2019 Status Report
for the
Makua and Oahu Implementation Plans

October 2019
Prepared by:
Oahu Army Natural Resources Program
Pacific Cooperative Studies Unit
Pacific International Center for High Technology Research

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LIST OF CONTRIBUTORS

Keith Adams	Natural Resource Management Technician
Daniel Adamski	Rare Plant Program Manager
Michelle Akamine	Monitoring Program Specialist
Makanani Akiona	Propagule Research Technician
Jane Beachy	Ecosystem Restoration Program Manager
Tyler Bogardus	Small Vertebrate Pest Stabilization Specialist
Matthew Burt	Elepaio Stabilization/Ungulate Program Coordinator
Timothy Chambers	Propagule Management Specialist
Deena Gary	Rare Invertebrate Conservation Specialist
Celeste Hanley	Environmental Outreach Specialist
Scott Heintzman	Natural Resource Management Coordinator
John Hintze	Natural Resource Management Technician
David Hoppe-Cruz	Natural Resource Management Technician
Stephanie Joe	Alien Invertebrate Control and Research Specialist
Roy Kam	Natural Resource Data Management Specialist
Eli Kimmerle	Natural Resource Management Technician
Kaia Kong	Natural Resource Management Technician
Linda Koch	Natural Resource GIS Specialist
Julia Lee	Senior Ecosystem Restoration Specialist
Christopher Lum	Plant Propagation Assistant
Karl Magnacca	Entomological Program Specialist
Taylor McCarthy	Support Operations Supervisor
Chelsea Osaki	Natural Resource Management Specialist
Jobriath Rohrer	Senior Natural Resource Management Coordinator
Thomas Russel	Natural Resource Management Technician
Wesley Shinsato	Natural Resource Management Technician
Clifford Smith	Natural Resource Operations Manager
Philip Taylor	Natural Resource Avian Conservation Specialist
Jamie Tanino	Natural Resource Management Coordinator
Melissa Valdez	Natural Resource Management Coordinator
Kimberly Welch	Environmental Outreach Specialist
Aubree Woods	Natural Resource Management Technician

*Cover photo: Emergence of a new forest at the Palikea North snail enclosure. Image from a series of photopoints used for documenting native plant restoration progress.

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EXECUTIVE SUMMARY

The Army natural resource program on Oahu (OANRP) has over 50 personnel on staff, comprised of management and administrative support staff, an ecosystem restoration crew, an ungulate management crew, three resource management crews, and a plant nursery/seed bank crew. Most of these staff are employed via a cooperative agreement funded by the U.S. Army Garrison, Hawaii to the University of Hawaii. Staff levels in Fiscal Year (FY) 2019 were slightly down from FY 2018. For FY 2019, OANRP received a total of $5,562,938 to implement Makua Implementation Plan (MIP) projects and Tier 1 projects from the Oahu Implementation Plan (OIP). This included funding for unexploded ordnance escort, technical expertise, plant propagation services and real estate negotiations. As in FY 2018, for FY 2019, 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 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 MIP and OIP. The period covered in this report is July 1, 2018 to June 30, 2019. This report covers Year 15 of the MIP and Year 12 of the OIP.

Hawaiian diacritics are not used in this document except in some appendices, 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 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 fifteenth year of the MIP Addendum (Addendum completed in 2005, original finalized in 2003) and the twelfth 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 finalizing the OIP, two additional species were added requiring stabilization, *Drosophila montgomeryi* and *Drosophila substenoptera*. Of the OIP plants, management activities are conducted with eleven taxa present in the Schofield Barracks West Range Action Area and in the Kahuku Training Area. In 2019, OANRP did not receive funding to support the remaining 12 OIP plant taxa and the six Koolau *Achatinella* species because of the lack of Army training impacts to these taxa in the Kawailoa Training Area. The MIP and OIP also require surveys of Army Landing Zones for weeds and the prevention and control of weeds on training areas.

The Army contracted the Army Corps of Engineers, Engineering Research and Development Center, Construction Engineering Research Laboratory to complete an updated Programmatic Biological Assessment (PBA) 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 plant and animal taxa given federal status in August 2012 and September 2016. The

decision was made to include Makua Military Reservation in this PBA, 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 PBA is expected in the fall of 2019 and a BO from the USFWS is anticipated in the summer of 2020. Management requirements will be determined through the consultation process and outlined in the Biological Opinion to be issued upon completion of this process.

Infrastructure

No major changes were required during this reporting period. The current facilities are meeting Program needs.

Landowner/Agency Cooperative Agreements and Partnerships

The Army could not meet its MIP and OIP goals without the cooperation of public and private landowners and agencies. OANRP continues to operate under a 20-year license agreement with Kamehameha Schools (KS) (expiring November 2030). A three-year license agreement with Hawaii Reserves, Inc. expired in March 2017 and needs to be renewed. The four-year license agreement with the Honolulu Board of Water Supply expired in November 2014 but this agreement contains a 'perpetual right of entry to maintain clause.' Although this clause exists, it is still important for this agreement to be renewed. Lastly, the 3-year right of entry agreement for Gill Ewa Lands expired in May 2019 and also needs to be renewed. The Army must utilize the Army Corps of Engineers (ACOE), Real Estate Division to enter into and renew real estate agreements. The ACOE office has experienced high staff turnover over the last 5 years that has complicated agreement renewal efforts. Currently, ACOE staffing is stable and pending renewals will be reinitiated. The Army also continues to work cooperatively under an MOU with the U.S. Navy.

In July 2011, an MOU was signed between the Army and the State of Hawaii, Department of Land and Natural Resources (DLNR) for the use of DLNR lands to meet MIP and OIP goals. Currently, the Army holds seven State of Hawaii permits for OANRP work on Oahu, 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, a State Parks Permit and a Protected Wildlife Permit. The Army and the State are working to establish a rental agreement for OANRP's use of the Nike site mid-elevation greenhouse and associated facilities. This process was severely delayed due to past staffing changes at the ACOE, Real Estate Division. As of spring 2019, a new and motivated team from ACOE was assigned to the project and progress is being made. DLNR has conveyed that if the Army is unable to establish this rental agreement, use of the Nike Nursery must be discontinued.

OANRP continues to provide and receive support from partner agencies including the Oahu Invasive Species Committee, Oahu Plant Extinction Prevention Program (OPEPP), Snail Extinction Prevention Program (SEPP) and the Koolau and Waianae Mountains Watershed Partnerships. The Army is also an official member of the Koolau Mountains Watershed Partnership, the Waianae Mountains Watershed Partnership, the Coordinating Group on Alien Pest Species and the Hawaii Rare Plant Restoration Group. Highlights of Army natural resource partnership work over this reporting year included cooperation in wildfire response, staff exchanges on high priority incipient invasive weed and restoration projects, aerial surveys for highly invasive species and pathogens, rare snail enclosure construction and maintenance, and numerous habitat improvements for endangered plant and invertebrate OPEPP and SEPP species.

Management Unit (MU) Protection

MU protection continued on several fronts during this reporting period through: 1) ungulate control/fencing efforts, 2) aggressive weed control including control of incipient invasives, 3) continued expansion of active habitat restoration effort through the outplanting of common natives, and 4) rodent control technique refinement for MU application.

During this reporting period, OANRP completed the Kaala and West Makaleha MU fence expansions begun in 2018. Additional fencing at Kaala was necessary to address points of ingress into the management unit. The West Makaleha fence was expanded to incorporate more habitat for IP stabilization activities. Additionally, ungulate staff responded to pig ingress at eight management units and goat ingress at Ohikilolo. Monitoring intervals are suitable for detecting any ungulates that breach fence boundaries and response is efficient. Pig eradication efforts are still underway within the Lihue MU and the Makua Perimeter Fence. For more details about OANRP ungulate control see Chapter 1 – Ungulate Control Program.

Ecosystem Restoration Program

In this reporting period, OANRP spent 11,456.5 hours controlling weeds across 642.62 ha. Incipient Control Area (ICA) efforts accounted for 525 ha (82% of total area controlled). Staff spent 3,157.5 (27.5% of total effort) hours on ICA management and conducted 667 visits to 262 ICAs. This is the greatest effort spent and area covered for incipient weeds in a reporting period to date. Of the ICA treatment area, 95% of it was spent treating 10 priority taxa, and of the treatment effort, 91% was spent treating 11 taxa. Nine ICAs were declared eradicated over the reporting period, for a total of 45 eradications over the last 15 years. However, 28 new ICAs were created. Weed Control Area (WCA) efforts covered 117.6 ha (18% of total area controlled). OANRP conducted control in WCAs for a total of 8,299 hours (72.5% of total effort) over 956 visits at 191 WCAs. Total effort increased from last year, while total area weeded decreased. Of special note is that access issues and unexploded ordnance safety concerns continue to restrict management at Lihue MU and portions of the Makua MU. This year, staff conducted an herbicide efficacy study for carpetgrass (*Axonopus fissifolius*) (Appendix 3-8).

OANRP conducted 164 road, landing zone, campsite and weed transect surveys to detect and prevent the spread of any newly introduced invasive species. OANRP submitted 16 non-native plant samples to Bishop Museum. Of these samples, one was a new island record for Oahu. Highlights are covered in Chapter 3 – Ecosystem Management.

To date, OANRP has completed a total of 22 Ecosystem Restoration Management Unit Plans (ERMUPs) for the highest priority and largest MUs. During this reporting period, an ERMUP was prepared for Keaau Hibiscus MU, and ERMUPs for Kahanahaiki, Makaha I & II, Palikea, and Puaakanoa MUs were updated, and are included in this year's report (see Appendices 3-1 to 3-5).

Complementary to other threat control programs, additive restoration work expanded during this reporting period. Numbers of outplants and outplant area was somewhat lower this year compared with last year, though considerably higher than in 2016 and 2017. In thirteen MUs, and across nearly 2.72 ha, 6,292 common native plants were planted to enhance recovery of native habitat, provide additional host plants for rare snails and rare *Drosophila* spp. flies, and to help stabilize habitat for rare plants. The two MUs that received the largest number of common outplants are Kahanahaiki and Palikea. In addition, the use of seeds sows, divisions, and transplants continue to complement outplanting and weed control efforts. Area of these efforts has increased every year since 2016, and reached 1.65 ha this year. Efforts over the last year mainly consisted of *Pipturus albidus* and *Bidens torta* seed sows, though a number of additional taxa were used for seeds sows, divisions, and transplants. Common native seed collection efforts also

increased to secure seed for planned restoration projects, for seed production sites, and for seed broadcast trials. This year, staff developed methods for propagating three common native fern taxa that may be produced on large scales for restoration efforts. See Chapter 3 – Ecosystem Management, for more information on habitat restoration efforts.

Rodent Control Program

OANRP maintains rodent control in MUs in large trapping grids year-round, depending on the resource targeted for protection. Small trapping grids were deployed for localized rodent control around rare plant and animal populations. Large trapping grids were used for rodent control across MUs as part of native habitat restoration efforts and to protect the rare species found there. In addition, OANRP continues to be on the cutting edge of research and development for new rodent control tools to increase efficiency and effectiveness. During this reporting period, OANRP maintained 31 year-round rodent control areas consisting of 1,421 A24 traps. As a result of OANRP testing A24 rat bait containing citric acid to repel slugs, the re-baiting interval has been extended from four to six months. This innovation has even further reduced the labor input required to maintain highly effective ecosystem-scale rodent control. In fact, within this reporting period, OANRP transitioned all seasonal rodent control grids to year-round grids due to the longevity of the new slug-repellent bait and new A24 baiting systems. The OANRP rodent control program continues to make considerable contributions in this area of conservation tool development for the State of Hawaii. See Chapter 8 Rodent Control for details on these projects.

Monitoring Program

The OANRP monitoring program conducted of several projects associated with vegetation and habitat monitoring, as well as projects informing rare species and target weed taxa management efforts. During this reporting period, staff:

- Conducted vegetation community monitoring for Ekahanui MU (results in Appendix 3-10).
- Monitored vegetation change associated with a restoration project in Makaha (results in Appendix 3-11).
- Conducted baseline vegetation monitoring to track change associated with restoration efforts at the 3 Points snail enclosure (results in Appendix 5-2).
- Conducted a soil compaction study at the 3 Points snail enclosure to address concerns about negative impacts from trampling (results in Appendix 5-3)
- Monitored vegetation change associated with restoration efforts at the Palikea North snail enclosure (results in Appendix 5-4).
- Analyzed temperature and relative humidity from data loggers kept at snail sites in Makaha and Hapapa to inform possible snail translocation from Makaha to Hapapa, and at snail release sites at Ekahanui and Palikea to examine possible environment explanations of differing success.
- Monitored ongoing seed sow trials of *Cyanea superba* subsp. *superba*.
- Monitored an ongoing seed sow trial for *Tetramolopium filiforme* var. *polyphyllum*.
- Began a laboratory trial to assess the effect of post-harvest fruit aging on *Cyanea longiflora* seed viability.
- Assisted with research efforts to measure fitness among the F1 generation of variously crossed *Cyanea grimesiana* subsp. *obatae*
- Investigated vegetation monitoring methodologies for Pahole MU.
- Assisted in re-reading the Welton vegetation monitoring plots in Pahole and Kapuna MUs.
- Initiated a trial to explore the efficacy of an organic herbicide to control fountain grass (*Cenchrus setaceus*).

- Continued to use the Gigapan System to guide management of *Chromolaena odorata* at KTA, and to monitor vegetation cover at Keaau and Ohikilolo Lower MU.
- Continued developing drone utilization protocols to capture photos documenting change over time.

Fire Management

This reporting period began with a series of fires along the west coast of Oahu that burned portions of Waianae Kai, Makaha and Keaau Valleys in August 2018; in all over 5,000 acres burned. The impact to natural resources was the most severe in Keaau where the fire swept through both the *Hibiscus brackenridgei* and *Gouania vitifolia* fences. Fortunately, portions of the *Hibiscus* fence were spared due to fuels modification conducted by OANRP staff. The Army Fire and Natural Resource teams were instrumental in extinguishing the Keaau fire and the mauka portion of the Makaha fire. The Army's back up seed collections and cuttings from living collections will be used in restoration efforts as appropriate. For a full summary of the effects of this fire see Appendix ES-4 in the 2018 status report, as this fire was mentioned in the 2018 executive summary.

In May 2019, one large fire (>177 acres) started near the northern boundary of Schofield Barracks on private land. Although this fire was not caused by training, the Army was involved in the response. Army helicopter assets addressed the fire line where it was burning on or near Army property. OANRP staff provided fire mapping support and tracked the fire's northern boundary relative to the Manuwai management unit, ready to respond if it was threatened. A full fire report was not prepared but a map of the fire is included as Appendix ES-3.

In May 2019, the Army conducted another successful prescribed burn at Schofield Barracks. The burn reduced fuel within the impact area as planned. The prescribed burn ignition was delayed until the fire referenced above was contained.

Outreach Program

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

During this reporting period, 2,681 military members were trained during the Environmental Compliance Officers course and the Range Safety Officer/Officer-in-charge briefings. These presentations were designed to educate service members in leadership roles about the rules and procedures in place to protect natural resources on training lands and their role in ensuring compliance.

Also over the past year, volunteers contributed 4,586 hours on 75 field days and 456.25 hours volunteering at the OANRP baseyard. In addition, the program hosted six summer interns. Many former interns return to work for OANRP after college graduation. See Chapter 2 – Environmental Outreach for more details.

Rare Plant Program

The current status of MIP and OIP rare plant taxa are presented in the Executive Summary tables on the following pages. These tables include: current status (with totals not including seedlings), last year's population numbers (not including seedlings), and the number of plants in the original IPs for comparison for each Manage for Stability population unit. Genetic storage and threat protection status is also

summarized for each Population Unit (PU). The number of PUs that have reached numeric stabilization goals is included.

As of the end of this reporting period, 40 of 98 MIP PUs (41%) and 10 of 31 (32%) PUs for OIP Tier 1 plant species are at or above the stabilization goal for the minimum number of reproducing plants. All data tables are included on the CDs distributed to IT members. During this reporting period, OANRP outplanted 1,499 individuals of 12 species of MIP and OIP taxa. In the last year, OANRP made 415 observations at *in situ* and outplanting sites.

Genetic storage of at least 50 seeds each from 50 individuals, at least three clones each in micro-propagation, or three clones in living collection 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 unique genetic storage requirements. 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.

For research highlights, living collection status updates, and rare plant reintroductions, please refer to Chapter 4- Rare Plant Highlights.

Table 1. MIP Plants Executive Summary.

Makua Implementation Plan - Executive Summary - Plants

# of Stable IP Population Units: 40 of 98

= 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 2018	# 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	2	2	0	0	2	53	0%	0%	No	
		Kahanahaiki to Keawapilau	1	0	1	0	1	8	0%	100%	No	
		Makaha	12	12	0	0	11	75	50%	100%	No	
		Makua	4	4	0	0	4	15	33%	100%	No	
		Alectryon macrococcus var. macrococcus Total:	19	18	1	0	18	151				0 of 4
Cenchrus agrimonioides var. agrimonioides	50											
		Central Ekahanui	209	165	44	44	261	20	62%	100%	Yes	
		Kahanahaiki and Pahole	280	238	42	17	268	276	60%	100%	Yes	
		Makaha and Waianae Kai	248	228	20	2	290	12	54%	97%	Yes	
		Cenchrus agrimonioides var. agrimonioides Total:	737	631	106	63	819	308				3 of 3
Cyanea grimesiana subsp. obatae	100											
		Kaluaa	95	85	10	0	109	0	75%	100%	No	
		North branch of South Ekahanui	102	70	32	0	147	5	100%	100%	No	
		Pahole to West Makaleha	67	49	18	2	103	46	94%	100%	No	
		Palikea (South Palawai)	949	930	19	7	920	63	67%	100%	Yes	
		Cyanea grimesiana subsp. obatae Total:	1213	1134	79	9	1279	114				1 of 4
Cyanea longiflora	75											
		Kapuna to West Makaleha	176	73	103	0	236	66	88%	100%	No	
		Makaha and Waianae Kai	49	31	18	3	246	4	45%	100%	No	
		Pahole	270	68	202	3	219	114	100%	100%	No	
		Cyanea longiflora Total:	495	172	323	6	701	184				0 of 3
Cyanea superba subsp. superba	50											
		Kahanahaiki	359	29	330	8	371	152	100%	100%	No	
		Makaha	286	39	247	0	180	0	N/A	100%	No	
		Manuwai	52	0	52	0	83	0	N/A	100%	No	
		Palikea	546	5	541	10	428	0	N/A	100%	No	
		Cyanea superba subsp. superba Total:	1243	73	1170	18	1062	152				0 of 4

Table 1 (continued).

Makua Implementation Plan - Executive Summary - Plants

# of Stable IP Population Units: 40 of 98

= 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 2018	# Plant In Original Report	% Completed Genetic Storage Requirement	% of Plants Protected from Ungulates	PU Met Goal?	# PU Met Goal
Cyrtandra dentata	50											
		Kahanahaiki	117	25	92	18	117	97	73%	100%	No	
		Kawaiiki (Koolaus)	21	2	19	1	21	50	0%	0%	No	
		Opaeula (Koolaus)	168	34	134	4	196	26	26%	100%	No	
		Pahole to West Makaleha	1709	468	1241	104	814	300	100%	100%	Yes	
		Cyrtandra dentata Total:	2015	529	1486	127	1148	473				1 of 4
Delissea waianaeensis	100											
		Ekahanui	62	59	3	0	219	58	100%	100%	No	
		Kahanahaiki to Keawapilau	115	110	5	0	146	34	100%	100%	Yes	
		Kaluaa	251	244	7	3	441	44	90%	100%	Yes	
		Manuwai	114	100	14	1	168	0	N/A	100%	Yes	
		Delissea waianaeensis Total:	542	513	29	4	974	136				3 of 4
Dubautia herbstobatae	50											
		Makaha	169	23	146	0	43	0	54%	0%	No	
		Ohikilolo Makai	137	133	4	0	137	700	0%	100%	Yes	
		Ohikilolo Mauka	400	373	27	0	400	1300	0%	100%	Yes	
		Dubautia herbstobatae Total:	706	529	177	0	580	2000				2 of 3
Euphorbia celastroides var. kaenana	25											
		East of Alau	22	20	2	0	22	26	81%	0%	No	
		Kaena	1154	880	274	0	1154	300	100%	0%	Yes	
		Makua	36	36	0	0	85	40	100%	100%	Yes	
		Puaakanoa	164	144	20	16	142	157	62%	0%	Yes	
		Euphorbia celastroides var. kaenana Total:	1376	1080	296	16	1403	523				3 of 4
Euphorbia herbstii	25											
		Kaluaa	96	6	90	0	90	0	N/A	100%	No	
		Kapuna to Pahole	141	47	94	0	78	170	32%	100%	Yes	
		Manuwai	0	0	0	0	0	0	N/A	100%	No	
		Euphorbia herbstii Total:	237	53	184	0	168	170				1 of 3
Flueggea neowawraea	50											
		Kahanahaiki to Kapuna	79	9	70	0	125	32	29%	100%	No	
		Makaha	37	7	30	0	44	4	36%	57%	No	
		Manuwai	11	0	11	0	16	0	N/A	100%	No	
		Ohikilolo	1	1	0	0	1	3	50%	100%	No	
		Flueggea neowawraea Total:	128	17	111	0	186	39				0 of 4

Table 1 (continued).

Makua Implementation Plan - Executive Summary - Plants

# of Stable IP Population Units: 40 of 98

= 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 2018	# Plant In Original Report	% Completed Genetic Storage Requirement	% of Plants Protected from Ungulates	PU Met Goal?	# PU Met Goal
Gouania vitifolia	50											
		Keaau	2	2	0	0	49	0	100%	100%	No	
		Gouania vitifolia Total:	2	2	0	0	49	0				0 of 1
Hesperomannia oahuensis	75											
		Haleauau	5	1	4	0	5	0	0%	100%	No	
		Makaha	72	9	63	0	80	13	33%	100%	No	
		Pahole NAR	2	2	0	0	24	8	N/A	100%	No	
		Pualii	61	22	39	0	72	0	N/A	100%	No	
		Hesperomannia oahuensis Total:	140	34	106	0	181	21				0 of 4
Hibiscus brackenridgei subsp. mokuleianus	50											
		Haili to Kawaiu	68	66	2	3	84	4	72%	0%	Yes	
		Keaau	113	70	43	0	86	0	100%	100%	Yes	
		Makua	72	68	4	1	95	7	86%	100%	Yes	
		Manuwai	54	53	1	5	71	0	N/A	100%	Yes	
		Hibiscus brackenridgei subsp. mokuleianus Total:	307	257	50	9	336	11				4 of 4
Kadua degeneri subsp. degeneri	50											
		Alaiheihe and Manuwai	141	76	65	4	147	60	82%	96%	Yes	
		Central Makaleha and West Branch of East Makaleha	34	13	21	0	49	47	71%	0%	No	
		Kahanahaiki to Pahole	69	58	11	41	202	161	100%	100%	Yes	
		Kadua degeneri subsp. degeneri Total:	244	147	97	45	398	268				2 of 3
Kadua parvula	50											
		Ekahanui	30	17	13	0	87	0	N/A	100%	No	
		Halona	149	21	128	0	35	64	100%	0%	No	
		Ohikilolo	241	86	155	20	239	66	100%	100%	Yes	
		Kadua parvula Total:	420	124	296	20	361	130				1 of 3
Melanthera tenuifolia	50											
		Kamaileunu and Waianae Kai	1061	815	246	274	1061	880	0%	0%	Yes	
		Mt. Kaala NAR	155	131	24	0	155	250	0%	100%	Yes	
		Ohikilolo	581	570	11	0	581	2009	8%	100%	Yes	
		Melanthera tenuifolia Total:	1797	1516	281	274	1797	3139				3 of 3

Table 1 (continued).

Makua Implementation Plan - Executive Summary - Plants

# of Stable IP Population Units: 40 of 98

= 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 2018	# Plant In Original Report	% Completed Genetic Storage Requirement	% of Plants Protected from Ungulates	PU Met Goal?	# PU Met Goal
Neraudia angulata	100											
		Kaluakauila	181	175	6	0	181	0	N/A	100%	Yes	
		Makua	49	45	4	0	49	29	46%	100%	No	
		Manuwai	167	36	131	0	160	12	75%	100%	No	
		Waianae Kai Mauka	13	11	2	0	13	46	31%	100%	No	
		Neraudia angulata Total:	410	267	143	0	403	87				1 of 4
Nototrichium humile	25											
		Kaluakauila	169	94	75	0	178	200	0%	100%	Yes	
		Makua (south side)	53	50	3	0	53	138	0%	100%	Yes	
		Manuwai	106	106	0	0	111	0	N/A	100%	Yes	
		Waianae Kai	189	53	136	0	264	200	12%	92%	Yes	
		Nototrichium humile Total:	517	303	214	0	606	538				4 of 4
Phyllostegia kaalaensis	50											
		Keawapilau to Kapuna	0	0	0	0	0	0	100%	100%	No	
		Makaha	0	0	0	0	0	0	N/A	100%	No	
		Manuwai	0	0	0	0	0	0	N/A	100%	No	
		Pahole	0	0	0	0	0	10	100%	100%	No	
		Phyllostegia kaalaensis Total:	0	0	0	0	0	10				0 of 4
Plantago princeps var. princeps	50											
		Ekahanui	43	1	42	0	56	33	84%	100%	No	
		Konahuanui	42	32	10	1	42	0	0%	100%	No	
		North Mohiakea	71	28	43	0	71	30	46%	100%	No	
		Ohikilolo	12	12	0	0	24	14	82%	100%	No	
		Plantago princeps var. princeps Total:	168	73	95	1	193	77				0 of 4
Pritchardia kaalae	25											
		Makaleha to Manuwai	134	123	11	0	134	141	0%	2%	Yes	
		Ohikilolo	1653	138	1515	74	1687	473	0%	100%	Yes	
		Ohikilolo East and West Makaleha	290	18	272	0	295	75	N/A	100%	No	
		Pritchardia kaalae Total:	2077	279	1798	74	2116	689				2 of 3
Sanicula mariversa	100											
		Kamaileunu	213	31	182	1	213	26	100%	100%	No	
		Keaau	43	0	43	2	43	141	79%	100%	No	
		Ohikilolo	216	12	204	0	216	162	34%	100%	No	
		Sanicula mariversa Total:	472	43	429	3	472	329				0 of 3

Table 1 (continued).

Makua Implementation Plan - Executive Summary - Plants

# of Stable IP Population Units: 40 of 98

= 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 2018	# Plant In Original Report	% Completed Genetic Storage Requirement	% of Plants Protected from Ungulates	PU Met Goal?	# PU Met Goal
Schiedea kaalae	50											
		Kaluaa and Waieli	138	128	10	1	143	55	100%	100%	Yes	
		Kaluanui	200	200	0	0	0	0	N/A	100%	Yes	
		Pahole	197	158	39	3	79	3	100%	100%	Yes	
		South Ekahanui	214	157	57	30	265	85	100%	100%	Yes	
		Schiedea kaalae Total:	749	643	106	34	487	143				4 of 4
Schiedea nuttallii	50											
		Kahanahaiki to Pahole	141	82	59	55	245	65	78%	100%	Yes	
		Kapuna-Keawapilau Ridge	164	75	89	45	100	4	100%	100%	Yes	
		Makaha	127	121	6	0	127	0	N/A	100%	Yes	
		Schiedea nuttallii Total:	432	278	154	100	472	69				3 of 3
Schiedea obovata	100											
		Kahanahaiki to Pahole	506	88	418	200	258	90	100%	100%	No	
		Keawapilau to West Makaleha	312	38	274	47	434	36	100%	100%	No	
		Makaha	173	20	153	0	20	0	N/A	100%	No	
		Schiedea obovata Total:	991	146	845	247	712	126				0 of 3
Tetramolopium filiforme	50											
		Kalena	42	26	16	0	42	0	24%	100%	No	
		Ohikilolo	2782	1740	1042	20	2782	2500	14%	100%	Yes	
		Puhawai	0	0	0	0	0	12	80%	0%	No	
		Waianae Kai	20	20	0	0	20	22	0%	0%	No	
		Tetramolopium filiforme Total:	2844	1786	1058	20	2844	2534				1 of 4
Viola chamissoniana subsp. chamissoniana	50											
		Halona	17	11	6	0	21	3	18%	0%	No	
		Makaha	53	42	11	0	53	50	12%	100%	No	
		Ohikilolo	340	107	233	0	340	0	0%	100%	Yes	
		Puu Kumakalii	44	44	0	0	44	20	14%	0%	No	
		Viola chamissoniana subsp. chamissoniana Total:	454	204	250	0	458	73				1 of 4

Table 2. OIP Plants Executive Summary.

Oahu Implementation Plan - Executive Summary - Plants

# of Stable IP Population Units: 10 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 2018	# 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	136	55	81	13	153	44	64%	100%	Yes	
		Kaawa to Puulu	200	28	172	0	214	124	14%	50%	No	
		Kahanahaiki	120	117	3	0	74	0	100%	100%	Yes	
		Makaha Makai	223	90	133	0	225	100	72%	74%	Yes	
		Abutilon sandwicense Total:	679	290	389	13	666	268				3 of 4
Cyanea acuminata	50											
		Helemano-Punaluu Summit Ridge to North Kaukonahua	322	20	302	0	158	72	100%	0%	No	
		Kaluanui and Maakua	249	123	126	50	249	0	0%	100%	Yes	
		Makaleha to Mohiakea	284	195	89	0	284	118	20%	100%	Yes	
		Cyanea acuminata Total:	855	338	517	50	691	190				2 of 3
Cyanea koolauensis	50											
		Kaipapau, Koloa and Kawainui	125	113	12	0	125	76	2%	85%	Yes	
		Opaeula to Helemano	28	21	7	0	28	13	0%	48%	No	
		Poamoho	39	20	19	0	39	12	5%	0%	No	
		Cyanea koolauensis Total:	192	154	38	0	192	101				1 of 3
Eugenia koolauensis	50											
		Kaunala	54	15	39	27	54	141	78%	93%	No	
		Oio	8	6	2	0	8	74	50%	83%	No	
		Pahipahialua	24	18	6	124	24	291	58%	100%	No	
		Eugenia koolauensis Total:	86	39	47	151	86	506				0 of 3
Gardenia mannii	50											
		Haleauau	60	2	58	0	64	2	38%	100%	No	
		Helemano and Poamoho	23	23	0	0	23	18	60%	4%	No	
		Lower Peahinaia	45	9	36	0	39	46	50%	56%	No	
		Gardenia mannii Total:	128	34	94	0	126	66				0 of 3
Hesperomannia swezeyi	25											
		Kamananui to Kaluanui	246	134	112	45	246	99	0%	4%	Yes	
		Kaukonahua	109	55	54	2	109	127	0%	0%	Yes	
		Lower Opaeula	26	11	15	6	26	24	0%	0%	No	
		Hesperomannia swezeyi Total:	381	200	181	53	381	250				2 of 3

Table 2 (continued).

Oahu Implementation Plan - Executive Summary - Plants

# of Stable IP Population Units: 10 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 2018	# 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	299	269	30	1	310	100	20%	88%	Yes	
		Koloa	22	3	19	0	22	0	N/A	100%	No	
		Labordia cyrtandrae Total:	321	272	49	1	332	100				1 of 2
Phyllostegia hirsuta	100											
		Haleauau to Mohiakea	34	32	2	0	49	18	59%	100%	No	
		Koloa	32	26	6	1	32	0	60%	92%	No	
		Puu Palikea	20	17	3	0	33	0	N/A	100%	No	
		Phyllostegia hirsuta Total:	86	75	11	1	114	18				0 of 3
Phyllostegia mollis	100											
		Ekahanui	1	1	0	0	1	35	100%	100%	No	
		Kaluaa	45	38	7	0	43	49	100%	100%	No	
		Pualii	0	0	0	0	0	0	100%	100%	No	
		Phyllostegia mollis Total:	46	39	7	0	44	84				0 of 3
Schiedea trinervis	50											
		Kalena to East Makaleha	647	296	351	377	647	376	100%	89%	Yes	
		Schiedea trinervis Total:	647	296	351	377	647	376				1 of 1
Stenogyne kanehoana	100											
		Haleauau	60	0	60	0	136	1	100%	100%	No	
		Kaluaa	24	5	19	0	26	79	100%	100%	No	
		Makaha	0	0	0	0	8	0	N/A	100%	No	
		Stenogyne kanehoana Total:	84	5	79	0	170	80				0 of 3

Achatinella mustelina Management

During this reporting period, OANRP continued: 1) monitoring wild snail populations, 2) controlling rats around wild snail populations, 3) improving rare snail habitat through weed control and host tree outplantings, 4) maintaining existing snail predator-proof enclosures, 5) constructing one new snail enclosure and 6) translocating snails into snail enclosures. The table below presents the status summary for the *A. mustelina*, which is the only rare snail taxon in the MIP. This report does not include an OIP rare snail table as these taxa are all Tier 2 or 3. Populations of *A. mustelina* in the MIP were genetically assigned to one of six evolutionarily significant units (ESU). The MIP goal is to achieve 300 total snails across all age classes in each of eight managed populations within the six ESUs. Six of the eight managed field populations have over 300 snails. While Ekahanui (ESU-E) does not meet the goal, over 200 additional snails are presently housed in the SEPP laboratory for captive rearing and safekeeping, awaiting future release at the Palikea North enclosure.

Table 3. Summary of MIP Rare Snail Management. Numbers reflect most recent counts of observed snails.

Achatinella mustelina ESU	Population	Number of Snails in MFS Pop. Reference Sites (PRS)	Number of Snails in No Mgmt. PRS	Number of Snails in PRS with Rat Control	Number of Snails in Enclosures	Planned Enclosure for Additional Snails Not Currently in Enclosures
A	Kahanahaiki	285	42	288	232 (Kahanahaiki) 53 (Pahole)	Kahanahaiki/ Pahole
B1	Ohikilolo	309	11	313	0	West Makaleha†
B2	East Makaleha	502	188	533	0	West Makaleha†
C	Lower Kaala NAR & Schofield Barracks West Range	302	10	306	0	Kaala†
D1	Central Kaluaa to Schofield Barraks South Range	761	41	767	761	Hapapa
D2	Makaha	254	10	138	0	Hapapa
D*	South Range to Lihue	0	391	0	0	Hapapa
E	Ekahanui	86	21	87	33	Palikea North
F	Puu Palikea	332	11	334	284	Palikea South

*Snails from this portion of the ESU are not managed for stability in the MIP
†Enclosure not yet constructed or not ready for snail introductions

During this reporting period, OANRP continued to maintain the Kahanahaiki and Puu Hapapa enclosures and cooperated with SEPP to maintain the Puu Palikea enclosure. OANRP initiated translocations into the Palikea North enclosure for Ekahanui (ESU-E) *A. mustelina*. In addition, construction of the Makaleha West enclosure was completed, and restoration is underway along with *Euglandina rosea* removal efforts. This new enclosure will be the home for ESU-B snails. OANRP and partners continued to monitor population trends for *A. mustelina* within the Kahanahaiki, Puu Hapapa, and Palikea enclosures using timed-count monitoring, and began monitoring at the Palikea North enclosure. Also, the State completed replacement of the Pahole snail enclosure, and *E. rosea* removal is underway.

Staff continue to examine the reliability of and seek out improvements to, enclosure barriers, structure, and predator control techniques. For more information on rare snail management, see Chapter 5 – *Achatinella mustelina* Management.

Rare Vertebrate Management

Currently, OANRP manages two species of rare vertebrates: the Oahu Elepaio (*Chasiempis ibidis*) and the Opeapea or Hawaiian hoary bat (*Lasiurus cinereus semotus*). Management consists of active predator control for the Oahu Elepaio and monitoring for Opeapea at Army installations across Oahu. Staff conduct spot monitoring for bat roosting in trees that need to be pruned or removed at Army installations during the bat pupping season.

In the 2019 breeding season, OANRP controlled rats to protect 100 pairs of Oahu Elepaio at four management sites, fulfilling the required 75 pairs for species management in the Oahu BO. Oahu Elepaio

monitoring was not conducted at Makua Valley because of access issues related to unexploded ordnance. The number of managed pairs and reproductive efforts in 2019 are summarized in the table below.

Table 4. Summary of Elepaio Management.

Year	Managed Pairs	Nest Success	Family Groups	Fledglings Observed	Fledglings/ Managed Pair
2019	100	64%	35	68	0.68

Nest success and the number of documented fledglings per managed pairs this year was high. Staff completed the conversion of predator control grids from snap traps to GoodNature A24 auto-resetting (A24) rat traps at all Elepaio MUs in 2019 to more effectively and efficiently protect Elepaio year-round from rodents. For more information, see the Chapter 6 - Rare Vertebrate Management and Chapter 8 – Rodent Management.

The U.S. Geological Survey completed an acoustic monitoring project for the Hawaiian hoary bats on Army installations on Oahu (results in Appendix 6-1). Bat presence occurred at two-thirds of the sites, with the highest frequency of detections observed at Dillingham Airfield and Schofield Barracks West Range. In early September 2015, an official Garrison policy was signed that formalizes a tree-cutting moratorium during the bat pupping season each year. Unfortunately, tree projects are often funded using year-end monies thus tree removal work coincides with summer months that are the bat pupping season. While the policy reduces the number of tree removal projects happening in the summer, some projects are unavoidable, and OANRP must survey trees slated for removal/pruning for roosting bats. During this performance period, OANRP and a contractor conducted 49 bat surveys over a total of 43 hours (not including travel time). No roosting bats were found. For more information, see the Chapter 6 - Rare Vertebrate Management.

Rare Insect Management

During this reporting period, OANRP continued to conduct regular monitoring of known *Drosophila* populations designated as 'manage for stability' and host tree outplanting efforts. This monitoring allows OANRP to track fluctuations and attempt to determine abundance patterns. *Drosophila* population numbers were moderately high during the second half of the reporting period, with the exception of *D. substenoptera* and *D. hemipeza* at Palikea, which had lower numbers than the previous year. Results of the surveys and management conducted during this reporting period are summarized in Chapter 7 – Rare Insect Management. Host tree outplanting this year occurred for *Drosophila montgomeryi* at Puaii and Palikea (98 and 177 *Urera glabra*, respectively), and for *D. substenoptera* at Palikea and Opaeula Lower (74 and 11 *Cheirodendron trigynum*, respectively). Additional *Drosophila* habitat management efforts to provide more shade and improve general habitat quality were accomplished this year through outplantings of common native plant taxa at Palikea and Opaeula Lower. Surveys near suitable hosts continue at training ranges to obtain a thorough picture of endangered *Drosophila* distribution at Army training ranges for use in the upcoming Biological Assessment.

Surveys for endangered *Hylaeus* bees are ongoing. This report does not contain a section covering this taxon, as there are no new results to report. Nesting has not yet been observed in artificial nest blocks.

OANRP continued to monitor and control threats to the *Megalagrion xanthomelas* population at Tripler Army Medical Center. Also in this reporting year, OANRP staff assisted DOFAW with the rearing of *M. xanthomelas* and reintroduction at two sites (Waianae Kai and Lyon Arboretum).

Alien Invertebrate Control and Research Program

The Alien Invertebrate Control Program continued to focus on slug control, Coconut Rhinoceros Beetle (CRB) (*Oryctes rhinoceros*) detection, and invasive ant detection during this past reporting period. OANRP has continually expanded its slug control program since 2010, protecting rare plants and rare plant habitat. OANRP continues to protect 49 rare species PUs from slugs within eleven MUs. Slug control is performed over a total of 5.2 ha. OANRP is a cooperator in control and detection efforts for CRB and the little fire ant (LFA) (*Wasmannia auropunctata*) on Oahu. This reporting year, there were no known breeding populations of CRB on Army-controlled lands. However, CRB was detected at Wheeler in July 2019, just after the reporting year ended, and additional traps were added in that area. LFA has not been detected during OANRP surveillance of new Army plantings and Army plant-holding facilities. In 2015, the Army established an official Garrison policy aimed at preventing the LFA from establishing on 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. Besides LFA, the Army surveys and controls, where feasible, populations of other invasive ants in management units or at important points of entry like greenhouses and landing zones.

Two trials were conducted in association with the molluscicide FerroxxAQ. These included FerroxxAQ persistence in a field setting, and *Euglandina rosea* response to FerroxxAQ treatment.

OANRP staff began Rapid Ohia Death (ROD) detection and sampling this past year. Ten samples from suspect trees were collected in the last reporting period, all of which tested negative for ROD.

Following the discovery of naio thrips (*Klambothrips myopori*) on Oahu in early 2019, OANRP staff began widespread surveys of wild naio (*Myoporum sandwicense*). Naio at the OANRP Schofield Baseyard were found to be infested and were removed from landscaping. OANRP ceased production of naio for common native plant restoration.

In addition to alien invertebrate control and pathogen detection, a research study was completed to help inform *A. mustelina* management, by examining the efficacy of non-electric barriers to repel *Euglandina rosea* at predator-proof snail enclosures (Appendix 9-1).

Research Projects

During previous reporting periods, OANRP funded research projects related to management of MIP and OIP taxa. During this reporting period, a new paper from one of these projects was prepared and is now in review:

- Bialic-Murphy L, Gaoue OG, Kawelo K, and Knight T. Evaluating the outcome of rare plant reintroductions.

In addition, OANRP supported the Hawaii VINE project by providing access or guidance during study plan development. The following are publications or updates on ongoing projects from this reporting period.

- Case, Samuel, 2018. Project update. Introduced game birds as seed dispersers in Hawaiian Forests. (Appendix ES-4)
- MacDonald, S. E., M. P. Ward, and J. H. Sperry. 2019. Manipulating social information to promote frugivory by birds on a Hawaiian island. Ecol Appl 00(00):e01963. 10.1002/eap.1963. (Appendix ES-5)

- Vizentin-Bugoni, J., C. E. Tarwater, J. T. Foster, D. R. Drake, J. M. Gleditsch, A. M. Hruska, J P. Kelley, and J. H. Sperry. 2019. Structure, spatial dynamics, and stability of novel seed dispersal mutualistic networks in Hawaii. Science. 364: 78-82. (Appendix ES-6)

TABLE OF CONTENTS

Appendix 9-1 Efficacy of non-electric, cut wire mesh barriers to repel *Euglandina rosea*

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

CHAPTER 1: UNGULATE MANAGEMENT

Notable projects from the 2018-2019 reporting year are discussed in the Project Highlights section of this chapter.

Threat control efforts are summarized for each Management Unit (MU) or non-MU land division. In total, about 1,745 meters of fencing was replaced, repaired, or built during the reporting year due to fence expansions, environmental damage, or deliberate vandalism. No large fence replacement projects were required, but two fence expansion projects were completed during the reporting period. Ungulate control data is presented with minimal discussion.

Table 1. Summary of fence repair projects during the 2018-2019 reporting period.

