Opaeula to Helemano	Manage for stability	23	Partial 48%	Partial 9%	No	No	No
Poamoho	Manage for stability	21	No	No	No	No	No

Action Area: Out

TaxonName: Cyanea koolauensis

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Halawa	Genetic Storage	4	No	No	No	No	No
Waialae Nui	Genetic Storage	2	No	No	No	No	No
Waiawa to Waimano	Genetic Storage	11	Partial 45%	No	No	No	No
Wailupe	Genetic Storage	1	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Cyanea longiflora

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kapuna to West Makaleha	Manage for stability	28	Yes	Partial 57%	No	Partial 18%	No
Pahole	Manage for stability	58	Yes	No	No	No	No

Action Area: Out

TaxonName: Cyanea longiflora

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Makaha and Waianae Kai	Manage for stability	110	Yes	Partial 100%	Partial 100%	Yes	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Cyanea superba subsp. superba

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki	Manage reintroduction for stability	58	Yes	Partial 78%	Yes	Partial 45%	No
Pahole to Kapuna	Manage reintroduction for stability	95	Yes	Partial 71%	Partial 60%	No	No

Action Area: Out

TaxonName: Cyanea superba subsp. superba

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Makaha	Manage reintroduction for stability	27	Yes	No	Yes	No	No
Manuwai	Manage reintroduction for stability	0	Yes	Yes	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Cyrtandra dentata

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki	Manage for stability	37	Yes	Yes	Yes	No	No
Kawaiiki (Koolaus)	Manage for stability	5	No	No	No	No	No
Opaeula (Koolaus)	Manage for stability	23	Partial 100%	No	No	No	No
Pahole to West Makaleha	Manage for stability	603	Partial 96%	No	No	No	No

Action Area: Out

TaxonName: Cyrtandra dentata

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Central Makaleha	Genetic Storage	3	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Delissea waianaeensis

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki to Keawapilau	Manage for stability	240	Yes	Partial 98%	Partial 12%	No	No
Kaluakauila	Manage reintroduction for storage	15	Yes	No	No	No	No
Kapuna	Manage reintroduction for storage	113	Yes	No	No	No	No
Palikea Gulch	Genetic Storage	1	No	No	No	No	Partial 100%
South Mohiakea	Genetic Storage	12	Yes	Yes	No	No	No

Action Area: Out

TaxonName: Delissea waianaeensis

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Ekahanui	Manage for stability	196	Yes	Partial 99%	Yes	Partial 99%	No
Kaluaa	Manage for stability	650	Yes	Partial 99%	No	Partial 55%	No
Kealia	Genetic Storage	4	No	No	No	No	No
Manuwai	Manage reintroduction for stability	88	Yes	Yes	Yes	No	No
Palawai	Genetic Storage	17	Partial 94%	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Dubautia herbstobatae

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Keaau	Genetic Storage	70	No	No	No	No	No
Makaha/Ohikilolo	Genetic Storage	350	No	No	No	No	No
Ohikilolo Makai	Manage for stability	89	Yes	No	No	No	No
Ohikilolo Mauka	Manage for stability	415	Yes	No	No	No	No

Action Area: Out

TaxonName: Dubautia herbstobatae

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kamaileunu	Genetic Storage	0	No	No	No	No	No
Makaha	Manage for stability	28	No	No	No	No	No
Waianae Kai	Genetic Storage	10	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Eugenia koolauensis

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Aimuu	Genetic Storage	8	No	No	No	No	No
Kaiwikoele and Kamananui	Genetic Storage	21	Partial 0%	No	No	No	No
Kaleleiki	Genetic Storage	14	Partial 50%	No	No	No	No
Kaunala	Manage for stability	20	Partial 95%	Partial 95%	No	No	No
Malaekahana	Genetic Storage	5	No	No	No	No	No
Ohiaai and East Oio	Genetic Storage	1	No	No	No	No	No
Oio	Manage for stability	5	Yes	No	No	No	No
Pahipahialua	Manage for stability	22	Yes	No	No	No	No

Action Area: Out

TaxonName: Eugenia koolauensis

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Hanaimoa	Genetic Storage	1	No	No	No	No	No
Palikea and Kaimuhole	Genetic Storage	1	No	No	No	No	Partial 100%

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Euphorbia celastroides var. kaenana

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
East Kahanahaiki	Genetic Storage	2	No	No	No	No	No
Kaluakauila	Genetic Storage	11	No	No	No	No	No
Makua	Manage for stability	85	Yes	Yes	No	No	Partial 100%
North Kahanahaiki	Genetic Storage	115	No	No	No	No	No
Puaakanoa	Manage for stability	150	No	No	No	No	No

Action Area: Out

TaxonName: Euphorbia celastroides var. kaenana

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
East of Alau	Manage for stability	21	No	No	No	No	No
Kaena	Manage for stability	579	No	No	No	No	No
Keawaula	Genetic Storage	43	No	No	No	No	No
Waianae Kai	Genetic Storage	34	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Euphorbia herbstii

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kapuna to Pahole	Manage for stability	56	Yes	Partial 96%	No	No	No
Manuwai	Manage reintroduction for stability	0	Yes	No	No	No	No

Action Area: Out

TaxonName: Euphorbia herbstii

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kaluaa	Manage reintroduction for stability	0	Yes	No	No	No	No
Makaha	Manage reintroduction for storage	4	Yes	No	Yes	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Flueggea neowawraea

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki to Kapuna	Manage for stability	6	Yes	Partial 0%	Partial 17%	No	No
Ohikilolo	Manage for stability	1	Yes	No	No	No	No
West Makaleha	Genetic Storage	6	No	No	No	No	No

Action Area: Out

TaxonName: Flueggea neowawraea

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Central and East Makaleha	Genetic Storage	5	No	No	No	No	No
Halona	Genetic Storage	1	No	No	No	No	No
Kauhiuhi	Genetic Storage	1	No	No	No	No	No
Makaha	Manage for stability	10	Partial 40%	Partial 0%	No	No	No
Manuwai	Manage reintroduction for stability	0	Yes	Yes	No	No	No
Mikilua	Genetic Storage	0	Yes	No	No	No	No
Mt. Kaala NAR	Genetic Storage	3	No	No	No	No	No
Nanakuli, south branch	Genetic Storage	1	No	No	No	No	No
Waianae Kai	Genetic Storage	1	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Gardenia mannii

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Haleauau	Manage for stability	69	Partial 100%	Partial 87%	No	No	No
Helemano and Poamoho	Manage for stability	17	No	No	No	No	No
Kaiwikoele, Kamananui, and Kawainui	Genetic Storage	13	No	No	No	No	No
Lower Peahinaia	Manage for stability	9	Partial 67%	Partial 56%	No	No	No
South Kaukonahua	Genetic Storage	1	No	No	No	No	No
Upper Opaeula/Helemano	Genetic Storage	1	Yes	No	No	No	No

Action Area: Out

TaxonName: Gardenia mannii

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Ihiihi-Kawainui ridge	Genetic Storage	2	No	No	No	No	No
Kaluaa and Maunauna	Genetic Storage	2	No	No	No	No	No
Kamananui-Malaekahana Summit Ridge	Genetic Storage	3	No	No	No	No	No
Kapakahi	Genetic Storage	2	No	No	No	No	No
Pukele	Genetic Storage	1	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Gouania vitifolia

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Keaau	Manage for stability	55	No	No	No	No	No

Action Area: Out

TaxonName: Gouania vitifolia

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Makaha (Future Introduction)	Manage reintroduction for stability	0	Yes	No	No	No	No
Manuwai (Future Introduction)	Manage reintroduction for stability	0	Yes	No	No	No	No
Waianae Kai	Genetic Storage	3	Yes	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Hesperomannia oahuensis

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Haleauau	Manage for stability	1	Yes	No	Yes	No	No
Pahole NAR	Manage reintroduction for stability	4	Yes	Yes	Yes	No	No

Action Area: Out

TaxonName: Hesperomannia oahuensis

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Makaha	Manage for stability	3	Yes	Partial 0%	Yes	Partial 0%	No
Napepeiauolelo	Genetic Storage	0	Yes	No	No	No	No
North Palawai	Genetic Storage	0	Yes	No	No	No	No
Pualii	Manage reintroduction for stability	6	Yes	Yes	Yes	No	No
Waianae Kai	Genetic Storage	0	Yes	No	Yes	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Hesperomannia swezeyi

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kamananui to Kaluanui	Manage for stability	134	Partial 4%	No	No	No	No
Kaukonahua	Manage for stability	55	No	No	No	No	No
Lower Opaeula	Manage for stability	18	No	No	No	No	No
Poamoho	Genetic Storage	21	No	No	No	No	No

Action Area: Out

TaxonName: Hesperomannia swezeyi

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Niu-Waimanalo Summit	Genetic Storage	1	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Hibiscus brackenridgei subsp. mokuleianus

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Keaau	Manage for stability	0	Yes	No	No	No	No
Makua	Manage for stability	80	Yes	Yes	No	No	Partial 100%

Action Area: Out

TaxonName: Hibiscus brackenridgei subsp. mokuleianus

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Haili to Kawaiu	Manage for stability	5	No	No	No	No	No
Manuwai	Manage reintroduction for stability	160	Yes	Yes	No	No	No
Waialua	Genetic Storage	49	Partial 37%	No	No	No	Partial 100%

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Kadua degeneri subsp. degeneri

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki to Pahole	Manage for stability	147	Yes	No	No	No	No

Action Area: Out

TaxonName: Kadua degeneri subsp. degeneri

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Alaiheihe and Manuwai	Manage for stability	78	Partial 95%	Partial 51%	No	No	No
Central Makaleha and West Branch of East Makaleha	Manage for stability	23	No	No	No	No	No
East branch of East Makaleha	Genetic Storage	0	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Kadua parvula

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Ohikilolo	Manage for stability	100	Yes	No	No	No	No

Action Area: Out

TaxonName: Kadua parvula

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Halona	Manage for stability	93	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Labordia cyrtandrae

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
East Makaleha to North Mohiakea	Manage for stability	295	Partial 88%	Partial 65%	No	No	No

Action Area: Out

TaxonName: Labordia cyrtandrae

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Koloa	Manage reintroduction for stability	33	Yes	No	No	No	No

(shaded) = Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Melanthera tenuifolia

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki	Genetic Storage	13	Partial 100%	No	No	No	No
Kaluakauila	Genetic Storage	4	Yes	No	No	No	No
Keawaula	Genetic Storage	137	No	No	No	No	No
Ohikilolo	Manage for stability	1109	Yes	No	No	No	Partial 52%

Action Area: Out

TaxonName: Melanthera tenuifolia

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kamaileunu and Waianae Kai	Manage for stability	815	No	No	No	No	No
Mt. Kaala NAR	Manage for stability	121	Yes	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Neraudia angulata

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kaluakauila	Manage reintroduction for stability	65	Yes	No	No	No	No
Kapuna	Genetic Storage	0	No	No	No	No	No
Makua	Manage for stability	120	Yes	No	No	No	No
Punapohaku	Genetic Storage	4	No	No	No	No	No

Action Area: Out

TaxonName: Neraudia angulata

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Halona	Genetic Storage	32	No	No	No	No	No
Leeward Puu Kaua	Genetic Storage	9	No	No	No	No	No
Makaha	Manage for stability (backup site)	52	Partial 94%	Partial 96%	No	No	No
Manuwai	Manage for stability	115	Yes	Yes	No	No	No
Waianae Kai Makai	Genetic Storage	13	Yes	No	No	No	Partial 100%
Waianae Kai Mauka	Manage for stability	13	Yes	Partial 100%	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Nototrichium humile

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki	Genetic Storage	50	Partial 100%	No	Partial 30%	No	No
Kaluakauila	Manage for stability	160	Yes	No	No	No	No
Keaau	Genetic Storage	21	No	No	No	No	No
Keawaula	Genetic Storage	35	No	No	No	No	No
Makua (East rim)	Genetic Storage	1	No	No	No	No	No
Makua (south side)	Manage for stability	50	Partial 100%	No	No	No	No
Punapohaku	Genetic Storage	178	No	No	No	No	No

Action Area: Out

TaxonName: Nototrichium humile

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kaimuhole and Palikea Gulch	Genetic Storage	29	No	No	No	No	Partial 100%
Keawapilau	Genetic Storage	1	No	No	No	No	No
Kolekole	Genetic Storage	12	Partial 33%	No	No	No	No
Makaha	Genetic Storage	22	No	No	No	No	No
Manuwai	Manage reintroduction for stability	115	Yes	Yes	No	No	No
Nanakuli	Genetic Storage	5	No	No	No	No	No
Puu Kaua (Leeward side)	Genetic Storage	2	No	No	No	No	No
Waianae Kai	Manage for stability	216	Partial 88%	Partial 88%	No	No	Partial 88%

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Phyllostegia hirsuta

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Haleauau to Mohiakea	Manage for stability	71	Partial 100%	Partial 85%	No	No	No
Helemano and Opaeula	Genetic Storage	1	Partial 0%	No	No	No	No
Helemano to Poamoho	Genetic Storage	2	No	No	No	No	No
Kaipapau and Kawainui	Genetic Storage	4	No	No	No	No	No
Kaukonahua	Genetic Storage	0	No	No	No	No	No
Kawaiiki	Genetic Storage	0	No	No	No	No	No
Koloa	Manage for stability	97	Partial 98%	Partial 98%	No	No	No

Action Area: Out

TaxonName: Phyllostegia hirsuta

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Hapapa to Kaluaa	Genetic Storage	2	Partial 0%	No	No	No	No
Kaluanui and Punaluu	Genetic Storage	5	No	No	No	No	No
Makaha-Waianae Kai Ridge	Genetic Storage	1	No	No	No	No	No
Palawai	Genetic Storage	0	No	No	No	No	No
Puu Palikea	Manage reintroduction for stability	114	Yes	Yes	No	No	No
Waiamano	Genetic Storage	1	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Phyllostegia kaalaensis

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Keawapilau to Kapuna	Manage reintroduction for stability	0	Yes	No	No	No	No
Pahole	Manage reintroduction for stability	0	Yes	No	No	No	No
Palikea Gulch	Genetic Storage	0	No	No	No	No	No

Action Area: Out

TaxonName: Phyllostegia kaalaensis

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Makaha	Manage reintroduction for stability	0	Yes	No	No	No	No
Manuwai	Manage reintroduction for stability	0	Yes	Yes	No	No	No
Waianae Kai	Genetic Storage	0	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Phyllostegia mollis

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Mohiakea	Genetic Storage	0	Yes	No	No	No	No

Action Area: Out

TaxonName: Phyllostegia mollis

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Ekahanui	Manage for stability	11	Yes	Partial 82%	Partial 100%	Partial 82%	No
Kaluaa	Manage for stability	88	Yes	Partial 100%	No	No	No
Pualii	Manage reintroduction for stability	11	Yes	No	No	No	No
Waieli	Genetic Storage	1	Partial 100%	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Plantago princeps var. princeps

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
North Mohiakea	Manage for stability	39	Yes	No	No	No	No
Ohikilolo	Manage for stability	0	Yes	No	No	No	No
Pahole	Genetic Storage	2	Yes	No	No	No	No

Action Area: Out

TaxonName: Plantago princeps var. princeps

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Ekahanui	Manage for stability	48	Yes	Partial 4%	Yes	No	No
Halona	Manage for stability	10	No	No	No	No	No
North Palawai	Genetic Storage	5	No	No	No	No	No
Waieli	Manage reintroduction for storage	12	Yes	Yes	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Pritchardia kaalae

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Ohikilolo	Manage for stability	85	Yes	Partial 12%	Partial 88%	No	No
Ohikilolo East and West Makaleha	Manage reintroduction for stability	4	Yes	No	No	No	No

Action Area: Out

TaxonName: Pritchardia kaalae

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Makaha	Genetic Storage	1	No	No	No	No	No
Makaleha to Manuwai	Manage for stability	122	Partial 2%	No	No	No	No
Waianae Kai	Genetic Storage	4	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Sanicula mariversa

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Keaau	Manage for stability	0	Yes	Yes	No	No	No
Ohikilolo	Manage for stability	0	Yes	No	No	No	No

Action Area: Out

TaxonName: Sanicula mariversa

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kamaileunu	Manage for stability	5	Yes	No	No	No	No
Puu Kawiwi	Genetic Storage	0	Yes	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Schiedea kaalae

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Pahole	Manage for stability	83	Yes	No	No	Partial 80%	No

Action Area: Out

TaxonName: Schiedea kaalae

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahana	Genetic Storage	8	Yes	No	No	No	No
Kaluaa and Waieli	Manage for stability	166	Yes	Partial 4%	No	Partial 4%	No
Maakua (Koolaus)	Manage for stability	10	No	No	No	No	No
Makaua (Koolaus)	Genetic Storage	85	Yes	No	No	No	No
North Palawai	Genetic Storage	0	Yes	No	No	No	No
South Ekahanui	Manage for stability	160	Yes	Partial 99%	Yes	Partial 99%	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Schiedea nuttallii

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki to Pahole	Manage for stability	108	Yes	Partial 0%	Partial 94%	Partial 90%	No
Kapuna-Keawapilau Ridge	Manage for stability	74	Yes	Partial 100%	Yes	No	No

Action Area: Out

TaxonName: Schiedea nuttallii

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Makaha	Manage reintroduction for stability	68	Yes	Partial 100%	Yes	Yes	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Schiedea obovata

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki to Pahole	Manage for stability	283	Yes	Partial 88%	Partial 88%	Partial 88%	No
Keawapilau to West Makaleha	Manage for stability	58	Partial 95%	Partial 60%	No	Partial 62%	No

Action Area: Out

TaxonName: Schiedea obovata

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Makaha	Manage reintroduction for stability	146	Yes	No	No	Yes	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Schiedea trinervis

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kalena to East Makaleha	Manage for stability	288	Partial 89%	Partial 43%	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Stenogyne kanehoana

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Haleauau	Manage reintroduction for stability	0	Partial	Partial	No	No	No

Action Area: Out

TaxonName: Stenogyne kanehoana

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kaluaa	Manage reintroduction for stability	26	Yes	No	No	No	No
Makaha	Manage reintroduction for stability	0	Yes	Partial	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Tetramolopium filiforme

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Kahanahaiki	Genetic Storage	40	No	No	No	No	No
Kalena	Manage for stability	24	Yes	No	No	No	No
Keaau	Genetic Storage	30	No	No	No	No	No
Makaha/Ohikilolo Ridge	Genetic Storage	300	No	No	No	No	No
Ohikilolo	Manage for stability	2394	Yes	No	No	No	No
Puhawai	Manage for stability	21	No	No	No	No	No

Action Area: Out

TaxonName: Tetramolopium filiforme

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Waianae Kai	Manage for stability	20	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Threat Control Summary

Action Area: In

TaxonName: Viola chamissoniana subsp. chamissoniana

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Keaau	Genetic Storage	40	No	No	No	No	No
Makaha/Ohikilolo Ridge	Genetic Storage	7	No	No	No	No	No
Ohikilolo	Manage for stability	386	Yes	No	No	No	No
Puu Kumakalii	Manage for stability	44	No	No	No	No	No

Action Area: Out

TaxonName: Viola chamissoniana subsp. chamissoniana

PopulationUnitName	ManagementDesignation	# Mature Plants	Ungulates Managed	Weeds Managed	Rats Managed	Slugs Managed	Fire Managed
Halona	Manage for stability	22	No	No	No	No	No
Kamaileunu	Genetic Storage	35	No	No	No	No	No
Makaha	Manage for stability	68	Yes	No	No	No	No
Makaleha	Genetic Storage	18	No	No	No	No	No
Puu Hapapa	Genetic Storage	7	No	No	No	No	No

= Threat to Taxon within Population Unit

No Shading = Absence of threat to Taxon within Population Unit

Ungulate Managed = Culmination of Cattle, Goats, and Pig threats

Yes=All PopRefSites within Population Unit have threat controlled

No=All PopRefSites within Population Unit have no threat control

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

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

Partial 0%= Threat partially controlled, but no mature plants

Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Abutilon sandwicense														
Kaawa to Puulu	Manage for stability	32	59	0	13	9	0	0	7	0	0	0	0	0%
Kahanahaiki	Manage reintroduction for stability	0	0	1	0	0	0	1	0	0	0	1	1	100%
Keaau	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0%
Action Area: Out														
Abutilon sandwicense														
East Makaleha	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	0%
Ekahanui and Huliwai	Manage for stability	5	15	8	10	9	0	0	9	5	0	0	5	38%
Makaha Makai	Manage for stability	92	133	2	72	67	0	1	63	54	0	0	54	100%
Makaha Mauka	Genetic Storage	13	1	8	19	17	0	0	16	9	0	0	9	43%
North Mikilua	Genetic Storage	9	11	0	0	0	0	0	0	0	0	0	0	0%
Waianae Kai	Genetic Storage	0	0	1	2	1	0	0	1	0	0	0	0	0%
West Makaleha	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	0%
		Total Current Mature	**Total Current Imm.**	**Total Dead and Repres.**	**Total # Plants w/ >=10 Seeds in SeedLab**	**Total # Plants w/ >=10 Est Vaible Seeds in SeedLab**	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants w/ >=50 Seeds in SeedLab**	**Total # Plants w/ >=50 Est Viable Seeds in SeedLab**	**Total # Plants w/ >=3 in Microprop**	**Total # Plants w/ >=3 Army Nursery**	**Total # Plants that Met Goal**	
		152	219	20	116	103	0	2	96	68	0	1	69	

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														
Alectryon macrococcus var. macrococcus														
Haleauau	No Management	0	0	0	0	0	0	1	0	0	0	0	0	0%
Kahanahaiki to Keawapilau	Manage for stability	1	0	0	0	0	0	0	0	0	0	0	0	0%
Makua	Manage for stability	11	0	1	0	0	0	2	0	0	0	2	2	17%
Palikea Gulch	No Management	2	0	0	0	0	0	0	0	0	0	0	0	0%
South Mohiakea	Genetic Storage	2	0	0	0	0	0	1	0	0	0	0	0	0%
South Mohiakea South Slope	No Management	1	0	0	0	0	0	0	0	0	0	0	0	0%
West Makaleha	Genetic Storage	13	0	0	0	0	0	3	0	0	0	0	0	0%

Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: Out														
Alectryon macrococcus var. macrococcus														
Alaiheihe	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Central and East Makaleha	No Management	12	0	0	0	0	0	0	0	0	0	0	0	0%
Central Kaluaa to Central Waieli	Manage for stability	3	0	0	0	0	0	0	0	0	0	0	0	0%
Ekahanui	No Management	4	0	0	0	0	0	0	0	0	0	0	0	0%
Huliwai	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Kaawa	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Kaomoku Nui	No Management	2	0	0	0	0	0	0	0	0	0	0	0	0%
Makaha	Manage for stability	36	0	0	0	0	0	18	0	0	0	1	1	3%
Manuwai	No Management	1	0	0	0	0	0	0	0	0	0	0	0	0%
North Waieli	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
South Kaluaa	No Management	2	0	0	0	0	0	2	0	0	0	1	1	50%
Waianae Kai	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0%

Total Current Mature	Total Current Imm.	Total Dead and Repres.	Total # Plants w/ >=10 Seeds in SeedLab	Total # Plants w/ >=10 Est Vaible Seeds in SeedLab	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants w/ >=50 Seeds in SeedLab	Total # Plants w/ >=50 Est Viable Seeds in SeedLab	Total # Plants w/ >=3 in Microprop	Total # Plants w/ >=3 Army Nursery	Total # Plants that Met Goal
91	0	1	0	0	0	27	0	0	0	4	4

Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
		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

Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Cyanea acuminata														
Helemano-Punaluu Summit Ridge to North Kaukonahua	Manage for stability	130	142	0	4	4	0	0	4	4	0	0	4	8%
Kahana and South Kaukonahua	Genetic Storage	2	0	0	0	0	0	0	0	0	0	0	0	0%
Makaleha to Mohiakea	Manage for stability	151	65	0	1	1	0	1	1	1	0	0	1	2%
Action Area: Out														
Cyanea acuminata														
Kahana and Makaua	Genetic Storage	11	3	0	1	1	0	0	1	0	0	0	0	0%
Kaipapau and Koloa	Genetic Storage	70	30	0	0	0	0	0	0	0	0	0	0	0%
Kaluanui and Maakua	Manage for stability	123	126	0	0	0	0	0	0	0	0	0	0	0%
Puukeahiakahoe	Genetic Storage	3	0	0	0	0	0	0	0	0	0	0	0	0%

Total Current Mature	Total Current Imm.	Total Dead and Repres.	Total # Plants w/ >=10 Seeds in SeedLab	Total # Plants w/ >=10 Est Vaible Seeds in SeedLab	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants w/ >=50 Seeds in SeedLab	Total # Plants w/ >=50 Est Viable Seeds in SeedLab	Total # Plants w/ >=3 in Microprop	Total # Plants w/ >=3 Army Nursery	Total # Plants that Met Goal
490	366	0	6	6	0	1	6	5	0	0	5

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														
Cyanea grimesiana subsp. obatae														
Haleauau	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Pahole to West Makaleha	Manage for stability	6	11	9	15	15	0	7	15	15	0	5	15	100%
Palikea Gulch	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Action Area: Out														
Cyanea grimesiana subsp. obatae														
Kaluaa	Manage for stability	2	0	1	3	3	0	0	3	3	0	0	3	100%
North branch of South Ekahanui	Manage reintroduction for stability	0	0	2	2	2	2	0	2	2	2	0	2	100%
Palikea (South Palawai)	Manage for stability	7	7	9	15	15	5	0	15	15	5	0	15	94%
		Total Current Mature	**Total Current Imm.**	**Total Dead and Repres.**	**Total # Plants w/ >=10 Seeds in SeedLab**	**Total # Plants w/ >=10 Est Vaible Seeds in SeedLab**	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants w/ >=50 Seeds in SeedLab**	**Total # Plants w/ >=50 Est Viable Seeds in SeedLab**	**Total # Plants w/ >=3 in Microprop**	**Total # Plants w/ >=3 Army Nursery**	**Total # Plants that Met Goal**	
		15	18	21	35	35	7	7	35	35	7	5	35	

Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	# of Potential Founders: Current Imm.	# of Potential Founders: Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	Partial Storage Status: # Plants >= 10 Est Viable in SeedLab	Partial Storage Status: # Plants >=1 Microprop	Partial Storage Status: # Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	Storage Goals: # Plants >= 50 Est. Viable in SeedLab	Storage Goals: # Plants >=3 in Microprop	Storage Goals: # Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Cyanea koolauensis														
Kaipapau, Koloa and Kawainui	Manage for stability	106	13	0	0	0	0	0	0	0	0	0	0	0%
Kamananui-Kawainui Ridge	Genetic Storage	6	2	0	0	0	0	0	0	0	0	0	0	0%
Kaukonahua	Genetic Storage	8	3	0	0	0	0	0	0	0	0	0	0	0%
Kawaiiki	Genetic Storage	4	4	0	0	0	0	0	0	0	0	0	0	0%
Lower Opaeula	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0%
Opaeula to Helemano	Manage for stability	23	4	0	0	0	0	0	0	0	0	0	0	0%
Poamoho	Manage for stability	21	18	0	0	0	0	0	0	0	0	0	0	0%
Action Area: Out														
Cyanea koolauensis														
Halawa	Genetic Storage	4	0	0	0	0	0	0	0	0	0	0	0	0%
Waialae Nui	Genetic Storage	2	0	0	0	0	0	0	0	0	0	0	0	0%
Waiawa to Waimano	Genetic Storage	11	2	0	0	0	0	0	0	0	0	0	0	0%
Wailupe	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0%

Total Current Mature	Total Current Imm.	Total Dead and Repres.	Total # Plants w/ >=10 Seeds in SeedLab	Total # Plants w/ >=10 Est Vaible Seeds in SeedLab	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants w/ >=50 Seeds in SeedLab	Total # Plants w/ >=50 Est Viable Seeds in SeedLab	Total # Plants w/ >=3 in Microprop	Total # Plants w/ >=3 Army Nursery	Total # Plants that Met Goal
187	46	0	0	0	0	0	0	0	0	0	0

Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	# of Potential Founders: Current Imm.	# of Potential Founders: Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	Partial Storage Status: # Plants >= 10 Est Viable in SeedLab	Partial Storage Status: # Plants >=1 Microprop	Partial Storage Status: # Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	Storage Goals: # Plants >= 50 Est. Viable in SeedLab	Storage Goals: # Plants >=3 in Microprop	Storage Goals: # Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Cyanea longiflora														
Kapuna to West Makaleha	Manage for stability	13	18	11	20	20	9	2	20	20	9	1	20	83%
Pahole	Manage for stability	58	104	16	55	55	1	4	53	52	1	2	53	100%
Action Area: Out														
Cyanea longiflora														
Makaha and Waianae Kai	Manage for stability	8	4	3	4	4	2	0	4	4	2	0	4	36%

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
79	126	30	79	79	12	6	77	76	12	3	77

Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	# of Potential Founders: Current Imm.	# of Potential Founders: Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	Partial Storage Status: # Plants >= 10 Est Viable in SeedLab	Partial Storage Status: # Plants >=1 Microprop	Partial Storage Status: # Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	Storage Goals: # Plants >= 50 Est. Viable in SeedLab	Storage Goals: # Plants >=3 in Microprop	Storage Goals: # Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Cyanea superba subsp. superba														
Kahanahaiki	Manage reintroduction for stability	0	0	3	3	3	2	1	3	3	2	0	3	100%

Total Current Mature	Total Current Imm.	Total Dead and Repres.	Total # Plants w/ >=10 Seeds in SeedLab	Total # Plants w/ >=10 Est Vaible Seeds in SeedLab	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants w/ >=50 Seeds in SeedLab	Total # Plants w/ >=50 Est Viable Seeds in SeedLab	Total # Plants w/ >=3 in Microprop	Total # Plants w/ >=3 Army Nursery	Total # Plants that Met Goal
0	0	3	3	3	2	1	3	3	2	0	3

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														
Cyrtandra dentata														
Kahanahaiki	Manage for stability	37	76	18	25	25	0	0	24	24	0	0	24	48%
Kawaiiki (Koolaus)	Manage for stability	5	79	0	0	0	0	0	0	0	0	0	0	0%
Opaeula (Koolaus)	Manage for stability	23	107	0	1	1	0	0	1	1	0	0	1	4%
Pahole to West Makaleha	Manage for stability	603	670	0	53	53	0	0	53	53	0	0	53	100%
Action Area: Out														
Cyrtandra dentata														
Central Makaleha	Genetic Storage	3	0	0	0	0	0	0	0	0	0	0	0	0%
		Total Current Mature	**Total Current Imm.**	**Total Dead and Repres.**	**Total # Plants w/ >=10 Seeds in SeedLab**	**Total # Plants w/ >=10 Est Vaible Seeds in SeedLab**	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants w/ >=50 Seeds in SeedLab**	**Total # Plants w/ >=50 Est Viable Seeds in SeedLab**	**Total # Plants w/ >=3 in Microprop**	**Total # Plants w/ >=3 Army Nursery**	**Total # Plants that Met Goal**	
		671	932	18	79	79	0	0	78	78	0	0	78	

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														
Delissea waianaeensis														
Kahanahaiki to Keawapilau	Manage for stability	3	6	9	13	13	1	0	13	13	1	0	13	100%
Palikea Gulch	Genetic Storage	1	0	6	7	7	4	0	7	7	3	0	7	100%
South Mohiakea	Genetic Storage	12	23	4	12	12	0	0	11	11	0	0	11	69%
Action Area: Out														
Delissea waianaeensis														
Ekahanui	Manage for stability	2	1	4	6	6	0	0	6	6	0	0	6	100%
Huliwai	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Kaawa	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Kaluaa	Manage for stability	5	2	3	7	7	0	0	7	7	0	0	7	88%
Kealia	Genetic Storage	4	13	3	5	5	0	0	5	5	0	0	5	71%
Palawai	Genetic Storage	17	47	7	22	22	0	0	22	22	0	0	22	92%

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
44	92	36	72	72	5	0	71	71	4	0	71

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														
Dubautia herbstobatae														
Keaau	Genetic Storage	70	0	0	0	0	0	0	0	0	0	0	0	0%
Makaha/Ohikilolo	Genetic Storage	350	0	0	1	0	0	0	0	0	0	0	0	0%
Ohikilolo Makai	Manage for stability	89	2	0	0	0	0	0	0	0	0	0	0	0%
Ohikilolo Mauka	Manage for stability	415	9	0	1	0	0	0	1	0	0	0	0	0%
Action Area: Out														
Dubautia herbstobatae														
Kamaileunu	Genetic Storage	0	0	1	1	0	0	1	1	0	0	1	1	100%
Makaha	Manage for stability	28	1	13	19	0	0	21	14	0	0	20	20	49%
Waianae Kai	Genetic Storage	10	4	0	5	0	0	3	4	0	0	3	3	30%
		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**	
		962	16	14	27	0	0	25	20	0	0	24	24	

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														
Eugenia koolauensis														
Aimuu	Genetic Storage	8	10	2	0	0	0	12	0	0	0	7	7	70%
Kaiwikoele and Kamananui	Genetic Storage	21	26	1	0	0	0	23	0	0	0	8	8	36%
Kaleleiki	Genetic Storage	14	54	14	0	0	0	22	0	0	0	0	0	0%
Kaunala	Manage for stability	20	39	6	0	0	0	29	0	0	0	9	9	35%
Malaekahana	Genetic Storage	5	21	0	0	0	0	5	0	0	0	2	2	40%
Ohiaai and East Oio	Genetic Storage	1	1	1	0	0	0	3	0	0	0	1	1	50%
Oio	Manage for stability	5	2	10	0	0	0	14	0	0	0	4	4	27%
Pahipahialua	Manage for stability	22	6	9	0	0	0	22	0	0	0	14	14	45%
Action Area: Out														
Eugenia koolauensis														
Hanaimoa	Genetic Storage	1	0	2	0	0	0	3	0	0	0	1	1	33%
Palikea and Kaimuhole	Genetic Storage	1	0	1	0	0	0	2	0	0	0	2	2	100%
		Total Current Mature	**Total Current Imm.**	**Total Dead and Repres.**	**Total # Plants w/ >=10 Seeds in SeedLab**	**Total # Plants w/ >=10 Est Vaible Seeds in SeedLab**	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants w/ >=50 Seeds in SeedLab**	**Total # Plants w/ >=50 Est Viable Seeds in SeedLab**	**Total # Plants w/ >=3 in Microprop**	**Total # Plants w/ >=3 Army Nursery**	**Total # Plants that Met Goal**	
		98	159	46	0	0	0	135	0	0	0	48	48	

Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Euphorbia celastroides var. kaenana														
East Kahanahaiki	Genetic Storage	2	0	0	1	0	0	0	0	0	0	0	0	0%
Kaluakauila	Genetic Storage	11	3	0	2	2	0	0	0	0	0	0	0	0%
Makua	Manage for stability	85	0	28	77	74	0	0	61	53	0	0	53	100%
North Kahanahaiki	Genetic Storage	115	36	4	14	14	0	0	11	8	0	0	8	16%
Puaakanoa	Manage for stability	150	16	3	48	42	0	0	29	28	0	0	28	56%
Action Area: Out														
Euphorbia celastroides var. kaenana														
East of Alau	Manage for stability	21	2	5	26	26	0	0	24	20	0	0	20	77%
Kaena	Manage for stability	579	896	1	68	67	0	0	66	58	0	0	58	100%
Keawaula	Genetic Storage	43	1	6	31	27	0	0	18	10	0	0	10	20%
Waianae Kai	Genetic Storage	34	0	0	0	0	0	0	0	0	0	0	0	0%

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
1040	954	47	267	252	0	0	209	177	0	0	177

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														
Euphorbia herbstii														
Kapuna to Pahole	Manage for stability	14	9	44	31	29	0	2	16	14	0	0	14	28%
Action Area: Out														
Euphorbia herbstii														
South Branch of South Ekahanui	No Management	0	0	2	0	0	0	0	0	0	0	0	0	0%

Total Current Mature	**Total Current Imm.**	**Total Dead and Repres.**	**Total # Plants w/ >=10 Seeds in SeedLab**	**Total # Plants w/ >=10 Est Vaible Seeds in SeedLab**	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants w/ >=50 Seeds in SeedLab**	**Total # Plants w/ >=50 Est Viable Seeds in SeedLab**	**Total # Plants w/ >=3 in Microprop**	**Total # Plants w/ >=3 Army Nursery**	**Total # Plants that Met Goal**
14	9	46	31	29	0	2	16	14	0	0	14

Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Flueggea neowawraea														
Kahanahaiki to Kapuna	Manage for stability	6	0	1	1	1	0	5	1	1	0	1	2	29%
Mohiakea	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Ohikilolo	Manage for stability	1	0	0	0	0	0	1	0	0	0	1	1	100%
West Makaleha	Genetic Storage	6	0	0	0	0	0	6	0	0	0	1	1	17%
Action Area: Out														
Flueggea neowawraea														
Central and East Makaleha	Genetic Storage	5	0	1	1	1	0	5	1	1	0	3	3	50%
Halona	Genetic Storage	1	0	0	0	0	0	1	0	0	0	1	1	100%
Kaluaa	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Kauhiuhi	Genetic Storage	1	0	0	0	0	0	1	0	0	0	1	1	100%
Makaha	Manage for stability	10	0	1	0	0	0	10	0	0	0	5	5	45%
Mikilua	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	0%
Mt. Kaala NAR	Genetic Storage	3	0	1	1	1	0	3	1	1	0	1	2	50%
Nanakuli, south branch	Genetic Storage	1	0	0	0	0	0	1	0	0	0	1	1	100%
Waianae Kai	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0%
		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**	
		35	0	4	3	3	0	33	3	3	0	15	17	

Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	# of Potential Founders: Current Imm.	# of Potential Founders: Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	Partial Storage Status: # Plants >= 10 Est Viable in SeedLab	Partial Storage Status: # Plants >=1 Microprop	Partial Storage Status: # Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	Storage Goals: # Plants >= 50 Est. Viable in SeedLab	Storage Goals: # Plants >=3 in Microprop	Storage Goals: # Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Gardenia mannii														
Haleauau	Manage for stability	3	0	5	0	0	0	4	0	0	0	4	4	50%
Helemano and Poamoho	Manage for stability	17	0	0	0	0	0	6	0	0	0	2	2	12%
Kaiwikoele, Kamananui, and Kawainui	Genetic Storage	13	0	0	0	0	0	0	0	0	0	0	0	0%
Lower Peahinaia	Manage for stability	9	1	0	0	0	0	4	0	0	0	1	1	11%
South Kaukonahua	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0%
Upper Opaeula/Helemano	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0%
Action Area: Out														
Gardenia mannii														
Ihiihi-Kawainui ridge	Genetic Storage	2	0	0	0	0	0	0	0	0	0	0	0	0%
Kaluaa and Maunauna	Genetic Storage	2	0	0	0	0	0	2	0	0	0	1	1	50%
Kamananui-Malaekahana Summit Ridge	Genetic Storage	3	0	0	0	0	0	2	0	0	0	0	0	0%
Kapakahi	Genetic Storage	2	0	0	0	0	0	0	0	0	0	0	0	0%
Pukele	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0%

Total Current Mature	Total Current Imm.	Total Dead and Repres.	Total # Plants w/ >=10 Seeds in SeedLab	Total # Plants w/ >=10 Est Vaible Seeds in SeedLab	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants w/ >=50 Seeds in SeedLab	Total # Plants w/ >=50 Est Viable Seeds in SeedLab	Total # Plants w/ >=3 in Microprop	Total # Plants w/ >=3 Army Nursery	Total # Plants that Met Goal
54	1	5	0	0	0	18	0	0	0	8	8

Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Gouania vitifolia														
Keaau	Manage for stability	55	0	4	56	49	0	5	44	31	0	2	31	62%
Action Area: Out														
Gouania vitifolia														
Waianae Kai	Genetic Storage	3	0	0	0	0	0	2	0	0	0	0	0	0%

Total Current Mature	Total Current Imm.	Total Dead and Repres.	Total # Plants w/ >=10 Seeds in SeedLab	Total # Plants w/ >=10 Est Vaible Seeds in SeedLab	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants w/ >=50 Seeds in SeedLab	Total # Plants w/ >=50 Est Viable Seeds in SeedLab	Total # Plants w/ >=3 in Microprop	Total # Plants w/ >=3 Army Nursery	Total # Plants that Met Goal
58	0	4	56	49	0	7	44	31	0	2	31

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														
Hesperomannia oahuensis														
Haleauau	Manage for stability	1	0	0	0	0	0	1	0	0	0	0	0	0%
Action Area: Out														
Hesperomannia oahuensis														
Kaaikukai	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Makaha	Manage for stability	3	2	0	0	0	0	0	0	0	0	0	0	0%
Napepeiauolelo	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	0%
North Palawai	Genetic Storage	0	0	4	0	0	0	4	0	0	0	0	0	0%
Waianae Kai	Genetic Storage	0	1	2	0	0	0	0	0	0	0	0	0	0%

Total Current Mature	Total Current Imm.	Total Dead and Repres.	Total # Plants w/ >=10 Seeds in SeedLab	Total # Plants w/ >=10 Est Vaible Seeds in SeedLab	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants w/ >=50 Seeds in SeedLab	Total # Plants w/ >=50 Est Viable Seeds in SeedLab	Total # Plants w/ >=3 in Microprop	Total # Plants w/ >=3 Army Nursery	Total # Plants that Met Goal
4	3	6	0	0	0	5	0	0	0	0	0

Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	# of Potential Founders: Current Imm.	# of Potential Founders: Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	Partial Storage Status: # Plants >= 10 Est Viable in SeedLab	Partial Storage Status: # Plants >=1 Microprop	Partial Storage Status: # Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	Storage Goals: # Plants >= 50 Est. Viable in SeedLab	Storage Goals: # Plants >=3 in Microprop	Storage Goals: # Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Hesperomannia swezeyi														
Kamananui to Kaluanui	Manage for stability	134	112	0	0	0	0	0	0	0	0	0	0	0%
Kaukonahua	Manage for stability	55	54	0	0	0	0	0	0	0	0	0	0	0%
Lower Opaeula	Manage for stability	18	21	0	0	0	0	0	0	0	0	0	0	0%
Palikea Gulch	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Poamoho	Genetic Storage	21	12	0	0	0	0	1	0	0	0	0	0	0%
Action Area: Out														
Hesperomannia swezeyi														
Niu-Waimanalo Summit Ridge	Genetic Storage	1	4	0	0	0	0	0	0	0	0	0	0	0%

Total Current Mature	Total Current Imm.	Total Dead and Repres.	Total # Plants w/ >=10 Seeds in SeedLab	Total # Plants w/ >=10 Est Vaible Seeds in SeedLab	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants w/ >=50 Seeds in SeedLab	Total # Plants w/ >=50 Est Viable Seeds in SeedLab	Total # Plants w/ >=3 in Microprop	Total # Plants w/ >=3 Army Nursery	Total # Plants that Met Goal
229	203	0	0	0	0	1	0	0	0	0	0

Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Hibiscus brackenridgei subsp. mokuleianus														
Keaau	Manage for stability	0	16	6	1	1	0	6	1	1	0	6	6	100%
Makua	Manage for stability	13	8	28	33	27	0	34	27	25	0	30	34	83%
Action Area: Out														
Hibiscus brackenridgei subsp. mokuleianus														
Haili to Kawaiu	Manage for stability	5	3	8	0	0	0	15	0	0	0	13	13	100%
Waialua	Genetic Storage	49	85	28	7	5	0	67	3	0	0	41	41	82%

Total Current Mature	Total Current Imm.	Total Dead and Repres.	Total # Plants w/ >=10 Seeds in SeedLab	Total # Plants w/ >=10 Est Vaible Seeds in SeedLab	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants w/ >=50 Seeds in SeedLab	Total # Plants w/ >=50 Est Viable Seeds in SeedLab	Total # Plants w/ >=3 in Microprop	Total # Plants w/ >=3 Army Nursery	Total # Plants that Met Goal
67	112	70	41	33	0	122	31	26	0	90	94

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														
Kadua degeneri subsp. degeneri														
Kahanahaiki to Pahole	Manage for stability	147	131	21	72	72	0	0	63	59	0	0	59	100%
Action Area: Out														
Kadua degeneri subsp. degeneri														
Alaiheihe and Manuwai	Manage for stability	25	2	16	30	30	1	0	29	27	1	0	28	68%
Central Makaleha and West Branch of East Makaleha	Manage for stability	23	13	21	39	37	0	0	36	30	0	0	30	68%
East branch of East Makaleha	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	0%
		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**	
		195	146	58	141	139	1	0	128	116	1	0	117	

Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Kadua parvula														
Ohikilolo	Manage for stability	100	157	15	108	104	0	0	102	97	0	0	97	100%
Action Area: Out														
Kadua parvula														
East Makaleha	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Halona	Manage for stability	93	28	19	70	67	0	0	62	55	0	0	55	100%

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
193	185	34	178	171	0	0	164	152	0	0	152

Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	# of Potential Founders: Current Imm.	# of Potential Founders: Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	Partial Storage Status: # Plants >= 10 Est Viable in SeedLab	Partial Storage Status: # Plants >=1 Microprop	Partial Storage Status: # Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	Storage Goals: # Plants >= 50 Est. Viable in SeedLab	Storage Goals: # Plants >=3 in Microprop	Storage Goals: # Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Labordia cyrtandrae														
East Makaleha to North Mohiakea	Manage for stability	74	0	0	8	7	4	6	7	7	2	2	9	18%
Action Area: Out														
Labordia cyrtandrae														
Manana	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%

Total Current Mature	**Total Current Imm.**	**Total Dead and Repres.**	**Total # Plants w/ >=10 Seeds in SeedLab**	**Total # Plants w/ >=10 Est Vaible Seeds in SeedLab**	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants w/ >=50 Seeds in SeedLab**	**Total # Plants w/ >=50 Est Viable Seeds in SeedLab**	**Total # Plants w/ >=3 in Microprop**	**Total # Plants w/ >=3 Army Nursery**	**Total # Plants that Met Goal**
74	0	0	8	7	4	6	7	7	2	2	9

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														
Melanthera tenuifolia														
Kahanahaiki	Genetic Storage	13	6	23	11	0	0	13	5	0	0	6	6	17%
Kaluakauila	Genetic Storage	4	80	0	9	0	0	16	1	0	0	11	11	100%
Keawaula	Genetic Storage	60	33	0	0	0	0	0	0	0	0	0	0	0%
Ohikilolo	Manage for stability	1109	8	19	16	0	0	8	13	0	0	6	6	12%
Action Area: Out														
Melanthera tenuifolia														
Kamaileunu and Waianae Kai	Manage for stability	815	246	0	0	0	0	0	0	0	0	0	0	0%
Mt. Kaala NAR	Manage for stability	121	4	0	0	0	0	0	0	0	0	0	0	0%
		Total Current Mature	**Total Current Imm.**	**Total Dead and Repres.**	**Total # Plants w/ >=10 Seeds in SeedLab**	**Total # Plants w/ >=10 Est Vaible Seeds in SeedLab**	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants w/ >=50 Seeds in SeedLab**	**Total # Plants w/ >=50 Est Viable Seeds in SeedLab**	**Total # Plants w/ >=3 in Microprop**	**Total # Plants w/ >=3 Army Nursery**	**Total # Plants that Met Goal**	
		2122	377	42	36	0	0	37	19	0	0	23	23	

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														
Neraudia angulata														
Kapuna	Genetic Storage	0	0	2	2	2	0	2	2	0	0	1	1	50%
Lower Kahanahaiki	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Makua	Manage for stability	25	4	31	2	2	0	23	1	0	0	21	21	42%
Punapohaku	Genetic Storage	4	0	0	0	0	0	4	0	0	0	3	3	75%
Action Area: Out														
Neraudia angulata														
Halona	Genetic Storage	32	5	8	0	0	0	9	0	0	0	6	6	15%
Leeward Puu Kaua	Genetic Storage	9	0	0	0	0	0	1	0	0	0	1	1	11%
Makaha	Manage for stability (backup site)	3	8	12	2	1	0	15	1	0	0	14	14	93%
Manuwai	Manage for stability	0	2	2	0	0	0	2	0	0	0	2	2	100%
Waianae Kai Makai	Genetic Storage	13	0	0	0	0	0	3	0	0	0	2	2	15%
Waianae Kai Mauka	Manage for stability	7	2	9	0	0	0	11	0	0	0	10	10	63%
		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**	
		93	21	64	6	5	0	70	4	0	0	60	60	

Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Nototrichium humile														
Kahanahaiki	Genetic Storage	50	2	0	0	0	0	1	0	0	0	0	0	0%
Kaluakauila	Manage for stability	160	48	1	2	1	0	0	1	1	0	0	1	2%
Keaau	Genetic Storage	21	31	0	0	0	0	0	0	0	0	0	0	0%
Keawaula	Genetic Storage	35	6	1	0	0	0	8	0	0	0	8	8	22%
Makua (East rim)	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0%
Makua (south side)	Manage for stability	43	3	0	0	0	0	0	0	0	0	0	0	0%
Punapohaku	Genetic Storage	178	77	1	0	0	0	36	0	0	0	35	35	70%
Action Area: Out														
Nototrichium humile														
Kaimuhole and Palikea Gulch	Genetic Storage	29	1	12	0	0	0	43	0	0	0	41	41	100%
Kealia	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Keawapilau	Genetic Storage	1	0	4	0	0	0	5	0	0	0	5	5	100%
Kolekole	Genetic Storage	12	0	0	0	0	0	10	0	0	0	10	10	83%
Makaha	Genetic Storage	22	5	0	0	0	0	0	0	0	0	0	0	0%
Nanakuli	Genetic Storage	5	0	0	0	0	0	0	0	0	0	0	0	0%
Pahole Gulch	No Management	0	0	0	0	0	0	0	0	0	0	0	0	0%
Puu Kaua (Leeward side)	Genetic Storage	2	0	0	0	0	0	0	0	0	0	0	0	0%
Waianae Kai	Manage for stability	216	54	0	0	0	0	2	0	0	0	2	2	4%

Genetic Storage Summary

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement
		Total Current Mature	**Total Current Imm.**	**Total Dead and Repres.**	**Total # Plants w/ >=10 Seeds in SeedLab**	**Total # Plants w/ >=10 Est Vaible Seeds in SeedLab**	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants w/ >=50 Seeds in SeedLab**	**Total # Plants w/ >=50 Est Viable Seeds in SeedLab**	**Total # Plants w/ >=3 in Microprop**	**Total # Plants w/ >=3 Army Nursery**	**Total # Plants that Met Goal**	
		775	227	19	2	1	0	105	1	1	0	101	102	

Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	# of Potential Founders: Current Imm.	# of Potential Founders: Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	Partial Storage Status: # Plants >= 10 Est Viable in SeedLab	Partial Storage Status: # Plants >=1 Microprop	Partial Storage Status: # Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	Storage Goals: # Plants >= 50 Est. Viable in SeedLab	Storage Goals: # Plants >=3 in Microprop	Storage Goals: # Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Phyllostegia hirsuta														
Haleauau to Mohiakea	Manage for stability	11	2	2	4	4	2	10	0	0	2	10	10	77%
Helemano and Opaeula	Genetic Storage	1	4	1	2	1	1	4	1	0	1	3	3	100%
Helemano to Poamoho	Genetic Storage	2	0	0	0	0	0	0	0	0	0	0	0	0%
Kaipapau and Kawainui	Genetic Storage	4	0	0	1	1	0	4	0	0	0	4	4	100%
Kaukonahua	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	0%
Kawaiiki	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	0%
Koloa	Manage for stability	6	3	2	1	1	1	6	1	0	1	6	6	75%
Action Area: Out														
Phyllostegia hirsuta														
Ekahanui	No Management	0	1	0	0	0	0	0	0	0	0	0	0	0%
Hapapa to Kaluaa	Genetic Storage	2	10	6	5	5	8	10	4	4	7	10	10	100%
Huliwai	No Management	0	0	1	1	1	1	2	1	0	1	2	2	100%
Kaluanui and Punaluu	Genetic Storage	5	3	0	0	0	0	0	0	0	0	0	0	0%
Makaha-Waianae Kai Ridge	Genetic Storage	1	0	0	0	0	0	1	0	0	0	1	1	100%
Palawai	Genetic Storage	0	0	0	0	0	0	0	0	0	0	0	0	0%
Waiamano	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0%
		Total Current Mature	**Total Current Imm.**	**Total Dead and Repres.**	**Total # Plants w/ >=10 Seeds in SeedLab**	**Total # Plants w/ >=10 Est Vaible Seeds in SeedLab**	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants w/ >=50 Seeds in SeedLab**	**Total # Plants w/ >=50 Est Viable Seeds in SeedLab**	**Total # Plants w/ >=3 in Microprop**	**Total # Plants w/ >=3 Army Nursery**	**Total # Plants that Met Goal**	
		33	23	12	14	13	13	37	7	4	12	36	36	

Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Phyllostegia kaalaensis														
Keawapilau to Kapuna	Manage reintroduction for stability	0	0	1	1	1	1	1	0	0	1	0	1	100%
Pahole	Manage reintroduction for stability	0	0	2	0	0	2	2	0	0	2	1	2	100%
Palikea Gulch	Genetic Storage	0	0	3	0	0	3	3	0	0	3	1	3	100%
Action Area: Out														
Phyllostegia kaalaensis														
Waianae Kai	Genetic Storage	0	0	2	1	0	2	2	0	0	2	0	2	100%

Total Current Mature	Total Current Imm.	Total Dead and Repres.	Total # Plants w/ >=10 Seeds in SeedLab	Total # Plants w/ >=10 Est Vaible Seeds in SeedLab	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants w/ >=50 Seeds in SeedLab	Total # Plants w/ >=50 Est Viable Seeds in SeedLab	Total # Plants w/ >=3 in Microprop	Total # Plants w/ >=3 Army Nursery	Total # Plants that Met Goal
0	0	8	2	1	8	8	0	0	8	2	8

Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
		Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Phyllostegia mollis														
Mohiakea	Genetic Storage	0	0	8	6	6	6	7	3	2	4	6	6	75%
Action Area: Out														
Phyllostegia mollis														
Ekahanui	Manage for stability	0	0	2	2	2	1	2	1	0	1	2	2	100%
Huliwai	No Management	0	0	1	1	1	1	1	1	1	1	1	1	100%
Kaluaa	Manage for stability	0	0	1	1	1	1	1	1	1	0	1	1	100%
Pualii	Manage reintroduction for stability	0	0	1	1	1	1	1	0	0	1	1	1	100%
Waieli	Genetic Storage	1	0	5	5	5	4	3	4	4	4	1	6	100%

Total Current Mature	Total Current Imm.	Total Dead and Repres.	Total # Plants w/ >=10 Seeds in SeedLab	Total # Plants w/ >=10 Est Vaible Seeds in SeedLab	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants w/ >=50 Seeds in SeedLab	Total # Plants w/ >=50 Est Viable Seeds in SeedLab	Total # Plants w/ >=3 in Microprop	Total # Plants w/ >=3 Army Nursery	Total # Plants that Met Goal
1	0	18	16	16	14	15	10	8	11	12	17

Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	# of Potential Founders: Current Imm.	# of Potential Founders: Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	Partial Storage Status: # Plants >= 10 Est Viable in SeedLab	Partial Storage Status: # Plants >=1 Microprop	Partial Storage Status: # Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	Storage Goals: # Plants >= 50 Est. Viable in SeedLab	Storage Goals: # Plants >=3 in Microprop	Storage Goals: # Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Plantago princeps var. princeps														
North Mohiakea	Manage for stability	39	12	9	20	20	0	1	19	19	0	0	19	40%
Ohikilolo	Manage for stability	0	0	17	19	18	0	0	12	12	0	0	12	71%
Pahole	Genetic Storage	2	2	3	4	4	0	0	3	3	0	0	3	60%
Action Area: Out														
Plantago princeps var. princeps														
Ekahanui	Manage for stability	46	122	34	68	66	0	12	59	42	0	1	42	84%
Halona	Manage for stability	10	1	7	22	22	0	0	22	18	0	0	18	100%
Konahuanui	No Management	100	10	0	5	4	0	0	0	0	0	0	0	0%
North Palawai	Genetic Storage	5	1	1	2	2	0	0	2	2	0	0	2	33%
Nuuanu	No Management	4	8	0	0	0	0	0	0	0	0	0	0	0%
Waiawa (Koolaus)	No Management	16	17	0	6	2	0	0	1	0	0	0	0	0%
		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**	
		222	173	71	146	138	0	13	118	96	0	1	96	

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														
Pritchardia kaalae														
Ohikilolo	Manage for stability	72	1178	0	1	0	1	0	1	0	0	0	0	0%
Action Area: Out														
Pritchardia kaalae														
Makaha	Genetic Storage	1	0	0	0	0	0	0	0	0	0	0	0	0%
Makaleha to Manuwai	Manage for stability	122	13	0	0	0	1	0	0	0	1	0	1	2%
Waianae Kai	Genetic Storage	4	5	0	0	0	0	0	0	0	0	0	0	0%

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
199	1196	0	1	0	2	0	1	0	1	0	1

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														
Sanicula mariversa														
Keaau	Manage for stability	0	43	43	68	64	0	0	50	30	0	0	30	70%
Ohikilolo	Manage for stability	0	30	58	59	43	0	6	25	17	0	1	18	36%
Action Area: Out														
Sanicula mariversa														
Kamaileunu	Manage for stability	5	408	39	76	76	0	0	62	55	0	0	55	100%
Puu Kawiwi	Genetic Storage	0	8	2	3	3	0	0	3	1	0	0	1	50%

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
5	489	142	206	186	0	6	140	103	0	1	104

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														
Schiedea kaalae														
Mohiakea	No Management	0	0	1	0	0	1	1	0	0	1	1	1	100%
Pahole	Manage for stability	2	0	0	2	2	2	2	2	2	1	0	2	100%
Action Area: Out														
Schiedea kaalae														
Huliwai	No Management	0	0	1	1	1	1	1	1	1	1	1	1	100%
Kahana	Genetic Storage	5	0	4	2	2	7	8	0	0	7	1	7	78%
Kaipapau	No Management	0	0	2	1	1	2	2	1	1	2	1	2	100%
Kaluaa and Waieli	Manage for stability	0	0	1	1	1	1	1	1	1	1	0	1	100%
Maakua (Koolaus)	Manage for stability	10	0	0	1	1	4	4	0	0	4	1	4	40%
Makaua (Koolaus)	Genetic Storage	1	0	0	0	0	1	1	0	0	1	0	1	100%
North Palawai	Genetic Storage	0	0	1	1	1	1	0	1	1	1	0	1	100%
South Ekahanui	Manage for stability	9	2	8	14	12	10	14	10	8	10	8	14	82%

Total Current Mature	Total Current Imm.	Total Dead and Repres.	Total # Plants w/ >=10 Seeds in SeedLab	Total # Plants w/ >=10 Est Vaible Seeds in SeedLab	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants w/ >=50 Seeds in SeedLab	Total # Plants w/ >=50 Est Viable Seeds in SeedLab	Total # Plants w/ >=3 in Microprop	Total # Plants w/ >=3 Army Nursery	Total # Plants that Met Goal
27	2	18	23	21	30	34	16	14	29	13	34

Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	# of Potential Founders: Current Imm.	# of Potential Founders: Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	Partial Storage Status: # Plants >= 10 Est Viable in SeedLab	Partial Storage Status: # Plants >=1 Microprop	Partial Storage Status: # Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	Storage Goals: # Plants >= 50 Est. Viable in SeedLab	Storage Goals: # Plants >=3 in Microprop	Storage Goals: # Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Schiedea nuttallii														
Kahanahaiki to Pahole	Manage for stability	6	0	38	34	30	2	44	24	8	2	42	42	95%
Kapuna-Keawapilau Ridge	Manage for stability	0	0	2	2	2	0	2	2	1	0	2	2	100%

Total Current Mature	Total Current Imm.	Total Dead and Repres.	Total # Plants w/ >=10 Seeds in SeedLab	Total # Plants w/ >=10 Est Vaible Seeds in SeedLab	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants w/ >=50 Seeds in SeedLab	Total # Plants w/ >=50 Est Viable Seeds in SeedLab	Total # Plants w/ >=3 in Microprop	Total # Plants w/ >=3 Army Nursery	Total # Plants that Met Goal
6	0	40	36	32	2	46	26	9	2	44	44

Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Schiedea obovata														
Kahanahaiki to Pahole	Manage for stability	0	0	5	5	5	1	0	5	5	1	0	5	100%
Keawapilau to West Makaleha	Manage for stability	12	524	72	79	79	1	0	78	77	0	0	77	100%

Total Current Mature	Total Current Imm.	Total Dead and Repres.	Total # Plants w/ >=10 Seeds in SeedLab	Total # Plants w/ >=10 Est Vaible Seeds in SeedLab	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants w/ >=50 Seeds in SeedLab	Total # Plants w/ >=50 Est Viable Seeds in SeedLab	Total # Plants w/ >=3 in Microprop	Total # Plants w/ >=3 Army Nursery	Total # Plants that Met Goal
12	524	77	84	84	2	0	83	82	1	0	82

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														
Schiedea trinervis														
Kalena to East Makaleha	Manage for stability	296	351	15	62	61	2	0	61	59	1	0	59	100%
		Total Current Mature	**Total Current Imm.**	**Total Dead and Repres.**	**Total # Plants w/ >=10 Seeds in SeedLab**	**Total # Plants w/ >=10 Est Vaible Seeds in SeedLab**	**Total # Plants w/ >=1 Microprop**	**Total # Plants w/ >=1 Army Nursery**	**Total # Plants w/ >=50 Seeds in SeedLab**	**Total # Plants w/ >=50 Est Viable Seeds in SeedLab**	**Total # Plants w/ >=3 in Microprop**	**Total # Plants w/ >=3 Army Nursery**	**Total # Plants that Met Goal**	
		296	351	15	62	61	2	0	61	59	1	0	59	

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														
Stenogyne kanehoana														
Haleauau	Manage reintroduction for stability	0	0	1	0	0	1	1	0	0	1	1	1	100%
Action Area: Out														
Stenogyne kanehoana														
Kaluaa	Manage reintroduction for stability	0	0	1	0	0	1	1	0	0	1	1	1	100%

Total Current Mature	Total Current Imm.	Total Dead and Repres.	Total # Plants w/ >=10 Seeds in SeedLab	Total # Plants w/ >=10 Est Vaible Seeds in SeedLab	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants w/ >=50 Seeds in SeedLab	Total # Plants w/ >=50 Est Viable Seeds in SeedLab	Total # Plants w/ >=3 in Microprop	Total # Plants w/ >=3 Army Nursery	Total # Plants that Met Goal
0	0	2	0	0	2	2	0	0	2	2	2

Genetic Storage Summary

		# of Potential Founders			Partial Storage Status				Storage Goals				Storage Goals Met	
Population Unit Name	Management Designation	Current Mature	Current Imm.	Dead and Repres.	# Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	# Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	# Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Tetramolopium filiforme														
Kahanahaiki	Genetic Storage	40	0	35	99	62	0	0	60	6	0	0	6	12%
Kalena	Manage for stability	24	93	6	6	5	0	2	6	2	0	2	3	10%
Keaau	Genetic Storage	30	41	0	17	15	0	0	2	1	0	0	1	3%
Makaha/Ohikilolo Ridge	Genetic Storage	300	0	0	0	0	0	0	0	0	0	0	0	0%
Ohikilolo	Manage for stability	2394	1464	38	146	62	0	1	53	7	0	1	7	14%
Puhawai	Manage for stability	0	0	5	4	4	0	0	4	4	0	0	4	80%
Action Area: Out														
Tetramolopium filiforme														
Waianae Kai	Manage for stability	20	0	0	1	1	0	0	0	0	0	0	0	0%

Total Current Mature	Total Current Imm.	Total Dead and Repres.	Total # Plants w/ >=10 Seeds in SeedLab	Total # Plants w/ >=10 Est Vaible Seeds in SeedLab	Total # Plants w/ >=1 Microprop	Total # Plants w/ >=1 Army Nursery	Total # Plants w/ >=50 Seeds in SeedLab	Total # Plants w/ >=50 Est Viable Seeds in SeedLab	Total # Plants w/ >=3 in Microprop	Total # Plants w/ >=3 Army Nursery	Total # Plants that Met Goal
2808	1598	84	273	149	0	3	125	20	0	3	21

Genetic Storage Summary

Population Unit Name	Management Designation	# of Potential Founders: Current Mature	Current Imm.	Dead and Repres.	Partial Storage Status: # Plants >= 10 in SeedLab	# Plants >= 10 Est Viable in SeedLab	# Plants >=1 Microprop	# Plants >=1 Army Nursery	Storage Goals: # Plants >= 50 in SeedLab	# Plants >= 50 Est. Viable in SeedLab	# Plants >=3 in Microprop	# Plants >=3 Army Nursery	Storage Goals Met: # Plants that Met Goal	% Completed Genetic Storage Requirement
Action Area: In														
Viola chamissoniana subsp. chamissoniana														
Keaau	Genetic Storage	40	10	0	0	0	0	0	0	0	0	0	0	0%
Makaha/Ohikilolo Ridge	Genetic Storage	7	0	0	0	0	0	0	0	0	0	0	0	0%
Ohikilolo	Manage for stability	386	25	0	1	0	0	0	0	0	0	0	0	0%
Puu Kumakalii	Manage for stability	44	0	0	12	0	0	11	3	0	0	11	11	25%
Action Area: Out														
Viola chamissoniana subsp. chamissoniana														
Halona	Manage for stability	22	5	2	4	0	0	4	1	0	0	3	3	13%
Kamaileunu	Genetic Storage	35	0	0	0	0	0	0	0	0	0	0	0	0%
Makaha	Manage for stability	68	11	0	0	0	0	0	0	0	0	0	0	0%
Makaleha	Genetic Storage	18	9	2	8	0	0	11	1	0	0	8	8	40%
Puu Hapapa	Genetic Storage	7	2	4	7	0	0	5	4	0	0	3	3	27%
		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**	
		627	62	8	32	0	0	31	9	0	0	25	25	

Tree Snail Monitoring Overview

BACKGROUND

The Army is responsible for stabilizing *Achatinella mustelina*. This involves management of numerous field sites with 8 geographically expansive locations across the Waianae Mountains. The goal set forth in the Makua Implementation Plan (MIP) 2003 and the Addendum to the MIP 2005 is to achieve a total of 300 *A. mustelina* at each of the 8 locations. The number of field sites is based on 6 (two of which are subdivided), genetically identified, Evolutionarily Significant Units (ESUs) and the number 300 snails was based on Dr. Michael Hadfield's tracking of wild populations within the Pahole Natural Area Reserve (Hadfield and Mountain 1980, Hadfield 1986, Hadfield *et al*. 1993). Monitoring is key in reporting progress toward the MIP goals and an integral part of the Oahu Army Natural Resource Program's (OANRP) tree snail stabilization program. This document is meant to summarize the OANRP prioritization scheme for management and monitoring of wild snail populations and to present and summarize the various monitoring protocols and strategies employed.