Fence:		Fence Effort	Total M Repaired	Total Panels	Total Hog Wire	Total Smooth	Total T Posts	Total Dead Man	Total Duck Bill	Total Skirts	Total Fickle
ANU-A	Manuwai Perimeter	Maintenance	6.40	0.50	0.00	0.00	0	0	0	0	0
ANU-B	Manuwai Interior	Maintenance	6.40	1.00	0.00	0.00	0	0	0	0	0
EKA-A	Ekahanui MU Perimeter	Maintenance	4.66	0.00	0.00	0.00	1	0	0	0	0
EKA-C	Unit I North Line	Maintenance	68.58	0.00	0.00	0.00	0	0	0	0	0
KAH-A	Kahanahaiki MU Subunit I Perimeter	Maintenance	3.66	1.50	0.00	0.00	14	0	0	0	0
KAL-C	Kaluaa/Waieli Section between I and II/III	Maintenance	2.44	0.00	0.00	0.00	0	0	0	0	0
KAP-C	Interior line that seperates Subunit III from IV	Maintenance	2.74	0.00	0.00	0.00	0	0	0	0	0
KEA-B	Keaau Hibiscus	Maintenance	0.61	0.00	0.00	0.00	0	0	0	0	0
KLO-A	Opaeula Lower I	Maintenance	325.40	0.00	0.00	0.00	0	0	0	32	0
KLO-G	Opaeula/Helemano	Maintenance	169.90	26.00	0.00	0.00	20	1	0	0	0
LEH-C	Three Points	Maintenance	50.90	0.00	2.00	0.00	0	0	0	0	0
LIH-B	Cyprus-Firebreak	Maintenance	50.75	0.00	0.00	0.00	0	0	0	5	0
LIH-C	Firebreak Road	Maintenance	39.49	4.50	0.00	0.00	6	10	0	0	0
MAK-D	Makaha Subunit II (Mauka and Makai)	Construction	0.00	0.00	3.00	0.00	0	0	0	0	0
MAK-D	Makaha Subunit II (Mauka and Makai)	Maintenance	936.96	0.50	0.00	0.00	27	0	0	0	848
MAK-E	Kamaili (Mauka and Makai)	Maintenance	18.29	6.00	0.00	0.00	21	0	0	0	0
MMR-A	Kaluakauila	Maintenance	1.83	0.00	0.00	0.00	0	0	0	0	0
MMR-B	Ohikilolo Section A and B	Maintenance	2.74	0.00	0.00	0.00	0	0	0	0	0
MMR-L	MMR Perimeter (Kahanahaiki-Kaluakauila)	Maintenance	40.32	0.00	0.00	0.00	0	0	0	0	0
PAH-A	Pahole Section A	Maintenance	1.22	0.00	0.00	0.00	0	0	0	0	0
PAK-A	Palikea Subunit I	Maintenance	10.06	1.50	0.00	0.00	6	0	0	0	0
PUA-A	North Pualii	Maintenance	1.83	0.00	0.00	0.00	0	0	0	0	0
			1745.18	41.50	5.00	0.00	95	11	0	37	848

The Ungulate Fence Check and Construction Inventory Summary table above shows the total amounts of each fence that required maintenance or construction throughout the reporting period. From the left, the first two columns are the code and name of each fence. Column four shows the length of fence that needed work expressed as meters. Columns 5-12 show the total amounts of material used including the number of fence panels, the length of hog wire and smooth wire, the number of t-posts, dead man anchors and duckbill anchors, and finally the length of skirting or fickle fence (deer mesh) in meters that is applied over the fence to keep animals from crossing.

PROJECT HIGHLIGHTS

Funding was secured to construct two small fences at Kaala and Makaleha West, and both were completed by August 2018. Currently, only one of the two ungulate management technician positions is filled currently. We are actively hiring for the second ungulate management tech position

Summary of Fencing Efforts

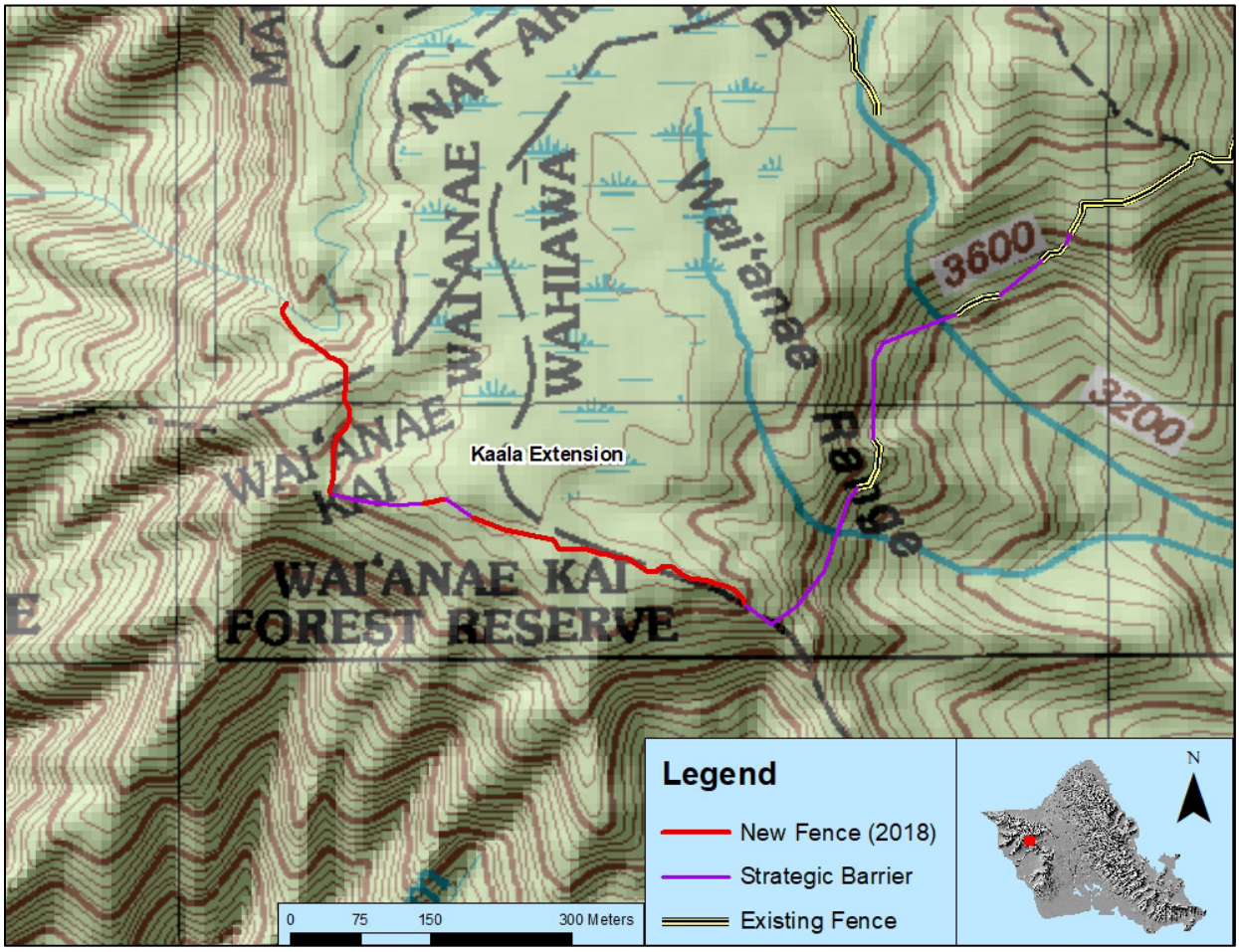

Figure 1. Map of Fence expansion at Kaala.

- **The Kaala Fence Expansion Project**: The Oahu Army Natural Resource Program (OANRP) secured year end funding to erect a fence on the Waianae Kai side of the summit of Kaala (Figure 1). The Kaala ungulate exclusion project closes off the western side of the summit to ungulate ingress utilizing a combination of fence panels and strategic barriers, which utilizes the cliff terrain around the base of the Kaala bog that is too steep for pigs to traverse. This contract was completed in August 2018.

Map removed to protect rare reources

Figure 2. Map of Fence expansion at 3-Points.

- **Makaleha West**: The OANRP secured year-end funding to expand the existing fence in Makaleha West (Figure 2). The Makaleha West project encloses the new snail enclosure as well as a larger area of suitable habitat for management of endangered plants. The Makaleha West project closed off this plateau area to ungulate ingress utilizing a combination of fence panels, hog wire and strategic fencing. There is a strategic barrier at a tall waterfall that is too steep for pigs to traverse. This contract was completed in July 2018.

Summary of Ungulate Removal Efforts

- **Ekahanui MU**: In November 2018, a small piglet was able to squeeze through the fence at Ekahanui Subunit I. The amount and size of the tracks and scat indicated that there was only one animal. Staff applied skirting and wire mesh over the fence in the areas with the highest pig traffic to reduce the threat of future incursions. The animal was able to escape on its own; no animal sign has been observed since.

- **Kaluaa and Waieli Subunit II MU**: Towards the end of June 2018, pig sign was observed in Kaluaa and Waieli Subunit II. By the amount of sign observed it appears one small pig was able to squeeze through the fence. Snaring and trapping operations were initiated and one sow was removed. Will look at applying deer fence mesh over areas of high pig traffic on exterior of fence.

- **Kaluaa and Waieli Subunit III MU**: Towards the end of April 2019, pig sign was observed in Kaluaa and Waieli Subunit III. By the amount of sign observed it appears one small to medium sized pig was able to access the MU, possibly, through a breach through Subunit I. A section of the perimeter fence in Subunit I was vandalized and an animal could have easily gotten through there and made its way into Subunit III. The vandalism was repaired, snaring/trapping operations were initiated and one boar was removed.

- **Kapuna Upper MU**: In September 2017, pig sign was observed in Kapuna Upper Subunit IV. Fence checks showed that the fence had been deliberately vandalized and propped open. At least two animals were observed on game cameras that were installed in response to the incursion. Snaring and trapping operations were initiated. Hawaii Department of Land and Natural Resources (DLNR) and OANRP staff agreed to split the unit in half so that each group could focus on a smaller area. One sow was removed by OANRP staff. It is believed that no animals remain as no new sign has been observed in the last year after extensive surveys. OANRP will continue to monitor the existing snares and survey our area to make sure.

- **Lihue MU**: A total of 547 pigs have been removed to date. No new animals were caught this year. Pig sign throughout the MU and the number of catches per year declined dramatically but sign is still visible in a few areas. Due to Unexploded Ordnance (UXO) policy changes, staff are prohibited from entering into a large area of the MU until the UXO can be removed (detonated). This policy change has effectively halted the potential of pig eradication until such time that the entire enclosure is UXO free or some other method of removal can be approved.

- **Makaha Subunit II MU**: Throughout the reporting period, five pigs were able to breach the fences at Subunit II, in both the Mauka and Makai units. A portion of the fickle fence that had been applied over the panels failed, rusting away so a small pig was able to enter into the unit. A newer, more durable product was purchased and reapplied over the fence. Staff are not allowed to manage a volunteer hunter program on BWS land, so ungulate management is limited to the use of snares. In Makaha, all snares must be removed when staff exit the MU. Snaring operations were conducted and two pigs were removed. The other three were already dead when they were initially found. There is very limited food and water resources in these small units and all of these pigs were quite small and young so we assume they were unable to cope alone in the harsh environments alone.

- **Makua Military Reservation (MMR)**: In October 2015, the last sections of the perimeter fence on the north side of MMR was completed. This enclosed the entire valley within ungulate fencing creating a barrier to ungulate movement into and out of the valley. OANRP has initiated an endeavor to eradicate all of the pigs from MMR. Snares are employed since hunting with dogs is not allowed due to explosive hazards that may remain from previous military training activities. Initial efforts started with the upper reaches above the cliffs and have slowly expanded to include the area within the former impact area. Due to UXO policy changes, staff have been prohibited from entering into previously accessed areas in this portion of MMR until the UXO can be removed (detonated). Staff would like to install live traps and baiting/shooting stations to try some alternative methods of removal along the road system, waiting on permission to use firearms. To date, 183 pigs have been removed.

- **Manuwai MU**: In August 2018, it appeared that one small pig was able to squeeze through the fence at Manuwai Subunit II. The amount of pig sign such as rooting, tracks and scat indicated that there was only one animal. OANRP staff conducted snaring/trapping operations and removed

one sow. Staff applied skirting and wire mesh over the fence in the areas with the highest pig traffic to reduce the threat of future incursions.

- **Ohikilolo MU**: Occasionally, goats are able to breach the ridge fence on Ohikilolo at MMR and OANRP staff are not certain how they are entering the unit. To prevent goats from reaching the cabin areas, where most managed rare taxa are located, OANRP staff have conducted snaring along the fenceline from Red Dirt Puu to the Ohikilolo cabin. Four goats were removed from the Ohikilolo MU fence area over the past reporting period. OANRP plans to check the snares quarterly and determine where the goats are breaching the ridge fence on Ohikilolo.

- **Opaeula Lower MU:** In April 2019, it appeared that one small pig was able to squeeze through the fence at Opaeula Lower MU. The amount of pig sign such as rooting, tracks and scat indicated that there was only one animal. OANRP staff conducted snaring/trapping operations and removed one young pig. Staff applied skirting and wire mesh over the fence in the areas with the highest pig traffic to reduce the threat of future incursions.

- **Palikea Subunit I:** In February 2019, a heavy windstorm blew over a large *Schinus terebinthifolius* causing a landslide to damage the fence. Staff repaired the damage but noticed sign a couple of days after that looked to be pig sign. Snaring/trapping operations were initiated but no animal was caught and no sign has been observed since. It is assumed that the animal either escaped or died on its own inside.

OIP/MIP Management Unit Fence Status

The MU status tables below show the current status of all completed fence units, organized by MU. The tables identify whether or not the fence is complete, whether it is ungulate free, identifies how many acres are actually protected versus acreage proposed in the Implementation Plan, and lists the year the fence was completed or is expected to be completed. 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 Population Units (PUs). The MFS PUs are divided by taxa: P (Plants), I (Invertebrates) and V (Vertebrates). The table also contains notes giving the highlights and status of each fence and lists the current threats to each fence unit.

Table 2. MIP Management Unit Status.

Management Unit	Management Unit Fence	Fenced	Ung Free	Acreage Current/ Proposed	Year Complete	# MFS PUs					Notes	Current Threats
						MIP		OIP				
						P	I	P	I	V		
ARMY LEASED AND OWNED LANDS												
Kahanahaiki	Kahanahaiki I	Yes	Yes	64/64	1996	9	1	1			Complete and ungulate free.	None
	Kahanahaiki II	Yes	Yes	30/30	2013						Complete and ungulate free.	None
Kaluakauila	Kaluakauila	Yes	Yes	104/104	2002	5					Complete and ungulate free.	None
Opaeula Lower	Opaeula Lower	Yes	Yes	26/26	2011	1		1	1		Complete and ungulate free.	None
Ohikilolo	Ohikilolo	Yes	No	3885/574	2002 2016	14	1				The Northern Makua rim section is complete, ungulate eradication has been initiated. There are six PU fences within the larger unit which are ungulate free. Since July 2006, 29 goats have been able to breach the fence; a couple may still be inside MMR but staff have not observed them since they were originally seen. Four goats removed in past reporting year.	Pig/Goat
Ohikilolo Lower	Ohikilolo Lower	Yes	No	70/70	2000	3					This strategic fence is complete.	Pig
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 (DLNR)												
Ekahanui	Ekahanui I	Yes	Yes	44/44	2001	6	1	2		1	Completed by the Nature Conservancy of Hawaii (TNCH). One pig breached the fence this year but was able to escape.	None
	Ekahanui II	Yes	Yes	165/159	2009						Complete and ungulate free.	None
Haili to Kealia	Haili to Kealia	No	-	-	-	1					As per DLNR Division of Forestry and Wildlife staff 'no fence needed'.	None
Kaena	Kaena	Partial	-	-	-	1					There is a predator proof fence installed by State but it only protects a portion of the *Euphorbia celastroides* var. *kaenana* plants.	None
Kaluaa/Waieli	Kaluaa/Waieli I	Yes	Yes	110/99	1999	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						Completed by TNCH. One pig breached the fence this year but staff were able to remove it.	None
	Kaluaa/Waieli III	Yes	Yes	43/11	2010						Complete and ungulate free. One pig breached the fence this year but staff were able to remove it.	None

Table 2 (continued).

Management Unit	Management Unit Fence	Fenced	Ung Free	Acreage Current/ Proposed	Year Complete	# MFS PUs					Notes	Current Threats
						MIP		OIP				
						P	I	P	I	V		
Keaau	Keaau II	Yes	Yes	8/33	2014	2					Complete and ungulate free. DLNR requested to reduce the size of original proposed MU fence.	None
	Keaau III	Yes	Yes	4/33	2015						Fence was built by the Oahu Plant Extinction Prevention Program (OPEPP) with assistance from the Waianae Mountain Watershed Partnership and OANRP staff.	None
Keaau/Makaha	Keaau/Makaha	Yes	Yes	1/3	2009	1					Complete and ungulate free.	None
Manuwai	Manuwai I	Yes	Yes	166/166	2011	3	1		1		Complete and ungulate free. A pig breached the fence this year and was removed.	None
Napepeiaoolelo	Napepeiaoolelo	Yes	Yes	1/1	2009	0					Complete and ungulate free.	None
Pahole	Pahole	Yes	Yes	224/224	1998	14	1				Complete and ungulate free.	None
Palikea	Palikea I	Yes	Yes	25/21	2008	1	1	1	2		Complete. Repaired weather damage and observed what was believed to be pig sign. Initiated snaring and trapping operations, no animals are believed to still be inside.	None
Kapuna Upper	Kapuna I/II	Yes	Yes	32/182	2007	13	1				Complete and ungulate free.	None
	Kapuna III	Yes	Yes	56/182	2007						Complete and ungulate free.	None
	Kapuna IV	Yes	Yes	342/224	2007						Complete and ungulate free	None
Waianae Kai	Slot Gulch	Yes	Yes	9/9	2010	1					Complete and ungulate free.	None
	Gouvit	Yes	Yes	1/1	2008	1					Complete and ungulate free.	None
	NerAng Mauka	No	No	1/1	2011						Complete. All management actions have been transferred to Kamaili unit due to the continuous rock fall damage and threat to personnel. Fence not being maintained.	Pig/Goat
Makaleha West	Makaleha West	Yes	Yes	11/11	2001 2016 2018	5					The *Schiedea obovata* and *Cyanea grimesiana* subsp. *obatae* PU fences are complete and pig free.	None
BOARD OF WATER SUPPLY												
Kamaileunu	Kamaileunu	Yes	Yes	5/2	2008	1			1		Both of the *Sanicula mariversa* PU fences at Kamaileunu and Kawiwi are completed and ungulate free.	None
Makaha	Makaha I	Yes	Yes	85/96	2007	8	1				Complete and ungulate free.	None
	Makaha II	Yes	Yes	16/66	2013	5		1			Complete. Pigs breached the fence this year and were removed	None

Table 3. OIP Management Unit Status.

Management Unit	Management Unit Fence	Fenced	Ung Free	Acreage Current/ Proposed	Year Complete	# MFS PUs					Notes	Current Threats
						MIP		OIP				
						P	I	P	I	V		
ARMY LEASED AND MANAGED LANDS												
Kaala-Army	Kaala	Yes	Yes	183/183	2008 2018			4	1		Strategic fences complete. Three pigs were caught in 2014, the first since 2010 and no sign since. New extension completed in August 2018.	None
Kaunala	Kaunala	Yes	Yes	5/5	2006			1			Complete and ungulate free.	None
Lihue	Lihue	Yes	No	1800/980	2012	3	1	6	3		Completed. Encompasses six PU fences and the original three proposed units. A total of 537 pigs have been removed, to date. There are very few pigs left in unit.	Pig
Oio	Oio	Yes	Yes	3/3	2006			1			Complete and ungulate free.	None
Opaeula / Helemano	Opaeula / Helemano	Yes	Yes	271/271	2001/ 2007			1			Complete and ungulate free.	None
Opaeula Lower	Opaeula Lower	Yes	Yes	16/16	2011	1		1	1		Complete and ungulate free. One pig breached the fence this year but was removed.	None
Pahipahialua	Pahipahialua	Yes	Yes	2/2	2006			1			Complete and ungulate free.	None
South Kaukonahua	South Kaukonahua I	No	No	0/95	TBD			1			The Tier 1 taxa *Hesperomannia swezeyi* occurs within this MU. DLNR is proposing to build a larger unit encompassing this proposed fence.	Pig
STATE OF HAWAII DEPARTMENT OF LAND AND NATURAL RESOURCES												
Huliwai	Huliwai	Yes	Yes	.3/1	2014			1			Complete and ungulate free.	None
Ekahanui	Ekahanui III	Yes	Yes	8/8	2010			1			Complete and ungulate free.	None
Manuwai	Manuwai II	Yes	Yes	138/138	2011	10	1	1	1		Complete and ungulate free. The Lihue and Manuwai II unit share a strategic boundary and the ungulate free status of Manuwai is subject to pig traffic from Lihue, which is unlikely but possible.	None
North Kaukonahua	North Kaukonahua	Yes	Yes	31/31	2017			1			Site is included within the larger Poamoho Natural Area Reserve (NAR) fence. Fence is completed and ungulate free.	None
Poamoho	Poamoho Lower II	Yes	Yes	5/5	2014			1			Site is included within the larger Poamoho NAR fence.	None
	Poamoho Pond	Yes	Yes	18/18	2014						Site is included in the larger Poamoho NAR fence.	None
Waimano	Waimano	Yes	Yes	4/4	2011						Complete and ungulate free. Transferred management of fence over to OPEPP.	None
North Pualii	North Pualii	Yes	Yes	25/25	2006	1		1	1		Completed by TNCH and ungulate free.	None

Table 3 (continued).

Management Unit	Management Unit Fence	Fenced	Ung Free	Acreage Current/ Proposed	Year Complete	# MFS PUs					Notes	Current Threats
						MIP		OIP				
						P	I	P	I	V		
BOARD OF WATER SUPPLY												
Kamaili	Kamaili	Yes	Yes	9/7	2014	1		1			Complete and ungulate free.	None
HAWAII RESERVES INC.												
Koloa	Koloa	Yes	Yes	176/160	2012			4			Complete and ungulate free.	None
KAMEHAMEHA SCHOOLS												
Waiawa	Waiawa I	No	No	0/136	TBD						Army training does not impact these tier 1, 2 and 3 taxa. To be constructed by DLNR Division of Forestry and Wildlife Native Ecosystems Protection and Management (NEPM) and the Koolau Mountain Watershed Partnership (KMWP).	Pig
	Waiawa II	No	No	0/136	TBD						Army training does not impact these tier 1, 2 and 3 taxa. To be constructed by NEPM and KMWP.	Pig
STATE OF HAWAII DEPARTMENT OF TRANSPORTATION												
North Halawa	North Halawa	Yes	Yes	.5/4	2010						Completed a small PU sized fence. Transferred management of fence over to OPEPP.	Pig
KUALOA RANCH INC.												
Kahana	Kahana	Yes	No	1/23	2010						Small PU fences were built around individual *Schiedea kaalae* plants in gulch. Larger unit will not be built until the Army trains in a way that may impact Tier 2 and 3 taxa.	None
U. S. FISH AND WILDLIFE SERVICE												
Kipapa	Kipapa	Yes	Yes	120/4	2015						U.S. Fish and Wildlife Service constructed a 120 acre unit.	None

CHAPTER 2: ENVIRONMENTAL OUTREACH

The Oahu Army Natural Resources Program (OANRP) is tasked with:

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

Updates to each of these actions are provided in detail within the following sections of this chapter.

2.1 VOLUNTEER PROGRAM

Outreach staff maintained a volunteer database of 2,450 individuals and communicated regularly with active volunteers.

Most volunteer outings consisted of individual members of the general public. In addition, specific community groups (e.g., schools, hiking clubs) and other members of the community with no affiliation volunteered with the program throughout the reporting year. The following specific community groups volunteered with OANRP in 2019:

- 2nd Infantry Brigade Combat Team, 25th ID
- Aha Kane Foundation
- American Society of Landscape Architects
- Aloha Aina Master's in Education Cohort, University of Hawaii at Manoa, College of Education
- Ke Kula Kaiapuni O Anuenue (Anuenue School)
- Kupu Pacific Resiliency Fellows
- Laau Hawaii - The Hawaiian Fern Project
- Le Jardin Academy
- Leeward Community College
- Mailikukahi Aina Momona Academy
- Malama Learning Center
- Malama Loko Ea Foundation
- University of Manchester, United Kingdom, Internship Program
- Mililani High School
- Nanakuli High School
- North Shore Outdoor Circle
- Office of Representative Gabbard, Hawaii 2nd Congressional District
- U.S. Department of Agriculture
- Waianae Intermediate School
- Waianae Place-Based Learning and Wellness Alliance

Figure 1. Malama Loko Ea Foundation staff and interns prepare to hike into Kahanahaiki for a day of invasive weed control.

The table below (Table 1) compares volunteer participation for 2019 with that of previous years, distinguishing between volunteer efforts spent in the field and around the baseyards.

Table 1. OANRP volunteer participation from 2010 to 2019.

Reporting Year	Total Volunteer Hours for Field Days*	Total Volunteer Hours at Worksite**	Total Volunteer Hours at Baseyard ***
2019	**4,634**	**1,207.75**	**456.25**
2018	4,168	1,356	413
2017	3397.5	905.75	489
2016	3,575.5	974.5	537.75
2015+	3,013.5	824	333.25
2014	4,421.5	1,133.75	490.75
2013	3,767.5	957	569.5
2012	4,302.5	1,261.5	602.5
2011	4,194	1,231	618
2010	3,415	1,299	885

**Includes driving time to and from trailhead, safety briefing, hiking time to and from worksite, and gear cleaning time at end of day*

***Includes actual time spent weeding, planting, etc.*

****Includes propagule processing, nursery maintenance, gear preparation, outreach support and maintenance of interpretive native gardens*

+Shorter reporting year, spanning nine (9) months

Volunteers spent a total of 75 days in the field this reporting year. Outreach staff led a total of 62 volunteer trips and facilitated 13 additional opportunities for volunteers to assist natural resource staff with miscellaneous field projects. These supplemental projects varied depending on volunteer abilities and program needs and are included in the summary of volunteer field actions in Table 2 (below).

Number of days in the field decreased this reporting year for volunteer projects due to a six-week volunteer program hiatus[1] and the related cancellation of volunteer trips. Despite this setback, total volunteer hours for field days in 2019 exceeded that of previous years. Outreach staff expanded capacity on volunteer outings through direct partnerships with the Federal natural resource manager and biologist, inter-agency partnerships and opportunities for volunteers with natural resource field staff.

Volunteer weed control efforts focused mainly within the Kaala and Kahanahaiki Management Units during the 2019 reporting year, with an emphasis on incipient weed control at Kaala and ecosystem weed control at Kahanahaiki. Volunteers also spent a significant portion of time within the Makaleha West MU in preparation for a new *Achatinella mustelina* enclosure.

[1]PICHTR suspended the OANRP volunteer program from October 15 through November 28, 2018 due to the cooperative agreement transition from PCSU to PICHTR.

Figure 2. Nanakuli High School students and Malama Learning Center staff learn to rebait self-resetting rat traps and collect trapping data in the field at Palehua.

In addition to weed control efforts, outreach staff coordinated volunteer support for predator control and snail enclosure activities. Working alongside the OANRP vertebrate pest avian stabilization specialist, volunteers learned about large-scale predator control in a forest setting and helped re-bait self-resetting rat traps at Palehua (Waimanalo to Kaaikukai No MU). Volunteers also worked with the OANRP rare snail conservation technician to help install predator barriers at various snail enclosures.

Two volunteers regularly supported activities at the OANRP baseyard, including projects in the seed conservation lab, rare plant nurseries, and native Hawaiian interpretive garden.

The following table (Table 2) summarizes volunteer work by project type and location.

Table 2. Volunteer field actions for reporting year 2019.

Management Unit	Type of Project	Number of Actions
Kaala	Incipient weed control	16
	Ecosystem weed control in WCAs	10
	Revegetation projects	3
Kahanahaiki	Ecosystem weed control in WCAs	18
	Snail enclosure projects	5
Kaluaa and Waieli	Ecosystem weed control in WCAs	6
	Snail enclosure projects	1
Kaluakauila	Fuels management in WCAs	2
Makaha	Ecosystem weed control in WCAs	3
	Trail maintenance	1
Makaleha West	Ecosystem weed control in WCAs	8
	Snail enclosure projects	5
	Trail maintenance	1
Pahole	Ecosystem weed control in WCAs	1
Palikea	Incipient weed control	2
	Ecosystem weed control in WCAs	7
	Snail enclosure projects	4

(continued on next page)

Table 2 (continued).

Management Unit	Type of Project	Number of Actions
Pualii North	Ecosystem weed control in WCAs	2
	Revegetation projects	1
SBW No MU	Revegetation projects	1
Waimanalo to Kaaikukai No MU	Ecosystem weed control in WCAs	1
	Incipient weed control	2
	Predator control	2

2.2 INTERNSHIPS AND MENTOR PROGRAMS

Outreach staff engaged youth and young adults interested in the field of natural resource management through internship and mentor programs, which included hands-on conservation field work.

- *Summer Internships*
  Outreach staff scored 32 applicants, interviewed nine applicants, and awarded six individuals with paid summer internships with natural resources field and horticultural crews. The summer internships began in June 2019 and lasted for 12 weeks. Outreach staff and field crews planned and implemented a four-day orientation session for the summer interns, consisting of new hire training modules and educational field activities at various management units.

- *Hawaii Youth Conservation Corps (HYCC)*
  OANRP Hosted two teams of HYCC members (totaling 14 youth for the two weeks combined) during the month of June. The first HYCC team spent a week with natural resources program field crews, rare plant staff and various specialists. The second HYCC team spent one full week with the "orange" natural resources field crew.

- *2019 Science Fairs*
  Staff mentored Oahu students at numerous events this year, providing feedback and guidance by judging projects at Sunset Beach Elementary School Science Fair, Windward District Science Fair, Leilehua Complex Science Fair, and the 2019 Hawaii State Science and Engineering Fair.

2.3 EDUCATIONAL MATERIALS

Outreach staff developed educational materials on natural resource issues specific to Makua and Oahu Implementation Plan taxa and their habitats. Materials ranged from interactive conference exhibits to interpretive signage. The following list highlights new or adapted educational materials.

Exhibits

- 2018 Hawaii Conservation Conference
  Provided an overview of the Army's rare snail program and highlighted the *Achatinella mustelina* enclosure approach to managing endangered Hawaiian tree snails.

- 2019 Schofield Barracks Fun Fest - Got Tracks?
  Participants identified predator tracks from tracking tunnel cards by matching select cards with photos of predators on a large tree exhibit.

Presentations

- Daniel K. Inouye Elementary School Native Tree Planting
  Emphasized native Hawaiian forest trees that provide important habitat for endangered Hawaiian plants and animals, along with tree planting considerations.
- Wheeler Middle School Science, Technology, Engineering, Art and Mathematics (STEAM) Fair
  Overview of OANRP management and hands-on "seed lab" activity with microscopes.
- Moanalua High School Career Day
  Overview of OANRP management and pathways to careers in endangered species conservation.
- Mid-Pacific Institute Career Day
  Developed by natural resource field technician Keith Adams, the presentation highlights the career experience of a natural resources field technician with OANRP.
- Nanakuli High School Field Biology Orientation
  Overview of island biology, natural resource management on Oahu, and orientation for volunteer service trips with OANRP.
- Range Safety Officer/Officer in Charge Natural Resources Brief
  Updated presentation that includes new information on Army training area wash facilities and detailed speaker notes to support presenters.

Publications

- Damselfly signs
  Designed two (8x6" and 12x18") aluminum interpretive signs (illustrated in Figure 3) for display at Lyon Arboretum ponds highlighting the importance of the orangeblack Hawaiian damselfly *(Megalagrion xanthomelas)* habitat and soliciting public support to not release aquarium animals.
- Wash facility smart card
  Developed pocket card for soldiers with detailed information on the Schofield Barracks Central, East Range and Kahuku Wash rack facilities, including wash rack hours, requirements and amenities.

Other Educational Materials

- Seed petri dish display printouts
  Each 8.5x11" printout features the Hawaiian and scientific name for seeds contained within petri dishes for seed lab interpretive tours, along with photos of each taxon in its natural habitat.

Figure 3. Outreach staff developed two interpretive signs for use at *Megalagrion xanthomelas* introduction sites at Lyon Arboretum.

2.4 OUTREACH EVENTS

Outreach staff disseminated information on natural resources specific to Army training lands at local schools, community events and conferences. In addition, outreach provided transportation support for hiking club members to facilitate trail clearing along the Schofield-Waikane Trail. These activities are summarized in the table and figure below (Table 3 and Figure 4). The total number of outreach events was 75 for this reporting year.

- Total number of people served (approximated): 4,268

Table 3. Outreach events for 2019.

Event	Format	Attendance	Audience
Halau Ohia Kaala Interpretive Hike	tour	88	community group/general public
Hawaii Trail and Mountain Club Trail Clearing Support	community service	19	
Hui Ku Like Kakou Kaala Interpretive Hike	tour	20	
Kanu Hawaii Volunteer Networking Event	presentation	40	
Lualualei Hawaiian Civic Club Kaala Interpretive Hike	tour	15	

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Table 3 (continued).

Event	Format	Attendance	Audience
Wahiawa Botanical Garden "Plant Doctor" Q&A	presentation	2	community group/general public (continued)
Wahiawa Rotary Club Baseyard Visit†	tour	2	
Waianae Neighborhood Board Baseyard Visit	tour	13	
University of Hawaii at Manoa, Botany and Natural Resources and Environmental Management Graduate Class Visit	presentation	19	higher education
University of Hawaii at Manoa, Natural Resources and Environmental Management Undergraduate Internship Class Visit	presentation	70	
Central District Science and Engineering Fair	community service	15	K-12 schools
Hawaii Agriculture and Environmental Awareness Day	presentation	120	
Home Educated Keiki Baseyard Visit	tour and presentation	30	
Kamalani Academy Classroom Visit	presentation	24	
Le Jardin Acadamy Environmental Issues Day Panel	panel	55	
Moanalua High School Career Day	presentation	75	
Nanakuli High School Baseyard Visit and Horticulture Project	tour/service	10	
Nanakuli High School Classroom Visit	presentation	12	
Nanakuli High School Monitoring Activity	presentation	15	
Sunset Beach Elementary School Science Fair	community service	12	
2nd Infantry Brigade Combat Team, 25th Infantry Division Baseyard Visit	tour	43	military
Environmental Compliance Officer (ECO) Trainings (4 presentations)	presentation	104	
Environmental Quality Control Committee Meeting	tour	25	
Makua Military Reservation Briefings (6 briefings)	presentation	88	
Range Safety Officer/Officer-in-Charge Briefings (RSO/OIC) (3x monthly)	presentation	2,577	
Schofield Barracks Fun Fest	exhibit	300	

(continued on next page)

†Baseyard visits include an interpretive tour through the Army Natural Resources Program's seed conservation lab, rare plant nursery and native Hawaiian interpretive garden at Schofield Barracks.

Table 3 (continued).

Event	Format	Attendance	Audience
Daniel K. Inouye Elementary School Assembly	presentation	106	military/K-12 schools
Science, Technology, Engineering, Art and Mathematics (STEAM) Fair, Wheeler Middle School	presentation	40	
2018 Hawaii Conservation Conference	exhibit	300	natural resource professionals
6th Annual Oahu Weed Control and Restoration Workshop Kahanahaiki Field Trip	tour	2	
Bishop Museum Baseyard Visit	tour	12	
City and County of Honolulu Storm Water Quality Branch Visit	presentation	15	
Total Number in Attendance			**4,268**

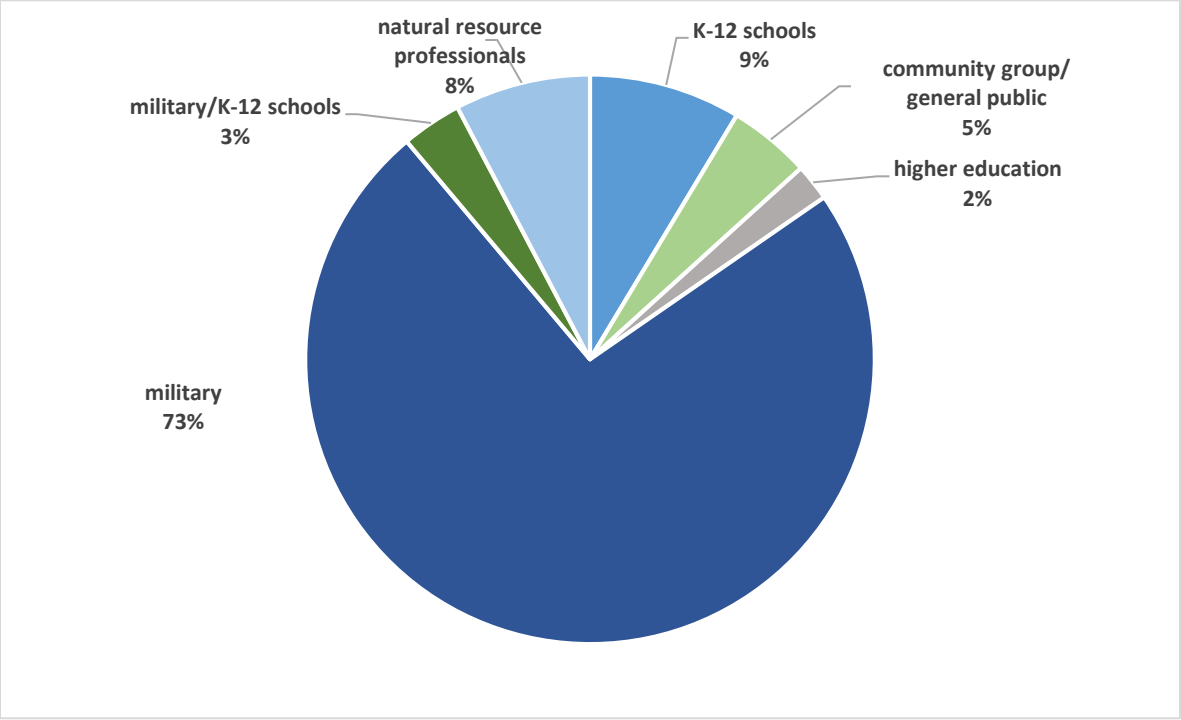

Figure 4. Target audience at 2019 outreach events.

2.5 CONTRIBUTIONS TO CONFERENCES AND WORKSHOPS

OANRP staff contributed to outreach by presenting research findings at various academic conferences and workshops. The table below (Table 4) summarizes contributions to conferences and workshops in the 2019 reporting year.

Table 4. Contributions to Conferences and Workshops.

Presentation Title	Format	Venue	Date	Author*
Protecting Endangered Oahu Elepaio Using Rodenticide within Schofield Barracks	oral presentation	2018 Hawaii Conservation Conference	2018-07-24	**Tyler Bogardus**, Aaron Shiels
Assessing the Effectiveness of ContraPest Rodent Birth Control in the Waianae Mountains, Oahu	oral presentation	2018 Hawaii Conservation Conference	2018-07-25	**Tyler Bogardus**, Brandy Pyzyna
Evaluation of the GoodNature A24 Rat Trap and Automatic Lure Pump (ALP)	oral presentation	2018 Hawaii Conservation Conference	2018-07-25	**Tyler Bogardus**
Hawaii Predator Control Hui	poster presentation	2018 Hawaii Conservation Conference	2018-07-25	Jon Sprague, Michelle Bogardus, Lisa Crampton, **Tyler Bogardus**, Rachel Sprague, Kyle Pias
Weed Control Spreadsheet Updates	oral presentation	6th Annual Oahu Weed Control and Restoration Workshop	2019-04-03	**Jane Beachy**
Considerations for Restoration Site Preparation	oral presentation	6th Annual Oahu Weed Control and Restoration Workshop	2019-04-04	**Jane Beachy**
How to get the plants you need: contracting private nurseries, partnerships and sanitation	oral presentation	6th Annual Oahu Weed Control and Restoration Workshop	2019-04-04	**Timothy Chambers**

**OANRP authors in bold font*

2.6 PUBLIC RELATIONS AND PUBLICATIONS

OANRP was regularly featured in articles, press releases, bulletins and scholarly journal articles this reporting year. Staff authored and coordinated published media with local, state, regional and national media and agencies. Staff escorted media staff into the field for coverage of natural resource news. See the table below (Table 5) for a summary of all media and publications relating to OANRP management in reporting year 2019.

Table 5. Media coverage and publications in 2019.

Title	Author	Publication	Date	Format
ContraPest Introduced in Hawaii	PCT Staff	Pest Control Technology http://www.pctonline.com/article/contrapest-data-hawaii-convservation-conference/	2018-08-01	online article
Two Fires Burning in Separate West Oahu Forest Reserves	Maui Now	Maui Now https://mauinow.com/2018/08/06/two-fires-burning-in-separate-west-oahu-forest-reserves/	2018-08-06	online news article
25 cool opportunities for National Public Lands Day	USA Today	USA Today https://www.usatoday.com/story/travel/experience/america/national-parks/2018/09/19/national-public-lands-day/1358440002/	2018-09-19	online news feature
Plant for Posterity	Cheung, Martha (photos by Kenna Reed)	Palm Magazine Issue VII	Fall 2018	magazine article
Damselflies in Distress Get Help at Island Pond	Maui Now	Maui Now https://mauinow.com/2019/05/31/damselflies-in-distress-get-help-at-island-pond/	2019-05-31	online news article
Damsels in Distress Get Help from Lyon Arboretum, DLNR	UH News	University of Hawaii News https://www.hawaii.edu/news/2019/05/31/lyon-arboretum-damselflies/	2019-05-31	online news article
Hawaii Comes to Rescue of Damselflies in Distress	Big Island Now	Big Island Now https://bigislandnow.com/2019/05/31/hawaii-comes-to-rescue-of-damselflies-in-distress/	2019-05-31	online news article
Scientists hopeful for endangered orangeblack Hawaiian damselfly	Hurley, Timothy	Honolulu Star Advertiser https://www.staradvertiser.com/2019/06/10/hawaii-news/scientists-hopeful-for-endangered-orangeblack-hawaiian-damselfly/	2019-06-10	online and printed news article
Guardians of the Native Hawaiian Forest: Defending the Endangered Species Capital of the Nation Alongside the Army's Natural Resources Program	U.S. Army Garrison-Hawaii	Natural Selections, Department of Defense Natural Resources Program, Summer 2019 https://www.denix.osd.mil/nr/resources/newsletter/2019/summer-2019-natural-selections-newsletter/	Summer 2019	online newsletter article

2.7 VOLUNTEER RECOGNITION

Each year, outreach staff nominate eligible volunteers for the President's Volunteer Service Award. Nominations for this reporting year included volunteer service from 01 July 2018 - 30 June 2019. A total of four individuals listed below in Table 6 volunteered over 100 hours with OANRP within the past 12 months. These volunteers will be honored with certificates signed by the President of the United States and commemorative pins.

Table 6. 2019 President's Volunteer Service Awardees.

Award Level	Name	Hours of Service in 2018-2019
Bronze	Kathleen Altz	154
Silver	Roy Kikuta	252
Silver	David Danzeiser	254.5
Silver	Elaine Mahoney	436.5

For adults 26 and older, award levels are based on number of hours of service: Gold = 500+, Silver = 250-499, Bronze = 100-249

2.8 GRANTS

OANRP received $8,878.11 from the 2018 National Public Lands Day Department of Defense Legacy Grant to support volunteer efforts to control invasive weeds within the Kaala cloud forest at Schofield Barracks West Range. Outreach staff hosted the National Public Lands Day volunteer event on September 22, 2018.