Many factors were considered in selecting population reference sites within the 8 geographic regions for management to be designated as 'manage for stability'. Habitat quality was one factor considered and sites with suitable and abundant host trees were favored. In addition, the relative native condition of the habitat was a factor, favoring native-dominated habitat. These are the same factors considered in decisions about where to construct habitat scale ungulate-proof fences (Management Units or MUs). Generally, MU fences were designed to incorporate multiple MIP species, *A. mustelina* being one of those considered in the placement of these fences. In addition, sites with gently sloping or flat terrain were incorporated in anticipation of predator proof-fence construction. Also considered were population numbers at the time of initial surveys. Sites with larger numbers of *A. mustelina* were favored over sites with lower numbers. Maximized management of greater numbers of snails may be achieved by focusing efforts on concentrated populations of snails using rat control grids and predator proof fences. Lastly, predator presence was considered. For example, one factor in selecting Ohikilolo as a site for management of ESU-B was the lack of *Euglandina rosea*. Unfortunately, both *E. rosea* and rats are abundant at all other *A. mustelina* sites. All of the above considerations relate to the relative ability of OANRP, given finite resources, to successfully achieve stability goals, control predators and protect *A. mustelina* in quality habitat.

Tree snail management involves threats that are very numerous and challenging to address. Many remaining populations are small, existing in degraded habitat, have up to three predators to manage per site and threat management techniques are limited. In the final MIP, protecting habitat was a top priority. Therefore, construction of ungulate-proof fences was the top priority. OANRP also initiated rat control using small-scale grids with snap traps and poison baits around tree snail 'hot-spots'. As additional snail locations were discovered across management units, OANRP adopted MU-scale rat control grids using best management practices from colleagues in New Zealand. Lastly, predator control fences were constructed at sites with suitable terrain and high concentrations of tree snails. Construction and planning for additional predator control fences is still underway.

MONITORING CHALLENGES

The challenging nature of tree snail monitoring cannot be understated as they are cryptic, often occur in low numbers and are mobile. OANRP's monitoring approaches have adapted through the years based on a trial and error and available methods. Each field situation and habitat warrants a different method in order to avoid negative impacts on habitat and to ensure that the method selected is the most suitable for the situation. Tree snails can be very easy to overlook. Snails are often tucked in-between dense foliage and can climb to the upper canopy where they may be out of reach and view of observers. Snails can be on host trees where slope requires the observer to be on rappel (see photo below). Tree snail monitoring is often a game of diminishing returns given an overall trend of decline in wild populations. The fewer snails present at a site, the more difficult it is to obtain reliable data on population trends and status. Tree snails are mobile, they move between trees, sometimes are found in understory vegetation and at times are observed on the ground. For an animal which appears rather sedentary, it cannot be assumed that snails remain in the same tree for most of their life. In addition, there are ~120 field populations of *A. mustelina*. OANRP cannot realistically dedicate the time and resources necessary to monitor each of these 120 sites intensively, nor is it practical in many cases, particularly at disparate populations with very low numbers where reliable monitoring data is difficult to achieve. Monitoring focus is therefore placed on those sites within habitat fences and tree snail enclosures which are designated 'manage for stability'. Amongst these 'manage for stability' sites, monitoring schedules are based on many factors which are outlined on page 5 in the monitoring prioritization section. The following is a timeline of important dates related to OANRP's tree snail monitoring program.

Vince Costello rappelling to survey habitat in Makaleha.

MONITORING TIMELINE

1995-2006 Conducted all tree snail monitoring and management under Dr. Michael Hadfield's guidance and permit (TE-826600). Mainly conducted surveys to establish distribution patterns and attempted to conduct population censuses. Used paint pen method and timed count monitoring within the Kahanahaiki exclosure after completion in 1998. Three OANRP staff were included on his permit as Authorized Individuals.

2006: OANRP authorized for some *Achatinella* activities under Army's permit (TE-043638).

2008 Kevin Hall began graduate studies using pre-printed paper dots with unique alphanumeric codes applied using cyanoacrylic glue to shell of the snail.

2010: Dr. Hadfield's USFWS permit amended to include use of the glue-dot method to mark adult snails. Juvenile snails must be marked with paint pen.

2011: USFWS hires Kevin Hall to write general *Achatinella* monitoring protocols. Protocols emphasize the use of glue dot and paint pen methods with intensive capture mark recapture plot establishment. Protocol defines primary, secondary and tertiary populations and prescribes different monitoring methods for each. OANRP registers concern to FWS with the primary population monitoring protocols based on observed harmful effects to tree snail habitats and host trees because of the intensity and frequency of monitoring conducted.

2011: Authorization to conduct *Achatinella* collection for captive propagation, reintroduction, translocation and release activities under Army's amended USFWS permit. Kevin Hall's unedited *Achatinella* monitoring protocol included as an attachment to the permit despite Army's concerns.

2012: Conduct Pu'u Hapapa snail reintroduction into predator enclosure. Concern raised over paint pen dots eroding shell tips. Literature search raised concern over using glues on *Achatinella*. Use of glues or paints on *Achatinella* ceases.

2014: Snail extinction prevention program conducts field trials with Hotspotter©, photo cataloguing method of tracking individual snails at Palikea enclosure.

2014: OANRP prepares most extensive *Achatinella mustelina* management plan for annual report since 2010. Includes table outlining monitoring plan for each ESU.

MONITORING TECHNIQUES

OANRP has employed various snail monitoring techniques over the years, each of which is described and discussed below.

Non-systematic counts:

This form of monitoring is used in association with documenting newly found population reference sites or expansions of previously known sites, as well as anecdotal information about known sites upon planned return visits or happenstance observations during the course of other resource management actions. Counts of snails may encompass either portions or the entirety of the known extent of the site, occur opportunistically during the day or night (when snails are more easily seen), and include unspecified amounts of time spent searching by varying numbers of observers with differing degrees of expertise. Given the cryptic nature of snails, this method does not reveal the total population size, but rather represents a subset of the population, even when the entire extent of the site is surveyed extensively by numerous skilled staff. This method does not provide data that can be compared over time. Much of the snail monitoring by OANRP in previous years has been done in this manner, as alternative forms of monitoring incorporating repeatable methods that provide data comparable over time remained in the experimental stage. As timed-count monitoring (described below) has been found to be an efficient and effective means of tracking population change, OANRP no longer uses non-systematic counts aside from the purposes of making anecdotal observations that are not meant to measure changes in population size.

Timed-Count Monitoring:

This method is used to monitor population growth. All visible snails are counted within a prescribed area (generally a subset of the areal extent of the population) by a specific number of skilled observers for a predetermined amount of time and time of day (day vs. night). Search aids that may be used (e.g., binoculars, flashlights, etc.) are also specified, and unspecified means of searching (ladders, tree climbing, etc.) may not be used. From this, repeatable measures may be made that are comparable over time. Due to the cryptic nature of snails, and because generally only a portion of the actual extent of the site is monitored, this method does not provide total population size information, but rather provides an index of change over time. However, if detection rates for a given site are known (e.g., by conducting timed-count monitoring following translocation of snails into a new location), population size may be roughly approximated (or a minimum population size if only a portion of the site is monitored). The interval for timed-count monitoring is based on the desired timeline for feedback of information. For example, quarterly monitoring was conducted within the Pu'u Hapapa snail enclosure in order to determine the success of lab snail reintroductions. In addition, translocation of wild snails into an enclosure is also a possible reason for conducting timed-count monitoring on a shorter interval. Given the large number of sites and limited resources for monitoring, most sites are scheduled for monitoring either every 2 or 3 years. OANRP has adopted timed-count monitoring for tracking population change in all sites, and has designated specific protocols and monitoring intervals for each (Chapter 3 in Status Report for the Makua and Oahu Implementation Plans 2014).

Capture-Mark-Recapture:

This method is used to estimate population size. Traditionally, this method involves capturing and marking all snails observed within a designated location, and at a later time(s) recapturing all snails observed within the same designated area (using the same number of individuals and time spent searching) to determine the number of marked and unmarked snails. To mark snails, OANRP used a paint pen to apply a colored dot to the tip of the snail's shell. Alternatively, if used in combination with obtaining survival, population viability analysis, and/or immigration data, a unique code may be assigned to individual snails. In association with Kevin Hall's graduate research, this was done by OANRP by adhering two paper punch-outs to the shell, one with a letter and the other a number printed on them, using a small drop of cyanoacrylic glue (see photos below). The total number of snails in the population may then be estimated by various formulae, the simplest (Lincoln-Petersen Method) being:

$$\text{Total \# in population} = \frac{(\text{\# marked on the first visit})\ (\text{total \# captured on the second visit})}{(\text{\# of marked snails recaptured on second visit})}$$

Paint dot applied to tip of tree snail.

Kevin Hall making paper punch-outs.

Letter-number combination tags.

Implicit in this method are the assumptions that all individuals have an equal chance of being captured on the second visit (i.e., individuals are randomly mixing), and that there is no immigration or emigration. These assumptions are problematic with regards to tree snails, as they are unlikely to be randomly mixing (snails at times may not move for extended periods of time, or may not move very far), while at other times may immigrate or emigrate if not confined to an enclosure. This method may also be problematic when small numbers are captured (as would be the case with many of our sites), as small differences in the number of recaptured snails can make a large difference in the population estimate. As an example, using the formula above, an estimated population size may double if by chance one additional snail happens to be recaptured:

$$\text{Est. pop. size of 10} = \frac{\text{(5 marked on first visit) (4 captured on second visit)}}{\text{(2 marked snails recaptured on second visit)}}$$

vs.

$$\text{Est. pop. size of 20} = \frac{\text{(5 marked on first visit) (4 captured on second visit)}}{\text{(1 marked snail recaptured on second visit)}}$$

The capture-mark-recapture method was used at Opaeula (for *A. sowerbyana*) and Kahanahaiki (for *A. mustelina*) by OANRP in association with Kevin Hall's graduate research. OANRP decided to discontinue use of this method for several reasons. There were concerns over the use of paint pens and glues, as OANRP observed that snails which had been marked with pens had eroding shell tips, and studies were found indicating glues may be harmful to snails. Because the assumptions inherent in this method are poorly met when applied to tree snails, the accuracy of the resulting population estimate is uncertain. Additionally, the degree of trampling that occurred at Opaeula associated with this form of monitoring was unacceptable. And ultimately, it was determined that the type of information obtained from this method, namely population estimates, is unnecessary with respect to MIP goals of maintaining 300 total snails per ESU. At least (or nearly) 300 snails have been counted via non-systematic counts and/or timed-counts for each ESU, and as discussed above, these counts represent subsets of the total population. From detection rates estimated following translocations of snails (30% at Hapapa, and 37% at Kahanahaiki), it is likely that the counts reflect roughly a third of the actual population, and as such, the goal of 300 snails is far exceeded in each ESU. It was determined that tracking population change via timed-counts produces more meaningful data, and importantly, may be conducted in a manner that does not harm snails.

In recent years, an alternative means has been developed using what is essentially the capture-mark-recapture method, but identifies snails via photography in lieu of marking, using Hotspotter© photo identification software. OANRP is exploring the use of this method, and determining its utility with respect to OANRP's management and goals.

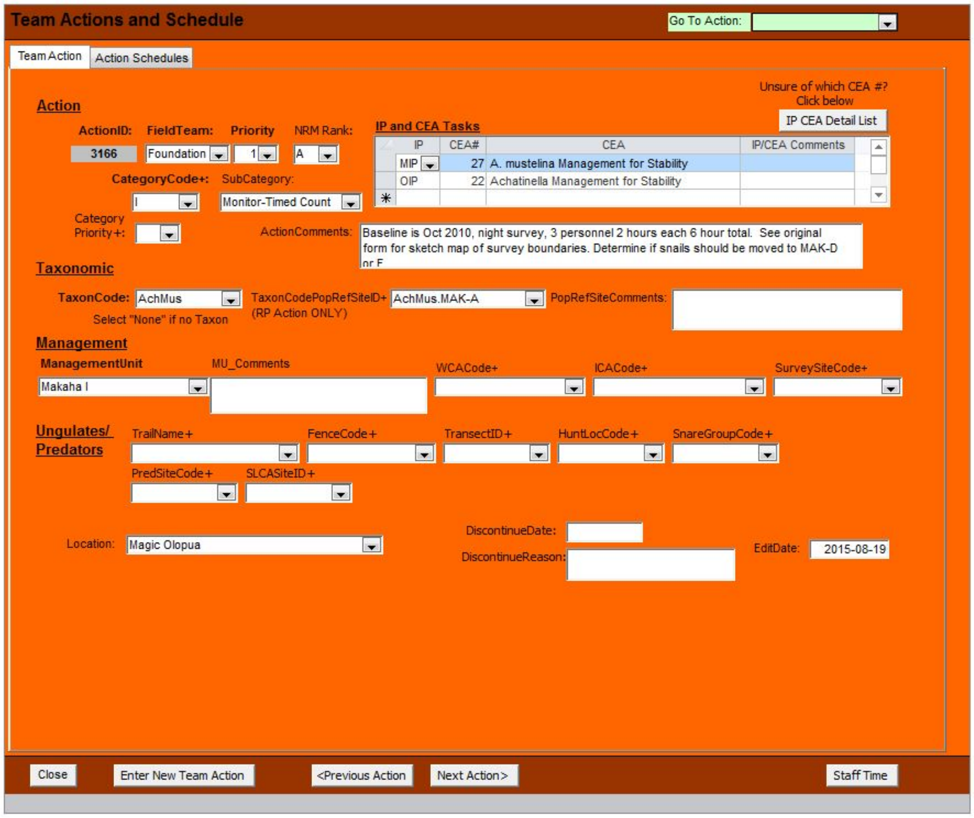
Ground-Shell Plots:

Monitoring ground shell plots provides an index of mortality change and is the most direct way to detect rat predation at a site. This method involves establishing a permanently-marked ground-level plot under host trees containing *Achatinella*. The plot is carefully searched for empty shells on the ground. These shells are removed from the plot to an area outside the plot. If a spike in mortality is observed, efforts may be made to determine and mitigate the cause, such as searching for and removing *Euglandina*, or, if available, may relocate snails into a snail enclosure. If rat predation is identified, managers can respond by increasing rat control until newly predated shells are not found in the plot or, if available, can relocate snails into a snail enclosure. Ground shell plot monitoring in snail enclosures may additionally provide evidence for any adverse responses to translocations. The interval for ground shell plot monitoring is based on the desired timeline for feedback of information. Similarly to timed-count monitoring intervals, more frequent monitoring occurs at the snail enclosures following translocations. Given the large number of sites and limited resources for monitoring, most manage for stability sites are scheduled for monitoring annually.

MONITORING SCHEDULE

All snail actions, including monitoring actions are scheduled using the Army's program database. The screenshot below is from the database. It shows the information for the timed-count monitoring action for the Achmus.MAK-A population reference site in Makaha. As shown, this action is a priority one. It is also given an "A" rank in the NRM column, the top priority as screened by OANRP's senior program managers. In the action comments section, the detailed baseline survey information is shown. Field crews must retrieve the specific information from the baseline monitoring rare snail observation form to follow. This data can be printed from the OANRP database. Under the action schedule tab (second screenshot below), OANRP managers designate the frequency that this monitoring event will happen each year. The database then folds this action into a comprehensive schedule by area for implementation in the applicable quarter by the field team responsible for this area. Team coordinators ensure that top priority actions are implemented. Lastly, field leaders record the hours spent conducting a given action by clicking on the staff time button at the bottom of this tab. This allows program managers to conduct quality checks and ensure that their priority one actions were implemented. In addition, field crews complete a rare snail observation form to track timed-count results in the database for comparison. These data are reviewed and considered in adapting strategies for management at each respective site.

ScheduleDB_TeamActions_Form



Team Actions and Schedule

Go To Action:

Team Action | Action Schedules

Unsure of which CEA #? Click below

IP CEA Detail List

Action

ActionID: 3166 FieldTeam: Foundation Priority: 1 NRM Rank: A

IP and CEA Tasks

IP	CEA#	CEA	IP/CEA Comments
MIP	27	A. mustelina Management for Stability	
OIP	22	Achatinella Management for Stability	

CategoryCode+: I SubCategory: Monitor-Timed Count

Category Priority+:

ActionComments: Baseline is Oct 2010, night survey, 3 personnel 2 hours each 6 hour total. See original form for sketch map of survey boundaries. Determine if snails should be moved to MAK-D or F

Taxonomic

TaxonCode: AchMus TaxonCodePopRefSiteID+ (RP Action ONLY): AchMus.MAK-A PopRefSiteComments:

Select "None" if no Taxon

Management

ManagementUnit: Makaha I MU_Comments WCACode+ ICACode+ SurveySiteCode+

Ungulates/ Predators

TrailName+ FenceCode+ TransectID+ HuntLocCode+ SnareGroupCode+

PredSiteCode+ SLCASiteID+

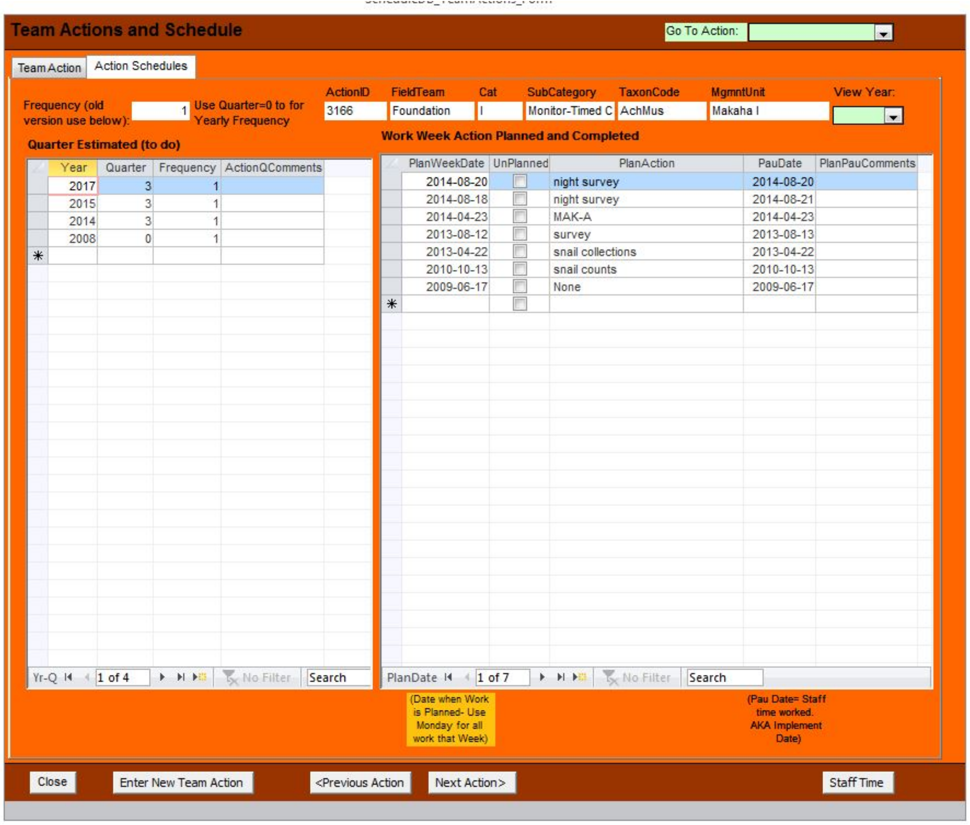
Location: Magic Olopua

DiscontinueDate:

DiscontinueReason:

EditDate: 2015-08-19

Close | Enter New Team Action | <Previous Action | Next Action> | Staff Time



Team Actions and Schedule

Go To Action:

Team Action | Action Schedules

Frequency (old version use below): 1 Use Quarter=0 to for Yearly Frequency

ActionID: 3166 FieldTeam: Foundation Cat: I SubCategory: Monitor-Timed C TaxonCode: AchMus MgmntUnit: Makaha I View Year:

Quarter Estimated (to do)

Year	Quarter	Frequency	ActionQComments
2017	3	1	
2015	3	1	
2014	3	1	
2008	0	1	

Yr-Q 1 of 4 No Filter Search

Work Week Action Planned and Completed

PlanWeekDate	UnPlanned	PlanAction	PauDate	PlanPauComments
2014-08-20		night survey	2014-08-20	
2014-08-18		night survey	2014-08-21	
2014-04-23		MAK-A	2014-04-23	
2013-08-12		survey	2013-08-13	
2013-04-22		snail collections	2013-04-22	
2010-10-13		snail counts	2010-10-13	
2009-06-17		None	2009-06-17	

PlanDate 1 of 7 No Filter Search

(Date when Work is Planned- Use Monday for all work that Week)

(Pau Date= Staff time worked. AKA Implement Date)

Close | Enter New Team Action | <Previous Action | Next Action> | Staff Time

MONITORING PRIORITIZATION

The Army must monitor *A. mustelina* in order to provide evidence that there are at least 300 total snails at each managed field site and to monitor population trends. If downward trends are detected, OANRP can investigate the potential cause of the decline. Demonstrating positive population growth indicates that current management is effective. Early identification of predation is another important reason for monitoring. In addition, a balance must be achieved between visiting field sites often enough to check on current population numbers and trends versus over-visitation leading to negative impacts on the habitat and *Achatinella* survivorship. The methods chosen must be carefully selected for each site after considering site characteristics, opportunities and limitations.

The best way to demonstrate the OANRP prioritization and planning approach for *Achatinella* monitoring is via an example. ESU-F, Pu'u Palikea area, will be used to show the nuances involved in determining OANRP *Achatinella* monitoring frequency and the methods applied. Please see the map below which illustrates the spread of *A. mustelina* population reference sites in the Palikea habitat fence. There are 20 sites with snails that fall within this ESU. To illustrate OANRP's monitoring approach for this ESU, the sites close to and within the habitat fence will be used, see the map below. The number of snails known at the site in 2014 is shown in parentheses following the population reference site code.

Map removed to protect rare resources. Available upon request

The number of snails observed during surveys varies dramatically between population reference sites. The goal at Palikea is to monitor each population reference site no less than every two years. The monitoring schedule is staggered so that about half of the sites will be monitored each year. This spreads out the workload of snail monitoring across years. In addition, the sites monitored in a given year are geographically spaced across the fenced habitat to ensure that each year OANRP is monitoring a representative sample. The table below is an updated version of the table presented in the *A. mustelina* management chapter in the 2014 annual report.

Ground shell plot monitoring and timed-count monitoring are the two methods currently applied within this ESU. Capture-mark-recapture methods are not currently employed by OANRP as this level of detailed information is not necessary for tracking population numbers relative to the *A. mustelina* stabilization goal. OANRP monitors ground shell plots annually in order to detect predation and respond with increased predator control. In general, ground shell plots are placed at sites with higher densities of tree snails and with larger numbers of individuals to ensure sufficient data will be captured. That being said, within the last year, snails at the two sites where ground shell plots were located, have been translocated into the Palikea snail enclosure. Thus, these plots have been discontinued and new ground shell plots will be installed at the two sites indicated below. The gray-shaded rows are discontinued monitoring actions since last year's report. These have been discontinued mainly due to the removal/translocation of snails at this population reference site into the Palikea snail enclosure.

ESU-F Monitoring Plan for MFS PRS (excerpt from 2014 annual report)

PRS	Monitoring Type	Monitoring Interval	Survey Years	Comments
KAA-A Mauna Kapu	TCM	every 3 years	N/A	Conduct night TCM with 2 personnel 2 hours each, for 4 person-hours total until translocation is complete. Translocation will require up to three visits. TRANSLOCATED SNAILS (DISCONTINUE)
PAK-A Puu Palikea Ohia Spot	TCM	every 2 years	N/A	Conduct night TCM for 2 person-hours. TRANSLOCATED SNAILS (DISCONTINUE)
	GSP	annually	N/A	GSP PAK-A-3 TRANSLOCATED SNAILS (DISCONTINUE)
PAK-C Steps	TCM	every 2 years	N/A	Conduct night TCM for 4 person-hours until translocation is complete. Translocation will require up to three visits. TRANSLOCATED SNAILS (DISCONTINUE)
PAK-D Joel's	TCM	every 2 years	2016, 2018	Conduct night TCM for 8 person-hours, (refer to VC for survey area boundaries from 2008-09-23). Based on results determine if snails should be translocated into enclosure. If translocation recommended, visit 3 times to collect all.
PAK-G Hame	TCM	every 2 years	N/A	Conduct baseline day surveys until translocation is complete. Translocation will require up to three visits. TRANSLOCATED SNAILS (DISCONTINUE)

PAK-H Hadfield's	TCM	every 2 years	2015, 2017	Conduct baseline day survey, recording hours to use as standard.
PAK-K Pilo	TCM	every 2 years	2015, 2017	Conduct day TCM for 4 person-hours.
	GSP	annually	2015, 2016	Install new GSP. GSP-PAK-K-1
PAK-L Olapa	TCM	every 2 years	2015, 2017	Conduct baseline survey, recording hours to use as standard. Determine night or day TCM based on terrain.
PAK-M Middle	TCM	every 2 years	2016, 2018	Conduct baseline night survey, recording hours to use as standard.
PAK-P Palikea Enclosure	TCM	annually	N/A	Conduct night TCM for 4 person-hour survey. Discontinued, changed to quarterly
PAK-P Palikea Enclosure	TCM	quarterly	2016, 2017	Once translocation is complete conduct night TCM, standard to be determined.
	GSP	quarterly	2016, 2017	Install two new GSPs. GSP-PAK-P-1 and GSP-PAK-P-2
PAK-Q Outside the Enclosure	TCM	every 2 years	2016, 2018	Conduct night TCM for 4 person-hours until translocation is complete. Translocation will require up to three visits. TRANSLOCATED SNAILS (DISCONTINUE)

Some of the population reference sites are in especially sensitive habitat which are negatively impacted by frequent monitoring events. In particular PAK-M, which has the largest number of remaining individuals, is uluhe fern dominated. If habitat was not a limitation in this situation, OANRP would select PAK-M to install a new ground shell plot because of the high density and total number of tree snails present at this site. Ground shell plots require regularly combing the ground that would lead to considerable ground disturbance. Therefore, this population reference site was not chosen for installation of a ground shell plot.

The table shows two lines for timed-count monitoring at PAK-P, the Palikea snail enclosure. Initially, OANRP were conducting TCM within the enclosure on an annual basis. The annual frequency was selected because, at the completion of the enclosure construction, the site was not the primary focus of tree snail stabilization efforts. Since this time, Jackson's chameleon presence at Palikea was not confirmed and management via the rat control grid alone was showing stable to increasing numbers at population reference sites. Since declining trends have been observed and Jackson's within the Palikea MU, OANRP has begun translocating snails into the enclosure. Thus, OANRP has switched to quarterly TCM in order to track the population changes over time more closely within the enclosure. This approach follows the monitoring timeline and methods employed at the Pu'u Hapapa and Kahanahaiki enclosures.

CONCLUSIONS

Many factors have affected the Army's snail monitoring approach through the years. This document is an attempt to illustrate the biology behind tree snail monitoring priorities, methods and schedule to the U.S. Fish and Wildlife Service. This information dovetails with the extensive *A. mustelina* plan presented in the 2014 annual report.

Literature Cited

Hadfield, M.G. and B.S. Mountain. 1981. A field study of a vanishing species, *Achatinella mustelina* (Gastropoda, Pulmonata), in the Waianae Mountains of Oahu. Pacific Science, 34: 345-358.

Hadfield, M.G. 1986. Extinction in Hawaiian Achatinelline snails. Malacologia 27: 67-81.

Hadfield, M.G., S.E. Miller, and A. H. Carwile, 1993. Decimation of endemic Hawaiian tree snails by alien predators. American Zoologist 33 (6): 610-622.

Hawaiian Hoary Bat

Acoustic and Thermal IR Monitoring Project for Tree Removal at Nehelani on Schofield Barracks 17-29 June 2015

Data prepared by C. Pinzari, for OANRP, July 2015

Survey Goals

Establish whether or not Hawaiian Hoary bats (*Lasiurus cinereus semotus*) are roosting with pups on four trees that are required to be removed for a construction project. The trees to be removed are (1) Mango (*Mangifera indica*), (1) Coconut palm (*Cocos nucifera*) and (2) Chinese Banyans (*Ficus microcarpa*) If bats present, discuss with regulatory agency possible mitigation measures to continue project or postpone removal of trees until pupping season is completed.

Survey Map

Map removed to protect rare resources. Available upon request

Figure 1. Map of the Nehelani construction project site which received bat acoustic survey. Green dots indicate location of the two acoustic detectors at the site.

Survey Methods

Acoustic surveys for bats were conducted from 17-29 June 2015 at the proposed tree cutting site for a total of 12 nights. Two SM2Bat+ ultrasonic “bat detector” (Wildlife Acoustics) were placed about 80 meters apart, on either end of the row of trees proposed to be removed (Figure 1).

Bat detectors were set to record bat echolocation calls or “pulses” from dusk until dawn, and a bat “event” was triggered, recorded as a sound file, and logged for each pass a flying bat made by the microphone of a detector during the night. The number of bat events and number of echolocation pulses within an event can be used to confirm bat presence and describe bat activity levels. Bat events can also contain information on foraging activity, by the presence of characteristic echolocation pulses that form a “feeding buzz”. Files collected during the recordings were scanned and filtered for bat presence using the program Kaleidoscope (version 1.1.22, Wildlife Acoustics) and visually inspected by sound and sight to confirm and count bat echolocation pulses. Foraging activity was also noted in call events containing feeding buzzes. Bat detectability (p), signifying presence or absence of the species for each survey was calculated using the program Presence (version 6.2, J.E. Hines, USGS). These acoustic surveys can detect whether bats are actively using the area within the range of the detectors with any frequency. The effective range of these detectors is upwards of about 50 m (C. Pinzari pers. comm.) A high detection rate could indicate the presence of a roost tree within the detection range. Whereby further surveys with a thermal imager would be required.

Visual surveys for bats were conducted on 29 June 2015, the day of the scheduled tree removal. A Fluke Ti400 thermal imager was employed to scan the tree for any roosting bats as well to confirm no presence. Scanning commenced from about 05:40 and completed around 07:00 from the ground scanning from different angles and locations around the two trees. An aerial bucket was also on site as an extra resource to scan higher in the tree.

Results and Discussion

Survey results show no measure of bat detectability at this location during the acoustic survey period. No bats were recorded passing through or utilizing the site during this time. The visual thermal IR survey detected no bats at all. Multiple species of birds were observed with the thermal IR, with visual confirmation, in and around the area. It was determined that there would be ‘No Effect’ to bats if the trees were removed.

Recommendations

Continue to utilize acoustical surveys to determine bat presence in these small well defined areas with low numbers of trees. Bat detectors can be placed within 40 meters of each other so that there is overlap in effective detection distance. If a bat is using the area around the detector frequently it is expected that there would be more activity, more passes, longer files, more than 1 per night, or more than 1 night. If bat activity is higher in a specific area then the thermal IR should be used to verify bat roosting.

Hawaiian Hoary Bat

Thermal IR Monitoring Project for Tree Removal at Vought Street on Wheeler Army Airfield 25 June 2015

Data prepared by C. Pinzari, for OANRP, June 2015

Survey Goals

Establish whether or not Hawaiian Hoary bats (*Lasiurus cinereus semotus*) are roosting with pups on two Coconut palm trees (*Cocos nucifera*) that are required to be trimmed for safety reasons. The trees were not trimmed prior to the pupping season so they still contained falling coconuts directly over residences. If bats present, discuss with regulatory agency possible mitigation measures to continue project or postpone removal of trees until pupping season is completed.

Survey Map

Map removed to protect rare resources. Available upon request

Figure 1. Map of the Vought Avenue project site which received bat acoustic surveys. Green dots indicate location of the trees to be trimmed at the site.

Survey Methods

Visual surveys for bats were conducted on 25 June 2015, the day of the scheduled tree trimming. A Fluke Ti400 thermal imager was employed to scan the tree for any roosting bats as well to confirm no presence. Scanning commenced at about 05:50 (#824 Vought Avenue.) and completed around 07:00 (#762 Vought Avenue) from the ground scanning from different angles and locations around the two trees.

Results and Discussion

The visual thermal IR survey detected no bats at all. Multiple species of birds were observed with the thermal IR, with visual confirmation, in and around the area. It was determined that there would be 'No Effect' to bats if the trees were removed.

Recommendations

Work with DPW to better monitor the contractors work so that trees that need trimming are not missed prior to the pupping season.

Hawaiian Hoary Bat

Acoustic Monitoring Project for Tree Removal at Maili Street on Schofield Barracks 01-14 July 2015

Data prepared by C. Pinzari, for OANRP, July 2015

Survey Goals

Establish whether or not Hawaiian Hoary bats (*Lasiurus cinereus semotus*) are roosting with pups on two trees that are required to be removed for a construction project. The trees to be removed are (1) Kukui nut (*Aleurites moluccanus*) and (1) *Eucalyptus spp*. If bats are present, discuss with regulatory agency possible mitigation measures to continue project or postpone removal of trees until pupping season is completed.

Survey Map

Map removed to protect rare resources. Available upon request

Figure 1. Map of the Maili Street project site which received bat acoustic survey. Green dots indicate location of the two trees to be removed at the site.

Survey Methods

Acoustic surveys for bats were conducted from 01-14 July 2015 at the proposed tree cutting site for a total of 13 nights. One SM2Bat+ ultrasonic "bat detector" (Wildlife Acoustics) was placed between the two trees proposed to be removed (Figure 1). The trees are only about 5 meters apart.

Bat detectors were set to record bat echolocation calls or "pulses" from dusk until dawn, wherein each bat "event" is triggered, recorded as a sound file, and logged for each pass a flying bat makes by the microphone of a detector during the night. The number of bat events and number of echolocation pulses within an event can be used to confirm bat presence and describe bat activity levels. Bat events can also contain information on foraging activity, by the presence of characteristic echolocation pulses that form a "feeding buzz". Files collected during the recordings were scanned and filtered for bat presence using the program Kaleidoscope (version 1.1.22, Wildlife Acoustics) and visually inspected by sound and sight to confirm and count bat echolocation pulses. Foraging activity was also noted in call events containing feeding buzzes. Bat detectability (p), signifying presence or absence of the species for each survey was calculated using the program Presence (version 6.2, J.E. Hines, USGS). These acoustic surveys can detect whether bats are actively using the area within the range of the detectors with any frequency. The effective range of these detectors is upwards of about 50 m (C. Pinzari pers. comm.) A high detection rate could indicate the presence of a roost tree within the detection range. Whereby further surveys with a thermal imager would be required.

Results and Discussion

Survey results show an extremely low measure of bat detectability at this location during the acoustic survey period. A single bat pass was recorded on 2 July at 20:22:26. It was a very short file, with three pulses of echolocation. This type of flight is considered a fly by, whereby the animal is just flying through to visit another site (C. Pinzari pers. comm.). It was determined that there would be 'No Effect' to bats if the trees were removed.

Recommendations

Continue to utilize acoustical surveys to determine bat presence in these small well defined areas with low numbers of trees. Bat detectors can be placed within 40 meters of each other so that there is overlap in effective detection distance. If a bat is using the area around the detector frequently it is expected that there would be more activity, more passes, longer files, more than 1 per night, or more than 1 night. If bat activity is higher in a specific area then the thermal IR should be used to verify bat roosting.

Hawaiian Hoary Bat

Thermal IR Monitoring Project for Tree Removal at Schofield Barracks Building 684 on 28 July 2015

Survey Goals

Establish whether or not Hawaiian Hoary bats (*Lasiurus cinereus semotus*) are roosting with pups on a Chinese arbovitae (*Platycladus orientalis*) that is infested with termites so requires removal for safety reasons. If bats present, discuss with regulatory agency possible mitigation measures to continue project or postpone removal of trees until pupping season is completed.

Survey Map

Map removed to protect rare resources. Available upon request

Figure 1. Map of the SB Bldg 684 project site which Fluke thermal imager surveys. Green dot indicates location of the tree to be removed at the site.

Figure 2. Chinese arbovitae (*Platycladus orientalis*) on site

Survey Methods

Visual surveys for bats were conducted on 28 July 2015, the day of the scheduled tree trimming. A Fluke Ti400 thermal imager was employed to scan the tree for any roosting bats as well to confirm no presence. Scanning commenced from 05:30-05:43 from the ground from different angles and locations.

Results and Discussion

The visual thermal IR survey detected no bats at all. Multiple species of birds were observed with the thermal IR, with visual confirmation, in and around the area. It was determined that there would be 'No Effect' to bats if the trees were removed.

Recommendations

Work with DPW to better monitor the contractors work so that trees that need trimming are not missed prior to the pupping season.

Thermal IR Monitoring Project for Tree Removal at Schofield Barracks Credit Union and Warrior Transition Battalion on 28 July 2015

Survey Goals

Establish whether or not Hawaiian Hoary bats (*Lasiurus cinereus semotus*) are roosting with pups on two Mexican fan palms (*Washingtonia robusta*), two Coconut palms (*Cocos nucifera*), 16 Royal palms (*Roystonea regia*), eight Loulu palms (*Pritchardia* spp.) and five queen palms (*Syagrus romanzoffiana*) that require trimming for safety reasons. If bats present, discuss with regulatory agency possible mitigation measures to continue project or postpone removal of trees until pupping season is completed.

Survey Map

Map removed to protect rare resources. Available upon request

Figure 1. Map of the SB Credit Union and Warrior Transition Battalion project site which Fluke thermal imager surveys. Red dot indicates location of the site.

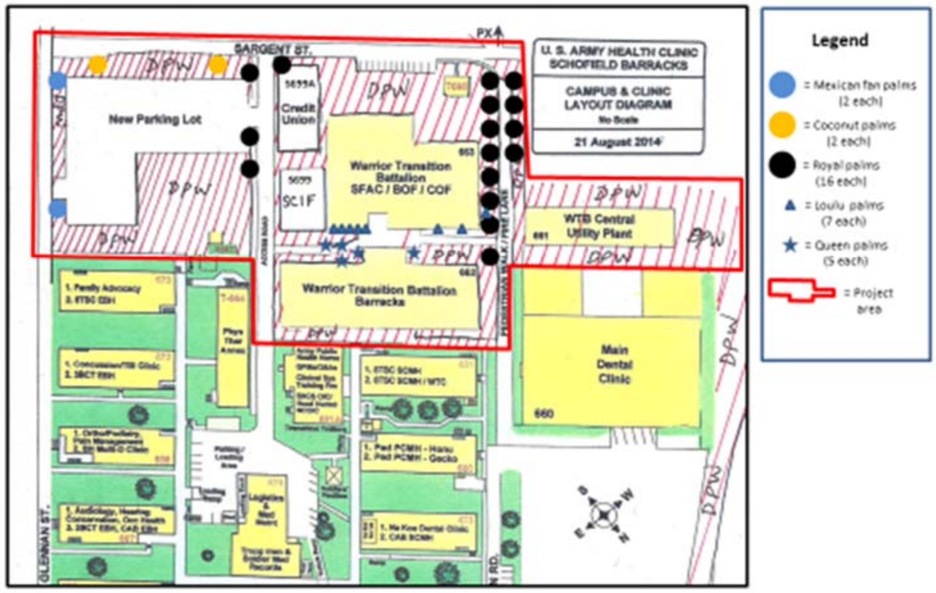


Figure 2. Map of palm locations

Survey Methods

Visual surveys for bats were conducted on 28 July 2015, the day of the scheduled tree trimming. A Fluke Ti400 thermal imager was employed to scan the tree for any roosting bats as well to confirm no presence. Scanning commenced from 05:45-06:30 from the ground from different angles and locations.

Results and Discussion

The visual thermal IR survey detected no bats at all. Multiple species of birds were observed with the thermal IR, with visual confirmation, in and around the area. It was determined that there would be No Effect to bats if the trees were removed.

Recommendations

Work with DPW to better monitor the contractors work so that trees that need trimming are not missed prior to the pupping season.

Figure 3. Photo samples of the palms on site

DEPARTMENT OF THE ARMY
US ARMY INSTALLATION MANAGEMENT COMMAND, PACIFIC REGION
HEADQUARTERS, UNITED STATES ARMY GARRISON, HAWAII
745 WRIGHT AVENUE, BUILDING 107, WHEELER ARMY AIRFIELD
SCHOFIELD BARRACKS, HAWAII 96857-5000

REPLY TO
ATTENTION OF

IMHW-ZA

MEMORANDUM FOR All Military Personnel, Contractors and Department of Defense Civilian Employees within United States Army Garrison, Hawaii (USAG-HI) Installations

SUBJECT: Policy Memorandum 72, Tree Cutting Moratorium

1. References.

a. Army Regulation (AR) 200-1, Environmental Protection and Enhancement, 13 December 2007.

b. Federal Endangered Species Act (1973).

2. Applicability. This policy applies to all Soldiers, civilians, family members, contractors, and other personnel who work on, reside on, or visit any U.S. Army installation, facility, or work site on the Island of Oahu.

3. Policy.

a. In February, 2014, the Natural Resource Program (NRP) discovered the presence of the Federally listed endangered species, Hawaiian Hoary Bat, *Lasiurus cinereus* semotus, at Schofield Barracks West Range. In addition, the NRP discovered the presence of the bat in Schofield Barracks East Range in Spring 2013. Bats have also been found by the US Geological Survey in numerous locations on Oahu spanning from Waikiki to Ford Island to the Waianae Moiuntains to the North Shore of Oahu. For this reason, bats are now considered to be ubiquitous on Oahu.

b. The Army is required to consult with the US Fish and Wildlife Service (USFWS) anytime an action may affect a listed threatened or endangered species or their critical habitat. In the meantime, the Army must practice avoidance.

c. The NRP is in the process of preparing a formal consultation package for the USFWS. Until a Biological Opinion is received from the USFWS, the following measures must be followed to maintain compliance with the Federal Endangered Species Act (1973):

(1) During the bat pupping season, 1 June to 15 September, there shall be no cutting or trimming of any tree over 15 feet tall.

(2) If a tree falls on it’s own that is over 15 feet tall, the Army may remove the tree.

IMHW-ZA
SUBJECT: Policy Memorandum 72, Tree Cutting Moratorium

(3) In case of an emergency situation, for example, a tree larger than 15 feet tall is threatening a power line, the staff must contact the Natural Resource Program for guidance, prior to cutting the tree.

(4) This policy applies to all Army installations on the island of Oahu, including housing. The policy pertains to cantonement as well as the actual training areas.

(5) This policy is in place until further notice.

4. Proponent. The proponent for administration of the Tree Cutting Moratorium is DPW, Environmental Division, at 655-9189.

RICHARD A. FROMM
COL, AD
Commanding

Army Regulation 200–1

Environmental Quality

Environmental Protection and Enhancement

Headquarters
Department of the Army
Washington, DC
13 December 2007

UNCLASSIFIED

SUMMARY of CHANGE

AR 200–1
Environmental Protection and Enhancement

This administrative revision, dated 13 December 2007--

o Updates the policy regarding Army Program Guidance Memorandum (para 15-1).

o Corrects typographical errors throughout the publication.

Headquarters
Department of the Army
Washington, DC
13 December 2007

*Army Regulation 200–1

Effective 27 December 2007

Environmental Quality

Environmental Protection and Enhancement

By Order of the Secretary of the Army:

GEORGE W. CASEY, JR.
General, United States Army
Chief of Staff

Official:

JOYCE E. MORROW
Administrative Assistant to the
Secretary of the Army

History. This publication is an administrative revision. The portions affected by this administrative revision are listed in the summary of change.

Summary. This regulation covers environmental protection and enhancement and provides the framework for the Army Environmental Management System.

Applicability. This regulation addresses environmental responsibilities of all Army organizations and agencies. Specifically, this regulation applies to—
(a) Active Army, Army National Guard/Army National Guard of the United States, and United States Army Reserve.
(b) Tenants, contractors, and lessees performing functions on real property under jurisdiction of the Department of the Army (for example, Army and Air Force Exchange Service (AAFES), Defense Commissary Agency (DECA)).
(c) Activities and operations under the purview of the Army even when performed off of installations.
(d) Formerly used defense sites (FUDS) and other excess properties managed by the Army. As used throughout this regulation, the term Army National Guard includes the Army National Guard of the United States.

Installations and facilities in foreign countries will comply with requirements of this regulation that specifically prescribe overseas requirements.

Contracts to operate Government-owned facilities will reference this regulation and will designate by specific citation the applicable provisions.

This regulation does not apply to civil works (CW) functions under the jurisdiction of the U.S. Army Corps of Engineers (USACE).

The terms "Army environmental programs" and "Army Environmental Program" must be read in context. All Army organizations, regardless of their organizational level or chain of command, have environmental responsibilities as part of their functions; these environmental responsibilities must be incorporated into the planning, programming, budgeting, and execution of their respective missions. The Assistant Chief of Staff for Installation Management, working through the Director of Environmental Programs (see Responsibilities, para 1–13x), has specific and more narrowly defined responsibilities that are planned, programmed, budgeted, and executed via assigned accounts. These accounts resource specifically prescribed and focused environmental efforts. Each organization must program and fund its environmental activities from the appropriate account of the proponent's operating budget, not necessarily an environmental account. Being mindful of the context in which requirements are articulated will help define the scope of the "program" being addressed and will preclude inappropriate resourcing decisions or expectations.

Proponent and exception authority. The proponent of this regulation is the Assistant Chief of Staff for Installation Management. The proponent has the authority to approve exceptions or waivers to this regulation that are consistent with law and regulations. The proponent may delegate this approval authority, in writing, to a division chief within the proponent agency or its direct reporting unit or field operating agency, in the grade of colonel or the civilian equivalent. Activities may request a waiver to this regulation by providing justification that includes a full analysis of the expected benefits and must include formal review by the activity's senior legal officer. All waiver requests will be endorsed by the commander or senior leader of the requesting activity and forwarded through their higher headquarters to the policy proponent. Refer to AR 25–30 for specific guidance.

Army management control process. This regulation contains management control provisions and identifies key management controls that must be evaluated.

Supplementation. Supplementation of this regulation and establishment of command or local forms are prohibited without prior approval from Assistant Chief of Staff for Installation Management, 600 Army Pentagon, Washington, DC 20310–0600.

Suggested improvements. Users are invited to send comments and suggested improvements on DA Form 2028 (Recommended Changes to Publications and Blank Forms) through the chain of command to HQDA, DAIM–ED, 600 Army Pentagon, Washington, DC 20310–0600.

Distribution. This publication is available in electronic media only and is intended for command levels C, D, and E for the Active Army, the Army National Guard/Army National Guard of the United States and the United States Army Reserve.

*This regulation supersedes AR 200–1, dated 28 August 2007.

Contents (Listed by paragraph and page number)

Contents—Continued

Contents—Continued

Contents—Continued

Figure List

Glossary

Index

Appendix 4-2 Tree Cutting Moratorium

Chapter 1
Introduction

Section I
General

1–1. Purpose

a. This regulation implements Federal, State, and local environmental laws and DOD policies for preserving, protecting, conserving, and restoring the quality of the environment. This regulation should be used in conjunction with 32 Code of Federal Regulations (CFR) Part 651 (32 CFR 651), which provides Army policy on National Environmental Policy Act (NEPA, 42 USC 4321–4347) requirements, and supplemental program guidance, which the proponent of this regulation may issue as needed to assure that programs remain current. Environmental stewardship includes, but is not limited to—

(1) Environmental components of installation sustainability.

(2) Environmental support to the Army training and testing mission.

(3) Environmental support during deployments and contingency operations on and off the installation, and operations at Army facilities that are not officially designated as installations.

(4) Compliance-related Cleanup (CC) Program.

(5) Army Defense Environmental Restoration Program (DERP).

(6) Formerly used defense sites (FUDS).

(7) Defense and State Memoranda of Agreement/Cooperative Agreement (DSMOA/CA) Program.

(8) Pollution prevention.

(9) Compliance with environmental legal mandates.

(10) Natural resources.

(11) Cultural resources.

(12) Environmental protection aspects of pest management.

(13) Environmental training for military and civilian personnel.

(14) Base realignment and closure (BRAC) environmental program.

(15) NEPA requirements.

(16) Operational noise.

(17) Environmental quality technology (EQT).

(18) Environmental Legislative/Regulatory Analysis and Monitoring Program (EL/RAMP).

(19) Environmental reporting and information management.

(20) Environmental considerations in real estate and materiel acquisition programs.

b. This regulation defines the framework for the Army Environmental Management System (EMS). All appropriate facilities were to have implemented a mission focused EMS by the end of calendar year (CY) 05, and must attain International Organization for Standardization standard 14001 (ISO 14001) conformance by the end of FY09. The Army EMS Commanders Guide, Army EMS Implementer's Guide, and Army EMS Aspects and Impact Methodology for Army Training Ranges provide detailed implementation guidance.

c. The chapters of this regulation reflect inclusion of the five interconnected EMS areas of policy, planning, implementation and operation, checking and corrective action, and management review.

(1) *Policy*. The Army Environmental Policy Statement reflects the Army's commitment to environmental protection and enhancement, pollution prevention, and continual improvement (chap 2).

(2) *Planning and implementation*. The Army will identify how its operations impact the environment. It will set objectives and targets for reducing impacts. It will identify and track applicable legal and other requirements, and will support operational effectiveness and improve program management (chap 3).

(3) *Program management and operation*. The Army will assign roles and responsibilities for environmental management (section II of this chap), provide required environmental training, establish procedures for communication within and outside the organization, document environmental procedures, and provide for emergency preparedness and response (chap 15).

(4) *Checking and corrective action*. The Army will monitor and measure its progress in achieving stated goals, objectives, and targets, and will identify and implement corrective actions (chap 16).

(5) *Management review*. The Army will periodically review program performance and management system implementation and ensure continual improvement (chap 17).

1–2. References

Required and related publications and prescribed and referenced forms are listed in appendix A.

1–3. Explanation of Abbreviations and Terms
Abbreviations and special terms used in this regulation are explained in the glossary.

Section II
Responsibilities

1–4. The Secretary of the Army
The Secretary of the Army (SA) serves as trustee for the natural and cultural resources managed by the Army. The SA is responsible for protecting and sustaining the quality of the air, land, and water resources entrusted to the Army. The SA signs the Army Environmental Policy Statement and certifies that the Army Environmental Program Objective Memorandum (POM) for the Army Environmental Restoration Program (ERP) meets all legal requirements and agreements.

1–5. The Assistant Secretary of the Army (Installations and Environment)
The Assistant Secretary of the Army (Installations and Environment) (ASA(I&E)) has primary responsibility for the Army's military environmental programs (that is, other than civil works (CW) functions of the U.S. Army Corps of Engineers (USACE)). Those responsibilities are carried out through the Deputy Assistant Secretary of the Army (Environment, Safety, and Occupational Health) (DASA(ESOH)) who will—

a. Provide overall policy, advocacy, program direction, and oversight across installations, logistics, acquisition, and operations. This includes, but is not necessarily limited to, military operations and activities (including training, deployments, and contingency operations) on and off the installation and operations at Army facilities that are not officially designated as installations or sites.

b. Establish long-term strategy and annual AEP goals, objectives, and metrics.

c. Serve as the Army's top management representative for the Army EMS.

d. Provide policy and oversight for EMS responsibilities per ISO 14001 and this regulation.

e. Serve as the Army's senior policy level official for historic preservation in accordance with Executive Order (EO) 13287, Preserve America, and as the Federal Preservation Officer for oversight and coordination of Army activities under the National Historic Preservation Act (NHPA), including approving and signing Army National Register of Historic Places (NRHP) nominations for Federally-owned and -controlled historic properties.

f. Serve as the primary point of contact with the Office of the Secretary of Defense (OSD), Congress, other Federal and State agencies, and other components for environmental matters.

g. On behalf of the SA, carry out DOD executive agent (EA) responsibilities for the following OSD programs: Environmental Information Technology Management (EITM), FUDS, DSMOA, Low-Level Radioactive Waste (LLRW), Defense Occupational Health Program (DOHP), National Defense Center for Environmental Excellence (NDCEE), DOD regional environmental coordinators (RECs), DOD Forestry Reserve Account, and environmental-related annexes to Master Data Exchange Agreements.

h. Provide policy, advocacy, program direction, and oversight for Formerly Used Defense Sites (FUDS), Base Realignment and Closure (BRAC), and the Army's Defense Environmental Restoration Program.

i. Approve selection of Army representative(s) for inter-service and interagency environmental committees.

j. Provide oversight and coordination of strategic outreach and communication.

k. Provide policy, advocacy, program direction, and oversight of the Army EQT Program.

l. Serve as a permanent co-chair of the Environmental Technology Technical Committee (ETTC); consolidate and prioritize Army environmental technology needs and ensure the cost-effective allocation of available resources, consistent with the Army Program Guidance Memorandum (APGM).

m. Provide policy, advocacy, program direction, and oversight of environmental support to the Army acquisition process.

(1) In conjunction with the Assistant Secretary of the Army (Acquisition, Logistics, and Technology) (ASA (ALT)), annually review Army environmental quality research, development, test, and evaluation (RDT&E) efforts.

(2) Provide representation on the Overarching Integration Product Teams (OIPT) supporting Army Systems Acquisition Review Councils (ASARC) to ensure Army material in all acquisition categories meet requisite environmental criteria prior to milestone reviews.

(3) Provide recommendations to the Milestone Decision Authority regarding program environmental quality requirements.

n. Review all Army weapons system acquisition programs for potential or real impacts to environmental quality and/or Army installations.

o. Review Army weapons system acquisition program environmental quality costs by participating on the Army Cost Review Boards (CRB) and providing representation on weapons system cost working group Integrated Product Teams (IPTs).

p. Develop and approve funding policies for environmental programs in coordination with the Assistant Secretary of the Army (Financial Management & Comptroller) (ASA (FM&C)), and with the ASA (ALT) for RDT&E efforts.

q. Approve Army environmental input to Program Objective Memorandum (POM) direction, priorities, and guidance.

r. Approve AEP POM and budget submissions, resource allocations, unfinanced requirements (UFRs), and budget adjustments recommended by the ACSIM in coordination with the DCS, G–8 and the ASA (FM&C).

s. Ensure that the Army's trust responsibility and government-to-government relationship with Federally-recognized Indian Tribes are fulfilled.

t. Approve NHPA compliance agreements, as required.

u. Approve and integrate the Army Environmental Policy Institute (AEPI) and U.S. Army Environmental Command (USAEC) annual work plans.

v. Provide supervision and program direction for the AEPI, to include POM, budget, and UFR approvals.

w. Consult with the ACSIM on selection of the Director of Environmental Programs (DEP).

x. Serve as the intermediate rater for the DEP and Commander, USAEC, and provide input into their performance objectives.

y. Act as co-chair with the ACSIM for the HQDA Environmental Quality Control Committee (EQCC).

z. Provide direction and delegate specific actions to the Army DOD RECs.

aa. Manage the operation of the regional environmental offices (REOs).

ab. Serve a permanent co-chair of the DOD Operational and Environmental Executive Steering Committee on Munitions (OEESCM).

ac. Report annually to the SA/CSA on AEP execution.

ad. Serve as point of contact for external audits of the AEP.

ae. Provide Congressional testimony and reports to Congress.

af. Provide programmatic environmental scoping and planning to include National Environmental Policy Act (NEPA) and Strategic Environmental Assessment (SEA).

ag. Oversee AEP support to natural and built environments, to include ranges.

ah. Ensure the AEP addresses overseas installations and activities.

ai. Integrate energy, pollution prevention, and EMS.

aj. Integrate ESOH programs and activities with force protection and national security.

ak. Execute the EL/RAMP.

1–6. The Assistant Secretary of the Army (Financial Management and Comptroller)

The Assistant Secretary of the Army (Financial Management and Comptroller) (ASA (FM&C)) will—

a. Issue planning, programming, budgeting, and execution (PPBE) system policy, Funding Authorization Document (FAD) footnotes for the Conservation Reimbursable Forestry and Agricultural/Grazing Outlease Programs, guidance for environmental programs, and Fish and Wildlife Conservation Fund (21X5095) apportionments, in coordination with the ASA (I&E).

b. Develop an independent cost estimate (ICE) that includes an environmental quality life cycle cost estimate (EQLCCE) for each weapons system. Reconciles differences in the EQLCCE, and the program office estimate (POE) in developing the Army cost position (ACP).

c. Collect and report environmental liabilities for the Army's Financial Statement.

1–7. The Assistant Secretary of the Army (Acquisition, Logistics, and Technology)

The Assistant Secretary of the Army (Acquisition, Logistics, and Technology) (ASA (ALT)) will—

a. Provide policy, guidance, oversight, and technical assistance to acquisition program managers and program executive offices as required to ensure integration of environmental quality considerations in all aspects of acquisition programs.

b. Plan, program, budget, and execute the Army's Environmental Quality Technology Program (for EQT Budget Activity 1, 2, and 3 Program initiatives) in coordination with the ASA (I&E) to maximize the ability of the Army to achieve its environmental strategy.

c. Develop policy to ensure procurement of materiel designed to minimize environmental impacts throughout its life cycle, while ensuring operational effectiveness.

d. Develop policy in coordination with the ASA (I&E) on acquisition of hazardous material.

e. Develop and oversee initiatives to reduce the volume and toxicity of hazardous materials and ozone depleting substances (ODS) used in Army materiel.

f. Review annually Army environmental quality technology program RDT&E efforts in conjunction with the ASA (I&E).

g. Designate the Director, Research and Laboratory Management, OASA(ALT), a permanent co-chair of the Environmental Technology Technical Committee (ETTC), who in conjunction with the ACSIM, consolidates and prioritizes Army environmental technology needs and ensures the cost-effective allocation of available resources, consistent with the APGM.

h. Integrate environmental considerations/awareness into acquisition programs and training in accordance with DODD 5000.1.

i. Ensure that environmental quality life cycle costs are clearly identified in the Program Office Estimate.

j. Serve as the proponent for the Army Green Procurement Program (GPP) to facilitate compliance with Affirmative Procurement requirements (for recovered materials and biobased items) and encourage the acquisition and use of environmentally preferable products and services.

k. Ensure all requests for proposal (RFP), contracts, and contract modifications include a requirement that bidders providing goods and services to installations certify (in the Representations and Certifications component of their proposal) that operations of their team (including subcontractors) will be consistent with the installation's and the Army's EMS.

l. Incorporate environmental and EMS requirements into appropriate acquisition regulations, policies, and procedures, and appoint a single point of contact for coordinating this action with the ACSIM/DEP.

m. Provide direct support to the Army Acquisition Community, Program Executive Officers, and Program/Product/Project Managers regarding environmental and affirmative procurement initiatives, issues and concerns by—

(1) Providing recommendations to the Army Acquisition Executive (AAE) or other decision authority about environmental issues associated with materiel and ASA (ALT) mission functions.

(2) Designating a single point of contact for coordinating environmental issues related to materiel development, logistics, and technology for Headquarters, Department of the Army (HQDA) component organizations in coordination with the Office of the ASA (I&E).

(3) Ensuring execution of environmental policy by acquisition managers.

1–8. The Chief of Public Affairs

The Chief of Public Affairs (CPA) will—

a. Provide policy, guidance, and oversight for public affairs support to the Army's environmental programs.

b. Provide advice and recommendations on handling the public affairs aspects of Section 552, Title 5, United States Code (5 USC 552) requests related to the environmental program.

1–9. The Deputy Chief of Staff, G–3/5/7

The Deputy Chief of Staff, G–3/5/7 (DCS, G–3/5/7) is responsible for developing and coordinating policy, programs, and initiatives to achieve directed levels of training readiness for the Army and serves as the overall integrator of Army Transformation. The DCS, G–3/5/7 will—

a. Serve as the focal point for spectrum activities encompassing force development, combat development, training development, resource management, and prioritization.

b. Establish priorities and requirements for Army ranges and training lands.

c. Exercise overall supervision, direction, and management oversight for the Sustainable Range Program (SRP). Specific responsibility for the SRP resides with the Chief, Training Support Systems Division (DAMO–TRS), who will—

(1) Serve as the HQDA functional proponent for the SRP and its core programs.

(2) Formulate policies and issue administrative programmatic guidance and instructions for implementing and sustaining the core programs within Army Commands (ACOMs), Army Service Component Commands (ASCCs), and Direct Reporting Units (DRUs), the Army National Guard (ARNG), and Headquarters, Installation Management Command (HQ IMCOM).

(3) Formulate policies for planning, programming, operating, and managing ranges and training lands that specify how the Army will—

(a) Resource range operations and modernization through the Range and Training Land Program, and land management and maintenance through the Integrated Training Area Management (ITAM) Program.

(b) Integrate range requirements into the overall Army infrastructure investment strategy in conjunction with the Office of the Assistant Chief of Staff for Installation Management (OACSIM).

(c) Centrally fund unexploded ordnance (UXO) clearance for range modernization projects.

(d) Centrally fund the preparation of NEPA documentation for range modernization projects and major training land acquisitions.

(e) Coordinate and synchronize range and training land policy to preclude conflicts between range operations and military training, natural and cultural resources management, environmental management, facilities management, and master planning activities.

(4) Serve as the co-chair of the Army Range Sustainment Integration Council (ARSIC).

1–10. The Deputy Chief of Staff, G–4

The Deputy Chief of Staff, G-4 (DCS, G-4) will—

a. Identify, program, and secure funds to address the environmental aspects of the functions for which the DCS, G–4 is responsible.

b. Incorporate environmental considerations and requirements into all aspects of the DCS, G–4 mission, to include materiel management, integrated logistics support, supply, transportation, maintenance management, and logistics training.

c. Serve as the staff proponent for policy development pertaining to hazardous materials minimization and management, to include inventory management per AR 710–2.

d. Ensure that timely hazardous material (HM) handling, packaging, and transportation training is provided to Army personnel within the continental United States (CONUS) and overseas as required.

e. Serve as the proponent for implementation of the Military Munitions Rule.

f. Execute quarantine responsibilities for transport and logistics.

1–11. The Deputy Chief of Staff, G–8

The Deputy Chief of Staff, G-8 (DCS, G-8) will—

a. Provide Army cross-PEG (Program Evaluation Group) funding process guidance to assure cost effective compliance with environmental legal mandates while optimizing benefits to the Army missions and operations.

b. Assure priority is given to resource allocation that cost effectively resolves environmental aspects that impact missions and operations needed to equip, sustain and train our combat forces.

c. Review plans and requirements of Senior Mission Commanders, Army Command/Army Service Component Command/Direct Reporting (ACOM/ASCC/DRU) commanders, acquisition program managers and garrison commanders that address compliance with legal environmental mandates and resolve environmental aspects impacting missions and operations.

d. Review plans and requirements for the Army Environmental Program in coordination with the Assistant Chief of Staff for Installation Management (ACSIM).

e. Conduct annual review of resources allocated to sustaining Army environmental compliance to overhead investments in the most cost effective manner.

1–12. Commander, U.S. Army Corps of Engineers

The Commander, U.S. Army Corps of Engineers (USACE) will—

a. Administer the Clean Water Act (CWA) Section 404 permit program pertaining to the discharge of dredged/fill material into waters/wetlands of the United States.

b. Provide additional environmental support to the Army and other DOD elements as requested.

c. Provide environmental support to other Federal, State, and local agencies when tasked.

d. Provide Army DERP execution support on a reimbursable basis to installations through Districts and the Centers of Expertise for hazardous, toxic, and radioactive waste (HTRW) and for munitions and explosives of concern (MEC).

e. Administer the DSMOA/CA Program for the Assistant Deputy Undersecretary of Defense (Environment, Safety, and Occupational Health) (ADUSD (ESOH)).

f. Serve as executing agency for the FUDS program, consistent with the FUDS Charter. Establish FUDS requirements and policy guidance for program management, planning, reporting, execution, data access, quality control, and performance measurement.

g. Provide technical support by implementing sustainable design and development (SDD) practices, including incorporating SDD/sustainable project rating tool (SPiRiT) and environmental criteria into the Army's project design and construction process. (NOTE: Beginning in FY08, SPiRiT will be replaced by Leadership in Energy and Environmental Design (LEED); all new construction must meet the LEED Silver standard.)

h. Incorporate environmental requirements into appropriate USACE activities, and appoint a single point of contact for coordinating this action with the ACSIM/DEP.

i. Approve and integrate the USACE Engineer Research and Development Center (ERDC) EQT program and provide overall policy direction for the ERDC.

1–13. The Assistant Chief of Staff for Installation Management

The Assistant Chief of Staff for Installation Management (ACSIM) will—

a. Serve as the HQDA proponent for the AEP.

b. Establish priorities, guidance, and procedures for installation operations, real property management, and environmental stewardship for all activities and functions within Army garrisons.

c. Promote environmental stewardship and sustainability in support of the ASA (I&E).

d. Incorporate environmental requirements into appropriate regulations, guidance documents, and procedures to support environmental stewardship.

e. Co-chair the HQDA annual Review and Analysis with the ASA (I&E).

f. Issue appropriate programming and funding guidance to ACOMs, ASCCs, DRUs, NGB–ARNG, HQ IMCOM, and special installations to support development of the environmental programs component of the Program Objective Memorandum (POM).

g. Develop and direct the planning, programming, and budget execution of the environmental components of the Installations Program Evaluation Group (II PEG) programs needed to sustain readiness and comply with appropriate Federal, State, and local laws, Executive Orders, DOD Directives overseas Final Governing Standards, international treaties and Status of Forces Agreements (SOFAs) in accordance with General Order #3 and APGM. This specifically includes base operations support (BOS) service activities addressed by the following Management Decision Packages (MDEPs):

(1) VENC (Environmental Compliance).

(2) VENN (Environmental Conservation).

(3) VEMR (Environmental Support to Ranges and Munitions).

(4) VEPP (Pollution Prevention).

(5) VEQT (Environmental Technology).

(6) ENVR (Environmental Restoration).

h. Direct execution of the environmental components of the Installations Program Evaluation Group (II PEG) programs.

i. Serve as proponent of the Army Compatible Use Buffer (ACUB) program.

j. Perform the EA duties for the DOD Forestry Reserve Account in coordination with the DASA (ESOH).

k. Provide representation for environmental and installation concerns on the Army Requirements Oversight Council (AROC).

l. Provide guidance on incorporating BRAC oversight and responsibilities on environmental and Military Munitions Response Program (MMRP) through the ACSIM BRAC Division (DAIM–BD).

m. As the Army's combat developer (CBTDEV) for installations, generate, validate, and prioritize environmental quality RDT&E requirements.

n. Serve as a member of the Environmental Technology Technical Council (ETTC).

o. Serve as proponent for Army SDD facility policies that are incorporated into the process of planning, designing, constructing, operating, maintaining, renovating, and disposing installation facilities.

p. Serve as the technical advisor to ASA (I&E) for all environmental matters impacting installation sustainment and materiel operation and support.

q. Promote and integrate installation sustainability across all functional areas (for example, logistics, environment, training, engineering).

r. Maintain an organization within the OACSIM that will—

(1) Provide to the ASA (I&E), and others as directed, an Environmental Quality Impact Analysis (EQIA) for major weapons systems acquisition program decision reviews.

(2) Provide technical support to the ASA(FM&C) for environmental quality life cycle cost estimates as part of the Army Cost Review process as required.

(3) Upon request, assist program managers in integrating environmental quality considerations into all aspects of the acquisition program.

s. Issue implementing guidance to eliminate ODS use on Army installations.

t. Issue implementing guidance with respect to endangered species critical habitat designation.

u. Provide annual authorities for the forestry, agricultural/grazing, and hunting and fishing fee reimbursable programs.

v. Serve as initial denial authority and acts on FOIA requests for records pertaining to environmental activities, other than litigation.

w. Manage the Environmental Restoration, Army (ER, A) account.

x. Manage environmental program responsibilities for base operations support (BOS) through the Office of the Director of Environmental Programs (ODEP). The ODEP will—

(1) Serve as the HQDA functional proponent for the Army Environmental Program (AEP).

(2) Provide HQDA oversight of the AEP that reflects overall Army compliance, stewardship, sustainability, and readiness priorities.

(3) Formulate and issue Army guidance and instructions for implementing and sustaining the AEP.

(4) Coordinate AEP requirements with all appropriate organizations to preclude conflicts, and to synchronize activities, among operations and training, real property management, and master planning.

(5) Identify, plan, program, budget, support, and defend military resource requirements for the AEP.

(6) Exercise primary Army staff (ARSTAF) responsibility to oversee, manage, and coordinate Army military

environmental programs as described in paragraphs 1–1a(1)-1–1a(20), including resource utilization and progress toward goals and objectives for II PEG funded programs.

(7) Serve as the proponent for the Army Environmental Awards Program.

(8) Establish the Configuration Control Management Board (CCMB) to advise the DEP on Army Environmental Reporting matters.

(9) Develop guidance for implementation, utilization, and coordination of geospatial information and services within the environmental program.

(10) Exercise primary ARSTAF responsibility to collect, coordinate, and integrate user requirements for the Army EQT Program through the Army Environmental Requirements and Technology Assessment (AERTA) process.

(11) Participate in the EQT Teams to ensure the Army's EQT user needs are effectively addressed.

(12) Provide guidance and recommendations on all issues directed to the ACSIM concerning policies and PPBE for the CC Program, Army DERP (including Installation Restoration Program (IRP) and MMRP), BRAC cleanup, and FUDS.

(13) Provide general oversight, resource requirements verification, and guidance for the execution of the FUDS Program to ensure program execution consistent with the FUDS Charter.

(14) Provide oversight of the Environmental Performance Assessment System (EPAS).

(15) Serve as the Executive Secretary to the DOD Operational and Environmental Executive Steering Committee for Munitions (OEESCM) and the HQDA EQCC.

(16) Serve as the chairman of the DOD Hazardous Waste Management Subcommittee.

(17) Serve as co-chair of the ARSIC.

(18) Execute EMS responsibilities per ISO 14001 and this regulation.

(19) Monitor the execution of the AEP to conform to EMS.

(20) Establish implementing guidance for Army environmental reporting systems.

(21) Provide upward reporting on progress in meeting AEP goals and objectives to HQDA leadership, OSD, and Congress.

(22) Develop appropriate Army-wide standards and metrics for the AEP.

(23) Designate two ACSIM representatives as voting members on the Armed Forces Pest Management Board (AFPMB). Designate Army senior consultant (ASC) and DOD certification officials for Army civilian personnel per DOD policies and procedures.

(24) Maintain an efficient and well-trained workforce.

(25) Coordinate AEP strategic outreach.

(26) Centrally manage the Conservation Reimbursable Forestry, Agricultural/Grazing Outlease, and Fish and Wildlife Conservation Programs; set installation specific Automatic Reimbursable Authority for forestry and agricultural/grazing at installations.

1–14. Commander, Installation Management Command

The Commander, Installation Management Command (IMCOM) will—

a. Execute sustainable base operations support for all installations under its purview in compliance with applicable laws and regulations (to include Final Governing Standards (FGS), and international agreements overseas) to support the Army training and testing mission.

b. Integrate program guidance, goals, and issue across installation functional areas (for example, logistics, environment, training, engineering, and planning).

c. Oversee management of installation environmental programs.

d. Provide program management reviews for the ACSIM and DASA (ESOH).

e. Monitor and track environmental performance of Regional Offices and the US Army Reserve.

f. Assist installations in the execution of the Army CC program.

g. Develop an annual program management plan (PMP), consistent with the Army Cleanup Strategy and Strategic Plan, for the CC Program.

h. Coordinate IMCOM issues that affect mission among senior mission commanders (SMCs), ACOMs, ASCCs, DRUs, and garrisons.

i. Coordinate the execution of the EPAS Program for the active Army through USAEC.

j. Participate in environmental awards activities as appropriate.

k. Review, analyze, perform quality assurance/quality control (QA/QC), and approve environmental requirements and data reported by installations.

l. Maintain an efficient and well-trained workforce.

m. Coordinate with the DCS, G–3/5/7, ACOMs, ASCCs, DRUs, and Directorate of Plans, Training, Mobilization, and Security (DPTMS) to ensure ITAM Program requirements are implemented in accordance with DAMO–TRS resource allocations and guidance.

n. Report progress in meeting AEP goals and objectives to HQDA leadership.

o. Provide guidance and assistance to garrisons and monitor the execution of IMCOM's portion of the AEP in accordance with EMS.

p. Assist IMCOM installations in negotiations with regulatory agencies to preclude adverse mission impacts or the inadvertent establishment of Army policy that may conflict with regulatory requirements.

q. Provide AEP technical implementation support through the Commander, USAEC, who will—

(1) Provide environmental technical products and services in support of Army training, operations, acquisition, and sound stewardship.

(2) Manage assigned elements of the Army Cleanup Program in accordance with ACSIM direction and guidance. Develop and execute an annual program management plan (PMP), consistent with the Army Cleanup Strategy and Strategic Plan, for the Army DERP.

(3) Provide technical support for pest management.

(4) Program for and coordinate execution of EPAS for the active Army.

(5) Provide program management for the Army DERP at active installations.

(6) Execute policy and guidance for Army environmental reporting systems.

(7) Provide technical support to the Chief, Training Support Systems Division, Office of the DCS, G–3/5/7 in support of the SRP core programs.

(8) Provide technical support and day-to-day operational oversight for Conservation Reimbursable Forestry, Agricultural/Grazing Outlease and Fee Collection Programs.

(9) Provide technical support to DASA (ESOH) in support of the ASARC and CRB.

(10) Provide technical support to the Army's EQT Program as it relates to installation issues.

(11) Provide outreach support to the AEP.

(12) Provide public affairs support to the AEP.

(13) Maintain an efficient and well-trained workforce.

(14) Provide Hazardous Material Management Program (HMMP) operational oversight to the DCS, G–4 for environmental hazardous material management.

(15) Perform data collection and analyses of HMMP environmental information to measure program success.

1–15. The Chief, Army Reserve

The Chief, Army Reserve (CAR) will—

a. Ensure environmentally sustainable operations.

b. Serve as the primary ARSTAF adviser for all Army Reserve mission-related environmental issues.

c. Ensure that Army environmental policy is implemented within the Army Reserve.

d. Ensure that environmental stewardship is incorporated into all aspects of the Army Reserve mission.

e. Coordinate with IMCOM on matters of mutual interest or concern.

1–16. National Guard Bureau - Director, Army National Guard

The National Guard Bureau – Director, Army National Guard (NGB-DARNG) will—

a. Execute environmentally sustainable base operations support in compliance with applicable laws and regulations to support the Army training and testing mission.

b. Ensure the NGB–DARNG acquires, manages and distributes resources; develops and administers policies and programs.

c. Serve as the "Channel of Communication" between the Army and the National Guard of the States, Territories and the District of Columbia.

d. Serve as the primary ARSTAF advisor for all ARNG environmental issues, and sign or appoint a designated representative to sign all ARNG Federal compliance agreements, consent orders, and environmental assessments, findings of no significant impact, and other pertinent Federal environmental documentation.

e. Coordinate with HQDA, State ARNGs, and other organizations to fulfill the NGB–ARNG's ARSTAF role as an Army component, the NGB–ARNGs role as the installation management organization for the State ARNGs, and the NGB–ARNG's role in performing ACOM, ASCC, or DRU functions.

f. Specific day-to-day responsibility for the environmental management program resides with the NGB–ARNG Chief of Environmental Programs (CEP). To carry out this responsibility, the NGB–ARNG CEP will—

(1) Ensure environmentally sustainable operations and planning.

(2) Ensure that Army environmental policy is implemented within the ARNG.

(3) Ensure that environmental stewardship is incorporated into all aspects of the ARNG mission.

(4) Integrate program guidance, goals, and issues across installation functional areas (for example, logistics, environment, training, engineering) and planning areas.

(5) Submit environmental base support requirements to the OACSIM. Budget and execute environmental resources consistent with program needs.

(6) Develop an annual program management plan (PMP), consistent with the Army Cleanup Strategy and Strategic Plan, for the Army CC Program; and provide program management reviews for the ACSIM and DASA (ESOH).

(7) Provide supplemental implementing guidance and instructions consistent with HQDA guidance for environmental reporting to the states.

(8) Report progress in meeting AEP goals and objectives to HQDA leadership.

(9) Provide State ARNGs guidance and assistance, and monitor the execution of the NGB–ARNG's portion of the AEP in accordance with EMS.

(10) Schedule and conduct all aspects of EPAS audits.

(11) Review, analyze, perform QA/QC, and approve environmental reporting data submitted by NGB–ARNG installations.

(12) Assist NGB–ARNG installations in negotiations with regulatory agencies to prevent adverse mission impacts due to Federal natural and cultural resources requirements.

(13) Support environmental awards activities.

(14) Maintain an efficient and well-trained workforce.

(15) At Federally-owned or leased NGB–ARNG installations, facilities, activities and properties—

(a) Provide oversight and facilitate coordination in the remediation process.

(b) Assist in the management and execution of ER, A-funded NGB–ARNG remediation sites.

(16) At Non-Federally-owned, Federally-supported NGB–ARNG installations, facilities, activities, and properties, provide guidance, planning, oversight, execution, monitoring, and reporting for NGB–ARNG cleanup sites.

1–17. The Judge Advocate General

The Judge Advocate General (TJAG) will provide legal advice to the Army on all environmental law matters, except those arising out of civil works (CW) and FUDS activities. The Chief, Environmental Law Division (ELD), will exercise those authorities on behalf of TJAG, and will specifically—

a. Serve as legal advisor to the ACSIM and DEP with regard to all environmental matters.

b. Advise the Army Secretariat in coordination with the General Counsel.

c. Provide technical channel supervision, coordination, and advice to all Army lawyers involved in Army environmental matters.

d. Monitor and provide advice regarding environmental legislation and regulatory developments that affect the Army.

e. Review and render legal opinions on all draft environmental orders, consent agreements, and settlements with Federal, State, or local regulatory officials (except those arising from FUDS) before signature.

f. Provide assistance to ACOMs, ASCCs, DRUs, IMCOM, NGB–ARNG, and installations in drafting or negotiating interagency agreements or orders on consent with Federal, State, and local regulators.

g. Be responsible for representing the Army in Federal and State litigation and for communicating the Army's position in litigation and settlement with the Department of Justice subject to the general oversight of the General Counsel.

h. Serve as agency counsel for the Army in appropriate administrative cases, hearings, and enforcement actions (ENFs).

i. Serve as initial denial authority and act on FOIA requests for records pertaining to environmental activities when the records relate to litigation in which the United States has an interest.

1–18. The Surgeon General

The Surgeon General (TSG) will—

a. Approve human health risk assessments and review environmental hazards and ecological risk assessments.

b. Provide policy on the human health aspects of Army installation activities and operations, to include those aspects associated with environmental contamination.

c. Integrate environmental awareness and technical information into the training programs sponsored by the Army Medical Department (AMEDD).

d. Serve as the Lead Agent for the DOD and as the Army representative in negotiating services with the Agency for Toxic Substances and Disease Registry (ATSDR).

e. Develop toxicological profiles concerning chemicals and hazardous substances commonly found on military installations. Develop and propose human health and safety environmental standards for chemical agents and explosive compounds, and other unregulated compounds when such standards do not exist.

f. Identify pollution-related health and ecological effects topics requiring research and development; and initiate needed research in areas where AMEDD has responsibility and provides toxicological and exposure data when required to support human health risk assessments.

g. Advise on human health aspects of environmental issues, including the “known and imminent substantial endangerment” (KISE) determination for environmental response actions overseas.

h. Provide technical assistance relating to health and, as requested, on environmental aspects of programs and initiatives.

i. Coordinate on the human and ecological health risk assessment portions of active installations, BRAC, and FUDS decision documents (DDs).

j. Promulgate policy for the disposition of dental, veterinary, medical, and pharmaceutical waste.

k. Provide two representatives as voting members on the AFPMB and designate personnel to serve as DOD pest management certification officials for Army uniformed personnel per DOD policies and procedures.

l. Coordinate with OACSIM for surveillance, prevention, and control of medically important pests and disease vectors and occupational health exposures from pest management operations.

m. Provide health and environmental risk communication support to all Army assets, to include training, consultation, conflict management, and facilitation.

n. Develop policy on occupational and public health issues related to Army environmental actions.

o. Through the U.S. Army Medical Command (MEDCOM) and the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) will—

(1) Plan, organize, budget, and execute medical support to the Army environmental program.

(2) Serve as the decision authority for determinations of public health threat arising from Army environmental activities.

(3) Provide a broad range of expertise and services in environmental health, occupational health, and preventive medicine to evaluate the health aspects of the Army’s environmental program.

(4) Provide environmental health support in all environmental media to Army and other DOD elements, as requested.

(5) Assist in the maintenance of the Military Item Disposal Instructions (MIDI) for the DOD.

(6) Provide preventive medicine leadership and services to anticipate, identify, assess and counter environmental and occupational health threats.

(7) Provide environmental health and occupational health expertise, products and services in support of training, operations, acquisition, research and development to assess the health risks associated with Army environmental programs and activities.

(8) Support USAEC with coordination and execution of the EPAS Program.

1–19. Army Command, Army Service Component Command, and Direct Reporting Unit commanders

The ACOM, ASCC, and DRU commanders, including those outside the continental United States (OCONUS), as used in this regulation, include the Director, NGB–ARNG when performing an ACOM, ASCC, or DRU role relative to State ARNGs, the State Adjutants General when performing an ACOM, ASCC, or DRU role relative to State ARNGs, and major subordinate commands (MSC). The ACOM, ASCC, and DRU commanders will—

a. Consistent with HQDA policy, provide oversight, policy, guidance, and resources to subordinate commands and activities to execute mission-related aspects of the Army’s environmental program, to include: training and deployments; industrial operations; research, technology, and testing activities; operations other than war; and other operations and activities not falling under the direct control of supporting Garrison/Installation commanders.

b. Ensure that subordinate units comply with the policies and standards of the installations on which they are tenants.

c. Ensure that all subordinate units comply with all applicable laws, regulations, internal directives and goals, EOs, and overseas FGS.

d. Fully integrate environmental considerations into ACOM, ASCC, and DRU mission requirements.

e. Participate in and fully support all installation internal and external assessments and audits, and implement corrective actions.

f. Support environmental awards activities.

g. Ensure that assigned environmental staff is efficient and well-trained.

h. ACOM, ASCC, and DRU commanders that exercise command and control of installations will execute the same responsibilities listed under paragraph 1–13, Commander, IMCOM, with the following exceptions:

(1) Environmental requirements must be submitted through the ACOM, ASCC, DRU, and NGB–ARNG chain of command unless otherwise specified in the ISSA.

(2) ACOM, ASCC, and DRU commanders must monitor and track environmental performance at subordinate installations.

i. Additionally, the Commander, U.S. Army North (USARNORTH) will—

(1) Provide, upon request, personnel/resources support to the National Response Team (NRT) or Regional Response Team (RRT) responding to an environmental emergency. The requester will reimburse the cost of the support.

(2) Serve as the lead for all phases of mobilization, deployment/redeployment operations, and environmental support activities related to national emergencies.

1–20. The Commanding General, U.S. Army Forces Command

The Commanding General (CG), and U.S. Army Forces Command (FORSCOM) will—

a. Incorporate environmental planning requirements in mobilization guidance as appropriate.

b. Coordinate with IMCOM and DCS, G–3/5/7 on environmental support for mission activities, to include training exercises, range operations, and mission MILCON projects.

c. Provide explosive ordnance disposal (EOD) units for emergency response activities.

1–21. The Commanding General, U.S. Army Materiel Command

The Commanding General, U.S. Army Materiel Command (CG, AMC) will—

a. Provide technical assistance to acquisition program managers and program executive offices as required to ensure integration of environmental quality considerations in all aspects of acquisition programs and weapons system's life cycle, such as acquisition, maintenance, disposal, and demilitarization.

b. Conduct environmental research, development, testing, and evaluation and technical investigations in support of its missions and activities.

c. Support ASA (ALT) efforts to develop an integrated Army Environmental Quality Science and Technology program, and manage the portion of that program that supports acquisition, logistics, and industrial base user needs.

d. Coordinate acquisition, logistics, and industrial base user needs with the USACE and the ACSIM in areas impacting installation EQT.

e. Execute low-level radioactive waste (LLRW) management, including disposal.

f. Ensure that contracts include provisions for operations at government-owned, contractor-operated (GOCO) facilities to meet and remain compliant with environmental legal mandates and protect the Army from liability and/or fines assessed due to contractor operations.

g. Review and revise military specifications, standards, and drawings, when appropriate, to eliminate and/or reduce the use of extremely hazardous substances and toxic chemicals. Coordinate this effort with other program offices as required.

h. Conduct ACOM responsibilities for installations under its purview (see para 1–19).

1–22. The Commanding General, U.S. Army Training and Doctrine Command

The Commanding General, U.S. Army Training and Doctrine Command (CG, TRADOC) will—

a. Ensure the development and implementation of environmental training and doctrine programs and products that support military training and readiness operations are consistent with regulatory requirements and Army environmental policies.

b. Ensure that the U.S. Army Engineer School solicits and prepares environmental training packages as required for Soldiers and makes them available on-line through Army Knowledge Online (AKO) and/or other appropriate websites.

c. Ensure requirements documents incorporate environmental resources sustainment and lessons learned into all appropriate Army and Joint doctrinal publications and references.

d. Ensure all training procedures, training manuals, training doctrine, and requirements documents include sound environmental practices and procedures.

e. Coordinate with the OACSIM regarding establishment of staffing or training standards for all modified tables of organization and equipment (MTOE) and tables of distribution and allowances (TDA) unit designated environmental officers. Ensure environmental officer responsibilities are consistent with regulatory requirements and Army environmental policies.

f. Ensure organizations/units are designed with equipment and personnel to meet established environmental requirements.

1–23. Senior mission commanders

Senior mission commanders (SMC) will—

a. Comply with installation policies, applicable Federal, State, and local environmental laws, regulations, EOs, and overseas FGS and signed agreements.

b. Participate in the installation's planning, sustainability efforts, and EMS.

c. Designate a representative to the Environmental Quality Control Committee (EQCC).

d. Ensure personnel receive appropriate environmental training.

e. Coordinate testing and fielding of technology with the garrison commander (GC).

f. Participate in and fully support all installation internal and external assessments and audits, and implement corrective actions.

g. Fund environmental requirements not covered in the standard installation services or the ISSA (this does not apply to military units).

h. Appoint trained environmental officer(s) to ensure operational compliance and coordination with installation environmental staff.

i. Immediately report spills or releases of petroleum, hazardous substances, or hazardous waste (HW) to the GC.

j. Participate in the development of integrated natural and cultural resources management plans to ensure they are compatible with and support the mission.

k. In conjunction with the GC, ensure environmental requirements that impact ranges and training land are incorporated into the installation range complex master plan.

l. Where appropriate, coordinate with JALS–EL early on all environmental agreements, including but not limited to, fine and penalty settlement agreements, prior to signing them.

1–24. Garrison commanders

Garrison commanders (GC) as used in this regulation include commanders of USAR Regional Readiness Support Commands (RRSCs), State Adjutants General relative to the concept of the State as an installation, OCONUS U.S. Army Garrisons, and GCs as appropriate as determined by the IMCOM, Headquarters NGB–ARNG, and State Adjutants General. The GC will—

a. Ensure that Base Support activities support military training and readiness operations, enhance mission accomplishment, and are conducted in a manner conducive to environmental stewardship (see para 1–1a).

b. Comply with applicable Federal, State, and local environmental laws, regulations, internal directives and goals, EOs, and overseas FGS.

c. Investigate regulatory enforcement actions, complaints, and spills/releases, and correct systemic problems. Document investigation, negotiation, and resolution of enforcement actions and submit through the respective chain of command to ODEP, and through technical legal channels to JALS–EL.

d. Ensure environmental requirements that impact ranges and training land are identified and incorporated into the installation range complex master plan. Ensure the affected SMC is made aware of these impacts.

e. Ensure installation activities incorporate applicable environmental requirements into all procurement actions.

f. Apply for, sign, arrange funding, and maintain all applicable Federal, State and local environmental permits. Incorporate potential mission surge conditions when applying for environmental permits.

g. Maintain appropriate environmental records as required by law.

h. Record enforcement actions within 48 hours via the Army Environmental Reporting Online (AERO).

i. Coordinate with JALS–EL early on all environmental agreements, including but not limited to, fine and penalty settlement agreements, prior to signing them. GCs may not delegate approval or signature authority.

j. Ensure that compliance agreements and consent orders that are attributable to a tenant's mission and/or operations are coordinated through applicable legal and command channels to determine the appropriate funding activity.

k. Assess the long-term resource impacts of all environmental agreements. Coordinate resource implications for agreements through command channels to IMCOM, NGB–ARNG, ACOMs, ASCCs, or DRUs as appropriate prior to approval.

l. Ensure that non-DOD HM (that is, HM owned and/or used by non-DOD entities) is not stored, treated, or disposed of on the installation unless approved by the ASA (I&E), his or her designee, or higher authority.

m. Ensure that the installation strategic planning office (or equivalent) incorporates sustainability principles into strategic and other installation management plans; coordinate installation strategic plans with the SMC prior to finalization.

n. Implement an installation-wide Hazardous Materials Management Program (HMMP).

o. Promote recycling/reuse programs and Green Procurement policies.

p. Organize and chair the installation EQCC.

q. Organize and chair the installation Technical Review Committee/Restoration Advisory Board (TRC/RAB), as required.

r. Implement and maintain a mission-focused EMS in accordance with the ISO 14001 standard. Third party registration to the standard is not required, and environmental funds will not be used for this purpose. However, GCs may pursue third party registration when it provides clear and documented mission benefits.

s. Champion the installation EMS and designate an EMS representative in the appropriate organizational planning cell; ensure all planning incorporates the requirements of the EMS.

t. Participate fully in EPAS, conduct annual internal environmental compliance assessments, and coordinate assessments with all tenants.

u. Prepare and execute the installation corrective action plan (ICAP); coordinate and monitor completion of installation-wide corrective actions.

v. Ensure all environmental program plans are completed and implemented per guidance in chapter 3.

w. Designate personnel who are responsible and accountable for executing major program requirements as prescribed in chapters 4 through 14.

x. Deposit all proceeds from Conservation Reimbursable Programs as outlined in Section 2665, Title 10, United States Code (10 USC 2665); Section 2667, Title 10, United States Code (10 USC 2667); and Sections 670a and 670b, Title 16, United States Code (16 USC 670a and 670b, Sikes Act).

y. Serve as the Federal Agency Official with responsibility for installation compliance with the Native American Graves Protection and Repatriation Act (NAGPRA).

z. Establish government-to-government relations with Federally recognized Indian Tribes and Native Alaskans.

aa. Maintain a public affairs program that encourages public involvement.

ab. Ensure that the installation master plan incorporates environmental considerations.

ac. Identify environmental requirements, forward through command channels, and maintain auditable records.

ad. Execute the environmental budget to meet critical requirements.

ae. Maintain an efficient and well-trained environmental staff.

af. Ensure that Army law enforcement personnel are trained in conservation law enforcement where appropriate.

ag. Ensure that sufficient numbers of professionally trained natural resource management personnel and natural resources law enforcement personnel are available and assigned the responsibility to perform tasks necessary to comply with Section 670e, Title 16, United States Code (16 USC 670e).

ah. Approve record of decision (ROD)/decision documents (DDs) for environmental response actions within delegated approval authority.

ai. Approve integrated natural resource management plans (INRMPs).

aj. Hold tenant units accountable for complying with the policies and standards of the installation.

ak. Approve annual reports of availability (ROA) for timber sales after review by higher headquarters and USAEC.

al. Designate an installation wildland fire program manager and approve the integrated wildland fire management plan.

1–25. Medical Department Activity/Medical Center/Health Service Support Area commanders

The Medical Department Activity/Medical Center/Health Service Support Area (MEDDAC/MEDCEN/HSSA) commanders will—

a. Comply with applicable Federal, State, and local environmental laws, regulations, EOs, and overseas FGS.

b. Manage and dispose of non-*Resource Conservation and Recovery Act* (RCRA) Subtitle C medical, dental, veterinary, pharmaceutical and regulated medical wastes in accordance with AR 40–5 and applicable regulations.

c. Verify disposal requirements via the MIDI system updated and maintained by USACHPPM.

d. Ensure that regulated medical waste manifests are only signed by those individuals who have been appropriately trained and are authorized in writing by the activity commander or supervisor.

e. Appoint a trained environmental officer to ensure operational compliance and coordination with installation environmental staff, to include the coordination of medical waste management plans.

f. Advise on health aspects of the installation environmental program, and provide technical consultation and support services.

g. Identify environmental requirements, forward through command channels, and maintain auditable records.

1–26. Tenants

A tenant is an authorized activity located on an installation that is not part of the garrison organization. This includes, but is not limited to, military units, the Army and Air Force Exchange Service (AAFES), and the Defense Commissary Agency (DeCA). Tenants will—

a. Comply with installation policies, applicable Federal, State, and local environmental laws, regulations, EOs, and overseas FGS.

b. Establish an ISSA with the GC that addresses environmental oversight, to include funding responsibilities and facility access (this does not apply to military units).

c. Participate in the installation's planning, sustainability, and EMS (note, however, that installations should evaluate their liabilities concerning non-governmental tenants to determine whether any of them can be exempted from the installation EMS).

d. Designate a representative to the EQCC.

e. Ensure personnel receive required environmental training.

f. Participate in all installation internal and external assessments and audits, to include programming for corrective actions.

g. Fund environmental requirements not covered in the standard installation services or the ISSA (this does not apply to military units).

h. Identify and submit environmental requirements to the supporting ACOM, ASCC, DRU/higher headquarters (this does not apply to military units).

i. Identify and coordinate non mission-specific environmental requirements with the GC.

j. Pay environmental fines and penalties resulting from their mission activities.

k. Immediately report spills or releases of hazardous substances to the on-scene coordinator (OSC). Pay or reimburse costs associated with cleanup and spill response if not covered in the standard installations services or the ISSA.

l. Report all instances of non-compliance and notification of enforcement actions to the GC immediately.

m. Ensure that non-DOD hazardous material is not stored, treated, or disposed of on the installation unless approved by the OASA (I&E), his or her designee, or higher authority.

1–27. Commanders of Government-Owned, Contractor-Operated facilities

The Commanders of Government-Owned, Contractor-Operated (GOCO) facilities will—

a. In coordination with the contracting officer, ensure that contracts include provisions for operations at GOCO facilities to meet and remain compliant with environmental legal mandates to protect the Army from liability and/or fines assessed due to contractor operations.

b. Comply with installation policies, applicable Federal, State, and local environmental laws, regulations, and EOs.

c. Ensure that contractors assume responsibility for management and disposal of contractor-generated solid and HW.

d. Ensure that non-DOD hazardous material is not stored, treated, or disposed of on the installation unless approved by the OASA (I&E), his or her designee, or higher authority.

e. Deposit all proceeds from Conservation Reimbursable Programs as outlined in 10 USC 2665, 10 USC 2667, and 16 USC 670b.

f. Execute EMS responsibilities in accordance with contract provisions.

g. Assess the long-term resource impacts of all environmental agreements in coordination with the acquisition community. Coordinate resource implications for agreements through command channels as appropriate prior to approval.

h. Ensure that all contractor personnel receive appropriate levels of training on environmental awareness, hazardous material/waste management, and the installation EMS.

1–28. Unit commanders

The unit commanders will—

a. Instill an environmental ethic in soldiers and civilians under their command.

b. Ensure personnel receive required environmental training.

c. Comply with installation policies, applicable Federal, State, and local environmental laws, regulations, EOs, and overseas FGS.

d. Report noncompliance and spills through appropriate channels to the GC.

e. Incorporate environmental responsibilities and environmental risk management into unit SOPs and operation orders (OPORDs) as appropriate; integrate environmental considerations into the planning and execution processes in accordance with FM 3–100.4.

f. Appoint and train environmental officers at appropriate organizational levels to ensure compliance actions take place (see FM 3–34.500 for environmental officer responsibilities).

g. Support the installation-wide EMS.

Chapter 2
Environmental Policy

2–1. Commitment to Environmental Stewardship

a. The Army is committed to environmental stewardship in all actions as an integral part of its mission and to ensure sustainability.

b. This regulation supports the *Army Strategy for the Environment*, 1 October 2004, which presents the Army's environmental vision as sustainable operations, installations, systems, and communities enabling the Army mission. Under the strategy, the Army's environmental mission is to sustain the environment to enable the Army mission and secure the future. In doing so, all Army organizations and activities will—

(1) Foster an ethic within the Army that takes us beyond environmental compliance to sustainability.

(2) Strengthen Army operational capability by reducing our environmental footprint through more sustainable practices.

(3) Meet current and future training, testing and other mission requirements by sustaining land, air, and water resources.

(4) Minimize impacts and total ownership costs of Army systems, materiel, facilities, and operations by integrating the principles and practices of sustainability.

(5) Enhance the well being of our soldiers, civilians, families, neighbors, and communities through leadership in sustainability.

(6) Use innovative technology and the principles of sustainability to meet user needs and anticipate future Army challenges.

2–2. Army Environmental Policy Statement

a. All Army organizations and activities will comply with applicable Federal, State, and local environmental laws, regulations, executive orders (EOs), or overseas Final Governing Standards (FGS) (see para 15–8 for additional specific overseas requirements); develop and implement pollution prevention and control strategies; and establish environmental priorities in consideration of the benefits to the sustainment of missions and operations.

b. All Army organizations and activities will strive to achieve continual improvement in overall environmental performance and supporting management systems.

c. All Army organizations will ensure that this policy is implemented, maintained, and communicated to all military and civilian employees and supporting contractors. In addition, this policy will be made readily available to the public upon request.

d. All contracts and contract modifications will specify that contractors are liable for any enforcement actions, fines, and/or penalties resulting from their failure to comply with applicable environmental requirements.

2–3. Legal Requirements

All references to legal requirements in this regulation are intended to refer to laws, regulations, and executive orders that, in the opinion of legal counsel, are applicable to the Army. While most environmental laws apply to the Army, some include exemptions (or provisions for requesting exemptions) for military activities under certain conditions. It is essential that Army counsel, including but not limited to the Office of the Judge Advocate General, Army Environmental Law Division, JALS–EL), be consulted on the applicability of all laws, regulations, initiatives, and executive orders. Similarly, all permits, agreements, notices of violations, enforcement actions, especially reports of potential liability under paragraph 16–4, require early and close coordination with Army legal counsel that is responsible for direct support to the command or activity. As necessary, legal counsel at the installation level will coordinate issues and positions within the appropriate Army legal chain. Precedent-setting opinions, all enforcement actions, and agreements must be coordinated with JALS–EL. The requirement to consult with legal counsel supporting a command or activity is considered an essential part of effectively using this regulation. Additionally, this regulation prescribes program requirements in terms of "will" and "must", which mean that the actions are mandatory. All Army organizations will incorporate environmental considerations and requirements into all aspects of the organization's mission.

Chapter 3
Planning and Implementation

3–1. Installation strategic planning

a. Environmental considerations must be incorporated into installation plans, including installation strategic plans. Installation strategic planning incorporates the concepts and philosophy of sustainability, the ultimate objective in strategic planning, and must be applied to and supported by all functional areas within the command.

b. Installation strategic planning is the long-term planning process that establishes the baseline and direction for all other plans and planning processes, including real property master plans (RPMPs), human resource plans, information technology (IT) and knowledge management plans, environmental management plans, functional business plans, etc. Guidance for these plans is provided by Headquarters, Installation Management Command (HQ, IMCOM), National Guard Bureau - Army National Guard (NGB–ARNG), and for special installations, owning Army Commands (ACOMs), Army Service Component Commands (ASCCs) and Direct Reporting Units (DRUs). This includes synthesizing and aligning pertinent information from The Army Plan, Army strategic planning guidance, Army programming and budgeting guidance, policies, and other sources of strategic guidance with the organizational mission, vision, values, principles, strategy maps, balanced scorecards, and so forth. The garrison commander (GC) applies this guidance to his or her own operations through the installation strategic planning process.

3–2. Activities, products, and services

a. The Army mans, equips, trains, sustains, mobilizes, deploys, and demobilizes the force as needed to support the combatant commanders.

b. Achieving the foregoing requires the Army to undertake a number of activities and to provide various products and services that include, but are not limited to (listed by mission/functional area):

(1) Weapons System Acquisition - including the major systems acquisition phases of concept and technology development, system development and demonstration, production and deployment, operations and support, and demilitarization and disposal.

(2) Logistics Support - including the acquisition, storage, distribution, and recovery of all classes of supply; maintenance of materials and equipment; transportation of personnel and materiel; and provision of support services such as food, commissaries, laundries, and property disposal.

(3) Training - including providing and conducting individual, functional, and organizational (both tactical and non-tactical) training.

(4) Infrastructure Development and Maintenance - including the total system of facilities; buildings; structures; horizontal transportation facilities (roads, railroads, bridges, dams, and airfields); utility, transport, and communication systems; ranges and other training areas; ports; airfields, and associated lands and equipment; and facilities (that is, real property) operation and maintenance, to include utilities, minor construction, and general engineering support.

(5) Industrial Operations - including the manufacture of commodities, equipment, and weapons systems.

(6) Base Operations Support - including all of the activities required to accomplish the missions and functions of assigned and tenant units and activities at the installation level.

(7) Health and Medical Support - including providing general health care and medical and dental support to personnel, as well as the operation and maintenance of Army hospitals, medical centers (MEDCENs), dental and veterinary clinics, medical treatment facilities, and supporting laboratories.

(8) Transportation Equipment - including tactical and non-tactical vehicles, fixed and rotary wing aircraft, rail systems, watercraft, and supporting maintenance operations.

(9) Mobilization and Deployment - including the assembly and organization of material and personnel resources in response to war or other emergencies including low intensity conflict and military operations other than war, and the physical movement of those resources to the theater of operations.

(10) Research, Development, Test, and Evaluation (RDT&E) - including the demonstration/validation and technology transfer of materiel, equipment, and weapons systems at Army proving grounds, laboratories, and related facilities.

3–3. Important environmental aspects

a. Environmental aspects are elements of products, activities, or services that interact with the environment. Important environmental aspects are those that result in mission or environmental impacts, and may include, but are not limited to:

(1) Air emissions (fugitive or from stacks), including but not limited to, Clean Air Act criteria pollutants (carbon dioxide, nitrous oxides, sulfur oxides, ozone, particulates, and lead), combustion gases, volatile organic compounds (VOCs), and hazardous air pollutants (HAPs).

(2) Generation of noise, vibration, odor, dust, heat, mold, light, radiation, and other nuisance activities.

(3) Discharges and disposals (point and non-point), spills, or other releases to soil or ground and/or surface waters, including sewage, sediment, or solid, hazardous, and other wastes.

(4) Natural resource alteration (that is, consumption or conservation), including water, timber, minerals, soil, and so forth. This includes the acquisition of goods and services that affect the consumption of natural resources.

(5) Ecological resource alteration, including wetland and endangered species protection or destruction.

(6) Cultural resource alteration, including historic properties; archeological sites; sacred sites; and properties of traditional cultural or religious importance to American Indians, Alaska Natives, and Native Hawaiians.

(7) Energy consumption or conservation, including electricity, fossil, alternative fuels, and renewable energy, such as solar energy.

b. All appropriate facilities (see glossary) will establish and maintain procedures to identify the environmental aspects of their operations, activities, products, or services that they can control and over which they can be expected to have an influence, to determine which have or can have impacts on the mission and/or the environment. This will include maintaining scientifically defensible information and inventories of facilities, resources, and environmental aspects, including geospatial information where the spatial location and extent of these affects their impact to mission and/or the environment. Installations must evaluate their liabilities concerning non-governmental tenants to determine whether any of them can be exempt from the installation EMS.

c. The aspects related to those important impacts will be considered in setting environmental objectives at all appropriate organizational levels. Additionally, appropriate facilities will consider processes for external communications on their important environmental aspects and document their decision regarding external communications.

d. Acquisition program managers should ensure that weapons systems are designed so that they can be tested, operated, maintained, repaired, and disposed of in accordance with applicable environmental, safety, and occupational health statutes, regulations, policies, and environmental treaties and agreements. (see PD: DODD 5000.1)

3–4. Environmental objectives and targets

a. An environmental objective is an overall environmental goal, arising from the environmental policy, which an organization sets for itself to achieve, and which is quantified where practicable (for example, reduce hazardous waste (HW) disposal by a certain amount). An environmental target is a detailed performance requirement, quantified where practicable, applicable to the organization or parts thereof, that arises from the environmental objectives and that needs to be set and met to achieve those objectives (for example, reduce HW disposal by a certain amount by a certain point in time). Environmental objectives and targets will be developed in consideration of impacts on Army operations.

b. Installations/activities will establish and maintain environmental objectives and targets for all operations and activities having the potential for important mission and/or environmental impact. Objectives and targets will be established at each relevant function and level within the organization, will be documented, and will meet DOD Measures of Merit (MOMs), Army-level program goals, objectives, and targets; long-term strategic goals; legal and other requirements; important environmental aspects; technological options; financial and operational requirements; and the views of interested parties, as appropriate.

c. Headquarters, Department of the Army (HQDA) will disseminate detailed Army-level program goals, objectives, and targets through periodic publication and update of appropriate plans, directives, and guidance documents.

3–5. Operational controls

a. Installations/activities will identify those operations and activities that are associated with important environmental aspects (see para 3–3a) and manage them consistent with established policies, objectives, and targets.

b. Installations/activities will establish and maintain documented standing operating procedures (SOPs) to avoid unacceptable environmental impacts from these operations and activities.

c. Contracting officers should ensure that contract provisions are consistent with SOPs.

3–6. Emergency preparedness and response

a. Installations/activities will establish and maintain procedures to identify the potential for and to respond to accidents and emergency situations, and for preventing and mitigating the environmental impacts that may be associated with them. These procedures will be tested periodically.

b. Installations/facilities will review and revise, where necessary, emergency preparedness and response procedures. In particular, critical reviews and revisions should be conducted after any occurrence of accidents or emergency situations.

3–7. Management programs

a. Appropriate facilities will establish and maintain management programs (see chaps 4 -14) for achieving objectives and targets, and will track and measure progress toward achieving them.

b. As a minimum, management programs will designate responsibility for achieving objectives and targets at each relevant function and organizational level, and specify the means and timeframe by which they are to be achieved.

c. Appropriate facilities will track their targets and objectives to measure continual improvement.

Chapter 4
Environmental Asset Management

Environmental assets entrusted to the Army's care include, but are not limited to, air, water, land, and natural and cultural resources. Specific DOD and Army policies, legal and other requirements, major program goals, and program requirements associated with environmental resources are presented in this section. The Office of the Assistant Chief of Staff for Installation Management (OACSIM) and the Office of the Director of Environmental Programs (ODEP) are responsible for environmental program policy implementation and Headquarters, Department of the Army (HQDA) level program oversight. The Installation Management Command (IMCOM) and National Guard Bureau - Army National Guard (NGB–ARNG) are responsible for executing environmental program requirements prescribed herein in accordance with this regulation and applicable federal, state, and local requirements. Technical support for addressing the various requirements prescribed in this section is the responsibility of the appropriate program offices within the U.S. Army Environmental Command (USAEC), U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM), Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA (ALT)) Environmental Support Office (ESO), and the Military Programs Directorate of the U.S. Army Corps of Engineers (USACE).

4–1. Air resources

a. *Policy*.

(1) Comply with applicable Federal, State and local air quality regulations, permit requirements, and overseas Final Governing Standards (FGS).

(2) Identify and implement cost-effective pollution prevention measures that will reduce toxic or criteria air emissions.

(3) Eliminate dependency on ozone depleting substances (ODS).

b. *Legal and other requirements*. Section 7401, Title 42, United States Code (42 USC 7401, et seq., Clean Air Act (CAA), as amended); Section 6901, Title 42, United States Code (42 USC 6901, et seq., the Resource Conservation and Recovery Act of 1976 (RCRA), as amended); the Energy Policy Act of 2005; applicable State and local requirements; or country-specific FGS requirements.

c. Major program goal. Achieve and maintain air quality standards to protect human health and the environment, while minimizing mission impacts.

d. Program requirements.

(1) Assess the need for and obtain necessary CAA Title V Operating Permits and all other applicable permits. (LD: 40 CFR 71.1)

(2) Update existing or obtain new permits as needed when planning to modify, construct, install, or remove from service an emissions source that is, or should be, regulated under a Title V or other permit. (LD: 40 CFR 71.6)

(3) Perform air emissions inventories as required by statute, regulation, permit, or country-specific FGS. (LD: 40 CFR 51; 40 CFR 70.6; 40 CFR 71.6; FGS)

(4) Determine the need to comply with New Source Performance Standards, New Source Review for Non-attainment, or for Prevention of Significant Deterioration (PSD). In addition, determine the need to perform a Conformity Determination. (LD: 40 CFR 51.307)

(5) Cooperate with Federal, State, and local authorities to achieve the goals of implementation plans. (LD: 40 CFR 51)

(6) Perform technology, permitting, and preconstruction assessments as required before beginning construction or reconstruction of air emissions sources. (LD: 40 CFR 51.160 and related State regulations)

(7) Establish a Risk Management Program and develop and maintain a risk management plan (RMP) when required under Section 112(r) of the CAA. (LD: 40 CFR 68.150–195)

(8) Implement and maintain plans to eliminate dependency on commercial acquisition of Class I ODS. (LD: 40 CFR 82)

(9) Reduce all ODS use to zero as cost-effective substitutes that meet applicable standards become available. (LD: 40 CFR 82)

(10) Recovered Class I ODS cannot be bartered, sold, or traded. Return recovered ODS that are excess to installation needs to the DOD ODS Reserve. (LD: 40 CFR 82)

(11) Coordinate natural resources activities having potential air quality impacts (for example, prescribed burning) with appropriate State and local officials.

(12) Comply with applicable Standards of Performance for New Stationary Sources and corresponding monitoring requirements. (LD: 40 CFR 60)

(13) Comply with all air toxics regulations, to include, but not limited to, applicable National Emission Standards for Hazardous Air Pollutants (NESHAP) maximum achievable control technology (MACT) requirements for regulated sources of hazardous air pollutants (HAPs). (LD: 40 CFR 63)

(14) Overseas installations will comply with permits obtained on their behalf in accordance with the FGS.

4–2. Water resources

a. General policy.

(1) Comply with applicable Federal, State, and local laws and regulations regarding water resources management and permitting. Overseas, the Army will comply with country-specific FGS requirements.

(2) Obtain and comply with all required Federal, State, and local Clean Water Act (CWA), Coastal Zone Management Act (CZMA), and Safe Drinking Water Act (SDWA) permits (includes wastewater and storm water permits, operational permits for drinking water systems, groundwater discharge permits, wetland 404/401 permits, septic system permits, underground injection control, and so forth).

(3) Overseas installations will comply with permits obtained on their behalf in accordance with the FGS.

(4) Identify and implement pollution prevention initiatives.

(5) Participate with regional authorities in the development and implementation of water resource initiatives and plans.

(6) Mitigation wetlands are wetlands that replace the functions performed by drained, filled, or degraded wetlands on installation project sites. They should, whenever possible, be sited within the same watershed as the affected installation wetlands and outside installation boundaries so installations can retain maximum land-use flexibility.

b. Recreational waters. Management of recreational waters at military installations will be in accordance with AR 40–5, TB MED 575, and TM 5–662.

c. Water resource protection and management.

(1) All Army organizations and activities will comply with legally applicable Federal, State, and local regulations, executive orders (EOs), and FGS to conserve, protect and restore surface water resources (including wetlands, estuaries, streams, lakes and so forth), and groundwater (wells and aquifers).

(2) Executive Order 11988 and EO 11990 address the actions Federal agencies take to identify and protect flood plains and wetlands, respectively.

(3) The CZMA requires that activities within the coastal zone of any state must be consistent with the state's coastal zone management plan.

d. Watershed management.

(1) *Policy.* Installations use a watershed management approach when evaluating projects and programs to satisfy environmental regulations, facility projects, and master planning that may impact the quality of water resources. Using a watershed approach means that installations should develop a framework or plan for coordinating, integrating and managing their mission activities that impact the quality of water resources located on (and those that migrate off) their installation. This approach also requires a strong commitment to involving stakeholders, both internal and external, in the management of these water resources. To implement applicable total maximum daily load (TMDL) regulations, all Army facilities will:

(a) Initiate and maintain contact with Federal and State water regulators concerning the process of setting TMDLs and allocations for water bodies located on or passing through Army installations.

(b) Integrate all aspects of CWA requirements, programs and available information (for example, the National Pollutant Discharge Elimination System (NPDES) program, 404 wetlands program, wellhead protection, storm water plans/projects, storm water construction permits, spill prevention, control, and countermeasures (SPCC) plans/projects, State CWA 319 requirements (State plans & strategies for reducing non-point source runoff)) with TMDL development and future planning. Ensure all of these programs are consistent with, and work together to attain compliance under, TMDL allocations once they are set by states.

(c) Ensure that activities required to meet other environmental legal requirements, like RCRA, that impact water quality in an impaired water or are impacted by an impaired water (for example, Chapter 35, Title 16, United States Code (16 USC Chapter 35)) are informed of CWA requirements. These non-CWA activities should be integrated into the management plan.

(d) Ensure other programs that are or may have their activities affected by identification of impaired waters and new TMDL allocations are informed of the impacts and requirements (for example, facilities construction, master planning, National Environmental Policy Act (NEPA) requirements).

(e) Ensure that watershed assessments and management plans are integrated with the installation master plan, integrated natural resources management plan (INRMP), and other plans as appropriate.

(f) Establish and integrate environmental education and participation programs required by CWA/SDWA/the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)/ESA and so forth for all Army personnel and their families based on watershed concepts and requirements to restore impaired waters and maintain designated uses of local water bodies.

(g) Ensure that mission and non-mission activities and construction designs utilize best management practices (BMPs) to minimize TMDL impacts.

(2) *Legal and other requirements.* The principal applicable laws governing water resource protection and management are the CWA, SDWA, and related Federal, State, and local implementing regulations; and for overseas installations, the country-specific FGS requirements.

(3) *Major program goal.* Implement the "Unified Federal Policy for a Watershed Approach to Federal Land and Resource Management". (PD: Unified Federal Policy for a Watershed Approach to Federal Land and Resource Management, 65 FR 62565–62572, 18 October 2000).

(4) *Program requirements.*

(a) Assess installation watershed impacts as appropriate, considering upstream and downstream water quality data or other background levels, proximity to potentially designated impaired waters, and any effects on mission activities. (PD: Unified Federal Policy for a Watershed Approach to Federal Land and Resource Management, 65 FR 62565–62572, 18 October 2000)

(b) Carry out Army activities consistent with EPA/State approved plans/strategies to restore impaired or threatened water bodies to their designated use. (LD: 40 CFR 130.12)

(c) Control soil erosion in accordance with applicable and appropriate Federal, State, or local requirements. (LD: 40 CFR 122.26)

(d) Comply with all applicable and appropriate State Source Water Assessment and Protection Program requirements as they relate to ground water (for example, wellhead protection plans) (LD: SDWAA 1996, PL 104–182, Sections 1428 and 1453); (LD: 40 CFR 144–148); and (LD: 40 CFR 149).

e. Wastewater and stormwater.

(1) *Policy.*

(a) Comply with facilities policy concerning use of wastewater collection/treatment systems that are owned and operated by public or private entities when economically feasible and when security is not compromised.

(b) Comply with all requirements, substantive and procedural, for control and abatement of water pollution, as outlined in the CWA that require Army compliance.

(c) Control or eliminate sources of pollutants and contaminants to protect water bodies and groundwater.

(d) Employ abatement measures for non-point source runoff from construction, facility operations, and land management activities.

(e) Encourage reuse or recycling of wastewater, sewage sludge, wash rack sediment, greases or oils, and other wastes whenever economically feasible and environmentally beneficial.

(2) *Legal and other requirements.* Applicable laws are Chapter 26, Title 33, United States Code (33 USC Chapter 26, as amended; Section 108 of Section 6961, Title 42, United States Code (42 USC 6961); Section 1401, et seq., Title 33, United States Code (33 USC 1401); Section 2701, Title 33, United States Code (33 USC 2701); and State and local laws; and for overseas installations, the country-specific FGS requirements.

(3) *Major program goals.* The Army's wastewater and stormwater management goals are to reduce the pollutant loadings in point source and non-point source discharges and to ensure efficient water reuse.

(4) *Program requirements.*

(a) Obtain and comply with NPDES and/or State discharge permits, to include all required plans. (LD: 40 CFR 122)

(b) Ensure that discharges from industrial activities to Federally-owned Treatment Works (FOTWs) and Publicly-owned Treatment Works (POTWs) comply with the substantive pretreatment requirements applicable to POTWs under the CWA. (LD: 40 CFR 403)

(c) Develop pretreatment programs as required to ensure FOTWs meet NPDES permit requirements and to improve opportunities for reuse of wastewater effluent and sewage sludge. (LD: 40 CFR 403)

(d) Develop and implement a stormwater management plan for a regulated Municipal Separate Stormwater Sewer System (MS4) as required in accordance with the installation's general permit. (LD: 40 CFR 122.26)

(e) Develop and implement a Stormwater Pollution Prevention Plan(s) (SWPPP) as required, in accordance with the installation's industrial, construction, or Municipal Separate Storm Sewer (MS4) storm water permit(s). (LD: 40 CFR 122.26)

(f) Develop and implement a spill prevention, control, and countermeasures plan (SPCCP), as required. (LD: CWA Section 311(j), 40 CFR 112.3)

(g) Perform shipboard or shore-side oil/water separation before the discharge of ballast water from watercraft. Effluent limitations from watercraft are prescribed by the U.S. Coast Guard (USCG) (LD: 33 CFR 151–158) EPA; (LD: 40 CFR 110); individual states; and TB 55–1900–206–14.

(h) Coordinate proposed military activities involving the discharge of fill material into waters of the United States, including wetlands, with, and if necessary, secure a permit from the local U.S. Army Corps of Engineers (USACE) district and appropriate State agency. (LD: 33 CFR 323; 40 CFR 230)

(i) Ensure that operators of wastewater (including industrial) treatment plants and wastewater collection systems have necessary training and certification. (LD: 42 USC 300g-8)

(j) Use analytical laboratories that are certified per applicable Federal, State, local or host nation (HN) requirements, as appropriate. (LD: 40 CFR 136; 40 CFR 141.28)

(k) Follow State approved plans and local permit requirements for non-point source water pollution control where applicable. (LD: 40 CFR 123)

f. Drinking water.

(1) *Policy.*

(a) Provide drinking water to fixed facilities in accordance with the requirements of the SDWA and applicable State and local regulations. Overseas, all Army organizations and activities will comply with country-specific FGS.

(b) Comply with Army facilities policy to transfer ownership and operation of water supply treatment systems to public and private entities when economically feasible and when security is not compromised.

(2) *Legal and other requirements.* Applicable laws are the SDWA, as amended; PL 109–58 (Energy Policy Act of 2005); and State and local laws; and for overseas installations, the country-specific FGS requirements.

(3) *Major program goals.* The Army's drinking water resource management goals are to consistently provide safe, aesthetically pleasing drinking water at adequate pressures and quantities to protect the health and quality of life of people living and working on our installations, and to better manage the cost of drinking water programs.

(4) *Program requirements.*

(a) Obtain and comply with all necessary water appropriation and use permits, National Pollutant Discharge Elimination System (NPDES) permits for wastewater discharges from drinking water treatment plants, or other permits that are required for operation of drinking water treatment systems at both fixed and field facilities. (LD: 40 CFR 122; 40 CFR 141–143)

(b) Comply with the provisions of the SDWA as implemented by State and local regulations which include, but are not limited to the following: (LD: 42 USC 300g-8; 40 CFR 136; 40 CFR 141.28)

1. Primary and Secondary drinking water standards.

2. Training and operator certification requirements.

3. Lead contamination control act requirements.

4. Public notification and consumer confidence reporting requirements.

5. Water system vulnerability assessment and emergency response plan requirements.

6. Certified laboratory requirements.

(c) Provide copies of annual Consumer Confidence Reports (CCRs) to the Installation Management Command (IMCOM) and State Adjutants General (where appropriate) by the end of each fiscal year.

(d) Perform a lifecycle cost analysis whenever the upgrade or construction of a new water supply facility is considered. Guidelines for military installations to perform the cost analysis are contained in AR 420–49, section 4–1.

(e) Monitor and upgrade Army water supply, treatment, distribution, and storage systems as needed to comply with environmental requirements. Routine operation, maintenance, and repair of Army water systems will be in accordance with AR 40–5; AR 420–49; AR 700–136; TB MED 576; TB MED 577; UFC 3–230–02; TM 5–810–5; TM 5–813–1 through TM 5–813–9; and USACHPPM TG 179.

(f) After consultation with supporting legal counsel, comply with applicable additional State and local drinking water regulations not covered under the SDWA.

4–3. Land resources

Land resources are the ranges, cantonment areas, and associated natural resources (to include soils and the biota they support).

a. Policy.

(1) Comply with applicable Federal, State, and local regulations regarding land resources management and permitting where applicable. Overseas, all Army organizations and activities will comply with applicable country-specific FGS.

(2) Provide for the conservation and rehabilitation of natural resources on Army lands.

(3) Integrate training and testing range operations and support activities within the installation environmental management system (EMS).

(4) Ensure that all management plans address range operations and activities as appropriate.

(5) Quantify environmental encroachment vulnerabilities and assess the feasibility of using external buffer zones to enhance testing and training capabilities. Where warranted, work with private landowners and eligible entities through the Army Compatible Use Buffer (ACUB) process.

(6) The management and conservation of natural and cultural resources under Army control, including planning, implementation, and enforcement functions, are inherently governmental functions that will not be contracted. Components that have contractor-operated installations or facilities will ensure that contract instruments clearly address contractor and government functions as they relate to natural and cultural resources.

b. Legal and other requirements. Principal statutes, regulations, and guidance applicable to the Army Natural Resources Management Program include:

(1) 16 USC 670a and 670b.

(2) 16 USC 35.

(3) 50 CFR 401–453, implementing regulations of the U.S. Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration (NOAA) - Fisheries.

(4) Sections 1801–1882, et seq., Title 16, United States Code (16 USC 1801–1882).

(5) 10 USC 2665.

(6) 10 USC 2667(d).

(7) Section 2671, Title 10, United States Code (10 USC 2671).

(8) Section 2684a, Title 10, United States Code (10 USC 2684a).

(9) Section 2694a, Title 10, United States Code (10 USC 2694a).

(10) Sections 1361–1407, Title 16, United States Code (16 USC 1361–1407).

(11) Sections 4701–4751, et seq., Title 16, United States Code (16 USC 4701–4751).

(12) Sections 661–667d, United States Code (16 USC 661–667d).

(13) Section 701, Title 16, United States Code (16 USC 701).

(14) Sections 703–712, Title 16, United States Code (16 USC 703–712).

(15) Sections 3371–3378, Title 16, United States Code (16 USC 3371–3378).

(16) Part 13, Title 50, Code of Federal Regulations (50 CFR 13).

(17) Part 21, Title 50, Code of Federal Regulations (50 CFR 21).

(18) Part 190, Title 32, Code of Federal Regulations (32 CFR 190).

(19) Parts 10–16, Title 50, Code of Federal Regulations (50 CFR 10–16).

(20) EO 13186.

(21) EO 13112.

(22) EO 13423.

(23) EO 11990.

(24) PL 108–136, sections 312, 319.

(25) DODD 4715.1E.

(26) DODI 4715.3.

(27) DODI 4715.5.

(28) Memorandum, Deputy Under Secretary of Defense for Installations and Environment (DUSD (I&E)), 10 October 2002, subject: Implementation of Sikes Act Improvement Act: Updated Guidance.

(29) Applicable FGS and any legally binding international agreements.

c. Major program goals. The Army's land resources management goals are to:

(1) Integrate natural resources stewardship and compliance responsibilities with operational requirements to help achieve sustainable ranges, training areas, and other land assets.

(2) Develop, initiate, and maintain programs for the conservation, utilization, and rehabilitation of natural resources on Army lands.

d. Program requirements.

(1) *Integrated natural resources management.*

(a) Develop and implement an integrated natural resources management plan (INRMP) in accordance with 16 USC 670a in cooperation with the USFWS and the State fish and wildlife agency unless significant natural resources are absent. OCONUS installations will develop and implement an INRMP in consonance with FGS requirements. Significant natural resources are present if one or more of the following criteria apply: (LD: 16 USC 670a).

1. Federally listed, proposed, or candidate species are onsite, or critical habitat has been designated or proposed on the installation, and on-installation conservation measures are necessary to conserve the federally listed species.

2. Conservation reimbursable forestry or agricultural outleasing activities consist of 100 acres or more.

3. Hunting and/or fishing takes place for which special State permits are issued by the installation in accordance with 16 USC 670a(b)(3).

4. The installation conducts intensive, on-the-ground military missions that require conservation measures to minimize impacts (for example, soil erosion control, prescribed fire) and sustain natural resources. Installations designated by the DCS, G–3/5/7 for management under the ITAM program meet this criterion.

5. Unique biological resources, wetlands, species at risk, or ecological issues require a level of planned management that can only be addressed by an INRMP.

6. In some cases, it may be difficult to determine whether an installation has significant natural resources. In these cases the ACSIM is delegated the authority to determine whether significant natural resources are present, and, therefore, whether an INRMP is required.

(b) Implement the INRMP by:

1. Actively requesting, receiving, and using funds for priority projects and activities.

2. Ensuring that sufficient numbers of professionally trained natural resources management personnel are available to perform the tasks required by the INRMP.

3. Coordinating annually with all cooperating offices.

4. Documenting specific INRMP action accomplishments undertaken each year.

(c) Prepare INRMPs that include components addressing specific natural resources (for example, endangered species, forests, flora, fauna, soil, wetlands) and their interdependency.

(d) Review the INRMP with regard to operation and effect by the parties thereto on a regular basis, but not less often than every 5 years. Update the INRMP as appropriate in concert with installation needs to obtain mutual agreement in coordination with the USFWS, State fish and game agency(ies), and other internal and external stakeholders. A 5-year update is not required if circumstances have not changed. (LD: 16 USC 670a).

(e) Use the INRMP, range complex master plan, and ITAM 5-year plan as the garrison commander's (GC) tools for planning and integrating land resources compliance and management activities with the military mission.

(f) Provide access to training and testing ranges through sustainment of installation land resources and in compliance with natural resources laws, regulations, EOs, and Army policies.

(g) To the extent appropriate and applicable, provide for no net loss in the capability of the installation lands to support the military mission. Identify and address threats to mission land use and give high priority to management objectives that protect mission capabilities of installation lands. (LD: 16 USC 670a).

(h) Designate and ensure that the installation has ready access to a qualified military, Department of the Army (DA) civilian, or State Army National Guard (ARNG) staff member (or ARNG contractor) to serve as installation natural resources coordinator.

(i) Assure NEPA requirements are satisfied when preparing the INRMP. (LD: 50 CFR 402.06; 42 USC 4331).

(j) Conduct appropriate internal and external coordination prior to GC approval of INRMPs and revisions (for example, with Director of Plans, Training, Mobilization, and Security (DPTMS); Staff Judge Advocate; Morale, Welfare, and Recreation; Provost Marshall, and so forth). INRMPs will meet the following conditions (note that 2–5 do not apply to overseas installations):

1. Concurrence from the installation's next higher headquarters, and coordination with affected Army Commands (ACOMs), Army Service Component Commands (ASCCs), Direct Reporting Units (DRUs), NGB–ARNG, and tenants.

2. Agreement from the Regional Directors of the USFWS concerning aspects within the scope of their authority. (LD: 16 USC 670a(a)(2)).

3. Coordination with NOAA–Fisheries in those instances where INRMPs include TES or critical habitat within the scope of their authority.

4. Concurrence from land management agencies exercising jurisdiction over installation property.

5. Agreement from the Director of the State fish and wildlife agency concerning aspects within the scope of their authority. (LD: 16 USC 670a(a)(2)).