The funds were used to purchase volunteer tools including gloves, handsaws, binoculars, rain jackets and a boot rack for volunteer rain boots.

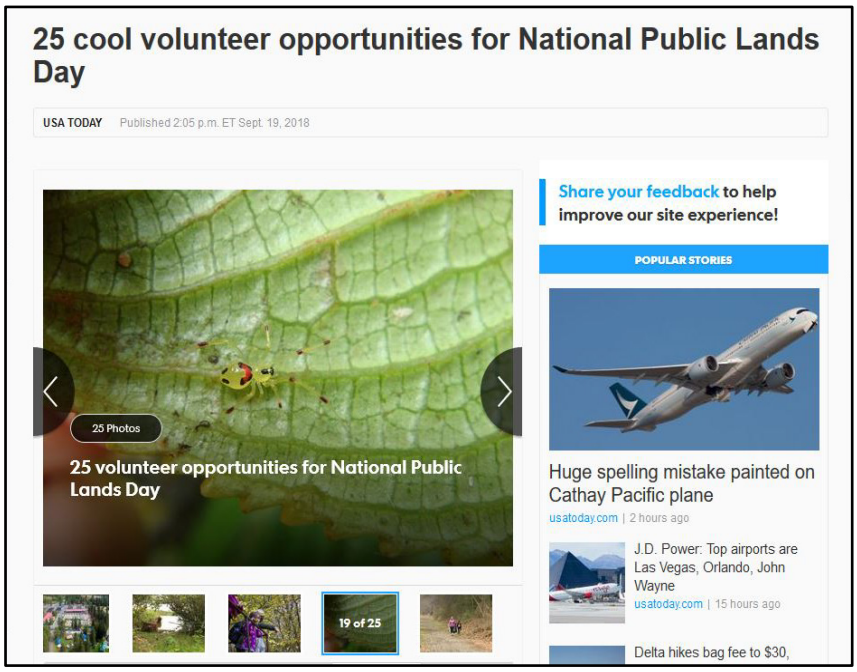

Figure 6. *USA Today* highlighted OANRP's National Public Lands Day 2018 volunteer project at Kaala on website.

CHAPTER 3: ECOSYSTEM MANAGEMENT

Notable projects from the 2018-2019 reporting year are discussed in the Project Highlights section of this chapter.

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

Ecosystem Restoration Management Unit Plans (ERMUP) have been written for many MUs and are available online at http://manoa.hawaii.edu/hpicesu/dpw_ermp.htm. Each ERMUP details all relevant threat control and restoration actions in each MU planned for the five years immediately following its finalization. The ERMUPs are working documents; the Oahu Army Natural Resources Program (OANRP) modifies them as needed and can provide the most current versions on request. This year, the Kahanahaiki, Keaau Hibiscus, Makaha I & II, Palikea, and Puaakanoa ERMUPs were revised; they are included as Appendices 3-1 to 3-5.

3.1 WEED CONTROL PROGRAM SUMMARY

MIP/OIP Goals

The stated MIP/OIP goals for weed control are:

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

Given the wide variety of habitat types, vegetation types, and weed levels encompassed in the MUs, these Implementation Plan 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 ERMUPs for each MU detail specific goals and monitoring expectations for each MU.

Figure 1. Staff and volunteers weeding at Kahanahaiki.

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 11,456.5 hours controlling weeds across 642.62 hectares (ha). These figures include both incipient and ecosystem control efforts by staff and volunteers but do not include survey efforts or travel time. Note that area is the total merged area swept, such that if the same 1 ha area is swept three times, it is reported as 1 ha, and not 3 ha. Table 1 lists efforts for previous reporting cycles. Note that all reporting periods, including this year, were 12 months in length, except 2014-2015, which covered only nine months. The hours/ha metric gives a sense of weed control intensity.

Table 1. Summary Statistics for Weed Control.

Report Year	Effort (hours)	Area (ha)	Hours/ha
2018-2019	11,456.5	642.6	17.83
2017-2018	10,398.5	528.2	19.69
2016-2017	9,309	593.9	15.67
2015-2016	8,447	539.5	15.66
2014-2015 (9 months)	4,654	325.9	14.28
2013-2014	7,600	286.5	26.53
2012-2013	6,967.6	267.7	26.03
2011-2012	5,860	275.7	21.25
2010-2011	5,778	259	22.31

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. Results of these surveys are discussed in section 3.5 below.

Figure 2. Controlling grass at Keaau Hibiscus MU.

Incipient Control Areas

All weed control geared towards eradication of a particular invasive weed is tracked via Incipient Control Areas (ICAs). Each ICA is species-specific and geographically defined. One infestation may be divided into several ICAs or one ICA, depending on infestation size, topographical features, and land ownership. Some ICA species are incipient island-wide, and are a priority for ICA management whenever found. Others are locally incipient to the MU, but widespread elsewhere. ICAs are primarily drawn in or near MUs. Those not located within or adjacent to an MU were selected for control either because they occur on an Army training range (for example, *Cenchrus setaceus* in MMR) or are particularly invasive (*Arthrostema ciliatum* in Kaluaa). In either case, the goal is eradication of the ICA. The goals, strategies, and techniques used vary between ICAs, depending on terrain, surrounding vegetation, target taxon, size of infestation, and a variety of other factors. 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 *Schizachyrium condensatum* in SBE or *Chromolaena odorata* in KTA, are quite large and require multiple 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. In certain cases, at ICAs where no mature plants were ever seen and total plant numbers were very low, this may be shortened to five years. OANRP currently controls 54 taxa in 305 ICAs.

Of the total 642.6 ha swept, ICA efforts covered 525 ha. This year, staff spent 3,157.5 hours on ICA management, conducted 667 visits to 47 taxa in 262 ICAs, achieved eradication at 9 ICAs, and created 28 new ICAs. This is the greatest effort spent and area covered for incipient weeds in a reporting period to date; see Table 2. Also, this is the greatest number of ICA sites visited in one year. ICA work accounted for 82% of the total area weeded and 27.5% of total weeding effort. This makes sense, as incipient control generally requires less time per acre than habitat restoration weed control.

Table 2. Summary Statistics for ICAs.

Report Year	# ICAs	Visits	Effort (hours)	Area (ha)	Hours/ha
2018-2019	262	667	3,157.5	525.0	6.01
2017-2018	234	674	2,645	381.9	6.93
2016-2017	233	662	2,572.8	467.3	5.51
2015-2016	175	539	2,452	388.1	6.32
2014-2015 (9 months)	147	333	1,537	245.6	6.26
2013-2012	157	389	1,753.6	196.4	8.93
2012-2013	152	311	1,369.2	184.3	7.43
2011-2012	115	260	1,661	219.3	7.57
2010-2011	130	281	665.5	164.0	4.06

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

While the majority of ICAs require minimal amounts of effort to control, some require significant investment of resources. Volunteers contribute significantly to ICA control efforts at Kaala and Palikea, which enables OANRP to divert staff time to more challenging taxa and/or work sites. A good example of this are ICAs for *Juncus effusus* and *Crocosmia* x *crocosmiiflora* along the boardwalk at Kaala. These taxa are highly invasive, but none of these boardwalk ICAs are located in direct proximity to IP taxa.

Volunteer effort here frees staff to focus on *Hedychium gardnerianum*, which directly threatens rare plants and their habitat, often in steep terrain, while maintaining pressure on the less immediate boardwalk ICA taxa threats.

The number of ICAs managed has increased steadily over the years. Part of this is due to the difficulty of determining when a site has been extirpated; ten years is a long time to monitor. Each year, staff note new locations of known priority species or discover entirely new taxa. While dispersal via Army training or OANRP management accounts for some of the new ICAs, some spread is likely due to public hikers, non-native animals, and wind events. Occasionally, if a species or site is determined to no longer be eradicable, the ICA is made inactive and/or addressed only during regular habitat weeding efforts. Even with improved strategies and control techniques, the time required to address ICA work grows along with the number of ICA sites. Encouragingly, this year no target plants were found at 107 out of 262 ICAs, and only one plant each was found at another 31 ICAs. In addition, staff were able to confidently declare eradication at nine ICAs this year, for a total of 45 eradications in OANRP's history; see Table 3.

Table 3. ICAs Eradicated in 2019.

Taxon	MU	ICA Code	Comments
Albizia chinensis	Pahole No MU	PaholeNoMU-AlbChi-01	No plants found for 10 years.
Cenchrus setaceus	Kahanahaiki	MMR-CenSet-05	No plants found for 3 years (seeds persist 1.5 years).
Cenchrus setaceus	MMR No MU	MMR-CenSet-03	No plants found for 3 years (seeds persist 1.5 years).
Cenchrus setaceus	MMR No MU	MMR-CenSet-04	No plants found for 3 years (seeds persist 1.5 years).
Cirsium vulgare	Kaluakauila	MMR-CirVul-02	No plants found for >10 years.
Dicliptera chinensis	Palikea	Palikea-DicChi-01	No plants found for 10 years.
Ehrharta stipoides	Ohikilolo	MMR-EhrSti-03	No plants found for >3 years (seeds persist 1.5 years).
Heterotheca grandiflora	SBE No MU	SBE-HetGra-02	Only 1 plant ever seen, and it was immature. No plants found for 5 years.
Setaria palmifolia	Kaala Army	Kaala-SetPal-01	No plants found for >10 years.

One ICA was discontinued this year, a *Sphaeropteris cooperi* site in Makaha. It was determined that *S. cooperi* is present elsewhere in Makaha Valley, and due to its ability to disperse naturally over great distances, was better suited as a priority target during habitat weed control efforts throughout the MU. Work at the four *Festuca arundinaceae* (now *Schedonorus*) ICAs at Kaala was suspended, due to the presence of this cryptic grass across the FAA facility, the difficulty of identifying non-flowering individuals, and the presence of other, higher priority targets. Keeping all non-native grasses from spreading from the road and facilities into the bog remains a priority. Work on this taxon may be resumed if additional resources become available.

Unfortunately, 28 new ICAs were also created, see Table 4. The suspected vectors for each ICA are listed in the table. For some ICAs, multiple vectors are possible, while others pose more of a mystery, such as the *Macfadyena* site. Staff are potential vectors at many of the ICAs, and are the most likely vector at eight to ten of them, although other conservation personnel (volunteers, researchers, and partners) may also be vectors at some sites. Recreational users are the most likely vector for six to eight of the sites. Military activity (training and/or maintenance) is the most likely vector for two new, high priority ICAs. Seven new *C. odorata* ICAs were found this year, they are discussed in section 3.6. The constant increase in new ICAs in recent years outpaces the rate at which ICAs are eradicated. This emphasizes the need for proper sanitation and decontamination practices, the importance of monitoring management sites for incipient weed ingress, and the need for research into the longevity of seeds for a variety of ICA taxa.

Table 4. New ICAs Found in 2019.

Taxon	MU	ICA Code	Vector Comments
Angiopteris evecta	Pahole	Pahole-AngEve-07	Natural dispersal or previously undetected.
Angiopteris evecta	Pahole	Pahole-AngEve-08	Natural dispersal or previously undetected.
Arthrostemma ciliatum	Palikea	Palikea-ArtCil-01	Staff/contractors/partners: found in heavily trafficked North Palikea Snail Enclosure; none known from nearby regions.
Chromolaena odorata	Kamaili	Kamaili-ChrOdo-01	Staff/recreation/unknown: found along MU fence, but discovery of more plants to the north suggests other vectors possible.
Chromolaena odorata	Kamaili	Kamaili-ChrOdo-02	Recreation/unknown: found in area not used by staff.
Chromolaena odorata	KTA No MU	KTA-ChrOdo-34	Recreation: adjacent to private campsite and Pupukea-Paumalu State Park Reserve.
Chromolaena odorata	KTA No MU	KTA-ChrOdo-35	Military/recreation.
Chromolaena odorata	Makaleha Central No MU	CMakalehaNoMU-ChrOdo-01	Staff/military/recreation/unknown: found at 1040ft elev. along Kaala Road in Forest Reserve; many potential road users.
Chromolaena odorata	Makaleha Central No MU	CMakalehaNoMU-ChrOdo-02	Staff/military/recreation/unknown: found at 800ft elev. along Kaala Road in ranch; many potential road users.
Chromolaena odorata	SBW No MU	SBWNoMU-ChrOdo-06	Military.
Crocosmia x crocosmiiflora	Nanakuli No MU	PalikeaNoMU-ChrOdo-03	Staff/partners/recreation: found along main access trail.
Dietes iridioides	Lihue	SBW-DieIri-01	Staff/unknown/previously undetected: found near an LZ, but staff rarely travel between LZ and closest ICA.
Ehrharta stipoides	Kahanahaiki	MMR-EhrSti-11	Staff: found at a regularly visited restoration site.
Ehrharta stipoides	Kahanahaiki	MMR-EhrSti-12	Staff: found at a regularly visited restoration site.
Ehrharta stipoides	Makaha I	Makaha-EhrSti-03	Staff: found at a regularly visited restoration site.
Ehrharta stipoides	Makaha No MU	MakahaNoMU-EhrSti-02	Staff/partners: site along major MU access trail.
Elephantopus mollis	Pahole	Pahole-EleMol-02	Staff/partners/recreation: found along Pahole/Makua east rim fence; taxon not widespread on Army lands.
Elephantopus mollis	Pahole	Pahole-EleMol-03	Staff/partners/recreation: found near first crossover on Pahole-Kahanahaiki access trail; taxon not widespread on Army lands.
Leptospermum scoparium	Kawaiiki No MU	KLOA-LepSco-07	Military/natural dispersal: found on edge of military LZ; taxon widespread to the east.
Macfadyena unguis-cati	Kahanahaiki	MMR-MacUng-01	Unknown: taxon not know from nearby areas or any other OANRP MUs.
Pterolepis glomerata	Kahanahaiki	MMR-PteGlo-05	Staff: found at a regularly visited restoration site.
Pterolepis glomerata	Lihue	SBW-PteGlo-01	Staff/unknown: found near an LZ; other ICAs nearby.
Pterolepis glomerata	Makaha II	Makaha-PteGlo-02	Recreation/staff: found near LZ and along a popular trail; not far from another ICA.
Pterolepis glomerata	Makaleha Central No MU	CMakalehaNoMU-PteGlo-02	Contractors/partners/staff: found along Kaala Road at LZ and gear staging area, also other ICAs present along road.
Rubus argutus	Ohikilolo	MMR-RubArg-07	Staff/recreation/natural dispersal: found near LZ and fence; closest large source is Kaala, fruit could be bird-dispersed.

Table 4 (continued).

Taxon	MU	ICA Code	Vector Comments
Setaria palmifolia	Kaala Army	Kaala-SetPal-02	Staff/partners/recreation: found along boardwalk used by a variety of people.
Sphaeropteris cooperi	Kapuna Upper	UpperKapuna-SphCoo-04	Natural dispersal: known large infestation in neighboring Makaleha gulch.
Sphagnum palustre	Kaala NAR	Kaala-SphPal-10	Staff: found by old rare plant reintroduction; another ICA very close by.

This year, there was a noteworthy increase in total ICA area treated. Some variation in area treated is expected at large ICAs which take multiple days to treat, while little variation is expected at small ICAs which can be thoroughly checked on one visit. Little to no variation in area treated was observed at 142 ICAs, suggesting these sites were checked in their entirety (or close to it) both last year and this year. This consistency is critical to achieving eradication. Only 16 ICAs had declines in treated area greater than 1 ha, and all of these are large infestation sites where the control strategy includes both targeted treatment of known hotspots and less frequent sweeps of surrounding areas. New ICAs account for 37.33 ha of the increase in area treated, primarily from two large new *C. odorata* ICAs, one of which is on KTA, and the other of which is on neighboring Pupukea Paumalu State Park Reserve. Staff do not have plans to continue work at the State Park Reserve in the future. Of the ICAs which showed an increase in treatment area, 29 of these had an increase of more than 1 ha, 13 of which had increases of more than 5 ha. Much of the increase can be attributed to aerial surveys and follow-up ground control at *Acacia mangium* and *Melochia umbellata* sites at KTA, and the *Leptospermum scoparium* site at Kumaipo/Makaha. Some can be attributed to trail surveys, binocular surveys, and ground sweeps of *C. odorata* sites at both SBW and KTA. In addition, staff expanded effort at the *Morella faya* infestation outside of Kaluaa & Waieli, in part because sweeps of this ICA assisted in delimiting the incipient *C. odorata* site there. Of the 525.01 ha treated for ICAs this year, the majority of this, 499.83 ha or 95%, was for just ten taxa: *C. odorata, A. mangium, S. condensatum, C. setaceus, R. tomentosa, Melochia umbellata, A. evecta, L. scoparium, Morella faya,* and *E. poepiggiana*.

Figure 3. Controlling *C. setaceus* at Ohikilolo Lower.

There was also a major increase in total ICA effort this report year. While equal numbers of ICAs had increases and decreases in effort, most of these differences were small (less than 15 hours). Only 12 ICAs had decreases in effort greater than 15 hours. Of these, by far the largest decline in effort was for the *C. odorata* infestation at Manuwai; high-effort delimiting surveys were completed at this ICA last year, and little effort was required to monitor the site this year. Other notable declines include reduced effort at several Kaala ICAs located near the trailhead; these sites are considered secondary priority, due to their distance from rare taxa). In contrast, 20 ICAs had increases in effort greater than 15 hours. The largest increase was for the core of the *S. condensatum* infestation at SBE; staff prioritized knockdown of this infestation this year, and focused on sweeping known infestation areas. Delimiting surveys for new *C. odorata* infestations at Kaluaa No MU, Kamaili, and Makaleha Central No MU also contributed to overall high effort this year. New ICAs accounted for 248.7 hours, or 8% of the total effort spent. Of the 3,157.5 hours spent on ICA treatment this year, the majority, 2,862 or 91%, were for just 11 taxa: *C. odorata, S. condensatum, R. tomentosa, S. palustre, C.* x *crocosmiiflora, A.evecta, J. effusus, A. mangium, L. scoparium, P. glomerata*, and *C. setaceus*. While the true measure of success is eradication, staff hope that eventually the effort needed to treat ICAs will decline as fewer individuals are found over subsequent visits.

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.

Table 5 highlights the 11 taxa which required the most control effort in the past year. Effort from report year 2018 is presented for comparison. Note that effort hours do not include travel or trip preparation, or most time spent surveying outside of known ICA boundaries to define infestation areas. See the Invasive Species Update sections (3.6) for more detailed discussion of *C. odorata*.

Figure 4. Searching for *Rhodomyrtus tomentosa* along Drum Road, KLOA.

Table 5. 2019 ICA Effort by Select Target Taxa.

Taxa	2019 Control	2018 Control	Comments
Chromolaena odorata	1,379.70 hrs 205.40 ha 171 visits	1,147.50 hrs 135.98 ha 155 visits	*Chromolaena odorata* continues to be the OANRP's top ICA priority. Staff efforts include treatments of hotspots, large sweeps, and aerial spraying; see Section 3.6. This year, buffer surveys around newly discovered infestation sites and trails surveys at KTA account for at least some of the increase in effort and area over last year. OANRP continued to contract OISC to conduct work across half of the KTA infestation; see Appendices 3-6 and 3-7 for OISC's progress report. OISC efforts are not included in the totals in this table.
Schizachyrium condensatum	522.00 hrs 79.29 ha 44 visits	284.50 hrs 92.63 ha 40 visits	This invasive, fire-adapted grass is only found on Army lands on Oahu. No new infestations of *S. condensatum* were discovered this year. The majority of effort and time was spent at SBE, where the largest and oldest infestations are found. There are seven ICAs at SBE, and the majority of plants are found in just two of them. Staff continued the same aggressive strategy employed last year, focusing efforts on hotspots via regular visits and treatment with preemergent herbicides, and sweeping minimally infested areas annually or biennially; the large increase in effort this year is entirely due to following this strategy in the infestation core. Some progress was evident. The largest ICA on Centerline Road showed a decline in the number of mature plants found, while the second-largest infestation on the north edge of the range also showed some declines in total plant numbers. The five small ICAs located along the Pineapple Junction road all saw some type of improvement, with no plants found on at least one visit to each ICA. This is a big step forward. No plants have been found at one ICA since 2016. Challenges remain, as military training and mowing provide constant disturbance and dispersal, and *S. condensatum* remains a cryptic target, one grass among a field of grasses. Last year, a small *S. condensatum* site was found at SBW within the live fire training range and Radiologically Controlled Area. Despite access restrictions, the ICA was controlled regularly and numbers of mature plants declined, although numbers of immature plants increased. Staff plan to conduct herbicide sprays at the site in future to improve suppression. Staff also discovered *S. condensatum* at Manuwai last year. This year, efforts focused on delimiting surveys around the infestation, which appears to be confined to one steep slope along the eastern ridge of the MU. Staff planned to conduct initial control via aerial spray, and received permission from the State, however, several attempts were unsuccessful, either due to range airspace scheduling issues or weather. Control of this site remains a priority, and staff will use a combination of ground and aerial treatments in future.
Rhodomyrtus tomentosa	194.25 hrs 32.98 ha 15 visits	98.75 hrs 46.60 ha 15 visits	*Rhodomyrtus tomentosa*, a small tree with bird-dispersed fruit, is locally common on windward Oahu but uncommon elsewhere. Staff manage it at SBE, Pahole, and KLOA. The largest infestation managed is at SBE, where 86% of total *R. tomentosa* effort was spent this year. The *R. tomentosa* and *S. condensatum* infestations overlap, and staff sweep for both taxa at the same time. The increase in effort this year reflects the increased effort on *S. condensatum*, which is the higher priority target. Much of the *R. tomentosa* infestation is located on large mowed fields; mowing makes plants more difficult to spot, and may also make them more difficult to control, perhaps by promoting strong root development. Staff switched to digging out plants, instead of only treating them with herbicide, and note that fewer re-sprouting plants are found. While there was no noteworthy drop in plant numbers, this could be masked by robust germination from seed. No plants have been seen at the smallest SBE ICA since 2017, and none have been seen at Pahole since 2013. The KLOA site was first discovered last year. Staff completed delimiting surveys this year, and determined that the infestation is relatively small (0.17 ha). Quite a bit of recruitment was found at the site, not surprising with the presence of mature plants.

Table 5 (continued).

Taxa	2019 Control	2018 Control	Comments
Sphagnum palustre	168.65 hrs 3.26 ha 27 visits	227.00 hrs 2.66 ha 23 visits	Control efforts have been very successful in removing the majority of the *S. palustre* infestation on the Army side of the Kaala boardwalk. Staff conducted work at eight ICAs this year, including a new ICA discovered at a rare plant reintroduction site just off the radio tower road. All ICAs are scheduled for annual monitoring and treatment, with the exception of the newest ICAs, which will be treated multiple times. This schedule allows time for moss to regrow to detectable levels between visits. Buffer surveys are scheduled around the core infestation on the Army side of the boardwalk every three years; staff started the latest round last year and finished them this year. The core ICA was expanded slightly to include new moss patches found. This year's decrease in effort is in part due to the completion of the buffer surveys and also reflective of the reduced time needed to treat the core. Staff continue to treat both the State and Army sides of the boardwalk corridor, and noted extensive grass growth along the boardwalk, which makes it difficult to spot and treat remaining patches of moss. A trial was installed to identify an effective grass control method which minimizes non-target impacts to the surrounding native habitat; see preliminary results in Appendix 3-8. The grass will be treated in the coming year to facilitate improved detection and control. Several of the ICAs treated this year are outliers, located along roads, trails, and transects; these remain persistent, with moss found at four of the five ICAs. If they continue to persist, staff may switch to twice a year checks. One consistent sign of improvement is the continued reduction of moss-killer used over the years. In the first year of control (2012-2013) 2,260 L were used. This quantity has steadily dropped, with 213 L used last year, and only 124 L used this year.
Crocosmia x *crocosmiiflora*	127.00 hrs 1.83 ha 31 visits	215.00 hrs 1.92 ha 30 visits	With showy orange flowers, *C. crocosmiiflora* is an invasive member of the Iridaceae. It primarily reproduces vegetatively via small, hardy corms, and rarely sets seed. It forms dense mats, displaces native understory, and thrives in wet habitats. This year, seven ICAs were checked at Kaala, three in Palikea, and three along the Palikea access trail. In the past, volunteers conducted the majority of control work on this taxon, digging plants out by hand. Last year, staff conducted an informal trial of a control technique used in New Zealand and determined that it was effective and efficient; however one of the herbicides in the spray mix is not labeled for forestry use, although it can be used around infrastructure. This year, control actions were adjusted to include herbicide sprays where allowed by the label, and to make better use of volunteer time. This resulted in a net decline of effort, as volunteer time was reduced. At Kaala, field staff applied herbicide sprays at three small ICAs located along the FAA fence, one ICA at the LZ/parking area, and another within the FAA facility. Little work had previously been done at many of these ICAs, as they were inappropriate for volunteers due to location or terrain. Volunteers continued to conduct all control work at the two ICAs along the boardwalk and inside the fence; at both, no matures were found and plant numbers continue to decline. In addition, volunteers controlled plants along the forested edge of the LZ, where it is difficult to reduce non-target impacts from spraying. Unfortunately, the tested spray mix cannot be used at any Palikea sites and volunteers continue to conduct the majority of control by hand. One new ICA was found along the Palikea access trail. Declining numbers of plants were observed at all ICAs, although the rate of decline has lessened in recent years. The largest ICA at Palikea was transitioned to field team management, as much of it is too steep for volunteers. Staff experimented with a different herbicide spray, but found it was not effective; staff will investigate options for obtaining a Special Local Needs label for forestry use of the effective spray, as eradication will be difficult to achieve using manual control alone.

Table 5 (continued).

Taxa	2019 Control	2018 Control	Comments
Angiopteris evecta	87.90 hrs 18.96 ha 19 visits	73.55 hrs 12.73 ha 24 visits	This long-lived, widespread fern has the potential to grow almost anywhere, from the wet Koolau summit to mesic Waianae forest. It is targeted for eradication in select MUs, but is considered a priority weed wherever it is found. Control was conducted at 14 ICAs this year, including two newly discovered ICAs in Pahole. It is likely these sites were present but undetected before, as staff have not surveyed all gulches within the Pahole fence. No plants were seen at four small ICAs, a promising trend. Last year, the control strategy for large ICAs in all MUs shifted from annual to biennial checks, with the exception of Kahanahaiki, to take advantage of *A. evecta's* slow rate of maturation. As a result, ICAs at Kapuna Upper and Kaluaa & Waieli were checked this year, but will not be surveyed next year. Some Pahole ICAs were checked this year, if staff were already in the area, but most are scheduled to be checked next year. Increases in immatures were observed at ICAs in Kapuna Upper and Kahanahaiki, while decreases were seen in Kaluaa & Waieli and Pahole, however, large numbers of immature ferns are notoriously difficult to estimate. More telling, only 1 mature plant was found this year (excepting the two new ICAs). However, the success of biennial checks in suppressing maturation won't be known for several more survey cycles. Kahanahaiki MU may be shifted to biennial checks in future. In order to better protect both Pahole and Kahanahaiki from further ingress of *A. evecta*, staff are considering requesting permission from the State to control a large infestation in Kapuahikahi Gulch, just north of the Pahole access road. Ideally, this would reduce the largest nearby source of spores.
Juncus effusus	86.50 hrs 0.93 ha 22 visits	86.63 hrs 1.00 ha 22 visits	*Juncus effusus* is a rush that thrives in wet environments and has very long-lived seeds. OANRP manages infestations at Kaala (9 ICAs) and Makaleha East (1 ICA). This year, no plants were found at the Makaleha East site, and the five outlier ICAs at Kaala, a promising trend. The remaining four ICAs include the core of the infestation along the boardwalk, as well as small secondary infestations along the radio tower road and along the FAA fence. These ICAs are the largest and oldest, and have persistent soil seed banks. Effort and area treated remained remarkably constant between this year and last year, with most effort spent in the four largest Kaala ICAs. Volunteers continue to conduct the majority of control along the boardwalk, although staff now control the two secondary infestations. OANRP anticipates that at some point, due to declining numbers of plants, this project will no longer be appropriate for volunteers and will be transitioned to a field team. There is a large population of *J. effusus* on the State side of the boardwalk which is currently not a high priority for NEPM management; this likely will act as a seed source for spread in the region. Preventing further spread of this weed is a priority.
Acacia mangium	85.50 hrs 83.04 ha 14 visits	5.20 hrs 1.06 ha 3 visits	This fast-growing tree is thought to originally have been planted at KTA to prevent erosion. Unfortunately, it is highly invasive, with a HPWRA score of 8 (scores > 6 are high risk), the ability to hybridize with other *Acacias*, and long-lived seeds. There are five ICAs for this taxon at KTA. No plants have been observed at the two smallest ICAs since 2010 and 2013. The other three ICAs range in size from 6.6-64.7 ha, making management much more challenging. At these sites, staff employ aerial surveys to detect emergent plants and follow up with ground sweeps. Some positive trends include no matures and declining numbers at the very large LZ Canes site.

Table 5 (continued).

Taxa	2019 Control	2018 Control	Comments
Leptospermum scoparium	82.50 hrs 9.03 ha 6 visits	6.00 hrs 1.56 ha 3 visits	Widespread across the northern Koolau mountains, this tree is fast-growing, has wind-dispersed seed, and is able to colonize intact areas of native forest. Staff control it at select outlier locations in both mountain ranges. This year, one new ICA was discovered at a military LZ on KLOA; this site is discussed in Section 3. 5 below. It is one of the lowest elevation sites, and is not continuous with the summit infestation. Staff monitored two other Koolau sites this year, including one on an old, unused military LZ (no plants have been seen at this ICA since 2015), and another near the Poamoho trail head (staff continue to find new plants at this site). There are two ICAs in the Waianae mountains, and both were checked this year. One is along the Kaala road; only one plant was ever seen here, back in 2010. The large increase in effort for this taxon is almost entirely due to an interagency project to control the large ICA located along Kumaipo ridge, located between Makaha and Waianae Kai valleys, leading up to Mt. Kaala. This ICA overlaps the Makaha II MU fence. Staff conducted an aerial survey of the area and followed up with ground control with staff from the Waianae Mountains Watershed Partnership. Staff plan to continue annual sweeps of this region in an effort to protect the nearby Makaha I & II and Kaala MUs. Staff noted a new location of *Leptospermum* on the northeastern cliffs of Makaha valley, below the Kaala road, outside of OANRP MUs. Staff do not currently plan to control this site, but reported it to the landowner.
Pterolepis glomerata	69.42 hrs 1.63 ha 71 visits	83.50 hrs 1.79 ha 82 visits	*Pterolepis glomerata* is only a target in the Waianae Mountains, where it is a control priority at all known sites in MUs and along the Kaala access road. Sites outside of MUs are of secondary priority at this time. The decrease in total *P. glomerata* control effort seen this year is due to small declines in effort at many ICAs, rather than a major reduction of effort at any one ICA. Staff conducted control at 24 ICAs, including four new ICAs; these were found in Kahanahaiki, Makaha II, Lihue, and Makaleha Central No MU (along the Kaala road). Potential vectors for these new ICAs are discussed in Table 4, and highlight the importance of sanitation. This spread is discouraging, but plant numbers at the new sites were low. On a positive note, no plants were found at 11 ICAs this year, despite multiple checks. This suggests that small infestations of *P. glomerata*, detected early and monitored regularly, may be eradicable despite its long-lived seed. Declines in plant numbers were seen at three ICAs, including the east fence spot at Manuwai, the shelter at Kaala (no plants found on four of five visits), and the overlook trail at Pahole. The Pahole site is much more open due to clearing work by the State and supplemental work by staff, which should aid control efforts in future. Unfortunately, plants were found at the Kahanahaiki 'chipper' ICA for the first time in years; while close to the original plant, it is unclear if the plants recruited from the soil seed bank or are the result of another introduction. The largest and oldest ICAs predictably are the most difficult to manage, and include two ICAs along the Kaala road, one large ICA each at Manuwai and Makaha, and one site in Makaleha West No MU. Staff will continue to prioritize control at these sites in an effort to provide suppression until an effective biocontrol (currently being pursued by DOFAW) is released.
Cenchrus setaceus	58.60 hrs 34.91 ha 22 visits	74.24hrs 28.35 ha 27 visits	This fire-prone grass is a high priority for control across Training Ranges and in MUs. Previous studies by the OANRP seed lab suggest seeds do not persist in the soil for longer than a year and half. An ICA is deemed eradicated after 3 years of regular checks with no plants found. This year, no new sites were found and three ICAs were declared eradicated, including one at Kahanahaiki and two along the fire break roads in MMR; all were small sites, with low numbers of plants historically. Two additional ICAs are approaching eradication, with no plants found since 2017; this includes another firebreak road site in MMR and a site in SBE. One ICA remains

Table 5 (continued).

Taxa	2019 Control	2018 Control	Comments
			in KTA; no plants had been detected at it for a couple years, but unfortunately several immatures were found this year. Immature plants can by cryptic, particularly at KTA, where they may blend in with surrounding vegetation. The majority of effort was spent on the largest infestation, located on the makai end of Ohikilolo ridge. Staff conducted one aerial spray, as well as ground control sweeps in the infestation core. Happily, no plants were found in the highly managed Hibiscus Patch or Upper and Lower Akoko Patches. Additional effort is needed at this ICA in the coming year. Another ICA runs along Ohikilolo ridge and into Keaau; most of it is located on private land. While OISC has worked on this ICA in the past, they have been unable to attain funding to continue control this year, particularly since the landowner does not allow the use of herbicides. OANRP staff continue to focus on controlling any plants seen immediately adjacent to the Ohikilolo ridge fence as an interim measure. This year, staff started a trial to test the efficacy of an organic herbicide, BurnOut, on *C. setaceus*. The trial was installed at Diamond Head and is not complete, although preliminary results suggest BurnOut is not an effective control technique. OANRP will continue to support any efforts to remove *C. setaceus* from Keaau and other locations in the Waianae mountains in future.

Figure 5. Photopoints of *S. palustre* control along the Kaala boardwalk. The photo on the left shows large banks of *S. palustre* at the advent of control efforts in 2011. The photo on the right, from winter of 2018, shows both the recovery of native vegetation and invasion of alien grasses along the boardwalk.

The ten MUs where the most ICA effort was spent this report year are highlighted in Table 6; they include all MUs with greater than 60 hours of ICA effort. MUs are listed in order of effort. Another six MUs had greater than 30 hours of effort, they are: Manuwai (54.0 hrs), Palikea (49.1 hrs), Kahanahaiki (46.6 hrs), Ohikilolo Lower (45.3 hrs), Waimea No MU (40.0 hrs), and Pahole (34.1 hrs).

Table 6. 2019 ICA Effort in Select MUs.

MU	# of Taxa	Taxa List	# of Visits	Effort (hrs)	Comments
KTA No MU	7	*Acacia mangium* *Cenchrus setaceus* *Chromolaena odorata* *Melochia umbellata* *Miscanthus floridulus* *Senecio madagascariensis* *Sideroxylon persimile*	139	884.95	28% of all ICA effort was spent at KTA this year. KTA is a high priority for incipient control efforts because it is one of the most heavily used Ranges and hosts several ecosystem-altering weeds, including the largest population of *C. odorata* in the State. *Chromolaena odorata* control accounts for 88% of time spent at KTA. Hours recorded here do not include hours spent by OISC or hours spent surveying trails in un-infested portions of KTA. See Section 3.6 for more discussion. While all other ICA taxa require comparatively less effort, *A. mangium, M. umbellata,* and *M. floridulus* all infest large areas (84.21 ha, 39.15 ha, and 34.77 ha, respectively); in comparison, the *C. setaceus, S. madagascariensis*, and *S. persimile* ICAs are all well under one ha each. See the discussions of *A. mangium* and *C. setaceus* in Table 5. There are seven *M. umbellata* ICAs at KTA. Of these, no plants have been seen at two of them since 2011 and 2013. Declining numbers were observed at two others. One ICA was not checked, but previously no plants had been seen at it since 2011. The two largest ICAs encompass much of Kaunala gulch. Staff aerially surveyed the gulch, but were not able to follow up with ground control at both ICAs. In future, staff will aim for annual treatment, but may shift to biennial treatment if time is limited. All known hotpots within the *M. floridulus* ICA were checked, and no live plants were found. A couple mature plants were treated during aerial spray operations for *C. odorata*. Fortunately, *M. floridulus* does not appear to recruit vigorously, although more focused surveys are needed to determine whether any plants remain in the steep portions of Pahipahialua gulch. No plants have been seen at the *S. madagascariensis* ICA since 2017. The *S. persimile* ICA was declared eradicated in 2013, but was checked this year anyway; fortunately, no plants were found.

Table 6 (continued).

MU	# of Taxa	Taxa List	# of Visits	Effort (hrs)	Comments
SBE No MU	7	*Cenchrus setaceus* *Chromolaena odorata* *Heterotheca grandiflora* *Rhodomyrtus tomentosa* *Schizachyrium condensatum* *Smilax bona-nox* *Vitex trifolia*	61	675.40	Located next to residential Wahiawa and heavily used for training, SBE is home to a diverse array of weeds not found on other Army lands. This year, 21% of all ICA effort was spent at SBE. Of this, 73% was spent on *S. condensatum* and 25% was spent on *R. tomentosa*; both taxa are discussed in Table 5. There was a major increase in total effort at SBE this year, all of which can be attributed to increased focus on *S. condensatum*. No plants have been seen at the single *C. setaceus* ICA since 2017, and it is on track for eradication. This grass has been introduced to and eradicated from SBE twice before, and is at risk from reintroduction via military training. No plants have been seen at any of the three *H. grandiflora* ICAs since 2014. One was declared eradicated this year, as it only ever had immature plants. The *S. bona-nox* ICA continues to persist, despite many years of control. It has not increased in area, and is considered a low risk compared to other incipient weeds at SBE. Staff will continue annual control and investigate alternative control techniques as time permits. Similarly, the two *V. trifolia* ICAs are also considered a low priority and are only checked annually. No plants have been found at the eastern ICA since 2014, although surveys have not been thorough. The western ICA is better defined, and no plants were found at it for the first time this year. No new ICA sites for any taxa were identified on SBE this year.
SBW No MU	3	*Chromolaena odorata* *Erythrina poepiggiana* *Schizachyrium condensatum*	41	318.50	ICA effort increased at SBW dramatically this year, by almost 75% over last year. Most of this is due to increased effort on *C. odorata*. One new site was found this year, on the north firebreak road. See Section 3.6 for further discussion. There are two *E. poepiggiana* ICAs at SBW, an outlier and a more established patch along Trimble Road. At the outlier, one previously treated plant was observed resprouting this year. This was surprising as the tree had long been considered dead, and it drives home how difficult it is to kill this taxon. Numbers continue to decline at the Trimble Road site, with fewer recruiting immature plants found than ever before. There is one *S. condensatum* ICA at SBW; it is discussed above in Table 5.
Kaala Army	9	*Angiopteris evecta* *Anthoxanthum odoratum* *Crocosmia* x *crocosmiiflora* *Diplazium esculentum* *Festuca arundinacea* *Juncus effusus* *Pterolepis glomerata* *Setaria palmifolia*	59	179.88	There was a large decline in total effort spent at Kaala Army this year of 125.7 hrs. This was due to a reduction in time spent on the three major ICA targets, *S. palustre, C. crocosmiiflora*, and *J. effusus*. These declines are discussed in Table 5, and reflect an intentional reduction in volunteer effort and decrease in time needed to conduct control. Of the effort spent at Kaala Army, 63% was spent on *S. palustre*, 17% was spent on *J. effusus*, and 13% was spent on *C. crocosmiiflora*. All other taxa account for 7%. All ICAs at Kaala are located either close to the road and FAA facility, or along the boardwalk or transect trail. Preventing spread of incipient weeds into the bog or surrounding forest is a priority. No plants were found at the single *A. evecta* ICA, or either *P. glomerata* ICA. One *S. palmifolia* ICA was declared eradicated, but a new site was discovered on the boardwalk. Plants were found at the single *A. odoratum* ICA for the first time since 2016; it is likely this grass was overlooked in the past. Low numbers of plants persist at the single *D. esculentum* ICA; this taxon is also cryptic and difficult to identify. As discussed above, work was halted at the *F. arundinaceae* ICAs, due to its distribution across the FAA facility.

Table 6 (continued).

MU	# of Taxa	Taxa List	# of Visits	Effort (hrs)	Comments
		Sphagnum palustre			
Kaala NAR	5	*Crocosmia* x *crocosmiifolia* *Diplazium esculentum* *Juncus effusus* *Pterolepis glomerata* *Sphagnum palustre*	35	162.90	The divide between Kaala NAR and Kaala Army MUs is somewhat artificial, as they form continuous habitat and face many of the same threats. However, the split is logistically helpful, as NEPM has primary oversight of the Kaala NAR. OANRP staff focus on select projects along the boardwalk and road to prevent incipient weed spread in the bog, and volunteers contribute greatly to these efforts. This year, there was a reduction in effort at Kaala NAR, primarily due to *C. crocosmiiflora* work, specifically fewer plants found at the boardwalk site and a shift in strategies at the LZ site, as discussed in Table 5. In contrast, volunteer effort increased at *J. effusus* and *S. palustre* sites. The *S. palustre* site at the radio tower road is particularly persistent, as standing water reduces the efficacy of herbicide sprays. Volunteers handpulled all moss at this site. Staff continued to find plants at the *D. esculentum* ICA; this fern is cryptic when small and difficult to identify. While staff did not regularly camp at Kaala, the *P. glomerata* site at the State Shelter was monitored quarterly. Plants were only found on one visit, although mature plants were found.
Kaluaa No MU	2	*Chromolaena odorata* *Morella faya*	9	141.50	The increased effort at Kaluaa No MU is entirely due to delimiting surveys conducted for *C. odorata*, which was discovered on the Kaluaa access trail in the previous report year. Buffer surveys were completed, and fortunately the infestation appears to be quite small in area (0.28 ha). Much of the buffer survey overlapped an existing *M. faya* ICA. This tree likely was planted in the region many years ago, and while a few immature plants have been found throughout the years, the taxon does not appear to have thrived in the area. No plants were found this year.
Kamaili	1	*Chromolaena odorata*	4	96.60	Staff discovered a single *C. odorata* at Kamaili in July 2018. A 200m buffer around the site was conducted, resulting in the discovery of a second site on the very edge of the buffer, see section 3.6. These buffer sweeps account for almost all effort spent at Kamaili this year.
Makaleha Central No MU	3	*Chromolaena odorata* *Pterolepis glomerate* *Verbesina encelioides*	15	72.80	All ICAs located in Makaleha Central No MU are either on or very close to the Kaala access road. Traveled by a variety of users, the road is the OANRP's primary access to several MUs. Invasive weeds on the road have the potential to be tracked into nearby MUs. This year, three new ICAs were identified, including two *C. odorata* locations and one *Pterolepis glomerata* site. One of the *C. odorata* sites was located near the forestry gate, and the other was located on ranch land. Buffer surveys were partially completed for one of the ICAs with the assistance of State personnel. These sites appear isolated, but are extremely concerning, as multiple vectors exist. The new *P. glomerata* site was discovered at an LZ used to sling materials to the West Makaleha Snail Enclosure. Aggressive control was conducted in an effort to sanitize the LZ. Control work continues at a second *P. glomerata* ICA with a persistent population. No *V. encelioides* was seen at the single ICA for this taxon; this site is on track to be declared eradicated in 2021.
Makaha No MU	3	*Chromolaena odorata*	6	70.50	In previous years, little time was spent controlling incipient weeds outside the Makaha I and II MUs. However, this year OANRP took over regular monitoring of a small *C. odorata* site on the

Table 6 (continued).