6. Opportunity for public comment provided (minimum of 30 days). (LD: Section 2905, PL 105–85).

(k) Coordinate the draft INRMP with the Office of the Director of Environmental Programs (ODEP) when requested.

(l) Integrate the INRMP with the installation master plan, range plans, training plans, integrated cultural resources management plans (ICRMPs), integrated pest management plans (IPMPs), cleanup installation action plans (IAPs), and other appropriate plans to ensure consistency.

(m) For installations that have training or testing missions, ensure the DPTMS (or Range Control staff or equivalent) provides a description of optimum mission landscape requirements (current and future (next 5 years)) to include recommendations for improving the capability, availability and accessibility of land.

(n) Establish specific goals and measurable objectives for all components of the INRMP. (LD: 16 USC 670a(b)) Establish metrics and measure progress towards achieving the objectives.

(o) Prioritize projects and required resources necessary to achieve the objectives of the INRMP and its components.

(p) Make unclassified portions of INRMPs available to the public through electronic format (for example, world wide web, compact disk, and so forth.). All INRMPs will undergo DPTMS security review prior to being made available. This requirement does not apply to overseas installations.

(q) Accurately report INRMP data using the metrics in the Army Environmental Data Base - Environmental Quality (AEDB–EQ) Report and the Reimbursable Programs Tracking System (RPTS).

(r) Conduct Planning Level Surveys (PLSs) and data analysis as the foundation for effective planning and decision-making. PLSs, with the exception of flora, will be maintained electronically as geospatial data, and will be submitted to the GIS Repository as they are updated. Existing Army scopes of work will be used when available. PLSs should be kept current according to an installation's specific needs, but at a minimum, will be reviewed and updated if necessary prior to the INRMP's revision. PLSs include as a minimum:

1. Topography. A map with elevation, elevation contours, and associated data consistent with U.S. Geological Survey (USGS) standards and topographic map products.

2. Wetlands. A description and map of the distribution and extent of wetlands consistent with the statement of work as defined in the Army/USFWS Memorandum of Agreement (MOA).

3. Surface waters. A survey that describes and maps the distribution and extent of surface waters, and is consistent with USGS standards.

4. Soils. A survey that classifies, categorizes, describes, and maps soils by map unit, and meets current National Cooperative Soil Survey standards and procedures.

5. Flora. An installation-wide vascular plant survey that produces a list of plant species with verified nomenclature, classification and annotation compatible with the Natural Resources Conservation Service's (NRCS) Plant List of Accepted Nomenclature, Taxonomy, and Symbols (PLANTS).

6. Vegetation communities. A survey, including field data, which describes and maps the distribution and extent of dominant and co-dominant plant communities (alliances).

7. Threatened and endangered (T&E) species. A survey that maps and shows the occurrence, habitat distribution, and habitat management areas of Federally endangered, threatened, proposed, candidate, and species at risk occurring on the installation.

8. Fauna. A survey, including field data, that describes and maps the distribution and extent of animals.

(s) Ensure that turbidity and sediment levels do not irreparably degrade aquatic biota and habitat from an ecosystem perspective, or significantly impact shallow ground water aquifers.

(t) Evaluate the feasibility and potential impacts of operating motorized off-road vehicles (ORVs) and non-motorized vehicles (for example, mountain bikes) on the military mission and natural and cultural resource management. If determined feasible, develop procedures for operating motorized ORVs and non-motorized vehicles that will protect resource values; preserve public health, safety, and welfare; and minimize use conflicts. (LD: EO 11644).

(u) Obtain ACSIM approval prior to setting aside areas for an exclusive use that might constrain future land use decisions. Obtain supporting ACOM, ASCC, DRU, or NGB–ARNG concurrence before submitting request to ACSIM.

(2) *Leases, easements, and other special land uses.*

(a) Address leases, easements, and other special land uses within the INRMP.

(b) Ensure all conditions of leases and easements are consistent with the military mission and natural resources conservation and protection.

(c) Follow the policies set forth in AR 405–80 regarding rights-of-way or easements.

(3) *Soil resources.*

(a) Use the INRMP for the planned management of soil resources across the entire installation. The Soil Erosion and Sediment Control Component (SESCC) to the INRMP will address the following soils policy.

(b) Keep soil erosion from water within tolerance limits as defined in soil surveys prepared by the U.S. Department of Agriculture (USDA), NRCS or as required by FGS or host nation authorities.

(c) Keep soil sediment, as a pollutant, in wetlands and waterways within compliance limits.

(d) Minimize the impact of land uses on soil erosion and sedimentation when and where possible, to include:

1. Locating physically intensive land disturbing activities on the least erodible soils.

2. Using climatic/seasonal changes in soil erosion as a factor in scheduling intensive mission operations and real property management activities.

3. Identifying and rehabilitating land disturbed by operations and real property management activities.

(4) *Flora and fauna.*

(a) Promote biodiversity and ecosystem sustainability on Army lands and waters consistent with the mission and INRMP objectives.

(b) Manage flora and fauna consistent with accepted scientific principles and in accordance with applicable laws and regulations, and, where lands and waters are suitable, for conservation of indigenous flora and fauna.

(c) Manage habitat to conserve and enhance existing flora and fauna consistent with the Army goal to conserve, protect, and sustain biological diversity while supporting the accomplishment of the military mission.

(d) Introduce or reintroduce any species only upon approval of the USFWS, the State, higher headquarters, and HQDA and include in the installation INRMP. In those instances where the training mission may be impacted, coordinate with the supporting ACOM, ASCC, DRU, or NGB–ARNG and secure joint approval from the OACSIM and the Office of the DCS, G–3/5/7, DAMO–TRS. (LD: EO 11987)

(e) Consult with NOAA–Fisheries on actions authorized, funded, or undertaken that may adversely impact fisheries or marine mammals. (LD: 16 USC 1801).

(5) *Threatened and endangered (T&E) species.*

(a) Prepare and implement an Endangered Species Management Component (ESMC) to the INRMP consistent with current policy and guidance.

(b) Carry out mission requirements in compliance with 16 USC 35.

(c) Integrate endangered species management and installation planning functions to ensure compliance with 16 USC 35. (LD: 50 CFR 402)

(d) In accordance with ACSIM guidance, take appropriate actions to preclude critical habitat designation.

(e) Assess all activities (to include Military Construction (MILCON)) at the earliest opportunity to determine whether they may affect listed species or critical habitat.

(f) Coordinate T&E actions or issues with ACOM, ASCC, and DRU commanders and other tenants that may be affected by them.

(g) Conduct biological assessments for activities that may have an effect on listed species or critical habitat where they are present or may be present in the action area. (LD: 50 CFR 402).

(h) Informally consult with the USFWS or NOAA–Fisheries, document the results in writing, and if necessary, conduct a biological assessment or biological evaluation (see glossary) to assess whether an action may affect a listed species or critical habitat. If the action is likely to adversely affect the listed species or its habitat, formal consultation is required. (LD: 50 CFR 402).

(i) Coordinate with affected installation organizations and the higher headquarters prior to initiating formal consultation. HQDA may identify proposed formal consultations that require higher level review. Installations will provide the proposal and supporting documentation as requested. ODEP, in coordination with JALS–EL, will review proposals and provide comments.

(j) Formally consult with the USFWS or NOAA–Fisheries when it is determined an action "may affect" a listed species or critical habitat. If the action is not likely to adversely affect the listed species or its habitat, and the USFWS or NOAA–Fisheries concur in writing, formal consultation is not required. (LD: 50 CFR 402).

(k) Confer with the USFWS or NOAA–Fisheries on any action that is likely to jeopardize the continued existence of any proposed species or result in the destruction or adverse modification of proposed critical habitat. (LD: 50 CFR 402.10).

(l) Review all ongoing and proposed actions immediately upon listing of a threatened or endangered species or designation of critical habitat to determine if formal consultation is necessary (even if a conference has previously occurred). (LD: 50 CFR 402).

(m) Complete a Biological Evaluation before initiating formal conference on actions affecting a proposed species or proposed critical habitat. (LD: 50 CFR 402.10).

(n) Develop and implement strategies to promote, in cooperation with other landowners, the use of conservation banking and/or ACUB initiatives to minimize impacts of an action on T&E species and/or critical habitat.

(o) Within 24 hours report 16 USC Chapter 35 (ESA) violations, by telephone or electronic means, through the chain of command to HQDA (ODEP and JALS–EL). Submit a followup written report within 7 days.

(p) Coordinate with higher headquarters and HQDA (ODEP and JALS–EL) in taking final action to correct any endangered species management problems contributing to the 16 USC 35 (ESA) violation(s).

(q) Ensure that T&E awareness is included in unit training for personnel who may come in contact with listed species and/or their habitats or critical habitat. Coordinate training with the installation engineer, environmental directorate, and ITAM sustainable range component.

(r) Obtain HQDA approval before supporting USFWS's or NOAA–Fisheries' introduction and/or reintroduction of Federal and State listed, proposed, and candidate species on Army lands.

(s) Protect the water rights necessary for the survival and recovery of listed, proposed, or candidate aquatic or riparian species. Coordinate all water rights issues with appropriate legal counsel.

(t) Participate in the listing/delisting process, recovery plan development, and critical habitat designation where the species in question may impact installation military missions.

(u) Cooperate with State and local authorities in the management of ACSIM-designated Army species at risk and habitats with the goal of avoiding listings that could adversely affect military readiness.

(v) Participate in regional/habitat-wide efforts to conserve candidate and ACSIM-designated Army species at risk and habitats when it has the potential to benefit the Army.

(w) Include State-listed species in the installation INRMP.

(6) *Species at risk.*

(a) In accordance with ACSIM guidance, manage species at risk and habitats to prevent listing that could affect military readiness.

(b) Program and plan for environmental conservation critical funding for designated Army species at risk and coordinate Real Property Services funding opportunities for other species at risk.

(c) Incorporate species at risk management in the INRMP.

(d) Implement management plans for species at risk to include, but not limited to, survey, monitoring, habitat enhancement, and protection.

(7) *Forest management.* Practice responsible stewardship of forested lands to support the mission.

(8) *Conservation reimbursable agricultural/grazing outleasing and forestry programs.*

(a) Conduct programs that are compatible with mission operations and that support conservation compliance, sustainability, and natural resources stewardship.

(b) Routinely examine Army land to determine what areas, if any, are available for outleasing and/or forest management. (PD: AR 405–80 and AR 405–90)

(c) Coordinate with DPTMS to establish needed doctrinal terrain and ground cover requirements.

(d) Maintain Conservation Reimbursable Programs where these provide a direct benefit to the mission and environmental goals.

(e) Deposit all revenues from agriculture and grazing outleases, forest product sales, or sale of equipment procured with Conservation Reimbursable funds into the Army Forestry Account or the Army Agricultural/Grazing Account per DFAS–IN Manual 37–100-**.

(f) Sell no forest products nor outlease land for agricultural or grazing purposes unless the effects of the sale or lease are compatible with the INRMP. (LD: 16 USC 670a)

(g) Ensure that equipment procured with Conservation Automatic Reimbursable Authority is not transferred to tables of distributions and allowances (TDAs) outside of the programs or Federal Government ownership. Salvage value for equipment procured with Conservation Automatic Reimbursable Authority (Forestry or Agricultural/Grazing Outlease) will be deposited into the Army timber or agricultural/grazing outlease proceeds accounts.

(h) Ensure that outleases do not grant offsets that exceed the total amount of outlease value. At a minimum, revenues must cover the costs of administering the installation lease. (LD: 10 USC 2667).

(i) Continue Conservation Reimbursable Programs on excess or base realignment and closure (BRAC) lands until title is no longer held by the Army. Clear-cuts on excess or BRAC lands are prohibited unless approved by ODEP.

(j) Use revenues generated from the reimbursable programs to maintain, improve, or rehabilitate previously degraded ecosystems on the installation.

1. Use revenues from agricultural/grazing outleases only for reimbursement of administrative costs of outleasing and other expenses incurred in support of multiple-land use management of natural resources.

2. Use revenues from forest product sales only for management of forests and natural resources that support forest stewardship on land affected by conservation reimbursable forestry programs.

3. Do not use automatic reimbursable authority to augment general operating expenses of the installation as overhead.

(k) Prepare determinations of availability (agricultural/grazing) and reports of availability (ROA) (forestry) as required by AR 405–80 and 405–90.

(l) Enter annual requirements into the Reimbursable Program Tracking System (RPTS).

(m) Assure that agricultural and forest products are not given away, abandoned, carelessly destroyed, used to offset contract costs or traded for services, supplies, or products or otherwise improperly removed.

(n) Assess lands to assure they are safe for nonmilitary purposes before outleasing. Document the environmental condition in a finding of suitability to lease (FOSL), Environmental Condition of Property (ECP) Report. (LD: 42 USC 4321).

(o) When disposing of forest products from Army land by any means other than a commercial sale, the fair market dollar value will be used. This amount will be deposited in the Army Forestry Account by the proponent. Forest products may be used to directly assist the military mission without payment.

(p) Account for all forest products and complete all commercial harvests before starting any construction that may impact forest resources.

(q) Ensure all Army solicitations and contracts for timber sales affected by Sections 620–620j, Title 16, United States Code (16 USC 620–620j) contain a provision restricting the export of unprocessed timber procured on Army land.

(9) *Hunting, Fishing, and Trapping.*

(a) Support the Provost Marshal in enforcement of State and Federal laws pertaining to hunting, fishing, and trapping.

(b) Coordinate with morale, welfare, and recreation (MWR) for the management and collection of fees for hunting, fishing and trapping. Do not expend environmental appropriated funds for non-appropriated fund (NAF) administration of hunting, fishing, and trapping activities.

(c) Deposit collected fees from the sale of Special State Licenses into the Army Fish and Wildlife Conservation Fund (21X5095). GCs are authorized to provide no-cost Special State Licenses for junior enlisted soldiers (pay grade E4 and below) and to institute a sliding fee schedule for enlisted soldiers based on ability to pay.

(d) Provide for controlled recreational access where feasible at Army installations containing land and water areas suitable for recreational use. (LD: 16 USC 670a).

(e) Provide access to uniformed personnel, family members, and the public to hunting, fishing, and trapping, consistent with security requirements and safety concerns. Membership in an organization, including rod and gun clubs, has no bearing on receiving access. Exceptions to the above include specific access rights protected by treaties with or retained by American Indian and Alaska Native Tribes (see also para 6–4).

(f) Provide access to disabled veterans, military dependents with disabilities, and other persons with disabilities when public access is available and when topographic, vegetative, and water resources allow access for such persons without substantial modification to the natural environment. Coordinate actions and solutions with appropriate organizations within the Army, OSD, and the Access Board as appropriate.

(g) Hunting, fishing, and trapping plans will be included in the INRMP for installations that have such programs.

(10) *Noxious weeds and invasive species management.* The Director of Public Works is the proponent for noxious weeds and invasive species management.

(a) Prepare and implement an invasive species management component (ISMC) of the INRMP consistent with specific Federal or State initiatives. (LD: EO 13112).

(b) Where applicable, synchronize invasive species management practices with objectives of the installation ITAM program.

(c) Conduct mission activities in a manner that precludes the introduction or spread of invasive species. (LD: EO 13112).

(d) Do not use invasive species in installation landscaping or land rehabilitation and management projects. (LD: EO 13112).

(e) Use the most effective and environmentally sound approach for controlling invasive species, to include the use (or reduction in use) of pesticides. (PD: DODI 4150.7).

(f) Assure that installation INRMP and pest management plan are in concert regarding noxious weeds management. (PD: DODI 4150.7).

(11) *Migratory birds.*

(a) Consistent with HQDA endorsement, implement conservation measures identified in the memorandum of understanding (MOU) between DOD and the USFWS pursuant to EO 13186.

(b) Obtain appropriate authorization (that is, take permit) from the USFWS before intentionally and directly taking any migratory bird species. Record any birds purposefully and intentionally taken under the authorization and provide an annual report to the USFWS. (LD: 16 USC 703–712).

(c) Establish procedures to avoid the unintentional take of migratory birds, including nests and eggs. (LD: 16 USC 703–712).

(12) *Wildland fire management.*

(a) Reduce wildfire potential using appropriate management practices such as prescribed burning, firebreak maintenance/construction, etc.

(b) Installations with unimproved grounds that present a wildfire hazard and/or installations that utilize prescribed

burns as a land management tool will develop and implement an integrated wildland fire management plan (IWFMP) that is compliant and integral with the INRMP, the installations' existing fire and emergency services program plan(s), and the ICRMP.

(c) Assure that all civilian, contractor, and emergency services personnel involved in wildland fire management possess the level of training and physical fitness needed for their expected level of involvement.

(d) Ensure that only qualified personnel conduct prescribed burns.

Chapter 5
Pest Management

5–1. Policy

a. Protect real property and the health of soldiers, civilians, and family members from pests through use of integrated pest management (IPM) strategies.

b. Reduce the use of chemical pesticides.

c. Reduce environmental risks from pesticides through proper storage, handling, application, and disposal of pesticides.

5–2. Legal and other requirements

Listed below are statutes, laws, regulations applicable to the Army Pest Management Program.

a. Section 136, Title 7, United States Code (7 USC 136).

b. DODI 4150.7.

c. DOD 4150.7–M.

d. DOD 4150.7–P.

e. DODI 4715.5.

f. AR 40–5

g. AR 420–10.

h. AR 385–10.

i. AR 210–50.

j. For overseas installations, the country-specific FGS requirements.

5–3. Major program goals

a. Monitor and control pests that pose a threat to the health and safety of the installation population.

b. Maintain current pest management plans at all installations.

c. Minimize the use of pesticides through appropriate surveillance methods and programs.

d. Ensure that all pesticide applicators are appropriately trained and certified.

e. Develop and enforce measures to properly store and safeguard pesticides and pesticide application equipment for installation pesticide security.

f. Ensure all pesticide waste is properly disposed.

5–4. Program requirements

a. Prepare an integrated pest management plan (IPMP) that defines pest management requirements, responsibilities, and resources needed to correct pest problems at each installation. Coordinate the IPMP with all affected parties. (PD: DODI 4150.7)

b. Conduct IPM programs in accordance with plans approved by garrison commander (GC), National Guard Bureau - Army National Guard (NGB–ARNG), Installation Management Command (IMCOM)-Korea, or IMCOM–Europe, as appropriate.

c. Establish procedures to store, secure, handle, apply, dispose, and manage pesticides that are consistent with Army safety and security requirements (PD: DODI 4150.7)

d. Conduct periodic program reviews at the installation using pest management professionals to ensure regulatory compliance and correct any deficiencies (PD: DODI 4150.7)

e. Ensure Army military and civilian personnel who apply or supervise application of pesticides on Army facilities or installations or during military contingencies, will be trained and certified in accordance with DOD certification standards. Non-DOD personnel (including State employees and contractors) who apply or supervise application of pesticides on Army facilities or installations will be trained and certified by the State where the Army facility or installation is located. Quality assurance evaluators that develop or review pest management contract specifications, or assess performance of those contracts will be trained in accordance with DOD policy and guidance. (PD: DODI 4150.7) *f*. Maintain and archive records and reports on all pesticide applications and operations made to all facilities and grounds to include those performed under contract by tenant and supported activities, by lessees per formal agreements, those installations and facilities in the base realignment and closure (BRAC) cleanup program, and for closing overseas installations. (PD: DODI 4150.7)

g. Ensure installation self-help programs are cost-effective and promote IPM approaches for control of minor nuisance pests through use of authorized pest management materiel, equipment, awareness training, and record keeping requirements. (PD: DODI 4150.7)

h. Ensure requirements for aerial pesticide applications over Army lands to control pests of medical, economic, or other emergencies or urgencies of military significance are addressed in an aerial spray statement of need (ASSON) and submitted to the U.S. Army Environmental Command (USAEC), NGB–ARNG, IMCOM–Korea, or IMCOM-–Europe as appropriate. (PD: DODI 4150.7)

i. Ensure pest management commercial solicitations incorporate Army requirements for the application and safe handling of pesticides and are forwarded to USAEC, NGB–ARNG, IMCOM–Korea or IMCOM–Europe as appropriate for technical review prior to solicitation. (PD: DODI 4150.7; DOD 4150.7–M; DOD 4150.7–P)

j. Appoint an installation pest management coordinator (IPMC). (PD: DODI 4150.7)

Chapter 6
Cultural Resources

6–1. Policy

Ensure that installations make informed decisions regarding the cultural resources under their control in compliance with public laws, in support of the military mission, and consistent with sound principles of cultural resources management.

6–2. Legal and other requirements

Statutes, laws, regulations, and other guidance applicable to the Army Cultural Resources Management Program include:

a. Section 470, Title 16, United States Code (16 USC 470).

b. Section 1996, Title 42, United States Code (42 USC 1996) and Executive Order (EO) 13007.

c. Section 3001, Title 25, United States Code (25 USC 3001).

d. Section 470aa-470mm, Title 16, United States Code (16 USC 470); Sections 431–433, Title 16, United States Code (16 USC 431–433); and Section 469, Title 16, United States Code (16 USC 469).

e. Part 79, Title 36, Code of Federal Regulations (36 CFR 79).

f. Part 800, Title 36, Code of Federal Regulations (36 CFR 800).

g. Part 229, Title 32, Code of Federal Regulations (32 CFR 229).

h. Part 10, Title 43, Code of Federal Regulations (43 CFR 10).

i. DOD American Indian and Alaska Native Policy Memorandum, 20 October 1998.

j. Presidential Memorandum for Heads of Executive Departments and Agencies, Government-to-Government Relations with Native American Tribal Governments, 29 April 1994.

k. EO 13175.

l. EO 13287.

m. For overseas installations, the country-specific FGS requirements.

6–3. Major program goal

Develop and implement procedures to protect against encumbrances to mission by ensuring that Army installations effectively manage cultural resources.

6–4. Program requirements

a. *General program management.*

(1) Develop integrated cultural resources management plans (ICRMPs) for use as a planning tool.

(2) Develop NHPA programmatic agreements (PAs) and memorandums of agreement (MOAs), Army alternate procedures (AAP) historic property component (HPC) plans, NAGPRA Comprehensive Agreements (CAs) and Plans of Action (POA), Cooperative Agreements, and other compliance documents as needed.

(3) Appoint a government (that is, Federal or State Army National Guard (ARNG)) employee as the installation cultural resources manager (CRM).

(4) Establish a government-to-government relationship with Federally recognized Indian Tribes, as needed. Initial formal government-to-government consultation with Federally recognized Indian Tribes will occur only between the

garrison commander (GC) or the Adjutant General (TAG) of an ARNG and the heads of tribal governments. Follow-on activities may be accomplished by staff.

(5) Establish a process that effects early coordination between the CRM and all staff elements, tenants, proponents of projects and actions, and other affected stakeholders to allow for proper identification, planning, and programming for cultural resource requirements.

b. National Historic Preservation Act compliance.

(1) Ensure that the GC functions as the agency official with responsibility for installation compliance with the National Historic Preservation Act (NHPA).

(2) Establish a historic preservation program, to include the identification, evaluation, and treatment of historic properties in consultation with the Advisory Council on Historic Preservation (ACHP), State Historic Preservation Officer (SHPO), local governments, Federally recognized Indian Tribes, Native Hawaiian organizations, and the public as appropriate. Document historic properties that will be substantially altered or destroyed as a result of Army actions. (LD: Section 110, NHPA; 36 CFR 800)

(3) Identify, evaluate, take into account, and treat the effects of all undertakings on historic properties. If an Army undertaking may affect properties of traditional religious or cultural significance to a Federally-recognized Indian Tribe, initiate consultation on a government-to-government basis. (LD: Section 106, NHPA; 36 CFR 800)

(4) Prepare and implement, as required, an NHPA Section 106 MOA, PA, or HPC, to address NHPA compliance for undertakings. Coordinate all NHPA compliance documents (for example, MOAs, PAs, HPCs) through the chain of command to obtain HQDA technical and legal review prior to execution. (LD: 36 CFR 800)

(5) Ensure that efforts to identify, evaluate, and treat historic properties consider the Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation, and are conducted under the supervision of personnel who meet applicable professional qualifications for undertaking such work. (LD: 36 CFR 61; Section 112, NHPA)

(6) Maintain an up-to-date listing of all historic properties, and where applicable, maintain historic status in conjunction with real property inventory and reporting guidelines. (LD: EO 13287)

(7) Withhold from public disclosure information about the location, character, or ownership of a historic property when the GC determines that disclosure may cause risk of harm to the historic property or may impede the use of a traditional religious site by practitioners. (LD: Section 304, NHPA)

(8) Consider alternatives for historic properties, including adaptive reuse, that are not needed for current or projected installation mission requirements. (LD: Section 111, NHPA)

(9) Nominate to the National Register of Historic Places (NRHP) only those properties that the Army plans to transfer out of Federal management through privatization efforts. Nominate other properties only when justified by exceptional circumstances. Avoid adversely affecting properties that are 50-years old or older that have not been evaluated for eligibility against NHPA criteria. Treat (assume) that all historic sites are eligible (that is, off-limits) until the SHPO concurs with the federal finding of non-eligible.

(10) Where disagreement occurs with the SHPO regarding the eligibility of a historic property for the NRHP, where applicable obtain a "Determination of Eligibility" from the Keeper of the National Register, National Park Service (NPS). (LD 36 CFR 800, 36 CFR 63)

(11) Undertake such planning and actions as may be necessary to minimize harm to any National Historic Landmark that may be directly and adversely affected as a result of Army actions. (LD: 36 CFR 800)

c. AIRFA, Executive Order 13007 and Executive Order 13175 compliance.

(1) Consult with Federally recognized Indian Tribes to provide access to sacred sites on Army installations. Consistent with appropriate health, safety mission constraints provide access to allow the practice of traditional religions, rights and ceremonies. The GC will maintain the appropriate confidentiality of sacred site locations. The GC may impose reasonable restrictions and conditions on access to sacred sites on Army installations for the protection of health and safety, or for reasons of national security. (LD: EO 13007)

(2) Avoid adversely affecting the physical integrity of sacred sites. Ensure reasonable notice is provided to Federally–recognized Indian Tribes when proposed actions may adversely affect or restrict access to the ceremonial use of, or the physical integrity of, sacred sites. (LD: EO 13007)

(3) Consult with tribal governments before taking actions that affect Federally recognized Indian Tribes. Assess the impact of Army plans, projects, programs, and activities on tribal trust resources and assure that tribal government rights and concerns are considered during the development of such plans, projects, programs and activities. (LD: EO 13175)

d. Native American Graves Protection and Repatriation Act compliance.

(1) Designate the GC as the Federal agency official with responsibility for installation compliance with Native American Graves Protection and Repatriation Act (NAGPRA). (LD: 43 CFR 10)

(2) Prepare CAs and POAs in coordination with Federally recognized Indian Tribes and Native Hawaiian organizations. Coordinate all NAGPRA CAs through the chain of command to obtain HQDA technical and legal review prior to execution. (LD: 43 CFR 10)

(3) Absent a CA, take reasonable steps to determine whether a planned activity (including MILCON) may result in the intentional excavation or inadvertent discovery of cultural items from Federally-owned or controlled Army lands. When cultural items may be encountered, the GC will implement consultation procedures and planning requirements of Section 3 and Section 5 of NAGPRA prior to issuing approval to proceed with the activity. (LD: 43 CFR 10.3 and 43 CFR 10.5)

(4) Establish initial communication with Federally recognized Indian Tribes via written correspondence between the GC and heads of tribal governments. Formally document all resulting agreements. (LD: 43 CFR 10)

(5) Inventory, summarize, and repatriate cultural items that are in existing collections under Army possession or control. Where there is a dispute as to the affiliation of cultural items, safeguard the cultural items until the dispute is resolved. (LD: 43 CFR 5, 6, 7, and 10)

e. ARPA and AHPA Compliance.

(1) Ensure the GC serves as the Federal land manager with responsibility for installation compliance with ARPA. (LD: 32 CFR 229)

(2) Ensure the GC serves as the Federal agency official with management authority over archeological collections and associated records. (LD: 36 CFR 79)

(3) Establish and include installation policy for management of, and for limitation of collection and removal of, paleontological resources in ICRMPs. Address known paleontological resources in any NEPA documentation prepared for actions that may impact or cause irreparable loss or destruction of such resources.

(4) Prohibit searching for or collection of historic properties (including archaeological resources) on Army installations except when authorized by the GC and pursuant to a permit issued under ARPA.

(5) Minimize the amount of archeological material remains permanently curated by reserving such treatment for diagnostic artifacts and other significant and environmentally sensitive material that will add important information to site interpretation.

(6) Curation of archeological materials from Army lands will occur only in 36 CFR 79-compliant repositories. Maximize use of off-installation facilities that are better able to provide for adequate long-term curatorial services.

(7) Do not disclose to the public information concerning the nature and location of any archaeological resource for which the excavation or removal requires a permit or other permission under ARPA or under any other provision of Federal law. (LD: Section 9a, ARPA 1979)

Chapter 7
Pollution Prevention

7–1. Policy

a. Pollution prevention is the Army's preferred approach, where timely and cost-effective, to achieve and maintain compliance with environmental laws and regulations.

b. Prevent pollution from all sources to the extent practicable by:

(1) Reducing pollutants at the source.

(2) Modifying manufacturing, packaging, and shipping processes, maintenance or other industrial practices.

(3) Modifying product designs.

(4) Developing and modifying acquisition systems.

(5) Recycling/reuse (to include implementing water and energy conservation measures), especially in closed-loop processes.

(6) Preventing disposal and transfer of pollution between media.

(7) Meeting affirmative procurement requirements and promoting the acquisition and use of environmentally preferable products and services.

(8) Promoting use of nontoxic substances.

c. Use pollution prevention to complement, and where practicable, replace traditional pollution control approaches.

d. Incorporate pollution prevention planning throughout the mission, operation, or product life cycle.

7–2. Legal and other requirements

a. 42 USC 6901, *(RCRA).*

b. PL 109–58.

c. Sections 6901–6992k, Title 42, United States Code (42 USC 6901–6992k)).

d. Sections 13101–13102, Title 42, United States Code (42 USC 13101–13102).

e. EO 13423.

f. DODI 4715.4.

g. AR 70–1.

7–3. Major program goals

a. Reduce use of products or processes that degrade the environment.

b. Invest in pollution prevention in all mission and support areas, as applicable.

c. Minimize the use of toxic and hazardous materials and processes in all life cycle phases of acquisition programs, logistics support, modification of existing weapons systems, and installation management.

d. Implement pollution prevention initiatives to reduce life cycle costs of military missions and improve demilitarization and disposal of systems.

e. Disseminate pollution prevention opportunities and lessons learned across the Army.

f. Incorporate a Hazardous Materials Management Program (HMMP) into logistics business practices to reduce hazardous material inventory and hazardous waste (HW) disposal.

7–4. Program requirements

a. Periodically review operations and conduct pollution prevention opportunity assessments. Maintain an updated installation pollution prevention plan. Implement cost-effective pollution prevention opportunities identified by the assessments.

b. Develop and implement a Green Procurement Program with emphasis on the mandatory purchasing preference programs (Affirmative Procurement for all designated Environmental Protection Agency (EPA) and DOD guidelines). (LD: EO 13423; 40 CFR 247)

c. Address environmental concerns throughout the acquisition life cycle. (PD: AR 70–1)

d. Emergency Planning and Community Right-to-Know Act (EPCRA).

(1) Army activities within the United States will comply with EPCRA. Army activities will prepare and maintain an inventory of hazardous substances present at the activity. (LD: EO 13423)

(2) Activities will submit EPCRA reports to Local Emergency Planning Committees (LEPC), State Emergency Response Commissions (SERC), local fire departments with jurisdiction over the activity, and EPA if they exceed reporting threshold quantities. Tier I and Tier II reports are due by 1 March in each calendar year. An activity may be a LEPC when appointed by a SERC. (LD: EO 13423)

(3) Activities will submit draft electronic Toxic Release Inventory (TRI) Form R reports to the U.S. Army Environmental Command (USAEC) via chain of command by 1 May of each calendar year. After review and comment from USAEC, activities will provide final report to the EPA by 1 July, with copy to USAEC. (LD: EO 13423)

Chapter 8
Munitions Use on Ranges

8–1. Policy

This chapter applies to operational ranges, which are defined as ranges that are under the jurisdiction, custody, or control of the Secretary of Defense and that are used for range activities; or, although not currently being used for range activities, that are still considered by the Secretary to be a range and have not been put to a new use that is incompatible with range activities. In managing operational ranges, all Army organizations and activities will—

a. Consider demilitarization, constituent migration, and range cleanup and clearance in the weapons systems total lifecycle cost.

b. Manage the Army munitions inventory to achieve and maintain compliance with the Military Munitions Rule (or applicable Final Governing Standards (FGS) overseas).

c. Whenever practicable, recycle obsolete, excess, or unserviceable munitions and munitions residue.

d. Incorporate environmental considerations into sustainable range designs to support mission requirements.

e. Coordinate with the Headquarters, Department of the Army, Deputy Chief of Staff, G–3/5/7 before closing an operational range.

8–2. Legal and other requirements

a. Section 9601, Title 42, United States Code (42 USC 9601); Section 300f, Title 42, United States Code (42 USC 300f); Section 26, Title 33, United States Code (33 USC 26); Section 7401, Title 42, United States Code (42USC 7401); FGS requirements; and other regulations that apply to soil, water, and air.

b. Sections 200 to 206, Part 266, Title 40, Code of Federal Regulations (40 CFR 266.200 to 40 CFR 266.206) or applicable State versions.

c. DODD 4715.11 and DODD 4715.12.

d. DODI 4140.62.

8–3. Major program goals
Identify and address environmental issues that impact the use of Army ranges.

8–4. Program requirements
a. Munitions management.

(1) Train munitions managers and handlers on the Munitions Rule and related State requirements (or applicable FGS requirements overseas). (PD: Munitions Action Plan)

(2) Audit for compliance with the Munitions Rule and related State requirements (or applicable FGS requirements overseas). (PD: Munitions Action Plan)

b. Environmental support to range operations.

(1) Prepare an annual Toxic Release Inventory (TRI) Form R for operational ranges as required and submit with the installation's TRI report to the U.S. Army Environmental Command (USAEC) via chain of command by 1 May of each calendar year (this does not apply overseas). After review and comment from USAEC, facilities will provide final report to the Environmental Protection Agency (EPA) by 1 July, with copy to USAEC (see para 7–4d).

(2) Respond to a release or substantial threat of release of munitions constituents (MC), munitions and explosives of concern (MEC), or unexploded ordnance (UXO) from an operational range to off-range areas, when such release poses or may pose an imminent and substantial threat to human health or the environment.

(3) Where practicable, maintain records of the historical uses of operational ranges; and retain environmental cleanup investigations, hydro-geologic, geologic, and soil surveys, and other environmental documents that support sustainable range planning.

(4) Maintain and sustain ranges in an environmentally compliant manner, and undertake emergency response action when appropriate.

c. Response to munitions and explosives of concern.

(1) Investigate and address, as appropriate, the explosives safety, human health, or environmental risks presented by MEC. (This can be as simple as a notification to the community with an education program about the hazards posed by military munitions and how to avoid them, or as complicated as a long-term response action involving sophisticated technology, specialized expertise, and significant resources.)

(2) Maintain permanent records of the coordinates of all areas known or suspected to contain MEC.

(3) Maintain permanent records of all MEC clearance operations, explosive ordnance disposal (EOD) incidents, and open burn/open detonation operations conducted on the range.

d. Chemical warfare agent wastes. Storage and disposal of chemical warfare agent waste and related agent-contaminated material may be subject to the requirements of RCRA or applicable State regulations (this does not apply overseas). Generators of chemical warfare agent waste and agent-contaminated material are responsible for ensuring proper storage and for paying disposal costs (this does not apply to Defense Environmental Restoration Program (DERP)-eligible sites).

Chapter 9
Materials Management

9–1. Hazardous materials
a. Policy.

(1) Follow approved standardized hazardous material management business practices as specified by the Deputy Chief of Staff, G–4 (DCS, G–4) and the Office of the Assistant Chief of Staff for Installation Management (OACSIM) to implement the Hazardous Material Management Program (HMMP).

(2) Review and approve hazardous material (HM) usage and track usage to using processes and work centers.

(3) Reduce the acquisition and use of hazardous materials and the generation of solid or hazardous wastes (HW) through centralized inventory control, best management practices (BMPs), pollution prevention actions, improved procurement practices, material re-use, recycling, and enhanced shelf-life management. HMs should be procured through the standard Army supply system. Use of government IMPAC credit cards to purchase HM is generally prohibited, and may only be allowed on a case-by-case basis by Garrison Commanders or their designated representative.

(4) Manage and dispose of pesticides, residues, and their containers in an environmentally safe manner.

(5) Do not allow the transport, storage, or disposal of non-DOD hazardous materials on Army installations unless approved by the Office of the Assistant Secretary of the Army for Installations and Environment (OASA (I&E)), his or her designee, or higher authority.

b. Legal and other requirements. Section 11011, Title 42, United States Code (42 USC 11011); Section 302–313, Title 33, United States Code (33 USC 26); and Executive Order (EO) 13423.

c. Major program goals. The goals of the HMMP are to reduce risk to public health and the environment by employing management controls and pollution prevention initiatives to comply with regulations and executive orders and to support sustainability.

d. Program requirements.

(1) Follow Army logistics policy for identifying, storing, and transporting hazardous materials as specified by the DCS, G–4. Related policy guidance can be found in safety, medical, acquisition and logistics regulations. Installation supplements involving any hazardous material management should be coordinated with the installation environmental coordinator, safety coordinator, and installation medical officer.

(2) Record, review, and analyze HM and HW operational data as a source of information to measure HMMP effectiveness.

9–2. Toxic substances

a. General. As used in this regulation, toxic substances include asbestos, polychlorinated biphenyls (PCBs), and lead-based paints (LBP). Generators will pay disposal costs for toxic substances (except that the installation will pay disposal costs for toxic substances that are also classified as a RCRA–C hazardous waste).

b. Asbestos management.

(1) *Policy.* The Army proponent for asbestos hazard management is the Assistant Chief of Staff for Installation Management (ACSIM), Directorate of Facilities and Housing. Army facility policy and guidance on asbestos management is provided in AR 420–70, chapter 3. The Army's medical policy related to asbestos is found in AR 40–5.

(2) *Legal and other requirements.* Applicable legal and other requirements for asbestos management include Section 2651, Title 15, United States Code (15 USC 2651); Section 1801, Title 49, United States Code (49 USC 1801); Section 2601, Title 15, United States Code (15 USC 2601); 42 USC 7401, as amended; Section 1001, Part 1910, Title 29, Code of Federal Regulations (29 CFR 1910.1001); Section 1101, Part 1926, Title 29, Code of Federal Regulations (29 CFR 1926.1101); for overseas installations, the country-specific FGS requirements.

(3) *Major program goals.* Prevent human exposure to asbestos hazards on Army-owned property and maintain compliance with all pertinent regulations. This also applies to accommodations made available to the Army for its exclusive use overseas.

(4) *Program requirements.*

(a) Comply with Sections 140–156, Part 61, Title 40, Code of Federal Regulations (40 CFR 61.140–156) requirements regarding fees and notification. (LD: 40 CFR Part 61.140–156; 40 CFR 70)

(b) Ensure that all workers in facilities where asbestos exposure may occur are trained under Environmental Protection Agency (EPA) and Occupational Safety and Health Administration (OSHA) regulations and asbestos safe work practices requirements. (LD: 40 CFR 763)

(c) Ensure that all workers that perform OSHA asbestos work are trained, equipped, and supervised according to EPA abatement and respiratory protection requirements. (LD: 29 CFR 1926.1101; 40 CFR 763)

(d) Use only laboratories accredited under the National Voluntary Laboratory Accreditation Program or host nation (HN) accredited laboratories for overseas installations for the quantitative measurement of bulk and air asbestos samples. (LD: 40 CFR 763.87)

(e) Remove/abate asbestos-containing material only when it:

1. Can no longer be managed in place.

2. Will be disturbed during maintenance, repair, or construction projects.

3. Is friable or will become friable during demolition of a facility.

4. Is economically justified to be removed during building deconstruction.

5. Has been identified to be a hazard and the Army is transferring ownership of the facility to a non-federal entity.

c. Polychlorinated biphenyl management.

(1) *Policy.* Army policy is for generators of polychlorinated biphenyl (PCBs) to manage them in place unless operational, economic, or regulatory considerations justify removal. Economic analyses include potential environmental damage.

(2) *Legal and other requirements.* Requirements for PCB management are found in 15 USC 2601, and applicable State and local requirements; and for overseas installations, the country-specific FGS requirements.

(3) *Major program goals.* Prevent human exposure to PCB hazards on Army-owned property and maintain compliance with pertinent regulations.

(4) *Program requirements.*

(a) Ensure that the inventory, management, reporting, storage, disposal, and cleanup of PCBs comply with Federal, State, and local regulations. (LD: 40 CFR 761)

(b) Require generators, commercial storers, transporters, and disposers of PCBs to have an EPA identification number. (LD: 40 CFR 761.20, 761.60(b), 761.202 through 761.205)

(c) Train personnel who handle or may potentially be exposed to PCBs to perform PCB-related responsibilities in a safe and environmentally sound manner. (LD: 29 CFR 1910.1200; 29 CFR 1910.120(q))

(d) Prohibit the new use or introduction of PCBs at Army facilities.

d. Lead-based paint management.

(1) *Policy.* The Army proponent for lead-based paint (LBP) management is the ACSIM, Directorate of Facilities and Housing. Army facility policy and guidance on LBP management is provided in AR 420–70, chapter 3.

(2) *Legal and other requirements.* Requirements for LBP management are found in 15 USC 2601; Section 1025, Part 1910, Title 29, Code of Federal Regulations (29 CFR 1910.1025); Section 62, Part 1926, Title 29, Code of Federal Regulations (29 CFR 1926.62); Part 745, Title 40, Code of Federal Regulations (40 CFR 745); AR 420–70, chapter 3; and applicable State and local requirements; for overseas installations, the country-specific FGS requirements.

(3) *Major program goals.* Prevent human exposure to LBP hazards on Army-owned property and maintain compliance with pertinent regulations.

(4) *Program requirements.*

(a) Ensure that all workers that perform lead abatement work in child occupied facilities and target housing are trained, equipped, and supervised according to EPA lead-based paint abatement requirements and OSHA requirements for lead in construction. (LD: 40 CFR 745 and 29 CFR 1926.62, respectively). Construction work impacting lead-based paint that is not considered abatement of lead-based paint in target housing or child occupied facilities need only comply with OSHA requirements. (LD: 29 CFR 1926.62)

(b) Per facility and housing BMPs, manage LBP and lead-contaminated soil in place unless operational, economic, and/or regulatory requirements dictate its removal.

(c) Disclose known LBP hazards in Army housing. (LD: 40 CFR 745)

(d) Ensure that disposal of LBP complies with Federal, State, and local regulations.

Chapter 10
Waste Management

10–1. Hazardous waste

a. Policy.

(1) Hazardous waste disposal costs are those costs associated with the collection, treatment, storage, transportation and disposal of hazardous wastes. This includes all Defense Reutilization and Marketing Service (or other contract agent) costs directly related to the packaging and offsite shipment of the wastes. It does not include the disposal of special wastes defined as non-hazardous unless otherwise defined as hazardous by State and local regulations, or country-specific Final Governing Standards (FGS); asbestos; chemical and biological agent waste; radioactive waste; and regulated medical wastes (RMW).

(a) Garrisons must directly charge or seek reimbursement from non-Army tenants and activities funded through an operating fund (Defense Business Operating Fund and Army Working Capital Fund), a procurement fund (Procurement of Ammunition, Army), a research and development fund (Research, Development, Test, and Evaluation and Army Test and Evaluation Command activities), and other DOD funded activities (primarily Defense Logistics Agency, Medical Command, and Defense Commissary Agency). Though appropriated funds can be used for a non-appropriated fund activity (Category C), it is subject to the availability of funds of HQ, IMCOM. Special installations will pay for hazardous waste disposal. Excess or expired hazardous materials must be handled in accordance with AR 710–2 and garrison procedures.

(b) Hazardous wastes generated under service, facility, maintenance or construction contracts (construction demolition debris, paints, soil disposal, disposal of sand from ranges, sludge from wash racks, oil/water separators, water treatment plants, and so forth.) should not be a separate cost and funded as part of the original contract.

(c) The Garrison environmental office will be considered the generator, for funding purposes, of orphan wastes found on post, and wastes from a household hazardous waste collection program.

(2) Comply with all applicable Federal, State, and local HW regulations, and FGS.

(3) Effectively manage HW and reduce its generation.

(4) Minimize the need for Army-owned or operated permitted HW treatment, storage, and disposal facilities.

(5) Minimize HW generation through pollution prevention actions, for example, source reduction, material substitution, and recycling/reuse. Where cost effective and timely, implement pollution prevention solutions to reduce or eliminate compliance requirements.

(6) Prohibit the storage of HW in underground storage tanks (USTs), except where allowed by FGS.

b. Legal and other requirements. 42 USC 6901, Subtitle C; Parts 260–279, Title 40, Code of Federal Regulations (40 CFR 260–279); DOD 4500.9–R, chapter 204; Parts 171–178, Title 49, Code of Federal Regulations (49 CFR 171–178); for overseas installations, the country-specific FGS requirements.

c. Major program goals. Continually reduce the volume of HW generated by Army installations, and maintain compliance with pertinent HW regulations.

d. Program requirements.

(1) Systematically evaluate waste streams to ensure all potential hazardous or special wastes are properly identified and characterized. (LD: 40 CFR 262.11; 40 CFR 264.13)

(2) Ensure that all persons handling or managing HW are provided with appropriate training.

(3) Develop and implement a hazardous waste management plan (HWMP) or other comparable document appropriate to the size and complexity of the operation. The HWMP (or other comparable document) should include, at a minimum, written procedures for all aspects of HW management, to include the identification, storage, and transporting of HW; training of personnel; tracking manifests; and maintaining required records.

(4) Maintain appropriate records in accordance with RCRA and applicable State or FGS requirements.

(5) Complete State/EPA or applicable FGS annual or biennial reporting requirements.

(6) Ensure that HW manifests are only signed by those individuals who have been appropriately trained, and are authorized in writing by the garrison commander (GC). (LD: 49 CFR 172.700–704 (Subpart H); DOD 4500.9–R, chapter 204)

(7) Ensure that the GC signs the RCRA HW permit applications for the installation, sub-installations, and supported facilities as the facility "owner." This responsibility cannot be delegated.

(a) Officials in charge of tenant activities will sign the permit application as the "operator."

(b) For the Defense Logistics Agency, the DRMS Commander will sign as the "operator."

(c) For Army Reserve facilities, the Reserve Readiness Command (RRC) Commander will sign as the facility "owner."

(d) For Army National Guard (ARNG) facilities, the Adjutant General (TAG) of the respective State or territory will sign as the facility "owner."

(e) For closed, transferred, or transferring facilities, the GC of the receiving installation will sign as "owner", and the agency maintaining control and influence over the closed or transferring facility's HW management program will sign the permit as "operator."

(f) For installations not under the purview of the IMCOM, the senior mission commander (SMC) will sign as the facility "owner."

(8) If non-DOD tenants require HW treatment, storage, and disposal facility permits, ensure that the contract, lease, or agreement with the non-DOD tenant holds the Army harmless and contains specific language regarding the operation of the facility, access, damages, and environmental liability in strict accordance with permit conditions. The GC will sign permit applications as the "owner," and the tenant will sign as the "operator" of the facility.

(9) Use the Defense Reutilization Marketing Office (DRMO) for HW disposal with the following exceptions:

(a) When DRMO has indicated or demonstrated the inability to provide the service, and only when a waiver has been approved in writing by the next higher echelon on a case-by-case basis. Waivers will be renewed in writing every 5 years.

(b) Hazardous waste generated incidental to the execution of service or construction contracts should be disposed of by the contractor performing the basic contract, at the contractor's expense, using the installation's generator identification number on the manifest. Such actions must be coordinated with the installation environmental coordinator and documented in writing. The GC remains the "owner" of the waste.

(c) Ensure that all contracts for HW disposal are reviewed by the installation environmental coordinator and the Director of Contracting, and approved by the GC. Such contracts must comply with contract standards in DOD 4160.21–M, chapter 10.

10–2. Solid waste

a. Policy. The Army proponent for solid waste management is the Assistant Chief of Staff for Installation Management (ACSIM), Directorate of Facilities and Housing. Army facility policy and guidance on solid waste management is provided in AR 420–49, chapter 3.

(1) Comply with legally applicable Federal, State, and local requirements, both substantive and procedural, for managing solid waste, including generation, collection, storage, and disposal. This includes the terms and conditions of State and Federal solid waste permits. Overseas, all Army organizations and activities will comply with country-specific FGS and any permits obtained on behalf of the installation by the host nation.

(2) Emphasize integrated solid waste management, pollution prevention, and individual participation to achieve compliance.

(3) Minimize solid waste generation and disposal, and maximize recovery, recycling, and reuse through pollution prevention actions.

(4) Integrate the management of wastes into construction and demolition (C&D) activities such that a significant amount of the materials generated can be reused in their original form with little or no processing, through systematic disassembly or deconstruction, more careful handling, segregating, and making them available to specialized markets.

(5) Ensure that waste accumulation, storage, or transfer facilities are designed and constructed to prevent releases to the environment.

b. Legal and other requirements.

(1) 42 USC 6901, Subtitle D (as amended); PL 98–616; Paragraph a, Sections 6941–6949, Title 42, United States Code (42 USC 6941–6949a, Subtitle D; as amended; Parts 239–258 and Part 261, Title 40, Code of Federal Regulations (40 CFR 239–258 and 261); applicable FGS; and EO 13423.

(2) AR 420–49, chapter 3 defines the Army's policy for managing solid waste. This section of AR 200–1 supplements AR 420–49 by identifying environmental aspects of solid waste management.

(3) AR 415–15, appendix F, Item F–37, Army Disposal/Demolition Program, describes the Army requirement to dispose of one square foot of facilities to offset each square foot of new construction added to the real property inventory.

(4) DA Pam 40–11, chapter 4, Section 4–11 defines the Army's policy for managing regulated medical wastes.

c. Major program goals. The environmental goals of the Army's solid waste management program are to protect public health and the environment by increasing solid waste diversion, minimizing the generation of solid wastes, and increasing the program's economic benefit by investing in pollution prevention initiatives and better managing costs associated with disposal and diversion.

d. Program requirements. Army installations with Army-owned landfills will operate under 42 USC 6941–6949a and meet the criteria of a municipal solid waste landfill (MSWLF) as defined by Federal regulation or State-approved program. Installations may also operate landfills specifically for construction and demolition debris, and/or non-hazardous industrial process wastes, as determined by their mission. These landfills will be operated in accordance with applicable Federal, State, and local regulations. (LD: 40 CFR 257, 258)

Chapter 11
Storage Tank Systems/Oil and Hazardous Substances Spills

11–1. Policy
Manage tank systems used to store oil and hazardous substances in an environmentally safe manner, prevent spills of these substances, and rapidly respond to spills.

11–2. Legal and other requirements
a. 42 USC 9601; 42 USC 11011; 33 USC 26, as amended to include Part 112, Title 40, Code of Federal Regulations (40 CFR 112); Part 300, Title 40, Code of Federal Regulations (40 CFR 300); 42 USC 6901, as amended to include Part 280, Title 40, Code of Federal Regulations (40 CFR 280) and Part 281, Title 40, Code of Federal Regulations (40 CFR 281); 33 USC 2701; 15 USC 2601, as amended; Public Law (PL 109–58), Sections 1521–1532; and AR 50–6. Related Federal laws and regulations are referenced in appendix A.

b. Overseas, all Army organizations and activities will comply with applicable Final Governing Standards (FGS).

11–3. Major program goal
Storage tanks used to transport, store, and handle oil and hazardous substances will be managed to protect the environment and public health.

11–4. Program requirements
a. Storage Tank Systems.

(1) Provide leak detection for regulated underground storage tanks (UST) by retrofit or inventory control procedures. (LD: 40 CFR 280.43)

(2) Provide leak detection, overfill protection, and cathodic protection for aboveground storage tanks (ASTs) as required. (LD: 40 CFR 112.8)

(3) Use double wall construction with interstitial monitoring on all new regulated USTs.

(4) Ensure that all UST systems are cathodically protected or constructed of non-metallic material to meet corrosion protection requirements. (LD: 40 CFR 280.20)

b. Oil and hazardous substance spills.

(1) Develop and implement a spill prevention, control, and countermeasures plan (SPCCP), as required. (LD: CWA Section 311(j), 40 CFR 112, and OPA)

(2) Ensure that the SPCCP addresses secondary containment (or lack there of) at oil and hazardous material storage facilities. (LD: 40 CFR 112.7)

(3) Develop and implement a facility spill contingency plan (SCP) for each oil and hazardous material storage facility that does not have adequate spill prevention structures in place. (LD: 40 CFR 112.7)

(4) Ensure secondary containment is provided for oil and hazardous material storage facilities, including piping. If it is determined that secondary containment is impracticable, the installation must address this in the SPCCP and facility SCP (an SCP is only required if adequate spill prevention structures are not in place). (LD: 40 CFR 112.7)

(5) Ensure the SPCCP is reviewed at least once every 5 years. Amend the plan within 6 months of a change that

materially affects its potential for discharge. If technical changes have been made, the plan must be signed by an individual with authority to commit the necessary resources to respond to a release, and certified by a professional engineer familiar with installation operations. (LD: 40 CFR 112.5)

(6) Use the Environmental Quality Control Committee (EQCC) to coordinate the SPCCP with affected installation elements.

(7) Maintain an accurate inventory of SPCCP applicable containers, including the location and/or spatial extent of such containers. (LD: 40 CFR 112.7)

(8) Prepare spill response plans and notification procedures, to include a facility response plan, as needed, for spills caused by Army actions, including coordination with local emergency planning authorities. (LD: 40 CFR 300.211; 40 CFR 112.20; 33 CFR 154; 49 CFR 130; 49 CFR 171–172)

(9) Conduct training to ensure proper response to spills or releases. This includes annual spill response exercises for the spill response organization. (LD: 29 CFR 1910.120 (e), (p), (q); 40 CFR 112.21)

(10) Ensure the garrison commander (GC) designates, in writing, a qualified on-scene coordinator (OSC) responsible for executing spill response. The local commander will designate in writing the OSC at USAR maintenance facilities. The State Adjutants General will designate in writing the OSC at Army National Guard (ARNG) maintenance facilities. (LD: 40 CFR 300.120)

(11) Ensure that facility operators and OSC understand and comply with Federal and State reportable quantity requirements.

(12) When a spill occurs, immediately report the spill or release to the OSC and implement the SCP and/or SPCCP. The OSC will determine if it exceeds reportable quantities and will notify regulatory authorities as required. Any spill that requires notification of regulatory authorities will be reported to the next higher headquarters. (LD: 40 CFR 112.4; 40 CFR 300.125; 33 CFR 153, Subpart B; 40 CFR 302)

(13) Assist Federal or State agencies in response to spills outside the Army property where practicable in accordance with AR 75–15.

(14) For outside the continental United States (OCONUS) installations, provide response assistance for spills off Army property in accordance with their applicable FGS and garrison SPCCP.

(15) For further guidance in managing ASTs and equipment subject to 40 CFR 112, refer to the 2 April 2004, DOD Joint Services Spill Prevention, Control, and Countermeasure (SPCC) Guidance.

Chapter 12
Environmental Cleanup

12–1. Policy

a. Comply with applicable Federal, State, local, and Department of Defense (DOD) requirements for the cleanup of contamination on Army installations and formerly used defense sites (FUDS). Figure 12–1 depicts the differences and commonalities among the various cleanup program areas. For overseas installations, only the Compliance-related Cleanup (CC) Program applies.

b. Accomplish early and continued public involvement in the cleanup programs.

c. Keep State regulatory agencies and the U.S. Environmental Protection Agency (EPA) informed of cleanup program activities, as appropriate.

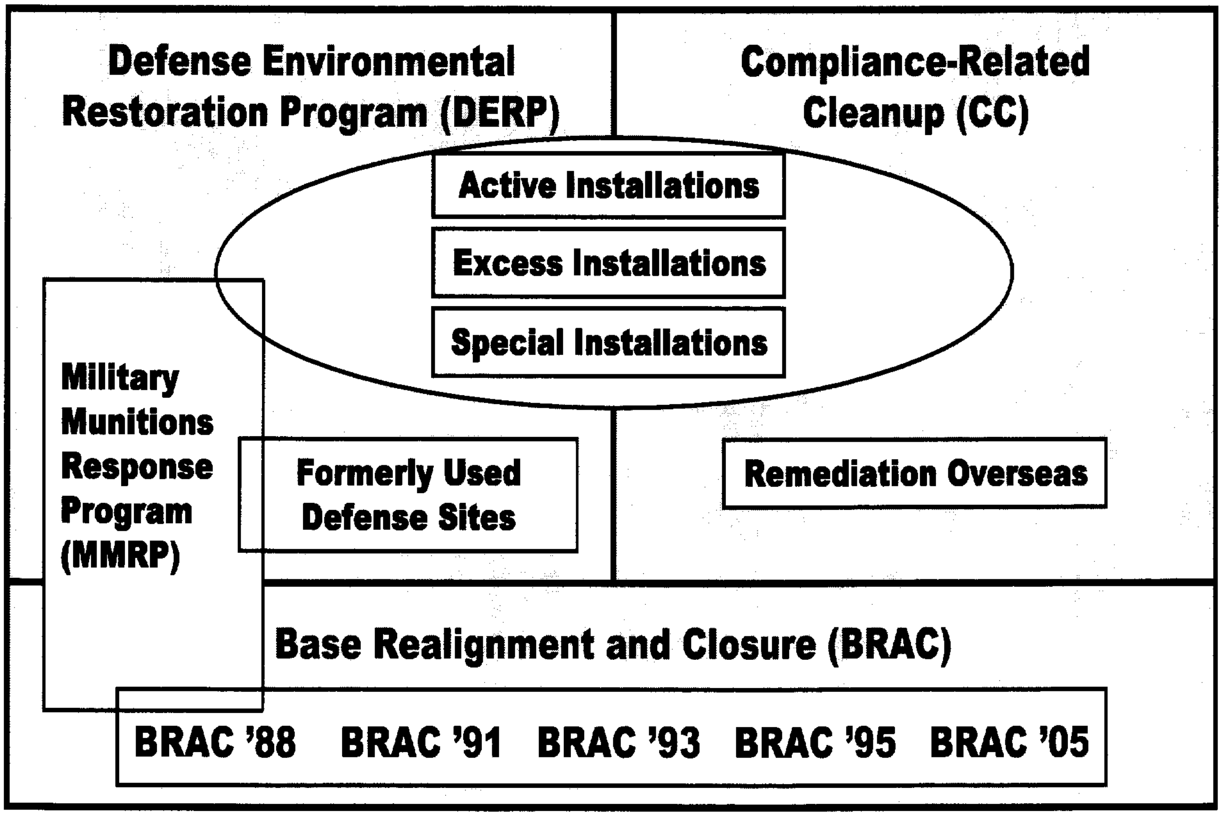


Figure 12–1. Army Environmental Cleanup Program Areas

12–2. Legal and other requirements

The following list of statutory requirements apply to environmental cleanup:

a. 42 USC 9601; 40 CFR 300; Section 120, Part 1910, Title 29, Code of Federal Regulations (29 CFR 1910.120); Executive Order (EO) 12580; and 42 USC 6901, Sections 3004u, 3004v, and 3008h; Section 2701, Title 10 United States Code (10 USC 2701); DOD 7000.14–R; DODI 4715.7, for all but overseas installations; DODI 4715.8; Engineer Regulation (ER) 200–3–1, formerly Used Defense Site (FUDS) Program Policy; Charter for the Formerly Used Defense Sites Program, 31 October 2003; and Office of the Assistant Secretary of the Army for Installations and Environment (OASA (I&E)) Deputy Assistant Secretary of the Army (Environment, Safety, and Occupational Health) (DASA (ESOH)) memorandum, 18 June 2004, subject: The Army Environmental Compliance-related Cleanup Program Eligibility. The Army environmental cleanup programs include the Army DERP at active, closing, and realigning installations; DERP at FUDS properties; and compliance-related cleanup (CC) at active and excess installations, including those overseas. Regulations that pertain to the Army's environmental cleanup programs are referenced in appendix A.

(1) Defense Environmental Restoration Program (DERP) cleanups (Installation Restoration Program (IRP), Military Munitions Response Program (MMRP), base realignment and closure (BRAC), FUDS) address hazardous substances, pollutants and contaminants, and military munitions sites, consistent with the provisions of 42 USC 9601, et seq. (CERCLA); 40 CFR 300 (National Oil and Hazardous Substances Pollution Contingency Plan); EO 12580; and 42 USC 6901, Sections 3004u, 3004v, and 3008h for activities that resulted in contamination prior to 17 October 1986 at non-permitted sites.

(2) Compliance related cleanup (CC) addresses cleanup requirements that are legally mandated but not eligible for funding under the Army DERP. The program focuses on the remediation of contamination at Army overseas facilities (it does not include actions to remedy contamination that are covered by environmental annexes to operations orders and similar operational directives), and on the cleanup of contamination resulting from operations that have occurred since 17 October 1986. This includes sites at Active Army, Army Reserve, Army National Guard (ARNG) Federally-owned facilities, as well as cleanup at non-Federally-owned, Federally-supported (State-owned, State-operated) ARNG

facilities. CC does not include initial response actions to address spills, but does include follow-on response action, if required.

b. The DERP is supplemented by the *DOD Management Guidance for the Defense Environmental Restoration Program (DERP),* September 2001. The DERP Management Guidance defines eligibility and addresses sites in the following three program categories:

(1) The IRP includes response actions to address releases of hazardous substances, pollutants and contaminants (as defined in CERCLA); petroleum, oil, lubricants (POL); DOD-unique materials; hazardous wastes (HW); and low-level radioactive materials or low-level radioactive wastes (LLRW). The IRP also includes military munitions (including munitions and explosives of concern (MEC), see glossary) or munitions constituents (MC) at a relatively small number of sites where the following three conditions all exist:

(a) The release occurred prior to 30 September 2000.

(b) The release is at a site that is not an operational range, an active munitions demilitarization facility, an active waste military munitions (WMM) treatment or disposal unit, or FUDS.

(c) The site was identified or included in the Army Environmental Data Base-Restoration (AEDB–R) or Formerly Used Defense Sites Management Information System (FUDSMIS) prior to 30 September 2000, and was not classified as "response complete."

(2) The MMRP addresses munitions responses at active or BRAC installations where the release occurred prior to 30 September 2002, and the release is at a site that is not a FUDS, an operational range, an active munitions demilitarization facility, or an active WMM treatment or disposal unit that operated after 30 September 2002, and the site was not identified or included in the AEDB–R prior to 30 September 2000.

(3) Building demolition/debris removal (BD/DR) addresses the demolition and removal of unsafe buildings and structures at facilities or sites that are or were owned by, leased to, or otherwise possessed by the United States and under the jurisdiction of the DOD.

12–3. Major program goals

Perform appropriate, cost-effective cleanup so that property is safe for Army use (or transfer as appropriate), sustains operations and training, and protects human health and the environment.

12–4. Program requirements

a. Cleanup program areas. All cleanup program areas must:

(1) Identify cleanup requirements at the site level using the more stringent of current or projected future land use as documented in the installation master plan, develop a reasonable schedule and cost to complete cleanup, record liabilities in a database of record, and pursue cleanup until regulatory agreement with site closure.

(2) Provide site-level data in response to Assistant Chief of Staff for Installation Management (ACSIM) data calls for updates to the databases of record.

(3) Develop and maintain an administrative record for National Priorities List (NPL) sites or similar documentation for non-NPL sites on the installation or U.S. Army Corps of Engineers (USACE) District responsible for FUDS.

(4) Prepare annual cost-to-complete estimates for each site in the program that reflect the environmental strategy and sequence as presented in the installation action plan (IAP), BRAC IAP, or FUDS management action plan (MAP). Maintain an audit trail for changes that occur in a fiscal year (FY) that reflects actions taken, change in estimates, and new or deleted requirements. Estimates must be based on reliable, complete and fully documented data and will be in constant year dollars. (LD: PL 101–576)

(5) Determine contamination migration. Garrison commanders (GCs) must approve off-site data collection and any off-post monitoring to ensure that contamination has not migrated off-site. (LD: EO 12580 at CERCLA sites; PD at other sites)

(6) Notify the DASA (ESOH) through the chain-of-command prior to initiating any off-site response actions. The Army has the authority to conduct response actions outside the installation boundary, however, the lack of Army control over this off-installation property, potential legal and technical complexity, sensitivity, and the necessity for increased public involvement requires additional oversight on these responses. This notification requirement does not apply to FUDS.

(7) Maintain a permanent document repository to ensure cleanup information is available to protect future Army liability at any date in the future.

(8) Document environmental response decisions in a CERCLA record of decision (ROD) or an equivalent decision document (DD) or action memorandum prior to conducting removal or remedial actions.