MU	# of Taxa	Taxa List	# of Visits	Effort (hrs)	Comments
		Ehrharta stipoides			north side of the valley from OISC, discovered a new *E. stipoides* site on the camp ridge access trail, and ramped up control efforts of *L. scoparium* along Kumaipo ridge. Since OISC completed buffer surveys for the *C. odorata* location, minimal effort is required to monitor this site, and no plants were seen this year. The *E. stipoides* likely was introduced to the area via staff, and requires quarterly monitoring; total numbers seen thus far have been low, and given the short seed life of this grass, prognosis for eradication is good. As discussed in Table 5, staff worked jointly with partners to conduct control of *L. scoparium*, and hope to suppress its spread.
		Leptospermum scoparium			
Kapuna Upper	4	*Angiopteris evecta*	14	66.40	Control efforts at Kapuna Upper focus primarily on the seven *A. evecta* ICAs. As discussed in Table 5, these ICAs are checked biennially. Two ICAs were missed and will be surveyed in the coming year. Plants were found at all five ICAs monitored, and mature plants were found at two ICAs. Staff spent almost 20 hours more checking *A. evecta* this year than last year, and also covered additional 11 ha. No plants have been seen at either of the *R. argutus* ICAs since 2010. Staff plan to check them through next year, and then hope to declare them eradicated. One new *S. cooperi* ICA was found this year, for a total of four ICAs. The newest site is located in Keawapilau, next to a rare taxa reintroduction. There is a large infestation to the west of the Kapuna fence, which may be the source for these plants. Staff plan to monitor all these ICAs annually, but will prioritize ICAs adjacent to rare taxa. NEPM leads control efforts on the *E. stipoides* ICAs. This year, staff controlled plants found in the trailside ICA during the course of other fieldwork, and monitored another ICA on a side ridge (no plants found).
		Ehrharta stipoides			
		Rubus argutus			
		Sphaeropteris cooperi			

Figure 6. Left, planting at the newly cleared restoration site in Kamaili. Right, an aggressively girdled *T. ciliata*.

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 an 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, integrity of native forest, level of invasive species presence, and fire threat. Some WCAs simply track trail and fenceline vegetation maintenance. WCAs drawn outside of MUs typically provide a way of tracking weed control effort at genetic storage rare plant sites, removal of a widespread weed not yet prevalent in an MU (for example *S. cooperi* just outside Palikea), or along access trails and roads. The goals and priorities for weeding in a particular WCA are detailed in the appropriate ERMUP and translated into actions in the OANRP database. Visitation rates are scheduled for each action. 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. For some low-priority WCAs, no control may be planned for many years. 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 117.6 ha. Staff spent 8,299 hours over 956 visits at 191 WCAs. WCA work accounted for 18% of the total area controlled and 72.5% 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. Table 7 compares this report year's efforts to previous report years. The 2015-2016 reporting period covered only nine months, but all other reporting periods cover 12 months each. Area data from 2008 through 2011 was not collected as accurately as current practices and is not presented for comparison.

Table 7. Summary Statistics for WCAs.

Report Year	Visits	Effort (hours)	Area (ha)	Hours/ha
2018-2019	956	8,299	117.6	70.57
2017-2018	951	7,753	146.3	52.99
2016-2017	727	6,736	126.6	53.21
2015-2016	713	5,995	151.3	39.62
2014-2015 (9 months)	352	3,117	80.4	38.77
2013-2014	526	5,846	90	64.96
2012-2013	532	5,620	83.4	67.39
2011-2012	443	4,199	57	73.67
2010-2011	409	5,123	*	
2009-2010	353	3,256	*	
2008-2009	267	2,652	*	

*Data not comparable

Total effort increased from last year, while total area weeded decreased. No goals are set for either metric in a given year, as scheduled actions change annually, but these totals can be useful in looking at overall weed program trends. Area weeded decreased at 32 MUs, but increased at 24, however, most of these changes are small. Only 13 MUs showed changes greater than 2 ha; these are summarized in Table 8. The largest decline was seen at Manuwai, and is due to the completion of targeted canopy surveys across the MU early this year. These canopy surveys were somewhat experimental and will be evaluated during the next vegetation belt-transect analysis. Similar targeted canopy sweeps took place at Kaluaa and Wailei and Makaha I, and contributed to area increases at these MUs. Last year, staff worked with KMWP to

conduct targeted sweeps at both Opaeula and Kaluanui No MU, but this year the same group worked instead at Poamoho North and Kaukonahua North. Infrastructure maintenance also played a role in weeded area changes. At Kapuna Upper, staff conducted less vegetation maintenance along the fenceline than last year; this fence is quite large, so the change accounts for most of the decrease in area. Typically, little effort is required at Makaha No MU, but following a storm, both the road and valley trail were blocked by fallen vegetation, which staff cleared to restore access. At Makaha I, part of the area increase is due to clearing of access trails for the rodent management grid. There are several factors at play in Lihue. This year, Range Division began conducting regular maintenance along the firebreak road, which includes a large portion of the fence corridor, thus negating the need for staff to work in this area. While this accounts for most of the drop in area treated, there also was a reduction in weeded area around rare taxa sites, primarily due to range access limitations caused by UXO disposal and Range Division's annual aerial spray and controlled burn. At Pahole, Ohikilolo, and Kaluakauila, while the majority of rare taxa sites were weeded, each of these weeded areas shrank. In contrast, part of the increase at Makaha I can be attributed to small increases in treatment area at the majority of rare taxa sties.

Table 8. Changes in Area Weeded > 2 ha between Report Years 2019 and 2018.

IP Management Unit	Increase in Area (ha)	IP Management Unit	Decrease in Area (ha)
Kaluaa and Waieli	+5.97	Manuwai	-13.19
Poamoho North	+4.58	Kapuna Upper	-6.61
Makaha I	+2.56	Pahole	-5.37
Kaukonahua North	+2.39	Kaluanui No MU	-5.16
Makaha No MU	+2.26	Opaeula	-4.97
		Lihue	-4.07
		Ohikilolo	-2.59
		Kaluakauila	-2.28

Figure 7. Controlling invasive pines at Kaluakauila

Table 9. Changes in Weeding Effort >20 hours between Report Years 2019 and 2018.

IP Management Unit	Increase in Effort (hrs)	IP Management Unit	Decrease in Effort (hrs)
Kahanahaiki	+305.9	Palikea	-328.8
Makaha I	+209.6	Honolulu East No MU	-106.0
Kaala Army	+145.7	Opaeula	-95.0
Makaleha West	+102.3	Kaluanui No MU	-83.0
Pahole	+69.6	Haili to Kealia I	-55.0
Kaluakauila	+58.0	Koloa	-53.0
Kamaili	+57.5	Lihue	-51.3
Opaeula Lower	+52.8	Waimea No MU	-47.5
Kaluaa and Waieli	+51.3	Manuwai	-41.8
Ohikilolo Lower	+49.5	Kapuna Upper	-24.1
Makaha II	+45.8	MMR No MU	-21.8
Ohikilolo	+43.5		
Keaau Hibiscus	+40.5		
Kaukonahua North	+40.0		
Poamoho North	+37.0		
KTA No MU	+29.0		
SBW No MU	+24.0		
Makaha No MU	+22.5		
Pualii North	+21.7		
Kaleleiki	+20.0		

Weeding effort increased at 35 MUs, and decreased at 21, although most of these +/- changes are negligible. Changes of 20 person hours or more are summarized in Table 9. Improved staffing levels on the field teams contributed greatly to effort increases at Kaleleiki, Kaluaa & Waieli, Kamaili, Makaha I, Makaha II, and Makaleha West. Access issues which affected both Ohikilolo and Ohikilolo Lower last year were resolved by this year, contributing to effort increases; in fact, effort levels at Ohikilolo Lower rebounded fully to pre-range closure levels. Unfortunately, access issues continued at Lihue; with limited time available at Schofield, less effort was spent weeding around rare taxa sites. The weather limited access to Koloa this year, resulting in less effort for both habitat sweeps and rare taxa site maintenance weeding. Increases in volunteer trips contributed greatly to effort increases at both Kaluakauila and Makaleha West. At Kaluakauila, a large soldier group assisted with pine removal; while staff would like to work with similar groups in future, availability of such groups is unpredictable and logistics are complicated. Extra trips occurred at Makaleha West to assist with clearing of the new snail enclosure. Targeted single-species/canopy sweeps contributed to increases in effort at Kaala Army, Kaluaa & Waieli, Kaluakauila, Keaau Hibiscus, Makaha I, Ohikilolo Lower, Pahole, and Pualii North, and for the decrease in effort at Manuwai. Restoration projects contributed to effort increases at Kahanahaiki, Kamaili, Keaau Hibiscus, Makaha I, Makaleha West (new snail enclosure), Ohikilolo, and Opaeula Lower. Restoration project related effort declined at Palikea and Haili to Kealia I, as several projects entered the maintenance phase. Weed control at rare taxa sites, both wild and reintroduced, increased at select sites in a variety of MUs, particularly Kahanahaiki, Kaluaa & Waieli, Kamaili, Kapuna Upper, Keaau Hibiscus, Makaha I, Makaha II, and Makaleha West, but decreased at Haili to Kealia I. Staff worked with partners on several weed control projects this year at Pahole, Kaukonahua North, and Poamoho North; similar efforts were conducted last year at Kapuna Upper, Opaeula, and Kaluanui No MU. Road and trail maintenance contributed to effort increases at KTA No MU, Makaha No MU, and Opaeula Lower, and to decreases decreased at Kapuna Upper and MMR No MU. Effort spent maintaining living collections increased at SBW No MU (the Kahua site), but decreased at Honolulu East No MU (Koko Crater) and Waimea No MU (Waimea Valley), as staff worked to improve efficiency by using herbicides and suppress weeds by fostering the growth of ground covers.

Table 10. MUs with 100 or More Hours of WCA Control Effort.

IP Management Unit	Hours	Visits	Area Weeded (ha)	Targeted Canopy or Single Taxa Sweeps Conducted?	Volunteer Projects Present?	Restoration Project On-going?
Kahanahaiki	1,877.55	176	10.01	Yes (*Montanoa hibiscifolia, Triumfetta semitriolba*, invasive grasses)	Yes	Yes
Palikea	1,016.41	127	4.67	Yes (invasive grasses)	Yes	Yes
Makaha I	656.85	67	6.47	Yes (*Toona ciliata*)	Yes	Yes
Kaala Army	599.00	51	9.48	Yes (*Hedychium gardnerianum, Odontonema cuspidatum, Psidium cattleianum, Sphaeropteris cooperi*)	Yes	Yes
Pahole	529.21	67	7.06	Yes (*M. hibiscifolia, Spathodea camplanulata, T. ciliata*)	Yes	No
Makaleha West	430.50	39	0.94	No	Yes	Yes
Kaluaa and Waieli	382.25	44	12.64	Yes (*Grevillea robusta, S; camplanulata, T. ciliata*)	Yes	No
Ohikilolo	311.75	32	4.18	Yes (*Clidemia hirta, T. ciliata*, invasive grasses)	No	Yes
Ohikilolo Lower	299.00	26	3.63	Yes (*Leucaena leucocephala, Vachellia farnesiana*)	No	Yes
Ekahanui	264.50	29	4.92	No	No	Yes
Kapuna Upper	263.90	35	3.25	No	No	No
Opaeula Lower	171.50	20	0.97	No	No	Yes
Makaha II	158.75	19	0.83	No	No	No
Kaluakauila	150.00	16	3.04	Yes (*G. robusta, L. leucocephala, Pinus luchuensis, P. cattleianum, Psidium guajava, Schinus terebinthifolius, Syzigium cumini*, invasive grasses)	Yes	Yes
Keaau Hibiscus	127.50	14	1.09	Yes (*L. leucocephala*, invasive grasses)	No	Yes
Pualii North	113.50	14	2.10	Yes (*Aleurites moluccana, G. robusta, Heliocarpus popayensis, Schefflera actinophylla, S. terebinthifolius, S. cumini, Trema orientalis*)	Yes	Yes
Manuwai	103.00	23	3.24	Yes (*Acacia confusa, G. robusta, S. terebinthifolius, T. ciliata*)	No	No
Kamaili	100.00	13	1.08	No	No	Yes

All MUs which received 100 hours or more of effort this report year are summarized in Table 10. Most of these MUs are large, host multiple rare IP taxa, contain large swaths of native forest, and are readily accessible; these include Kahanahaiki, Palikea, Pahole, Kaala Army, Makaha I, Kaluaa and Waieli, Kapuna Upper, Ohikilolo, Ekahanui, and Manuwai. Several of other MUs in the table are significantly smaller, but support several IP taxa and include patches of native forest; these include Kamaili, Makaleha West, Opaeula Lower, Makaha II, Kaluakauila, and Pualii North. Two MUs on the list are located in severely degraded habitat and host one or two IP taxa; these include Ohikilolo Lower, and Keaau Hibiscus. Both are dominated by alien grasses. Maintaining fuel reduction areas around the rare taxa at these MUs is a high priority and requires consistent, large inputs of time.

All MUs are managed by an assigned field team. The team is responsible for the bulk of weed control efforts, particularly any weed control at rare taxa sites. Other factors which contribute to overall effort in an MU include: targeted canopy or single species sweeps not focused around IP taxa (carried out by either the assigned field team or weed-project focused Ecosystem Restoration team), active volunteer projects (led by the Outreach team), and active restoration projects incorporating aggressive weed control coupled with native taxa restoration. These three factors are included in Table 10, and provide some insight into

the levels of effort spent at various MUs. Team weeding efforts at Kahanahaiki, for example, are bolstered by targeted sweeps for priority weeds, volunteer work at several different sites, and a growing number of restoration projects. In contrast, management of Kapuna Upper this year focused solely on rare taxa sites and was carried out by the field team. Note that only restoration projects associated with proactive weed control that occurred this year were included in the table.

Figure 8. Effective grass control at Palikea.

Figure 9. Controlling a long *Roystonea regia* at Opaeula Lower.

In the OANRP database, specific reports can be generated that 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 or MUs and to judge whether the effort spent was sufficient to improve habitat quality. Since goals for each site vary, estimating the effort needed for each WCA is very challenging.

Control efforts for all MU are summarized in Table 11. The table lists all MUs where WCA control was conducted in the past year. Note that some WCAs specifically track weed control along fencelines and trails. For these visits, the intent is simply to maintain infrastructure, as opposed to improve habitat. These infrastructure WCAs generally encompass an entire MU, overlapping other WCAs, and explain why the total WCA area is double the MU area. Data from the 2018 report is included for reference. This year's data is shaded and in bold. For each year, the total actual area weeded is reported. The number of separate weeding trips is recorded as number of visits, and the effort is recorded in person hours spent weeding (travel and set-up time is not included). While these statistics are not a replacement for vegetation monitoring, they detail the investment OANRP has made over the years.

Figure 10. Two photopoints showing the results of weed control and active restoration at the Upper Akoko patch in the Ohikilolo Lower MU. Left: Thick grasses and stands of *L. leucocephala* blanket the area in 2002, at the start management. Right: In the winter of 2018, after years of weed control, dense outplanting, and some natural recruitment, *D. viscosa* and other native shrubs have transformed the landscape.

Table 11. MU WCA Weed Control Summary, Report Years 2019 and 2018.

Management Unit	MU area (ha)	Total WCA area (ha)	2019 Report Year			2018 Report Year			Comments
			Area weeded (ha)	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Alaiheihe No MU	N/A	11.35	**1.97**	**1**	**4.00**	1.97	1	10.00	This area includes the Lower Kaala NAR access road. Staff sprayed roadside weeds between the forestry gate and Manuwai fence to facilitate access.
Ekahanui	87.5	179.44	**4.92**	**29**	**264.50**	3.61	27	262.20	Efforts in this large, highly degraded MU are centered on select, small rare taxa locations. Weed control efforts expanded at several rare taxa sites this year, including Palai Gulch, the Abutilon Fence, the Cenchrus A Ridge, and the south crestline. Restoration work continued at the *Cenchrus agrimonioides* var. *agrimonioides* site on the north fenceline. Staff continued to maintain trails for the rodent control grid.
Ekahanui No MU	N/A	15.95	**0.002** ***(15 m²)***	**1**	**0.50**	0.07 *(655 m²)*	2	0.50	Staff sprayed patches of the invasive grass *Urochloa maxima* on the primary Ekahanui access trail.
Haili to Kealia I	7.91	1.03	**0.14**	**4**	**41.00**	0.30	9	96.00	Weed control targeted woody weeds and grasses around the *Hibiscus brackenridgii* subsp. *mokuleianus* reintroduction and associated common native outplants along the Kealia trail. Last year, staff spent extra effort preparing the site for restoration plantings.
Haili to Kealia No MU	N/A	28.13	**0.07** ***(669 m²)***	**1**	**1.00**	0	0	0	This area encompasses the Kuaokala access road. Staff treated *U. maxima* at a site close to where the road and Makua rim fence meet.
Helemano	60.63	61.86	**0**	**0**	**0**	0	0	0	Helemano is a low priority MU due to the small number of Tier 1 taxa, and is challenging to access due to weather. No management was conducted in the past two years.

Table 11 (continued).

Management Unit	MU area (ha)	Total WCA area (ha)	2019 Report Year			2018 Report Year			Comments
			Area weeded (ha)	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Honolulu East No MU	N/A	1.85	**1.85**	**10**	**44.00**	1.85	15	150.00	Weed control was conducted around rare plant living collections at Koko Crater Botanical Garden. Greenhouse staff reduced visits this year, and used herbicide sprays to improve efficiency.
Huliwai	0.12	0.20	**0.15**	**3**	**15.00**	0.15	3	4.00	This small MU is centered at an *Abutilon sandwicensis* population. The entire enclosure was weeded this year.
Huliwai No MU	N/A	9.53	**0.02** ***(160 m²)***	**1**	**4.00**	0.24	2	6.25	Staff conducted weed control around a *Cenchrus agrimonioides* var. *agrimonioides* site during a monitoring trip.
Kaala Army	49.02	51.52	**9.48**	**51**	**599.00**	9.77	46	453.28	*Hedychium gardnerianum* continues to be the primary weed target at Kaala, along with *P. cattleianum*. This year, staff started another round of sweeps at Kaala-01, continued sweeps at Kaala-02, began treatment at Kaala-05, and swept a portion of the FAA facility. Remaining weed effort occurred at rare taxa sites, the boardwalk trailhead, the *Odontonema stricta* site, and along fencelines.
Kaala NAR	20.03	22.25	**0.13**	**7**	**16.50**	0.71	6	10.00	Last year, staff assisted NEPM with *H. gardnerianum* treatment along the State side of the boardwalk. This year, effort focused on maintaining the area around the shelter/campsite and treating vegetation along the radio tower road to improve detectability of *S. palustre*. A few plots of grass were sprayed along the boardwalk as part of a trial.
Kaena	10.06	3.28	**0.04**	**3**	**13**	0.19	1	10.00	The vegetation matrix at Kaena appears to be relatively stable and requires little effort to maintain. This year, efforts focused on *Euphorbia celastroides* var. *kaenana* patches on the westernmost edge of the population and inside the predator proof fence.

Table 11 (continued).

Management Unit	MU area (ha)	Total WCA area (ha)	2019 Report Year			2018 Report Year			Comments
			Area weeded (ha)	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Kaena East of Alau	14.51	1.20	**0.32**	**3**	**13.00**	0.70	2	14.00	Weed control focused on reducing fuels around the small *E. celastroides* var. *kaenana* site, including a buffer to the east and the access trail.
Kahanahaiki	37.7	82.52	**10.01**	**176**	**1877.55**	11.61	168	1571.70	Effort spent weeding again increased at this MU. In part, this is due to continued emphasis on restoration sites and expanded work around rare taxa sites. Volunteers continue to contribute greatly to weed projects at Kahanahaiki. There was a small decline in area weeded, as *G. robusta* sweeps conducted last year were not repeated this year. Vegetation monitoring results presented last year noted that weed control and restoration had a positive effect on native cover. Some recommendations from the study were incorporated this year, including expansion of restoration projects, targeted sweeps for select species (*M. hibiscifolia*, *N. brownii*), and control of some *S. terebinthifolius* patches in Maile Flats. Others will be prioritized in the coming years, particularly largescale sweeps of native forest zones in Maile Flats.
Kaleleiki	0.12	0.80	**0.10**	**1**	**20.00**	0	0	0	Staff controlled weeds along the fenceline. This *Eugenia. koolauensis* population has been heavily impacted by the *Austropuccinia* rust, and weed control is a low priority until new options for *E. koolauensis* management are discovered.
Kaluaa and Waieli	80.97	164.10	**12.64**	**44**	**382.25**	6.67	33	331.00	Control efforts increased at almost every WCA in this MU this year, in part due to increased team staffing. Work increased at many rare plant sites and continued at the Hapapa Snail Enclosure. Volunteer groups assisted in weeding native forest patches. Targeted canopy sweeps account for most of the area treated. Some fenceline maintenance was conducted.

Table 11 (continued).

Management Unit	MU area (ha)	Total WCA area (ha)	2019 Report Year			2018 Report Year			Comments
			Area weeded (ha)	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Kaluaa No MU	N/A	14.26	**0.43**	**1**	**2.00**	0	0	0	Staff sprayed weeds along the LZ and one of the primary access trails.
Kaluakauila	42.73	51.99	**3.04**	**16**	**150.00**	5.32	18	92.00	Weed control efforts continued to focus around rare taxa sites, grass control in native forest patches and along trails, and fuel reduction along fencelines. The increase in effort is primarily due to work by a soldier volunteer group which controlled fire-prone *P. luchuensis* and other tree weeds along the fence. Since no common native outplantings were planned for this year, little weeding was done at these sites; outplanting will resume next year.
Kaluanui No MU	N/A	209.57	**0**	**0**	**0**	5.16	3	83.00	Last year, staff assisted KMWP with sweeps in the State Kaluanui enclosure.
Kamaileunu No MU	N/A	9.88	**0.13**	**3**	**15.50**	0.04 *(375 m²)*	3	10.00	Both the trail and LZ were maintained to facilitate access to the Kamaili fences. In addition, part of the large *M. hibiscifolia* stand adjacent to the LZ was treated.
Kamaili	2.57	3.92	**1.08**	**13**	**100.00**	0.68	6	42.5	This MU is divided into mauka and makai fences. At both, efforts focused on rare taxa sites, limited sweeps in native forest patches, and fenceline maintenance. In addition, in the mauka fence a restoration project was started in the gulch below a wild *A. sandwicensis* site; this accounts for much of the increase in effort.

Table 11 (continued).

Management Unit	MU area (ha)	Total WCA area (ha)	2019 Report Year			2018 Report Year			Comments
			Area weeded (ha)	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Kapuna Upper	172.35	177.64	**3.25**	**35**	**263.90**	9.86	32	288.00	Although effort and area both dropped this year, weed control increased at rare taxa sites. Rather, the decline is due to less vegetation maintenance along fences, and a reduction in the area swept on joint trips with NEPM. Vegetation monitoring results presented last year noted a decline in forest quality across the MU, and suggested that targeted canopy sweeps, restoration projects, and an overall increase in weeding effort is likely necessary to meet IP vegetation goals. These suggestions have not yet been implemented. Staff hope to discuss options with NEPM, the primary land manager, this year.
Kaukonahua North	12.29	269.20	**2.39**	**1**	**40.00**	0	0	0	This MU hosts primarily Tier 2 taxa, and thus is a low priority for weed control. OANRP staff and KMWP conducted targeted sweeps for *A. evecta* and *P. cattleianum* along the summit.
Keaau and Makaha	1.19	0.18	**0**	**0**	**0**	0.09 *(869 m²)*	1	3	This small enclosure protects a *Sanicula mariversa* population. This rare plant site was not monitored this year, staff opted to not make an extra trip to the area solely to control weeds.
Keaau Hibiscus	3.64	3.67	**1.09**	**14**	**127.50**	0.69	10	87.00	All weeding effort focused around wild and reintroduced *H. brackenridgei* subsp. *mokuleianus*, common native outplantings, and along the fenceline. After the August 2018 fire, staff ramped up weed control as a means of reducing fuels directly around rare taxa.
Keaau No MU	N/A	0.65	**0.31**	**5**	**20.00**	0.46	4	20.00	To facilitate faster access, a new LZ was installed above the Keaau Hibiscus fence. The trail leading to this LZ, the LZ itself, and the trail to the road were maintained. Both grasses and woody weeds were removed.

Table 11 (continued).

Management Unit	MU area (ha)	Total WCA area (ha)	2019 Report Year			2018 Report Year			Comments
			Area weeded (ha)	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Koloa	71.54	72.95	**0.76**	**9**	**33.50**	1.20	8	86.50	Located at the summit of the Koolau Mountains, weather poses a major challenge to conducting effective weed control. Two camp trips occurred this year, but weather conditions were not conducive to herbicide use. One rare plant reintroduction site was weeded, but the majority of time was spent on a couple targeted sweeps for *P. cattleianum*.
KTA No MU	N/A	2.95	**0.70**	**3**	**29.00**	0	0	0	Thick grasses, vines, and shrubs were controlled along an overgrown road at KTA. This road is closed to soldier traffic, but is used by staff to access part of the *C. odorata* core.
Lihue	711.92	714.90	**1.15**	**10**	**67.00**	**5.21**	**17**	**118.25**	Access and UXO issues continue to restrict management at Lihue. With limited time available, there was a reduction in effort around some rare taxa sites, particularly those which are not thriving. Fortunately, the habitat at a couple rare taxa sites requires little weed management. The small *Delissea waianaensis* fence in Mohiakea was swept in its entirety. Vegetation maintenance occurred along one rodent control trail and the northern fenceline. Range Division conducted vegetation maintenance on the firebreak road, along which runs the western edge of the Lihue fence, negating the need for staff weed the fence.
Makaha I	34.20	71.20	**6.47**	**67**	**656.85**	3.92	42	447.25	Both effort and area weeded increased dramatically at Makaha I. One big factor was the increase in team staffing, which allowed for additional weed control at rare taxa sites and one targeted sweep for *T. ciliata.* Volunteer projects remain on-going at two sites. Restoration projects expanded, with the addition of a new site on Camp Ridge. All rodent control trails were maintained this year.

Table 11 (continued).

Management Unit	MU area (ha)	Total WCA area (ha)	2019 Report Year			2018 Report Year			Comments
			Area weeded (ha)	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Makaha II	26.69	15.29	**1.83**	**19**	**158.75**	0.23	11	113.00	As at Makaha I, increased team staffing allowed for additional weeding effort in Makaha II. Efforts focused around rare taxa sites, including new reintroduction sites and some fenceline maintenance.
Makaha No MU	N/A	12.70	**2.26**	**2**	**22.50**	0	0	0	Large storms in late 2018 knocked down trees on the road and main trail. These were cleared to allow crews to access Makaha I.
Makaleha Central No MU	N/A	0.19	**0.05** ***(504 m²)***	**1**	**8.00**	0	0	0	Weed control was coupled with monitoring of the *Kadua degeneri* var. *degeneri* population.
Makaleha East West Branch	1.14	1.23	**0.09** ***(869 m²)***	**1**	**9.00**	0	0	0	Weed control was coupled with monitoring of the *Kadua degeneri* var. *degeneri* population.
Makaleha West	38.05	1.67	**0.94**	**39**	**430.50**	0.82	25	328.25	This MU has two widely separated WCAs. Most effort took place at the southern WCA, the '3-Points' fence. While the majority of time was spent at the new snail enclosure, effort also increased at rare taxa and restoration sites throughout the fence. This reflects improved team staffing. Volunteer trips doubled as well, primarily to assist with weed control through the snail enclosure. The northern WCA is a small fence which protects a *Schiedea obovata* site. Staff weeded around the *S. obovata* and cleared the fenceline.

Table 11 (continued).

Management Unit	MU area (ha)	Total WCA area (ha)	2019 Report Year			2018 Report Year			Comments
			Area weeded (ha)	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Manuwai	122.49	254.74	**3.24**	**23**	**103.00**	16.42	24	144.81	Much of Manuwai is highly degraded forest in steep terrain. Effort this year focused primarily around rare taxa sites. This MU is at high risk of damage from fire. Grass control and fuel reduction were conducted in the northern part of the MU, particularly along fencelines. Only one large landscape sweep for canopy weeds was conducted, in contrast to last year, and this accounts for much of the decline in area and effort this year. These canopy sweeps have now been completed over most of the hike-able portions of the MU; they will be evaluated during regular MU belt transect monitoring.
Manuwai No MU	N/A	4.17	**3.98**	**2**	**3.00**	4.17	6	19.00	Staff cleared grasses, primarily *U. maxima*, along the western access road and trail.
MMR No MU	N/A	22.01	**0.58**	**7**	**24.75**	1.24	9	46.50	All effort was spent maintaining vegetation along the Makua-Kuaokala and Makua East Rim fencelines, including spraying grass and clearing fallen trees. Efficiency improved via use of herbicide sprays designed to suppress grass in degraded habitat.
Nanakuli No MU	N/A	6.01	**1.38**	**3**	**22.5**	1.57	1	17.50	This leeward facing bowl stretches between the Palikea and Palikea IV MUs. Staff swept it for *S. cooperi*, to reduce ingress into neighboring MUs. Grasses and other weeds on the LZ and ridge connecting it to Palikea were controlled.
Napepeiaoolelo	0.75	0.48	**0**	**0**	**0**	0.07 *(651 m²)*	1	2	The *Hesperomannia oahuensis* protected by this fence has been dead since 2013. Last year, vegetation was controlled along the fence. Staff did not visit the area this year.
Oahu South Central No MU	N/A	10.46	**0**	**0**	**0**	0.67	1	11.00	There is a living collection of *H. brackenridgii* subsp. *mokuleianus* in Kapolei, but it is currently considered inactive. No vegetative maintenance was conducted at it this year.

Table 11 (continued).

Management Unit	MU area (ha)	Total WCA area (ha)	2019 Report Year			2018 Report Year			Comments
			Area weeded (ha)	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Ohikilolo	232.79	139.17	**4.18**	**32**	**311.75**	6.77	41	268.25	The Lower Makua portion of the MU was closed due to UXO issues for the entire year. All work reported here occurred in the Ohikilolo Ridge portion of the MU. Efforts continued to focus on rare taxa sites, native forest patches, grass control, restoration projects, and sweeps for *Clidemia hirta*. Much of the increase in time can be attributed to site preparation for common native outplantings in the 'Mauka Patch.'
Ohikilolo Lower	28.75	4.54	**3.63**	**26**	**299.00**	3.44	22	249.50	Work at this MU is focused in 3 WCAs centered on rare taxa. The goal of weed control is to reduce fuels while increasing native vegetation cover. With full access this year, effort increased. All sites were swept for both grasses and woody weeds, and restoration plantings continued at the Hibiscus Patch. At the Upper Akoko Patch, where restoration plantings occurred in 2016 and 2017, staff noted both outplants and wild recruits are beginning to fill in and are starting to suppress weed growth; this is also evident in photopoints started in 2002 and in gigapan monitoring started in 2016.
Oio	1.33	1.39	**0.04** ***(386 m²)***	**1**	**3.00**	0	0	0	Until effective techniques to combat *Austropuccinia* rust in the field are found, staff are hesitant to commit resources to habitat restoration at any *E. koolauensis* sites, including all three MUs in KTA: Kaunala, Oio, and Pahipahialua (not listed again in this table). This year, staff cleared weeds along the Oio fence.
Opaeula	50.93	50.42	**0**	**0**	**0**	4.97	4	95.00	This MU hosts primarily Tier 2 taxa, and thus is a low priority for weed control. Last year, staff and KMWP weed sweeps across part of the MU.

Table 11 (continued).

Management Unit	MU area (ha)	Total WCA area (ha)	2019 Report Year			2018 Report Year			Comments
			Area weeded (ha)	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Opaeula Lower	10.15	13.96	**0.97**	**20**	**171.50**	1.24	18	118.75	Effort increased this year, primarily due to increased effort at the two restoration sites (one near the weatherport and the other at the *Gardenia mannii* outplanting) and additional fenceline maintenance. An isolated palm (likely *Roystonea regia*) was controlled in a gulch on the eastern end of the MU.
Pahole	88.02	193.65	**7.06**	**67**	**529.21**	12.43	78	459.65	This is the third year in a row where effort increased at Pahole. This cannot be attributed to one particular type of project, but rather to higher intensity work at all sites, particularly rare taxa sites. One priority target sweep was conducted in the main gulch. Grass sprays along the Kahanahaiki-Pahole access trail continue to be a priority. Staff assisted NEPM with restoration projects in Gulch 1.
Pahole No MU	N/A	14.92	**9.03**	**18**	**43.75**	8.58	12	53.00	Staff controlled weeds along the Pahole road, around the Nike greenhouse and LZ, along the beginning of the Kahanahaiki-Pahole access trail, on the access trail to the main gulch, and around the *Cenchrus agrimonioides* var. *agrimonioides* at near the crossover.
Palawai No MU	N/A	5.97	**2.34**	**2**	**20.00**	2.24	1	13.50	This area immediately abuts the Palikea MU. Staff swept it for *S. cooperi* to reduce ingress of this highly invasive fern into the enclosure.

Table 11 (continued).

Management Unit	MU area (ha)	Total WCA area (ha)	2019 Report Year			2018 Report Year			Comments
			Area weeded (ha)	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Palikea	9.95	22.14	**4.67**	**127**	**1016.41**	5.86	157	1345.25	Although area and effort dropped at Palikea this year, both are still very high for such a small MU. Weed control continued to focus on restoration projects, rare taxa sites, and to a lesser degree, fence/trail maintenance. Some of the reduction is due to several large restoration projects entering the maintenance phase. This includes the Palikea North Snail Enclosure, which is now much more vegetated, thanks to three years of aggressive outplanting. Vegetation monitoring results were presented last year, and indicated that while native canopy increased, target weed levels did as well. Some recommendations have already been incorporated, including prioritizing grass control in managed areas, increasing effort in the TNC fence, expanding restoration projects, and post-poning further *M. faya* removal until another round of IPA monitoring is conducted.
Palikea V	1.40	0.02	**0**	**0**	**0**	0.02 *(176 m²)*	1	6	Last year, staff cleared a new landing zone in this MU to facilitate access. The site was not visited this year.
Poamoho North	257.77	260.43	**4.58**	**2**	**37.00**	0	0	0	This MU is of moderate priority, as it contains few MFS IP taxa and is actively managed by two other agencies. This year, staff assisted KMWP on one camp trip and conducted targeted sweeps for *A. evecta* and *P. cattleianum*.
Puaakanoa	10.7	2.21	**0.80**	**5**	**16.00**	0.48	4	10.00	This region is steep, rocky, and at risk for fire. Efforts focused on improving habitat and reducing fuels around two *E. celastroides* var. *kaenana* sites, and maintaining the fenceline. Previous control efforts were effective at knocking down large fuels, so low effort was sufficient this year.

Table 11 (continued).

Management Unit	MU area (ha)	Total WCA area (ha)	2019 Report Year			2018 Report Year			Comments
			Area weeded (ha)	**# Visits**	**Effort (person hours)**	Area weeded (ha)	# Visits	Effort (person hours)	
Pualii North	7.99	10.98	**2.10**	**14**	**113.50**	1.91	19	91.80	This year, staff weeded at wild and reintroduced rare taxa sites (including potential *Drosophila* sites), in native forest patches, along the fenceline, and conducted one canopy weed sweep. Volunteers continue to weed in the gulch.
SBE No MU	N/A	4.22	**0.09 *(853 m²)***	**3**	**2**	0.15	5	10.00	Weeds were maintained at East Base to reduce the potential for staff and volunteers to act as vectors. Last year, the sediment disposal site on SBE was weeded, but the site was discontinued.
SBW No MU	N/A	2.61	**1.50**	**16**	**95.00**	1.68	27	71.00	This year, staff continued controlling weeds at the Kahua Living Collection site; this accounts for majority of effort. Staff also continued to regularly maintain weeds at West Base to reduce the potential for staff to act as vectors.
Waianae Kai	3.66	1.14	**0.04 *(444 m²)***	**1**	**4.50**	0.11	3	7	Staff conducted limited weed control near the fence and around a native forest patch. No rare taxa sites were weeded this year.
Waianae Kai No MU	N/Z	3.85	**0.04 *(400 m²)***	**1**	**6.00**	0	0	0	This unfenced site is home to the largest known *Drosophila montgomeryi* population. Weed control was conducted around this rock talus site.
Waimanalo to Kaaikukai No MU	N/A	2.35	**0.29**	**4**	**22.00**	0.51	4	3.25	This area encompasses the Palikea access trail. Staff controlled alien grasses along the trail to reduce the potential for weed spread, and a volunteer group treated woody weeds at the Meadow site.
Waimea No MU	N/A	0.27	**0.27**	**8**	**25.50**	0.27	18	73.00	The rare plant living collections at Waimea Valley were maintained throughout the year. *Commelina diffusa* was left around the collections to provide weed suppression.
TOTAL	N/A	3695.67	**117.62**	**956**	**8,298.67**	146.30	951	7753.44	Total effort increased notably (+545 hrs) this year, while visits increased slightly (+5 trips), and area treated decreased (-28.68 ha).

3.2 INTER-AGENCY INVASIVE PLANT COLLABORATION

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

- Bishop Museum. Plant samples were submitted to and identified by the Bishop Museum Herbarium staff. Noteworthy finds are discussed in Section 3.5.
- Board of Water Supply (BWS). BWS reviews OANRP weed control actions in Makaha Valley.
- Coordinating Group on Alien Pest Species (CGAPS). The Federal Biologist participates in the CGAPs working groups on mosquitoes and coconut rhinoceros beetle.
- Federal Aviation Administration (FAA), Kaala facility. Staff shared information on invasive plants found within the FAA facility on the summit of Kaala, and also conducted control. In addition, staff shared information about *Chromolaena odorata* with them, after it was found along the Kaala access road. FAA personnel were receptive to the OANRP's concerns.
- Hawaii Agricultural Research Center (HARC). This year, staff continued to assist HARC with their project to develop fungus-resistant *Acacia koa* stock for the Waianae Mountains. Once fungus-resistant stock is developed, OANRP will be able to use it in restoration projects.
- Hawaii Department of Agriculture (HDOA). OANRP maintains contact with staff in the Plant Industry Division. This year, staff began working with HDOA on the development of a biocontrol for *C. odorata*, further discussed in Section 3.6.
- Hawaiian Electric Company (HECO). OANRP maintains a positive working relationship with HECO staff. HECO accesses parts of Army training ranges to maintain their infrastructure. They continue to be aware of range sanitation requirements. Staff shared the location of particularly invasive weeds on Army lands with them.
- Hawaii Army National Guard (HIARNG). OANRP supports the HIARNG Conservation Manager's efforts to better educate National Guard soldiers on invasive species issues. This year, HIARNG provided OANRP with a study location at Diamond Head to test the efficacy of an organic herbicide on *Cenchrus setaceus*. This trial is currently underway, and will be completed in winter of 2019.
- Koolau Mountains Watershed Partnership (KMWP). The Army is an active member of the partnership. This year, one field team camped with KMWP to assist in controlling priority weeds at Poamoho North and Kaukonahua North MUs.
- Naval Facilities Engineering Command (NAVFAC) Marianas. NAVFAC staff assisted the OANRP by providing a sample of *C. odorata* for a genetic study.
- Oahu Invasive Species Committee (OISC). OANRP serves on the OISC steering committee and attends all OISC meetings. In the past year, joint projects and collaborations included the following:
    - Staff assisted with aerial ball sprayer treatments of *C. odorata* at Kahana Valley State Park. This complemented OISC's ground control work at this infestation.

- OANRP continues to collaborate with OISC on a variety of *C. odorata* issues, including sharing information about newly discovered infestations, contracting OISC to conduct control on KTA, surveying steep slopes with gigapan imagery, collaborating on overall management strategy, and pursuing a biocontrol.

- State of Hawaii: Dept. of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DOFAW), Natural Area Reserve System (NARS), Forest Reserves (FS), Native Ecosystems Protection and Management (NEPM), and State Parks. Several OANRP MUs are located on State land. In the past year, collaborations with State staff included the following:
    - Staff regularly shared information with NEPM about new invasive weed locations, and weed control/restoration projects. This year, staff continued to assist with NEPM *S. palustre* control efforts at Kaala by treating both sides of the boardwalk corridor. Federal staff also provided expertise on *Ehrharta stipoides* detection; this grass is incipient along the Mokuleia trail, and difficult to spot. OANRP continues to assist NEPM with 80 person hours of weed control effort per year, as part of a work swap agreement. This year, staff fulfilled the hours via assisting with sweeps of a high-quality *Diospyros* spp. patch in Kapuna Upper and working on NEPM restoration sites in Pahole.
    - Staff conducted a survey of trails in the Pupukea-Paumalu State Park Reserve, after discovering a lone *C. odorata* along the Ehukai pillbox trail last year. Numerous plants were found, and results were shared with State Parks staff and OISC.
    - In 2017, NEPM released *Tectococcus ovatus*, a biocontrol for *P. cattleianum*, at several locations along the Kahanahaiki-Pahole border. This year, staff noticed *T. ovatus* galls at a couple sites within Kahanahaiki, and reported this positive news to NEPM. Although the galls were observed only 75m and 265m from the most robust release site, and infestation levels were light, it is encouraging to see that this slow-moving biocontrol has moved into Kahanahaiki.

Figure 11. Small *P. cattleianum* plants infested with the gall-forming biocontrol *T. ovatus* in Kahanahaiki.

- University of Hawaii, Dr. Cliff Morden. Staff continue to collaborate with Dr. Morden and OISC on genetic testing of *C. odorata*; see Section 3.6 for details.
- University of Hawaii, College of Tropical Agriculture and Human Resources (CTAHR), Dr. James Leary. Staff completed a two year Incision Point Application (IPA) trial on *Citharexylum caudatum* and *Psidium cattleianum* var. *lucidum* this year, following methodology established by Dr. Leary. For a full description of IPA technique, see 2009-2014 MIP and OIP Status Reports. Results are summarized in Table 12. Unfortunately, Dr. Leary left CTAHR in early 2019. He remains interested in publishing trial results with program staff, as time allows.
- Waianae Mountains Watershed Partnership (WMWP). The Army is a member of the partnership. This year, staff collaborated with WMWP on control of the only known infestation of *Leptospermum scoparium* in the Waianae Mountains. Staff plan to continue this in the future.
- Waimea Valley. OANRP manages two rare taxa living collection sites at Waimea, and conducts vegetation maintenance around them.

Table 12. Results of IPA control trial on *P. cattleianum* var. *lucidum* and *C. caudatum*, 25 months.

Species (Family)/ Control Technique	Product (active ingredient)	Results	Summary
Citharexylum caudatum (Verbenaceae) 20 trees tested (25-47cm circum.), 5 trees per product. 4 cuts/tree, 0.5ml of undiluted product/cut.	Garlon 4 Ultra (triclopyr)	At 6 months, 5 trees had major defoliation. At 12 months, 1 was dead (circum = 33cm). At 25 months, 3 others were poor and 1 was recovering. **May be effective at higher doses.**	Polaris showed the most promising IPA results, although mortality was low even after two years. Suggest 1 cut/10 cm of trunk. Mortality likely higher with other control techniques and chemistries.
	Milestone (aminopyralid)	At 6 months, 1 tree had major defoliation. At 25 months, 1 was in poor health (circum = 32cm), while 4 were moderate/healthy. **Not recommended.**	
	Polaris (imazapyr)	At 6 months, 1 tree was dead (circum = 45cm). At 25 months, 2 were dead (circum = 45cm and 29.5cm), 2 were very poor, and 1 seemed to be recovering. Effects slow, may be faster at higher rates. **Recommended with reservations.**	
	Ranger Pro (glyphosate)	At 6 months, 3 trees had major defoliation. At 25 months, 2 had major defoliation, while 3 were of moderate health. **Not recommended.**	
Psidium cattleianum var. *lucidum* (Myrtaceae) 20 trees tested (50-80cm circum.), 5 trees per product. 6 cuts/tree, 0.5ml of undiluted product/cut.	Garlon 4 Ultra (triclopyr)	At 13 months, 5 trees were in poor health, with major defoliation. At 25 months, there was some recovery in 3 trees, but all were still in poor health. **May be effective at higher doses.**	Milestone was the most effective using IPA, particularly on trees < 60 cm in diameter. Suggest 1 cut/10cm trunk. This taxon appears susceptible to Milestone and Garlon 4.
	Milestone (aminopyralid)	At 13 months, 1 tree was dead (circum = 56cm), and 3 were in poor health. At 19 months, 3 were dead (circum < 60cm). At 25 months, the remaining 2 largest were in poor health. **Recommended.**	
	Polaris (imazapyr)	At 19 months, 1 tree was in poor health, and all had some defoliation. At 25 months, 4 were recovering. **Not recommended.**	
	Ranger Pro (glyphosate)	At 13 months, 1 tree had major defoliation, while all others were healthy. At 25 months, all 5 were healthy. **Not recommended.**	

This year, staff participated in the Sixth Annual Oahu Natural Areas Restoration and Weed Management Workshop, held April 3-4, 2019 at Aloha Stadium. The interagency hui Priority Oahu Native Ecosystems (Priority ONE) organizes and hosts this annual workshop. It is a valuable way to share information, data, and control techniques among local agencies conducting active weed control management and habitat

restoration work, and is structured to encourage discussion. Several staff were on the planning committee this year, and helped to structure and put on the event. This year, the workshop expanded to two days, plus a third day for optional field trips, see Appendix 3-9. The first day was dedicated to weed control and restoration field projects, including short talks followed by ample discussion time, but also included an in-depth presentation on herbicide use by Dr. Joe DeFrank of CTAHR. In addition, a panel of rare taxa experts discussed avoidance and minimization concerns with respect to weed control and restoration and shared information about the habitat needs of rare plants and animals. The second day of the conference was dedicated to restoration and native plant propagation, and was divided into three sections: collecting and planning, propagation and amplification, and deployment and planting. Each section included short talks followed by either break-out discussion sessions or a panel discussion. The third day of the workshop included optional field trips. In addition to serving on the planning committee, OANRP staff also presented at the conference and ran a field trip.

Figure 12. Workshop attendees during a presentation (bottom left), and celebrating in the endzone (top left). A field trip to restoration sites at Kahanahaiki (right).

3.3 VEGETATION MONITORING

This year, vegetation belt transect monitoring was conducted and analyzed for the Ekahanui MU (Appendix 3-10). The results of this study will be used to modify weed control plans at this MU. Vegetation monitoring options for Pahole MU were researched and discussed with the State. Belt transect monitoring will be installed at Pahole in 2021. Point-intercept vegetation monitoring was conducted at the Makaha ‘Giant Ohia’ Restoration Area, the North Palikea Snail Enclosure, and the Three-Points/West Makaleha Snail Enclosure. All three sites are considered major restoration projects, and results are discussed in detail in Appendices 3-11, 5-4, and 5-2, respectively. Gigapan imagery was taken at Ohikilolo Lower this year. Results are being analyzed and will be presented next year.

3.4 INVASIVE SPECIES SPREAD PREVENTION ON ARMY TRAINING RANGES

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

Soldier Training

- OANRP conducts presentations for Army troops, contractors and other active military personnel providing information on how training and maintenance actions can impact natural resources on Army training lands.
- OANRP staff present and update the natural resource section of the Officer in Charge/Range Safety Officer (OIC/RSO) briefs, held three times a month. The OICs and RSOs for each unit are required to attend this brief before they can schedule or conduct any training on Army lands. This is the most direct way for staff to highlight natural resources concerns to soldiers, particularly the need to clean vehicles and gear and report fires. OANRP staff split briefing duties with DPW Cultural Resources staff, with each office presenting a joint natural/cultural resources message in alternate months. In addition, OANRP staff present at the monthly Environmental Compliance Officer training, a three-day class for enlisted personnel and contractors that work on Army training lands.
- Prior to any training at MMR, units receive a joint brief from Range Control, DPW Cultural Resources, and DPW Natural Resources. In the Natural Resources portion of the brief, staff emphasize prevention of invasive species spread and wash rack use. This year, a total of seven MMR briefings were conducted.
- The Federal Natural Resource Manager and Biologist regularly attend and present at quarterly USARHAW Environmental Quality Control Committee (EQCC) meetings. These meetings are the primary way environmental concerns, from clean water to natural resources to hazardous waste, are conveyed to unit commanders. For the second year, EQCC meetings incorporated hands-on elements and toured the OANRP baseyard to learn about natural resources issues. An informational video was created by the Garrison for soldiers to watch before using the Central Vehicle Wash Facility (CVWF), and was publicized at the EQCC; https://vimeo.com/117847345.

Integrated Training Area Management (ITAM), Range Division, DPW, and Contractors

- Federal staff worked with Center for Environmental Management of Military Lands (CEMML) contractors to advise them on vegetation cutting at FP 308 at Schofield Barracks West Range. CEMML was tasked with tree cutting to open the view plain. Federal staff surveyed the area to ensure it was clear of *C. odorata*. CEMML contractors work under the Range Division and conduct much of the vegetation maintenance on range. CEMML requested photos of priority invasive weeds for their staff; OANRP produced posters (Appendix 3-12) for their base yard as well as pressed and laminated weed samples.
- A private contractor was hired to revegetate Army lands in Kunia. Federal staff advised the contractor on the hydro seed mix to be used to ensure invasive species were avoided.

Wash Rack Status

- The 2014 Wash Rack Utilization Policy to Control Invasive Species is still in effect. Federal staff proposed updates to the policy in 2017, and followed up on it again during the past year, but the new policy has not yet been signed.

- In 2017, Federal Staff worked with the DPW Engineering Department on signs reminding personnel to use the wash racks, to be posted on all exit gates at KTA, SBE, SBS, and SBW. The signs were fabricated and installed in August 2018.

Figure 13. Vehicle wash rack signs installed in SBE.

- This year, the Federal Natural Resource Manager continued to serve as the Contracting Officer Representative (COR) for the Central Vehicle Wash Facility (CVWF) at Schofield Barracks, and both the KTA and SBE Wash Racks. This allowed OANRP to have greater oversight and understanding of the challenges involved in keeping these facilities functional. Federal and program staff created a 'smart card' with information about the wash racks for soldiers (Appendix 3-13); the intent of the card was to further publicize the importance of using the wash racks, as well as provide information on their operating hours.
- The CVWF, SBE Wash Rack, and KTA Wash Rack were all at least partially operational for most of the year. The CVWF, located on Schofield Barracks, is the only facility capable of handling large, tracked vehicles, and also has the greatest capacity for washing highly soiled vehicles. In February the CVWF extended the hours of operation to 0830-1530. This improved the accessibility of this facility to units.
- The KTA Wash Rack was plagued by equipment problems early in the year. While parts of the facility were always operational, the facility as a whole could not accommodate large units for part of the year. Inventories conducted in January showed major problems with multiple features; large-volume fire hoses were broken, many of the pressure washer hoses, spray guns, pumps and reels were leaky or broken, valves were broken, and wands were unusable or with broken tips. Fortunately, many of the issues were addressed and systems were reported to be functional in February. No issues were reported during the large Lightning Forge training event.
- The current contractor has greatly improved oversight of the facilities; over the last year, the contractor instituted daily inspections of the CVWF and weekly inspections at KTA and SBE. Major repairs were made at all facilities. While there continue to be issues, overall utility is much improved over last year. In September 2019, of the current COR will shift to another DPW department, however Federal staff are optimistic that they will be able to have productive communication with the new COR.
- DPW Utilities installed backup water lines for portable power washers at the CVWF. As repairs are often required, this system will allow soldiers to wash vehicles when the primary system is not operable.

Figure 14. Left: new plumbing installed for hoses at the CVWR. Right: Water can be drawn from the hydrant bypassing the existing CVWR waterlines.

- Analysis of RFMSS data on wash rack use is encouraging, with increases this year for all three wash racks in the number of days the facilities were available, scheduled, and utilized. The days utilized are tracked by the contractor, not the units. However, small groups using the wash racks are not tracked, as the contractor is typically not on site for these groups, suggesting that utilized days may be an underestimate. Despite these positive steps, there is much room for improvement and enforcement, such as improved tracking of wash rack use by small groups, particularly vegetation maintenance crews, and the issues discussed in the KTA section below.

Wash Rack Sediment Disposal

- In June 2018 the sediment basins at the CVWF were cleaned out and dumped at the landfill off Area X. After the sediment was spread thin it was sprayed with rye grass hydromulch. Since then staff monitored the site eight times and have not found any notable invasive species. The area is currently being mowed by the contractor along with the rest of the landfill site. Staff plan to continue monitoring the site quarterly through June 2020, and then will transition to once or twice a year checks. If additional sediment is disposed of at the site, quarterly checks will be resumed. This has proven to be an effective way to dispose of and monitor sediments.

Figure 15. Hydromulched sediment spread out at the landfill site showing common weeds growing with hydromulched Rye and Bermuda Grass in August 2018.

PTA

- Staff coordinated with CEMML staff at Pohakuloa Training Area (PTA) on Hawaii island to share notable weed finds in range areas. As soldiers often train at both PTA and Oahu ranges, there is a risk of weeds spreading between the islands. Sharing information on notable invasive species allows crews to be aware of potential new threats.

KTA

- Several new *C. odorata* sites were discovered at KTA this year. All were located along roads or trails. It is unclear if these new sites were spread via military training or trespassing recreational motocross riders. The continued spread of *C. odorata* across KTA highlights the importance of cleaning gear and vehicles before leaving KTA, the omnipresent and intractable problem of preventing trespassing, and the extremely invasive nature of *C. odorata*.
- Staff continue to note examples of trespassing and encroachment at KTA, such as motocross riders using the area during the week (motocross use is only allowed on weekends) and outside of the designated motocross park, photos from motocross internet sites showing riders in unauthorized areas, and well-used roads and trails leading directly off range with no barriers or markers. In previous years, staff reported finding a zipline tower on the edge of the Delta range. It is unclear what actions the Army is able to take to prevent unauthorized access.
- Last year, there were major staffing challenges at KTA Range Control, which led to poor facilitation and enforcement of wash rack use. This improved this year, although challenges remain and it is not clear that Range Control staff consistently ensure units use the wash rack. OANRP staff have received reports indicating that on some occasions, Range Control staff discouraged users from using the wash rack, saying that it was too much work for them to unlock the facility. This year, Federal staff worked to institute the use of a wash rack use log so that personnel would be reminded to use the rack and there would be some accountability. Unfortunately, it has been difficult to ensure this practice is adopted. There have been multiple incidents when staff found the log was not in use. Federal staff will continue to address this issue.
- Two fires occurred at KTA this year, both in March. Both were relatively small, but were located in areas known to be infested with *C. odorata*. Such fires exacerbate the *C. odorata* problem, as it thrives following such disturbances.
- In April scorched vegetation was found on LZ Summit Split Rock in Kahuku Training Area (KTA). This was likely due to exhaust burns from an MV22 Osprey. Federal staff are following up on this with Range Division and Army Wildland Fire.

Figure 16. Suspected MV22 vegetation impacts.

KLOA

- One new highly invasive species site was discovered on KLOA this year. During the annual survey of LZ Black, staff discovered a small population of *Leptospermum scoparium*. While this tree is widespread at the summit of the northern Koolau range to the east, this location represents the most westernmost known outlier. The vector for this site is unclear. Helicopters landing at infested LZs could possibly transport *L. scoparium* seed to LZ Black, however wind dispersal is equally likely. The infestation is on the extreme edge of the LZ, in an area which does not appear to have been used actively for some time. It includes two large mature trees, suggesting the plants were undetected for years.

- In January, severely dried/scorched vegetation was found on LZ Black in Kawailoa Training Area (KLOA). This was likely due to exhaust burns from an MV22 Osprey. Federal staff reported impacts to Range Division and Army Wildland Fire. ITAM staff was informed and vegetation management considerations were discussed, particularly regular mowing of the LZ to avoid risk of fire.

Figure 17. Suspected MV22 vegetation impacts.

MMR

- Program and Federal staff reviewed a proposal for a training event called 'Spur Ride.' Staff emphasized the importance of cleaning gear prior to entering MMR, and investigated options for conducting outreach to the participants on the unique natural resources found in Makua Valley.

SBE

- Staff continue to maintain cones, rope, and signs around select *S. condensatum* hotpsots to prevent accidental mowing of this highly invasive grass by maintenance crews. Despite this, staff noted several occasions where cones appeared to have been run over, either by mowers or soldiers. While the system is imperfect, it is an important tool for communicating with other range users.

SBW

- Only one new high priority incipient invasive weed site was found on SBW this year. In February 2019 staff found one mature *C. odorata* on the northern firebreak road while conducting the annual road survey. This is an outlier site, distant from another known *C. odorata* locations at

SBW. Since the region is not heavily used for training, but road work was done in this region in the previous year, road work seems to be the most likely vector. Federal staff continue to stress the importance of sanitation to Range Maintenance and other contract staff.

- Federal staff advised Range division on soil usage to build-up fighting positions/protective sites in the MPRC. The soil came from an area in Schofield without concerning invasive species. Staff will monitor the area during annual road surveys.
- A private contractor was hired to spray herbicide across much of the area within the firebreak road at SBW this year, prior to the prescribed burn in May. OANRP staff worked with this contractor in the past and stored some of their gear at West Base. Staff provided the contractor with maps of sensitive habitat and 'no-spray' buffer areas to avoid any incursion into elepaio habitat, and ensured the contractor's gear was accounted for. In April, the contractor sprayed the range, including a portion of the *C. odorata* infestation area adjacent to McCarthy flats. This suppressed the grass in the area, allowing staff to conduct surveys and control more safely.

Figure 18. A group of soldiers volunteered at West Makaleha, improving the access trail to the site.

3.5 WEED SURVEY UPDATES: NEW FINDS

Staff conducted surveys along Roads and LZs used by both natural resource staff and the Army. All surveys where drivable roads may vary year to year are tracked and stored in Geographic Information Systems (GIS).

LZ surveys were conducted for the first time at Kaluanui Weatherport LZ (LZ-Kaluanui-219), Keaau Ilima LZ (LZ-KEAAU-218), Manuwai West LZ (LZ-Manuwai-165), Culvert 37 LZ on the Kaala Road (LZ-MOKFR-217), Keaau Baseball Field LZ (LZ-KEAAU-220), and LZ Chief in Lihue (LZ-SBW-206). Staff also surveyed locations of potential introductions such as OANRP camp sites, baseyards, Army wash rack sediment disposal and storage sites, and MU access trails. A Palikea weed transect survey (WT-Palikea-02) was updated this year in order to survey along a more regularly used access trail. Surveys were conducted for the first time this year at the Landfill Sediment Dump site near the OANRP West Baseyard (OS-SBW-04) and will continue quarterly. All sediment cleared out of the Central Vehicle Wash Rack is deposited at this location, making it a high priority for regular surveillance. Surveys of all military LZs and high-use natural resource LZs, campsites, and roads were conducted at least once throughout the course of the 2019 report year, with the exception of the Hapapa shelter campsite.

Table 13. Summary of Surveys Conducted.

Survey Type	Description	# Surveys Conducted this Year
Road Survey	All drivable roads on Army Training Ranges were surveyed. MU access roads are surveyed annually or every other year; this year several were not on the schedule.	23 road surveys
LZ Survey	Actively used Army LZs are surveyed once per year. OANRP LZs are surveyed only if used within a given quarter.	103 surveys on 47 LZs
Transect Survey	Surveys are conducted annually along high use access trails to MUs, selected MU fencelines, and high-traffic trails inside MUs.	13 surveys on 12 weed transects
Camp/Other Survey	Surveys are conducted at staff campsites and other potential locations of introduction, such as wash rack sediment disposal sites, baseyards, and other staging locations. Survey frequency varies based on location and use.	25 surveys at 9 sites

Survey sites are depicted in Figure 19. Locations of LZ and camp/other survey sites surveyed this year are depicted as points. Incidental observations, or those made by staff during the course of regular work or on personal time, are identified as stars. Surveys along roads and transects are portrayed as lines.

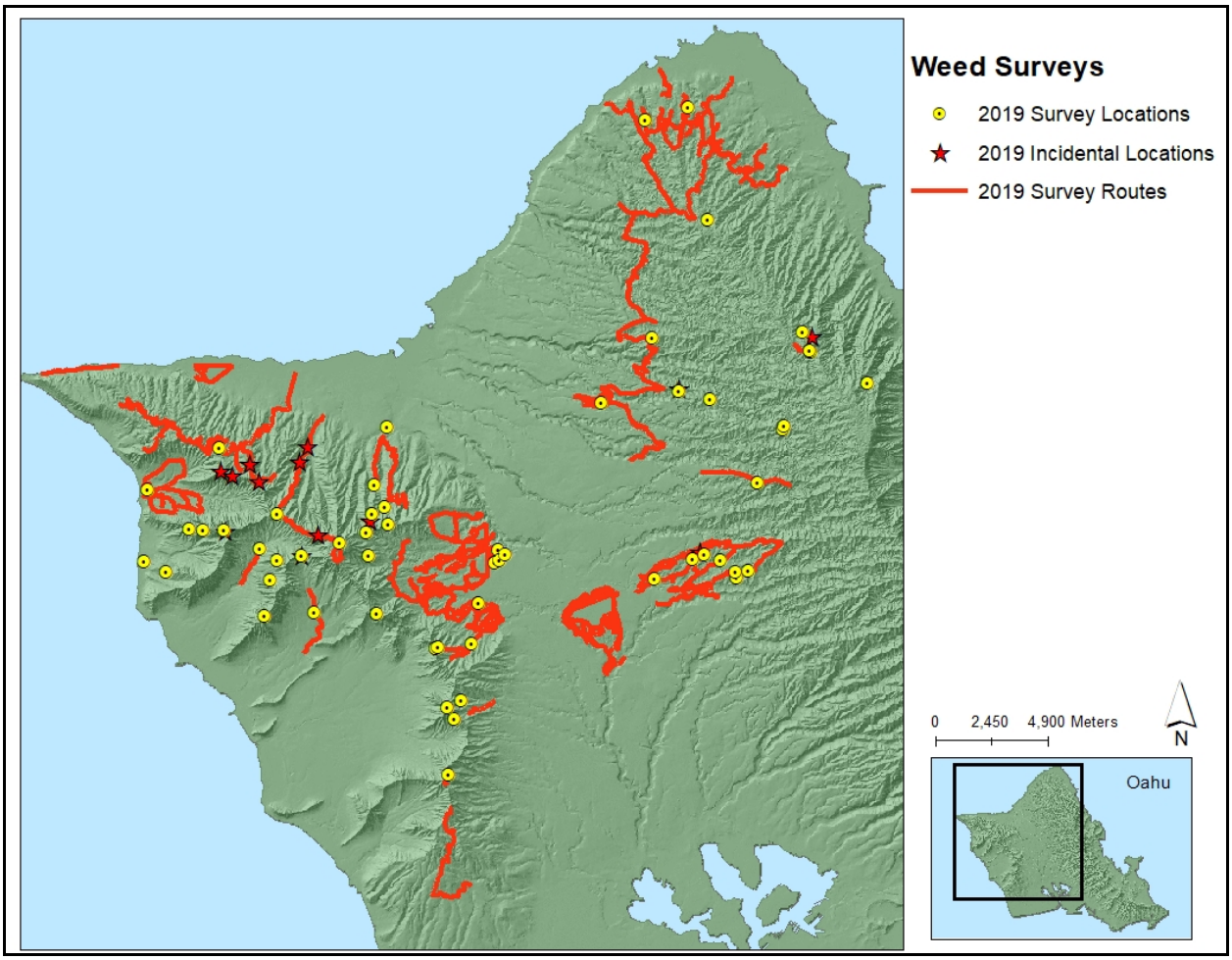

Figure 19. Map of surveys conducted in 2019.

Survey data are tracked in the OANRP database. Each year, the list of new weed species on each survey is reviewed. Noteworthy species are discussed in Table 14. Many noteworthy species were found this year, particularly on road surveys and LZ surveys. While most of these species are not considered to be ecosystem altering, they often favor disturbed habitats and have the ability to spread along fencelines and trails. In order to prevent the introduction of these species into the MUs, management of vegetation on LZs and some drop zones (DZs) is a priority. This includes controlling select invasive weeds, as well as preventative maintenance to make sites less diverse and more sterile, to reduce the potential of helicopters and gear to spread seeds.

Unusual and notable plants found during the course of other field work are referenced as "incidental" in the table. OANRP contracted the Bishop Museum to identify unknown species. This year, a total of 16 alien taxa submissions were sent to Bishop Museum for identification or to document new locales for select taxa. Only one species found this year, *Spermacoce latifolia,* was a new island record. *Blechnopsis orientalis,* formerly known as *Blechnum orientale,* was found along Kaala Road and resulted in a range extension, as it previously had only ever been documented in the Koolau Mountains.

Table 14. Summary of Noteworthy Alien Taxa Found on Surveys.

Survey Type	Survey Code/ Description	Significant Alien Taxa Seen	Discussion
Road	**RS-KAALA-01** Kaala Road	*Blechnopsis orientalis*	This large fern was found on a clay bank along Kaala Road. A sample was submitted to Bishop Museum staff for identification after being reared in the OANRP nursery until reaching maturity. This is not a new species to Oahu, but this discovery did result in a range extension to the Waianae Mountains. *Blechnum orientalis* exhibits highly invasive behavior in the Koolaus, growing through dense native fern cover. For the time being, staff will continue to document sightings of this species and will control plants whenever found. There are no current eradication plans, as this fern appears to be widely dispersed via wind-borne spores.
		Plantago debilis	This species can easily be mistaken for other *Plantago* species. It is known from urban areas in Manoa and Kapalama. A sample was collected and submitted to Bishop Museum staff to confirm its identity. Bishop Museum staff noted that *P. debilis* is variable in leaf shape. Some plants lack any of the leaf margin projections that normally occur on most specimens. It is likely that this species has gone undetected by staff due to its similarity to common *Plantago* species. This taxon does not appear to be ecosystem altering. No control is planned.
Road	**RS-KTA-08** Range roads in the Alpha and Bravo ranges of KTA	*Cyperus difformis*	This species is classified as naturalized in Hawaii. No previous data has been collected on *C. difformis* within OANRP MUs, but this could potentially be due to misidentification of other *Cyperus* species. A sample was collected and submitted to Bishop Museum staff to confirm its identity. This sedge will not likely be a major ecosystem altering weed within an environment as competitive as KTA. No control is planned.
Road	**RS-KTA-10** Range roads in the Charlie and Delta ranges of KTA	*Cleome gynandra*	A relatively common herbaceous weed, which is classified as naturalized in Hawaii. No previous data has been collected for this species throughout any of OANRP's MUs. A sample was collected and submitted to Bishop Museum staff to confirm its identity. No control is planned.
		Spermacoce latifolia	This small herbaceous weed looks very similar to more commonly found *Spermacoce* species. A sample was collected and submitted to Bishop Museum staff to confirm its identity. This is a new island record, however no control is planned for *S. latifolia* at this time, as it is not located in priority habitat and is unlikely to be ecosystem altering. No control is planned.
Road	**RS-SBE-01** All range roads in SBE	*Caesalpinia decapetala*	There have been no previously collected data points for this species in SBE. *Caesalpinia decapetala* is ranked high on the Hawaii-Pacific Weed Risk Assessment (HPWRA), and is known to cause significant ecological harm. Locations of this taxon will be mapped, but not controlled unless they threaten native forest.
Road	**RS-SBW-04** All range roads within the Kolekole, BAX, and McCarthy Flats ranges at Schofield.	*Chromolaena odorata*	Found on the North Firebreak Road at West Range, Schofield Barracks. This is the northernmost spot it has been seen in SBW. Only one mature plant was found. A buffer sweep is planned to delimit the population. Control of *C. odorata* is always a priority and frequent checks will continue to be conducted. See section 3.6.

Table 14 (continued).

Survey Type	Survey Code/ Description	Significant Alien Taxa Seen	Discussion
Road	**RS-Wheeler-01** All cantonment and accessible dirt roads on Wheeler AA.	*Albizia procera*	This plant was found on the perimeter of Wheeler Army Airfield, along Kunia Road. A sample was collected and submitted to Bishop Museum staff to confirm its identity. Like many other *Albizia* trees in this area, this *A. procera* may have been planted but could have the potential to naturalize. Staff will monitor it for spread.
LZ	**LZ-Kaluanui-219** Kaluanui Weatherport	*Schefflera actinophylla*	This was the first survey conducted at Kaluanui LZ, so staff are unsure of the distribution of *S. actinophylla* in the area. This species, however, is known to be a habitat modifier and can cause significant ecological damage. It is widespread across much of the windward Koolaus at moderate-low elevations. No control is planned.
		Rhynchospora caduca	Similarly, as this was the first survey conducted at Kaluanui LZ, staff are unsure of the distribution of *R. caduca* in the area. This species is widespread in lower elevations, however it now occurs on nearly every Koolau LZ. No control is planned.
LZ	**LZ-MMR-012** Ohikilolo Camp LZ	*Rubus argutus*	This was made into an ICA (MMR-RubArg-07) and is always controlled as it is not widely distributed throughout this MU. *Rubus argutus* rates high on the HPWRA, and is known to be extremely invasive in areas such as Kaala. Staff will monitor this ICA quarterly and control plants if found.
LZ	**LZ-SBS-164** LZ Cat	*Eragrostis cilianensis*	This grass is classified as naturalized in Hawaii. No previous data has been collected for *E. cilianensis* throughout OANRP MUs. This is not a species of concern at this time, and no control is planned.
LZ	**LZ-SBW-057** Nalu's LZ	*Dietes iridioides*	*Dietes iridioides* is known from the Manuwai/Alaiheihe area, but is not abundant. It spreads vegetatively and is a control target. This individual was found in the process of searching for *P. glomerata*, which was found the same area on the same date. This site was made into ICA (SBW-DieIri-01).
		Nephrolepis brownii	Staff emphasis on learning to distinguish this invasive fern from its native counterpart may speak to increases in observations of this species on several surveys. It is a problematic understory weed able to create dense thickets, can hybridize with native *Nephrolepis* species, and is therefore a priority target for control in forested areas and around valuable resources. No control is planned at this site.
		Pterolepis glomerata	This species is widespread throughout the Koolau mountain range, and has been found in multiple locations in the Waianae mountain range, but is always prioritized for control in the Waianae mountains due to its ability to invade native habitat and the persistent seed bank characteristic of the family *Melastomataceae*. The discovery, made right off of the LZ at SBW, resulted in a new ICA (SBW-PteGlo-01), which will continue to be checked quarterly.
Transect	**WT-Kaala-01** Kaala boardwalk	*Setaria palmifolia*	Though previously found at the Kaala summit in 2002, no other plants were observed in the region until this year. This species is known to form expansive mats and thrives in wet habitat. It is widely distributed in lowland areas, but is considered incipient at Kaala. The discovery at this particular site will result in the creation of a new ICA and staff will diligently track/control any further spread of *S. palmifolia* throughout the MU.

Table 14 (continued).

Survey Type	Survey Code/ Description	Significant Alien Taxa Seen	Discussion
Multiple Surveys	**RS-Wheeler-01** Wheeler Road **LZ-SBW-055** Kamaohanui **WT-Kaala-03** Kaala Transect Trail **WT-Palikea-02** Palikea Access Trail	*Drymaria cordata*	This groundcover has been difficult to control at other known locations, such as the Hapapa snail enclosure and along the Pahole trail. It has sticky seeds and is easily transported along trails by humans and animals. It should be targeted for control on LZs and staff access trails to prevent further spread.
Multiple Surveys	**RS-KTA-07** Southwest range roads at KTA **RS-SBE-01** Range roads at SBE	*Elephantopus mollis*	Found in a few spots in the Kahanahaiki/Pahole area, only one other data point for the Koolau mountain range has been collected within our management units. The *Elephantopus* found in Kahuku is the northernmost we have seen. This species is locally abundant elsewhere on Oahu. No control is planned for these locations.
Multiple Surveys	**RS-Kaala-01** Kaala Road **WT-Kapuna-01** Mokuleia Trail	*Sphaeropteris cooperii*	This species is known from SBW, and has a widespread distribution but has not previously been seen directly along the Kaala Road. There are, however, infestations in Lihue and West Makaleha gulch, both of which are nearby. *Sphaeropteris cooperi* was also recently found along the Kaala Boardwalk. Staff should be on the look-out for more *S. cooperi* invading the summit area. Sightings of *S. cooperii* found outside current ICAs and on State land (Mokuleia trail), will be shared with the State. Control of this species is a priority and is conducted opportunistically. Long-term management of both these sites will be left to the discretion of the State.
Incidental	**Kahanahaiki**	*Macfadyena unguis-cati*	This vine was found during rat tunnel checks, near a *C. agriminioides* var. *agriminioides* zone. This is the first documentation of *M. unguis-cati* in Kahanahaiki. It is considered likely to be invasive in Hawaii, per its HPWRA rating, has small barbs, and can grow thickly over other vegetation. A new ICA (MMR-MacUng-01) was established and will be checked two to four times a year.
Incidental	**Kawaiiki No MU**	*Leptospermum scoparium*	These individuals were found on LZ Black. *Leptospermum scoparium* is known to be highly invasive. It is widespread throughout the northern Koolau mountains, while there are more isolated populations in the Waianae mountains in areas such as Makaha. No large scale control of *L. scoparium* is being conducted in the Koolau mountain range, but staff would like to work to eradicate populations on military LZs in the Koolaus. This site has been made into an ICA (KLOA-LepSco-07).
Incidental	**Koloa**	*Oxyspora paniculata*	This species was found on the north/windward side of Koloa about 2 feet off the fenceline. The sample was submitted to Bishop Museum staff. All previous specimens documented by Bishop Museum are clustered around Manoa, ranging from Lulumahu Gulch west of Konahuanui to the Waahila summit. This is the northernmost record. This plant will be controlled whenever it is found in Koloa.
Incidental	**Lihue**	*Vanda tricolor*	This large orchid was collected in 2012 and grown until it could be identified. A sample was submitted to Bishop Museum staff and was determined to likely be *V. tricolor*, which has previously been documented as naturalizing on Oahu in Palolo Valley.

Table 14 (continued).

Survey Type	Survey Code/ Description	Significant Alien Taxa Seen	Discussion
Incidental	**Makaha II**	*Pterolepis glomerata*	The individual found at the Kumaipo LZ was mature and had just flowered. This spot was made into an ICA (Makaha-PteGlo-02) which will be checked two to four times a year.
Incidental	**Makaleha Central No MU**	*Chromolaena odorata*	One individual was found near Culvert 16 on the Kaala road, and later another plant was found below the Forestry gate on ranch land. Buffer sweeps have since been conducted to delimit the population. These discoveries resulted in a range extension. See section 3.6.
Incidental	**Makaleha East No MU**	*Sphaeropteris cooperii*	These individuals were found off the Kaala Road, down a gulch near Culvert 58. As mentioned above, *S. cooperii* is always a species of concern and is controlled whenever possible. As this site is on State land, State staff have been notified of this population. Long term management will be left to their discretion.
Incidental	**Manuwai**	*Araucaria columnaris*	*Araucaria columnaris* is known to naturalize and is also known to be allelopathic. This plant was found on a cliff and cannot be reached on foot. There are no immediate plans to control this plant at this site, as it will require rappelling. Staff will, however, continue to monitor it.
Incidental	**Pahole**	*Elephantopus mollis*	This site was made into an ICA (Pahole-EleMol-03). The first plant found was mature, but fruit was not ripe. A few small individuals have also been found in subsequent ICA checks. Hikers could be potential vectors.
Incidental	**SBE No MU**	*Cuphea hyssopifolia*	This specimen was found while conducting grass control at SBE. A sample was collected and submitted to Bishop Museum staff for identification. *Cuphea hyssopifolia* has been classified as naturalized in Hawaii, and could easily be mistaken for other *Cuphea* species.
Incidental	**Upper Kapuna**	*Elephantopus mollis*	*Elephantopus mollis* is found in a few spots in the Kahanahaiki/Pahole area, where it is treated as an incipient species. As this particular *E. mollis* was found along a publicly accessible trail, staff conducted initial control but long term management will be left to the discretion of the State.

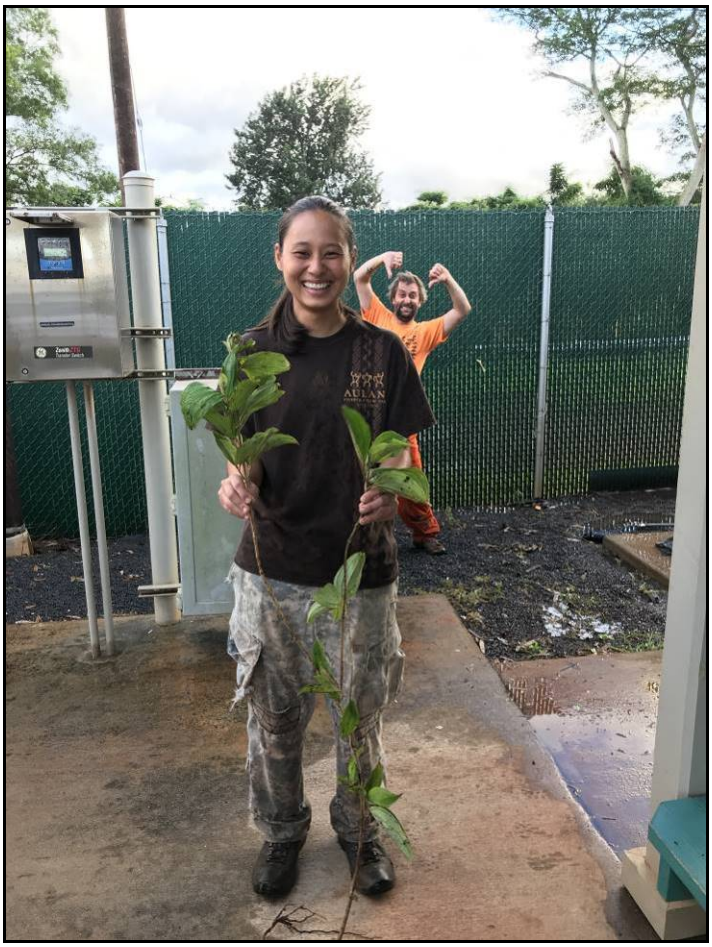

Figure 20. Staff members with *O. paniculata*.

Figure 21. Close up view of *O. paniculata*.

Figure 22. Close up view of *S. latifolia*.

Figure 23. Large patch of *S. latifolia* at KTA.

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

Control of *C. odorata* is a high priority for OANRP. Please see the 2011 Year End Report, Appendix 1-2 to view the original draft management plan for *C. odorata*. This year, *C. odorata* control efforts alone accounted for 43.7% (1,379.70 hours) of the time spent on ICA work, and 39.1% (205.40 ha) of all ICA area controlled. Although high, these statistics under-represent the resources required to combat *C. odorata*, as they do not include staff time spent conducting surveys outside of ICAs, developing and maintaining spray equipment, managing detailed data sheets, or coordinating with Range and DPW staff, and do not include money spent on equipment, herbicide, helicopters, and dedicated gear, or the cost and hours spent via the OISC contract.

The status of *C. odorata* management is mixed. Updates for each location where OANRP works on *C. odorata* are provided here; locations are discussed in order of the date in which they were discovered, such that KTA is presented first and Makaleha Central (Kaala Road) is presented last. In addition, short updates on seed longevity trials, assistance provided to partners, and biocontrol research are included.

Since early 2017, OANRP staff have used dedicated tabis, packs, gloves, and brushes for *C. odorata* control work. Staff are regularly reminded of the importance of practicing good sanitation and regular decontamination of field gear. Staff are directed to clean their gear either in the field at the infestation site, or at the KTA wash rack, or back at West Base. All sediment from the wash rack is collected in a basin on site; the basin has yet to be emptied, but when it is, OANRP will monitor the sediment. Annual weed surveys are conducted across West Base, and high risk weeds like *C. odorata* are a particular focus of these surveys. All *C. odorata* material collected in the field is disposed of in dedicated bins at West Base and taken to H-Power.

Despite the resources put towards *C. odorata* control, new infestation locations continue to appear. This year, plants were found in Kamaili gulch in Makaha valley, and along the Kaala road in Makaleha. OANRP is one possible vector for these new sites, but other potential vectors exist, including recreationalists. OISC noted plants spreading west of KTA on a private ranch. No *C. odorata* surveys have been conducted outside of known infestation areas on Oahu, so it is possible that new infestations may be found in the future. To date, all discoveries off of Army training ranges have been opportunistic. It is clear that *C. odorata* is dispersing effectively via a variety of vectors, and efforts to reduce its spread via staff decontamination measures or Army sanitation requirements are insufficient. In order to better understand the scope of *C. odorata* invasion on Oahu and set realistic goals for control, island-wide surveys are needed. In order to reduce the dispersal of *C. odorata*, public groups and communities must be engaged. It is unclear if the Army has any legal responsibility for island-wide surveys or outreach, and OANRP efforts are currently focused on Army lands and IP MUs.

Staff are actively considering new strategies for *C. odorata* management, including: biocontrol, habitat alteration, community outreach, partner outreach, early detection surveys off Army lands, advocating for improved range security, and testing novel post- and pre-emergent herbicides. Of highest priority is the pursuit of a biocontrol; this is discussed in depth at the end of section 3.6. Another option is to alter the habitat of infestation areas to make them less favorable for *C. odorata*, which thrives in areas with high-light levels, regular disturbance, and low canopies. This could be done by outplanting fast-growing trees and groundcovers (alien or native) to create dense shade and reduce bare ground. Such projects could also be an effective way to conduct outreach with community groups like the North Shore Community Land Trust, by giving them a positive way to assist with management efforts while learning about the threats posed by *C. odorata* to agriculture, ranching, native forest, and human health. Targeted outreach could be done to neighboring property owners around KTA, for example Kupu, which was recently hired by Turtle Bay to manage its agricultural land; this land directly abuts the most heavily infested gulches in KTA.

Staff have limited time to work off of Army lands, but devoting a set amount of time to surveying strategically chosen trails may be possible. For example, in the Waianae Mountains, surveys of trails in the Kuaokala Hunting Area, Mokuleia Forest Reserve, and Kaukonahua gulch would benefit nearby MUs. Promoting improved Training Range security is challenging, as the existing bureaucracy is slow to make and enforce systemic changes. In addition to continuing to highlight the costs of *C. odorata*, staff take smaller actions, such as reporting unofficial roads which lead off range at KTA, and requesting that ITAM install barriers across them. Lastly, staff plan to experiment with different herbicides to see if new products, like Esplanade, result in longer suppression of the seed bank.

Figure 24. This *C. odorata* is less than 30cm tall, and already has set seed.

Seed Longevity Trial Update

Seed longevity and the persistence of seeds in soil plays a large role in management strategy. To gain more understanding of seed longevity, staff installed two field trials with buried seed. Seed was collected and placed into packets of 1,250 seed, which were buried 6-8 inches underground. Two bags each were removed at several intervals during the first year, then once a year. The first trial was installed in at KTA in 2011 and ran for six years. Results were presented by OANRP in 2018, and found that seed viability was high at three months (72.75% germination), but declined notably after six years (13.5%). These results suggested the *C. odorata* forms a short-term persistent seed bank.

The second trial was installed at SBW in 2016, and will run for ten years. Initial viability for the seed lot was 63.00%. Unfortunately, subsequent testing has not followed the same pattern as the KTA trial. Germination rates of all seed tested thus far varied between 38.75-64.54%, with no obvious trends. Some variation in germination rate is expected, since the seeds used were not tested to see if they were filled with embryos, and Asteraceae achenes are known to have widely varying fill rates. The most recent three year results show 54.92% germination, which is not an appreciable decline from initial levels. Staff hope to see the same decline at six years as was seen at KTA, but time will tell. Seed lab staff suspect that *C. odorata* seeds may have some kind of dormancy, and note that germination rates are unlikely to decline

gradually, but rather will probably continue to fluctuate until a sharp decline is noted. This is discouraging news, and further highlights the incredibly insidious and invasive nature of *C. odorata*.

Figure 25. *Chromolaena odorata* flowers with brown stamens, showing the flowers are past their prime. At the bottom of the image, a flower head is broken apart, showing achenes with a dark seed coat, indicating that the seeds are mature.

When conducting ground control, staff generally collect and bag all seed heads to reduce the formation of a persistence seed bank. Sometimes flower heads are also collected, but not always. In February of 2019, staff collected some flower heads with brown stamens (as opposed to fresh white stamens), broke them apart, and noted that achenes with dark seed coats had already formed, see Figure 25. OISC staff reported similar observations. These seed were sown on agar plates in the seed lab, and had a germination rate of 35%. While this is lower than what staff have seen for fully matured seed, it highlights how quickly seeds develop. It is unclear if such young seed has the same ability to persist in soil as mature seed, but staff hope to investigate this via a controlled trial in the coming year. For now, staff collect both seed and flower heads, particularly at small or outlier infestations.

In the first quarter of 2019, OISC staff observed that some flowering plants they sprayed in January had developed mature seed a month later. The plants were treated foliarly with a spray mix of 2% RangerPro and 0.16% Oust diluted in water. While the spray treatment was effective at killing the plants, it apparently did not do so before the plants were able to set seed. This suggests that sprays would probably be more effective if completed before plants flowering begins. Some of the seeds from the treated plants were collected and passed on to the OANRP seed lab. The seed had a 53% germination rate. Staff are interested in learning more about how long Oust sprayed directly on seeds inhibits germination. To study this, a trial with controls and replicates is needed. However, many factors play in to the persistence of Oust, including rainfall and soil type, and it may be difficult to design a trial that is informative without being burdensome. Staff will consider options in the coming year.

KTA Update

Chromolaena odorata was first discovered at KTA in 2011 on an annual road survey. KTA contains the largest known infestation of *C. odorata* in the State. Located on the northern tip of Oahu, KTA stretches from the Koolau summit down to a series of large bluffs just above Kamehameha highway. While the mauka portions of the range host large patches of native forest, the lower elevations are dominated by alien vegetation and experience regular disturbance from military training and recreational use. *Chromolaena odorata* has spread across much of the lower elevations of KTA, but the core of the infestation stretches between Kaunala and Pahipahialua gulches on the west end of the range. Other dense patches of plants are found between Keaaulu and Lamaloa gulches on the far east end of the range, and around certain roads and training facilities. Figure 26 shows the distribution of ICAs across KTA.