(9) Coordinate remedial documents with Natural Resource Trustees.

(10) Work cooperatively with regulatory agencies to ensure that the Army's cleanup goals are accomplished cost-effectively, and in accordance with applicable laws and regulations.

(11) Fully support public involvement in cleanup programs where there is potential impact on the health, environment, and economic well being of the local community.

(12) Maintain an inventory and maps of land use controls (LUCs) resulting from response decisions, and at active installations, integrate them into the installation master plan.

(13) Establish procedures for evaluating implemented remedies that:

(a) Optimize the overall performance and effectiveness of the remedy.

(b) Control the operation and maintenance cost of remedies in the remedial operations phase.

(c) Assess whether remedial action objectives specified in the ROD/DD for the site are being achieved and whether treatment systems are still needed.

(d) Determine whether different remedial action objectives or different technologies are more appropriate.

b. Army Defense Environmental Restoration Program. The DERP addresses sites at real property under U.S. jurisdiction, custody, and control of the Army to include: (LD: 10 USC 2701(c))

(1) Active and excess U.S. Army and U.S. Army Reserve installations and facilities.

(2) Federally owned or leased ARNG installations, activities, and properties.

(3) Contractor activities, lessees, and other tenants on Army installations or facilities.

(4) The Army DERP addresses contamination at sites on active installations in the three categories described previously: IRP, MMRP, and BD/DR. The Army funds the DERP at active installations with Environmental Restoration, Army (ER, A) funds authorized and appropriated specifically to execute the DERP at active installations. ER, A is "fenced" and must be used for the restoration projects in the approved IAP for sites included in AEDB–R. (LD: 10 USC 2703)

(5) For IRP category sites:

(a) Conduct screening for past use of hazardous substances, pollutants and contaminants and the potential for contamination (or reassessment, if appropriate) at active Army and Federally-owned NGB–ARNG installations and sub-installations. (LD: 10 USC 2701)

(b) Conduct studies and response actions in accordance with the annual IAP approved by the GC (or equivalent).

(c) Establish an information repository and administrative record to provide public access to information about the cleanup activities at the installation. (LD: 42 USC 9613 and 9620)

(d) Establish an effective community involvement program, to include a community relations plan (CRP) at NPL sites (LD: 40 CFR 300.155) or public involvement and response plan for Army installations with an active cleanup program.

(e) Negotiate a Federal Facilities Agreement/Interagency Agreement at NPL sites complying with the DOD approved model agreement. (LD: CERCLA Section 120(e)(2) and 120(e)(4))

(f) Establish a Technical Review Committee (TRC) or Restoration Advisory Board (RAB) when applicable to allow the local community an opportunity to participate in the remedy selection process. Form a RAB at all BRAC installations where closure involves the transfer of property to the community, unless otherwise determined by the ACSIM. At installations on the NPL, a RAB will meet the requirements of paragraph c, Section 2705, Title 10, United States Code (10 USC 2705(c)) for a TRC. (LD: 10 USC 2705(d))

(g) Initiate action to have the site expeditiously deleted from the NPL by EPA once all site completion criteria are met, or request partial delisting of specific operable units, as appropriate. (LD: 40 CFR 300.425)

(6) For MMRP category sites: conduct response actions to address military munitions or the chemical residues of munitions at active installations.

(7) For BD/DR: BD/DR program category responses for buildings unused since 17 October 1986 may be undertaken when the requirement to demolish the building(s) is an integral part of activities under an IRP or MMRP category response. Any other ER, A funded BD/DR program category response for buildings unused since 17 October 1986 may only be undertaken when specifically authorized by the Assistant Deputy Undersecretary of Defense (Environment, Safety, and Occupational Health) (ADUSD (ESOH)).

c. Base realignment and closure.

(1) The Base Realignment and Closure (BRAC) cleanup program addresses sites at installations designated for closure or realignment by Base Closure legislation and is funded from the Base Closure Account (BCA) using DOD's DERP authority. At closing installations, cleanup requirements consist of previously identified IRP and MMRP category requirements plus those closure related compliance actions required for property transfer. The BRAC cleanup program may address BD/DR category requirements for unsafe buildings or structures unused since 17 October 1986, where the activities are an integral part of actions under the IRP or MMRP category responses.

(2) Army activities will—

(a) Update BRAC IAPs annually.

(b) Ensure that BRAC cleanup activities comply with the ADUSD(E) policy guidance for Fast Track Cleanups and the Base Redevelopment and Realignment Manual.

(c) Strive to transfer BRAC property to productive reuse.

d. Compliance-related cleanup.

(1) The CC includes actions to address contamination at Army facilities overseas; contamination resulting from

operations that have occurred since October 1986 (that is, non-DERP) at Army Active, Excess, and Special installations, and ARNG Federally owned facilities; and contamination at non-Federally-owned, Federally-supported ARNG facilities.

(2) The CC projects are projects needed to further investigate, and if necessary, conduct response actions to address contaminants that present an imminent and substantial threat to human health and/or the environment.

(3) Undertake CC projects when needed to address the following requirements:

(a) Releases under CERCLA or RCRA corrective action that are not eligible for funding under the DOD Management Guidance for the DERP (for example, releases that occurred on or after 17 October 1986).

(b) Cleanup mandated under authority of Federal and/or State environmental laws that are not being addressed under other cleanup programs (for example, DERP, BRAC, and so forth).

(c) Releases from HW treatment, storage, or disposal facilities (TSDF) or solid waste landfills that are undergoing RCRA closure.

(d) Releases from a RCRA underground storage tank (UST) if it was in service as of 17 October 1986.

(e) Army contamination beyond the installation boundary where necessary to protect human health and the environment (and not eligible for DERP funding).

(f) Contamination at overseas installations in accordance with DODI 4715.8.

(g) Contamination at non-Federally-owned, Federally-supported ARNG sites, regardless of date.

(h) Munitions responses at ranges closed after 30 September 2002.

(i) Response actions outside the boundaries of operational ranges required as a result of the Range Assessment Program established in accordance with DODD 4715.11.

(j) Non-DERP environmental liabilities at excess installations.

(k) Army Commands (ACOMs), Army Service Component Commands (ASCCs), and Direct Reporting Units (DRUs) with special installations will program and budget mission or working capital fund resources to address non-DERP, CC eligible releases. Special installations are eligible for Army DERP consistent with DERP eligibility requirements.

e. Other.

(1) *Formerly used defense sites (FUDS).*

(a) Under the DERP, the FUDS Program addresses properties that were under the jurisdiction of the Secretary of Defense and owned by, leased by, or otherwise possessed by the United States, or otherwise under the operational control of the Secretary of Defense or the military components that were transferred from DOD control prior to 17 October 1986. The FUDS program addresses sites in the following program categories: IRP; MMRP; and BD/DR. Also eligible are former DOD sites that were transferred after 17 October 1986, but that have a completed Findings and Determination of Eligibility (FDE) and a final inventory project report (INPR), signed prior to 30 September 2000 stating that the property was FUDS eligible, and that were listed in Restoration Management Information System (RMIS) as a FUDS property prior to 30 September 2000.

(b) The ADUSD (ESOH) establishes overall FUDS program policy and budget guidance. Regardless of which military service formerly controlled the property, the Army is the executive agent (EA) to administer the FUDS program. General policy on management and execution of the FUDS program is provided in the DOD Management Guidance for the DERP and the FUDS Program Charter. The ASA (I&E) and ACSIM are, respectively, the Army Secretariat and Army Staff (ARSTAF) proponents for the FUDS program. The USACE is responsible for management and execution of the FUDS Program.

(c) Specific FUDS execution guidance and procedures are provided in USACE's Engineer Regulation (ER) 200–3–1.

(2) *Defense and State Memoranda of Agreement/Cooperative Agreement (CA).*

(a) DOD, through the Defense and State Memoranda of Agreement/Cooperative Agreement (DSMOA/CA) program, involves State/Territorial governments in the environmental restoration of DOD installations including FUDS properties. The Office of the Secretary of Defense (OSD) has given the Army the authority to negotiate DSMOAs and recommend approval of DSMOAs to the ADUSD (ESOH). USACE executes the DSMOA/CA Program for all military services.

(b) Authority for this program is contained in 10 USC 2701(d) which allows the Secretary of Defense to enter into agreements on a reimbursable basis with states/territories to support DERP cleanup efforts at DOD installations. The DSMOA/CA program does not apply to compliance-related cleanup (CC). Specific criteria, funding information, and services eligible for State reimbursement for this program are contained in Part 28835, Title 57, Federal Register (57 FR 28835), dated 29 June 1992.

(c) Funding for the Army's contribution to the DSMOA/CA Program will be provided by the Army from the ER, A; Environmental Restoration, FUDS (ER, F); and BCA accounts.

(3) *Memorandum of Understanding between DOD and the Agency for Toxic Substances and Disease Registry.*

(a) DOD has entered into a MOU with ATSDR that delineates the responsibilities and procedures under which

Agency for Toxic Substances and Disease Registry (ATSDR) and DOD will conduct activities mandated in CERCLA. The MOU is the single document governing the relationship between DOD and ATSDR.

(b) Funding for the ATSDR to conduct Army-related studies under the MOU with DOD is provided by the Army from the ER, A; ER, F; and BCA accounts. Each military component funds its own ATSDR services.

(c) Refer to the U.S. Army Environmental Restoration Programs Guidance Manual and the Guidelines for the Coordination of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Activities Between Agency for Toxic Substances and Disease Registry and Department of Defense for additional information about the roles of ATSDR and DOD components in DOD cleanup activities.

(4) *Exemptions*. The above guidance for environmental cleanup does not apply to:

(a) Contractor-owned and contractor-operated facilities that are not on real property controlled by the Army.

(b) Properties that are not on real property that is or was owned, controlled, or otherwise under the jurisdiction of DOD (that is, a third-party site).

(c) Responses to releases that occur solely as a result of an act of war.

(d) Emergency response to and cleanup of a release from any routine operation, management, or maintenance at an operating Army facility or site that does not become a cleanup project.

(e) Routine range maintenance and sustainment activities at operational ranges.

Chapter 13
Environmental Quality Technology

The Environmental Quality Technology (EQT) effort is planned, programmed, and budgeted for at Headquarters, Department of the Army (HQDA) level. It focuses investments on the Army's most pressing needs and provides visibility of the Army's environmental research, development, test, and evaluation (RDT&E) efforts. EQT requirements are identified and validated through the Army Environmental Requirements and Technology Assessments (AERTA). The AERTA requires a review of new and existing requirements to determine if changes in doctrine, organization, training, materiel, leadership and education, or personnel and facilities (DOTMLPF) will resolve the requirement(s). Only those requirements requiring a materiel solution will be included in the AERTA. Requirements with other than materiel solutions will be forwarded to the appropriate proponent/organization for action. The EQT Program Operating Principles, October 2001, provide detailed guidance.

13–1. Environmental Technology Technical Council

a. The Army established an Environmental Technology Technical Council (ETTC) to provide management oversight and endorsement of the EQT programs formulation process. The Deputy Assistant Secretary of the Army (Environment, Safety, and Occupational Health) (DASA (ESOH)) and the Director, Research and Laboratory Management, Office of the Assistant Secretary of the Army for Acquisition, Logistics, and Technology (OASA (ALT)) co-chair the ETTC.

b. The ETTC consists of members representing the operational, logistics, scientific and engineering, planning, resource management, infrastructure, and medical interests of the Army. The ETTC consolidates and prioritizes Army environmental technology needs, and articulates the requirements to the appropriate proponent.

c. The ETTC establishes technology teams as needed to carry out its assigned functions.

d. The ETTC meets as needed to endorse new programs and to review technology priorities and program execution.

13–2. Policy

Provide environmental quality RDT&E and technology transfer to resolve the Army's EQT requirements. EQT efforts are integrated and coordinated with other Defense RDT&E initiatives, such as the National Defense Center for Environmental Excellence (NDCEE), Strategic Environmental Research and Development Program (SERDP), the Environmental Security Technology Certification Program (ESTCP), and Federal and State government and international forums, to leverage their technology output, reduce total life-cycle costs, and resolve these EQT requirements in a timely manner.

a. Focus efforts on high priority user defined requirements.

b. Implement technology development when technology is not commercially available.

c. Provide an adequate science and engineering base to sustain future technology needs.

d. Focus efforts of the Army EQT program to support and enhance technology transfer of validated capabilities and processes.

13–3. Legal and other requirements

10 USC 160, Sections 2706 and 2709.

13–4. Major program goals
The Army goal for EQT is to enable mission readiness through the development and exploitation of technology that provides sustainable installations, training lands, and weapons systems.

13–5. Major requirements
a. Identify and document user requirements and invest in high priority environmental requirements providing validated solutions to the end-user for qualification, production, or fielding.

b. Leverage other DOD and Congressionally-directed initiatives to help resolve Army environmental requirements.

c. Use the EQT requirements to prioritize the Army funded efforts at the NDCEE.

Chapter 14
Operational Noise

14–1. Policy
a. Evaluate and document the impact of noise produced by ongoing and proposed Army actions/activities and minimize annoyance to humans to the extent practicable.

b. Develop installation noise management plans as appropriate.

c. Reduce noise to acceptable levels in on-post noise sensitive locations (for example, medical treatment, education, family housing) through appropriate land use planning and/or architectural and engineering controls.

d. Monitor, record, archive and address operational noise complaints.

e. Develop and procure weapons systems and other military combat equipment (for example, electrical generators, etc.) that produce less noise, when consistent with operational requirements. Measure the noise emitted by all combat equipment and weapons systems to be used in training before deployed to units.

f. Procure commercially manufactured products, or those adapted for general military use that produce less noise, and comply with regulatory noise emissions standards.

g. Acquire property only as a last resort to resolve off-post noise issues.

h. Manage operational noise issues and community relations to maintain sustainable testing and training capabilities and prevent encroachment.

14–2. Legal and other requirements
Property and tort law; Noise Control Act of 1972, Quiet Communities Act of 1978; AR 95–1; AR 210–20; AR 350–19; and applicable State and local laws.

14–3. Major program goals
a. Control operational noise to protect the health and welfare of people, on- and off- post, impacted by all Army-produced noise, including on- and off-post noise sources.

b. Reduce community annoyance from operational noise to the extent feasible, consistent with Army training and materiel testing mission requirements.

c. Actively engage local communities in land use planning in areas subject to high levels of operational noise and a high potential for noise complaints.

14–4. Program requirements
a. Noise descriptors (metrics) appropriate for determination of compatible land use, and assessment procedures will be based on the best available scientific information.

(1) The day-night level (DNL) is the primary descriptor for military noise, except small arms, see table 14–1. The DNL is the time weighted energy average sound level with a 10-decibel (dB) penalty added to the nighttime levels (2200 to 0700 hours). The DNL noise metric may be further defined, as appropriate, by the installation with a specific, designated time period (for example, annual average DNL, average busy month DNL). The typical assessment period over which the noise energy is averaged is 250 days for Active Army installations and 104 days for Army Reserve and National Guard installations. The use of average busy month DNL is appropriate when the OPTEMPO is significantly different during certain peak periods of the year. For future land use planning and encroachment assessment purposes, a reasonable annual growth factor in activity (for example, 10 or 15 percent) may be assumed.

(2) Supplemental metrics, such as single event noise data (for example, Peak, PK 15(met) or CSEL), may be employed where appropriate to provide additional information on the effects of noise from test and training ranges. A-weighted maximum noise levels will be used to assess aviation low level military training routes (MTRs) and/or flight tracks.

(3) The use of average noise levels over a protracted time period generally does not adequately assess the probability of community noise complaints. Assess the risk of noise complaints from large caliber impulsive noise

resulting from testing and training activities, ex. armor, artillery, mortars and demolition activities, in terms of a single event metric, either peak sound pressure level (PK 15(met)) or C-weighted sound exposure level (CSEL). The metric PK 15(met) accounts for statistical variation in received single event peak noise level that is due to weather. It is the calculated peak noise level, without frequency weighting, expected to be exceeded by 15 percent of all events that might occur. If there are multiple weapon types fired from one location, or multiple firing locations, the single event level used should be the loudest level that occurs at each receiver location.

(4) Assess noise from small arms ranges using a single event metric, either PK 15(met) or A-weighted sound exposure level (ASEL).

(5) Use the land use planning zone (LUPZ) contour to better predict noise impacts when levels of operations at airfields or large caliber weapons ranges are above average.

(6) Use available DOD noise assessment software as the primary means of operational noise assessment.

(7) Prepare noise maps showing noise zones and limits as defined in tables 14–1 and 14–2.

(8) Manage noise-sensitive land uses, such as housing, schools, and medical facilities as being acceptable within the LUPZ and noise zone I, normally not recommended in noise zone II, and not recommended in noise zone III. These noise zones are defined in table 14–1.

(9) Single event noise limits in table 14–2 correspond to areas of low to high risk of noise complaints from large caliber weapons and weapons systems. These should be used to supplement the noise zones defined in table 14–1 for land use decisions. Noise sensitive land uses are discouraged in areas where PK 15(met) is between 115 and 130 dB; medium risk of complaints. Noise sensitive land uses are strongly discouraged in areas equal to or greater than PK 15(met) = 130 dB; high risk of noise complaints. For infrequent noise events, installations should determine if land use compatibility within these areas is necessary for mission protection. In the case of infrequent noise events, such as the detonation of explosives, the installation should communicate with the public.

(10) Transportation and industrial noise will be assessed on a case by case basis using appropriate noise metrics, including U.S. Department of Transportation guidelines.

b. Address issues concerning building vibration and rattle due to weapons blast through the appropriate subject matter experts and legal counsel.

c. Address noise impacts on domestic animals and wildlife, as required, through the study of each species' response or a surrogate response to noise. The noise levels set forth herein apply to humans only and do not apply to domestic animals or wildlife.

Table 14–1
Noise Limits for Noise Zones

Noise zone	Noise limits (dB)	Noise limits (dB)	Noise limits (dB)
	Aviation ADNL	Impulsive CDNL	Small arms — PK 15(met)
LUPZ	60 - 65	57 - 62	N/A
I	< 65	< 62	<87
II	65 - 75	62 - 70	87 - 104
III	>75	>70	>104

Legend for Table 14-1:
dB=decibel
LUPZ=land use planning zone
ADNL=A-weighted day-night levels
CDNL=C-weighted day-night levels
PK 15(met)=Single event peak level exceeded by 15 percent of events
<=less than
>=greater than
N/A=Not Applicable

Table 14–2
Risk of Noise Complaints by Level of Noise

Risk of Noise complaints	Large caliber weapons noise limits (dB) PK 15(met)
Low	< 115
Medium	115 - 130
High	130 - 140
Risk of physiological damage to unprotected human ears and structural damage claims	> 140

Legend for Table 14-2:

dB = decibel

PK 15(met) = Single event peak level exceeded by 15 percent of events

Notes:

[1] Although local conditions regarding the need for housing may require noise-sensitive land uses in Noise Zone II, on or off post, this type of land use is strongly discouraged. The absence of viable alternative development options should be determined and an evaluation should be conducted locally prior to local approvals indicating that a demonstrated community need for the noise-sensitive land use would not be met if development were prohibited in Noise Zone II.

[2] Where the community determines that these uses must be allowed, measures to achieve an outdoor to indoor noise level reduction (NLR) of at least 25 dB to 30 dB in Noise Zone II, from small arms and aviation noise, should be incorporated into building codes and be in individual approvals. The NLR for communities subject to large caliber weapons and weapons system noise is lacking scientific studies to accomplish the recommended NLR. For this reason it is strongly discouraged that noise-sensitive land uses be allowed in Noise Zone II from large caliber weapons.

[3] Normal permanent construction can be expected to provide a NLR of 20 dB, for aircraft and small arms, thus the reduction requirements are often stated as 5, 10 or 15 dB over standard construction and normally assume mechanical ventilation, upgraded Sound Transmission Class (STC) ratings in windows and doors and closed windows year round. Additional consideration should be given to modifying NLR levels based on peak noise levels or vibrations.

[4] NLR criteria will not eliminate outdoor noise problems. However, building location and site planning, and design and use of berms and barriers, can help mitigate outdoor noise exposure NLR particularly from ground level aircraft sources. Barriers are generally not effective in noise reduction for large arms such as artillery and armor, large explosions, or from high-level aircraft sources.

Chapter 15
Program Management and Operation

15–1. Structure and resourcing

a. Army Environmental Funding Policy.

(1) Army organizations are responsible for addressing environmental requirements for activities under their purview to ensure timely compliance with legal mandates, and for sustaining environmental stewardship.

(2) Environmental requirements must be funded from the appropriate account of the proponent who has the responsibility for the action, not necessarily the Installations Program Evaluation Group (II PEG) environmental program accounts.

b. Programming and budgeting. Commensurate with their responsibilities, Army organizations (to include tenants) will plan, program, budget, and execute resources to:

(1) Mitigate actual or imminent health and environmental hazards.

(2) Comply with Federal, State and local statutes, regulations, agreements, and other judgments, applicable executive orders (EOs), Final Governing Standards (FGS), and legally-binding international agreements at overseas installations.

(3) Sustain the quality and continued availability of lands for essential operations, training, and testing by protecting natural and cultural resources.

(4) Maintain an adequately trained and staffed organization for environmental monitoring and program management.

(5) Employ cost-effective pollution prevention and reuse/recycle-based solutions in all mission areas as the preferred approach for meeting compliance requirements, reducing operating costs, and maintaining environmental stewardship.

(6) Focus environmental quality technology (EQT) research and innovative applications to achieve program goals and reduce program costs.

(7) Address environmental quality costs associated with weapons system life cycle within the context and requirements of the life cycle cost estimate, and adequately assess these costs in the acquisition milestone review process.

c. Investment strategy. Army organizations will make prudent investments in environmental initiatives that support mission accomplishment, enhance readiness, reduce future funding needs, prevent or mitigate pollution, improve compliance, and reduce the overall cost of compliance with applicable environmental requirements.

d. Payment of fines and penalties for environmental violations. Fines, penalties, and supplemental environmental project (SEP) costs will be paid by the organization against which the fine or penalty has been assessed, using applicable Army appropriations unless otherwise required by law. Payment of fines and penalties will be charged to the funding account of the operation causing the violation. Contracting Officers will ensure that contracts require contractors to pay fines or penalties resulting from their operations.

e. Compliance agreements and consent orders. Compliance agreements and consent orders attributable to a tenant's mission and/or operations will be financed with mission funds and must be coordinated through the mission chain of command.

15–2. Environmental Quality Control Committee

a. Installations will establish Environmental Quality Control Committees (EQCCs) chaired by the Garrison Commander (GC). In overseas areas, the EQCC may be organized at the appropriate military community level. The EQCC will include major and sub-installations and tenant activities. EQCCs will meet at least quarterly and document decisions.

b. The EQCC should consist of members representing the operational, logistics, engineering, planning, resource management, legal, medical, environmental, morale, welfare, and recreation (MWR), commissary, exchange service, and safety interests of the command, including military installation tenant activities.

c. The EQCC will help to plan, execute, and monitor actions and programs with environmental implications. The committee will identify issues, make recommendations, and advise the GC.

15–3. Environmental training, awareness, and competence

a. All personnel who perform tasks that can cause significant environmental impacts will be competent on the basis of appropriate education, training, and/or experience.

b. Personnel in non-environmental managerial functions will receive appropriate technical and/or awareness training.

c. All organizations will identify training needs (including legally mandated training), document training taken, and evaluate effectiveness.

d. Supervisors are responsible to ensure their employees are properly trained.

e. Organizations should use the most effective and efficient education and training sources available, such as academia, private vendors, Federal or State agencies, workshops and conferences, and distributive training. Army organizations will develop training courses only when such training courses do not exist. Proposals to develop training courses will be coordinated with higher headquarters and Training and Doctrine Command (TRADOC).

f. The U.S. Army Engineer School (USAES) is responsible for developing and integrating environmental considerations into personnel training.

g. All organizations will ensure applicable personnel at all levels conform to a single installation-wide environmental management system (EMS).

15–4. Communications

a. Internal. Organizations at all levels will establish and maintain procedures for internal communication among all their levels and functions and report environmental incidents.

b. External.

(1) Organizations at all levels will establish and maintain procedures for receiving, documenting, and responding to communication from external interested parties in coordination with the Public Affairs staff.

(2) Organizations will only provide information on publicly accessible, non-restricted Army environmental Web sites that have been properly cleared for release by the appropriate Public Affairs Office (PAO).

(3) Information available to the public through the Internet will be consistent with guidance issued by the Army Chief Information Officer/G–6 (CIO/G-6).

(4) All environmental agreements must be reviewed and approved by the next higher echelon. Proposed agreements and their review will include consideration of long-term Army resource commitments. In addition, environmental agreements with regulatory agencies will be forwarded through command channels to the JALS–EL for review prior to signature, and those resulting from tenant activities will be coordinated with the tenant, the Army Commands (ACOMs), Army Service Component Commands (ASCCs), Direct Reporting Units (DRUs), National Guard Bureau-Army National Guard (NGB–ARNG), and the Installation Management Command (IMCOM), if applicable.

(5) Army elements will include public involvement as a component of the decision making process to build mutual understanding with interested parties through two-way communication. Dialogue will strive to reduce miscommunication and foster a mutually beneficial exchange of information.

15–5. Real property acquisition, leases, outgrants, and disposal transactions

a. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requires the Army to perform certain actions to assess the environmental condition of property prior to entering into designated real property transactions. These transactions include fee acquisition of real property on behalf of the United States, deeds divesting title from the United States, transfers of jurisdiction between federal agencies, and leases of Army-controlled real property to non-Army entities.

b. This section is not applicable to reassignments within Army or DOD elements; to acquisition of less than fee; or to other outgrants (license, easement, or permit). However, the Environmental Condition of Property (ECP) requirements of this section apply, as a matter of policy, to DA licenses to the National Guard Bureau (NGB), licenses for State National Guard Components, and to state land acquisition where the land will be provided for federally funded construction. Army proponents will conduct these transactions in accordance with the procedures found in AR 405–10; AR 405–80; AR 405–90; Section 2688, Title 10, United States Code (10 USC 2688); 32 CFR 651; and Part 800, Title 36, Code of Federal Regulations (36 CFR 800). Base Realignment and Closure (BRAC) actions will comply with DODI 4165.66M, or its successor. The Army proponent may elect to perform an environmental site assessment for the inapplicable transactions. (LD: 42 USC 9620(h))

c. Except as noted in *b*. above, Army will assess, determine, and document the environmental condition of transferable property in an ECP Report. The ECP Report will summarize historical, cultural, and environmental conditions and include references to publicly available and related reports, studies, and permits. The report will provide an accurate summary of the environmental condition of the property. If the property will be deeded or leased, the site may require additional site characterization to meet applicable regulatory requirements or to help value the property. (Note: The GC/Army proponent is responsible for initiating the ECP Report.)

(1) An ECP Report will normally result in a conclusion regarding the advisability of the transaction and forms the basis for Findings of Suitability, if applicable to the transaction. Environmental contamination and potential environmental liabilities associated with properties being considered for acquisition, lease, and disposal will be determined prior to completing the transaction. The ECP Report and, if applicable, the Findings of Suitability, are an integral part of the Report of Availability or the Disposal Report which form the basis for the Army official with delegated authority to approve the real property transaction and for USACE to prepare the required legal documents, land use controls and covenants. (Note: Findings of Suitability are required for BRAC disposals, both transfers and leases, but are not required for active installation leases.) (LD: 42 USC 9620(h))

(2) Content of the ECP Report depends upon the nature of the transaction and the proposed transferee/lessee. Transfers or leases between the Army and non-federal entities will require at a minimum, a Phase I ECP Report. Where conditions indicate uncertainty regarding the condition of property, a Phase II ECP Report is also required.

(3) The ECP Report will comply with applicable American Society for Testing and Materials (“ASTM”) Standards, such as ASTM E1527, E1903, and D6008 and will be consistent with the DOD Base Redevelopment and Realignment Manual (BRRM) for BRAC actions.

(4) An ECP Report is optional for reassignments within the Army and between Army and another DOD component depending on whether the HQDA approval authority deems it necessary. Those reassignments without an ECP Report should have a statement describing the environmental condition with the package forwarded to HQDA for approval. (PD)

(5) For non-BRAC actions, the ECP report will be attached to the environmental section of the Report of Availability or Disposal Report (AR 405–80 and AR 405–90) that is submitted to the Army decision-making official.

(6) Fee acquisitions and fee acquisition by State Guard components for land that will be provided for federally funded construction require an ECP Report to comply with EPA’s “All Appropriate Inquiry” rules under CERCLA prior to obtaining title to the real property so as to preserve defenses to CERCLA liability as an innocent land owner, bona fide prospective purchaser, or contiguous property owner and to reduce risk to Army and ensure that Army pays appropriate consideration for the property. The Army component will perform due diligence in determining the environmental condition of the property using applicable Environmental Protection Agency guidelines and applicable American Society for Testing and Materials (“ASTM”) Standards on real property acquisition (ASTM E 1527). (LD: 42 USC 9620)

(7) The activity initiating the property transfer or lease will include the ECP Report with the Disposal Report or Report of Availability for the transaction.

d. Active installation leases and non-lease outgrants (easements, license, permit):

(1) The environmental section of the Report of Availability (ROA) (AR 405–80) will be used to document the environmental condition of the property being leased by active installations. There is no requirement to prepare a FOSL. The non-BRAC ECP included with the ROA will include, as an appendix, the appropriate environmental protection provisions necessary for continued human health and environmental protection.

(2) The GC (or equivalent) or the NGB having accountability for the real property at the installation may determine that the environmental section of the ROA alone may be sufficient to document environmental requirements for permits, licenses, easements, and similar real estate actions where environmental concerns are very minor. Under these circumstances an ECP report would not be required.

(3) An ECP report will be done as an exception to this section when licenses are issued to state National Guard components; when hazardous materials will be stored for one year or more or disposed on Army property except when authorized by 10 USC 2692 (as amended); and where the authorized use of Army lands and facilities poses a hazard to human health or the environment. Leasing space to others for trailer sites or automatic teller machines (ATMs) does not require an ECP Report except where extraordinary circumstances exist.

e. The GC (or equivalent) is responsible for determining the appropriate ECP category (ASTM D5746) for a property being transferred based on the results of the ECP Report and actions taken to address contamination. (PD) *f*. For real property transactions initiated by non-Army parties: (PD)

(1) The party initiating the transaction is responsible for funding and completing the ECP Report.

(2) The GC/Army proponent should approve the ECP Report.

(3) The Army may prepare the ECP Report, even though others initiated the transaction, if it has demonstrable benefit to the Army.

g. For non-BRAC transfers when GSA is the disposal agent, Army prepares the ECP Report. However, disposal by GSA is not considered a transfer of jurisdiction to GSA. The level of detail for the ECP Report will be coordinated with GSA. (PD)

h. Findings of Suitability are listed below:

(1) The Finding of Suitability to Transfer (FOST) / Finding of Suitability for Early Transfer (FOSET)/or BRAC Finding of Suitability to Lease (FOSL) will certify that the property is compatible with the proposed use and that the use restrictions or remedies in place (if any) are protective of human health and the environment. (PD)

(2) Deeds divesting title or leases executed under BRAC or other special legislative authority will proceed only after a FOST/FOSET/FOSL.

(3) A FOSET is required when transferring title to property pursuant to the provisions of CERCLA 120(h)(3)(c) (early transfer authority), when remedial action has not been completed prior to transfer. (LD: CERCLA 120(h)(3)(c)) (PD)

(4) A FOST is not required for deeds divesting title when disposed by the General Services Administration (GSA).

(5) Responsibility for environmental remediation for transfers or interchanges between the Army and other federal entities will be addressed in the Memorandum of Agreement between the Army and the transferee. The Army requires an ECP Report which will be initiated per paragraph f. above and provided to the transferee.

(6) The BRAC FOST/FOSET/FOSLs will be coordinated with regulators and made available to the public for their review. (PD)

i. Review and approval authorities are listed below:

(1) The IMCOM, Army commands or service component commands and direct reporting units with special installations, or Army National Guard (NGB–ARNG) will review and approve ECP Reports in coordination with the affected organizations. (PD)

(2) Approval authorities for ECP Report, FOST, FOSET, and BRAC FOSL documents for property disposals are in table 15–1 below. (PD)

(3) The Deputy Assistant Secretary of the Army (Environment, Safety, and Occupational Health) (DASA (ESOH)) will—

(a) Recommend approval for fee acquisition of property with an ECP Category designation of 5 or above or with known or suspected munitions and explosives of concern (MEC);

(b) Recommend approval for proceeding with the transfer to non-DOD federal agencies for properties with known or suspected MEC;

(c) Approve the FOSTs/BRAC FOSLs and approve the ECP report for non-BRAC leases for properties with known or suspected munitions and explosives of concern (MEC); and

(d) Approve all FOSETs

(4) The approving official will ensure that the document(s) receive appropriate legal and environmental professional review prior to approving the document(s).

j. Real property transactions require preparation of appropriate National Environmental Policy Act (NEPA) documentation per 32 CFR Part 651. (LD: 32 CFR 651)

k. Lease Termination. Upon termination of any lease, the Army proponent and lessee may jointly conduct a final lease close out using the ECP Report funded by the lessee to ascertain any changes in the environmental condition of the subject property. If the lessee refuses to participate, the GC/Army proponent will conduct the final assessment at the lessee's expense and provide a copy to the grantee. If an environmentally significant change has occurred, it will be documented as an amendment to the ECP Report, or a previous environmental site assessment report, if one was done, and the lessee will be required to make suitable compensation. The lessee will be made aware of these requirements and procedures in the original lease document. (PD)

l. Lease Renewals. ECP requirements must be met before renewing existing leases. If the lease did not have an environmental site assessment performed originally, an ECP must be done prior to renewal. For renewal of existing leases that have previously had an ECP, or other versions of site assessment documents, the GC/Army proponent must ascertain if environmental conditions have changed. If an environmentally significant change has occurred, it will be documented as a supplement or amendment to the original assessment report. An environmentally significant change involves the storage of a hazardous substance for a year or more, a known release of such substance, or its disposal on the property. The revised report will be processed in accordance with paragraph 15–5c above. A copy of the ECP report and/or any supplements or amendments will be provided to the grantee. (PD) *m*. See also Leases, Easements, and Other Special Land Uses, paragraph 4–3d(2) and Conservation Reimbursable Agricultural/Grazing Outleasing and Forestry Programs, paragraph 4–3d(8).

n. Table 15–2 summarizes the documents required for the various types of real property acquisition, leases, and disposal transactions.

Table 15–1
Property disposal approval authorities[1, 3]

	PROGRAM		
DOCUMENT	**ACTIVE**	**LEGACY BRAC**	**BRAC 05**
ECP Category Designation[2]	Garrison Commander	Garrison Commander	Garrison Commander
ECP Report	IMCOM[4]	BRAC D	IMCOM[4]
FOST[5]	ECP 1–4: IMCOM[4]	ECP 1–4: BRAC D[4]	ECP 1–4: IMCOM[4]
	ECP 5–7: N/A	ECP 5–7: N/A	ECP 5–7: N/A
FOSET[5]	ECP 5–7: DASA (ESOH)	ECP 5–7: DASA (ESOH)	ECP 5–7: DASA (ESOH)
FOSL	Not Required	ECP 1–7: BRAC D[4]	ECP 1–7: IMCOM[4]

Notes:
[1] The approving official will ensure that the document(s) receive appropriate legal and environmental professional review prior to approving the document(s).
[2] DOD ECP Designation (ASTM D5746).
[3] Transactions with known or suspected MEC require DASA (ESOH) approval.
[4] Army commands or service component commands and direct supporting units with special installations and NGB exercise this authority for their installations. Approval authority may delegate ECP 1–2 to installations.
[5] Documents are not required for GSA transfers; refer to AR 405–90.

Table 15–2
Documents required

DOCUMENT	ECP Report[5]	FINDING OF SUITABILITY
ACQUISITION		
Fee title for USA	Yes	No
Less than Fee (easement, permit, license)	No	No
Inlease[1]	No	No
DISPOSAL DOCUMENTS		
Deed divesting title from USA	Yes	FOST/FOSET
Report as Excess to GSA[2]	Yes	No
Transfer to another Fed Agency	Yes	No
Reassignment within DA or DOD[3]	Optional	No
Release or termination of less than fee estate[4]	No	No
OUTGRANTS		
Lease Documents	Yes	No, use ROA to document
Other outgrants (license, easement, permit)	No, use ROA to document	No, use ROA to document
License to NGB	Yes	No

Notes:
[1] Type of less than fee; however, an ECP may be done for large, long-term leases.
[2] Reporting as Excess to GSA is not a transfer or reassignment to GSA.
[3] Within DoD elements, doing an ECP Report is optional for those reassignments requiring HQDA approval (see para 15–5(c)(4) above). The Army proponent will consult the HQDA activity requiring approval prior to initiating a Report of Availability without an ECP Report.
[4] Release, Affidavit, or other non-deed document – if a deed is required, then follow deed policy.
[5] The ECP Report will be forwarded with the ROA or Disposal Report.

15–6. Military construction and Morale, Welfare, and Recreation Construction on Army installations

Military Construction (MILCON) includes major and minor construction projects funded by Military Construction, Army (MCA); Military Construction, Army Reserve (MCAR); Military Construction, National Guard (MCNG); Army Family Housing (AFH); Defense MILCON; and Tenant Service MILCON. For specific guidance for MILCON planning and environmental/safety remediation see AR 415–15, and AR 210–20. Morale, Welfare, and Recreation (MWR) construction includes Army appropriated fund (APF) and non-appropriated fund (NAF) construction depending on the type of facility (see AR 215–1).

a. Pre-construction site selection. Preparation of environmental documentation and site survey is considered advance planning and will be funded from other than MILCON or NAF. The project proponent at the installation is responsible for funding and executing the environmental survey, unexploded ordnance survey, and associated documentation of a proposed MILCON/MWR construction site before site selection. Installations will coordinate site selection activities with the supporting IMCOM Regional Office.

(1) When selecting a proposed site, the installation should consider locations that avoid unnecessary environmental remediation and/or mitigation costs. However, installations should consider using all existing infrastructure wisely, to include locations that may require some degree of remediation and/or mitigation. A final determination should be based on sound economic and relative risk analysis.

(2) If a proposed project must be sited in a known environmentally sensitive area where an Army cleanup program has already cleaned to current or reasonably anticipated future land use, the cost of design and construction of mitigation measures required as a direct result of MILCON or NAF projects may be paid from MILCON funds if included in the cost estimate and description of work on the DD Form 1391, FY_ Military Construction Project Data. AR 415–15 and DA Pam 415–15 provide detailed guidance for completing DD Form 1391 for MILCON and NAF.

(3) Non-Army tenants on Army installations are responsible for funding environmental surveys and associated documentation of proposed MILCON or NAF construction sites where they are the user.

b. Site categorization. The IMCOM/ACOM/ASCC/DRU/NGB–ARNG is responsible for certifying the site categorization. Sites are classified into the three following categories.

(1) Category I - There is no reason to expect contamination will be encountered during the construction.

(2) Category II - There is no known contamination, there remains some potential that contamination may be encountered during construction.

(3) Category III - The site is known to be contaminated or there is strong suspicion contamination will be encountered during construction.

c. Site clearance standards. Site categorizations will be completed in accordance with:

(1) ASTM D6008–96: Standard Practice for Conducting Environmental Baseline Surveys.

(2) ASTM E1527–00: Environmental Site Assessments: Phase I Site Assessment Process.

(3) ASTM E1903–97: Environmental Site Assessments: Phase II Site Assessment Process.

d. Discovered contamination. The installation or MILCON proponent is responsible for the remediation/cleanup of environmental contaminants discovered during the execution of a MILCON or NAF construction project.

(1) If removal of discovered contamination adequately addresses the environmental condition of the property for construction and a decision of no further action is secured by the installation, the project should proceed.

(2) If initial response activities are not adequate and additional remediation/cleanup is required, the project proponent is responsible for identifying the environmental requirements and securing funds.

(3) Construction contractor costs (such as direct delays costs and unabsorbed or extended overhead) incidental to discovery, remediation and cleanup, however, will be MILCON funded or APF or NAF funded as appropriate for MWR projects to the extent it is determined that the Army is responsible and liable for such costs.

15–7. National security emergencies and exemptions/waivers

a. In conducting their mission, GCs should anticipate and allow for mission surge conditions that could result during times of national security emergencies, including but not limited to contingency operations, suppression of insurrection, humanitarian and civic assistance, peace-keeping activities, and disaster relief. In cases where mission surge conditions could potentially exceed permit limitations or other environmental requirements, the GC should request an exemption in accordance with this section.

b. In evaluating possible courses of action, the GC will consult with legal counsel and determine the appropriateness of seeking an environmental exemption or waiver.

c. In national security emergencies, the requirements of this regulation remain in effect unless waived by the ACSIM.

d. If a GC anticipates that surge conditions could result in a violation of Federal or State environmental law or regulation, as soon as practicable, the GC should consult with the appropriate Federal, State, or local authorities on a mutually agreeable course of action. If a satisfactory resolution cannot be agreed upon, the GC will submit a request for a national security exemption to HQDA, DAIM–ED through the chain of command. The request must include:

(1) Identification of the action prompting need for exemption;

(2) The statute(s) from which an exemption is sought;
(3) The applicable statutory exemption provision(s);
(4) Adequate supporting information and justification for the exemption; and
(5) Alternatives considered and the reasons they were not adopted.

e. ACSIM will coordinate with other Army staff (ARSTAF) elements and will forward the request with a recommendation to the Assistant Secretary of the Army (Installations and Environment) (ASA (I&E)), who may transmit the request to the Office of the Secretary of Defense (OSD) for disposition.

f. In the event an exemption is denied or cannot be granted in a timely manner, the ACSIM will provide specific guidance on the resolution of the conflicts identified in the request.

15–8. Army Environmental Program in Foreign Countries

a. Policy. This section clarifies environmental policy and requirements applicable to permanent installations or facilities located in foreign countries. This section does not apply to training, off-installation deployments, contingency operations, or those locations for which no DOD Environmental Executive Agent (EEA) has been designated.

(1) Army policy in foreign countries is to comply with applicable standards, criteria and regulations that preserve, protect, and enhance environmental quality and human health. These standards, criteria, and regulations include the country-specific FGS, DODI 4715.5, DODI 4715.8, EO 12088, and EO 12114.

(2) The FGS define the environmental standards for Army permanent installations in foreign countries. The FGS take precedence over requirements of this regulation unless otherwise specifically noted in this section. Army facilities in a foreign nation with no FGS will comply with DOD 4715.05–G and applicable international agreements.

(3) Only the designated DOD EEA can revise an FGS. In cases where it is necessary to comply with more protective criteria than the FGS prescribes, the GC must consult with the EEA.

(4) Waivers to an FGS may be granted only by the DOD-designated EEA or the Unified Command (combatant commanders) in accordance with the country-specific FGS and DOD designated EEA waiver policy.

(5) Hazardous waste (HW) that cannot be disposed of in accordance with the FGS will be returned to the United States or another location where the disposal criteria can be met. In addition to compliance standards for disposal, all Army organizations and activities will comply with the provisions of any applicable Status of Forces Agreement (SOFA) or other legally-binding international agreements respecting the shipping and storage of HW.

(6) An external Environmental Performance Assessment System (EPAS) assessment will be conducted at overseas installations in accordance with DODI 4715.5 and the country-specific FGS (generally this will be every 3 years).

(7) Environmental remediation at overseas installations is addressed in paragraph 12–4, and will be conducted in accordance with DODI 4715.8.

b. Program requirements. Program requirements for overseas activities are addressed throughout this regulation. Additionally:

(1) Army ACOMs, ASCCs, DRUs, IMCOM, and installations will comply with the provisions of DODI 4715.5, DODI 4715.8, and appropriate country-specific implementing guidance per the DOD designated EEA.

(2) GCs will consider the adverse impacts of installation activities on a property listed on the World Heritage List, European Union natural conservation site of importance, or a host nation's (HN) equivalent of the U.S. National Register of Historic Places (NRHP). Reasonable effort will be made to avoid or mitigate any adverse effects.

(3) GCs will consider the adverse impacts of installation activities on internationally protected animal and plant species and their habitat, to include flora and fauna in a HN's equivalent of the Endangered Species Act (16 USC 35 (ESA)). Reasonable effort will be made to avoid or minimize adverse effects on such resources.

(4) Army components (that is, Active, Reserve, ARNG) participating in joint operations will comply with the environmental annex as specified by combatant command plans (for example, an annex L to the operation plan (OPLAN)).

(5) Army commanders will report overseas violations through command channels to DAIM–ED, with a courtesy copy to JALS–EL.

15–9. Environmental Management System documentation and document control

a. Installations will establish and maintain information in paper or electronic form to describe the core elements of the management system and their interaction, and provide direction to related documentation.

b. Installations will establish and maintain procedures for controlling all documents required by the ISO 14001 standard to ensure that: they can be located; they are periodically reviewed, revised as necessary, and approved for adequacy by authorized personnel; the current versions of relevant documents are available at all locations where operations essential to the effective functioning of the EMS are performed; obsolete documents are promptly removed from all points of issue and points of use, or otherwise assured against unintended use; and any obsolete documents retained for legal and/or knowledge preservation purposes are suitably identified.

c. Documentation will be legible, dated (with dates of revision), and readily identifiable, maintained in an orderly manner and retained for a specific period. Procedures and responsibilities will be established and maintained concerning the creation and modification of the various types of documents.

Chapter 16
Checking and Corrective Action

16–1. Environmental performance assessments and Environmental Management System audits

a. General.

(1) Garrison commanders (GCs) should maintain an inventory of compliance sites and activities with potential to impact the environment.

(2) Audits conducted under the Environmental Performance Assessment System (EPAS) will include all operations and activities within the installation boundary (including operational ranges, and other training areas), or a representative sample of similar activity types, and will evaluate overall environmental program performance and conformance with ISO 14001.

(3) Assessments will include tenant activities, outgrants, leases, and other activities under the purview of the Army.

(4) Generally, assessments will not include privatized facilities. However, special circumstances related to facility and/or associated land lease or ownership status could warrant their inclusion. Accordingly, installations will report the status of their privatized facilities to the U.S. Army Environmental Command (USAEC) EPAS Program Manager as soon as possible after being notified of a scheduled EPAS audit so that a determination regarding inclusion/exclusion can be made.

b. External assessments.

(1) CONUS external performance assessments are scheduled based on risk analysis and in consultation with HQDA and appropriate commands. Outside the continental United States (OCONUS) external assessments are conducted every three years in accordance with DODI 4715.5.

(2) External assessments will be conducted using a team of independent assessors not associated with the installation and having the necessary organizational and subject matter expertise. This expertise will include the requisite environmental media and regulatory expertise as well as expertise in the functional mission areas that are the subject of the assessment.

(3) External assessments will be conducted using Headquarters, Department of the Army (HQDA) approved protocols. OCONUS, these protocols will be based on the country-specific final governing standards (FGS).

(4) Individuals performing external assessments will provide required assessment data into the Army approved application/database (AEDB–EPAS) to assist in producing the draft and final Environmental Performance Assessment Report (EPAR) and the draft installation corrective action plan (ICAP).

(5) Army installations will prepare the draft ICAP, identify corrective actions, and secure resources for correction through the chain of command.

(6) Assessment results and ICAP will be made available to the Environmental Quality Control Committee (EQCC).

(7) Draft ICAP will be forwarded to affected units, Army Commands (ACOM), Army Service Component Commands (ASCC), Direct Reporting Units (DRU), and/or tenants for review.

c. Internal assessments.

(1) Internal assessments will be conducted annually, at a minimum, by installation personnel as part of their regular management, checking, and corrective action functions, unless an external assessment is conducted that calendar year.

(2) Army installations will provide required internal assessment data into the Army approved application/database (AEDB–EPAS) to assist in producing the draft ICAP.

(3) Internal assessments will include a review of previous assessments and draft ICAP, review corrective actions not completed, assess compliance with any new regulatory requirements, and address areas specified by higher command.

(4) Installations will notify their respective command when their internal assessment has been completed.

(5) Assessment results and ICAP will be made available to the Environmental Quality Control Committee (EQCC).

d. Installation Corrective Action Plan (ICAP).

(1) Each installation will prepare or revise a draft ICAP in accordance with Army requirements.

(2) The ICAP will track externally and internally reported compliance and program performance deficiencies.

(3) The ICAP will remain in draft.

e. Releasability. All draft assessment reports and supporting papers are internal working documents. The draft documents must be marked "for official use only" (FOUO) and distribution will be handled accordingly. All requests for release of reports will be referred to the appropriate installation Freedom of Information Act (FOIA) Officer.

f. Environmental Performance Assessment System (EPAS) in-progress review (IPR). The Director of Environmental

Programs (DEP) may convene an IPR as necessary to review the performance of the program and to identify and resolve issues.

16–2. Monitoring and measurement

a. Installation Management Command (IMCOM), National Guard Bureau-Army National Guard (NGB–ARNG), Army Commands (ACOMs), Army Service Component Commands (ASCCs), Direct Reporting Units (DRUs), installations, and tenants will establish and maintain documented procedures to monitor and measure, on a regular basis, the key characteristics of those operations and activities that can have an impact on the environment. This will include the recording of information to track performance, relevant operational controls, and conformance with the organization's environmental objectives and targets.

b. Monitoring equipment will be calibrated and maintained and records of this process will be retained according to installation standard operating procedures.

16–3. Army environmental information and reporting

a. *Army Environmental Information Policy*. Army environmental information is an asset that will be managed as part of the Army I&E information technology (IT) portfolio management. Environmental information investments will meet the Chief Information Officer (CIO)/Deputy Chief of Staff, G–6 (DCS, G–6) Army Knowledge Management (AKM) goals, adhere to the I&E IT domain governance process, and be incorporated into the Office of the Assistant Chief of Staff for Installation Management (OACSIM) Business Enterprise Architecture (BEA) strategy and plan.

b. *Program goal*. Army environmental information will facilitate planning, execution, monitoring, and reporting of programs at all activity levels in support of the Army mission. Environmental information and information tools will be built in standardized formats and incorporated into the Army enterprise architecture.

c. *Coordination requirements*. Army environmental reporting systems will be coordinated with the OACSIM Business Transformation Board of Directors (BT BOD).

(1) The DEP represents functional environmental information requirements at the BT BOD.

(2) USAEC represents technical environmental information requirements at the BT BOD.

(3) Environmental reporting systems will be executed in accordance with the OACSIM BEA Strategy and plan.

d. *Primary Systems*. The following are the Army's primary systems for data collection and reporting:

(1) *Army Environmental Data Base - Environmental Quality (AEDB–EQ)*. The AEDB–EQ serves as a primary source of information for reporting the Army's environmental status to Senior Army Leadership, DOD, and Congress. AEDB–EQ tracks Army compliance with environmental laws (to include permits and enforcement actions) and regulations to determine Army progress towards meeting the DOD Measures of Merit (MOMs), and allows the Army to populate other required reports.

(2) *Environmental Restoration Information System (ERIS)*. ERIS and ERIS Range document the Army environmental restoration and range program field data to support a central repository for Army installation chemical, geological, and remedial action data.

(3) *Army Environmental Data Base-Restoration (AEDB–R)*. This is the database of record for collecting and reporting data for sites being cleaned up under the purview of Environmental Restoration, Army (ER, A) or Base Closure Account (BCA).

(4) *Army Environmental Data Base-Compliance-Related Cleanup (AEDB–CC)*. This is the database of record that identifies and documents requirements for the cleanup of contamination at Army sites that are not eligible for the Defense Environmental Restoration Program (DERP).

(5) *Reimbursable Programs Tracking System (RPTS)*. RPTS stores data used to report the financial elements of the agricultural grazing, reimbursable forestry, hunting, fishing and trapping fees, the DOD Forestry Reserve Account, and the Army Wildland Fire programs.

(6) *Army Environmental Data Base - Environmental Performance Assessment System (AEDB–EPAS)*. The AEDB–EPAS serves as a primary source of information for reporting, collecting, tracking, and analyzing the Army's environmental compliance and conformance data from external and internal audits.

(7) *Installation Status Report, Natural Infrastructure*. The ISR–NI collects and reports on the readiness of Army installations. The information is collected annually based upon 18 media within the Army Environmental Program (AEP).

(8) *Toxic release inventory (TRI)*. Installations meeting established threshold criteria are to submit an annual TRI report as required by the *Emergency Planning and Community Right-to-Know Act* (EPCRA) and Executive Order (EO) 13423.

(9) *Solid Waste Annual Reporting-Web (SWARWeb) System*. SWARWeb is a web-based system to support integrated solid waste management at the installation level. It allows the tracking of solid waste and construction and deconstruction debris waste generation and costs as well as waste diversion through recycling and reuse.

(10) *Hazardous Substance Management System (HSMS)*. HSMS is an installation centric client-server software

system to support the integrated management of hazardous materials. It is capable of tracking the authorized ordering, issue and return of hazardous material as well as the disposal of hazardous waste (HW).

16–4. Reporting violations

a. Installation Commanders will enter enforcement actions (ENF) using official electronic Army Environmental Quality Reporting System ((for example, Army Environmental Data Base - Environmental Quality (AEDB–EQ)) reporting mechanisms with verification/confirmation through proper Command channels (for example, ACCS, DRUs, MSCs, regional offices, ACOMS) to the AEC. Initial reports for ENFs must be reported in accordance with current Army environmental quality reporting policy requirements as published and updated by the HQDA. Initial reports will be entered via the Army Environmental Quality Reporting System within 48 hours (2 business days) for any ENF involving:

(1) Criminal enforcement;

(2) A fine, penalty, fee, or tax;

(3) Installation-wide (show stopper or major mission restriction), Army-wide, or DOD-wide impact, media attention, or community (on/off post) impact; or,

(4) Third party fault (that is, a non-Army entity is responsible in whole or part for the alleged violation(s)).

b. All other ENFs will be reported/entered into the AEDB–EQ within 7 business days through proper Command channels.

c. The aforementioned 48 hours (2 business days) reporting includes notification to HQDA (DAIM–ED (ODEP) & JALS–ELD (Army Legal Office) through proper Command channels. Additionally, coordinate with JALS–ELD (Army Legal Office) in writing, through technical legal channels, regarding litigation, administrative proceedings, and settlement negotiations.

16–5. Nonconformance and corrective and preventive action

a. All Army facilities identified by HQDA for environmental management system (EMS) implementation will accomplish the following in accordance with the ISO 14001 standard:

(1) Establish and maintain procedures for defining responsibility and authority for handling and investigating nonconformance with the facility's EMS requirements and procedures.

(2) Implement and record any changes in the documented procedures resulting from corrective and preventive action.

b. Any corrective or preventive action taken to eliminate the causes of actual or potential nonconformance will be appropriate to the magnitude of problems and commensurate with the environmental impact encountered, if any.

16–6. Environmental records

a. *General*.

(1) IMCOM, NGB–ARNG, ACOMs, ASCCs, DRUs, installations, and tenants will establish and maintain procedures for identification, maintenance, and disposition of environmental records, to include training records and the results of audits and reviews.

(2) Environmental records will be legible, identifiable and traceable to the activity, product, or service involved, and will contain the name and office symbol of the point of contact for that record.

(3) Environmental records will be stored and maintained (in hard copy or electronic format) in such a way that they are readily retrievable and protected against damage, deterioration, or loss.

b. *Recordkeeping guidelines*. Environmental records will be maintained, as appropriate, to demonstrate conformance to ISO 14001, and requirements set forth in AR 25–400–2.

c. *Environmental cleanup documents*. All installations and facilities will provide copies of environmental cleanup documents to the electronic permanent repository at USAEC. Environmental cleanup documents that should be submitted are detailed in the Army Environmental Cleanup Program Permanent Document Repository Guidance, which was issued 29 Sep 2004. Copies of the guidance are available from the USAEC Cleanup Division.

Chapter 17
Management Review

17–1. Environmental Management System management reviews

a. Installations will establish written procedures for conducting recurring management reviews of their environmental management system (EMS).

b. At least annually, Garrison commanders (in conjunction with the Environmental Quality Control Committee (EQCC) or equivalent) of all appropriate facilities will conduct a management review of their respective environmental management system (EMS) to ensure its continuing suitability, adequacy, and effectiveness.

c. The management review process will ensure that the necessary information is collected to allow management to carry out this evaluation.

d. The management review, which will be documented, will address the possible need for changes to policy, objectives, and other elements of the EMS in light of EMS audit results, changing circumstances, and the commitment to continual improvement.

17–2. Headquarters, Department of the Army environmental program reviews

HQDA will conduct periodic program reviews to ensure adequate oversight, program effectiveness, and proper resource allocation and execution.

Appendix A
References

DOD Directives are available at www.dtic.mil/whs/directives. United States Codes (USC) are available at www.gpoaccess.gov/uscode/. Executive Orders are available at www.archieves.gov/federal_register/executive_orders/disposition_tables.html. Code of Federal Regulations (CFR) are available at www.gpoaccess.gov/cfr/index.html.

Section I
Required Publications

AR 11–2
Management Control. (Cited in para 1–4.)

AR 25–400–2
Army Records Information Management System (ARIMS). (Cited in para 16–6.)

AR 40–5
Preventive Medicine. (Cited in paras 1–25, 4–2, 5–2, 9–2.)

AR 50–6
Chemical Surety. (Cited in para 11–2.)

AR 70–1
Army Acquisition Policy. (Cited in paras 7–2 , 7–4.)

AR 75–15
Policy for Explosive Ordnance Disposal (O). (Cited in para 11–4.)

AR 95–1
Flight Regulations. (Cited in para 14–2.)

AR 210–20
Real Property Master Planning for Army Installations. (Cited in paras 14–2, 15–6.)

AR 210–50
Housing Management. (Cited in para 5–2.)

AR 350–19
The Army Sustainable Range Program. (Cited in para 14–2.)

AR 385–10
The Army Safety Program. (Cited in para 5–2.)

AR 405–10
Acquisition of Real Property and Interests Therein. (Cited in para 15–5.)

AR 405–80
Management of Title and Granting Use of Real Property. (Cited in paras 4–3, 15–5.)

AR 405–90
Disposal of Real Estate. (Cited in paras 4–3, 15–5.)

AR 415–15
Army Military Construction and Nonappropriated Fund Construction Program Development and Execution. (Cited in paras 10–2, 15–6.)

AR 420–10
Management of Installation Directorates of Public Works. (Cited in para 5–2.)

AR 420–49
Utility Services. (Cited in paras 4–2, 10–2.)

AR 420–70
Buildings and Structures. (Cited in para 9–2.)

AR 700–136
Tactical Land–Based Water Resources Management. (Cited in para 4–2.)

AR 710–2
Supply Policy Below the National Level. (Cited in paras 1–10, 10–1.)

U.S. Army EMS Aspects and Impact Methodology for Army Training Ranges
Implementation Guidance. (Cited in para 1–1.) (Available at www.sustainability.army.mil.)

U.S. Army EMS Commanders Guide
Implementation Guidance. (Cited in para 1–1.) (Available at www.sustainability.army.mil.)

U.S. Army EMS Implementer’s Guide
Implementation Guidance. (Cited in para 1–1.) (Available at www.sustainability.army.mil.)

Army Strategy for the Environment
Brochure, 1 Nov 04. (Cited in para 2–1.) (Available at www.asaie.army.mil.)

ASTM D6008–96 (2005)
Standard Practice for Conducting Environmental Baseline Surveys. (Cited in para 15–6.) (Available for ordering at www.webstore.ansi.org.)

ASTM E1527–00
Standard Practice Environmental Site Assessments: Phase I Environment Site Assessment Process. (Cited in para 15–6.) (Available for ordering at www.webstore.ansi.org.)

ASTM E1903–97 (2002)
Standard Guide for Environmental Site Assessments: Phase II Environment Site Assessment Process. (Cited in para 15–6.) (Available for ordering at www.webstore.ansi.org.)

DA PAM 40–11
Preventive Medicine. (Cited in para 10–2.)

DA PAM 415–15
Army Military Construction Program Development and Execution. (Cited in para 15–6.)

DFAS–IN Manual 37–100–**
Financial Management - The Army Management Structure FY04. (Cited in para 4–3.) (Available at www.asafm.army.mil.)

DOD American Indian and Alaska Native Policy Memorandum
Policy Document, 20 Oct 1998. (Cited in para 6–2.) (Available at www.denix.osd.mil.)

DOD Management Guidance for the Defense Environmental Restoration Program (DERP)
Guidance Document, September 2001. (Cited in para 12–2.) (Available at www.denix.osd.mil.)

DOD 4150.7–M
DOD Pest Management Training and Certification. (Cited in paras 5–2, 5–4.)

DOD 4150.7–P
DOD Plan for the Certification of Pesticide Applicators. (Cited in paras 5–2, 5–4.)

DOD 4160.21–M
Defense Material Disposition Manual. (Cited in para 10–1.)

DOD 4500.9–R
Defense Transportation Regulation. (Cited in para 10–1.)

DOD 4715.5–G
Overseas Environmental Baseline Guidance Document. (Cited in para 15–8.)

DOD 7000.14–R
DOD Financial Management Regulation (FMRS). (Cited in para 12–2.)

DODD 4715.1
Environmental Security. (Cited in para 4–3.)

DODD 4715.11
Environmental and Explosives Safety Management on Operational Ranges Within the United States. (Cited in paras 8–2, 12–4.)

DODD 4715.12
Environmental and Explosives Safety Management on Operational Ranges Outside the United States. (Cited in para 8–2.)

DODD 5000.1
The Defense Acquisition System. (Cited in paras 1–7, 3–3.)

DODI 4150.7
DOD Pest Management Program. (Cited in paras 4–3, 5–2, 5–4.)

DODI 4715.3
Environmental Conservation Program. (Cited in para 4–3.)

DODI 4715.4
Pollution Prevention, Jun 1996. (Cited in para 7–2.)

DODI 4715.5
Management of Environmental Compliance at Overseas Installations. (Cited in paras 4–3, 5–2, 15–8, 16–1.)

DODI 4715.7
Environmental Restoration Program. (Cited in para 12–2.)

DODI 4715.8
Environmental Remediation for DOD Activities Overseas. (Cited in paras 12–2, 12–4, 15–8.)

EO 11988
Floodplain Management, 42 FR 26951 (Cited in para 4–2.)

EO 11990
Protection of Wetlands. (Cited in paras 4–2, 4–3.)

EO 12580
Superfund Implementation, 52 FR 2923. (Cited in paras 12–2, 12–4.)

EO 13007
Indian Sacred Sites, 61 FR 26771. (Cited in para 6–4.)

EO 13112
Invasive Species (Cited in para 4–3.)

EO 13175
Consultation and Coordination with Indian Tribal Governments, 65 FR 67249. (Cited in paras 6–2, 6–4.)

EO 13186
Responsibilities of Federal Agencies to Protect Migratory Birds, 66 FR 3853. (Cited in para 4–3.)

EO 13287
Preserve America. (Cited in paras 1–5, 6–2, 6–4.)

EO 13423
Strengthening Federal Environmental, Energy, and Transportation Management. (Cited in paras 4–3, 7–2, 7–4, 9–1, 10–2, 16–3, B–2.)

ER 200–3–1
Formerly Used Defense Sites Program Policy. (Cited in paras 12–2, 12–4.)

Field Manual (FM) 3–100.4
Environmental Considerations in Military Operations. (Cited in para 1–28.)

ISO 14001 (also known as ANSI/ISO 14001–2004)
Environmental Management System Requirements - Specifications with Guidance for Use (Cited in paras 1–1, 1–13, 1–24, 15–9, 16–1, 16–5, 16–6.) (Available for ordering at www.webstore.ansi.org.)

Memorandum, DUSD (I&E), 10 October 2002
Implementation of Sikes Act Improvement Act: Updated Guidance. (Cited in para 4–3.) (Available at www.aec.army.mil/usaec/natural.)

PL 108–136
National Defense Authorization Act FY04. (Cited in para 4–3.)

PL 109–58
Energy Policy Act of 2005 (Cited in paras 4–2, 11–2.)

TB MED 575
Swimming Pools and Bathing Facilities. (Cited in para 4–2.)

TB MED 576
Occupational and Environmental Health: Sanitary Control and Surveillance of Water Supplies at Fixed Installations. (Cited in para 4–2.)

TB MED 577
Occupational and Environmental Health: Sanitary Control and Surveillance of Field Water Supplies. (Cited in para 4–2.)

TB 55–1900–206–14
Control and Abatement of Pollution by Army Watercraft. (Cited in para 4–2.)

TM 5–662
Swimming Pool Operation and Maintenance. (Cited in para 4–2.)

TM 5–813–1
Water Supply: Sources and General Considerations. (Cited in para 4–2.) (Available at www.usace.army.mil.)

TM 5–813–3
Water Supply: Water Treatment. (Cited in para 4–2.) (Available at www.usace.army.mil.)

TM 5–813–4
Water Supply: Water Storage. (Cited in para 4–2.) (Available at www.usace.army.mil.)

TM 5–813–5
Water Supply: Water Distribution. (Cited in para 4–2.) (Available at www.usace.army.mil.)