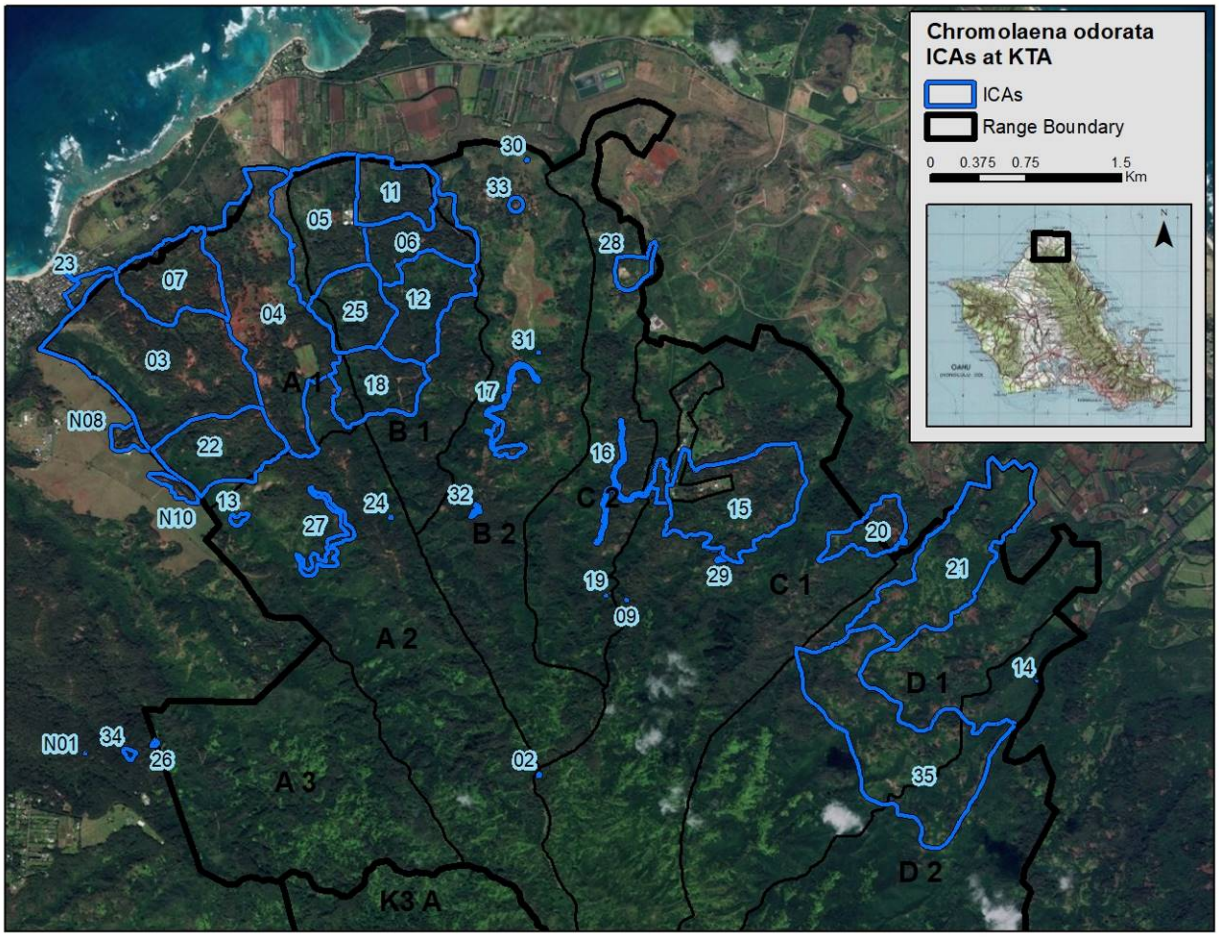

Figure 26. *Chromolaena. odorata* Incipient Control Areas at KTA.

There are many vectors for *C. odorata* spread at KTA, including military training, range vegetation management, legal motocross riders in the State's motocross park, trespassers, feral ungulates, and staff. The boundaries of KTA are not fenced, and many trails lead from neighboring properties directly on to the range. Hunters, motocross riders, mountain bikers, hikers, and neighboring businesses can easily access portions of the range and become unknowing vectors for *C. odorata*. Completely blocking access to the range is impossible, but OANRP hopes to address this with Range Division in future. As discussed in section 3.4 above, military vehicles departing KTA must use the wash rack, although this has been difficult to enforce.

Control efforts at KTA account for 25% of all incipient control effort this report year. In addition, OANRP continues to contract OISC to conduct control across almost half of the primary infestation. See Appendices 3-6 and 3-7 for a summary of OISC's work, including maps of areas treated this year; these efforts are not included in tables and maps below. Highlights of management efforts are presented here.

- Surveys. *Chromolaena odorata* has spread far and wide across KTA and continues to show up in new locations. Documenting its spread and identifying new control sites is a priority. This year, staff conducted annual road surveys, one aerial survey of the makai edge of the range, extensive trail surveys, and two post-fire surveys, swept some priority buffer areas, and kept an eye out for *C. odorata* during the course of other field work; see Figure 27. In all, staff surveyed 5.63 ha on the ground, monitored 71.13 km of roads, flew 2.72 km, and walked 273.16 km of trails. Numerous *C. odorata* were found, requiring the creation of new ICAs and expansion of existing ICAs, both of which are discussed below. The *C. odorata* points in Figure 27 depict all new locations and most controlled locations from this report year; note that the number of plants at each point varies widely, with some points in densely populated zones. As is shown in Figure 27, *C. odorata* is steadily expanding across the lower elevations of KTA, and is now locally widespread, rather than incipient.

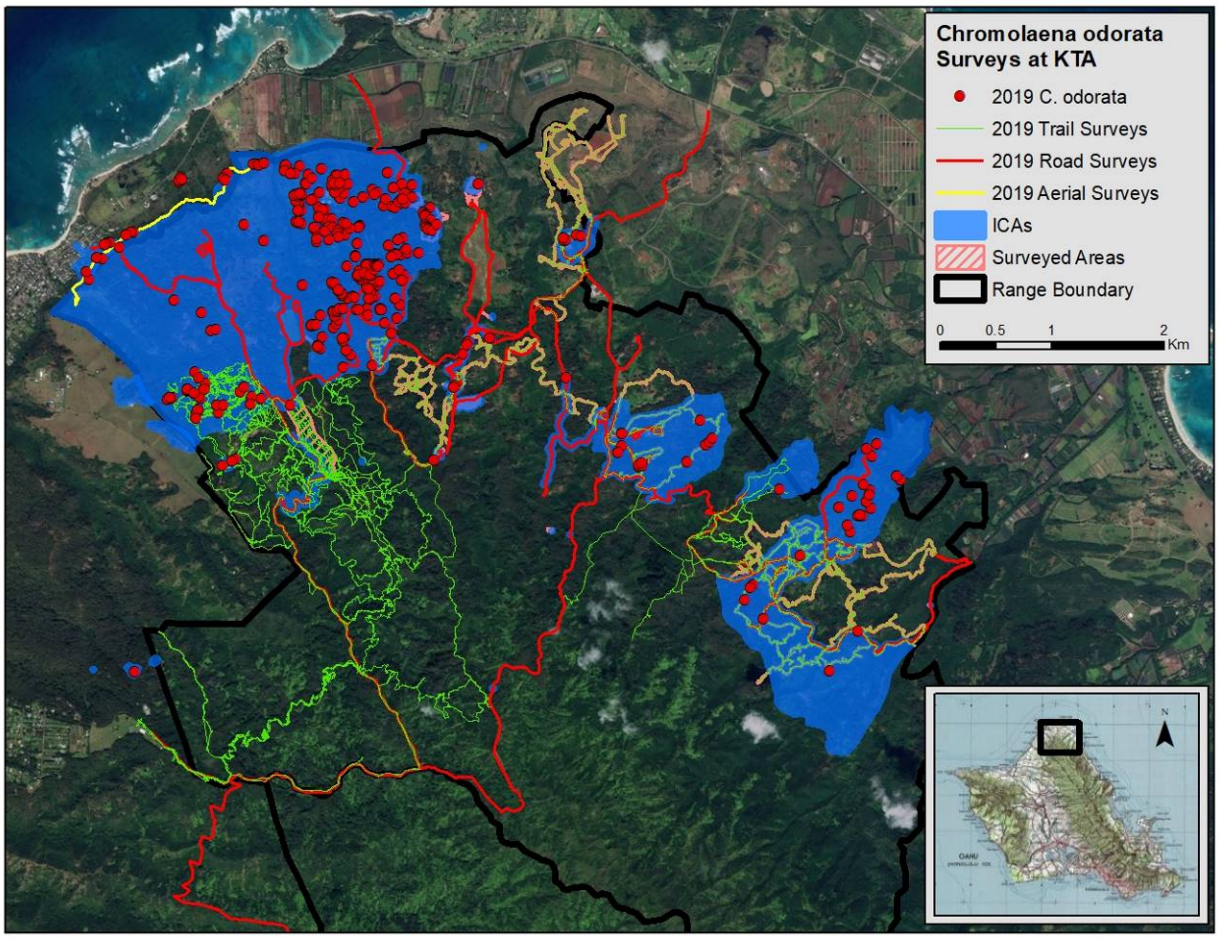

Figure 27. Surveys for *C. odorata* across KTA.

- New ICAs. Two new ICAs were created this year, numbers 34-35.
    - ICA-34, Boy Scouts: While hiking down to the Kaleleiki fence on September 24, 2018, staff found one immature plant at the top of the trail at the Boy Scout camp. There are numerous trails throughout the camp, some of which likely connect to trails in the

Pupukea-Paumalu State Park Reserve to the northeast. It possible *C. odorata* is spreading through the area. Staff will conduct outreach to the camp and conduct trail surveys in the coming year.

- ICA-35, Hina Lamaloa: This ICA was created after plants were found at several different locations during trail and road surveys in the D1 and D2 ranges. Staff walked trails on October 31, 2018 and February 6, 2019, and found a single plant along the Delta Road, one patch of plants on a trail between Hina and Lamaloa gulches, and another patch of plants on a trail which loops mauka of the Kahuku Split Rock LZ. On March 25, 2019, staff conducting the annual road survey found another immature plant at a different location, also close to Kahuku Split Rock LZ. The LZ area is heavily used for military training, and it is unknown whether or not soldiers regularly use any of the nearby trails. The Delta road terminates at a locked gate abutting farmland, but numerous motocross trails loop around the gate. The makai portions of D1 and D2 host two large ICAs and some dense patches of *C. odora*. Since there are numerous potential vectors in the area, and the known plants ae widely dispersed, a large ICA was created to facilitate regular checks of trails in the area in future years.

- ICA Changes. The boundaries of 12 ICAs were expanded this year. Some relatively small expansions (0.01 – 1.21 ha) were made to include new patches of *C. odorata* just outside ICA borders; these include: ICAs 04, 06, 13, 17, 20, 23, and 27. Larger expansions (0.45 – 43.87 ha) were made to include plants found on trail surveys, road surveys, or opportunistically; these include ICAs 15, 16, 18, 21, and 28. The largest expansions (15.06 – 43.87 ha) also better include highly trafficked roads and trails adjacent to ICAs which should be regularly monitored to prevent spread; these include ICAs 15, 18, and 21.

Figure 28. Spraying a *C. odorata* hotspot at KTA.

- Control Summary. All control efforts are summarized in Table 15. Area, effort and number of visits are reported for the 2019 and 2018 report years. The dates of the most recently removed mature and immature plants are included. The *C. odorata* infestation now covers 855.16 ha in KTA. This is a huge area, and staff are unable to sweep every inch of it, despite contracting OISC to work in the motocross park, the highest priority area. Different strategies are employed in different ICAs as a means of stretching limited resources. The core of the infestation is divided between ICAs 03, 04, 05, 07, and 25. The other ICAs are either on the fringes of the core, represent separate infestations, or are outliers. The strategies used at each ICA are detailed in the 2016 Year End Report, and the "Type/ Strategy" column provides a quick reference to management approach at each ICA:
    - Outlier. These are geographically small sites, usually with very few individual plants found. After discovery, these ICAs are monitored two to four times per year. After five years with no plants found, the monitoring interval decreases to once a year.
    - OISC contract + OANRP hotspot. OISC was contracted to sweep several ICAs fully twice a year. The ICAs covered by the contract are numbers 03, 04, and 07; they span the western end of the primary infestation and include the State Motocross Park. Hotspots are drawn around high densities of plants. OANRP sprays the hotspots 1-4 times per year with pre-emergent herbicide.
    - Sweep + Hotspot. Strategy at these ICAs includes rigorous sweeps across the whole ICA, in addition to more intensive monitoring and treatment with pre-emergent herbicides at Hotspots. Hotspots are tracked and monitored within ICAs. Whenever possible, staff use highly effective power sprayer equipment at Hotspots.
    - Sweep + Hotspot + Aerial Spray. As above, except aerial sprays are used to treat large, remote patches of plants which are either inaccessible to the power sprayer or located on steep cliffs.
    - Trails + Roads + Hotspots. Management at these ICAs is limited to surveys of all trails and roads 1-2 times per year, rather than landscape-wide sweeps. Staff observed that *C. odorata* spreads easily into new areas along trails and roads. Hotspots are tracked and aggressively treated. This approach is used only in ICAs with low plant density.
    - Trails + Roads + Hotspots + Sweep. As above, except portions of these ICAs are fully swept. This approach is used when *C. odorata* density is high in select areas of an ICA.
    - Private Land. OANRP does not have permission to work on infestations on private land, but OISC does. Staff assist OISC at these ICAs as feasible.

  At all ICAs except those designated as outliers, it is difficult to see much progress. High plant numbers persisted and numbers of hotspots increased despite aggressive control. While some hotspots shifted from active to inactive, others remain persistent, likely due to the high volume of seed deposited in the soil in previous years. Lone plants in large ICAs are easily controlled, but plants continue to spread, resulting in little net gain. Staff experimented with the herbicide Polaris (active ingredient = imazapyr) in hopes of suppressing recruitment for a longer time than Ranger Pro and Sulfomet sprays have been able to do in the past. Polaris has been effective in controlling plants (see Figure 29), although it is not yet known if has a longer suppression time, and is more than five times the cost of Ranger Pro. If it does provide improved suppression, it will be used in future. In the coming year, staff plan to shift strategies at some ICAs to better utilize limited resources. ICAs 03, 04, and 07 will be swept by OISC just once per year, instead of twice. This will free up resources for work off of KTA and for pursuit of a biocontrol. ICA 25 will switch from a sweep-centric strategy to surveys of trails and roads, coupled with aerial and ground-based hotspot treatments. ICA-28 expanded this year and will switch from ICA-wide monitoring to surveys of trails and roads and focused treatment of hotspots.

Table 15. KTA Control Efforts.

ICA Code	ICA Area (ha)	2019 Report Year			2018 Report Year			Date Last Mature Plant Found	Date Last Immature Plant Found	Type/Strategy
		Area Weeded (ha)	Effort	# Visits	Area Weeded (ha)	Effort	# Visits			
WaimeaNoMU-ChrOdo-01	0.0064	0	0	0	0.0064	0.5	1	none	2011-04-05	Outlier
KTA-ChrOdo-02	0.0328	0.0228	1.0	1	0.0112	1.0	1	none	2011-08-22	Outlier
KTA-ChrOdo-03	118.44	8.33	149.0	10	3.57	94.5	6	2019-03-12	2019-03-12	OISC Contract + OANRP hotspot
KTA-ChrOdo-04	112.84	9.57	57.25	9	5.86	107.0	11	2019-03-28	2019-03-28	OISC Contract + OANRP hotspot
KTA-ChrOdo-05	57.96	31.87	225.75	17	29.61	200.1	16	2019-04-02	2019-04-02	Sweep + Hotspot + Aerial spray
KTA-ChrOdo-06	32.65	10.02	76.75	6	25.30	104.0	5	2019-05-08	2019-05-08	Sweep + Hotspot
KTA-ChrOdo-07	41.27	0.0075	0.25	1	1.61	43.0	4	2018-04-24	2018-08-29	OISC Contract + OANRP hotspot
AimuuNoMU-ChrOdo-08	4.59	0	0	0	0	0	0	N/A	2016-08-16	Private Land. OISC.
KTA-ChrOdo-09	0.0078	0.0078	0.5	1	0.0078	0.5	1	2013-01-09	2013-09-10	Outlier
AimuuNoMU-ChrOdo-10	3.73	0	0	0	0	0	0	N/A	2016-01-21	Private Land. OISC.
KTA-ChrOdo-11	28.74	15.48	28.5	3	4.02	3.0	3	2019-04-24	2019-04-24	Sweep + Hotspot
KTA-ChrOdo-12	39.79	10.91	43.0	4	11.51	55.0	5	2019-05-08	2019-05-09	Trails + Roads + Hotspots + Sweep
KTA-ChrOdo-13	0.85	0.37	2.5	2	0	0	0	2018-12-13	none	Outlier
KTA-ChrOdo-14	0.0006	0.0006	0.5	1	0.0006	0.3	1	2014-01-07	none	Outlier
KTA-ChrOdo-15	67.38	5.87	12.0	4	6.52	2.5	2	2019-02-06	2019-02-06	Trails + Roads + Hotspots + Sweep
KTA-ChrOdo-16	6.20	3.99	8.0	5	1.82	8.5	4	2017-12-12	2019-06-25	Trails + Roads + Hotspots
KTA-ChrOdo-17	4.53	2.16	8.0	3	3.42	15.5	2	2017-11-14	2018-10-16	Trails + Roads + Hotspots
KTA-ChrOdo-18	33.65	6.80	27.4	5	2.32	22.5	2	2018-10-25	2019-06-25	Trails + Roads + Hotspots + Sweep
KTA-ChrOdo-19	0.0078	0.0050	2.0	1	0.0078	2.0	1	none	2014-09-24	Outlier

Table 15 (continued).

ICA Code	ICA Area (ha)	2019 Report Year			2018 Report Year			Date Last Mature Plant Found	Date Last Immature Plant Found	Type/Strategy
		Area Weeded (ha)	Effort	# Visits	Area Weeded (ha)	Effort	# Visits			
KTA-ChrOdo-20	17.33	0.91	2.0	1	3.99	36.3	4	2017-12-05	2018-10-18	Trails + Roads + Hotspots + Sweep
KTA-ChrOdo-21	79.99	7.30	46.0	3	6.62	55.25	5	2019-05-09	2019-05-09	Trails + Roads + Hotspots + Sweep
KTA-ChrOdo-22	43.8	12.04	30.5	3	0.95	4.0	1	2019-01-30	2019-01-30	Roads + Trails + Hotspots + Sweep
KahukuLaie-ChrOdo-23	4.68	0.37	1.25	1	0.21	1.75	2	2016-04-27	2018-08-29	OANRP Roads + OISC Private Land
KTA-ChrOdo-24	0.0316	0.0316	1.1	3	0.0316	1.25	3	2016-03-02	none	Outlier
KTA-ChrOdo-25	31.27	3.74	17.55	8	7.96	70.85	6	2019-05-15	2019-05-15	Sweep + Hotspot + Aerial spray
KTA-ChrOdo-26	0.18	0.10	6.0	2	0.11	7.0	4	2016-09-08	2018-06-28	Outlier
KTA-ChrOdo-27	5.92	1.07	2.5	3	2.60	4.5	2	2018-01-30	2017-07-11	Trails + Roads + Hotspots
KTA-ChrOdo-28	6.71	1.45	4.2	3	0.35	1.3	2	2019-06-24	2019-06-24	Outlier
KTA-ChrOdo-29	0.42	0.0078	0.5	1	0.0078	0.8	2	none	2017-03-07	Outlier
KTA-ChrOdo-30	0.0155	0.0155	1.5	2	0.0155	4.0	3	none	2017-11-14	Outlier
KTA-ChrOdo-31	0.0078	0.0078	2.25	3	0.0078	6.5	4	2017-11-14	none	Outlier
KTA-ChrOdo-32	0.31	0.26	4.0	3	0.30	4.75	3	2018-02-01	2019-03-25	Outlier
KTA-ChrOdo-33	0.99	0.69	4.0	1	0.23	1.0	1	2018-06-21	2018-09-27	Outlier
KTA-ChrOdo-34	0.54	0.0078	0.25	1	n/a	n/a	n/a	none	2018-09-24	Trails + Roads + Hotspots
KTA-ChrOdo-35	118.61	5.46	12.6	3	n/a	n/a	n/a	2018-10-31	2019-03-25	Trails + Roads + Hotspots
TOTALS	855.16	**138.89**	**778.6**	**114**	118.96	859.20	107			

Figure 29. The patches of *C. odorata* on the left were treated with a 1.5% dilution of Polaris in water. The photos on the right show the same patches three months later.

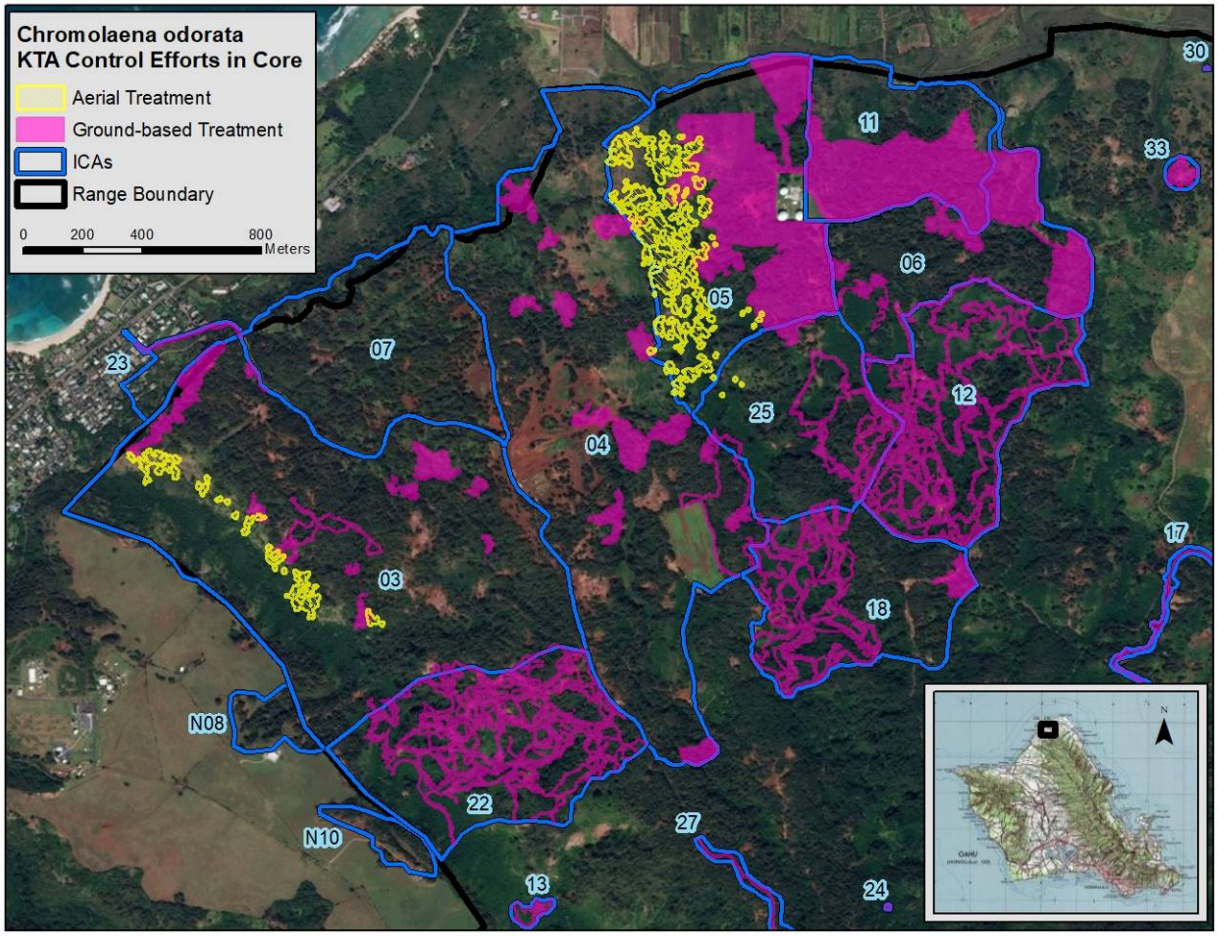

Figure 30. Aerial and Ground Treatment in the KTA Core Infestation.

Table 16. KTA Aerial and Ground Treatment Area.

Report Year	Total Area Treated (ha)	Aerial Spray Area (ha)	Ground-Based Treatment Area (ha)
2018-2019	138.89	11.34	128.28
2017-2018	118.96	8.13	112.56
2016-2017	146.36	13.36	140.87
2015-2016	98.24	6.36	91.89
2014-2015	71.27	3.98	67.29

- Aerial Sprays. This year, 11.34 ha were sprayed aerially and 128.28 ha were treated on the ground, for a total of 138.89 ha of *C. odorata* controlled (ground and aerial treatments overlap); see Table 16. Figure 30 shows aerial and ground control efforts across the primary infestation. Aerial sprays were conducted in four different ICAs this year. While efforts focused in Pahipahialua gulch at ICA-05 (8.65 ha), areas directly adjacent in ICA-25 (415 m²) and ICA-04 (0.33 ha) were also sprayed. In addition, sprays continued at hotspots in Kaunala gulch at ICA-03 (2.32 ha). Aerial spray areas are calculated from GIS tracks of flight paths for each spray operation and include some areas which are surveyed but not sprayed. Last year aerial sprays occurred on eight dates, but this year staff were able to spray on eleven dates; this contributed to the increase in aerially treated area. Weather and range availability continue to be major factors in scheduling aerial sprays. Aerial operations are cancelled if moderate to heavy rain is expected, or

if winds are above 10-15mph. The other major factor is pilot availability. Aerial operations require an experienced pilot with excellent long-line skills and the ability to pick out *C. odorata*. Last year, a Big Island-based pilot conducted most of the aerial control work; while his experience and skill is excellent, the logistics of scheduling operations reduced flexibility. This year, most of the aerial work was conducted by an Oahu-based pilot with the same company. While this pilot has less experience, his skills have improved greatly and operations have been much more flexible, leading to fewer cancellations. Aerial sprays are an incredibly useful management tool, but OANRP is not sure if they will be an option in the coming year. In June of 2019, prior to aerial operations scheduled for July, the Army's Public Affairs Office (PAO) received many complaints from North Shore community members about the use of aerial sprays with glyphosate at KTA. Federal staff and PAO have been working with community, but until the situation is resolved, all aerial spray operations at KTA have been halted.

Figure 31. Steep, grassy cliffs in Kaunala gulch. *Chromolaena odorata* found on this terrain is most safely and efficiently treated via aerial sprays.

- Outlier ICAs. Control efforts at the outlier ICAs have been successful in reducing plant numbers. Control status is summarized in Table 17; ICAs are listed by the date plants were last observed. One ICA was transitioned out of the outlier category this year; ICA-28 was expanded to include several *C. odorata* patches newly discovered on trail surveys. All outlier ICAs were monitored at least once this year. Staff will monitor outliers for at least ten years after the last plant was seen, or until more information is known about seed longevity. While the status of these outlier ICAs is one of the few bright spots at KTA, it is important to remember that these ICAs represent a small portion of the total infestation.

Table 17. KTA Outlier ICA Status.

ICA Code	Plant Type & Total Number	Date Last Observed	Comments
WaimeaNoMU-ChrOdo-01	Immature only (1)	2011 April	None found since initial discovery. While this ICA was not specifically checked this year, the trail which runs through it was surveyed, with no plants found.
KTA-ChrOdo-02	Immature only (1)	2011 April	None found since initial discovery.
KTA-ChrOdo-09	Mature (1) and immature (1) plants	2013 September	Plants found on separate visits in 2013. No plants have been found since.

Table 17 (continued).

ICA Code	Plant Type & Total Number	Date Last Observed	Comments
KTA-ChrOdo-14	Mature only (1)	2014 January	None found since initial discovery.
KTA-ChrOdo-19	Immature only (1)	2014 September	None found since initial discovery.
KTA-ChrOdo-24	Mature only (1)	2016 March	None found since initial discovery.
KTA-ChrOdo-29	Immature only (1)	2017 March	None found since initial discovery.
KTA-ChrOdo-30	Immature only (1)	2017 November	New last year. No plants have been found since initial discovery, but nearby regions are heavily used for training and there is a high risk of further spread.
KTA-ChrOdo-31	Mature only (1)	2017 November	New last year. Original plant was large, but growing in marginal habitat (heavy shade), and site was sprayed with pre-emergent herbicide. No plants found since, but nearby regions are heavily used for training and there is a high risk of further spread.
KTA-ChrOdo-26	Mature (1) and immature (6) plants	2018 June	Found in 2016, when 1 mature plant was pulled. All other plants found have been immature. No plants were seen this year.
KTA-ChrOdo-33	Mature (1) and immature (1) plants	2018 September	New last year. First found in June 2018, when 1 mature with spent panicles was found. Only 1 immature plant was found this year. Additional surveys are needed. Nearby regions are heavily used for training and there is a high risk of further spread.
KTA-ChrOdo-13	Mature only (6)	2018 December	Found in 2015, this site initially did not receive regular control due to a gap in oversight. 2 visits were made this year and 5 mature plants were controlled. Habitat is marginal (dense canopy), but there is a lot of motocross activity in the area.
KTA-ChrOdo-32	Mature (1) and immature (3) plants	2019 March	New last year. 1 seeding mature plant was found February 2018, and the site was treated with pre-emergent soon after. Buffer surveys were done both last year and this year. Only 1 immature plant was found this year.

- Makai Bluffs and Private Land. The bluffs lining the north edge of KTA are steep, thickly vegetated, and difficult to survey. While portions of them lie within KTA, one section is owned by the State, and the majority is privately owned. This year, staff conducted an aerial survey over part of the bluffs, and found several patches of plants clearly off Army lands. In addition, while volunteering in October of 2018 at Hoola Na Pua, a non-profit on State land just makai of Pahipahialua gulch, staff found and controlled 13 plants, and reported the find to OISC. Last year, staff noted plants on the border of the Keana Farms/Climbworks property along the northeast edge of KTA. This year, OISC conducted surveys at Keana Farms and noted a large infestation; see Appendices 3-6 and 3-7. These discoveries, plus OANRP's discovery of *C. odorata* at the Pupukea-Paumalu State Park Reserve and the Pupukea Boy Scout camp, clearly indicate the *C. odorata* is moving off-range on to neighboring properties. Since these plants are not on Army lands, they are not a top priority for OANRP, however OISC does not have the resources to manage them either. Eradication or suppression of *C. odorata* cannot be achieved on Oahu without some type of management at these sites, and other strategies are needed. Options include conducting outreach to the landowners and encouraging them to control *C. odorata* on their own land, shifting OANRP focus from Army lands to neighboring properties, and pursuing a biocontrol. Staff will discuss potential strategy changes with the Army.

SBW Update

Chromolaena odorata was first discovered at SBW in May of 2013 on an annual road survey. SBW contains the second largest *C. odorata* infestation found on Army training lands after KTA. For the most part, the infestation is confined to the eastern end of Mohiakea gulch, bordered by the McCarthy Flats ranges to the north and Area X to the south. Several outlier sites are located along training range roads. See Figure 32. Training activities in SBW are much different than in KTA. As opposed to navigating across large areas, units tend to set up at select locations. While soldiers may venture into the edges of the *C. odorata* infestation, contractors and civilians conducting maintenance and vegetation management are much more likely to come in to contact with *C. odorata* and present the greatest risk as vectors. OANRP works to maintain positive relationships with these groups, as discussed in Section 3.4 above.

Most of the ICAs are located in the UXO contamination zone, which complicates ground operations. Staff must work with a UXO escort and be able to see the ground (i.e., no thick understory vegetation). If UXO is found, all personnel must depart the area immediately until the item is removed or detonated. If UXO is found early in the day, this means that little to no work is done on that day at that site, although staff can often relocate to another work site outside the safety zone. Control efforts are also limited by range availability. Although some ICAs can be checked when the range is active, others can only be checked when the range is cold (no live-fire training), and some tasks are logistically simpler when soldiers are not on site. Usually, Range Division schedules one week per month for range maintenance; staff conduct as much work at SBW as possible during those cold weeks.

Table 18 summarizes control efforts at SBW this year; control efforts from last report year are included for reference. The Type/Strategy listed for each ICA is defined in the KTA Control Summary discussion above. Due to differences in overall infestation size, terrain, military training, and UXO presence, fewer management strategies are employed at SBW than at KTA. Four ICAs are designated as outliers, while the largest two require a combination of sweeps/surveys and intensive hotspot control.

Table 18. SBW Control Efforts.

ICA Code and Type/Strategy	2019 Report Year				2018 Report Year		
	ICA Area (ha)	Area Weeded (ha)	Effort (hours)	# Visits	Area Weeded (ha)	Effort (hours)	# Visits
SBWNoMU-ChrOdo-01 Sweep + Hotspot + Aerial Spray	35.13	13.12	104.75	11	4.69	46.5	9
SBWNoMU-ChrOdo-02 Outlier	1.10	1.10	5.50	3	0.84	5.5	4
SBWNoMU-ChrOdo-03 Outlier	0.80	0.80	11.00	3	0.51	5.0	5
SBWNoMU-ChrOdo-04 Sweep + Hotspot + Aerial Spray	27.12	19.11	165.25	10	10.62	92.0	13
SBWNoMU-ChrOdo-05 Outlier	0.11	0.11	4.00	4	0.092	9.60	3
SBWNoMU-ChrOdo-06 Outlier	0.0078	0.0078	1.00	1	n/a	n/a	n/a
TOTAL	64.28	**34.24**	**291.50**	**32**	16.76	158.6	34

Total effort and treated area increased from last year. This primarily was the result of the expansion of the core infestation. In the course of surveying the 200 m buffer around ICAs-01 and -04, plants were found both further southwest (up gulch) and northeast (down gulch) than ever before. Both ICAs were expanded to include these new plants. Despite this, control efforts in the core went well this year: hotspots were

treated multiple times, aerial sprays were completed in challenging gulch areas, and staff conducted more large surveys than before. Still, this expansion highlights the importance of completing buffer surveys; without a fully delimited infestation, staff continue to play catch up with management strategy. On a more positive note, *C. odorata* numbers dropped at all outlier ICAs. Each ICA is discussed in more detail below. In addition to these control efforts, staff continued annual weed surveys of all training area roads in SBW and SBS as an early detection measure. These surveys resulted in one new ICA.

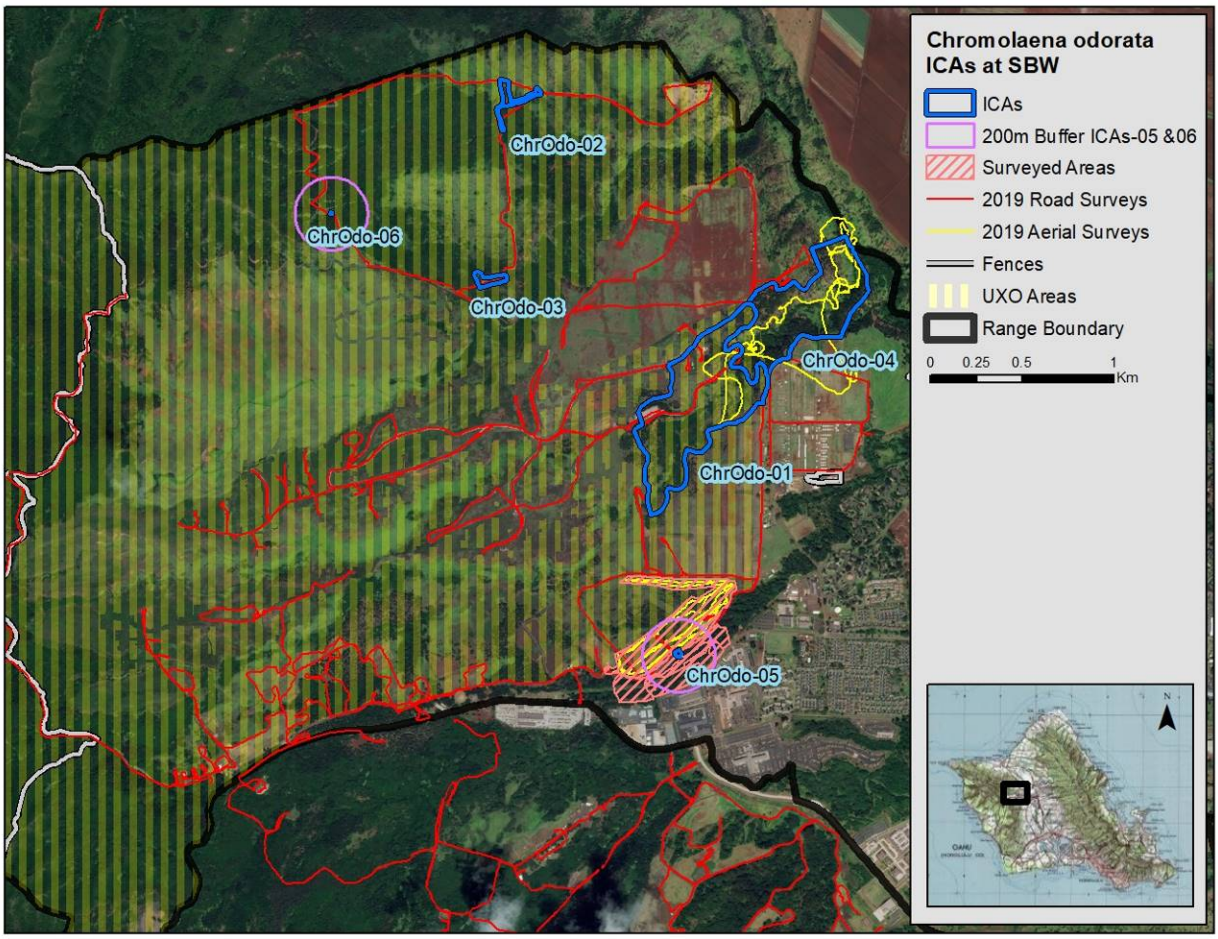

Figure 32. *C. odorata* ICA locations at SBW.

- SBWNoMU-ChrOdo-01. This ICA covers the western half of the primary *C. odorata* infestation, see Figure 33. It is bordered by roads on all sides except the southeast, where it abuts heavily mowed fields. Much of the ICA is dominated by dense stands of *U. maxima*, but some portions include mixed alien canopy trees. The grass is so thick in some areas that *C. odortata* does not appear to easily colonize it, unless a disturbance creates bare ground. These grass patches are unsafe to survey from the ground due to UXO concerns. This year, some portions of this grassy habitat were surveyed aerially (2.38 ha), while others were surveyed with binoculars from several vantage points. In the course of conducting buffer surveys, some plants were found on the west edge of the ICA. The ICA was expanded by 12.85 ha, more than needed for the new plants, to include one actively used road and one overgrown road; both are potential introduction points for *C. odorata*. Keeping *C. odorata* off of roadways is a high priority to prevent military and support vehicles from serving as vectors. It is hoped that the heavily managed training ranges surrounding much of the ICA will prove to be a barrier to further passive spread. Since the ICA is very large,

it has been divided into different zones and hotspots to facilitate communication and treatment. This year, ground-based control was conducted across 11.42 ha, and aerial sprays/surveys were conducted across 2.41 ha. Total area controlled increased by 8.43 ha over last year, while effort increased by 58.25 hours. Staff continued to treat hotspots aggressively with foliar sprays and regularly used products like Polaris and Sulfomet, which provide extended suppression. While plant numbers did not drop this year, staff noted marked declines at all but the newest hotspots. In addition, in April of 2019, approximately 13 ha of the southwest corner of the ICA was aerially boom sprayed by contractors preparing the range for a controlled burn; this spray is not included in Figure 33. While the boom spray did not target *C. odorata*, it did knock back a lot of *U. maxima* and will allow staff to safely access this portion of the ICA in the coming year.

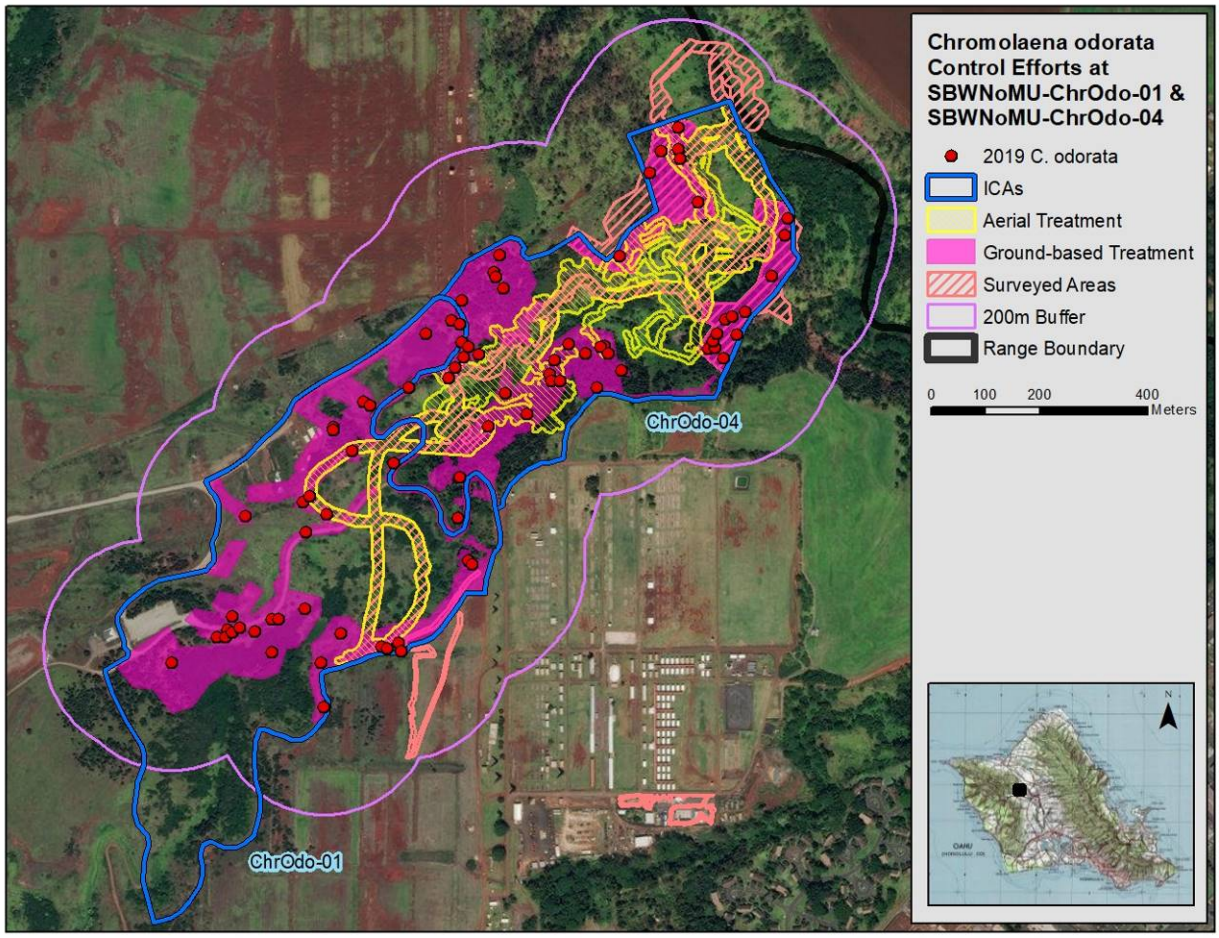

Figure 33. Aerial and ground treatment and surveyed areas in SBW Core Infestation.

- SBWNoMU-ChrOdo-02. This is the most northerly of the ICAs at SBW, and was discovered in February of 2014. For the second year in a row, no plants were found at the ICA. In fact, no plants have been seen since January of 2017, and the last mature plant was controlled in April of 2016. This positive trend suggests that the strategy of consistent visits and aggressive pre-emergent sprays employed in previous years has been effective. The main challenge at this site is keeping the thick, fast-growing *U. maxima* which dominates the area from growing over all known hotspots and reducing detectability of any *C. odorata* which may germinate. Last year, staff made this a priority, treating the site three times, but no sprays were conducted this year. The coming year, staff will monitor the ICA quarterly and control alien grasses to maintain visibility.

- SBWNoMU-ChrOdo-03. First found in July of 2014, this ICA is located close to a training target. This year, plant numbers continued to decline, with only one plant found (a mature), as compared to one mature, 33 immatures, and 20 seedlings last year. However, the single mature was located on the opposite (southern) side of the road to all other observed plants, necessitating a small expansion of the ICA, see Figure 34. Staff surveyed 0.57 ha around the plant, outside of the ICA, to ensure that no other patches were located on the southern edge of the road or in the gulch beyond it. Staff will continue to check the ICA quarterly in the coming year.

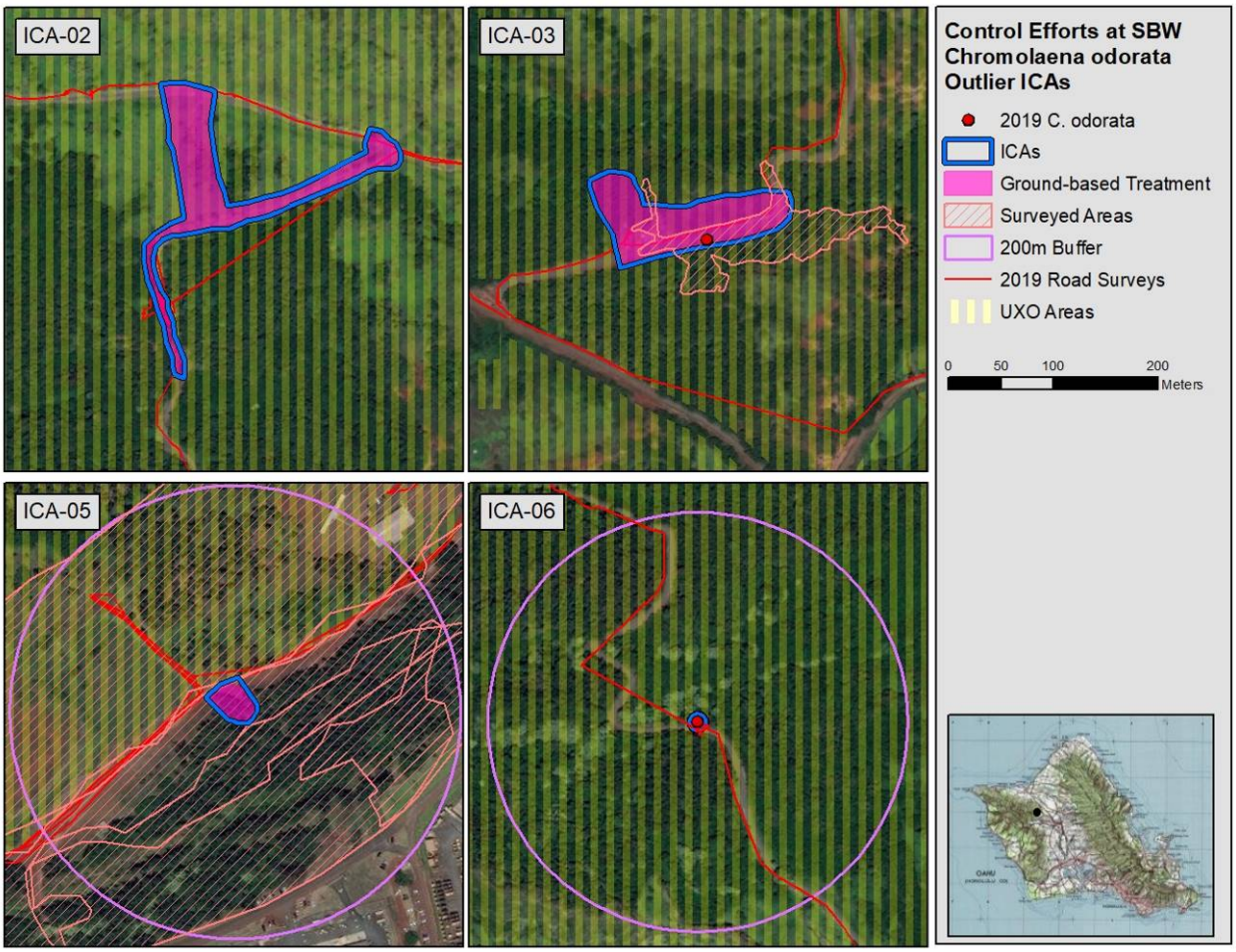

Figure 34. Survey and control efforts at SBW outlier ICAs.

- SBWNoMU-ChrOdo-04. This ICA encompasses the eastern portion of the primary *C. odorata* infestation, including the core. The terrain is challenging. Portions of the gulch are dominated by dense grass, the slopes are very steep, and there is a high UXO hazard which limits ground access. Since the ICA is very large, it has been divided into different zones and hotspots to facilitate communication and treatment. This year, staff surveyed 5.07 ha on the ground and 6.69 ha aerially, which resulted in the ICA expanding by 3.33 ha to include new plants found. In addition, ground-based control was conducted across 10.79 ha, and aerial treatments/surveys occurred over 10.77 ha, see Figure 33. In contrast, last year 7.71 ha were controlled on the ground and 5.05 has were controlled from the air. This year, total area controlled increased by 8.49 ha and effort increased by 73.25 hrs. Staff continued to treat hotspots aggressively with foliar sprays and regularly used products like Polaris and Sulfomet, which provide extended suppression. In addition to targeting *C. odorata* with aerial sprays, thick grass was strategically sprayed to

improve access to select areas. This allowed staff to sweep more terrain, particularly in the gulch, than ever before. In the coming year, staff plan to continue complementary aerial and ground work, flagging hotspots for aerial sprays, and using aerial sprays to facilitate improved ground coverage.

- SBWNoMU-ChrOdo-05. No plants have been seen at this roadside ICA in the Kolekole Ranges since it was initially discovered in November of 2017. Fortunately, the plant was removed while it was flowering and before it set seed. The ICA has been checked quarterly, and was treated once with pre-emergent herbicides. This year, staff completed 200 m buffer surveys around the ICA without finding any new plants, see Figure 34. The southern half of the buffer was swept on the ground, but the northern half, which is located in the UXO contamination area, was surveyed aerially in December 2018, during the *C. odorata* flowering season. In addition, annual surveys of range roads passing through the buffer were completed in February 2019. The only portion of the buffer not swept was the extreme southern edge, as it is an infertile concrete paradise. Staff will continue to monitor the ICA quarterly for another year, then will transition to biannual checks. Annual road surveys will continue to be a high priority, as they are a critical early detection action.
- SBWNoMU-ChrOdo-06. One mature plant was spotted on February 19, 2019 during the annual road survey of the north firebreak. Major construction work occurred along this portion of the road within the past couple years, and this is the suspected vector for the plant. The plant was growing on the side of a tall berm and no other plants were seen either directly nearby, or elsewhere along the north firebreak. The closest known *C. odorata* is approximately 860 m away. Buffer surveys have not yet been conducted at this ICA, as work at ICAs-01 and -04 was prioritized instead. The entire buffer is within the UXO contamination zone, see Figure 34. Staff will survey accessible portions of the buffer from the ground, and will also conduct aerial surveys across the entire buffer during the coming winter *C. odorata* flowering season. The ICA will monitored quarterly in the coming year.

SBE Update

First discovered in October 2014, there is one ICA at SBE. Only 15 immature plants, including one mature, have ever been seen at the site. A 200 meter buffer survey around the infestation was completed in 2014-2015. Although the single mature plant did set seed, staff treated the area with pre-emergent herbicide. No plants have been observed since February 2015, and it appears likely that no seed bank was formed. The ICA was monitored quarterly in 2015 and 2016. Due to the lack of observed recruitment, staff transitioned to twice a year checks in 2017. In the 2018 report year, an extra visit was conducted opportunistically due to the ICA's close proximity to other management sites. This year's control efforts are summarized in Table 19. Although one visit was missed, this is not critical due to the positive results of previous efforts. The site will be checked biannually for the next couple years, and will eventually transition to annual monitoring at least until 2025 (ten years after the last observed plant). As seed longevity trials progress, staff will revise plans based on the best available data.

Table 19. SBE Control Efforts.

ICA Code	2019 Report Year				2018 Report Year		
	ICA Area (m^2)	Area Weeded (m^2)	Effort (hours)	# Visits	Area Weeded (m^2)	Effort (hours)	# Visits
SBE-ChrOdo-01	0.18	0.18	1.50	1	0.18	3.00	3

Given the intensity of training at SBE and the high number of plants at KTA and SBW, there is a risk of that *C. odorata* will be reintroduced to SBE. Fortunately, staff already survey or sweep much of the actively utilized areas of SBE. Road surveys are conducted once a year and include all drivable trails.

Large areas are regularly swept in the course of ICA control work on *S. condensatum* and *R. tomentosa*. These action hopefully will facilitate early detection of any new *C. odorata* infestations.

Manuwai Update

Chromolaena odorata was first found at Manuwai in February 2017. Only three plants, including one mature, have ever been found at the single ICA. Control efforts for both this report year and last report year are summarized in Table 20. Last year, staff prioritized delimiting surveys for the ICA. Due to the steep terrain, dense vegetation, marginal quality of the habitat for *C. odorata*, and suspected vector for the ICA, a 200 meter buffer survey was not considered feasible or useful. Instead, staff identified high priority areas to sweep based on the most likely vector pathways. All of these high priority areas were swept last year, 14.09 ha in total, and no other infestation sites were found. These surveys account for the high effort and numerous visits last year. Since these high priority areas were in steep, densely vegetated terrain, and staff had only moderate confidence in the detectability of *C. odorata*, they will be swept again in 2022-2023.

Table 20. Manuwai Control Efforts.

ICA Code	2019 Report Year				2018 Report Year		
	ICA Area (m²)	Area Weeded (m²)	Effort (hours)	# Visits	Area Weeded (m²)	Effort (hours)	# Visits
Manuwai-ChrOdo-01	78	78	1.75	4	78	125.70	10

This year, control efforts focused only on the defined ICA, which was checked quarterly. Starting in 2020, visits will be reduced to twice per year, as it appears that a seed bank was not formed at the site. Staff will continue to look for *C. odorata* opportunistically in the course of other management work, and enforce good sanitation practices.

Kaluaa No MU Update

While hiking along the one of the main access trails to Kaluaa and Waieli in May of 2018, staff found two *C. odorata* plants just off the trail. One of the plants was large, mature, and full of seed. Control efforts are summarized in Table 21. This year, staff regularly monitored and treated the ICA and completed surveys of a 200 meter buffer to delimit the infestation, see Figure 35. No additional plants were found in new locations.

Table 21. Kaluaa No MU Control Efforts.

ICA Code	2019 Report Year				2018 Report Year		
	ICA Area (m²)	Area Weeded (m²)	Effort (hours)	# Visits	Area Weeded (m²)	Effort (hours)	# Visits
KaluaaNoMU-ChrOdo-01	2801	2740	98.0	7	812	1.0	1

The ICA was visited quarterly, and treated three times with pre-emergent herbicide to reduce recruitment. Since the discovery of the ICA, two mature plants, 32 immature plants, and eight seedlings have been controlled. While these numbers are small, it is too early to tell if a persistent seed bank was formed at this site, and quarterly control will continue in the coming year.

Survey effort accounts for the majority of time and the high number of visits this year. In all, 14.94 ha were surveyed for *C. odorata*, and happily all plants found were in close proximity to each other; the final ICA is small, less than an acre. Fortunately, much of the area is densely forested, not the open, scrubby habitat preferred by *C. odorata*. Annual weed surveys of trail transects and roads continued this year, and

serve as important early detection actions in the region. Three trail transects leading to and within the Kaluaa and Waieli fence were monitored, as well as all roads in SBS, including the Kaluaa access road. No new *C. odorata* sites were detected. These surveys will continue in the future, and staff will continue to look for *C. odorata* opportunistically during the course of other field work.

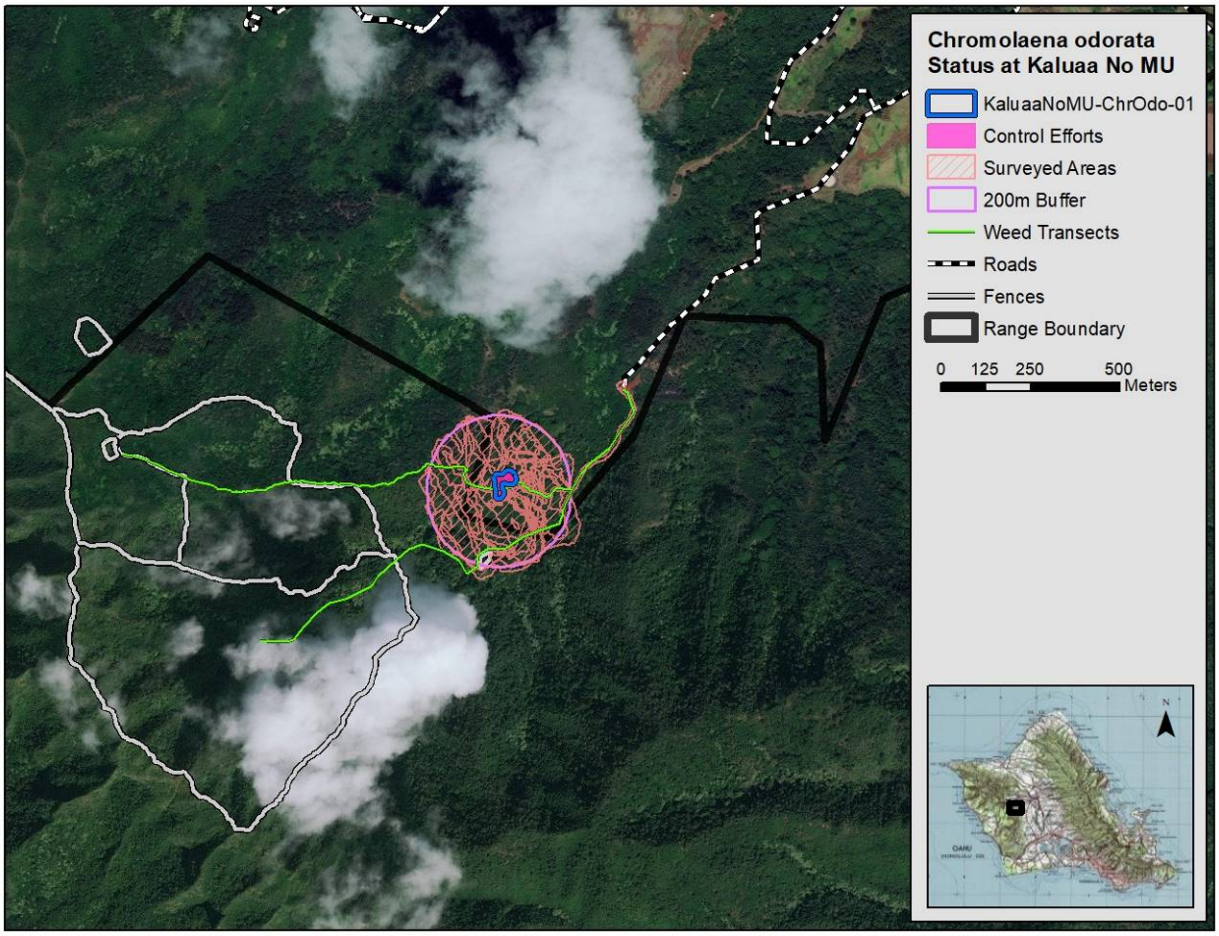

Figure 35. *C. odorata* infestation site at Kaluaa No MU, and delimiting buffer surveys.

Kamaili Update

During the course of other field work, staff found one large immature *C. odorata* growing along a fence at Kamaili. The Kamaili MU is unusual in that it is made up of two separate fenced exclosures, Kamaili Mauka and Kamaili Makai, separated by 500 m and several small ridges and gulches. The plant was found just inside the western edge of the Kamaili Mauka fence. This fenceline is walked quarterly by staff, and it seems likely that staff are the vector for this ICA. As a result, the proposed 200 m buffer for delimiting surveys was expanded to include the trail linking the Mauka and Makai fences to each other and the LZ, as well as the access trail leading down to the Makaha road, see Figure 36. Most (10.85 ha) of the 200 m buffer was swept this year, and these sweeps account for the majority of the effort and visits. An additional 1.21 ha was swept during general habitat weed control efforts in both fences and along the linking trail. While the access trail to the road was not used often this year, it was used by staff with some regularity in the past, and will be surveyed in the coming year.

During delimiting surveys in June of 2019, a new *C. odorata* site was found on the crest of a ridge north of the Mauka fence. The plant was small and immature, and in an area rarely accessed by OANRP. While

some rare plants are known from the gulches to either side of the ridge, they are monitored infrequently, and the ridge itself is rarely, if ever hiked by staff. This suggests another vector may be at play in Makaha, potentially recreational hikers, ungulates, or some unknown element. The 200 m buffer was expanded around the new plant. The terrain in all of the buffers is rocky, challenging, and some portions are too steep to survey. Staff will focus on completing surveys of all accessible portions in the coming year.

Control efforts for the year are summarized in Table 22. Since no other plants have been found at Kamaili-ChrOdo-01, it is possible that no seed bank was formed. Both ICAs will be monitored quarterly in the next year.

Table 22. Kamaili Control Efforts.

ICA Code	2019 Report Year				2018 Report Year		
	ICA Area (m²)	Area Weeded (m²)	Effort (hours)	# Visits	Area Weeded (m²)	Effort (hours)	# Visits
Kamaili-ChrOdo-01	78	78	96.1	3	n/a	n/a	n/a
Kamaili-ChrOdo-02	78	78	0.5	1	n/a	n/a	n/a
TOTAL	156	**156**	**96.6**	**4**	n/a	n/a	n/a

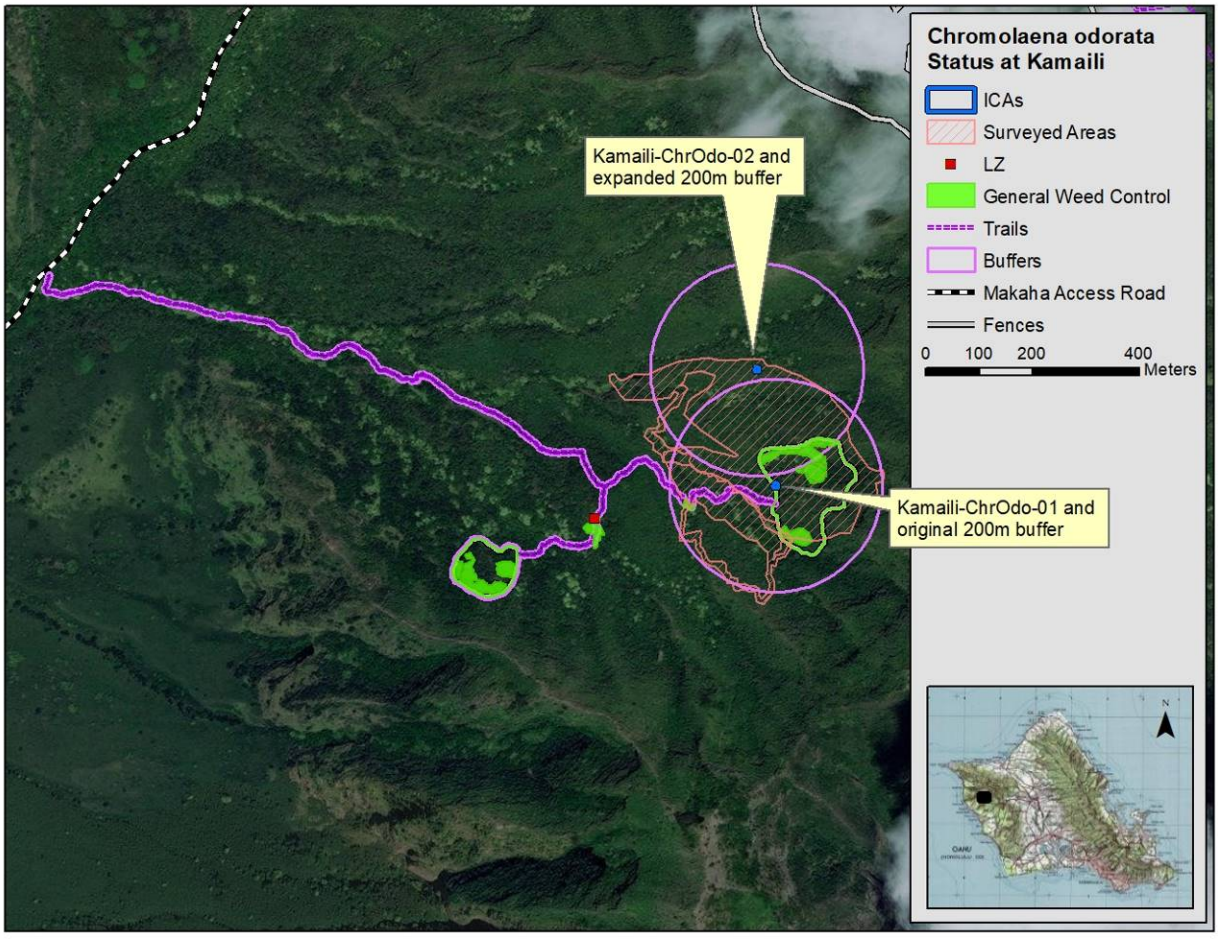

Figure 36. *C. odorata* infestation sites at Kamaili, and status of buffer surveys.

Makaleha Central No MU Update

Sharp-eyed staff spotted a single small immature *C. odorata* just past culvert 16 on the Kaala access road in October of 2018. Oddly, the plant was not at a gate, pull-out, LZ, or parking area typically used by staff, partners, the FAA, or other road users. Instead, it was on a narrow section of the road, growing on a steep clay bank. While it is possible that a seed may have hitched a ride on an OANRP vehicle, this scenario is unlikely, as vehicles are washed weekly. However, there are few other potential vectors, all of which are equally as unlikely: trespassers sometimes pass through the area; a military unit conducted a training exercise at the top of Kaala earlier in the year; agencies like HECO access the road to conduct equipment maintenance; and partner conservation agencies use the road regularly, although none of them work in *C. odorata* infested areas. More worryingly, an unidentified infestation may be located nearby, acting as a dispersal source. A 200 m buffer was drawn around the plant, and half of it was surveyed this year, 5.98 ha, with no additional plants found. The remainder of the buffer will be surveyed in the coming year. In addition, the Kaala road is surveyed for weeds annually, always in the first quarter of the new year. This year's survey did not turn up any additional *C. odorata* sites. Control efforts are summarized in Table 23. No other plants were found in CMakalehaNoMU-ChrOdo-01, despite quarterly checks.

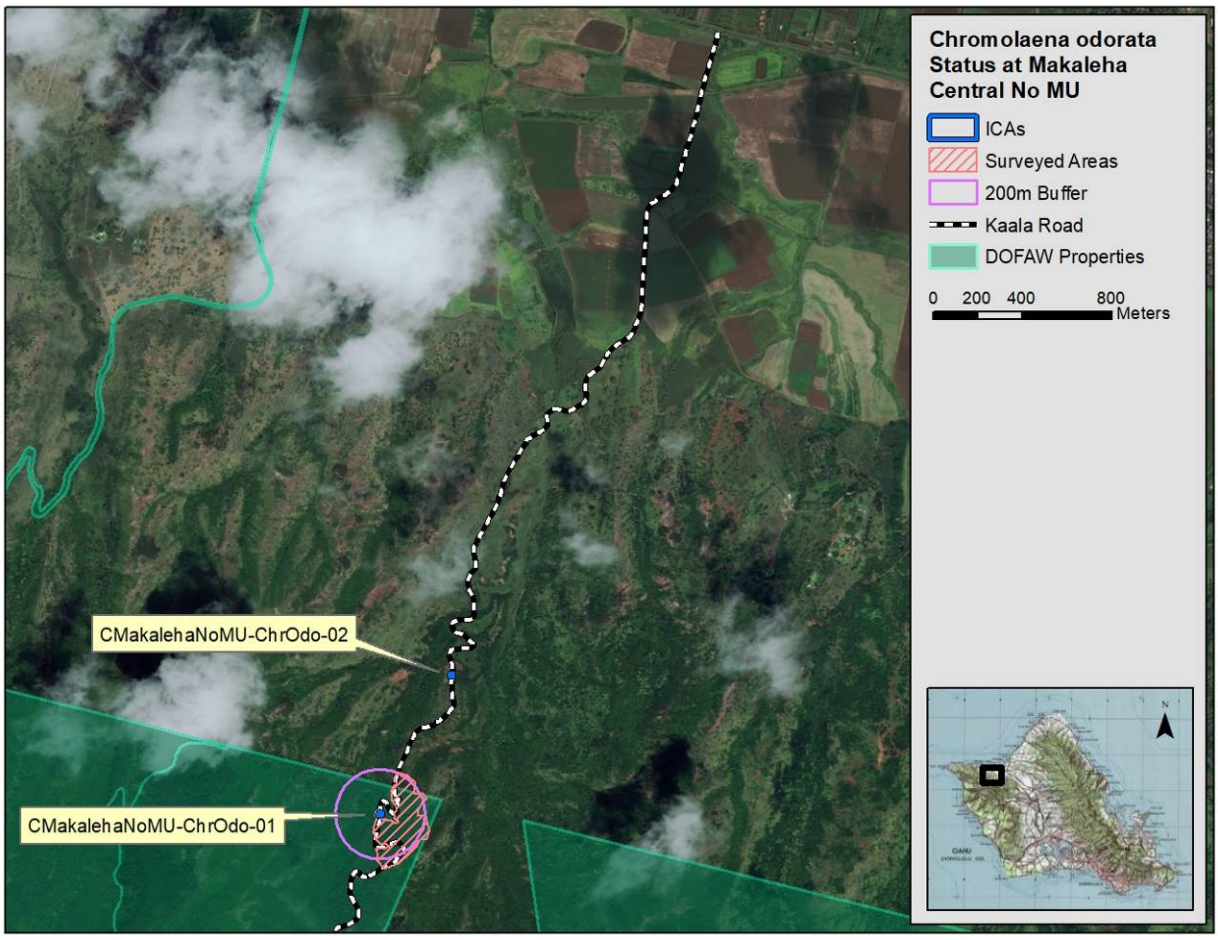

Figure 37. *C. odorata* infestation sites along the Kaala Road, in Makaleha Central No MU.

After splitting off of Farrington Highway, the Kaala road passes through private farm land, then a ranch, before crossing on to the Mokuleia Forest Reserve. The lower portion of the road is dry, open, and subject to regular disturbance from agriculture and grazing; it is prime habitat for *C. odorata*. In May of 2019, another sharp-eyed staff spotted a mature plant growing along the road in the ranch. The plant was

handpulled and the location marked. This plant could have been introduced at the same time and via the same vector as the plant on forestry land. It may indicate there is a larger infestation somewhere on the ranch. OANRP contacted the rancher, who gave verbal permission for staff to conduct surveys on his land and control any plants found. Delimiting surveys in a 200 m buffer around the site are planned for the coming year.

Table 23. Makaleha Central No MU Control Efforts.

ICA Code	2019 Report Year				2018 Report Year		
	ICA Area (m²)	Area Weeded (m²)	Effort (hours)	# Visits	Area Weeded (m²)	Effort (hours)	# Visits
CMakalehaNoMU-ChrOdo-01	313	313	62.75	4	n/a	n/a	n/a
CMakalehaNoMU-ChrOdo-02	313	130	0.50	1	n/a	n/a	n/a
TOTAL	625	**442**	**63.25**	**5**	n/a	n/a	n/a

Non-IP Locations and Partner Assistance Update

OANRP continues to collaborate with partners with *C. odorata* infestations on non-IP lands as feasible. Efforts vary from year to year, depending on partner need, discovery of new sites, and staff availability. This year's efforts are briefly summarized here.

- Lanikai. An off-duty OANRP staff discovered a single immature *C. odorata* along a beach access in Lanikai in 2016. The find was reported to OISC, who conducted surveys in the surrounding neighborhood and determined it was an isolated outlier. The same staff person who found the plant continues to monitor the beach access path, including multiple checks this year. Her observations are shared with OISC, which allows them to focus elsewhere. No other plants have been seen since 2016.

- Kahana Valley State Park. OISC manages a *C. odorata* infestation in the mauka regions of Kahana Valley. This isolated site was discovered in 2013, and OISC has had success in significantly reducing the population. This year, OANRP assisted OISC with one aerial spray operation at the site, providing aerial spray equipment and two staff to operate it. The aerial treatment complemented OISC's ground-based control efforts. OANRP will continue to support control efforts at Kahana in future.

- Makaha Valley. *Chromolaena odorata* was first found in Makaha Valley in December 2017. A hiker posted a photo of a plant on social media, and OANRP staff followed up with a site visit; two plants were found, one mature and one immature, on the north side of the valley far from IP MUs and work sites. The find was reported to OISC and BWS. OISC conducted extensive buffer surveys around the site, but no other plants were seen. This year, OANRP offered to take over monitoring of the original site from OISC, since it is distant from other OISC work locations. Control efforts are summarized in Table 24. In addition, staff surveyed 1.15 ha between the site and the end of the road, see Figure 38.

Table 24. Makaha No MU Control Efforts.

ICA Code	2019 Report Year				2018 Report Year		
	ICA Area (m²)	Area Weeded (m²)	Effort (hours)	# Visits	Area Weeded (m²)	Effort (hours)	# Visits
MakahaNoMU-ChrOdo-01	19.5	19.5	1.5	1	n/a	n/a	n/a

In August and September of 2018, WMWP staff discovered a couple *C. odorata* along their 'grant-in-aid' (GIA) fence line. The GIA site is about 420 m east of the original location, on the opposite side of the valley, and separated from the Kamaili plants by a little more than a kilometer and a large ridge.

WMWP does not work in areas known to have *C. odorata*, and thus is unlikely to be the vector for these plants, and OANRP does not work in the GIA fence. Makaha is managed by BWS and is not open to public hiking, however, there are numerous trails throughout the valley, and it appears to be a popular local hiking and hunting spot. In the absence of a more likely source, it is assumed that *C. odorata* was introduced to the area via recreational use. There may be an undiscovered infestation somewhere in the valley acting as a source for these widely distributed sites. OISC plans to survey all trails in the valley and look for additional *C. odorata* sites. OANRP will support partner management efforts, and look for *C. odorata* whenever conducting field work in the valley.

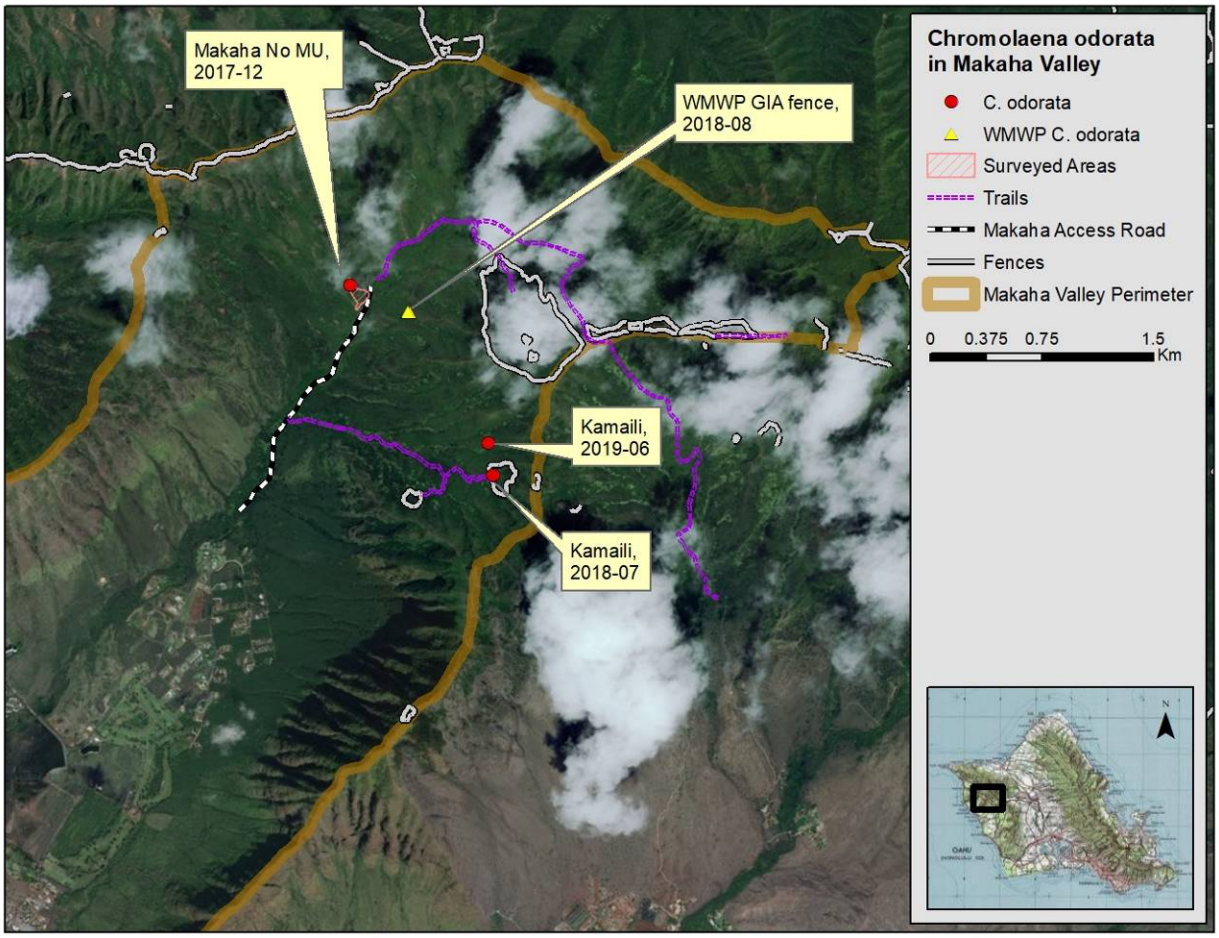

Figure 38. *C. odorata* sites known from Makaha Valley.

- Pupukea-Paumalu State Park Reserve. Last report year, in April 2018 an off-duty OANRP staff on a weekend recreational hike found one mature *C. odorata* on the Ehukai trail in the Pupukea-Paumalu State Park Reserve. This year, OANRP obtained a State Parks Permit to survey all the trails in the Reserve and control any *C. odorata* found, with the intent of determining the extent of the infestation and thus assisting partner agencies. OANRP completed all trail surveys in the first half of the report year, see Figure 39, and shared the results with OISC. Over 40 hours, staff hiked 84.5 km on an intricate network of trails, surveyed 31.67 ha of trailside habitat, and controlled 40 mature and 116 immatures plants, mostly via hand pulling. Only one plant location was not treated due to time limitations and the density of the patch. OANRP does not plan to conduct regular management work in the Reserve in future, as it is off of Army lands and outside of IP MUs.

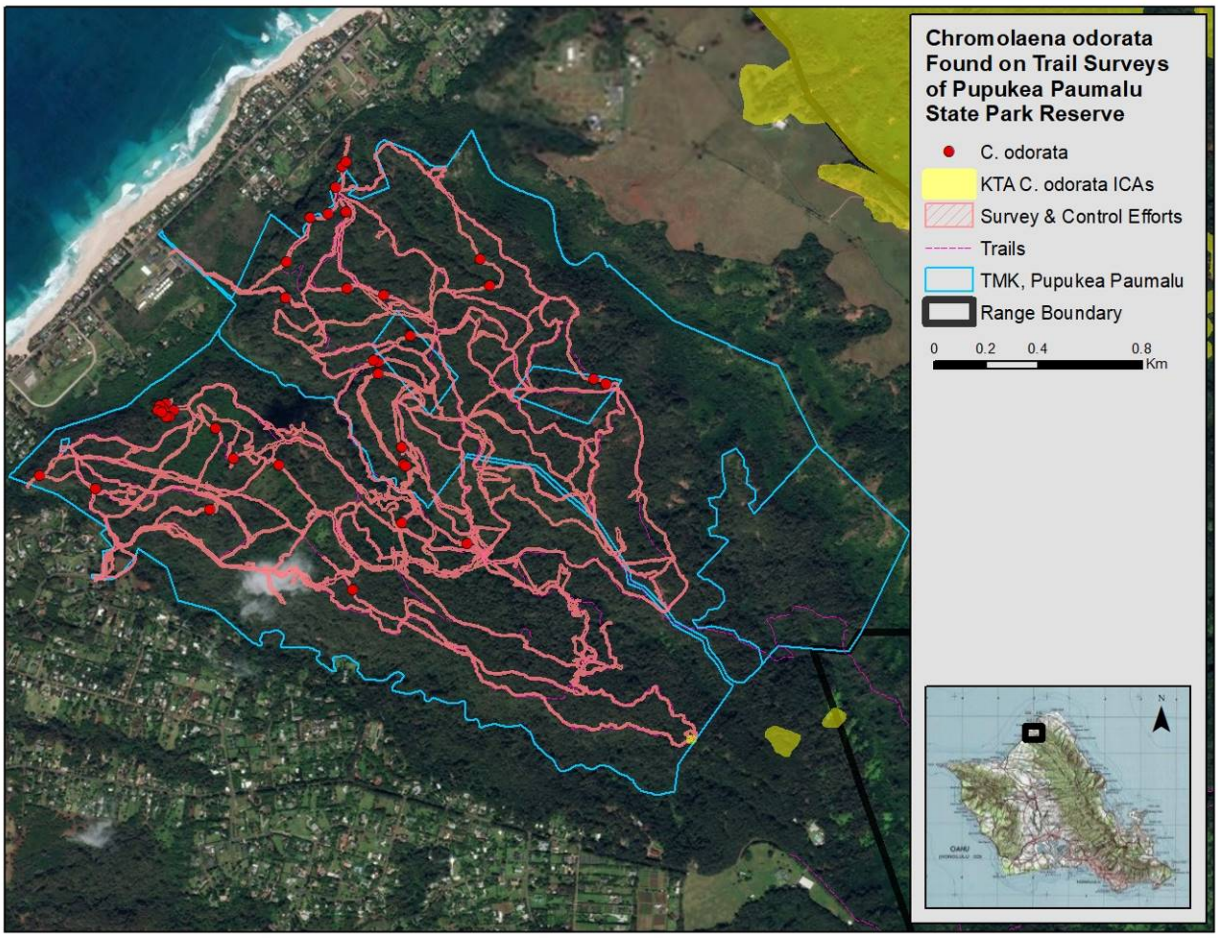

Figure 39. Surveyed areas and *C. odorata* locations in the Pupukea-Paumalu State Park Reserve.

The trails in the Pupukea-Paumalu State Park Reserve are popular with hikers and mountain bikers, and are sometimes used by motocross riders; recreational use is the suspected vector for the dispersal of *C. odorata* to the Reserve. While most of the Reserve is separated from KTA by private land, the mauka/eastern edge of it is adjacent to the KTA Alpha 3 training area and some trails connect the regions. The North Shore Community Land Trust works with the State Parks Department to manage the area. OANRP shared the results of the trail surveys with OISC. Conducting large-scale management at the Reserve is not an option for OISC. Instead, OISC has conducted outreach to the North Shore Community Land Trust and facilitated control of *C. odorata* in the Reserve by volunteers. Given the spread of *C. odorata* both OANRP and OISC have seen in the past couple years, community engagement will be vital to reducing the impact and dispersal of *C. odorata* in future. OANRP will continue to support partner agency and community efforts at the Reserve.

Figure 40. Hikers in the Pupukea-Paumalu State Park Reserve, with a *C. odorata* plant in the foreground.

Biocontrol Update

Chromolaena odorata is an island-wide threat and no single agency has the capacity to address the species as a whole. OANRP has been unable to make net gains in control of this weed thus far. Fortunately, there is strong interagency support for the pursuit of a biocontrol, as biocontrol agents have successfully been used to manage *C. odorata* elsewhere in the world. As discussed in OANRP 2018, the most promising biocontrol is *Cecidochares connexa*, a gall-forming tephritid fly. The International Organization for Biological Control of Noxious Animals and Plants (IOBC) Working Group on Chromolaena endorses this agent: "*C. connexa* is the best biocontrol agent for chromolaena [*sic*] available at present, in terms of host range, efficacy and east of establishment." Galls develop on the stems of plants affected by *C. connexa*, and act as resource sinks; heavily galled plants are reported to have little flower/seed set. In addition, *C. connexa* is easy to rear and establish in the field, and disperses widely. There are two different biotypes of *C. odorata*: the Asian/West African (AWA) type and South African (SA) type. These names do not refer to the origin of the biotype, but to the area infested by it. The IOBC states, "due to (*C. connexa's*) narrow host range, it cannot develop on the SA biotype of chromolaena." This year, OANRP worked with Dr. Cliff Morden (University of Hawaii) to determine via genetic testing which biotype is present in Hawaii. Morphologically, the Hawaii plants most closely resemble the AWA type. This was confirmed by Dr. Morden, who tested samples from infestations around the island as well as a sample from Guam. Results will be drafted and published in the future. These results support the pursuit of the next phase of research on *C. connexa*, host-specificity testing.

OANRP worked with a variety of partners this year to prepare for host-specificity testing trials, including OISC, DOFAW, USFWS, HDOA, USDA, and an Australian biocontrol expert who has researched *C. connexa* for release elsewhere in the Pacific, Dr. Michael Day. Fortunately, *C. connexa* has undergone multiple host-specificity trials, and there is strong evidence that it is very specific to *C. odorata*. Researchers tested 136 taxa in 30 families, and *C. odorata* was the only species determined to be an effective host for *C. connexa*; see Appendix 3-14 for a complete list of the tested taxa. As a result, initial talks with USFWS indicate that only one species per genus of Hawaiian Asteraceae, plus a short list of six

ecologically significant native taxa in other families, will need to go through host-specificity trials with *C. connexa*. Table 25 lists the taxa proposed for testing.

Table 25. Taxa Proposed for Host Specificity Testing for the *C. connexa*, a potential biocontrol for *C. odorata*.