TM 5–813–7
Water Supply: Special Projects, Volume 7. (Cited in para 4–2.) (Available at www.usace.army.mil.)

TM 5–813–8
Water Supply: Water Desalination. (Cited in para 4–2.) (Available at www.usace.army.mil.)

TM 5–813–9
Water Supply: Pumping Stations. (Cited in para 4–2.) (Available at www.usace.army.mil.)

UFC 3–230–02
Unified Facilities Criteria - Operation and Maintenance: Water Supply Systems. (Cited in para 4–2.) (Available at wbdg.org.ccb/.)

USACHPPM TG–179
Guide for Providing Safe Drinking Water at Army Installations. (Cited in para 4–2.) (Available at chppm–www.apgea.army.mil.)

5 USC 552
Freedom of Information Act, as amended (FOIA) (Cited in paras 1–8, 16–1.)

7 USC 136, et seq.
Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended. (Cited in para 5–2.)

10 USC 2665
Sale of Certain Interest in Lands; Logs. (Cited in paras 1–24, 1–27, 4–3.)

10 USC 2667
Leases: Non-excess Property of Military Departments. (Cited in paras 1–24, 1–27, 4–3.)

10 USC 2671
Military Reservations and Facilities, Hunting, Fishing, and Trapping. (Cited in para 4–3.)

10 USC 2684a
Agreements to Limit Encroachment and other Constraints on Military Training, Testing, and Operations. (Cited in para 4–3.)

10 USC 2688
Utility Systems: Conveyance Authority. (Cited in para 15–5.)

10 USC 2694a
Conveyance of Surplus Real Property for natural resource conservation. (Cited in para 4–3.)

10 USC 2701, et seq.
Defense Environmental Restoration Program (DERP). (Cited in paras 12–2, 12–4.)

15 USC 2601, et seq.
Toxic Substances Control Act (TSCA), as amended. (Cited in paras 9–2, 11–2.)

15 USC 2651, et seq.
Asbestos Hazard Emergency Response Act (AHERA). (Cited in para 9–2.)

16 USC 31
Marine Mammal Protection Act. (Cited in para 4–3.)

16 USC 35
Endangered Species Act of 1973 (ESA). (Cited in paras 4–2, 4–3, 15–8.)

16 USC 431
Antiquities Act of 1906. (Cited in para 6–2.)

16 USC 432
Permits to examine ruins, excavations, and gathering of objects; regulations. (Cited in para 6–2.)

16 USC 433
American antiquities. (Cited in para 6–2.)

16 USC 469
Archeological and Historic Preservation Act of 1974 (AHPA), as amended. (Cited in paras 6–2, 6–4.)

16 USC 470
National Historic Preservation Act of 1966 (NHPA), as amended. (Cited in paras 1–5, 6–2, 6–4).)

16 USC 620–620j
Forest Resources Conservation and Shortage Relief Act of 1990. (Cited in para 4–3.) (Available at www.fws.gov.laws/.)

16 USC 661–667e
Fish and Wildlife Coordination Act. (Cited in para 4–3.) (Available at www.fws.gov.laws/.)

16 USC 670a–670b
Sikes Act. (Cited in paras 1–24, 4–3.) (Available at www.fws.gov.laws/.)

16 USC 670a
Program for Conservation and Rehabilitation of Natural Resources on Military Installations. (Cited in para 4–3.)

16 USC 670b
Migratory Game Birds; Permits; Fees; Stamp Act and State Law Requirements (Sikes Act). (Cited in paras 1–24, 1–27.)

16 USC 670e
Applicability to Other Laws; National Forest Lands. (Cited in para 1–24.)

16 USC 701
Games and wild birds; preservation. (Cited in para 4–3.)

16 USC 703–712
Migratory Bird Treaty Act (MBTA). (Cited in para 4–3.)

16 USC 1801–1882
Magnuson Fishery Conservation and Management Act. (Cited in para 4–3.)

16 USC 3371–3378
Lacey Act (Cited in para 4–3.)

16 USC 4701–4751
Aquatic Nuisance Prevention and Control. (Cited in para 4–3.)

25 USC 32
Native American Graves Protection and Repatriation Act of 1990 (NAGPRA). (Cited in paras 1–24, 6–2, 6–4.)

29 CFR 1910.120
Occupational Safety and Health Standards, Hazardous Waste Operations and Emergency Response. (Cited in para 12–2.)

29 CFR 1910.1001
Occupational Safety and Health Standards, Asbestos. (Cited in para 9–2.)

29 CFR 1910.1025
Occupational Safety and Health Standards, Lead. (Cited in para 9–2.)

29 CFR 1910.1200
Occupational Safety and Health Standards, Hazard Communication. (Cited in para 9–2.)

29 CFR 1926.1101
Safety and Health Regulations for Constructions. (Cited in para 9–2.)

29 CFR 1926.62
Safety and Health Regulations for Construction, Lead. (Cited in para 9–2.)

32 CFR 190
Office of the Secretary of Defense (OSD), Natural Resources Management Program. (Cited in para 4–3.)

32 CFR 651
Environmental Analysis of Army Actions. (Cited in paras 1–1, 15–5.)

33 USC 26
Clean Water Act (CWA). (Cited in paras 4–2, 8–2, 9–1, 11–2, 11–4.)

33 USC 1401
Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA), as amended (Ocean Dumping). (Cited in para 4–2.)

33 USC 2702 to 2761
Oil Pollution Act of 1990 (OPA). (Cited in para 3–14.)

42 USC 300f
Safe Drinking Water Act (SDWA), as amended. (Cited in paras 4–2, 8–2, 12–2.)

42 USC 1996
American Indian Religious Freedom Act of 1978 (AIRFA). (Cited in paras 6–2, 6–4.)

42 USC 4321–4347
National Environmental Policy Act of 1969, as amended (NEPA). (Cited in paras 1–1, 4–2, 4–3, B–4.)

42 USC 6901
Resource Conservation and Recovery Act (RCRA), as amended. (Cited in paras 1–25, 4–1, 4–2, 7–2, 8–2, 8–4, 10–1, 10–2, 11–2, 12–2.)

42 USC 4901
Noise Control Act of 1972. (Cited in para 14–2.)

42 USC 6901–6992k
Hazardous and Solid Waste Amendments of 1984 (HSWA). (Cited in para 7–2.)

42 USC 6941–6949a
Subtitle D, the Resource Conservation and Recovery Act (RCRA). (Cited in para 10–2.)

42 USC 6961
Federal Facility Compliance Act of 1992. (Cited in paras 4–2, 10–1.)

42 USC 7401
Clean Air Act, as amended (CAA). (Cited in paras 4–1, 8–2, 9–2, 11–2.)

42 USC 9601
Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA). (Cited in paras 4–2, 8–1, 11–2, 12–2, 12–4, 15–5.)

42 USC 11011
Emergency Planning and Community Right-to-Know Act (EPCRA). (Cited in paras 7–5, 9–1, 11–2.)

42 USC 13101–13102
Pollution Prevention Act of 1990 (PPA). (Cited in paras 7–2, 11–2.)

36 CFR 79
Curation of Federally-Owned and -Administered Archeological Collections. (Cited in paras 6–2, 6–4.)

36 CFR 800
Protection of Historic Properties. (Cited in paras 6–2, 6–4, 15–5.)

40 CFR 61
National Emission Standards for Hazardous Air Pollutants (NESHAP). (Cited in paras 4–1, 9–2.)

40 CFR 112
Oil Pollution Prevention. (Cited in paras 11–2, 11–4.)

40 CFR 260–279
Hazardous Waste. (Cited in para 10–1.)

40 CFR 261
Identification and Listing of Hazardous Waste. (Cited in para 10–2.)

40 CFR 266.200–206
EPA's Military Munitions Rule. (Cited in para 8–2.)

40 CFR 280
Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks. (Cited in para 11–2.)

40 CFR 281
Approval of State Underground Storage Tank Programs. (Cited in para 11–2.)

40 CFR 300
National Oil and Hazardous Substances Pollution Contingency Plan. (Cited in paras 11–2, 11–4, 12–2.)

40 CFR 302
Designation, Reportable Quantities, and Notification. (Cited in para 11–4.)

40 CFR 403
General Pretreatment Regulations for Existing and New Sources of Pollution. (Cited in para 4–2.)

40 CFR 745
Lead-based Paint Poisoning Prevention in Certain Residential Structures. (Cited in para 9–2.)

43 CFR 5
Making Pictures, Television Productions or Sound Tracks on Certain Areas Under the Jurisdiction of the Department of the Interior (Cited in para 6–4.)

43 CFR 6
Patent Regulations - Table of Contents (Cited in para 6–4.)

43 CFR 7
Protection of Archeological Resources (Cited in para 6–4.)

43 CFR 10
Native American Graves Protection and Repatriation Regulations. (Cited in paras 6–2, 6–4.)

43 CFR 10.3
Native American Graves Protection and Repatriation Regulations - International Archeological Excavations. (Cited in para 6–4.)

43 CFR 10.5
Native American Graves Protection and Repatriation Regulations - Consultation. (Cited in para 6–4.)

49 USC 1801
Federal Hazardous Materials Transportation Law. (Cited in para 9–2.)

50 CFR 10–16
Taking, Possession, Transportation, Sale, Purchase, and Barter, Exportation and Importation of Wildlife and Plants. (Cited in para 4–3.)

50 CFR 13
US Fish and Wildlife Service (USFWS) General Permit Procedures (Cited in para 4–3.)

50 CFR 21
and Migratory Bird Permits. (Cited in para 4–3.)

50 CFR 402
Endangered Species Act of 1973, as amended. (Cited in para 4–3.)

57 FR 28835
DOD - Office of the Secretary of Defense Environmental Restoration Program. (Cited in para 12–4.)

Section II
Related Publications

A related publication is a source of additional information. The user does not have to read it to understand this regulation. DOD Directives are available at www.dtic.mil/whs/directives. United States Codes (USC) are available at www.gpoaccess.gov/uscode/. Executive Orders are available at www.archieves.gov/federal_register/executive_orders/disposition_tables.html. Code of Federal Regulations (CFR) are available at www.gpoaccess.gov/cfr/index.html. Public laws are available at http://thomas.loc.gov/bss/. EPA publications are available at http://www.epa.gov/epahome/publications.htm. Military standards are available at http://assist.daps.dla.mil/quicksearch/.

AR 1–1
Planning, Programming, Budgeting, and Execution System

AR 5–4
Department of the Army Productivity Improvement Program.

AR 5–20
Competitive Sourcing Program

AR 10–87
Major Army Commands in the Continental United States

AR 11–9
Army Radiation Safety Program

AR 11–27
Army Energy Program

AR 25–55
The Department of the Army Freedom of Information Act Program

AR 37–49
Budgeting, Funding, and Reimbursement for Base Operations Support of Army Activities

AR 40–7
Use of Investigational Drugs and Devices in Humans and the Use of Schedule I Controlled Drug Substances

AR 40–13
Medical Support-Nuclear/Chemical Accidents and Incidents

AR 50–5
Nuclear Surety

AR 50–7
Army Reactor Program

AR 56–9
Watercraft

AR 70–65
Management of Controlled Substances, Ethyl Alcohol and Hazardous Biological Substances in Army Research, Development, Test, and Evaluation Facilities

AR 75–1
Malfunctions Involving Ammunition and Explosives

AR 75–14
Interservice Responsibilities for Explosive Ordnance Disposal

AR 350–1
Army Training and Leader Development

AR 360–1
The Army Public Affairs Program

AR 385–16
System Safety Engineering and Management

AR 385–40
Accident Reporting and Records

AR 385–64
US Army Explosives Safety Program

AR 420–90
Fire and Emergency Services.

AR 700–141
Hazardous Materials Information Resource System (RCS DDFM&P (A,Q,&AR)1486)

AR 725–50
Requisitioning, Receipt, and Issue System

AR 750–1
Army Material Maintenance Policy

DA PAM 40–8
Occupational Health Guidelines for the Evaluation and Control of Occupational Exposure to Nerve Agents GA, GB, GD, AND VX

DA PAM 40–501
Hearing Conservation Program

DA PAM 200–1
Environmental Protection and Enhancement

DASA (ESOH) Directive, 13 Jul 01
HQDA Memorandum, Army Environmental Management System - Action Memorandum.

DODD 3200.15
Sustainment of Ranges and Operating Areas (OPAREAs)

DODI 4000.19
Interservice and Intragovernmental Support

DODI 4715.10
Environmental Education, Training and Career Development

DODI 6055.6
DOD Fire and Emergency Services (F&ES) Program

EM 385–1–1
Safety and Health Requirements (Available at www.usace.army.mil/publications/

EO 11514
Protection and Enhancement of Environmental Quality

EO 11644
Use of Off-Road Vehicles in the Public Lands

EO 12114
Environmental Effects Abroad of Major Federal Actions

EO 12759
Federal Energy Management

EO 12844
Federal Use of Alternatively Fueled Vehicles

EP 1130–2–540
Environmental Stewardship Operations and Maintenance Guidance and Procedures (Available at www.usace.army.mil/publications/

EPA–340/1–90–018
Asbestos/NESHAP Regulated Asbestos Containing Materials Guidance

EPA–560/5–85–024
Guidance for Controlling Asbestos-Containing Materials in Buildings

EPA–600/4–85–049
Measuring Airborne Asbestos Following an Abatement Action

EPA–600/9–79–045
National Pollutant Discharge Elimination System (NPDES) Best Management Practices Guidance Document

EPA–560–OPTS–86–001
A Guide to Respiratory Protection for the Asbestos Abatement Industry

ER 200–3–1
FUDS Program Policy

FM 5–19
Composite Risk Mangement

JP Publication 4–04
Joint Doctrine for Civil Engineering Support

MIL–STD–3007
Standard Practice for Unified Facilities Criteria and Unified Facilities Guide Specifications (Available at http://assist.daps.dla.mil/quicksearch.)

MIL–STD–129P
Military Marking for Shipment and Storage

MIL–STD–1474D
Department of Defense Design Criteria Standard, Noise Limits

NFPA 295
Standard for Wildlife Control. (Available for ordering at www.webstore.ansi.org.)

NFPA 299
Standard for Protection of Life and Property from Wildfire (Available for ordering at www.webstore.ansi.org.)

NFPA 1051
Standard for Wildland Fire Fighter Professional Qualifications (Available for ordering at www.webstore.ansi.org.)

OMB Circular A–95
Evaluation, Review, and Coordination of Federal and Federally Assisted Programs and Projects. (Available for ordering at the Office of Management and Budget's information line.)

PL 99–145, section 1412
National Defense Authorization Act of 1986 - Destruction of Existing Stockpile of Lethal Chemical Weapons

PL 101–576
Chief Financial Officers Act of 1990.

PL 101–637
Asbestos School Hazard Abatement Reauthorization Act

PL 102–484
National Defense Authorization Act for FY93

PL 102–550
Residential Lead Based Paint Hazard Reduction Act 1992

PL 105–85
National Defense Authorization Act for FY98

PL 106–065
National Defense Authorization Act for FY00

PL 107–188
Public Health Security and Bioterrorism Preparedness and Response Act of 2002; Title IV–Drinking Water Security and Safety

PMS 310–1/NFES 1414
National Wildfire Coordinating Group Wildland Fire and Prescribed Fire Qualification System Guide, Jan 2000

SB 8–75 – medcase
Army Medical Department Supply Information

TB MED 513
Guidelines for the Evaluation and Control of Asbestos Exposure

TC 25–1
Training Land

TM 3–250
Storage, Shipment, Handling and Disposal of Chemical Agents and Hazardous Chemicals

TM 3–261
Handling and Disposal of Unwanted Radioactive Material

TM 5–629
Weed Control and Plant Growth Regulation

TM 5–630
Natural Resources - Land Management

TM 5–632
Military Entomology Operational Handbook

TM 5–633
Natural Resources - Fish and Wildlife Management

TM 5–635
Natural Resources - Outdoor Recreation and Cultural Values

TM 5–814–5
Sanitary Landfills

TM 38–250
Preparing Hazardous Materials for Military Air Shipment

TM 38–410
Storage and Handling of Hazardous Materials

USACHPPM TG No. 135
Data Base for Assessing the Annoyance of the Noise of Small Arms (Available at chppm-www.apgea.army.mil.)

USACHPPM TG No. 177
Commander's Guide to Regulated Medical Waste Management at Army Medical Treatment Facilities (Available at chppm-www.apgea.army.mil.)

USACHPPM TG No. 197
Guide for Developing an Integrated Solid Waste Management Plans at Army Installations (Available at chppm-www.apgea.army.mil.)

USACHPPM TG No. 198
Childhood Lead Poisoning Prevention/Lead-Based Paint Management Program on DOD Installations (Available at chppm-www.apgea.army.mil.)

10 CFR 20
Nuclear Regulatory Commission - Standards for Protection Against Radiation

14 CFR 150
Federal Aviation Administration, Department of Transportation - Airport Noise Compatibility Planning

24 CFR 51
Office of the Secretary, Department of Housing and Urban Development - Environmental Criteria and Standards

29 CFR 1910.120e, p, q
Occupational Safety and Health Administration (OSHA), Department of Labor (DOL) - Occupational Safety Health Standards - Hazardous Waste Operations and Emergency Response.

29 CFR 1926
Occupational Safety and Health Administration (OSHA), Department of Labor (DOL) - Safety and Health Regulations for Construction

32 CFR 229
Office of the Secretary of Defense - Protection of Archeological Resources: Uniform Regulations

32 CFR 651.18
Department of the Army - Environmental Analysis of Army Actions - Introduction.

33 CFR 153
Coast Guard (CG), Department of Homeland Security (DHS) - Control of Pollution by Oil and Hazardous Substances, Discharge Removal

33 CFR 154
CG, DHS - Facilities Transferring Oil or Hazardous Material in Bulk

33 CFR 159
CG, DHS - Marine Sanitation Devices

33 CFR 209
Corps of Engineers, Department of the Army, DOD - Administrative Procedure

33 CFR 320
Corps of Engineers, Department of the Army, DOD - General Regulatory Policies

36 CFR 60
National Park Service (NPS), Department of the Interior (DOI) - National Register of Historic Places

36 CFR 61
NPS, DOI - Procedures for State, Tribal, and Local Government Historic Preservation Programs

36 CFR 63
NPS, DOI - Determinations of Eligibility for Inclusion in the National Register of Historic Places

40 CFR 51
EPA - Requirements for the Preparation, Adoption, and Submittal of Implementation Plans

40 CFR 51.1
EPA - Requirements for the Preparation, Adoption, and Submittal of Implementation Plans - Who is Responsible for Actions Described in this Subpart?

40 CFR 51.307
EPA - Requirements for the Preparation, Adoption, and Submittal of Implementation Plans - New Source Review

40 CFR 63
EPA - National Emission Standards for Hazardous Air Pollutants for Source Categories.

40 CFR 68
EPA - Chemical Accident Prevention Provision

40 CFR 70
EPA - State Operating Permit Programs.

40 CFR 70.6
EPA - State Operating Permit Programs - Permit Content.

40 CFR 71
EPA - Federal Operating Permit Programs.

40 CFR 71.1
EPA - Federal Operating Permit Programs - Program Overview.

40 CFR 71.6
EPA - Federal Operating Permit Programs - Permit Content.

40 CFR 82
EPA - Protection of Stratospheric Ozone

40 CFR 112.3
EPA - Oil Pollution Prevention - Requirement to Prepare and Implement a Spill Prevention, Control, and Countermeasure Plan

40 CFR 112.4
EPA - Oil Pollution Prevention - Amendment of Spill Prevention, Control, and Countermeasure Plan by Regional Administrator.

40 CFR 112.5
EPA - Oil Pollution Prevention - Amendment of Spill Prevention, Control, and Countermeasure Plan by Owners or Operators.

40 CFR 112.7
EPA - Oil Pollution Prevention - General Requirements for Spill Prevention, Control, and Countermeasure Plans

40 CFR 112.8
EPA - Oil Pollution Prevention - Spill Prevention, Control, and Countermeasure Plan Requirements for Onshore Facilities (excluding production facilities).

40 CFR 112.20
EPA - Oil Pollution Prevention - Facility Response Plans.

40 CFR 112.21
EPA - Oil Pollution Prevention - Facility Response Training and Drills/Exercises.

40 CFR 122
EPA - EPA Administered Permit Programs: The National Pollutant Discharge Elimination System (NPDES).

40 CFR 122.26
EPA - EPA Administered Permit Programs - The National Pollutant Discharge Elimination System (NPDES) - Storm Water Discharges

40 CFR 123
EPA - State Program Requirements

40 CFR 125
EPA - Criteria and Standards for the National Pollution Discharge Elimination System (NPDES)

40 CFR 130.12
EPA - Water Quality Planning and Management - Coordination with Other Programs

40 CFR 136
EPA - Guidelines Establishing Test Procedures for the Analysis of Pollutants

40 CFR 140
EPA - Marine Sanitation Device Standard.

40 CFR 141
EPA - National Primary Drinking Water Regulations

40 CFR 141.28
EPA - National Primary Drinking Water Regulations - Certified Laboratories

40 CFR 142
EPA - National Primary Drinking Water Regulations Implementation

40 CFR 143
EPA - National Secondary Drinking Water Regulations

40 CFR 144
EPA - Underground Injection Control Program.

40 CFR 146
EPA - Underground Injection Control Program: Criteria and Standards

40 CFR 147
EPA - State Underground Injection Control Programs

40 CFR 148
EPA - Hazardous Waste Injection Restrictions

40 CFR 149
EPA - Sole Source Aquifers.

40 CFR 202
EPA - Motor Carriers Engaged in Interstate Commerce

40 CFR 204
EPA - EPA Noise Emission Standards for Construction Equipment

40 CFR 205
EPA - Transportation Equipment Noise Emission Controls

40 CFR 225
EPA - Dredged Material Permits

40 CFR 230
EPA - Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material.

40 CFR 239
EPA - Requirements for State Permit Program Determination of Adequacy

40 CFR 240
EPA - Guidelines for the Thermal Processing of Solid Wastes

40 CFR 243
EPA - Guidelines for the Storage and Collection of Residential, Commercial, and Institutional Solid Waste

40 CFR 246
EPA - Source Separation for Materials Recovery Guidelines

40 CFR 247
EPA - Comprehensive Procurement Guideline for Products Containing Recovered Materials.

40 CFR 257
EPA - Criteria for Classification of Solid Waste Disposal Facilities and Practices.

40 CFR 258
EPA - Criteria for Municipal Solid Waste Landfills.

40 CFR 262
EPA - Standards Applicable to Generators of Hazardous Waste

40 CFR 262.11
EPA - Standards Applicable to Generators of Hazardous Waste - Hazardous Waste Determination.

40 CFR 264.13
EPA - Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities - General Waste Analysis.

40 CFR 264
EPA - Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities

40 CFR 265
EPA - Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities

40 CFR 273
EPA - Standards for Universal Waste Management

40 CFR 280
EPA - Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST)

40 CFR 280.20
EPA - Technical Standards and Corrective Action Requirements for Owners and Operators of USTs - Performance Standards for New Underground Storage Tank Systems

40 CFR 280.43
EPA - Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks - Methods of Release Detection for Tanks

40 CFR 300.120
EPA - National Oil and Hazardous Substance Pollution Contingency Plan - On-scene Coordinators and Remedial Project Managers: General Responsibilities

40 CFR 300.125
EPA - National Oil and Hazardous Substance Pollution Contingency Plan - Notification and Communications

40 CFR 300.155
EPA - National Oil and Hazardous Substance Pollution Contingency Plan - Public Information and Community Relations

40 CFR 300.211
EPA - National Oil and Hazardous Substance Pollution Contingency Plan - Facility and Vessel Response Plans

40 CFR 300.425
EPA - National Oil and Hazardous Substance Pollution Contingency Plan - Establishing Remedial Priorities

40 CFR 372
EPA - Toxic Chemical Release Reporting: Community Right-to-Know

40 CFR 503
EPA - Standards for the Use or Disposal of Sewage Sludge

40 CFR 761
EPA - Polychlorinated Biphenyls (PCB) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions.

40 CFR 761.20
EPA - Polychlorinated Biphenyls (PCB) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions - Prohibitions and Exceptions.

40 CFR 761.60b
EPA - Polychlorinated Biphenyls (PCB) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions - Disposal Requirements.

40 CFR 761.202
EPA - Polychlorinated Biphenyls (PCB) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions - EPA Identification Numbers.

40 CFR 761.205
EPA - Polychlorinated Biphenyls (PCB) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions - Notification of PCB Waste Activity (EPA Form 7710–53)

40 CFR 763
EPA - Asbestos

40 CFR 763.87
EPA - Asbestos - Analysis

43 CFR 5
Subtitle A - Office of the Secretary of the Interior - Making Pictures, Television Productions or Sound Tracks on Certain Areas Under the Jurisdiction of the Department of the Interior

43 CFR 6
Subtitle A - Office of the Secretary of the Interior - Patent Regulations

43 CFR 7
Subtitle A - Office of the Secretary of the Interior - Protection of Archaeological Resources

48 CFR 6
Federal Acquisition Regulations - Competition Requirements

49 CFR 106
Pipeline and Hazardous Materials Safety Administration, Department of Transportation - Rulemaking Procedures

49 CFR 130
Pipeline and Hazardous Materials Safety Administration, Department of Transportation - Oil Spill Prevention and Response Plans

49 CFR 171
Pipeline and Hazardous Materials Safety Administration, Department of Transportation - Subtitle B - Other Regulations Relating to Transportation - General information, regulations, and definitions

49 CFR 172
Pipeline and Hazardous Materials Safety Administration, Department of Transportation - Subtitle B - Other Regulations Relating to Transportation - Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements

49 CFR 173
Pipeline and Hazardous Materials Safety Administration, Department of Transportation - Subtitle B - Other Regulations Relating to Transportation - Shippers—General Requirements for Shipments and Packagings

49 CFR 174
Pipeline and Hazardous Materials Safety Administration, Department of Transportation - Subtitle B - Other Regulations Relating to Transportation - Carriage by Rail

49 CFR 175
Pipeline and Hazardous Materials Safety Administration, Department of Transportation - Subtitle B - Other Regulations Relating to Transportation - Carriage by Aircraft

49 CFR 176
Pipeline and Hazardous Materials Safety Administration, Department of Transportation - Subtitle B - Other Regulations Relating to Transportation - Carriage by Vessel

49 CFR 177
Pipeline and Hazardous Materials Safety Administration, Department of Transportation - Subtitle B - Other Regulations Relating to Transportation - Carriage by Public Highway

49 CFR 178
Pipeline and Hazardous Materials Safety Administration, Department of Transportation - Subtitle B - Other Regulations Relating to Transportation - Specifications for Packagings

50 CFR 222
National Marine Fisheries Service, National Oceanic and Atmospheric Administration (NOAA), Department of Commerce (DOC) - General Endangered and Threatened Marine Species

50 CFR 402.06
Endangered Species Act of 1973, as amended - Coordination with Other Environmental Reviews.

50 CFR 402.10
Endangered Species Act of 1973, as amended - Conference on Proposed Species or Proposed Critical Habitat

65 FR 62565–62572
Unified Federal Policy for a Watershed Approach to Federal Land and Resource Management, 18 Oct 2000 (Available at www.epa.gov/Fedrgstr/search/html.)

31 USC 1341
Anti-Deficiency Act

33 USC 401
Saint Lawrence Seaway Development Corporation, Department of Transportation - Seaway Regulations and Rules

42 USC 300g–8
The Public Health and Welfare - National Drinking Water Regulations

42 USC 4331
National Environmental Policy - Congressional Declaration of National Environmental Policy

42 USC 9613
Comprehensive Environmental Response, Compensation, and Liability - Civil Proceedings

42 USC 9617
Comprehensive Environmental Response, Compensation, and Liability - Public Participation

42 USC 9620
Comprehensive Environmental Response, Compensation, and Liability - Federal Facilities

42 USC 9620h
Comprehensive Environmental Response, Compensation, and Liability - Property Transferred by Federal Agencies

49 USC 5102
Transportation - Hazardous Material Transportation Act

50 USC 1521
Lethal Chemical Agents and Munitions

Section III
Prescribed Forms
This section contains no entries.

Section IV
Referenced Forms

DA Forms are available on the Army Publishing Directorate Web site www.apd.army.mil: DD Forms are available from OSD Web site http://www.dtic.mil/whs/directives/infomgt/forms/formsprogram.htm.)

DA Form 11–2–R
Management Control Evaluation Certification Statement

DD Form 1391
FY_ Military Construction Project Data

Appendix B
Installation Management Control Evaluation Checklist

B–1. Function.
The function covered by this checklist is Environmental Management.

B–2. Purpose.
The purpose of this checklist is to assist installation managers and staff in evaluating the key management controls listed below. It is not intended to cover all controls. The garrison commander (GC) or designated representative(s) will perform this checklist.

B–3. Instructions.
Answers must be based on the actual testing of Key management controls (for example, document analysis, direct observation, sampling simulation, other). Answers which indicate deficiencies must be explained and corrective action indicated in supporting documentation. These management controls must be evaluated at least every five years. Certification that this evaluation has been conducted must be accomplished on DA Form 11–2–R, Management Control Evaluation Certification Statement.

B–4. Test Questions.
a. Program Performance.

(1) Does the installation have an Environmental Quality Control Committee (EQCC), formally constituted and chaired by the garrison commander (GC), which provides a forum to enhance, address and resolve environmental issues?

(2) Is a multidisciplinary program in place to identify and proactively control environmental risks?

(3) Does the installation have pollution prevention policies and programs in place and operating to reduce pollution through source reduction, reuse, recycling, or energy/water use reduction?

(4) Does the installation have the requisite plans in place required by environmental permits?

(5) Are all personnel (including appointed environmental officers) trained and equipped sufficiently to execute their duties in an environmentally safe and compliant manner and to respond properly in case of environmental emergency?

(6) Are problems that are identified through internal audits, complaints, spills or enforcement actions (ENFs) investigated to determine systemic causes and promptly corrected? (PD/LD: DASA (ESOH) directive, 13 July 2001, and EO 13423)

(7) Does the installation have an installation internal assessment plan (IIAP)? (PD/LD: DASA (ESOH) directive, 13 July 2001, and EO 13423)

(8) Is the IIAP updated annually and included in the documentation of the installation Environmental Management System (EMS)? (PD/LD: DASA (ESOH) directive, 13 July 2001, EO 13423, and AR 11–2)

b. Environmental Condition.

(1) Are all solid waste streams systematically characterized to determine if they are hazardous? Is the basis for the determination (i.e. generator knowledge or analytical results) documented and the waste disposed of properly?

(2) Are all unit projects, activities and work requests coordinated with the environmental officer?

(3) Is adequate National Environmental Policy Act (NEPA) documentation routinely prepared and considered as an integral part of the planning process (NOTE: Overseas installations should follow the Environmental Review Guide (ERG) since NEPA does not apply overseas.)?

(4) Are Environmental Performance Assessment System (EPAS) evaluations and the corrective actions in the installation corrective action plan (ICAP) completed in a timely manner?

(5) Are deficiencies identified in the ICAP that require funds forwarded to the responsible proponent for inclusion in appropriate programming and budgeting documents?

c. Mission Impact.

(1) Are management practices in place in order to improve the C-rating of mission critical environmental areas?

(2) Does top management (that is, GC, EQCC) periodically review the IIAP?

(3) Does top management review the open findings in the ICAP and ensure that adequate efforts are being made to close them?

d. Compliance.

(1) Are required reports and records complete and accurate? Is required reporting submitted to regulators in a timely and accurate manner? Is required reporting submitted to higher headquarters in a timely and accurate manner? Does the installation and the higher headquarters review and approve environmental data reported to HQDA?

(2) Are physical inspections conducted on a regular basis? Do they detect environmental problems and are they tracked to ensure corrective action? Are environmental compliance deficiencies recorded in the ICAP?

B–5. Supersession.
This checklist replaces the checklist published in AR 200–1, dated 21 February 1997.

B–6. Comments.
Help make this a better tool for evaluating management controls. Submit comments to HQDA, Director of Environmental Programs (DEP), 600 Army Pentagon, Washington, DC 20310–0600.

Glossary

Section I
Abbreviations

AAE
Army Acquisition Executive

AAFES
Army and Air Force Exchange Service

AAP
Army alternate procedures

AC
hydrogen cyanide

ACHP
Advisory Council on Historic Preservation

ACOM
Army Command

ACP
Army cost position

ACSIM
Assistant Chief of Staff for Installation Management

ACUB
Army Compatible Use Buffer

ADCON
administrative control

ADNL
A-weighted day-night level

ADUSD (E)
Assistant Deputy Undersecretary of Defense (Environment) - now ADUSD (ESOH)

ADUSD (ESOH)
Assistant Deputy Undersecretary of Defense (Environment, Safety, and Occupational Health)

AECS
Army Environmental Cleanup Strategy

AEDB
Army Environmental Data Base

AEDB–CC
Army Environmental Data Base - Compliance-Related Cleanup

AEDB–EQ
Army Environmental Data Base - Environmental Quality

AEDB–R
Army Environmental Data Base - Restoration

AEP
Army Environmental Program

AEPI
Army Environmental Policy Institute

AERO
Army Environmental Reporting Online

AERTA
Army Environmental Requirements Technology Assessment

AFH
Army Family Housing

AFJMAN
Air Force Joint Manual

AFPMB
Armed Forces Pest Management Board

AHERA
Asbestos Hazard Emergency Response Act

AHPA
Archeological and Historical Preservation Act

AIRFA
American Indian Religious Freedom Act

AKM
Army Knowledge Management

ALT
Acquisition, logistics, and technology

AMC
Army Materiel Command

AMEDD
Army Medical Department

ANSI
American National Standards Institute

APP
Affirmative Procurement Program

AR
Army regulation

ARIMS
Army Records Information Management System

ARNG
Army National Guard

AROC
Army Requirements Oversight Council

ARPA
Archeological Resources Protection Act

ARSIC
Army Range Sustainment Integration Council

ARSTAF
Army staff

ASA
Assistant Secretary of the Army

ASA (ALT)
Assistant Secretary of the Army (Acquisition, Logistics and Technology)

ASA (FM&C)
Assistant Secretary of the Army (Financial Management & Comptroller)

ASA (I&E)
Assistant Secretary of the Army (Installations and Environment)

ASARC
Army System Acquisition Review Council

ASARCCT
Army System Acquisition Review Council Coordination Team

ASC
Army senior consultant

ASCC
Army Service Component Command

ASEL
a-weighted sound exposure level

ASSON
aerial spray statement of need

AST
aboveground storage tank

ATEC
Army Test and Evaluation Command

ATSDR
Agency for Toxic Substances and Disease Registry

AWCF
Army Working Capital Fund

BCA
Base Closure Account

BCP
base realignment and closure cleanup plan

BD/DR
building demolition/debris removal

BMP
best management practice

BO
biological opinion

BOD
board of directors

BOS
base operations support

BRAC
base realignment and closure

BRAC
Base Closure and Realignment Commission

BT
Business Transformation

CA
Comprehensive Agreement

CA
Cooperative Agreement

CAA
Clean Air Act

CAIS
chemical agent identification set

CAR
Chief, Army Reserve

CBTDEV
combat developer

CC
compliance–related cleanup

CCMB
Configuration Control Management Board

CCR
Consumer Confidence Report

CEGS
Corps of Engineers guide specification

CERCLA
Comprehensive Environmental Response, Compensation, and Liability Act

CERFA
Community Environmental Response Facilitation Act

CEP
Chief of Environmental Programs

CFR
Code of Federal Regulations

CG
Carbonyl dichloride (phosgene)

CG
commanding general

CIO
Chief Information Officer

CK
cyanogen chloride

CN
w-chloroacetophenone

CONUS
continental United States

CPA
Chief of Public Affairs

CRB
Cost Review Board

CRM
cultural resources manager

CRP
community relations plan

CS
o-chlorobenzylidenemalononitrile (tear gas)

CSEL
c-weighted sound exposure level

CW
civil works

CWA
Clean Water Act

CWM
chemical warfare materiel

CWS
community water system

DA
Department of the Army

DA PAM
Department of the Army pamphlet

DARNG
Director, Army National Guard

DASA (ESOH)
Deputy Assistant Secretary of the Army (Environment, Safety, and Occupational Health)

dB
decibel

DC
District of Columbia

DCS
Deputy Chief of Staff

DD
decision document

DeCA
Defense Commissary Agency

DENIX
Defense Environmental Network and Information Exchange

DEP
Director of Environmental Programs

DERP
Defense Environmental Restoration Program

DFAS
Defense Finance and Accounting Service

DHP
Defense Health Program

DLAPS
Defense Logistics Agency Publishing System

DMM
discarded military munitions

DNL
day-night level

DOD
Department of Defense

DODD
Department of Defense Directive

DODI
Department of Defense Instruction

DOI
Department of the Interior

DPTMS
Directorate of Plans, Training, Mobilization, and Security

DRMO
Defense Reutilization and Marketing Office

DRMS
Defense Reutilization and Marketing Service

DRU
Direct Reporting Unit

DSMOA
Defense and State Memoranda of Agreement

DUSD
Deputy Under Secretary of Defense

EA
executive agent or environmental assessment or enterprise architecture

ECP
Environmental Condition of Property

EIS
Environmental Impact Statement

EITM
Environmental Information Technology Management

ELD
Environmental Law Division

EL/RAMP
Environmental Legislative/Regulatory Analysis and Monitoring Program

EM
engineer manual

EMS
Environmental Management System

ENF
enforcement action

EO
executive order or environmental officer

EOD
explosive ordnance disposal

EP
engineer publication

EPA
Environmental Protection Agency

EPAR
Environmental Performance Assessment Report

EPAS
Environmental Performance Assessment System

EPCRA
Emergency Planning and Community Right-to-Know Act

EQCC
Environmental Quality Control Committee

EQIA
Environmental Quality Impact Analysis

EQLCCE
Environmental quality life cycle cost estimate

EQT
Environmental Quality Technology

ER
engineer regulation

ER, A
Environmental Restoration, Army

ER, F
Environmental Restoration, FUDS

ERDC
Engineer Research and Development Center

ERIS
Environmental Restoration Information System

ERP
Environmental Restoration Program

ESA
Endangered Species Act

ESMC
Endangered Species Management Component

ESO
Environmental Support Office

ESTCP
Environmental Security Technology Certification Program

ETTC
Environmental Technology Technical Council

FAD
Funding authorization document

FDE
Findings and Determination of Eligibility

FFCA
Federal Facilities Compliance Act

FGS
Final Governing Standards

FIFRA
Federal Insecticide, Fungicide, and Rodenticide Act

FM
field manual

FMR
financial management regulation

FOA
field operating agency

FOIA
Freedom of Information Act

FORSCOM
Forces Command

FOSET
finding of suitability for early transfer

FOSL
finding of suitability to lease

FOST
finding of suitability to transfer

FOTW
Federally-owned treatment works

FOUO
for official use only

FUDS
formerly used defense sites

FUDSMIS
Formerly Used Defense Sites Management Information System

FWPCA
Federal Water Pollution Control Act

FY
fiscal year

GC
garrison commander

GOCO
government-owned, contractor-operated

GPP
Green Procurement Program

GSA
General Services Administration

HAP
hazardous air pollutant

HDBK
Handbook

HM
hazardous material

HMMP
Hazardous Materials Management Program

HN
host nation

HPC
historic property component

HQ
Headquarters

HQDA
Headquarters, Department of the Army

HQ IMCOM
Headquarters, Installation Management Command

HSMS
Hazardous Substance Management System

HSSA
health service support area

HSWA
Hazardous and Solid Waste Amendments

HTRW
hazardous, toxic, and radioactive waste

HW
hazardous waste

IAP
installation action plan

IC
installation commander

ICAP
installation corrective action plan

ICE
independent cost estimate

ICRMP
integrated cultural resources management plan

IDN
initial distribution number

IIAP
installation internal assessment plan

II PEG
Installations Program Evaluation Group

IMCOM
Installation Management Command

INPR
inventory project report

INRMP
integrated natural resources management plan

IPM
integrated pest management

IPMC
integrated pest management coordinator

IPMP
integrated pest management plan

IPR
in-progress review

IR
installation restoration

IR
interim reference

IRP
Installation Restoration Program

ISMC
invasive species management component

ISO
International Organization for Standardization

ISR
installation status report

ISSA
Installation Services Support Agreement

IT
information technology

ITAM
Integrated Training Area Management

IWFMP
integrated wildland fire management plan

JCS
Joint Chiefs of Staff

JFLCC
Joint Forces Land Component Command

JP
joint publication

JTF
Joint Task Force

KISE
known and imminent substantial endangerment

LBP
lead-based paint

LD
legal driver

LCTA
land condition trend analysis

LEPC
Local Emergency Planning Committee

LLRW
low-level radioactive waste

LTR
letter

LUC
land use control

LUPZ
land use planning zone

MACT
maximum achievable control technology

MAIS
Major Automated Information System

MAP
management action plan

MBTA
Migratory Bird Treaty Act

MC
munitions constituents

MCA
Military Construction, Army

MCAR
Military Construction, Army Reserve

MCNG
Military Construction, National Guard

MDAP
Major Defense Acquisition Program

MEC
Munitions and explosives of concern

MEDCEN
medical center

MEDCOM
Army Medical Command

MEDDAC
medical department activity

MIDI
Military Item Disposal Instructions

MIL
military

MMRP
Military Munitions Response Program

MOA
memorandum of agreement

MOM
measure of merit

MOU
memorandum of understanding

MPRSA
Marine Protection, Research, and Sanctuaries Act

MS4
Municipal Separate Stormwater Sewer System

MSC
major subordinate command

MSWLF
municipal solid waste landfill

MTOE
modified tables of organization and equipment

MWR
morale, welfare, and recreation

NAF
non-appropriated fund

NAGPRA
Native American Graves Protection and Repatriation Act

NDAA
National Defense Authorization Act

NDCEE
National Defense Center for Environmental Excellence

NEPA
National Environmental Policy Act

NESHAP
National Emissions Standards for Hazardous Air Pollutants

NFES
National Fire Equipment System

NFPA
National Fire Protection Association

NGB
National Guard Bureau

NGB–ARNG
National Guard Bureau - Army National Guard

NGB–DARNG
National Guard Bureau - Director, Army National Guard

NHPA
National Historic Preservation Act

NLR
noise level reduction

NOAA–Fisheries
National Oceanic and Atmospheric Administration - Fisheries

NPDES
National Pollutant Discharge Elimination System

NPL
National Priorities List

NPS
National Park Service

NRC
National Response Center

NRCS
Natural Resources Conservation Service

NRHP
National Register of Historic Places

NRT
National Response Team

NTNCWS
Non-Transient Non-Community Water System

OACSIM
Office of the Assistant Chief of Staff for Installation Management

OASA (ALT)
Office of the Assistant Secretary of the Army (Acquisition, Logistics, and Technology)

OASA (I&E)
Office of the Assistant Secretary of the Army (Installations and Environment)

OCONUS
outside the continental United States

ODEP
Office of the Director of Environmental Programs

ODS
ozone depleting substances

OEBGD
Overseas Environmental Baseline Guidance Document

OEESCM
Operational and Environmental Executive Steering Committee on Munitions

OIPT
Overarching Integration Process Team

OMB
Office of Management and Budget

OPA
Oil Pollution Act

OPLAN
operation plan

OPORD
operation order

OPTEMPO
operating tempo

OPTS
Office of Pesticides and Toxic Substances

ORV
off-road vehicle

OSC
on-scene coordinator

OSD
Office of the Secretary of Defense

OSHA
Occupational Safety and Health Act or Occupational Safety and Health Administration

OTJAG
Office of the Judge Advocate General

PA
programmatic agreement

PAA
procurement Army ammunition

PAM
pamphlet

PAO
Public Affairs Office

PCB
polychlorinated biphenyl

PD
policy decision

Pk
peak sound pressure level

PL
public Law

PLANTS
Plant List of Accepted Nomenclature, Taxonomy, and Symbols

PLS
Planning Level Survey

PMP
program management plan

PMS
Publications Management System

POL
petroleum, oil, lubricants

POM
program objective memorandum

POTW
publicly-owned treatment works

PPA
Pollution Prevention Act

PPBE
planning, programming, budgeting, and execution

PPMP
professional pest management personnel

PSD
prevention of significant deterioration

QA/QC
quality assurance/quality control

RAB
Restoration Advisory Board

RCRA
Resource Conservation and Recovery Act

RCS
Reports Control System

RDT&E
research, development, test, and evaluation

RDX
cyclotrimethylenetrinitramine

READ
Repository of Environmental Army Documents

REC
regional environmental coordinator

REO
regional environmental office

RFP
request for proposal

RMIS
Restoration Management Information System

RMP
risk management plan

RMW
regulated medical waste

ROA
reports of availability

ROD
record of decision

RPMP
real property master plan

RPTS
Reimbursable Programs Tracking System

RRC
Regional Readiness Command

RRC
Reserve Readiness Command

RRSC
Regional Readiness Support Command

RRT
Regional Response Team

RTLA
range and training land assessment

RTLP
Range and Training Lands Program

SA
Secretary of the Army

SARA
Superfund Amendments and Reauthorization Act

SB
supply bulletin

SCP
spill contingency plan

SDD
sustainable design and development

SDWA
Safe Drinking Water Act

SDWAA
Safe Drinking Water Act Amendments

SEP
supplemental environmental project

SERC
State Emergency Response Commission

SERDP
Strategic Environmental Research and Development Program

SESCC
Soil Erosion and Sediment Control Component

SHPO
State historic preservation officer

SMC
senior mission commander

SOFA
Status of Forces Agreement

SPCC
spill prevention, control and countermeasures

SPCCP
spill prevention, control, and countermeasures plan

SPiRiT
sustainable project rating tool

SRP
Sustainable Range Program

STC
Sound Transmission Class

std
standard

SWARS
Solid Waste Annual Reporting System

SWPPP
stormwater pollution prevention plan

T&E
threatened and endangered

TAG
The Adjutant General

TB
technical bulletin

TB MED
technical bulletin, medical

TC
training circular

TDA
tables of distribution and allowances

TG
technical guide

TJAG
The Judge Advocate General

TM
technical manual

TMDL
total maximum daily load

TNCWS
Transient Non-Community Water System

TNT
trinitrotoluene

TO&E
table of organization and equipment

TRADOC
Training and Doctrine Command

TRC
Technical Review Committee

TRI
toxic release inventory

TSCA
Toxic Substances Control Act

TSG
The Surgeon General

TWCF
transportation working capital funds

USACE
U.S. Army Corps of Engineers

USACHPPM
U.S. Army Center for Health Promotion and Preventive Medicine

USAEC
U.S. Army Environmental Command

USAES
U.S. Army Engineer School

USC
United States Code

USCG
U.S. Coast Guard

USDA
U.S. Department of Agriculture

USFWS
U.S. Fish and Wildlife Service

USGS
U.S. Geological Survey

UST
underground storage tank

UXO
unexploded ordnance

VOC
volatile organic compound

WMM
waste military munitions

Section II
Terms

Acquisition, Real Estate
Obtain, use, or control real property by purchase, condemnation, donation, exchange, easement, license, lease, permit, revestment and recapture as defined in AR 405–10.

Acquisition, Life Cycle
Applies to processes and procedures by which defense services identify requirements; conduct research, development, test and evaluation; develop logistics support; field and ultimately dispose of materiel systems and equipment; and upgrade existing systems/equipment.

Action
All activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies in the United States or upon the high seas.

Action area
All areas to be affected, directly or indirectly, by the Federal agency action and not merely the immediate area involved in the action.

Activity
A unit, organization, or installation that performs a function or mission.

Adverse effect (under NHPA)
A harmful or detrimental change in the character or use of historic properties. Adverse effects include, but are not

limited to, physical destruction, damage, or alteration; isolation from or alteration of the setting; introduction of visual, audible, or atmospheric elements that are out of character; neglect; and transfer, lease, or sale of historic property.

Aerial Spray Statement of Need
A formal document prepared by DOD pest management consultant with certification in DOD Category 11, Aerial Application. If this document states that the proposed project is justified, preparation of an environmental assessment or environmental impact statement (EIS) is initiated and prepared.

Agency official (under NAGPRA)
Any individual authorized by delegation of authority within a Federal agency to perform the duties relating to these regulations (43 CFR 10). (43 CFR 10.2 (a)(2)) For Army installations the garrison commander (GC) serves as the agency official under NAGPRA.

Agricultural lease or outlease
Use of Army lands under a lease to an agency, organization, or person for growing crops or grazing animals.

Appropriate facilities
For purposes of EMS implementation, appropriate facilities are defined as the Army major installations identified by ACSIM as having operations and activities with the potential to significantly impact human health and/or the environment. Appropriate facilities must fully comply with EMS implementation requirements specified in this regulation. ACSIM will periodically update the appropriate facilities listing and promptly advise those installations that are added or removed.

Archaeological resource (under ARPA)
Any material of human life or activities that is at least 100 years of age, and which is of archaeological interest.

Army alternate procedures (AAP)
Procedures that Army installations and facilities may elect to follow in lieu of Advisory Council on Historic Preservation (ACHP) regulations to comply with the goals and mandates of the National Historic Preservation Act (NHPA) Section 106.

Army Command (ACOM)
An Army force, designated by the Secretary of the Army, performing multiple Army Service Title 10 functions (3013b) across multiple disciplines. Command responsibilities are those established by the Secretary and normally associated with administrative control (ADCON).

Army compatible use buffer (ACUB)
Formal agreements between Army and eligible entities for acquisition by the entities of land or interest in land and water rights from willing sellers. Formal agreements include limiting encroachment through acquisition of development rights, cooperative agreements (CAs), conservation easements, and other means to support land acquisition or affect land use in accordance with applicable laws. Development and implementation of an ACUB does not constitute an acquisition of real property. Land conveyances for conservation may supplement ACUBs. Authority is 10 USC 2684a and 2694a.

Army proponent
The Army unit, element, or organization responsible for initiating or carrying out the proposed action.

Army Senior Consultant
The individual designated by the DEP, who serves as the senior Army staff officer for technical guidance and management of the Army Pest Management Program and as ACSIM representative to the Executive Council of the Armed Forces Pest Management Board.

Army Service Component Command (ASCC)
An Army force, designated by the Secretary of the Army, comprised primarily of operational organizations serving as an Army component for a combatant commander. If designated by the combatant commander, serves as a Joint Forces Land Component Command (JFLCC) or Joint Task Force (JTF). Command responsibilities are those established by the Secretary and normally associated with operational control (OPCON) and administrative control (ADCON).

Best management practice
Best management practices are methods that have been determined to be the most effective and practical means of preventing or reducing pollution and/or environmental impacts.

Biological assessment
Information prepared by or under the direction of a Federal agency using the procedures in 50 CFR 402.12 concerning listed and proposed species and designated and proposed critical habitat that may be present in the action area and the evaluation of potential effects of the action on such species and habitat.

Biological diversity
The variety of life and its processes. It includes the variety of living organisms, the genetic differences among them, and the communities and ecosystems in which they occur.

Biological evaluation
A written document setting forth an installation's biologically supportable rationale for determining the affects an action will have on a listed or proposed species or critical habitat. A biological evaluation is an informal document and is used for actions only if a biological assessment is not required.

Biological opinion (BO)
The document that states the opinion of the U.S. Fish and Wildlife Service (USFWS) or National Oceanic and Atmospheric Administration (NOAA) - Fisheries as to whether or not the Federal agency action is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat; a summary of the information on which the opinion is based and a detailed discussion of the effects of the action on listed species or designated critical habitat.

Candidate species
(see species designations)

Certification as pesticide applicator
The formal recognition of training and competency to perform pesticide applications per the DOD Instruction and Plan. DOD employees certified per the DOD Plan can, without obtaining additional State certification, use and supervise the use of restricted-use pesticides while engaged in performing their official duties.

Certification official (pesticide applicators)
The DOD professional pest management personnel (PPMP) who reviews and validates the qualifications of DOD pesticide applicators to meet the standards in the DOD Plan. In the Army, certification officials are nominated by the ASC through the DEP, for approval by the Executive Director, AFPMB. See Pest management consultant.

Certified pesticide applicator
Any individual who applies pesticides or supervises the use of pesticides by others and who has been authorized to do so by successfully completing a training program approved by the Environmental Protection Agency (EPA), followed by formal certification by DOD, State or for overseas, by the Installation Management Command (IMCOM) certification official.

Chemical warfare agent
A substance which, because of its chemical properties, is used in military operations or terrorist attacks to kill, seriously injure, or incapacitate humans or animals or deny use of water, food supplies, and/or other indigenous resources to combatants or civilian populations. Some types of pesticides and herbicides (especially organophosphate-based substances) were initially developed and tested for use as chemical warfare agents, and only later adapted for non-military and agricultural applications. Chemical warfare agents are the V- and G-series nerve agents; H-series (that is, "mustard" agents) and L-series (that is, lewisite) blister agents; and certain industrial chemicals, including: hydrogen cyanide (AC), cyanogen chloride (CK), or carbonyl dichloride (called phosgene or CG)), when contained in a military munition. Chemical warfare agents do not include: riot control agents (for example, w-chloroacetophenone (CN); o-chlorobenzylidenemalononitrile ((CS) tear gas); chemical herbicides; smoke or incendiary compounds; and industrial chemicals that are not configured as a military munition.

Chemical warfare materiel
Items generally configured as a munition containing a chemical substance that is intended to kill, seriously injure, or incapacitate a person through its physiological effects. CWM includes V- and G-series nerve agent; H-series (mustard) and L-series (lewisite) blister agent, in other-than-munition configuration; and certain industrial chemicals (for example, hydrogen cyanide (AC), cyanogen chloride (CK), or carbonyl dichloride (called phosgene or CG)) configured as a

military munition. Due to their hazards, prevalence, and military-unique application, chemical agent identification sets (CAIS) are also considered CWM. CWM does not include: riot control agents; chemical herbicides; industrial chemicals (for example, AC, CK, or CG) not configured as a munition; smoke and flame producing items; or soil, water, debris or other media contaminated with chemical warfare agents.

Class I and Class II ozone depleting substances (ODS)
Class I ODS have a greater ozone-depletion potential than Class II ODS. Class II ODS are generally considered safer than Class I ODS. Class I and Class II are defined in the Clean Air Act (CAA) Amendments of 1990. (See 40 CFR 82, Appendix A and B).

Command
A unit or units, an organization, or an area under the command of one individual.

Community water system
A public water system that supplies water to the same population year-round.

Compliance agreement
Any negotiated agreement between regulatory officials and regulatee for the purpose of attaining or maintaining compliance. Regulatee must have participated and influenced the terms of the agreement.

Compliance-related cleanup
Compliance-related cleanup (CC) includes actions to address contamination at Army facilities overseas; contamination resulting from operations that have occurred since October 1986 (i.e., non-DERP) at Army Active, Excess, and Special installations, and Army National Guard (ARNG) Federally-owned facilities; and contamination at Non-Federally owned, Federally-supported ARNG facilities. As a key element of the broader Army Environmental Cleanup Strategy (AECS) and its associated Environmental Cleanup Strategic Plan, the CC mission at Army installations and facilities is to perform appropriate, cost-effective cleanup to protect human health, safety, and the environment, and to sustain operational readiness and training. Specifically, for overseas facilities, the CC mission is to address contamination that resulted from Army operations, presents a known imminent and substantial endangerment to human health and safety, and is located on or emanates from an Army facility. The CC Guidance Manual, September 2004, provides specific guidance on CC procedures and project eligibility.

Comprehensive agreement (under NAGPRA)
Agreements developed regarding the treatment and disposition of human remains, funerary objects, sacred objects, or objects of cultural patrimony excavated intentionally or discovered inadvertently on Federal lands.

Conference
The process which involves informal discussions between a Federal agency and the USFWS or NOAA–Fisheries regarding the impact of an action on proposed species or proposed critical habitat and recommendations to minimize or avoid the adverse effects.

Conservation
The wise use and scientific management of natural and cultural resources according to principles that provide optimum public benefit, continued productivity and sustainability for present and future generations, and support of the military mission.

Conservation law enforcement professional
A DOD law enforcement professional with additional training in natural resources and Archaeological Resources Protection Act (ARPA) law enforcement training.

Conservation Reimbursable and Fee Collection Programs
Includes the Army’s proceeds generating Forestry, Fish and Wildlife, and Agricultural/Grazing Outlease programs.

Conserve/conservation (of species)
To use and the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to 16 USC Chapter 35 (ESA) are no longer necessary.

Construction
Any land-disturbing activity.

Consumer Confidence Report
A water quality report provided to consumers annually, as required under 40 CFR 141, Subpart O. All community water systems (CWS) are required to prepare and distribute annual CCRs that briefly summarize information regarding water sources, detected contaminants, compliance, and educational information.

Contaminant
An undesirable substance (physical, chemical, biological, or radiological) not normally present, or an unusually high concentration of a naturally occurring substance in water or soil.

Contingency plan
A document setting out an organized, planned, and coordinated course of action to be followed in case of a fire, explosion, or other accident that releases toxic chemicals, hazardous waste (HW), or radioactive materials that threaten human health or the environment.

Continual improvement
The process of enhancing the environmental management system to achieve improvements in overall environmental performance in line with the organization's environmental policy.

Critical habitat
Specific areas within the geographical area occupied by the species at the time it is listed in accordance with 16 USC Chapter 35 (ESA), on which are found those physical or biological features (1) essential to the conservation of the species, and (2) which may require special management considerations or protection. It also includes specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the 16 USC Chapter 35 (ESA), upon a determination by the Secretary of Interior or Commerce that such areas are essential for the conservation of the species. The areas formally designated as critical habitat by the USFWS or NOAA–Fisheries and listed in 50 CFR 17 and 226.

Cultural resources
Historic properties as defined by the NHPA, cultural items as defined by NAGPRA, archeological resources as defined by ARPA, sacred sites as defined in EO 13007 to which access is afforded under AIRFA, significant paleontological items as described by 16 USC 431–433 (Antiquities Act of 1906), and collections and associated records as defined in 36 CFR 79.

Curation
An integral element of the archaeological process that refers to the long term management and preservation of archaeological materials and their associated documentation.

Destruction or adverse modification
The direct or indirect alteration that appreciably diminishes the value of critical habitat for both the survival and recovery of a listed species. Such alterations include, but are not limited to, alterations adversely modifying any of those physical or biological features that were the basis for determining T&E habitat to be critical.

Direct Reporting Unit (DRU)
An Army organization comprised of one or more units with institutional or operational functions, designated by the Secretary of the Army, providing broad general support to the Army in a normally single, unique discipline not otherwise available elsewhere in the Army. DRUs report directly to a Headquarters, Department of the Army principal and/or Army Command and operate under authorities established by the Secretary of the Army.

Discarded military munitions
Military munitions that have been abandoned without proper disposal or removed from storage in a military magazine or other storage area for the purpose of disposal. The term does not include unexploded ordnance (UXO), military munitions that are being held for future use or planned disposal, or military munitions that have been properly disposed of consistent with applicable environmental laws and regulations. (10 USC 2710(e)(2)).

Discharge
A term that includes the accidental or intentional spilling, leaking, pumping, pouring, emitting, emptying, or dumping of a substance into or on any land or water (40 CFR 260.10).

Discharge classifications (for oil)
The classifications of accidental discharges listed below, provided to guide the on-scene coordinator (OSC), are criteria for general response actions. They are not criteria for reporting, nor do they imply associated degrees of hazard to the

public health or welfare, nor are they measures of environmental damage. However, a discharge that is a substantial threat to the public health or welfare, or results in critical public concern, will be classed as a major discharge. Discharges are quantitatively measured as follows:

a. Minor discharge: A discharge to the inland waters or less than 1,000 gallons of oil; or a discharge of less than 10, 000 gallons of oil to the coastal waters.

b. Medium discharge: A discharge of 1,000 gallons to 10,000 gallons of oil to the inland waters, or a discharge of 10,000 to 100,000 gallons of oil to coastal waters.

c. Major discharge: A discharge of more than 10,000 gallons of oil to the inland waters, or more than 100,000 gallons of oil to the coastal waters.

Disposal (real property)
Any authorized method of permanently divesting DA of control of and responsibility for real property. Reference AR 405–90 for definition of real property.

Disposal (waste)
The discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or HW into or on any land or water. The act is such that the solid waste or HW, or any constituent thereof, may enter the environment or be emitted into the air or discharged into any waters, including ground water (40 CFR 260.10).

Domestic sewage
Waste and wastewater from humans or from household operations that are discharged to or otherwise enter treatment works.

Ecosystem sustainability
A condition of living communities that meets, or can be manipulated to meet, current mission, compliance, stewardship and production needs without compromising the future ability to meet those needs. Compliance and stewardship include the protection of all resources, especially soil, water, threatened and endangered (T&E) species, and wildlife.

Effect (under NHPA)
Alteration to the characteristics of a historic property qualifying it for inclusion in or eligibility for the National Register.

Effluent limitation
Any restriction established by the EPA on quantities, rates, and concentrations of chemical, physical, biological and other constituents which are discharged from point sources, other than new sources, into navigable waters, the waters of the contiguous zone or the ocean.

Eligible entities
As it pertains to Section 2684a, National Defense Authorization Act (NDAA) fiscal year (FY) 03, an eligible entity that can enter into cooperative agreements (CAs) with the military can be a State government or political subdivision, or a private entity whose purpose is land and natural resource conservations, restoration, or preservation. As it pertains to Section 2694a, NDAA FY03, an eligible entity can be a State government or political subdivision, or a non-profit organization whose primary purpose is natural resource conservation on real property.

Emission standards
Limits on the quality of emissions that may be discharged to the atmosphere from any regulated source, established by Federal, State, local, and host nation (HN) authorities.

EMS Representative
The individual(s) appointed in writing by an organization's leadership who has defined roles, responsibilities, and authority for ensuring that EMS requirements are established, implemented, and maintained in accordance with ISO 14001 and this regulation. The EMS representative will report on the performance of the EMS to management for review and continual improvement of the EMS.

Encroachment
All external influences threatening or constraining testing and training activities required for force readiness and weapons acquisition. Such encroachment stems from environmental (for example, noise, endangered species, cultural resources, UXO, and munitions constituents (MC)), social (for example, urban sprawl), and economic (for example, changing land values) influences. Impacts include, but are not limited to, restrictions on available testing and training

locations; restrictions on available times and duration for testing and training; reduced effectiveness of testing and training activities; and restrictions on weapons systems, equipment, and munitions used during testing and training.

Enforcement action
A formal, written notification by the EPA or other authorized Federal, State, inter-state, regional or local environmental regulatory agency of violation of any applicable statutory or regulatory requirement. Enforcement action does not include warning letters, notices to comply, notices of potential liability, notices of significant noncompliance, pre-enforcement conference letters, informal notices of deficiencies, or notices of deficiencies to permit applications. One written notice, regardless of the number of individual violations, findings, or citations listed in it, counts as one enforcement action. If the enforcement action cites violations in more than one statutory requirement, then count it as multiple enforcement actions, one under each of the applicable statutory requirement categories. Items found to be out of compliance during an internal or other DOD Component review, compliance reviews, or audits are not included in this definition of enforcement action.

Environment
All of the following are elements of the natural and man-made environment:
a. Navigable waters.
b. Near-shore and open waters and any other surface water.
c. Groundwater.
d. Drinking water supply.
e. Land surface or subsurface area.
f. Ambient air.
g. Vegetation.
h. Wildlife.
i. Humans.
j. Noise.
k. Cultural resources.
l. Socioeconomics.
m. Coastal resources.

Environmental agreement
Environmental agreements are formal agreements between the Army and other entities to address actual or potential environmental concerns, delineate roles and responsibilities related to specific actions of mutual interest, and/or to reach consensus on courses of action. Environmental agreements include but are not limited to consent orders, compliance agreements, consent agreements, settlements, Federal facility agreements, ACUB agreements, and inter-agency agreements.

Environmental aspect
An element of an organization's activities, products, or services that can interact with the environment. A priority environmental aspect is an environmental aspect that has or can have an impact on the mission and/or the environment.

Environmental audit
A systematic, documented, verification process of objectively obtaining and evaluating evidence to determine whether specified environmental activities, events, conditions, management systems, or information about these matters conform to audit criteria (for example, compliance with Federal, State, and local environmental regulations) and communicating the results of this process to management. These reviews are not audits as defined in DODI 7600.2.

Environmental awareness training
Environmental knowledge conveyed by written or on-line information, hands-on training, or formal presentations. It is often provided outside a normal school classroom or regularly-scheduled class. It has limited applicability to teaching competence in specific job skills. It is intended to promote an environmental stewardship ethic and create an understanding of the importance of performing job skills in accordance with appropriate environmental requirements. It also encourages consultation with environmental staff and Army or local compliance publications to determine specific procedures.

Environmental condition of property
The Army does not consider the transfer of property from the Army to another Federal agency for their end use to be a deed transfer. The Army must sufficiently document the environmental condition of property being transferred to another Federal agency; therefore, an Environmental Baseline Survey is required. Also, the Army requires an Environmental Condition of Property (ECP) report, a document similar to a finding of suitability to transfer (FOST).

a. An ECP is the same as a FOST, with the following exceptions:

(1) Regulatory participation/review should parallel DOD finding of suitability to lease (FOSL) guidance, which does not require mandatory 30-day review, but early document sharing is encouraged.

(2) IMCOM Regions sign the ECP for categories 1, 2, 3, and 4 (see category descriptions below). Regions may further delegate authority for ECP categories 1 and 2 to GCs. GCs should decide on a property's suitability for lease or transfer. During staffing of the real estate action, HQDA and the Regions, as appropriate, will review the ECP for concurrence.

(3) CERCLA covenant and warranty are not required, since there is no deed.

(4) Transfer prior to all cleanup being complete is allowed and is encouraged.

(5) The Army should negotiate responsibility for environmental cleanup and compliance requirements with the Federal agency acquiring the property.

b. DOD guidance defines seven categories for describing the ECP, based on the extent of environmental contamination on the property and on the status of any associated restoration activities. These categories are defined with respect to CERCLA hazardous substances:

c. Category 1: Areas where no release or disposal of hazardous substances or petroleum products has occurred (including no migration of these substances from adjacent areas).

d. Category 2: Areas where only release or disposal of petroleum products has occurred.

e. Category 3: Areas where release, disposal, and/or migration of hazardous substances has occurred, but at concentrations that do not require a removal or remedial response.

f. Category 4: Areas where release, disposal, and/or migration of hazardous substances has occurred and all removal or remedial actions to protect human health and the environment have been taken.

g. Category 5: Areas where release, disposal, and/or migration of hazardous substances has occurred and removal or remedial actions are under way, but where all required remedial actions have not yet been taken.

h. Category 6: Areas where release, disposal, and/or migration of hazardous substances have occurred, but where required actions have not yet been implemented.

i. Category 7: Areas that have not been evaluated or that require additional evaluation.

Environmental considerations

The spectrum of environmental media resources, or programs that may impact on, or are affected by, the planning and execution of military operations. Factors may include, but are not limited to, environmental compliance, pollution prevention, conservation, protection of historical and cultural sites, and protection of flora and fauna (Joint Publication (JP) 1–02).

Environmental enhancement

Actions taken to improve the environment. These actions include measures intended to prevent or abate environmental pollution and to meet environmental quality standards.

Environmental hazard

Environmental hazards include all activities that may pollute, create negative noise related effects, degrade archeological/cultural resources, or negatively affect threatened or endangered species habitat. They may also include environmental health related hazards. (See FM 3–100.4, chap 2).

Environmental impact

Any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's activities, products, or services.

Environmental management system (EMS)

That part of an organization's overall management system that includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing, and maintaining the organization's environmental policy.

Environmental management system (EMS) audit

A systematic and documented verification process of objectively obtaining and evaluating evidence to determine whether an organization's environmental management system (EMS) conforms to the EMS audit criteria set by the organization, and for communication of the results of this process to management.

Environmental objective

An overall environmental goal, arising from the environmental policy, that an organization sets for itself to achieve, and which is quantified where practicable.

Environmental officer
An individual assigned to a table of organization and equipment (TO&E) or table of distributions and allowances (TDA) organization or unit to accomplish environmental compliance requirements on behalf of his or her responsible commander, director, or supervisor. Designated person also coordinates with supporting permanent installation environmental staff for requirements clarification and assistance. In the Army National Guard (ARNG), coordination is with NGB–ARNG State environmental staff; in the Reserves, with Regional Support Command environmental staff. Organizational levels, and required grade or rank, suitable for assignment of compliance officer duties will be determined by the commander. Commanders should consider mandatory Federal training requirements as well as mission workloads in determining assignment of environmental officers at Battalion and unit (Company, Battery, Troop) level.

Environmental performance
Measurable results of the environmental management system, related to an organization's control of its environmental aspects, based on its environmental policy, objective, and targets.

Environmental planning
Efforts that consider the impact of day-to-day base operations and activities, operational readiness activities, training, exercises, or weapons system introduction on the environment, and where necessary, allow decision makers to take early action to eliminate or mitigate those impacts. Additionally, environmental planning may require consultation or submission of documentation to demonstrate that environmental considerations have been taken.

Environmental policy
A statement by the organization of its intentions and principles in relation to its overall environmental performance that provides a framework for action and for the setting of its environmental objectives and targets.

Environmental pollution
The condition resulting from the presence of chemical, mineral, radioactive, or biological substances that

a. Alter the natural environment.

b. Adversely affect human health or the quality of life, biosystems, the environment, in structures and equipment, recreational opportunities, aesthetics, and/or natural beauty.

Environmental target
A detailed performance requirement based on ISO 14001, quantified where practicable, applicable to the organization or parts thereof, that arises from the environmental objectives and that needs to be set and met in order to achieve those objectives.

Environmental training
Instruction whose primary purpose is to provide measurable competence for doing specific environmental jobs or tasks. Some is mandated by law or regulation. Commonly taught in a classroom, by such methods as lecture, discussion, or practical exercise. However, other methods may also be used, including web-based or other "distance learning." Environmental training includes both separate environmental courses and environmental content in non-environmental courses.

Environmental stewardship
Management and oversight of environmental, natural and living resource assets including but not limited to land, air, water, soils, vegetation, and wildlife. The Army's objective is to plan, initiate, and carry out its actions and programs in a manner that minimizes adverse effects on the environment without impairing the mission and to manage impacts so as to sustain the capability of Army lands to support future as well as present mission uses of ranges and training lands. See also paragraph 1–1(a).

EPA Identification Number
The number assigned by EPA to each HW generator, transporter, and treatment, storage or disposal facility. Reference 40 CFR 260.10; 264.11; 265.11; TB 43–0244, Unit Level Procedures for Handling Service Supplies, Hazardous Materials, and Waste.

Estuary
Regions of interaction between rivers and near-shore ocean waters, where tidal action and river flow mix fresh and salt water. Such areas include bays, mouths of rivers, salt marshes, and lagoons. These brackish water ecosystems shelter and feed marine life, birds, and wildlife.

Executive agent
Executive agents (EA) are individuals designated by the Office of the Secretary of Defense (OSD) and are responsible for development, maintenance, oversight of and compliance with the Final Governing Standards (FGS) for specified foreign nations. Executive agents are also responsible for consulting with host-nation authorities on environmental issues, as required to maintain effective cooperation on environmental matters, and should coordinate with other DOD components in the specific nation.

Explosives or munitions emergency response
All immediate response activities by an explosives and munitions emergency response specialist to control, mitigate, or eliminate the actual or potential threat encountered during an explosives or munitions emergency. An explosives or munitions emergency response may include in-place, render-safe procedures, treatment or destruction of the explosives or munitions, and/or transporting those items to another location to be rendered safe, treated, or destroyed. Any reasonable delay in the completion of an explosives or munitions emergency response caused by a necessary, unforeseen, or uncontrollable circumstance will not terminate the explosives or munitions emergency. Explosives and munitions emergency responses can occur on either public or private lands and are not limited to responses at Resource Conservation and Recovery Act (RCRA) facilities. (Military Munitions Rule, 40 CFR 260.10).

Extremely hazardous substance
A substance included in appendix A or B of 40 CFR 355.

Facility
Facilities include buildings, structures, public works, equipment aircraft, vessels, and other vehicles and property under control of, or constructed or manufactured for leasing to the Army.

Federal
Of or pertaining to a department, agency, or instrumentality of the Federal Government of the United States.

Federal agency official
An individual designated by the head of any department, agency, or instrumentality of the United States (excluding the Smithsonian Institution) as having specific authority to represent the organization on official matters.

Federal Land Manager
An individual having specific authority to manage any land other than tribal lands which are controlled or owned by the United States, including lands selected by but not yet conveyed to Alaska Native Corporations and groups organized pursuant to the Alaska Native Claims Settlement Act of 1971.

Federally-listed Species
(see species designations)

Federally-owned treatment works (FOTW)
A facility that is owned and operated by a department, agency, or instrumentality of the Federal government treating wastewater, a majority of which is domestic sewage, prior to discharge in accordance with a permit issued under section 402 of the Federal Water Pollution Control Act (FWPCA).

Fees
Monetary charges by a regulator for some type of service. Examples include permits, registrations, and inspections.

Final Governing Standards (FGS)
The FGS are a comprehensive set of country-specific substantive environmental provisions, typically technical limitations on effluent, discharges, etc., or a specific management practice, with which all DOD components must comply in a given foreign nation. The FGS are developed by the DOD designated executive agent (EA) via a comparative analysis of standards in the Overseas Environmental Baseline Guidance Document (OEBGD), generally applicable host-nation laws, and relevant international agreements. The FGS generally include the standards determined by the EA to be more protective of human health and the environment.

Finding of suitability for early transfer (FOSET)
The primary purpose of a finding of suitability for early transfer (FOSET) is to document that the property is suitable for early transfer for the use intended by the transferee, and the intended use is consistent with protection of human health and the environment. A FOSET must demonstrate that the deed or other agreement proposed to govern the transfer between the United States and the transferee of the property contains the appropriate response action assurances specified in CERCLA Section 120(h)(3)(C)(ii): the Federal agency requesting the deferral has provided

notice, by publication in a newspaper of general circulation in the vicinity of the property, of the proposed transfer and of the opportunity for the public to submit, within a period of not less than 30 days after the date of the notice, written comments on the suitability of the property for transfer; and the deferral and the transfer of the property will not substantially delay any necessary response action at the property.

Finding of suitability to lease (FOSL)
A finding of suitability to lease (FOSL) is the document that conveys the result of the evaluation process used to determine that DOD property is environmentally suitable to lease. The determination of suitability to lease property is made only when the intended use of the leased property is consistent with protection of human health and the environment and will not interfere with any existing or planned environmental restoration activities. A FOSL is not required, unless deemed necessary by the DOD Component, for easements for use of real property. The FOSL and the process for preparing one are similar to the FOST and its preparation process. Similar to the FOST, preparation of a FOSL does not obviate the need to comply with the National Environmental Policy Act (NEPA).

Finding of suitability to transfer (FOST)
The primary purpose of a finding of suitability to transfer is to document that the property is environmentally suitable for transfer by deed under CERCLA and DOD FOST Guidance. The FOST process was developed to meet the statutory and regulatory requirements associated with transferring Federal real estate. A FOST must demonstrate that either the property is uncontaminated or that all necessary remediation has been completed or is in place and operating properly and successfully. These demonstrations are necessary to support the deed covenant required by CERCLA Section 120(h) that all remedial action necessary to protect human health and the environment has been taken. In addition, under CERCLA Section 120(3)(A), a deed to transfer property by the United States must contain (1) notice of the type and quantity of hazardous substances, (2) notice of the time at which such hazardous substance, storage, release, or disposal took place, and (3) a description of any remediation action taken.

Fine
Any monetary penalty or assessment levied for violation of any environmental law or regulation.

Forest management
The science, the art and the practice of managing the natural resources that occur on or in association with forest lands to achieve installation and Army goals.

Forest products
All plant materials in wooded areas that have commercial value.

Formal consultation
The process between the USFWS or NOAA–Fisheries and a Federal agency that commences with the Federal agency's written request for consultation and concludes with the issuance of a BO from the USFWS or NOAA–Fisheries.

Formerly used defense sites (FUDS)
A FUDS is defined as a facility or site (property) that was under the jurisdiction of the Secretary of Defense and owned by, leased to, or otherwise possessed by the United States at the time of actions leading to contamination by hazardous substances. By DERP policy, the FUDS program is limited to those real properties that were transferred from DOD control prior to 17 October 1986. FUDS properties can be located within the 50 States, District of Columbia, Territories, Commonwealths, and possessions of the United States.

Garrison commander (GC)
The GC is a military officer, Lieutenant Colonel or Colonel, selected by the Department of the Army. The GC commands the garrison, and is responsible for day-to-day operations to maintain living and working conditions for all personnel on the installation. The GC is the lead for base support operations management for the senior mission commander/installation commander (SMC/IC). The GC is rated by the Regional Director and senior rated by the mission commander, either the IC or SMC, as applicable. The GC is IMCOM's executive agent at installation level, providing IMCOM services and obtaining resources through IMCOM channels. The GC also provides continuity of installation command during mission activity deployments. The GC may be appointed as Summary Courts Martial convening authority or Special Courts Martial convening authority for the installation and its supported area. In some cases, the senior IMCOM official on an installation may be a civilian, the Garrison Manager (GM). A GM, as the civilian equivalent of a GC, has the same responsibility and authority as the military counterpart, with the exception of Uniform Code of Military Justice (UCMJ) and command authority, as defined by AR 600–20 (para 1–5a). The GC/GM:

a. Commands the U.S. Army Garrison.

b. Provides IMCOM services in accordance with respective guidance and common levels of support.

c. Coordinates and integrates the delivery of garrison support activity services.
d. Prioritizes requirements and support operations.

Generator
See Hazardous waste generator.

Grounds
This definition is used to classify installation acreage according to the level of grounds maintenance required and includes all land and water acreage for which an installation commander has responsibility (including satellite areas). Grounds are grouped into the following three categories:

a. Improved grounds. This category includes acreage on which intensive grounds maintenance activities must be planned and performed annually as fixed requirements. Activities include mowing, irrigation, fertilization, cultivation, aeration, seeding, sodding, spraying, pruning, trimming; weed, dust and erosion control; drainage, planting for landscape effect, wind and sound abatement, and other intensive practices.

b. Semi-improved grounds. This category includes areas on which periodic recurring grounds maintenance is performed but to a lesser degree than on improved grounds. Practices normally include such cyclic variables such as soil sterilization, weed and brush control, drainage maintenance, mowing for fire protection and major land repair/restoration/rehabilitation that may result from mission activities. Semi-improved grounds acreage may be combined with improved grounds acreage for reporting purposes only when two categories of grounds (improved and other than improved) are used.

c. Unimproved grounds. All other acreage (including water areas, areas under buildings and surfaced areas) not classified as improved or semi-improved. Practices and intervals of attention are generally unpredictable such as might evolve from flood, fire, insects, or disease epidemics

Groundwater
Water contained within the earth's subsurface that is under pressure equal to or greater than atmospheric pressure.

Habitat
An area where a plant or animal species lives, grows, and reproduces, and the environment that satisfies any of their life requirements.

Harmful discharge (of oil)
Harmful discharges are such that they do at least one of the following:
a. Violate applicable water quality standards.
b. Cause a film or sheen upon, or discoloration of, the surface of the water or adjoining shorelines.

Hazardous chemical
A hazardous chemical is defined in 40 CFR 355 and 370 which implement the Emergency Planning and Community Right-to-Know Act (EPCRA). Those sections define hazardous chemical as defined under Paragraph (c), Section 1200, Part 1910, Title 29, Code of Federal Regulations (29 CFR 1910.1200), except that such term does not include the following substances:

a. Any food, food additive, color additive, drug, or cosmetic regulated by the Food and Drug Administration.

b. Any substance present as a solid in any manufactured item to the extent exposure to the substance does not occur under normal conditions of use.

c. Any substance to the extent it is used for personal, family, or household purposes, or is present in the same form and concentration as a product packaged for distribution and used by the general public.

d. Any substance to the extent it is used in a research laboratory or a hospital or other medical facility under the direct supervision of a technically qualified individual.

e. Any substance to the extent it is used in routine agricultural operations or is a fertilizer held for sale by a retailer to the ultimate customer.

Hazardous material
A material as defined by Federal Standard, Material Safety Data, Transportation Data and Disposal Data for Hazardous Materials Furnished to Government Activities ((FED–STD–313C, 3 April 96) (The General Services Administration (GSA) has authorized the use of this Federal standard by all Federal agencies)).

a. Any item or chemical which is a "health hazard" or "physical hazard" as defined by the Occupational Safety and Health Act (OSHA) in 29 CFR 1910.1200, which includes the following:

(1) Chemicals which are carcinogens, toxic, or highly toxic agents, reproductive toxins; irritants, corrosives, sensitizers, nephrotoxins, neurotoxins, agents which act on the hematopoietic system, and agents which damage the lungs, skin, eyes, or mucus membranes.

(2) Chemicals which are combustible liquids, compressed gases, explosives, flammable liquids, flammable solids, organic peroxides, oxidizers, pyrophorics, unstable (reactive) or water-reactive.

(3) Chemicals which in the course of normal handling, use, or storage operations may produce or release dusts, gases, fumes, vapors, mists or smoke which have any of the above characteristics.

b. Any item or chemical which is reportable or potentially reportable or notifiable as inventory under the requirements of the Hazardous Chemical Reporting (40 CFR 370), or as an environmental release under the reporting requirements of the Toxic Chemical Release Reporting: Community Right To Know (40 CFR 372), which include chemicals with special characteristics which in the opinion of the manufacturer can cause harm to people, plants, or animals when released by spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment (including the abandonment or discarding of barrels, containers, and other receptacles).

c. Any item or chemical which, when being transported or moved, is a risk to public safety or an environmental hazard and is regulated as such by one or more of the following:

(1) Department of Transportation Hazardous Materials Regulations (49 CFR 100–180).

(2) International Maritime Dangerous Goods Code of the International Maritime Organization.

(3) Dangerous Goods Regulations of the International Air Transport Association.

(4) Technical Instructions of the International Civil Aviation Organization.

(5) U.S. Air Force Joint Manual, Preparing Hazardous Materials for Military Air Shipments (AFJMAN 24–204).

Hazardous substance

A substance as defined by section 101(14) of CERCLA.

a. For the purposes of this regulation a hazardous substance is any of the following:

(1) Any substance designated pursuant to section 311(b)(2)(A) of the CWA.

(2) Any element, compound, mixture, solution, or substance designated pursuant to section 102 of the CAA.

(3) Any HW having the characteristics identified under the RCRA.

(4) Any toxic pollutant listed under 15 USC 2601, et seq. (TSCA).

(5) Any hazardous air pollutant (HAP) listed under section 112 of the CAA.

(6) Any imminently hazardous chemical substance or mixture with respect to which the EPA Administrator has taken action pursuant to subsection 7 of 15 USC 2601, et seq. (TSCA).

b. The term does not include:

(1) Petroleum, including crude oil or any fraction thereof, which is not otherwise specifically listed or designated as a hazardous substance in paragraph a above.

(2) Natural gas, natural gas liquids, liquefied natural gas, or synthetic gas usable for fuel (or mixtures or natural gas and such synthetic gas usable for fuel).

(3) A list of hazardous substances is found in Section 4, Part 302, Title 40, Code of Federal Regulations (40 CFR 302.4).

Hazardous waste (HW)

A waste identified in Section 3, Part 261, Title 40, Code of Federal Regulations (40 CFR 261.3) or applicable foreign law, rule, or regulation (see also solid waste).

Hazardous waste disposal

As defined in 40 CFR 260.10, disposal means the discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or HW into or on any land or water so that such solid waste or HW or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including ground waters.

Hazardous waste generator

The HW generator is defined in 40 CFR 260.10 and DOD 4715.5–G (OEBGD) C6.2.3. Any person or activity (unit, organization, or tenant), whose act or process produces HW identified or listed in part 261.10 or whose act first causes a HW to become subject to regulation. For reporting purposes in the Army, the GC is considered the generator. For fiscal purposes, the generator is the unit.

Hazardous waste storage

As defined in 40 CFR 260.10, the holding of HW for a temporary period, at the end of which the HW is treated, disposed of, or stored elsewhere.

Hazardous waste treatment

As defined in 40 CFR 260.10, any method, technique, or process, including neutralization, designed to change the physical, chemical, or biological character or composition of any HW so as to neutralize such waste, or so as to recover energy or material resources from the waste, or so as to render such waste non-hazardous or less hazardous; safer to transport, store, or dispose of; or amenable for recovery, amenable for storage, or reduced in volume.

Historic district (under NHPA)
A geographical area encompassing a number of historic properties (see historic property below).

Historic property (under NHPA)
Any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the National Register of Historic Places (NRHP) maintained by the Secretary of the Interior. This term includes artifacts, records, and remains that are related to and located within such properties. The term includes properties of traditional religious and cultural importance to an Indian Tribe or Native Hawaiian organization and that meet the National Register criteria.

Inadvertent discovery (under NAGPRA)
Inadvertent discovery means the unanticipated encounter or detection of human remains, funerary objects, sacred objects, or objects of cultural patrimony found under or on the surface of Federal or tribal lands.

Incidental take
For 16 USC Chapter 35 (ESA) incidental take is defined as "take of a listed fish or wildlife species that results from , but is not the purpose of, carrying out an otherwise lawful activity by the Federal Agency or applicant (50 CFR 402. 02).

Indian Tribe
Indian Tribe means an Indian or Alaska Native Tribe, band, nation, pueblo, village, or community that the Secretary of the Interior acknowledges to exist as an Indian Tribe pursuant to the Federally Recognized Indian Tribe List Act of 1994, 25 USC 479a.

Inspection
Any visit by a regulatory agency, with legal authority, for the purpose of assessing regulatory compliance.

Installation
An aggregation of contiguous, or near contiguous, real property holdings commanded by a centrally-selected commander. Installations represent management organizations. An installation may be made of one or more sites. In addition, two types of "virtual" installations exist within the Army. The Army National Guard has virtual installations, identified as each state commanded by the Adjutant General, under which are Readiness Centers or sites. Each Army Reserve regional readiness command is, likewise, defined as a virtual installation under which Reserve centers are identified as sites.

Installation Commander (IC)
The IC is usually the senior mission commander (SMC) residing on the installation or in the surrounding community. The IC is responsible for mission activity services. The IC may be appointed as General Courts Martial convening authority for the installation and its support area.

a. The IC's installation management responsibilities include:

(1) Senior rate the GC.

(2) Act as principal customer advocate to the GC.

(3) Serve as the senior Army spokesperson to the surrounding community.

(4) Provide installation management services that are the responsibility of the senior mission activity.

(5) Oversee and prioritize force protection implementation.

(6) Approve priorities for training and training support services, mission support, MCA projects, well being programs and force protection.

(7) Approve installation-level policies for Soldiers in accordance with respective Army regulations.

b. The IC's responsibilities may change in instances where the IC is remotely located away from the installation and does not have day-to-day oversight of installation activities.

Installation corrective action plan (ICAP)
A comprehensive plan developed by each installation that lists Environmental Performance Assessment System (EPAS) findings, proposed corrective actions, and the status of the findings. Installations are required to enter the ICAP in the EPAS software, and provide a copy to their commanders for review every year.

Installation Engineer
The installation level engineer responsible for the management, operation and maintenance of all real property to include: buildings, pavements, utility systems, natural and cultural resources, and environmental programs.

Installation Pest Management Coordinator
The individual officially designated by the installation commander to coordinate and oversee the installation pest management program and installation pest management plan. Pest management coordinators will be certified as pesticide applicators if their job responsibilities require them to apply or supervise the use of pesticides.

Integrated cultural resources management plan (ICRMP)
A 5-year plan developed and implemented by an installation commander to provide for the management of cultural resources in a way that maximizes beneficial effects on such resources and minimizes adverse effects and impacts without impeding the mission.

Integrated natural resources management plan (INRMP)
The installation commander's adaptive plan for managing natural resources to support and be consistent with the military mission while protecting and enhancing those resources for multiple use, sustainable yield, and biological integrity. The management of natural resources is a series of processes over a long period. The INRMP provides incremental steps to achieve those long-term goals, and normally includes a five–year schedule of activities.

Integrated pest management
Integrated pest management (IPM) is a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks.

Integrated pest management plan
The IPMP is a long-range, comprehensive, planning and operational document required by DODI 4150.7 to ensure the establishment and maintenance of a safe, effective, and environmentally sound program for preventing and controlling damage to human health, facilities, infrastructure, materiel, or the environment that may be caused by problem species of insects, plants, animals, etc.

Integrated solid waste management
A practice using several alternative waste management techniques to manage and dispose of specific components of the municipal solid waste stream. Waste management alternatives include source reduction, recycling, composting, energy recovery, and land filling. (From EPA, Decision Maker's Guide, Volume II).

Integrated Training Area Management (ITAM) Program
The Army program for the management and sustainment of military training and testing lands, and other land uses which provides for: standardized range and training land assessment (RTLA) to inventory and monitor land; rehabilitation, revegetation and maintenance technologies; sustainable range awareness; decision support systems; and integration of military training requirements with land capabilities.

International agreement
An international agreement is a multilateral or bilateral treaty, a base rights or access agreement, a Status of Forces Agreement (SOFA), including practices and standards established pursuant to such agreement.

Invasive species
An alien species whose introduction causes or is likely to cause economic or environmental harm or harm to human health. Alien species means with respect to a particular ecosystem, any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem.

International Organization for Standardization (ISO) 14000/14001
ISO 14000 is a group of voluntary international standards addressing environmental management systems, environmental auditing, environmental labeling, environmental performance evaluation, and life cycle assessments. The standards were developed by the International Organization for Standardization (ISO) and are commonly referred to as the ISO 14000 series. The series provides an organization with a systematic approach to environmental management. ISO 14001 provides the detailed specifications and requirements for an environmental management system, or EMS. A complete copy of the standard is available on the Defense Environmental Network and Information Exchange (DENIX).

Jeopardize the continued existence of
To engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of

both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species.

Land Condition Trend Analysis (LCTA) methods
Standardized land (soil, vegetation, topographic and wildlife) inventory and monitoring procedures used for the analysis and comparability of Army lands over time.

Land management
The planning and execution of programs to improve, utilize and maintain all land and water areas for the greatest long-term net public benefit while supporting the military mission. Included are subordinate land uses that are mutually compatible and consistent with maintaining environmental qualities.

Land use planning zone (LUPZ)
A contour that is used to account for days of higher than average operations. Noise sensitive land uses are compatible within the LUPZ.

Leak (release) detection system
A system capable of detecting the failure of either the primary or secondary containment structure or the presence of a release of product waste or accumulated liquid in the secondary containment structure. Such a system must employ operational controls (for example, daily visual inspections for releases into the secondary containment system of the aboveground tank) or consist of an interstitial monitoring device designed to continuously and automatically detect the failure of the primary or secondary containment structure in the presence of a release of HW into the secondary containment structure.

Lease
A written agreement which conveys a possessory interest in real property, usually exclusive, for a period of time for a specified purpose.

Lifecycle cost analysis
Determination of expenses incurred of a product or process over its entire existence. It includes all the cost of mining the raw materials to the eventual destruction and/or disposal of the product or process.

Listed hazardous substance
A substance designated under any of the following (any HW listed under or having the HW characteristics identified according to section 3001 of the RCRA & any substance listed under section 102 of CERCLA):
a. Sections 307(a) and 311(b)(2)(A) of CWA.
b. Section 112 of CAA.
c. Section 7 of 15 USC 2601, et seq. (TSCA).

Listed species
Any species of fish, wildlife, or plant which has been determined to be endangered or threatened under section 4 of 16 USC 35 (ESA). Listed species are found in 50 CFR 17.11–17.12.

Low-level radioactive waste (LLRW)
Radioactive waste not classified as high level radioactive waste, transuranic waste, or a byproduct material as defined in subsection 11(i)(2) of Section 2011, Title 42, United States Code, (42 USC 2011, Atomic Energy Act). See also radioactive material below.

Materiel
All items (including ships, tanks, self propelled weapons, aircraft, etc., and related spares, repair parts, and support equipment, but excluding real property, installations, and utilities) necessary to equip, operate, maintain, and support military activities without distinctions as to its application for administrative or combat purposes.

Measure of merit (MOM)
An objective criterion used to measure progress in achieving established DOD environmental performance goals.

Memorandum of agreement (under NHPA)
The document that records the terms and conditions agreed upon to resolve the adverse effects of an undertaking upon historic properties.

Memorandum of understanding (MOU)
A written document executed by the parties which establishes policies or procedures of mutual concern. It does not require either party to obligate funds and does not create a legally binding commitment.

Military munitions
Military munitions means all ammunition products and components produced for or used by the armed forces for national defense and security, including ammunition products or components under the control of the DOD, the USCG, the Department of Energy, and the ARNG. The term includes confined gaseous, liquid, and solid propellants, explosives, pyrotechnics, chemical and riot control agents, smokes, and incendiaries, including bulk explosives and chemical warfare agents, chemical munitions, rockets, guided and ballistic missiles, bombs, warheads, mortar rounds, artillery ammunition, small arms ammunition, grenades, mines, torpedoes, depth charges, cluster munitions and dispensers, demolition charges, and devices and components thereof. The term does not include wholly inert items, improvised explosive devices, and nuclear weapons, nuclear devices, and nuclear components, except that the term does include non-nuclear components of nuclear devices that are managed under the nuclear weapons program of the Department of Energy after all required sanitization operations under 42 USC 2011 (Atomic Energy Act) have been completed. (10 USC 2710(e)(3)(A) and (B)).

Military munitions response
DOD response actions (removal or remedial) to investigate and address the explosives safety, human health, or environmental risks presented by munitions and explosives of concern (MEC), discarded military munitions (DMM) and MC. (The response could be as simple as a notification to the community with an education program about the hazards posed by military munitions and how to avoid them, or as complicated as a long-term response action involving sophisticated technology, specialized expertise, and significant resources.)

Monitoring
The assessment of emissions and ambient air quality conditions. The following monitoring techniques are used:
a. Emission estimates.
b. Visible emission readings.
c. Diffusion or dispersion estimates.
d. Sampling or measurement with analytical instruments.

Multiple use
The integrated management of all natural resources, each with the other, to achieve the optimum use and enjoyment while maintaining the environmental qualities, ecological relationships and aesthetic values in proper balance.

Municipal Separate Storm Sewer System (MS4)
Any conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels or storm drains) owned by a state, city, local municipality, or Federal government and that is designed for the collection and conveyance of storm water, which is not combined with a sanitary sewer and not part of a publicly-owned treatment works (POTW).

Munitions and explosives of concern (MEC)
This term, which distinguishes specific categories of military munitions that may pose unique explosives safety risks, means:
a. UXO, as defined in 10 USC 101(e)(5)(A);
b. Discarded military munitions (DMM), as defined in 10 USC 2710(e)(2); or
c. MC (e.g., trinitrotoluene (TNT), cyclotrimethylenetrinitramine (RDX)), as defined in 10 USC 2710(e)(3), present in high enough concentrations to pose an explosive hazard.

Munitions constituents (MC)
Any material originating from UXO, discarded military munitions (DMM), or other military munitions, including explosive and non-explosive materials, and emission, degradation, or breakdown elements of such ordnance or munitions. (10 USC 2710)

Munitions response
Response actions, including investigations, removal actions, and remedial actions to address the explosives safety, human health, or environmental risk presented by MEC, DMM, or MC.

National Environmental Policy Act (NEPA)
U.S. statute that requires all Federal agencies to consider the potential effects of proposed actions on the human and natural environment.

National Pollutant Discharge Elimination System (NPDES) permit
A permit issued pursuant to section 402 of the FWPCA. A NPDES permit is required for the discharge of pollutants from any point source into waters of the United States.

National Register of Historic Places (NRHP)
The nation's inventory of known historic properties that have been formally listed by the National Park Service (NPS). The NRHP is administered by the NPS on the behalf of the Secretary of the Interior. National Register listings include districts, landscapes, sites, buildings, structures, and objects that meet the set of criteria found in 36 CFR 60.4

National Response Team (NRT)
A team of representatives from the primary and advisory agencies that serves as the national policy-making body for planning and preparedness actions to prevent and minimize accidental pollution discharges.

Native American Graves Protection and Repatriation Act (NAGPRA) Items
Human remains, funerary objects, sacred objects, or objects of cultural patrimony that are excavated intentionally from or inadvertently discovered on Federal or tribal lands.

Native Hawaiian Organization
Any organization that serves and represents the interests of, has a primary stated purpose to provide services to, and has expertise in Native Hawaiians and Native Hawaiian affairs. Such organizations must include the Office of Hawaiian Affairs and Hui Malama I Na Kupuna 'O Hawaii Nei.

Natural resources
The viable and/or renewable products of nature and their environments of soil, air, and water. Included are the plants and animals occurring on grasslands, rangelands, croplands, forests, lakes, and streams.

Noise zones I, II, and III
Land use planning areas for the purpose of maintaining uses that are compatible with the existing and future noise environments.

Non-Federal
Any entity that is not part of a department, agency, or instrumentality of the Federal government of the United States.

Non-point source
Diffuse sources of pollution (that is, without a single point of origin or not introduced into a receiving water from a discrete conveyance). Pollutants are generally carried off the land by stormwater or snow melt. Common non-point sources include agriculture, forestry, urban, construction, dams, channels, land disposal, saltwater intrusion, and city streets.

Noxious weed
Plant species identified by Federal or State agencies as requiring control or eradication.

Off-road vehicle (ORV)
A vehicle designed for travel on natural terrain. The term excludes a registered motorboat confined to use on open water and a military, emergency, or law enforcement vehicle during use by an employee or agent of the Government or one of its contractors in the course of employment or agency representation.

Oil
Oil or petroleum products of any kind or in any form, and oil mixed with wastes other than dredged spoil.

On-scene coordinator (OSC)
The Federal official pre-designated by EPA or USCG to coordinate and direct Federal responses under subpart D, and removals under subpart E, of 40 CFR 300 (National Oil and Hazardous Substances Pollution Contingency Plan); or

a. The DOD or U.S. Department of Energy official designated to coordinate and direct the removal actions from releases of hazardous substances, pollutants, or contaminants where either the release is on, or the sole source of the release is from, any facility or vessel under the jurisdiction, custody, or control of their departments respectively; or,

b. The official designated by any other Federal department or agency to coordinate and direct removal actions other than emergencies where either the release is on, or the sole source of the release from, any facility or vessel under the jurisdiction, custody, or control of those departments and agencies.

Open burning
The combustion of any material without the characteristics below:
a. Control of combustion air to maintain adequate temperature for efficient combustion.
b. Containment of the combustion reaction in an enclosed device to provide enough residence time and mixing for complete combustion.
c. Control of emission of the gaseous combustion products.

Operating tempo (OPTEMPO)
Operating tempo is the pace of unit training that the Army believes it needs to conduct to maintain its fleet of tracked and wheeled vehicles at a prescribed readiness level. Stated another way, it is a resource gauge the Army measures to indicate the amount of miles or operating hours required to execute a unit commanders training strategy to achieve a given specific readiness level.

Operational noise
The outdoor noise environment consisting of the noise, including ambient noise, from all sources. The noise environment of the work place is not considered operational noise.

Operational range
A range that is under the jurisdiction, custody, or control of the Secretary of Defense and that is used for range activities; or although not currently being used for range activities, that is still considered by the Secretary to be a range and has not been put to a new use that is incompatible with range activities (10 USC 101(e)(3)(A) and (B)). Also includes "military range," "active range," and "inactive range" as those terms are defined in 40 CFR 266.201.

Operational readiness
The umbrella term and supporting program that encompasses all the resources required of a unit to maintain readiness standards.

Organization
Company, corporation, authority, or institution, or part or combination thereof, whether incorporated or not, public or private, that has its own functions and administration.

Outdoor recreation
Recreational program, activity, or opportunity that is dependent on the natural environment. Examples are hunting, fishing, trapping, picnicking, bird-watching, ORV use, hiking and interpretive trails use, wild and scenic river use, and underdeveloped camping areas. Developed or constructed activities such as golf courses, lodging facilities, boat launching ramps, and marinas are not included.

Outgrant
Reference AR 405–80 for specific definitions. A real property legal document which conveys or gives the right to use Army-controlled real property, including leases, permits, licenses, and easements.

Overseas Environmental Baseline Guidance Document (OEBGD)
A set of objective criteria and management practices developed by the DOD, to protect human health and the environment at overseas installations, and to be used by the designated EA during the comparative analysis process used to develop FGS. In addition, the OEBGD contains implementing guidance for executive agents, garrison commanders and DOD components.

Permanent installation
An aggregation of real property holdings under the jurisdiction of the DOD, controlled by and at which an Active Army unit or activity is permanently assigned.

Pest management
The prevention and control of animal and insect disease vectors and other pests that may adversely affect the DOD mission or military operations; the health and well-being of people; or structures, materiel, or property.

Pest management consultant
Personnel who meet the DOD educational and experience criteria for PPMP and who serve at IMCOM, USACHPPM regions, National Guard Bureau (NGB) and higher Army-levels of command. Pest management consultants interpret

and establish program standards for installation programs and are responsible for evaluating and providing technical guidance to support these programs.

Pest management quality assurance evaluator
Personnel technically qualified in the management and oversight of pesticide applicators and pest management contracts by training, per DOD standards, which protect the Government's interest through on-site performance evaluation of commercial contracts involving pest management or other contracts that involve the use of pesticides. See AR 5–20.

Pesticide
Any substance or mixture of substances, including chemical biological control agents, that may prevent, destroy, repel, or mitigate pests and are specifically labeled for use by the EPA. Also, any substance or mixture of substances used as a plant regulator, defoliant, desiccant, disinfectant, or biocide.

Pesticide security
The prevention of intrusion to areas used to store pesticides and other toxic chemicals to ensure that they have appropriate security protections to prevent intruder access to equipment used in mixing, loading, and applying pesticides. Pesticide applicators must have proper authorization and identification.

Pests
Arthropods, birds, rodents, nematodes, fungi, bacteria, viruses, algae, snails, marine borers, snakes, weeds, mollusks, and other organisms (except for excluding microbial/bacterial/viral disease pathogens, but including organisms that may transmit human or animal disease-causing organisms) that adversely affect readiness, military operations, or the well-being of personnel and animals; attack or damage real property, supplies, equipment, or vegetation; or are otherwise undesirable.

Point source
Any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharged.

Pollutant (water)
Dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal and agricultural waste discharged into water. A broad term which generally encompasses most material which is added to the water constitutes a pollutant.

Pollution
See environmental pollution.

Pollution prevention
Use of processes, materials, or products that avoid, reduce, or control pollution, which may include recycling, treatment, process changes, control mechanisms, efficient use of resources and material substitution.

Pollution prevention opportunity assessment
Provides the technical and economic information necessary for selecting appropriate pollution prevention techniques.

Pollution prevention plan
A plan developed and maintained by an installation commander that sets forth the installation's contribution to the goals and requirements established by EO 13423, including reductions in use and release of toxic chemicals and ODS and in the generation of HW.

Prescribed burning
Skillful application of fire to natural fuels under conditions of weather, fuel moisture, soil moisture, etc., to allow confinement of the fire to a predetermined area while producing the intensity of heat and rate of spread required to accomplish certain planned benefits. These benefits may include all or one or more objectives of silviculture, wildlife management, grazing, hazard reduction, etc. Its objective is to employ fire scientifically to realize maximum net benefits at minimum damage (if any) and acceptable cost.

Pretreatment (wastewater)
The reduction of the amount of pollutants, the elimination of pollutants, or the alteration of the nature of pollutant

properties in wastewater prior to or in lieu of discharging or otherwise introducing such pollutants into a treatment works.

Pretreatment standard
Any regulation containing pollutant discharge limits promulgated by the EPA in accordance with section 307(b) and (c) of the FWPCA, which applies to Industrial Users. This includes prohibitive discharge limits established pursuant to Section 5, Part 403, Title 40, Code of Federal Regulations (40 CFR 403.5).

Primary agencies (for NRT)
The Federal departments or agencies comprising the National Response Team (NRT); i.e., the Departments of Commerce, Interior, Transportation, and Defense; and the EPA. These agencies have primary responsibility and resources to promote effective operation of the national oil and hazardous substances pollution contingency plan.

Primary drinking water standards
Standards for those contaminants in drinking water, which may cause an adverse health effect on the consumer. In the form of maximum contaminant levels, treatment, techniques, or action levels, these standards are federally enforceable.

Proactive
Taking the initiative by acting rather than reacting to events.

Professional pest management professional
The DOD military officers commissioned in the Medical Service or Biomedical Sciences Corps or DOD civilian personnel with college degrees in biological or agricultural sciences that are in a current assignment that includes pest management responsibilities exercised regularly. The DOD civilian employees also will meet Office of Personnel Management qualification standards. Based on assignment, some PPMP are Certifying Officials.

Programmatic agreement (PA) (under NHPA)
A document that records the terms and conditions agreed upon to resolve the potential adverse effects of a Federal agency program, complex undertaking or other situations in accordance with 36 CFR 800.14(b), NHPA.

Proponent
Proponent identification depends on the nature and scope of a proposed action. Any Army organization may be a proponent (for example, for a project, program, or regulation). In general, the proponent is the unit, element, or organization that is responsible for initiating and/or carrying out the proposed action. The proponent is responsible for programming and/or securing funding for such actions.

Proposed species
A fish, wildlife, or plant species that is proposed in the Federal Register to be listed as endangered or threatened under 16 USC 35 (ESA).

Publicly-owned treatment works (POTW)
Any device or system used in the treatment (including recycling and reclamation) of municipal sewage or industrial wastes of a liquid nature which is owned by a State or municipality.

Public water systems
Systems that provide water for human consumption through pipes or other constructed conveyances to at least 15 service connections or serves an average of at least 25 people for at least 60 days a year. There are three types of public water systems:
a. Community Water System (CWS): A public water system that supplies water to the same population year-round.
b. Non-Transient Non-Community Water System (NTNCWS): A public water system that regularly supplies water to at least 25 of the same people at least six months per year, but not year-round. Some examples are schools, factories, office buildings, and hospitals which have their own water systems.
c. Transient Non-Community Water System (TNCWS): a public water system that does not regularly supply water to at least 25 of the same persons over six months per year.

Quarantine
A restraint placed upon the activities or communication of persons or the transport of goods designed to prevent the spread of disease or pests.

Radioactive material
Any material or combination of materials that spontaneously emit ionizing radiation.

Range
A designated land or water area that is set aside, managed, and used for range activities of the DOD. The term includes firing lines and positions, maneuver areas, firing lanes, test pads, detonation pads, impact areas, electronic scoring sites, buffer zones with restricted access, and exclusionary areas. The term also includes airspace areas designated for military use in accordance with regulations and procedures prescribed by the Administrator of the Federal Aviation Administration.

Range activities
Research, development, testing, and evaluation of military munitions, other ordnance, and weapons systems; and the training of members of the armed forces in the use and handling of military munitions, other ordnance, and weapons systems.

Real property
This includes the definition for real property found in the Federal Property Management Regulations, 41 CFR 101–47. 103.12.

Reclamation
Regeneration of a material, or processing of a material to recover a usable product. Examples include recovery of lead from spent batteries, or the regeneration of spent solvents.

Recovery
The improvement in the status of listed species to the point at which listing is no longer appropriate under the criteria set out in section 4(a)(1) of 16 USC 35 (ESA).

Recovery plan
A plan developed by the USFWS or NOAA–Fisheries, as required by 16 USC 35 (ESA), for the conservation, survival, and recovery of a listed species.

Recreational waters
Recreational waters are water bodies that are commonly used for recreational purposes. They include, but are not necessarily limited to, swimming pools, water parks, hot tubs, lakes, rivers, and the ocean.

Recycling
The process by which materials otherwise destined for disposal are collected, reprocessed, or remanufactured, and are reused. A distinction exists between onsite recycling (that is, where a waste is discharged from a process, but not from the installation, for recycling) and off-site recycling (that is, were the waste is transported from the generating activity to an off-site recycler).

Regional administrator
The regional administrator of the EPA regional office in which the subject property is located.

Regional Response Team (RRT)
A team of regional Federal representatives of the primary or selected advisory agencies. It acts within its region as an emergency response team that performs functions like those of the NRT.

Regulated tank
A tank constructed above, below, or on the ground, which is regulated by Federal or State authorities because it contains an oil or hazardous substance. Above ground tank requirements are found at 40 CFR 110, underground storage tank (UST) requirements at 40 CFR 280. Exceptions for heating oil tanks are found at 40 CFR 280.12. State regulations may be more stringent.

Release
A discharge of one or more hazardous substances into the environment by any means. Excluded are minor releases within the workplace, emissions from engine exhaust, and normal applications of fertilizer.

Reportable spill or event
A release of a reportable quantity of oil or hazardous substance into the environment. The EPA National Response Center (NRC) is to be notified immediately.

a. For oil (defined by 40 CFR 110): A discharge of such quantities of oil into or upon the navigable waters of the United States, its adjoining shorelines, or the contiguous zone so as to meet the qualifications listed in harmful discharge (of oil) into navigable waters or into or beyond the contiguous zone above.

b. For hazardous substances: Any release of one or more reportable substances in reportable quantities into the environment.

Response action
The cleanup or removal of released hazardous substances from the environment. This includes actions necessary in the event of the threat of release of hazardous substances into the environment; such actions as may be necessary to monitor, assess, and evaluate the release or threat of release of hazardous substances; the disposal of removed material; or the taking of such other actions as may be necessary to prevent, minimize, or mitigate damage to the public health or welfare or to the environment, which may otherwise result from a release or threat of release.

Resource recovery
A term describing the extraction and use of materials and energy from the waste stream. The term is sometimes used synonymously with energy recovery.

Restoration Advisory Board (RAB)
A RAB is a forum of representatives of the DOD, EPA, State and local government, and public representative(s) of the potentially affected community. RAB members can provide input to the Army's environmental restoration program (ERP) at both operating and closing or realigning installations. The RAB reflects the diverse makeup of the community, gives all stakeholders the opportunity to participate in the cleanup process, and make their views known to decision makers.

Reuse
A material is used or reused if it is either:

a. Used as an ingredient (including use as an intermediate) in an industrial process to make a product (for example, distillation bottoms from one process used as a feedstock in another process).

b. Used in a particular function or application as an effective substitute (for example, spent battery acid accumulated by the DRMO could be used in industrial waste-water treatment facilities to precipitate phosphorous, and act as a sludge conditioner).

Risk assessment
Environmental risk assessment is the formal systematic evaluation of any environmental hazard that may pose a risk to human health or the environment. It may include an on-site investigation to determine the existence, nature, severity, and location of hazards and options for reducing the hazards.

Sacred site
Any site that traditional Native American religious leaders use for the practice of traditional Native American religions by their present-day adherents.

Secondary drinking water standards
Standards for those contaminants in drinking water, which may affect the aesthetic quality of the water, but have no adverse health effects. In the form of secondary maximum contaminant levels, these standards are not federally enforceable, but may be enforced by a State regulatory agency.

Senior mission commander (SMC)
The SMC will be a General Officer and designated by Senior Army Leadership. The SMC is responsible for the primary mission activity on several installations. The SMC provides executive level oversight of installation management services to the mission activities and other customers. The SMC need not reside or work on the installation. SMC installation management responsibilities are to:

a. Assist the GC in obtaining resources by advocating priority needs through the Army Commands (ACOMs), Army Service Component Commands (ASCCs), Direct Reporting Units (DRUs), and the IMBOD.

b. Act as the principal customer advocate to the IC and GC.

c. Approve the priorities for mission support, MCA projects, well-being programs and force protection requirements.

d. Provide overall force protection guidance.

e. Senior rate the GC.

Sewage sludge
Any solid, semi-solid, or liquid residue removed during the treatment of municipal wastewater or domestic sewage.

Significant paleontological resources
Paleontological resources (i.e., fossil remains) associated with events that have made an important contribution to the broad pattern of history or the lives of persons who were of importance in the past, or that yield or may yield information that is important to history or pre-history.

Site
A physically defined location which can be supported by a legal boundary survey which closes a polygon. It can be owned, leased, or otherwise possessed or used. A site may exist in one of three forms: land only; facility or facilities only; or land and all the facilities on it. A site is the sum of all real property at a specific location.

Sludge
Any solid, semi-solid, or liquid waste generated from a municipal, commercial, or industrial wastewater treatment plant, water supply treatment plant, or air pollution control facility exclusive of the treated effluent from a wastewater treatment plant (40 CFR 260.10).

Sole source aquifer
A groundwater source demonstrated to be the only or primary viable source of drinking water for a community or an aquifer that supplies 50 percent or more of the drinking water of an area.

Solid waste
Any discarded material that is not excluded by 40 CFR 261.4(a) or that is not excluded by variance granted under 40 CFR 260.30 and 260.31 (40 CFR 261.2).

Source reduction
Any practice which reduces the amount of any hazardous substance, pollutant, or contaminant entering any waste stream or otherwise released to the environment prior to recycling, treatment, or disposal; or, any practice which reduces the hazards to public health and the environment associated with the release of such substances, pollutants, or contaminants (Pollution Prevention Act (PPA) of 1990).

Source water
The water taken from rivers, reservoirs, or wells for use as drinking water.

Special installation
Special installations are generally very small, mostly industrial, and typically do not have a stand-alone installation staff. Command, control, manpower, and funding remain with the Army Commands (ACOMs), Army Service Component Commands (ASCCs), and Direct Reporting Units (DRUs), while traditional base operations support (BOS) oversight is provided by the IMCOM. These installations primarily use funds other than operation and maintenance funds (i.e., mission funds) to conduct traditional garrison operations in support of its primary mission. Several mission fund types are used in the operation of these installations, including: Army Working Capital Funds (AWCF); transportation working capital funds (TWCF); chemical program funds; Defense Health Program (DHP) funds; procurement Army ammunition (PAA) funds; and research, development, test, and evaluation (RDT&E) funds.

Special State (installation) license
A license prepared and issued by the installation in accordance with 10 USC 670 and the fish and wildlife cooperative plan to individuals participating in hunting, fishing, or trapping activities. It is valid only on the installation where issued. A fee is collected and used for fish and wildlife management activities in accordance with the integrated natural resources management plan (INRMP).

Species designations
The following species designations apply.

a. 16 USC Chapter 35 (ESA).

(1) Endangered species. Any species, plant or animal, which is in danger of extinction throughout all or a significant portion of its range, as listed by the U.S. Department of Interior (DOI).

(2) Threatened species. Any species, plant or animal, which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range, as listed by the DOI.

(3) Candidate species. Plant or animal taxa considered for possible addition to the List of T&E Species. These are taxa for which the USFWS has on file sufficient information on biological vulnerability and threats to support issuance of a proposal to list, but issuance of a proposed rule is currently precluded by higher priority actions.

b. State listed species. Any species, plant or animal, which is listed by the appropriate State as threatened or endangered within the State. (Note: these species may not be federally listed).

c. Species At Risk or Habitats. Plant and animal species and associated habitats that are not federally listed as threatened or endangered under 16 USC Chapter 35 (ESA), but are either federally listed as candidates or are ranked by NatureServe as critically imperiled or imperiled throughout their range.

d. Army Species At Risk or Habitats. Species at risk or habitats that could be listed in the near future and/or for which the listing could have significant impact on military readiness and which are designated by HQDA.

Spill
A generic term, as used in this regulation, which encompasses the accidental and the deliberate but unpermitted discharge or release of a pollutant. For distinction, see discharge classifications, harmful discharge and so forth, potential discharge, release, and reportable spill or event. For comparison, see discharge and federally permitted release.

State historic preservation officer (SHPO) (under NHPA)
The official appointed or designated pursuant to section 101(b)(1) of the act to administer the State historic preservation program or a representative designated to act for the SHPO.

Status of Forces Agreement (SOFA)
Agreement on the stationing or operations of forces to which the United States is a party, such as:

a. Multilateral or bilateral stationing or base rights agreement.

b. Arrangements or understanding concluded there under.

Storage
The holding of hazardous substances (as defined in this section), other than for a temporary period of less than 30 days, prior to the hazardous substance being either used, neutralized, disposed of, or stored elsewhere.

Storage tank system
Storage tank systems include the tank(s), all connected piping, any ancillary equipment, and the containment system.

Sub-Installation
A grouping of facilities that are under the control of an installation garrison, but are not physically located within the principal installation boundary.

Surface water
All water naturally open to the atmosphere (rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, and so forth) and all springs, wells, or other collectors directly influenced by surface water.

Surveillance
Thorough inspections or surveys made before and after pest management treatments to determine the presence and prevalence of pests or disease vectors.

Sustainability
Meeting present needs without compromising the ability of future generations to meet their own needs.

Sustainable yield
The production of renewable resources a land or water area can maintain in perpetuity at a given intensity of management without impairment of the resource.

Take
Take means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. Harm is further defined to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering. Harass is defined as actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering.

Tank
Any stationary device designed to contain an accumulation of used oil (40 CFR 279.1) or HW (260.10), oil (40 CFR 112 and 40 CFR 280.12) or regulated substance (40 CFR 280.12) which is constructed primarily of non-earthen materials (for example, wood, concrete, steel, plastic) which provides structural support.

Technical guide (TG)
Technical guidance prepared by the AFPMB on specific pest management and disease vector control topics. TMs are

available from the DOD AFPMB, Forest Glen Section, Walter Reed Army Medical Center, Washington, DC 20307–5001.

Technical Review Committee (TRC)
TRCs are established as required by CERCLA Section 211 to facilitate review and comment on response actions and proposed actions at Army installations. The Army establishes TRCs for installations where there is no community interest towards establishment of a RAB. Note, however, that the TRC is being replaced by the RAB where appropriate. Installations that already have TRCs should consider converting the committee to a RAB (see Restoration Advisory Board for additional information).

Tenant
An authorized activity located on an installation that is not part of the garrison organization. Tenants include, but are not limited to, military units, the Army and Air Force Exchange Service (AAFES), and the Defense Commissary Agency (DeCA).

Toxic chemical
A chemical listed in 40 CFR 372.65 or added to that list by the EPA and required to be reported yearly in the EPCRA Toxic Releases Inventory.

Toxic pollutant
Those pollutants or combinations of pollutants, including disease-causing agents which, after discharge and upon exposure, ingestion, inhalation or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, will cause death; disease; behavioral abnormalities; cancer; generic mutations physiological malfunctions, including malfunctions in reproduction; or physical deformations in such organisms or their offspring.

Transfer
Reference AR 405–90. Change in jurisdiction over real property from one Federal agency or department to another, including military departments and defense agencies.

Treatment
Any method, technique, or process, including neutralization, designed to change the physical, chemical, or biological character or composition of any HW so as to neutralize such waste, or so as to recover energy or material resources from the waste, or so as to render such waste non-hazardous, or less hazardous; safe to transport, store, or dispose of; or amenable for recovery, amenable for storage, or reduced in volume.

Underground injection
Subsurface emplacement of fluids, often wastes, through a bored, drilled or driven well.

Undertaking
A project, activity, or program funded in whole or in part under the direct or indirect jurisdiction of a Federal agency, including those carried out by or on behalf of a Federal agency; those carried out with Federal financial assistance; and those requiring a Federal permit, license or approval.

Unexploded ordnance (UXO)
UXO are military munitions that:

a. Have been primed, fused, armed, or otherwise prepared for action.

b. Have been fired, dropped, launched, projected, or placed in such a manner as to constitute a hazard to operations, installations, personnel, or material.

c. Remain unexploded, either by malfunction, design, or any other cause. (10 USC 101(e)(5)).

Unintentional Take
As defined for migratory birds (Migratory Bird Treaty Act (MBTA)) - take, that results from, but is not the purpose of, the activity in question, take of this type is sometimes referred to as incidental or indirect.

Unit commander
A commissioned officer of the United States armed forces designated to command a military unit.

U.S. jurisdiction
The 50 states, the District of Columbia, the commonwealths of Puerto Rico and the Northern Mariana Islands, the

territories of Guam and American Samoa, the U.S. Virgin Islands, and any other territory or possession over which the United States has jurisdiction.

Vessel
Any type of watercraft or other artificial contrivance used, or capable of being used, as a means of transportation on water, other than a public vessel.

Vulnerability assessment
An assessment of elements in the community that are susceptible to damage if hazardous materials are released.

Waste minimization
Two definitions are:

a. Any source reduction or recycling activity that is undertaken by a generator that results in the reduction of the quantity of HW, or the reduction in toxicity of HW, that is either generated or subsequently treated, stored, or disposed of. Such activities must be consistent with the goals of minimizing present and future threats to human health and the environment.

b. A working definition of waste minimization reflects two types of activities, source reduction or elimination of waste at the point of generation (for example, within a process), and recycling.

Wastewater
The spent or used water from individual homes, a community, a farm, or an industry that contains dissolved or suspended matter.

Water conservation
The beneficial reduction of water uses or water losses.

Water resource
Any groundwater or surface water source and associated (lake or ocean) shoreline. See also surface water, and groundwater.

Watershed
A region or area bounded peripherally by a water parting and draining ultimately to a particular watercourse or body of water.

Waterworks permit
Any permit required to operate a drinking water treatment facility, such as a source water appropriation permit or an operating permit.

Weed
A plant growing where it is not desired.

Wellhead protection area
The surface and subsurface area surrounding a water well or well field supplying a public water system, through which contaminants are reasonably likely to move toward and reach such well or well field.

Wetlands
Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Common terms used to describe various wetlands include marshes, bogs, swamps, small ponds, sloughs, potholes, river overflows, oxbows, mud flats, and wet meadows.

Wildland fire
Any non-structural fire that occurs on unimproved grounds. This includes wildfires and prescribed fires.

Wildlife management
The practical application of scientific and technical principles to wildlife populations and habitats so as to maintain such populations essentially for ecological, recreational, and/or scientific purposes.

Section III
Special Abbreviations and Terms
This section contains no entries

Index

Federal Endangered Species Act (1973) access: https://www.law.cornell.edu/uscode/text/16/chapter-35

U.S. Code › Title 16 › Chapter 35

16 U.S. Code Chapter 35 - ENDANGERED SPECIES

Current through Pub. L. 114-19. (See Public Laws for the current Congress.)

US Code | Notes

prev | next

U.S. Code Toolbox

Wex: Environmental Law: Overview
Download the PDF (61 pgs)
Title 16 USC, RSS Feed
Table of Popular Names
Parallel Table of Authorities

Stay Involved

DEPARTMENT OF THE ARMY
US ARMY INSTALLATION MANAGEMENT COMMAND, PACIFIC REGION
HEADQUARTERS, UNITED STATES ARMY GARRISON, HAWAII
745 WRIGHT AVENUE, BUILDING 107, WHEELER ARMY AIRFIELD
SCHOFIELD BARRACKS, HAWAII 96857-5000

REPLY TO
ATTENTION OF

IMHW-ZA

MEMORANDUM FOR All Military Personnel, Contractors and Department of Defense Civilian Employees within United States Army Garrison, Hawaii (USAG-HI) Installations

SUBJECT: Policy Memorandum USAG-HI-72, Tree Cutting Moratorium

1. References.

a. Army Regulation (AR) 200-1, Environmental Protection and Enhancement, 13 Dec 07.

b. Federal Endangered Species Act (1973).

2. Applicability. This policy applies to all Soldiers, civilians, family members, contractors, and other personnel who work on, reside on, or visit any U.S. Army installation, facility, or work site on the Island of Oahu.

3. Policy.

a. In February, 2014, the Natural Resource Program (NRP) discovered the presence of the Federally-listed endangered species, Hawaiian Hoary Bat, *Lasiurus cinereus semotus*, at Schofield Barracks West Range. In addition, the NRP discovered the presence of the bat in Schofield Barracks East Range in Spring 2013. Bats have also been found by the US Geological Survey in numerous locations on Oahu spanning from Waikiki to Ford Island to the Waianae Mountains to the North Shore of Oahu. For this reason, bats are now considered to be ubiquitous on Oahu.

b. The Army is required to consult with the US Fish and Wildlife Service (USFWS) anytime an action may affect a listed threatened or endangered species or their critical habitat. In the meantime, the Army must practice avoidance.

c. The NRP is in the process of preparing a formal consultation package for the USFWS. Until a Biological Opinion is received from the USFWS, the following measures must be followed to maintain compliance with the Federal Endangered Species Act of 1973:

(1) During the bat pupping season, 1 June to 15 September, there shall be no cutting or trimming of any tree over 15 feet tall.

(2) If a tree falls on its own that is over 15 feet tall, the Army may remove the tree.

IMHW-ZA
SUBJECT: Policy Memorandum USAG-HI-72, Tree Cutting Moratorium

(3) In case of an emergency situation, e.g., a tree larger than 15 feet tall is threatening a power line, the staff must contact the Natural Resource Program for guidance prior to cutting the tree.

(4) This policy applies to all Army installations on the island of Oahu, including housing. The policy pertains to cantonment as well as to the actual training areas.

(5) This policy is effective immediately and remains in effect until rescinded or superseded in writing.

4. Proponent. The proponent for administration of the Tree Cutting Moratorium is the DPW Environmental Division, at 655-9189.

RICHARD A. FROMM
COL, AD
Commanding

DISTRIBUTION
Electronic Media

OANRP Diaphacinone-50 Hand Broadcast Study

Table of Contents

EXECUTIVE SUMMARY

The Army is required to stabilize populations of endangered species and their habitat as per Biological Opinions issued by the U.S. Fish and Wildlife Service. Introduced rats (*Rattus* spp.)_are one of the largest threats to endangered plants, snails and birds. Oahu Army Natural Resources Program (OANRP) has been engaged in rodent control since 1995 using various techniques including snap traps, automatic traps, rodenticide applied in bait stations and physical barriers. Since 2012, OANRP halted rodenticide use because of a change in the Special Local Needs (SLN) label that makes bait-station application unfeasible in the steep, rugged terrain where the work is conducted. Relying solely on traps has not been effective in keeping populations below the targeted 10% tracking in monitoring tunnels, particularly during the period of peak rat abundance (typically Fall/Winter). In attempt to combat this problem in Hawaiian habitats, OANRP would like to determine the effectiveness of a "one-time" two-application hand-broadcast (applications spaced approximately 5-7 days apart) and canopy baiting of rodenticide bait (Diphacinone-50) during a period of high rat abundance within Kahanahaiki Management Unit (a fenced Unit where ungulates are excluded) in the Waianae Mountains. Hand broadcast application will involve OANRP staff walking a grid of trails while evenly distributing rodenticide bait; canopy baiting involves placing bait, held in small cloth bags, into trees within the grid. These application methods comply within the Diphacinone-50 label (EPA Registration No. 56228-35). Hand broadcast method of rat control was assessed in the Programmatic Environmental Assessment for the Final Implementation Plan for Oahu Training Areas, March 2010, FNSI June 2010. USDA National Wildlife Research Center (NWRC) will provide the monitoring associated with this study (e.g., bait application according to label, efficacy of this rat-reduction method, and non-target impacts).

1. INTRODUCTION to Project Plan

This is the project plan to study a hand broadcast and canopy baiting application of Diaphacinone-50 for control of *Rattus* spp. at Kahanahaiki Management Unit, northern Waianae Mountains, Oahu. The project plan includes two parts: 1) the operational plan, and 2) the monitoring plan (inserted as an Appendix to this document; NWRC Study Protocol QA-2523). This project plan was written collaboratively by Oahu Army Natural Resources Program (OANRP), with funding from the Army, and the USDA APHIS Wildlife Services (WS), and USDA APHIS WS National Wildlife Research Center (NWRC). The OANRP will lead in the operation, particularly bait application, whereas WS/NWRC will provide project oversight and will lead in the monitoring of this study.

2. GOAL, OBJECTIVES and OUTCOMES

2.1. Goal

The goal of this project is:

"To study if a hand broadcast and canopy baiting application of Diphacinone-50 in combination with a grid of mechanical traps (already in operation) has a seasonal knockdown effect on the rat population at Kahanahaiki (ideally <10% tracking activity through the winter)."

2.2. Objectives and Outcomes

Objectives	Outcomes
1. To determine if a 2-application hand broadcast of Diphacinone-50 is an effective method for seasonal knockdown of *Rattus* spp. at Kahanahaiki	1.1 Reduction of rat activity (ideally <10% measured by tracking tunnels, corriflute tabs and GoodNature chew cards), and >80% local mortality of rats (using fates of rats with radio collars).
2. Study non-target effects	2.1 Gain information on non-target effects (carcasses searches, tests of diphacinone residues through food web)
3. Use results to make management decisions and develop protocols for other MU's	3.1 Determine if seasonal hand broadcast is a safe and effective option for seasonal control of rats.
	3.2 Staff will have skills and knowledge to undertake other hand broadcast operations at other Management Units (MUs).

3. THE SITE, TARGET SPECIES, and NEED for SUPPLEMENTAL RAT CONTROL USING SEASONAL BAIT APPLICATION

3.1. The Site and Rat Management History

The Kahanahaiki Management Unit (MU) is located at 500-660 m elevation in the Waianae mountain range (21^o 32' N, 158^o 11' W), within the Makua Military Reservation (MMR), on Oahu, Hawaii (Figure 1). The rat control area within the MU is approximately 70 acres and is fenced to exclude ungulates. Overall, the north and east aspects are relatively native while the south and west exposures are dominated by weeds. Kahanahaiki is home to many rare taxa, including plants and snails; 12 plant species and two animals are listed as endangered (Joe and Daehler 2008). Non-native rodents are ubiquitous at Kahanahaiki, including black rats (*Rattus rattus*), Pacific rats (*R. exulans*), and house mice (*Mus musculus*); black rats are numerically dominant, outnumbering Pacific rats by >10-fold (Shiels 2010). Negative impacts of each of these three rodent species at Kahanahaiki has been reported to span native plants, insects, snails, and birds (Meyer and Shiels 2009; Shiels et al. 2013). One endangered plant, *Cyanea superba*, is highly vulnerable to black rat predation, and large-scale and intensive snap-trapping at Kahanahaiki reduced seed predation by rats from 47% to just 4% in one season (Pender et al. 2013). Several additional native plants receive high predation by black rats at Kahanahaiki (Shiels and Drake 2011), implying that these native forests may potentially experience a shift in species composition attributable to invasive rats (particularly black rats).

The U.S. Army is required to stabilize populations of endangered species and their habitat as per Biological Opinions issued by the U.S. Fish and Wildlife Service. Due to the large negative effects of introduced rats on natural resources at Kahanahaiki, Oahu Army Natural Resources Program (OANRP) has been engaged in rodent control since 1995 using various techniques including snap traps, automatic traps, rodenticide applied in bait stations and physical barriers. Due to the high habitat quality and small size of the Kahanahaiki, a large scale Victor Snap grid of 402 traps was installed in May 2009 for Kahanahaiki-wide protection (Figure 1). In general, these traps were re-baited twice per month. After a general knock-down in the rat population in 2009, much fluctuation had occurred and the targeted levels of rat suppression were not always being met with the large-scale snap-trapping (Pender et al. 2013); this resulted in noticeable losses of native and endangered seeds and predation of native snails by rats.

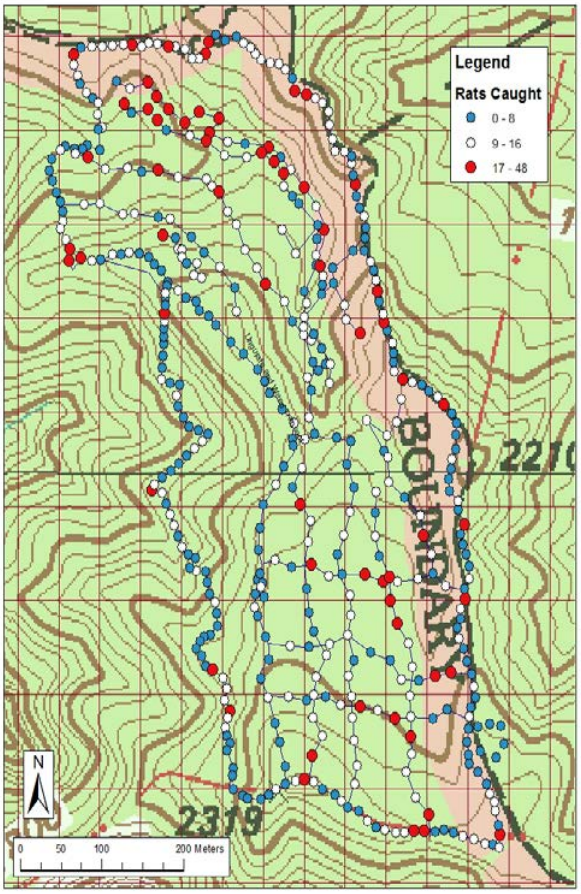


Figure 1. Map of Kahanahaiki snap-trap grid displaying total rat catches (2009-2014).

OANRP rat-control tools became more limited in 2012, which was when OANRP halted rodenticide use because of a change in the Special Local Needs (SLN) label that made bait-station application unfeasible in the steep, rugged terrain where the work (at the MU and elsewhere) is conducted. During a trial in 2012 and 2013, Goodnature A24 rat + stoat traps (Goodnature Limited, Wellington, NZ), which are self-resetting traps that can fire 24 times with one CO_2 cartridge, were shown to be effective in controlling rat activity at a nearby site, Pahole gulch. Because of these results a grid of A24s was installed at Kahanahaiki and snap-traps were discontinued. In July 2014, 83 Goodnature A24s were installed on existing trails at a spacing of approximately 50 x 100 meters. In December 2014, an additional 36 A24s were installed within the gulch area to achieve a device spacing of 25 x 100meters (Figure 2).

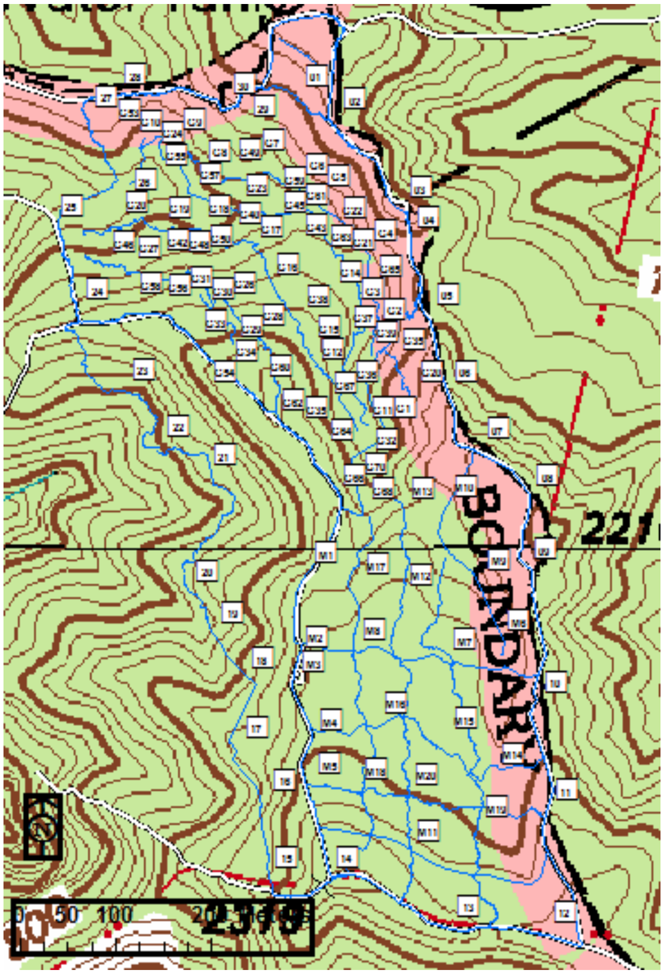


Figure 2. Map of Kahanahaiki Goodnature A-24 trap grid.

Monitoring of rat activity at Kahanahaiki as well as a control site via tracking tunnels was implemented to determine efficacy of trapping devices. The management objectives for this MU articulate that there should be less than 10% activity levels in rat tracking tunnels. An acceptable level of rat activity, which promotes stable or increasing native/endangered snail (*Achatinella mustelina*) and plant (*Cyanea. superba* subsp. *superba*) populations, has not been clearly identified. It could be very low, less than 2%, or very high, 40%; in New Zealand, studies have shown that rat activity levels of 10% are low enough to maintain certain rare bird populations (Innes et al. 1999). A 10% activity level may also be the most achievable level using a large scale trapping grid. Results of the past six years of monitoring of the snap-trap grid (May 2009-April 2014) and the subsequent A-24 grid (May 2014 to present) show seasonal winter spikes of rat activity up to 78.4% (Figure 3). Thererfore, relying solely on traps (snap-traps or A24s) has not been effective in keeping populations below the targeted 10% tracking in monitoring tunnels, particularly during the period of peak rat abundance (typically Fall/Winter; Figure 3). The goal of this project will be to reduce the rat population (and therefore tracking) at Kahanahaiki during the seasonal peaks (roughly November-February; Figure 3).

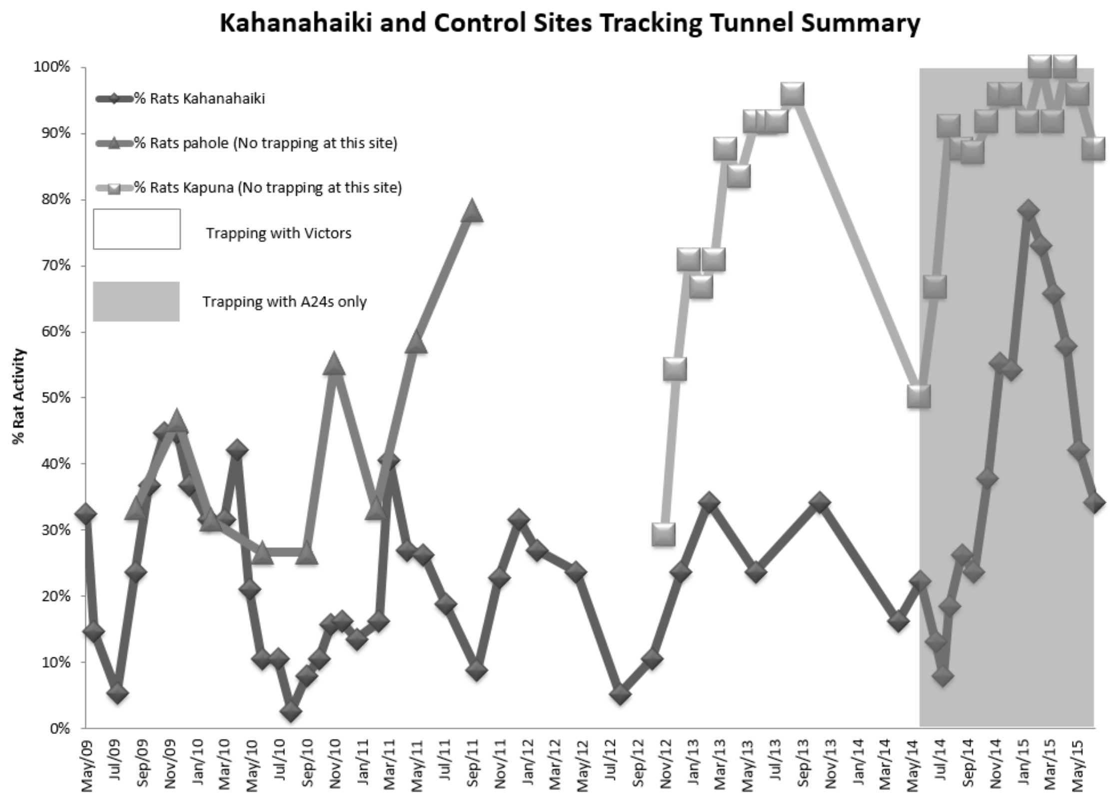


Figure 3. Percent rat activity (based on tracking tunnels) at Kahanahaiki (the rat-trapping site), and two sites where no rat trapping occurs (Pahole and Kapuna). The shaded area from May 2014-May 2015 is when only A24 traps were used at the rat-trapping site; whereas the non-shaded (May 2009-April 2014) was when only Victor snap-traps were used at the rat-trapping site.

Upon recent assessment of OANRP rat control at Kahanahaiki, and the conclusion that it is not meeting targeted rat suppression (i.e., tracking tunnels are rarely <10%), three rat control techniques were considered at Kahanahaiki:

1. A seasonal Hand Broadcast and Canopy Baiting Application of Diphacinone-50 over the Kahanahaiki along a pre-established grid of trails, with the continuation of mechanical trapping.
2. Continuous bait stations filled with Ramik rodenticide, and set in accordance with the SLN.
3. Exclusive use of mechanical traps placed along a grid of trails.

- **Technique 1 – Hand Broadcast and Canopy Baiting Application:** This method may be considered the most appropriate option and be the most efficient and effective way of adequately controlling the seasonal spike in rat activity within the MU. This method allows for greater bait interaction than bait boxes (bait boxes deter some individauls from entry; Recht 1988), thus potentially a better control method for suppressing rat populations. In addition to the hand broadcast, we will also be employing canopy bags to increase our effectiveness in targeting any rats that favor the arboreal habitat. Through several tracking methods, Shiels (2010) found that rats at Kahanahaiki frequent the arboreal, ground, and underground (burrowing) habitats. Mechanical traps would be used prior to, during, and after the broadcast to provide year round control. In addition, traps would only be required to be deployed at densities adequate to control moderate to low levels of rats as the combination approach will be used during the high spikes.

- **Technique 2 – Use of Bait Stations of Ramik:** This technique has been considered but it has been determined that it is not possible to adhere to the 225m buffer requirement in the SLN given the location of resources to be protected and the surrounding cliffs and steep terrain.
- **Technique 3** – **Exclusive Use of Mechanical Traps:** This has been the only method used at this site for the past six years. Tracking tunnel data shows that this method alone is not adequate to meet management goals at the current trap density.

4. Methods for the Hand Broadcast and Canopy Bait Application

Establishment of baiting transects

Trails that have already been established at Kahanahaiki for snap-trapping (Figure 1) and A24s (Figure 2) will be used as baiting transects in this study. These trails (transects) are generally <50 meters apart. Spreading bait along and adjacent to these transects will generally leave <30 meters between baits, which should minimize chances that a given rat will not interact with bait based on rat home range sizes at Kahanahaiki (average of 4 ha for black rats, and 1.8 ha for Pacific rats; Shiels 2010), as well as linear distance moved in a night from point of capture (black rat: mean 20 m, maximum 30 m; Pacific rats: mean 25 m, maximum 40 m; Shiels 2010). Installing additional trails for this two-bait application study is not warranted given the significant disturbance to the fragile habitat and native/rare species that is caused by installing trails.

Applicator training

All OANRP staff (~40 personnel) are certified for applying diphacinone rodenticide (i.e., a license to "purchase and use restricted pesticides" issued as the "State of Hawaii, Dept. of Agriculture, Division of Plant Industry, CERTIFICATION FOR COMMERCIAL APPLICATORS OF RESTRICTED PESTICIDES"). There are 7-10 OANRP personnel anticipated to be applying the bait for this study. In addition to each of the personnel being licensed to apply/use restricted pesticides, they will get additional training in advance of the applications that will clarify methodological details specific to application and bait distribution pattern (see below) within Kahanahaiki forest. Included in this training will be throwing dog-food pellets (a surrogate to Diphacinone-50 bait) on flat ground that has markings out to 10 m; such calibration for each personnel will help ensure even spread of bait in the field at the proper application rate (i.e., according to the Diphacinone-50 label; see below).

Bait staging

Once bait arrives in Hawaii, it will be stored according to the label and in a cool dry place. Because of the difficulty of navigating the terrain at Kahanahaiki, bait caches will be established prior to the beginning of the study. Bait will be flown by helicopter on-site ~1-7 days prior to the initial hand broadcast application. These bait caches (stockpile locations) will consist of metal trash cans with locking lids filled with the bait in original closed container, providing tamper resistant storage. Locations will be selected to allow the applicators to carry 13.8 kg of bait before arriving at the next station. We estimate approximately 14 stations will be needed. GIS will be used to identify the areas to place bait stockpile locations.

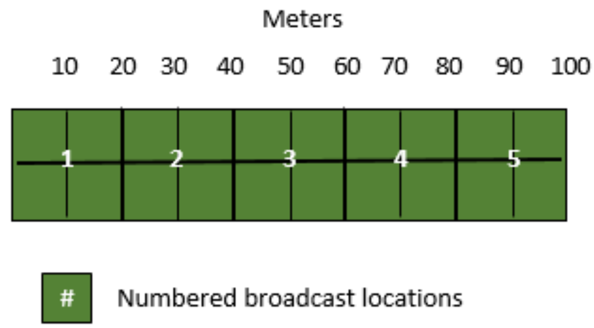


Figure 4. Example of how bait will be stockpiled in "broadcast locations". At each broadcast station, bait will be distributed in all directions within a 20 meter square (530 g of bait at odd numbered stations and 439 g of bait for even numbered stations).

Bait application

All application amounts will be according to the label (Diphacinone 50: Conservation, EPA Reg. No.: 56228-35, State of Hawaii Lic. No. 8600.1). For ground broadcast the rate is 11.1 to 13.8 kg bait/ha per treatment for the first treatment, and no more than 13.8 kg/ha for the second treatment. At Kahanahaiki, bait will be spread 10 meters in all directions at "broadcast locations", every 20 meters along the trails (Figure 4). This will make for continuous baiting in a 10 m distance from each side of the trail throughout the trail system (Figure 5). At all "broadcast locations" 495 g of bait will be distributed equally in all directions within a 20 meter square, making the application rate to the ground for all locations 12.375 kg/ha. To ensure equal amounts of bait being distributed at each broadcast location, staff will have a plastic container/scoop that measures out the appropriate amount to be broadcasted. Staff will then reach into the container with a gloved hand and hand broadcast the bait as equally as possible throughout the area.

At all even numbered "broadcast locations" a canopy bag containing 113 g of bait will tied onto a tree (see below). Thus, the application rate of bait at even stations to the ground (12.375 kg/ha) is combined with canopy (1.356 kg/ha) is 13.731kg/ha (i.e., under the maximum "Aerial and Ground Broadcast" rate according to label).

Using the 10 meter buffer this will equal 25 broadcast locations or 500 meters of trail per/ha. The total area of the trails with a 10 meter buffer on each side equals 14.16 ha. For this area we will be broadcasting to the ground at a rate of 12.375 kg/ha for a total of 175.23 kg, and hanging canopy bags at every other broadcast location (the evens) for a total of 19.20 kg.

In some areas there are cliffs and terrain that do not allow for the addition of trails, however because of the steepness it is possible for applicators to broadcast much farther than 10 meters from the already established trails. This area is in green (Figure 5) and contributes 6.11 ha. Special instructions on how much additional bait to broadcast in the green areas will be provided to the staff that will apply the bait. In these areas canopy bags will not be used so the application rate will be the label maximum of 13.8 kg/ha for a total of 84.32 kg.

We will also be using 22 g of bait at 90 bait availability monitoring plots for a total of 1.98 kg.

Although the entire fenced unit of Kahanahaiki is approximately 36 ha, the total area to be broadcasted equals 20.27 ha. When all methods are combined a total amount of 280.73 kg of bait will be needed per broadcast. Because two broadcasts will occur, 561.46kg or 1237.81lbs of total bait will be needed.

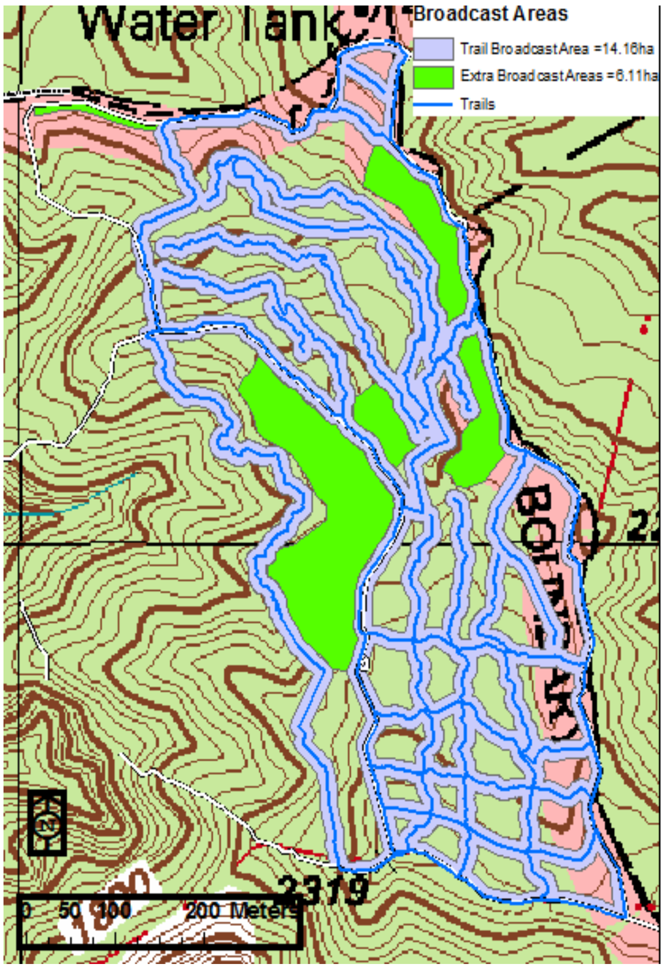


Figure 5. Map of Kahanahaiki with 10 meter buffers (light blue) associated with trails (dark blue) and extra broadcast areas (green). Although the entire fenced unit of Kahanahaiki is approximately 36 ha, the total area to be broadcasted (blue+green) equals 20.27 ha.

The label recommends the addition of canopy baiting in areas where sufficient food and cover are available to harbour populations of rodents in canopies of trees and shrubs. According to the label 113 g to 200 g of bait should be placed in each cloth bag (Figure 6). At all even numbered "broadcast locations" (Figure 6) a canopy bag containing 113 g of bait will be placed in the canopy. This amount and spacing is according to the label; the label states that canopy bags should be placed at intervals of 50 m or less. The bags will be tied to the trees at < 3 m height (target of 2-3 m height, based on Shiels (2010) average black rat activity above ground of 2.8 m, Pacific rat is 0.3 m).

Figure 6. Example of cloth canopy bags that will be used for canopy baiting.

Timing of Operation

We plan to conduct broadcast applications in October 2015. This timing coincides with the disappearance of strawberry guava (*Psidium cattleianum*) fruit, which is one of the major food sources for rats at Kahanahaiki (Shiels 2010; Shiels and Drake 2011). Strawberry guava fruiting normally occurs June-September (peaking in July/August), and September/October is generally the beginning of increased rodent activity measured in the tracking tunnels (Figure 3).

Signage

Warning signs will be posted along the fence line and on the trail leading to Kahanahaiki (Figure 7). Signs will include the date of the broadcast and they will remain on site for 2 months following the first bait application.

CAUTION

THIS AREA HAS BEEN BAITED WITH DIPHACINONE POISION TO CONTROL RODENTS

HAZARD TO HUMANS AND DOMESTIC ANIMALS

IF YOU HAVE QUESTIONS
PLEASE CONTACT THE ARMY'S
ENVIRONMENTAL DIVISION AT (808) 655-9191

Figure 7. Warning sign that will be posted along the trails leading to Kahanahaiki, and the fence line that surrounds Kahanahaiki.

5.Monitoring Efforts

As stated in the Introduction, OANRP will be conducting (taking lead on) the operational aspects of this study that are outlined above, whereas WS/NWRC will lead in the monitoring of this study. For objectivity and best practice procedures, the agency leading the operational aspects of the study should be different than those leading in the monitoring (Pitt et al. 2015). A detailed Monitoring Plan can be found in Appendix 1, which also constitutes the WS/NWRC study protocol (QA-2523). A summary of the main aspects of the Monitoring Plan are briefly listed below, but refer to the full monitoring plan in Appendix 1 for full details.

Monitoring for this study will include the following:

1) Abidance by the Diphacinone-50 label's application rate. NWRC/WS staff will measure bait densities in established plots throughout Kahanahaiki to ensure bait was applied to the site at a rate of no greater than 13.8 kg/ha per application.
2) Bait fate will be monitored by revisiting plots at set intervals after each bait application and bait densities will be measured. Motion cameras will also monitor subsets of bait to determine the types of animals consuming or removing bait.
3) Rodent monitoring will occur before, during, and after hand broadcast by use of rodent tracking tunnels (ink cards baited and inserted into tunnels to establish rodent activity based on foot-tracks), as well as chew cards and tabs. Such monitoring will occur at Kahanahaiki, and a nearby site (Kapuna) that does not have any rodent control. OANRP staff will help collect the tracking and chew cards and tabs and give them to NWRC/WS at the end of the day for NWRC/WS analysis. These monitoring techniques will help to assess the efficacy of the rodenticide application on the rat population.
4) Rodent fates will be assessed by attaching radio-collars to a subset of rats and mice captured prior to the bait application. These individuals will be followed in the subsequent days/weeks following the bait applications in order to assess the proportion of collared rodents in the study area that did not survive the effects of rodenticide baiting. Rodent carcass searches will also be conducted before, during, and after bait application.
5) Non-target effects. As will any project that uses toxicant bait, we expect that there will be some negative effects to non-target organisms (see Pitt et al. 2015). Justification for proceeding with such a control tool that harms some non-target species is that the longer-term effects of a reduced rat population will provide greater benefit to the native species and habitat that goes beyond the number (and types) of non-target mortalities. There are no expected negative impacts to threatened or endangered species as a result of this hand broadcast. There are expected non-target impacts and this study will monitor those (see monitoring section for more information; Appendix 1). These impacts would include some species being affected by eating the bait directly or consuming any animal that has consumed the toxicant. Briefly, in our non-target monitoring at Kahanahaiki, we will: 1) conduct carcass searches before, during, and after bait application, and 2) assess the levels of diphacinone

residue in the food web by sampling (pre- and post-bait application), game birds, lizards, and invertebrates (slugs and insects).

Rodent monitoring

Three monitoring methods will be used to track the % change of rodent activity before, during, and after the hand broadcast (Figure 8). Chew cards and corriflute chew tabs will be left out for 3 nights while tracking tunnel cards will be left out for 1 night.

Figure 8. Tracking tunnel, GoodNature Chew card, and Corriflute chew tab.

At Kahanahaiki we will use 42 tracking tunnels, 38 GoodNature Chew cards, and 38 corriflute chew tabs (Figure 9). 38 Tracking tunnels are currently being monitored on site however for this project an additional four will be added to cover the Unit II line.

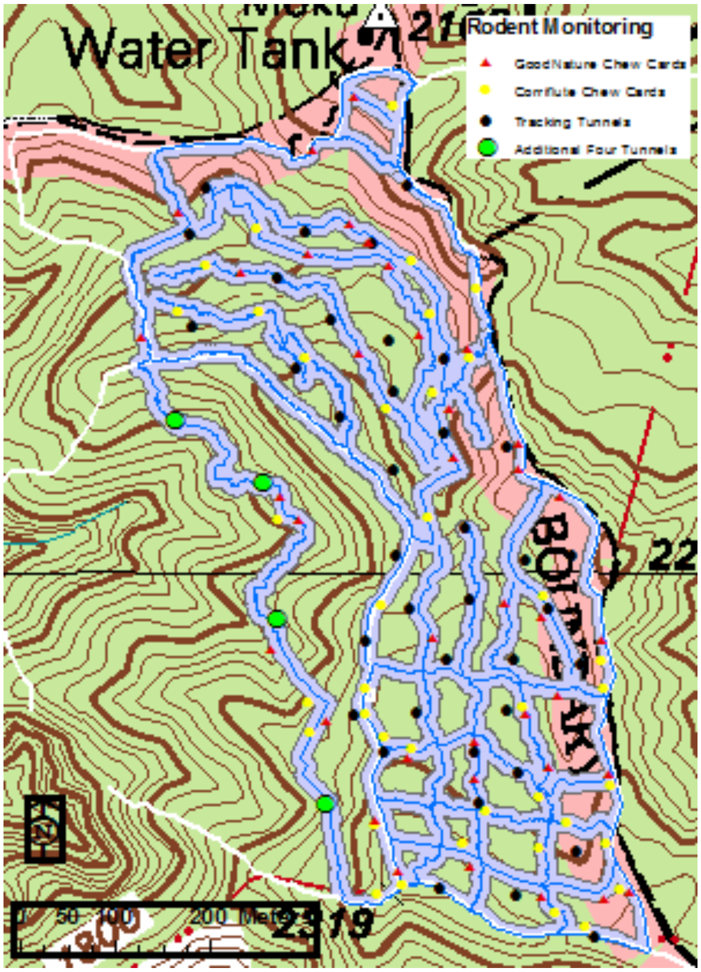


Figure 9. Locations of three rodent monitoring methods at Kahanahaiki.

Monitoring at a control site will also be conducted on the same schedule as the study site. The control site will include 24 tracking tunnels, 24 Good Nature Chew cards, and 24 corriflute chew tabs (Figure 10).

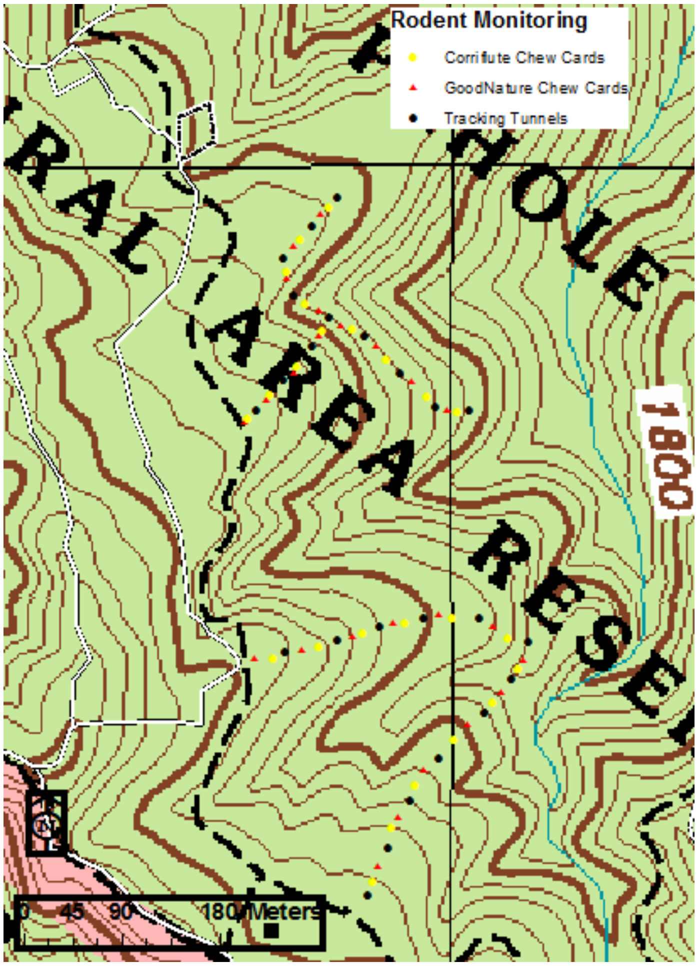


Figure 10. Rodent monitoring device locations at the control site Kapuna.

All three rodent monitoring methods will be initiated one month before the 1st hand broadcast and be used for the duration of the project. Rodent monitoring will be done on the following schedule:

1. 1 month prior to the 1st broadcast
2. The day before the 1st broadcast
3. The day before the 2nd broadcast
4. 7 days after the 2nd broadcast
5. 21 days after the 2nd broadcast
6. 7 weeks after the 2nd broadcast
7. Monthly thereafter with the method deemed most sensitive

Bait availability monitoring

Bait availability monitoring will be initiated on the day of the 1st hand broadcast and continue for 14 days. We don't have plans of doing pre broadcast bait availability monitoring with a non-toxic bait as we will be applying the recommended amount on the label 11.1 to 13.8kg/ha. We have established 90, 1-meter square monitoring plots within the broadcast area using ArcGIS random point generator (Figure 11).

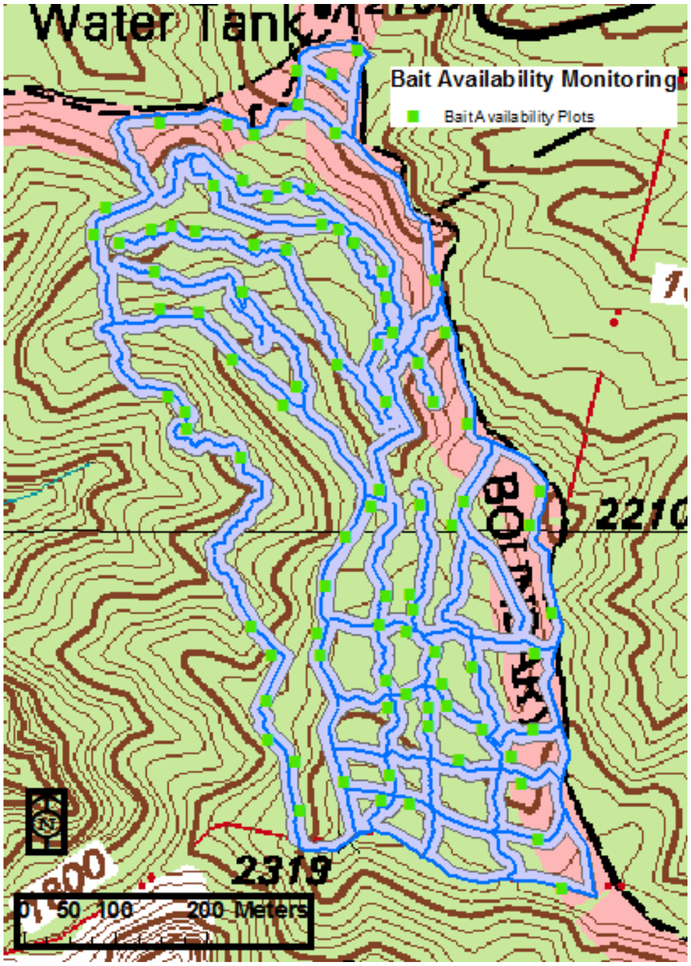


Figure 11. Bait availability monitoring plot locations.

Plots will be denoted with pin flags at each corner. Due to the low amount of bait that could be hand broadcasted into a 1meter plot, assuming that a completely equal distribution of pellets will result in ~2.5 pellets per monitoring plot, twenty pellets (.022kg) will be manually placed in a regular pattern within each plot (Figure 12).

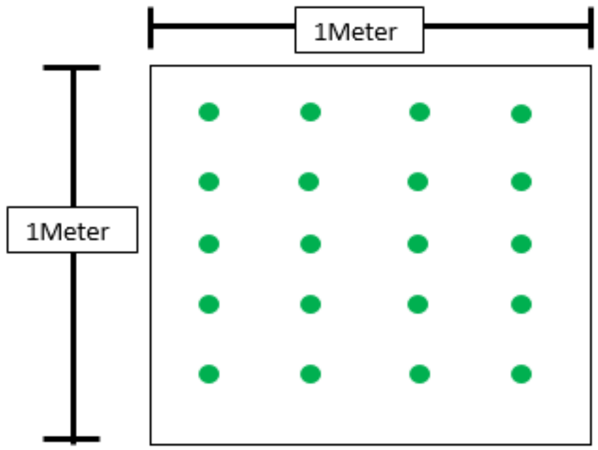


Figure 12. Example of distribution of baits within bait availability monitoring plot.

This bait will be subtracted from the bait broadcasted from the odd numbered locations. Any bait from the hand broadcast that is found in the plots before the twenty baits are manually placed will be broadcasted out of the plot. These procedures will be followed for the 2nd broadcast as well.

During the monitoring period all bait within the plots will be counted and recorded, any partial pellet will be recorded to the nearest 25%. Any pellets that appear to be wet or mouldy will be recorded and noted (Figure 13). Monitoring will begin on the first day soon after the pellets have been broadcasted to obtain an accurate baseline. Plots will then be read daily for 14 days from the first broadcast.

Bait availability monitoring form

Date:

Observer:

Plot #	# Of Good Bait (to nearest .25)	# Of Wet/Moldy Bait	Comments
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Figure 13. Example of Bait availability monitoring form

The monitoring team will also be visually inspecting the canopy bags for signs of take. All canopy bags will be checked daily for 14 days from the first broadcast. An approximation of % bait remaining will be recorded as well as any signs of take or disturbance (Figure 14).

Canopy Bag monitoring form

Date:

Observer:

Bag #	~% Bait Remaining	Comments
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Figure 14. Example of Canopy monitoring form.

Monitoring the area for dead animals

The label states that "For all methods of baiting, monitor the baited area periodically and, using gloves, collect and dispose of any dead animals and spilled bait properly. Dead animals and spilled bait may be buried on site if the depth of burial makes excavation by non-target animals extremely unlikely." The crew responsible for bait availability monitoring will also be responsible for searching all trails for any dead animals and will dispose them according to the label. A gps point, species, sex and condition will be recorded for all carcasses found. Training will be given to staff on properly identifying and recording this information.

Issues with the proposed method

There are no expected negative impacts to threatened or endangered species as a result of this hand broadcast. There are expected non-target impacts and this study will monitor those, see monitoring section for more info. These impacts would include some species being affected by eating the bait directly or consuming any animal that has consumed the toxin.

6. PROJECT TIMELINE

Table 1. Project Milestones

Milestone	Date	Responsible

Operational Planning Stage		
Site Visit	5/14/15	OANRP/USDA
Complete Project Plan	July/August	OANRP/USDA
Order bait	August	USDA
Implementation Stage - pre-operation phase		
Trails and pickup stations	August	OANRP
Establish bait availability plots	August	OANRP/USDA
Conduct pre-broadcast non-target monitoring	September	OANRP/USDA
Attach radio collars to a subset of rats and mice	September	USDA
Conduct pre-broadcast %rat activity monitoring	September	OANRP/USDA
Implementation Stage – Operational phase		
Conduct Hand Broadcast	October	OANRP
Conduct associated monitoring activities including non-target effects	October	USDA
Sustaining the Project Stage		

Literature Cited

Innes, J.G., R. Hay, I. Flux, P. Bradfield, H. Speed, and P. Jansen. 1999. Successful recovery of North Island kokako *Callaeas cinerea wilsoni* populations, by adaptive management. *Biological Conservation* 87: 201-224.

Joe, S.M., and C.C. Daehler. 2008. Invasive slugs as underappreciated obstacles to rare plant restoration: evidence from the Hawaiian Island. *Biological Invasions* 10: 245-255.

Meyer, W.M., and A.B. Shiels. 2009. Black rat (*Rattus rattus*) predation on non-indigenous snails in Hawai`i: complex management implications. *Pacific Science* 63: 339-347.

Pender, R.J., A.B. Shiels, L. Bialic-Murphy, and S.M. Mosher. 2013. Large-scale rodent control reduces pre- and post-dispersal seed predation of the endangered Hawaiian lobeliad, *Cyanea superba* subsp. *superba* (Campanulaceae). *Biological Invasions* 15: 213-223.

Pitt, W.C., A.R. Berentsen, A.B. Shiels, S.F. Volker, J.D. Eisemann, A. Wegmann, and G. Howald. 2015. Non-target species mortality and the measurement of brodifacoum rodenticide residues after a rat (*Rattus rattus*) eradication on Palmyra Atoll, tropical Pacific. *Biological Conservation* 185: 36-46.

Recht, M.A. 1988. The biology of domestic rats: telemetry yields insights for pest control. Proceedings for the Vertebrate Pest Conference 13: 98-100.

Shiels, A.B. Ecology and impacts of introduced rodents (*Rattus* spp. and *Mus musculus*) in the Hawaiian Islands. Ph.D. Dissertation. University of Hawaii at Manoa. 218 pp.

Shiels, A.B., and D.R. Drake. 2011. Are introduced rats (*Rattus rattus*) both seed predators and dispersers in Hawaii? *Biological Invasions* 13: 883-894.

Shiels, A.B., C.A. Flores, A. Khamsing, P.D. Krushelnycky, S.M. Mosher, and D.R. Drake. 2013. Dietary niche differentiation among three species of invasive rodents (*Rattus rattus*, *R. exulans*, *Mus musculus*). *Biological Invasions* 15: 1037-1048.

DEPARTMENT OF THE ARMY
US ARMY INSTALLATION MANAGEMENT COMMAND, PACIFIC REGION
HEADQUARTERS, UNITED STATES ARMY GARRISON, HAWAII
745 WRIGHT AVENUE, BUILDING 107, WHEELER ARMY AIRFIELD
SCHOFIELD BARRACKS, HAWAII 96857-5000

REPLY TO
ATTENTION OF

IMHW-ZA

24 Jul 15

MEMORANDUM FOR All Military Personnel and Department of Defense Civilian Employees within United States Army Garrison, Hawaii (USAG-HI) Installations [MSE Hawaii, IPC, DPW, AFFES]

SUBJECT: Policy Memorandum USAG-HI-71, Avoidance of Little Fire Ant Introduction

1. References.

a. Army Regulation (AR) 200-1, Environmental Protection and Enhancement, 13 Dec 07.

b. Sikes Act, 16 USC 670a-670o, as amended through Public Law 118-84, Enacted 28 Oct 09.

c. Department of Defense Instruction (DODI) 4715.03, 18 Mar 11.

d. Executive Order 13112, Invasive Species, 3 Feb 99.

e. USAG-HI Integrated Natural Resources Management Plan, 2010-2014.

2. Applicability. This policy applies to all Soldiers, Civilians, Family members, contractors, and any other person, ("covered person"), who installs landscaping on any U.S. Army installation, facility, housing area, or work site in the State of Hawaii, ("covered area"). This policy also applies to all products sold at the Army and Air Force Exchange Service, including but not limited to: plants, mulch, and wood products.

3. Policy.

a. Protecting our environment is one of the most important aspects of accomplishing the USAG-HI mission. USAG-HI is committed to reducing the spread of invasive species that harm the local Hawaiian environment. Invasive species are often unintended hitchhikers on cargo and other trade conveyances. Still more species are deliberately introduced as pets, ornamental plants, crops, food, or for recreation, pest control or other purposes. Most non-native species, including most of our sources of food and fiber, are not harmful, and many are highly beneficial. A small percentage of non-native species cause great harm to the environment, the economy or human health. Non-native species that cause harm are collectively known as invasive species.

b. USAG-HI aims to ensure that the Little Fire Ant (LFA), *Wasmannia punctata*, an invasive species that was recently introduced to the State of Hawaii, does not become established on U.S. Army installations. LFA has the potential to infest homes and cause painful stings on both adults and children. The LFA also stings pets, such as dogs or cats on their eyes, which has the potential to cause blindness.

c. Pursuant to a Biological Opinion with the U.S. Fish and Wildlife Service, USAG-HI must monitor invasive species and develop methods to eradicate invasive species. To achieve this end, all new USAG-HI landscaping projects must be sourced from LFA free nurseries. For confidentiality reasons, the Hawaii Department of Health has not published a formal list of nurseries that are not fire ant free. However, the agency has disclosed that these nurseries are located in the Waimanalo area on the Windward coast of Oahu. Therefore, it is *strongly* recommended that the covered persons not purchase or install any landscaping products purchased from the Waimanalo area until further notice.

d. Any individual who proposes or initiates a new landscaping project is required to contact the Directorate of Public Works Natural Resource Program (NRP), at 655-9189 or 655-9191, to obtain an approval certificate for the project prior to purchasing the landscaping materials.

e. Once the landscaping materials are installed, the project proponent must provide NRP personnel access to survey and inspect the newly landscaped sites. The purpose of the inspection is to look for LFA. If LFA are found, the project proponent or contractor who installed the plants must provide the labor and funding to remove the LFA. Under these circumstances, the responsible party may only use pest management controls that comply with the current USAG-HI Pest Management Plan and obtain approval from the Installation Pest Management Coordinator (IPMC) prior to any treatment. A copy of the Pest Management Plan may be obtained at Building 104 on Wheeler Army Airfield from the Pest Management Program Manager, 656-3093. The IPMC can provide guidance on how to comply with the Pest Management Plan.

f. The enclosures to this policy memorandum contain additional information about LFA and how to test plants for their presence.

g. This policy memorandum is effective immediately and remains in effect until cancelled or superseded in writing.

4. The proponent for administration of the Avoidance of Little Fire Ant Introduction policy is the DPW Environmental Division, at 655-9189 or 655-9191.

RICHARD A. FROMM
COL, AD
Commanding

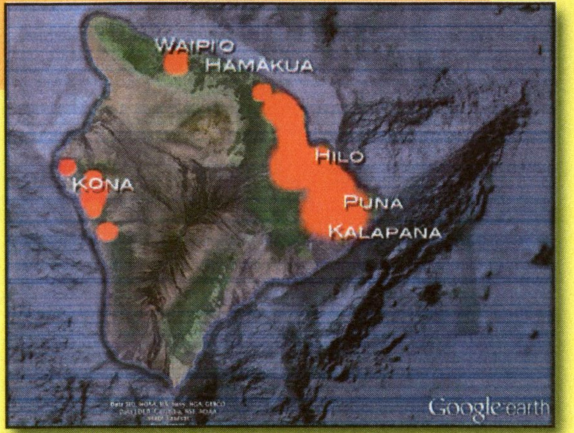
2 Encls
1. Little Fire Ant Brochure
2. Little Fire Ant Testing Brochure

DISTRIBUTION
Electronic Media

What is the Little Fire Ant?

Little Fire Ants (LFA) are a new, invasive stinging ant that will spread across the Hawaiian islands if we don't take action now.

LFA infest yards, houses, farms and forests. Their powerful stings harm people and wildlife. LFA sting the eyes of pets, leading to blindness. LFA damage crops, food production, and the economy everywhere they have spread. LFA alter (or impact) people's lives because their stings are unavoidable.



Hawaii Island LFA infested areas (2014)

LFA was discovered in the Puna area of Hawaii Island in 1999 and has since spread, hidden in plants, logs, greenwaste, gravel, and even cars. Interisland spread has been somewhat limited by plant treatment and inspection, but LFA continue to spread.

In December 2013, LFA were discovered in hapuu logs at nurseries and garden shops on Oahu and Maui, and in landscaping on Lanai. Many of the hapuu sold to the public remain unaccounted for. There are many other pathways that LFA may be transported and introduced to other islands.

A multi-agency response has been launched to survey and treat potential LFA locations not found on Hawaii Island. Everyone needs to test their homes and yards and report possible LFA. We need your kokua.

Detect - Report - Stop the Little Fire Ant

DETECT

HDOA locations for dropping off or mailing samples:

Kauai: 4398A Pua Loke Street
Lihue, HI 96766

Oahu: 1428 S. King St
Honolulu, HI 96814

Maui: 635 Mua Street
Kahului, HI 96732

Molokai: *(call 643-PEST for instructions)*

Hawaii Island: Hawaii Ant Lab / HDOA
16 E. Lanikaula St
Hilo, HI 96720

REPORT

Immediately report suspected LFA to any of the following places:

Hawaii Department of Agriculture Statewide Hotline: 643-PEST (7378)

Kauai Invasive Species Committee: 821-1490
Oahu Invasive Species Committee: 266-7994
Maui Invasive Species Committee: 573-6472
Molokai Invasive Species Committee: 553-5236
Big Island Invasive Species Committee: 933-3340
Hawaii Ant Lab: 315-5656 (Hawaii Island)

LEARN MORE

For more information about LFA, visit:
www.littlefireants.com or www.LFAHawaii.org

Partners and Contributors: Hawaii Department of Agriculture, Department of Land and Natural Resources, US Fish & Wildlife Service, Hawaii Ant Lab, Hawaii Invasive Species Council, Coordinating Group on Alien Pest Species, the Invasive Species Committees of Hawaii, College of Tropical Agriculture and Human Resources, University of Hawaii, The Nature Conservancy, Oahu Army Natural Resources Program, Pacific Cooperative Studies Unit, City and County of Honolulu,

Little Fire Ant

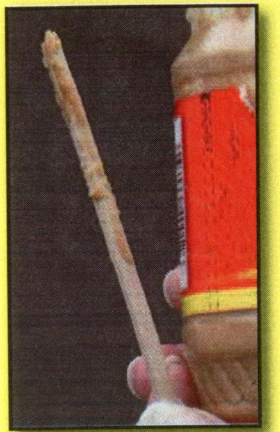
Wasmannia auropunctata

Detect - Report - Stop Little Fire Ant!

Protect Your Family

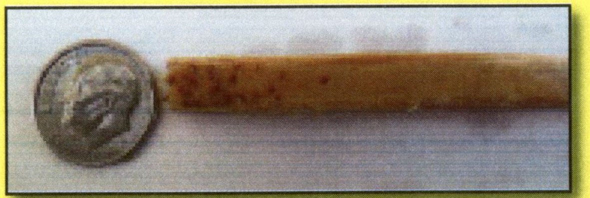
DETECT

Supplies: peanut butter, disposable chopsticks, zip top bags, and a pen.



1. Place sticks with a ***thin*** smear of peanut butter* every few feet in and around plants in your yard, garden, and lanai. Focus on shady, moist areas, the bottoms of pots, and where plants' leaves meet the stem.

**Regular peanut butter, not natural or fat free.*
***For those with a peanut allergy, use pieces of luncheon meat.*



2. Leave the sticks in place for ***1 hour*** during the cool part of the day.

3. Check sticks without moving them. Collect the stick if:
- The ants are uniformly orange/red and VERY small.
- You are unsure about the ants.

4. Very carefully place it directly into the bag (so ants don't fall off).

5. Seal the bag, label it with your name, address and phone number, and **put it in your freezer overnight** to kill the ants.

*View ***How to Survey for LFA*** video at http://vimeo.com/97558997

REPORT

Call the Hawaii Department of Agriculture (HDOA) statewide **pest hotline at 643-PEST** to report that you might have LFA. Drop off (or mail) the sample (zip top bag with frozen ants) at any HDOA office (see back for locations).

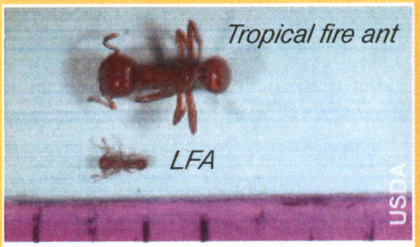
HDOA will contact you when the ants are identified. **Do not disturb the ants** and **do not control or treat the area.** This will make the nests difficult to find and possibly spread them further.

STOP LFA

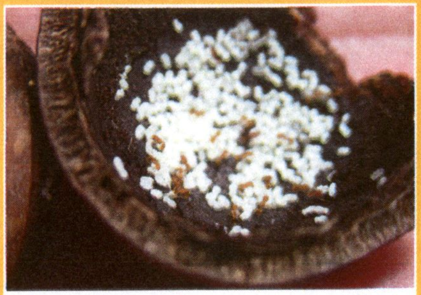
If HDOA confirms you don't have LFA, congratulations and thank you! Remain vigilant. **Always quarantine and test any new plants,** cut flowers, plant materials, mulch, soil and other items.

If you do have LFA, call HDOA about what to do next. We can help you control it, but we need your help to map and control every location of LFA to help prevent it from spreading.

How to identify LFA:
- *Tiny ants: 1/16 inch, as long as a penny is thick*
- *Orange-red in color*
- *Slow-moving*



Look-alike: Tropical fire ant
- *Common larger stinging ant*
- *Widespread*
- *Builds ground nests in sunny, dry areas*
- *Nests have distinct openings*



An entire LFA colony can fit in macadamia nut shell
- *LFA don't form mounds*
- *Nests don't have distinct openings*
- *Nests in moist, shady areas, in trees, under tree bark, under rocks, within logs & in leaf litter*

Little Fire Ants are on the move, and could be in your plants or yard. Find out today using this simple test.

1. Smear a very thin coat of peanut butter on disposable chopsticks. Place them every few feet in and around plants in shady, moist areas, and up in banana leaf axles. Be sure peanut butter is in contact with surface of test site. (You can substitute spam or lunch meat for peanut butter.)

2. Leave the peanut butter chopsticks out for an hour during the day.

3. Check all chopsticks. If the ants you see are any one or more of the of the following, they are NOT LFA;
   -black -large head with a small body
   -fast-moving -more than one color

4. If you are unsure about the ants, or if you find orange or red ants that are VERY small, about as long as a penny is thick, you may have LFA, but a positive identification will require help.

5. Place the chopstick with ants into a zip-top bag, label it with your contact information, and place it in the freezer overnight to kill the ants.

6. The next day, deliver or mail your sample to the nearest Hawai'i Department of Agriculture (HDOA) office. You can also call the HDOA pest hotline at 643-PEST (643-7378), or the Oahu Invasive Species Committee at 266-7994 to make a report and get help. DO NOT move or spray infested materials, and do not move live ants! You are seeing the workers, and we need them alive to help us get to the queens.

7. Always quarantine and test your new plants and plant materials and other items from infested areas, because LFA will continue to be a threat to ALL our islands.

On Oahu, mail or drop off your samples at:

HDOA Plant Pest Control OR **HDOA Plant Quarantine Branch**
1428 S. King Street **1849 Auiki Street**
Honolulu, HI 96814 **Honolulu, HI 96819**

Little Fire Ants are on the move, and could be in your plants or yard. Find out today using this simple test.

1. Smear a very thin coat of peanut butter on disposable chopsticks. Place them every few feet in and around plants in shady, moist areas, and up in banana leaf axles. Be sure peanut butter is in contact with surface of test site. (You can substitute spam or lunch meat for peanut butter.)

2. Leave the peanut butter chopsticks out for an hour during the day.

3. Check all chopsticks. If the ants you see are any one or more of the of the following, they are NOT LFA;
   -black -large head with a small body
   -fast-moving -more than one color

4. If you are unsure about the ants, or if you find orange or red ants that are VERY small, about as long as a penny is thick, you may have LFA, but a positive identification will require help.

5. Place the chopstick with ants into a zip-top bag, label it with your contact information, and place it in the freezer overnight to kill the ants.

6. The next day, deliver or mail your sample to the nearest Hawai'i Department of Agriculture (HDOA) office. You can also call the HDOA pest hotline at 643-PEST (643-7378), or the Oahu Invasive Species Committee at 266-7994 to make a report and get help. DO NOT move or spray infested materials, and do not move live ants! You are seeing the workers, and we need them alive to help us get to the queens.

7. Always quarantine and test your new plants and plant materials and other items from infested areas, because LFA will continue to be a threat to ALL our islands.

On Oahu, mail or drop off your samples at:

HDOA Plant Pest Control OR **HDOA Plant Quarantine Branch**
1428 S. King Street **1849 Auiki Street**
Honolulu, HI 96814 **Honolulu, HI 96819**

SPREAD THE WORD, NOT THE PEST!!

For more information visit: www.LFAHawaii.org
or www.littlefireants.com

EARLY DETECTION IS OAHU'S GREATEST CHANCE OF CONTROLLING LITTLE FIRE ANT.

- Little Fire Ants (LFA) are new to Oahu.
- Arrived in December 2013 on hapuu logs from Hawaii Island.
- Unknown how many hapuu logs were sold before LFA were detected.

- LFA are one color...orange.
- LFA are tiny, about 1/16th of an inch...that's the thickness of a penny.
- LFA are very slow-moving and don't cling to surfaces very well.

- LFA live not only on the ground, but also in the trees.
- LFA fall from trees, stinging whomever happens to be underneath.

- LFA deliver painful stings that can look like a rash and last for days.
- LFA can sting animals in their eyes, causing pain and blindness.

- LFA farm agriculture pests such as mealy bugs and scale, causing decreased crop production.
- Large LFA infestations are difficult and expensive to control.

SPREAD THE WORD, NOT THE PEST!!

For more information visit: www.LFAHawaii.org
or www.littlefireants.com

EARLY DETECTION IS OAHU'S GREATEST CHANCE OF CONTROLLING LITTLE FIRE ANT.

- Little Fire Ants (LFA) are new to Oahu.
- Arrived in December 2013 on hapuu logs from Hawaii Island.
- Unknown how many hapuu logs were sold before LFA were detected.

- LFA are one color...orange.
- LFA are tiny, about 1/16th of an inch...that's the thickness of a penny.
- LFA are very slow-moving and don't cling to surfaces very well.

- LFA live not only on the ground, but also in the trees.
- LFA fall from trees, stinging whomever happens to be underneath.

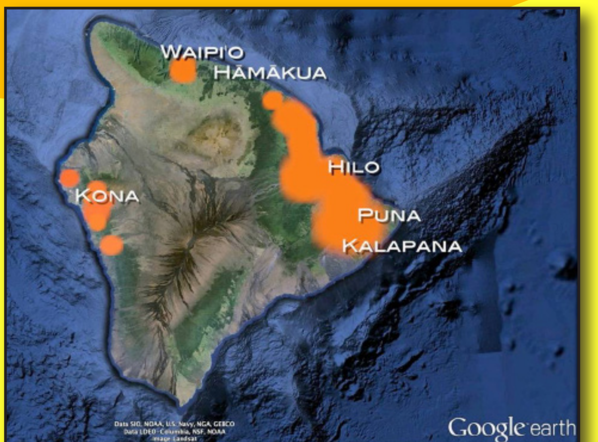
- LFA deliver painful stings that can look like a rash and last for days.
- LFA can sting animals in their eyes, causing pain and blindness.

- LFA farm agriculture pests such as mealy bugs and scale, causing decreased crop production.
- Large LFA infestations are difficult and expensive to control.

What is the Little Fire Ant?

Little Fire Ants (LFA) are a new, invasive stinging ant that will spread across the Hawaiian islands if we don't take action now.

LFA infest yards, houses, farms and forests. Their powerful stings harm people and wildlife. LFA sting the eyes of pets, leading to blindness. LFA damage crops, food production, and the economy everywhere they have spread. LFA alter (or impact) people's lives because their stings are unavoidable.



Hawaii Island LFA infested areas (2014)

LFA was discovered in the Puna area of Hawaii Island in 1999 and has since spread, hidden in plants, logs, greenwaste, gravel, and even cars. Interisland spread has been somewhat limited by plant treatment and inspection, but LFA continue to spread.

In December 2013, LFA were discovered in hapuu logs at nurseries and garden shops on Oahu and Maui, and in landscaping on Lanai. Many of the hapuu sold to the public remain unaccounted for. There are many other pathways that LFA may be transported and introduced to other islands.

A multi-agency response has been launched to survey and treat potential LFA locations not found on Hawaii Island. Everyone needs to test their homes and yards and report possible LFA. We need your kokua.

Detect - Report - Stop the Little Fire Ant

DETECT

HDOA locations for dropping off or mailing samples:

Kauai: 4398A Pua Loke Street
Lihue, HI 96766

Oahu: 1428 S. King St
Honolulu, HI 96814

Maui: 635 Mua Street
Kahului, HI 96732

Molokai: *(call 643-PEST for instructions)*

Hawaii Island: Hawaii Ant Lab / HDOA
16 E. Lanikaula St
Hilo, HI 96720

REPORT

Immediately report suspected LFA to any of the following places:

Hawaii Department of Agriculture Statewide Hotline: 643-PEST (7378)

Kauai Invasive Species Committee: 821-1490
Oahu Invasive Species Committee: 266-7994
Maui Invasive Species Committee: 573-6472
Molokai Invasive Species Committee: 553-5236
Big Island Invasive Species Committee: 933-3340
Hawaii Ant Lab: 315-5656 (Hawaii Island)

LEARN MORE

For more information about LFA, visit:
www.littlefireants.com or www.LFAHawaii.org

Partners and Contributors: Hawaii Department of Agriculture, Department of Land and Natural Resources, US Fish & Wildlife Service, Hawaii Ant Lab, Hawaii Invasive Species Council, Coordinating Group on Alien Pest Species, the Invasive Species Committees of Hawaii, College of Tropical Agriculture and Human Resources, University of Hawaii, The Nature Conservancy, Oahu Army Natural Resources Program, Pacific Cooperative Studies Unit, City and County of Honolulu,

Little Fire Ant

Wasmannia auropunctata

Detect - Report - Stop Little Fire Ant!

Protect Your Family

DETECT

Supplies: peanut butter, disposable chopsticks, zip top bags, and a pen.

1. Place sticks with a ***thin*** smear of peanut butter* every few feet in and around plants in your yard, garden, and lanai. Focus on shady, moist areas, the bottoms of pots, and where plants' leaves meet the stem.

**Regular peanut butter, not natural or fat free.*
***For those with a peanut allergy, use pieces of luncheon meat.*

2. Leave the sticks in place for ***1 hour*** during the cool part of the day.

3. Check sticks without moving them. Collect the stick if:
- The ants are uniformly orange/red and VERY small.
- You are unsure about the ants.

4. Very carefully place it directly into the bag (so ants don't fall off).

5. Seal the bag, label it with your name, address and phone number, and **put it in your freezer overnight** to kill the ants.

*View ***How to Survey for LFA*** video at http://vimeo.com/97558997

REPORT

Call the Hawaii Department of Agriculture (HDOA) statewide **pest hotline at 643-PEST** to report that you might have LFA. Drop off (or mail) the sample (zip top bag with frozen ants) at any HDOA office (see back for locations).

HDOA will contact you when the ants are identified. **Do not disturb the ants** and **do not control or treat the area.** This will make the nests difficult to find and possibly spread them further.

STOP LFA

If HDOA confirms you don't have LFA, congratulations and thank you! Remain vigilant. **Always quarantine and test any new plants**, cut flowers, plant materials, mulch, soil and other items.

If you do have LFA, call HDOA about what to do next. We can help you control it, but we need your help to map and control every location of LFA to help prevent it from spreading.

How to identify LFA:
- *Tiny ants: 1/16 inch, as long as a penny is thick*
- *Orange-red in color*
- *Slow-moving*

Look-alike: Tropical fire ant
- *Common larger stinging ant*
- *Widespread*
- *Builds ground nests in sunny, dry areas*
- *Nests have distinct openings*

An entire LFA colony can fit in macadamia nut shell
- *LFA don't form mounds*
- *Nests don't have distinct openings*
- *Nests in moist, shady areas, in trees, under tree bark, under rocks, within logs & in leaf litter*

Little Fire Ants are on the move, and could be in your plants or yard. Find out today using this simple test.

1. Smear a very thin coat of peanut butter on disposable chopsticks. Place them every few feet in and around plants in shady, moist areas, and up in banana leaf axles. Be sure peanut butter is in contact with surface of test site. (You can substitute spam or lunch meat for peanut butter.)

2. Leave the peanut butter chopsticks out for an hour during the day.

3. Check all chopsticks. If the ants you see are any one or more of the of the following, they are NOT LFA;
   -black -large head with a small body
   -fast-moving -more than one color

4. If you are unsure about the ants, or if you find orange or red ants that are VERY small, about as long as a penny is thick, you may have LFA, but a positive identification will require help.

5. Place the chopstick with ants into a zip-top bag, label it with your contact information, and place it in the freezer overnight to kill the ants.

6. The next day, deliver or mail your sample to the nearest Hawaiʻi Department of Agriculture (HDOA) office. You can also call the HDOA pest hotline at 643-PEST (643-7378), or the Oahu Invasive Species Committee at 266-7994 to make a report and get help. DO NOT move or spray infested materials, and do not move live ants! You are seeing the workers, and we need them alive to help us get to the queens.

7. Always quarantine and test your new plants and plant materials and other items from infested areas, because LFA will continue to be a threat to ALL our islands.

On Oahu, mail or drop off your samples at:

HDOA Plant Pest Control	OR	HDOA Plant Quarantine Branch
1428 S. King Street		1849 Auiki Street
Honolulu, HI 96814		Honolulu, HI 96819

Little Fire Ants are on the move, and could be in your plants or yard. Find out today using this simple test.

1. Smear a very thin coat of peanut butter on disposable chopsticks. Place them every few feet in and around plants in shady, moist areas, and up in banana leaf axles. Be sure peanut butter is in contact with surface of test site. (You can substitute spam or lunch meat for peanut butter.)

2. Leave the peanut butter chopsticks out for an hour during the day.

3. Check all chopsticks. If the ants you see are any one or more of the of the following, they are NOT LFA;
   -black -large head with a small body
   -fast-moving -more than one color

4. If you are unsure about the ants, or if you find orange or red ants that are VERY small, about as long as a penny is thick, you may have LFA, but a positive identification will require help.

5. Place the chopstick with ants into a zip-top bag, label it with your contact information, and place it in the freezer overnight to kill the ants.

6. The next day, deliver or mail your sample to the nearest Hawaiʻi Department of Agriculture (HDOA) office. You can also call the HDOA pest hotline at 643-PEST (643-7378), or the Oahu Invasive Species Committee at 266-7994 to make a report and get help. DO NOT move or spray infested materials, and do not move live ants! You are seeing the workers, and we need them alive to help us get to the queens.

7. Always quarantine and test your new plants and plant materials and other items from infested areas, because LFA will continue to be a threat to ALL our islands.

On Oahu, mail or drop off your samples at:

HDOA Plant Pest Control	OR	HDOA Plant Quarantine Branch
1428 S. King Street		1849 Auiki Street
Honolulu, HI 96814		Honolulu, HI 96819

SPREAD THE WORD, NOT THE PEST!!

For more information visit: www.LFAHawaii.org
or www.littlefireants.com

EARLY DETECTION IS OAHU'S GREATEST CHANCE OF CONTROLLING LITTLE FIRE ANT.

- Little Fire Ants (LFA) are new to Oahu.
- Arrived in December 2013 on hapuu logs from Hawaii Island.
- Unknown how many hapuu logs were sold before LFA were detected.

- LFA are one color…orange.
- LFA are tiny, about 1/16th of an inch…that's the thickness of a penny.
- LFA are very slow-moving and don't cling to surfaces very well.

- LFA live not only on the ground, but also in the trees.
- LFA fall from trees, stinging whomever happens to be underneath.

- LFA deliver painful stings that can look like a rash and last for days.
- LFA can sting animals in their eyes, causing pain and blindness.

- LFA farm agriculture pests such as mealy bugs and scale, causing decreased crop production.
- Large LFA infestations are difficult and expensive to control.

SPREAD THE WORD, NOT THE PEST!!

For more information visit: www.LFAHawaii.org
or www.littlefireants.com

EARLY DETECTION IS OAHU'S GREATEST CHANCE OF CONTROLLING LITTLE FIRE ANT.

- Little Fire Ants (LFA) are new to Oahu.
- Arrived in December 2013 on hapuu logs from Hawaii Island.
- Unknown how many hapuu logs were sold before LFA were detected.

- LFA are one color…orange.
- LFA are tiny, about 1/16th of an inch…that's the thickness of a penny.
- LFA are very slow-moving and don't cling to surfaces very well.

- LFA live not only on the ground, but also in the trees.
- LFA fall from trees, stinging whomever happens to be underneath.

- LFA deliver painful stings that can look like a rash and last for days.
- LFA can sting animals in their eyes, causing pain and blindness.

- LFA farm agriculture pests such as mealy bugs and scale, causing decreased crop production.
- Large LFA infestations are difficult and expensive to control.