Taxon	Family, Subfamily, Tribe (per Mabberley, 2017)
Hesperomannia swezeyi	Asteraceae, X. Cichorioideae, 5. Vernonieae
Pseudognaphalium sandwicensium var. *sandwicensium*	Asteraceae, XII. Asteroideae, 3. Gnaphalieae
Keysseria spp.	Asteraceae, XII. Asteroideae, 4. Astereae
Remya spp.	Asteraceae, XII. Asteroideae, 4. Astereae
Tetramolopium filiforme	Asteraceae, XII. Asteroideae, 4. Astereae
Artemisia australis	Asteraceae, XII. Asteroideae, 5. Anthemideae
Bidens torta	Asteraceae, XIII. Heliantheae alliance, 03. Coreopsideae
Lipochaeta lobata subsp. *lobata*	Asteraceae, XIII. Heliantheae alliance, 09. Heliantheae
Melanthera tenuifolia	Asteraceae, XIII. Heliantheae alliance, 09. Heliantheae
Argyroxiphium spp.	Asteraceae, XIII. Heliantheae alliance, 11. Madieae
Dubautia herbst-obatae	Asteraceae, XIII. Heliantheae alliance, 11. Madieae
Wilkesia spp.	Asteraceae, XIII. Heliantheae alliance, 11. Madieae
Adenostemma viscosum	Asteraceae, XIII. Heliantheae alliance, 13. Eupatorieae
Cibotium chamisoi	Dicksoniaceae
Acacia koa	Fabaceae
Sophora chrysophylla	Fabaceae
Sapindus oahuensis	Sapindaceae
Metrosideros polymorpha	Myrtaceae
Dodonea viscosa	Sapindaceae

Both HDOA and USDA are potential options for conducting the testing, and Dr. Day has agreed to provide expert on-site leadership and guidance, as he is very familiar with both *C. connexa* and *C. odorata*. OANRP plans to grow all the plants used for testing, thus allowing research staff to focus solely on the trial. DOFAW has already begun to assist OANRP in tracking down propagules of the plants needed. In the coming year, OANRP will continue to work with partners to address the myriad other issues which need to be figured out prior to testing, including obtaining permits, securing funding, and hiring staff if needed. While much work remains to be done, OANRP is cautiously optimistic that host-specificity trials may begin as early as the winter of 2020. Once host-specificity testing is complete, an Environmental Assessment will need to be completed. DOFAW has expertise with this process, and will likely take the lead. Assuming *C. connexa* is eventually approved for release, OANRP will develop a plan for monitoring its impacts, and adjust field strategy in light of its performance.

Figure 41. *Chromolaena odorata* can reproduce vegetatively, as is shown by the root development on this fallen branch.

3.7 RESTORATION ACTIONS UPDATE

3.7.1. Management Unit Summaries

This year, restoration actions continued in high priority WCAs. Restoration activities aim to complement weed control efforts in areas with high weed recruitment, to restore connectivity and structure to native forest patches, and to replace vegetation following removal of dense patches of alien plant species. In general, the most common restoration approach entails conducting seed sows with fast-growing native species and/or outplanting plants that are also expected to establish either understory or canopy cover quickly. Some more nuanced approaches are taken for projects which specifically benefit rare taxa, such as *Drosophila* spp. and *Achatinella* spp., where host specificity and/or habitat specificity is critical.

Restoration actions are tracked within WCAs, as two types: 1) outplantings; and 2) seed sows, divisions, transplants (SDTs). Outplantings require a higher level of planning and effort, and SDT actions can be done opportunistically and as needed. Area for each restoration type is calculated by merging all the efforts into a single geographic footprint within a given WCA for the year (overlapping areas are not additive). Reporting of numbers of outplants and restoration area began in 2016, and total number of outplants and area totals for outplants and SDT efforts to date are shown in Figure 42 and 43 below. Total number of outplants in each MU since 2016 is shown in Figure 44, followed by Table 26, summarizing restoration actions for each MU for the last report year. Total number of plants, outplant area, and SDT area for 2019 is also presented in Table 26. More detailed restoration information is presented, organized by MU, with maps showing locations of restoration activities and the specific WCAs in which those occurred, at the end of all the summaries.

Numbers of outplants and outplant area were somewhat lower this year compared with last year, though considerably higher than in 2016 and 2017. SDT area has increased every year since 2016. Staff expects that both area and numbers of outplants will vary from year to year, as project needs and production limitations vary. Four MUs that received restoration efforts last year did not this year (Haili to Kealia, Kaluaa and Waieli, Kaluakauila, and Kapuna Upper), while restoration efforts were conducted for the first time at five new MUs (Ekahanui, Kaala Army, Kamaili, Makaleha West, and Pualii North). Outplants continued to account for the largest restoration action area. Hand broadcast seed sows were conducted at restoration sites that were cleared of large swaths of alien vegetation to establish quick cover. Sows were mostly conducted with *B. torta* and *Pipturus albidus,* but a few other species were opportunistically broadcast as well; no formal follow-up on those has been conducted. In the future, staff hope to collect enough seed from a variety of taxa to be able to conduct seed sow trials. Staff would like to pin down best practices for broadcast sows for a variety of species, as well as to determine how both processed and stored seed perform and compare to each other. This year, staff were able to develop methods for propagating *Microlepia strigosa, Cibotium chamissoi,* and *Doodia kunthiana*. Utilizing these methods, hundreds of containerized ferns can be produced throughout the year, and can be easily carried into the field for outplanting. This consistent supply of fern species is very useful in supplementing weed control efforts and establishing understory at restoration sites.

Individual outplant survival is not monitored. Outplants are re-visited post-planting as needed for supplemental water and to take general observations about overall outplant health. Vegetation monitoring occurs at a subset of restoration sites. Those thought to warrant the effort associated with monitoring include but are not limited to: sites where significant amounts of alien canopy have been removed (all of the Ecosystem Restoration team sites), sites like those in Makaha on Board of Water supply land where data can be presented to the land owner about native vegetation response after weed control with herbicide, or sites like snail enclosures where monitoring can help assess appropriate habitat for snails. Monitoring techniques vary at each restoration site and include vegetation plot monitoring, point-intercept vegetation monitoring, photopoints, and Gigapan Imagery analysis. The MU belt plot monitoring that

looks at overall success of management across the MU as a whole includes analysis of restoration effort impacts when possible.

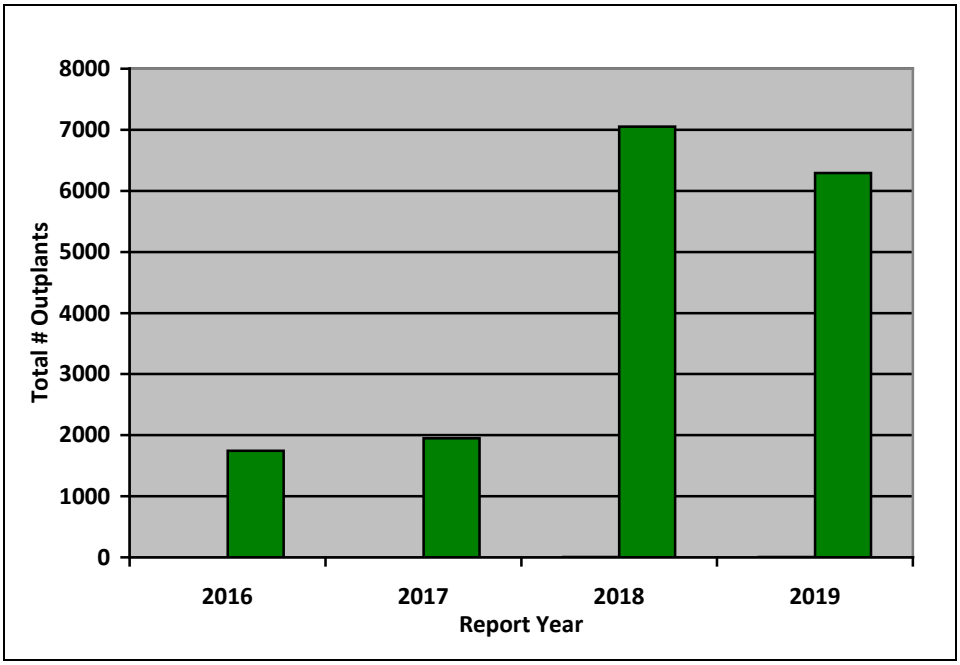

Figure 42. Total number of outplants each year since 2016.

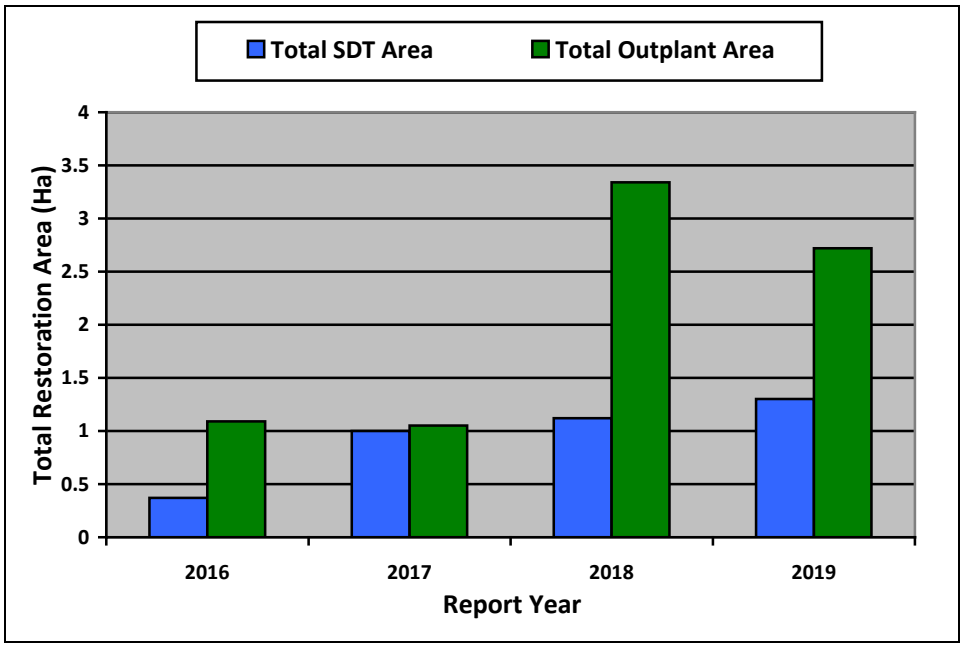

Figure 43. Total outplant area and SDT area each year since 2016.

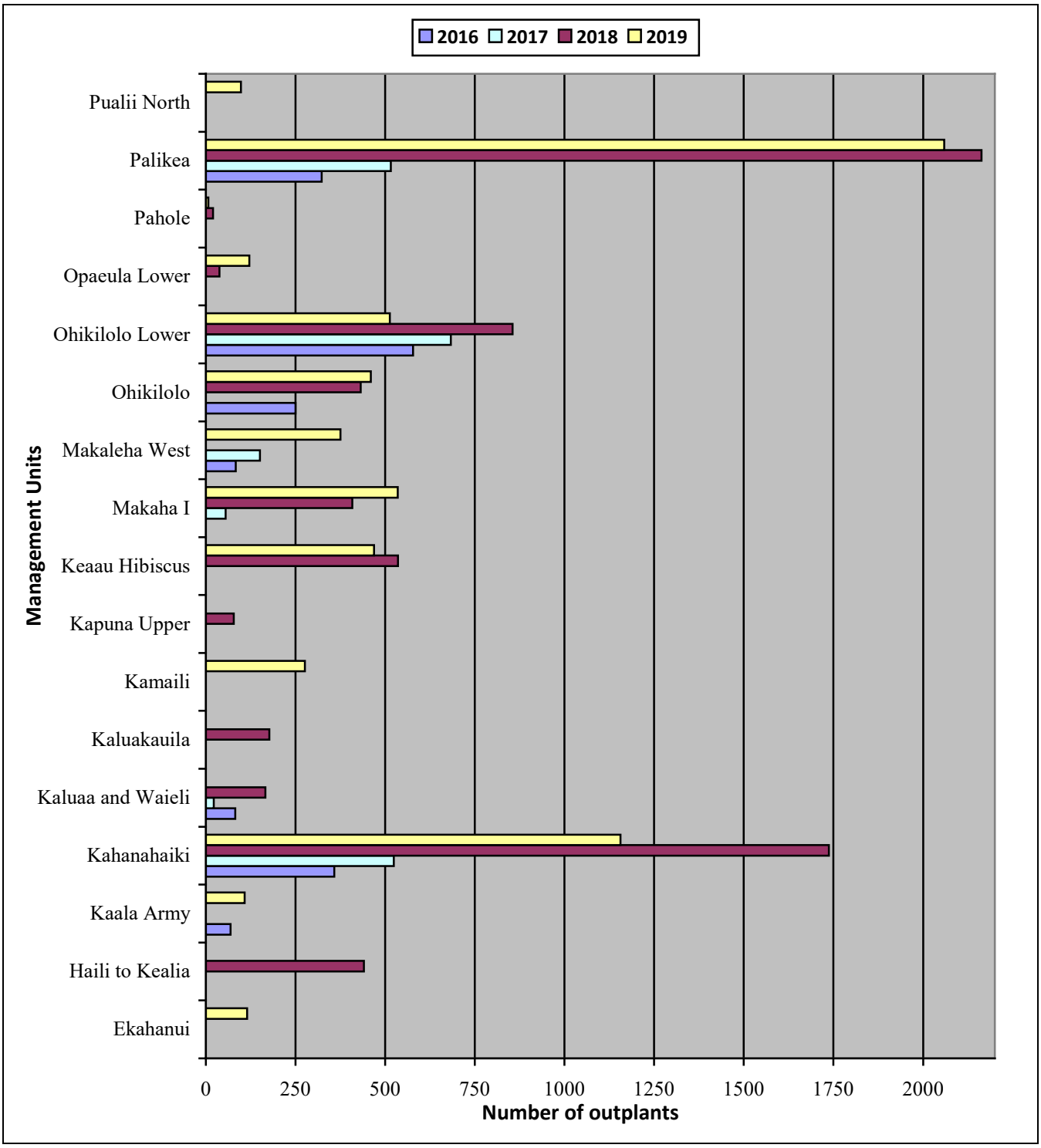

Figure 44. Number of outplants in each MU for each report year since 2016.

Table 26. Summary of 2019 Restoration Actions by MU.

MU	Total # Outplants	Total Outplant Area (m^2)	SDT Total Area (m^2)
Ekahanui	115	520	-
Kaala Army	108	238	-
Kahanahaiki	1,156	4,283	4,323
Kamaili	276	749	-
Keaau Hibiscus	469	1,583	-
Makaha I	535	3,879	2,368
Makaleha West	375	1,771	-
Ohikilolo	460	2,059	-
Ohikilolo Lower	513	1,267	-
Opaeula Lower	121	479	-
Pahole	7	162	162
Palikea	2,059	9,906	6,166
Pualii North	98	293	-
Total:	6,292	27,189	13,019

Figure 45. Staff member demonstrating outplanting to volunteers at Three Points snail exclosure.

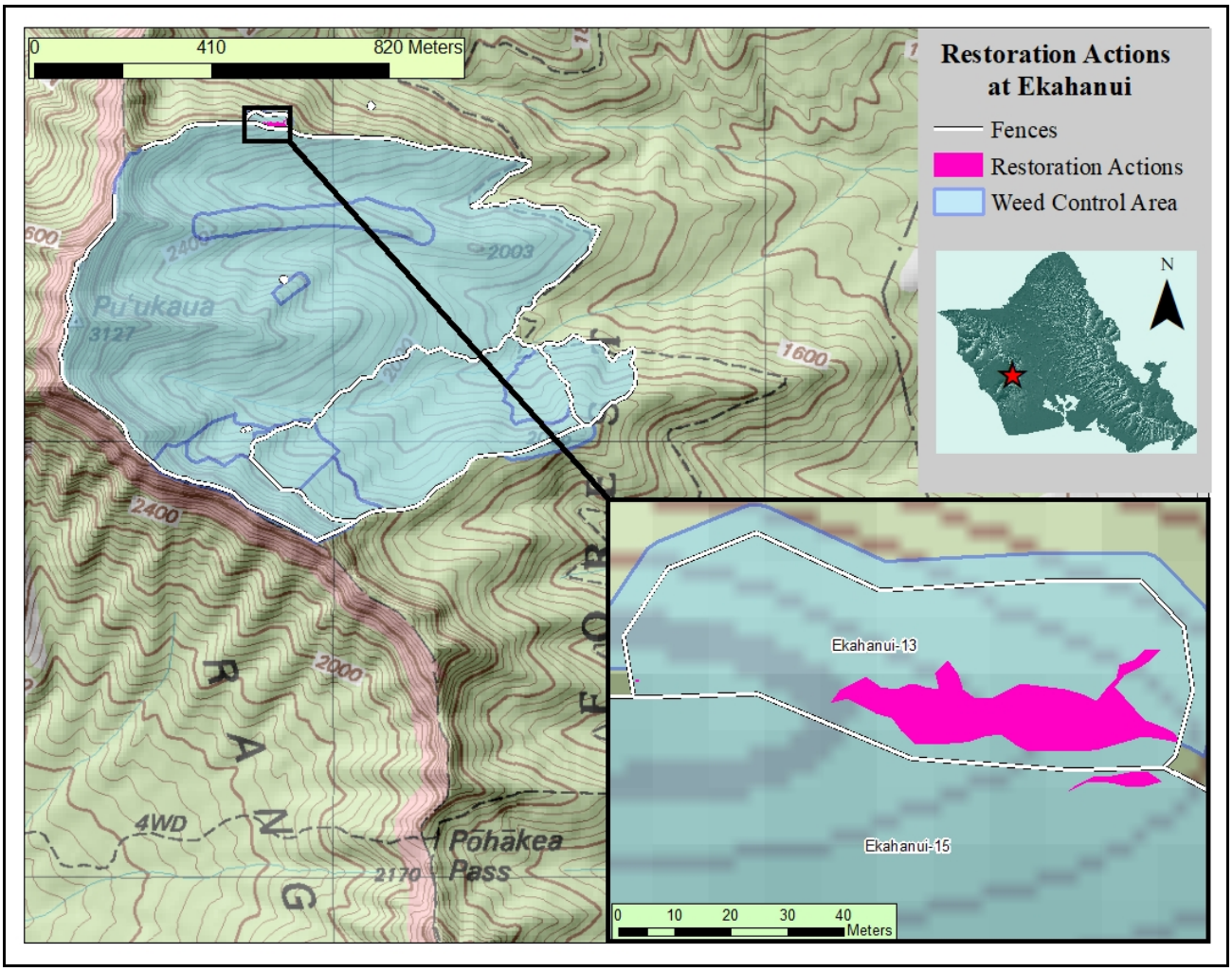

Figure 46. Map of 2019 Restoration Sites in respective WCAs in Ekahanui.

Table 27. Summary of 2019 Restoration Actions in Ekahanui.

MU	Restoration Action	# of plants	Area (m²)	Taxa
Ekahanui	Outplanting	115	520	*Acacia koa*, *Labordia kaalae*, *Metrosideros polymorpha* var. *glaberrima*, *Pittosporum confertiflorum*, *Psychotria mariniana*, *Santalum freycinetianum* var. *freycinetianum*, *Sophora chrysophylla*
Outplants were planted near a population of *C. agriminioides* var. *agriminioides*. With an abundance of *P. cattleianum* in the canopy, and plans to continually fell trees in the future, outplants were placed strategically in open spots along the southeast corner of this particular area to improve the habitat.				

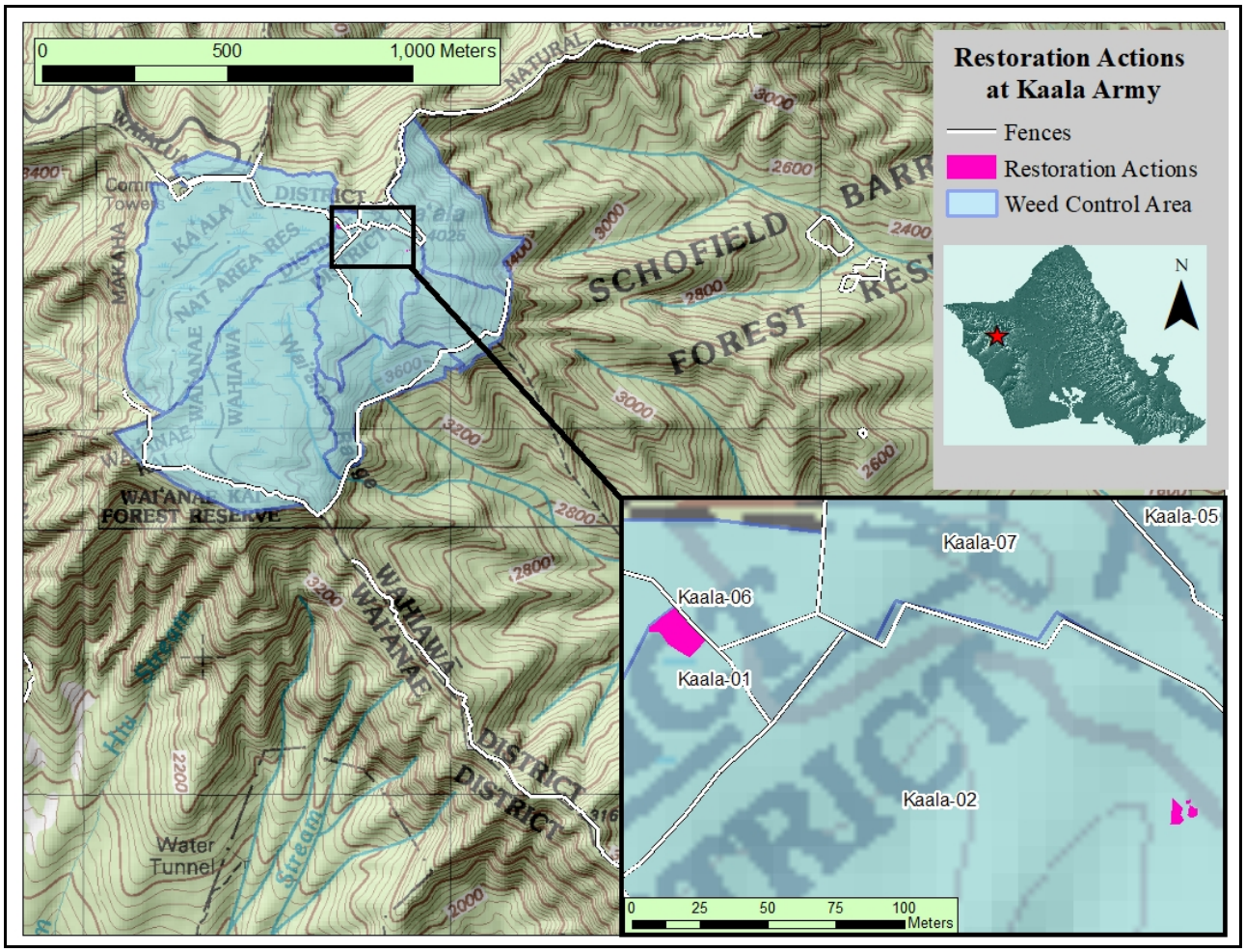

Figure 47. Map of 2019 Restoration Sites in respective WCAs in Kaala Army.

Table 28. Summary of 2019 Restoration Actions in Kaala Army.

MU	Restoration Action	# of plants	Area (m²)	Taxa
Kaala Army	Outplanting	108	238	*Antidesma platyphyllum*, *Coprosma ochracea*, *Coprosma longifolia*, *Leptecophylla tameameaie*, *Metrosideros macropus*, *Vaccinium calycinum*
Outplantings were in two spots: near the entrance to the Kaala Boardwalk, and in an area below the FAA fence. The latter is a new outplanting site where volunteers cleared *C. hirta*, *O. stricta*, as well as large mats of *C. diffusa.* While plants grow slowly in this wet environment, staff hope to reduce open habitat easily colonized by priority incipient weeds.				

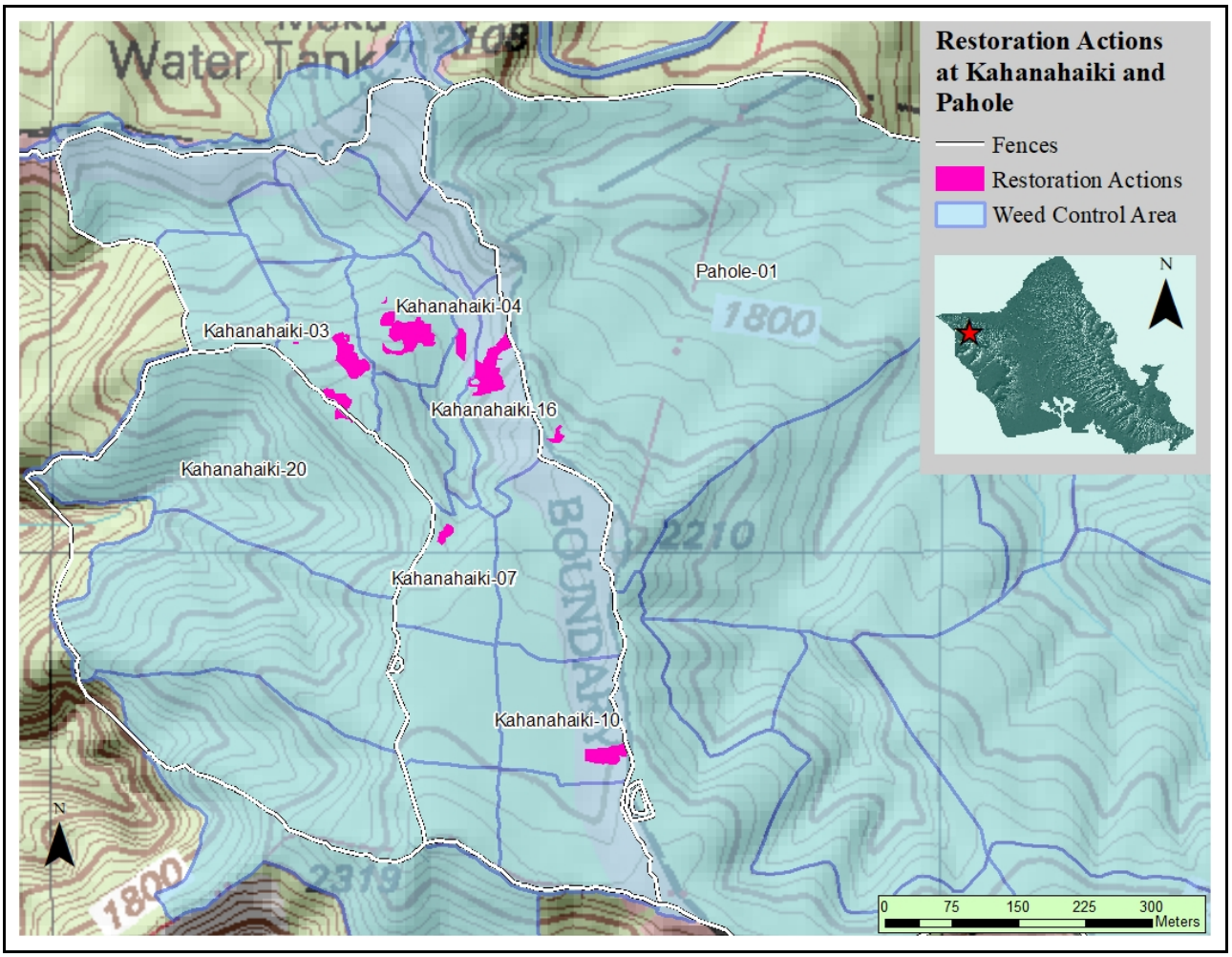

Figure 48. Map of 2019 Restoration Sites in respective WCAs in Kahanahaiki and Pahole.

Table 29. Summary of 2019 Restoration Actions in Kahanahaiki and Pahole.

MU	Restoration Action	# of plants	Area (m²)	Taxa
Kahanahaiki	Outplanting	1,156	4,289	*A. koa*, *Alyxia stellata*, *Bidens torta*, *Carex meyenii*, *Carex wahuensis*, *Dianella sandwicensis*, *Dodonaea viscosa*, *Hibiscus arnottianus* subsp. *arnottianus*, *Ipomoea indica*, *Kadua affinis*, *M. strigosa*, *Myrsine lessertiana*, *P. albidus*, *Pisonia brunoniana*, *Pisonia umbellifera*, *Pittosporum flocculosum*, *Planchonella sandwicensis*, *Polyscias oahuensis*, *P. mariniana*, *Urera glabra*
Outplants were planted in an expanding number of restoration sites, including three sites which are weed-dominated and have required aggressive control efforts and clear-cutting. Two of the outplanting sites were in areas with mixed-mesic habitat and required more gradual control efforts. In addition to these restoration areas, common native outplants were planted at two rare plant reintroduction sites to improve habitat. *Ipomoea indica* was used as an experimental outplanting at one of the restoration sites for a fast-growing ground cover to be used in future restoration efforts.				
Kahanahaiki	SDT	N/A	4,323	*B. torta*, *C. wahuensis*, *Charpentiera obovata*, *C. chamissoi*, *D. sandwicensis*, *K. affinis*, *Nephrolepis exaltata* subsp. *hawaiiensis*, *P. albidus*, *P. umbellifera*

Table 29 (continued).

MU	Restoration Action	# of plants	Area (m²)	Taxa
Seed sows of a variety of species were conducted throughout six sites this year. Transplants of *P. umbellifera,* as well as divisions of various ferns and *D. sandwicensis* were done at two clear-cut restoration sites. Many of the selected sites are in newly cleared areas, have bare dirt spots that may be susceptible to erosion, or have shown promise with native recruitment after weeding efforts. SDTs allow staff to quickly foster native plant colonization of these areas.				
Pahole	Outplanting	7	162	*C. meyenii*
Carex meyenii was placed strategically in bare dirt spots around new *Schiedea nuttallii* outplantings to improve the habitat by adding native understory around the rare taxon.				
Pahole	SDT	N/A	162	*C. meyenii*, *C. chamissoi*
The intention of transplanting these two species was to create a windbreak and appropriate habitat for the upcoming outplanting of *S. nuttallii* at this site.				

Figure 49. Staff member outplanting *A. koa*.

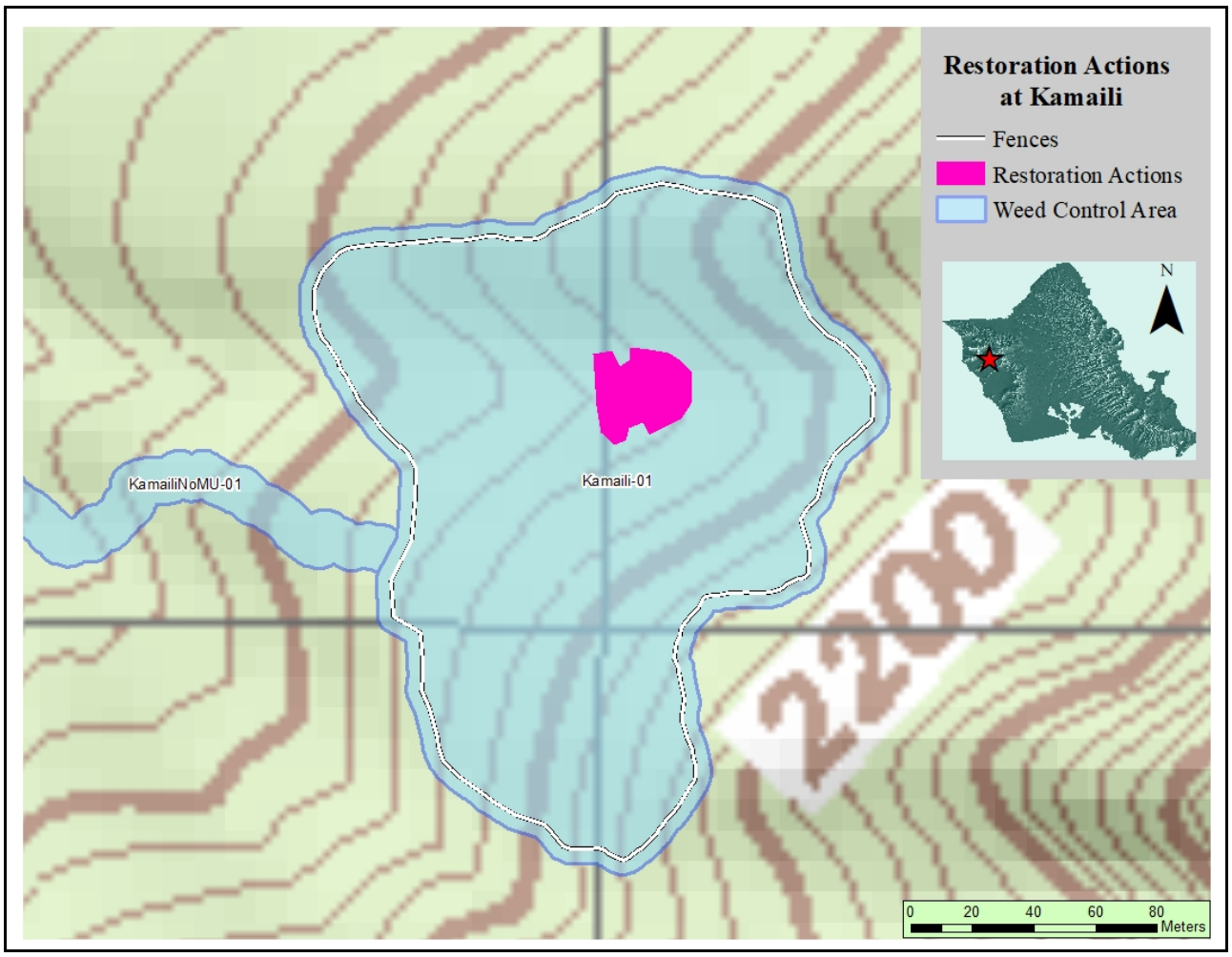

Figure 50. Map of 2019 Restoration Sites in respective WCAs in Kamaili.

Table 30. Summary of 2019 Restoration Actions in Kamaili.

MU	Restoration Action	# of plants	Area (m²)	Taxa
Kamaili	Outplanting	276	749	*A. koa, Antidesma pulvinatum, D. viscosa, H. arnottianus* subsp. *arnottianus, Plumbago zeylanica*
Outplants were planted in the northernmost bowl of the mauka fence, below and adjacent to a wild population of *A. sandwicense.* The area immediately around much of the *A. sandwicense* is extremely rocky, while this selected site had safer terrain. Staff expect that *A. sandwicense* may have success in recruiting in the light gaps created by this outplanting effort. This was the first common native outplanting event in Kamaili.				

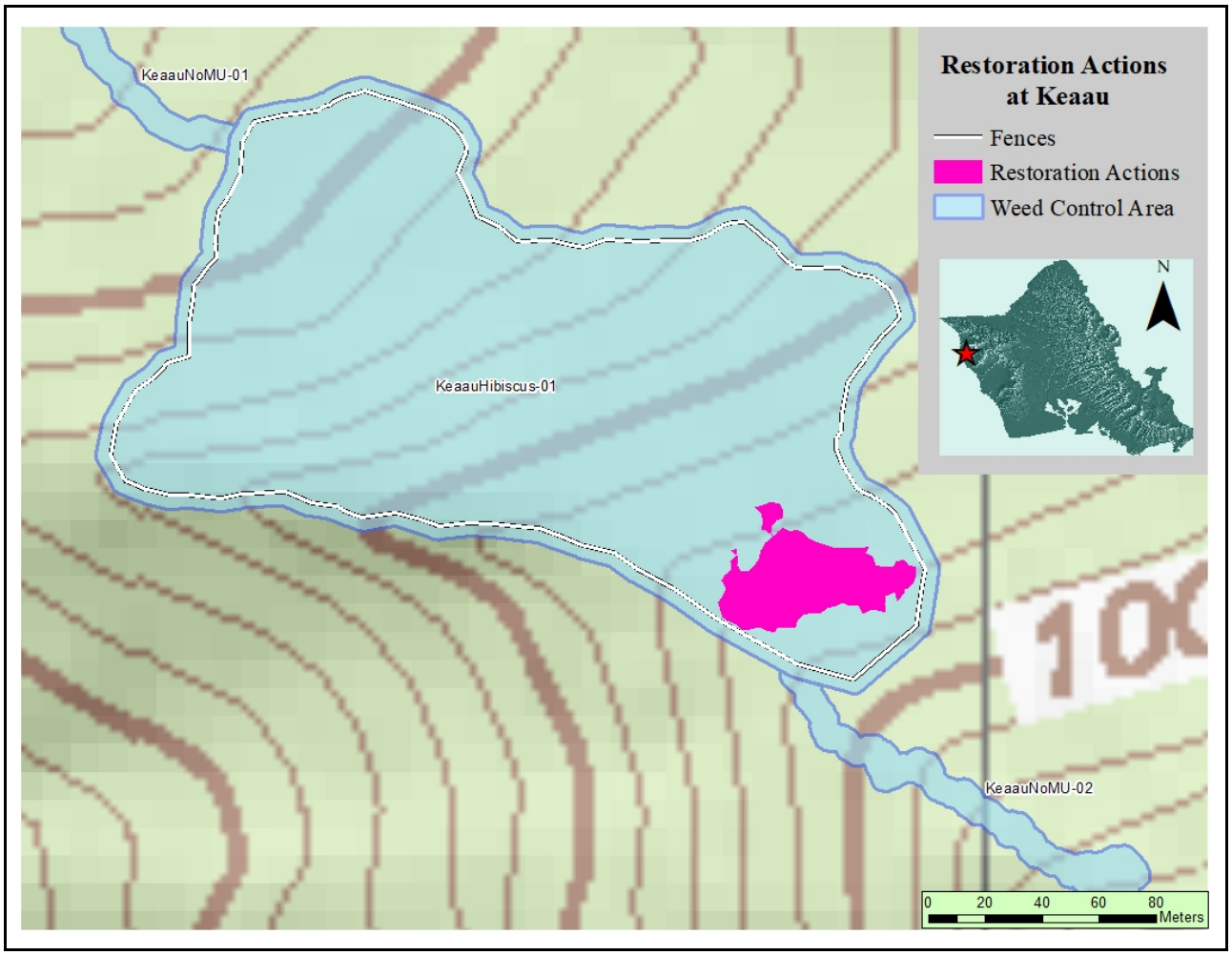

Figure 51. Map of 2019 Restoration Sites in respective WCAs in Keaau Hibiscus.

Table 31. Summary of 2019 Restoration Actions in Keaau Hibiscus.

MU	Restoration Action	# of plants	Area (m²)	Taxa
Keaau Hibiscus	Outplanting	469	1,583	*D. viscosa*, *Erythrina sandwicensis*, *Myoporum sandwicensis*, *Polyscias sandwicensis*, *Senna gaudichaudii*, *Sida fallax*
As Keaau is an extremely hot and dry area, outplants were planted around the *H. brackenridgei* subsp. *mokuleianus* reintroduction population with the intention of suppressing grass and creating a fuel break. This was an expansion of common native outplantings from previous years. Finding outplanting spots is becoming increasingly difficult as the terrain is rocky and soil is limited. In August of 2018, a fire started in Makaha and spread to this Keaau *H. brackenridgei* subsp. *mokuleianus* patch. Plants previously outplanted around the rare taxon were not yet large enough to create much of a fuel break, but staff noticed that the fire did not do as much damage in areas where they conducted intensive grass control.				

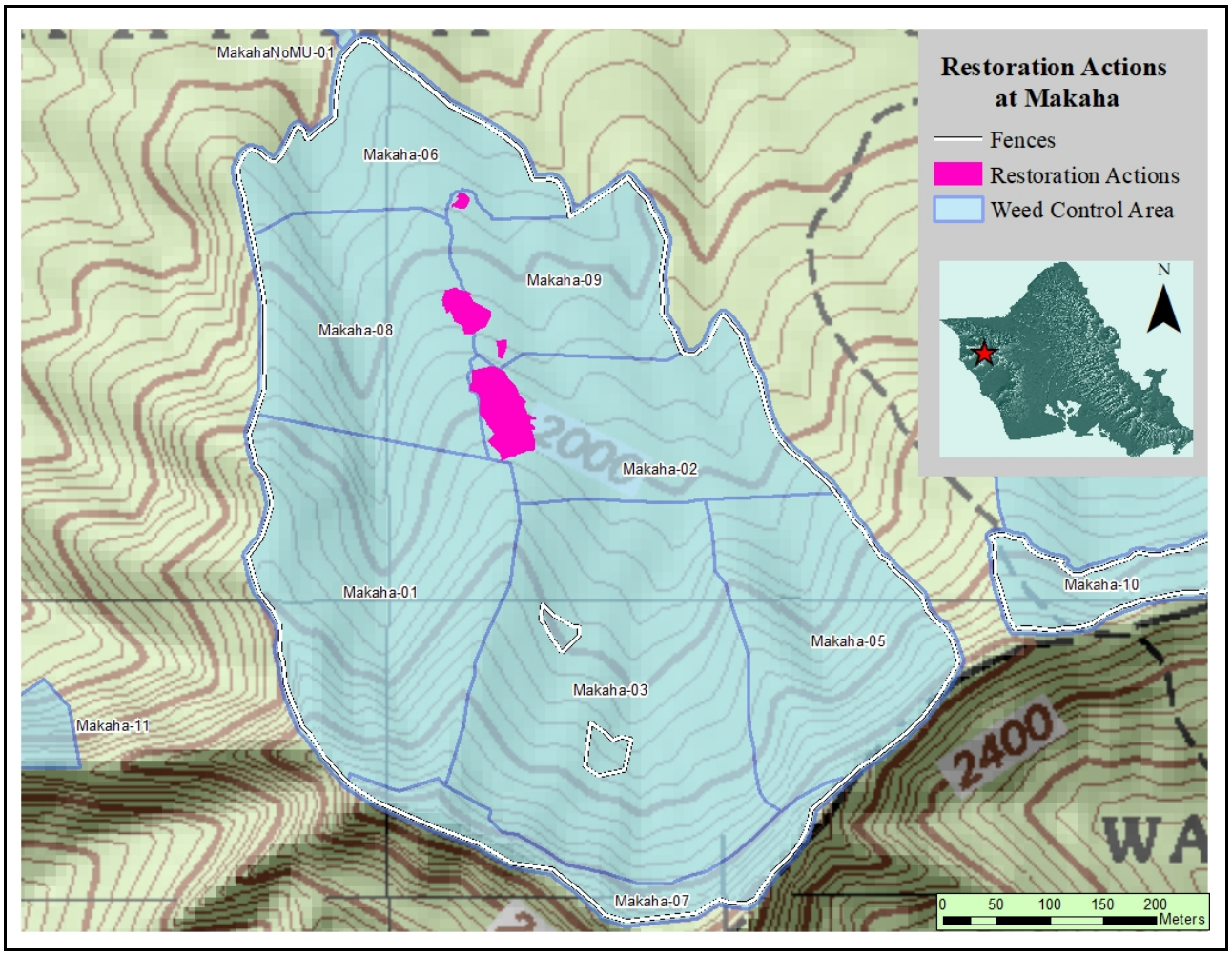

Figure 52. Map of 2019 Restoration Sites in respective WCA in Makaha I.

Table 32. Summary of 2019 Restoration Actions in Makaha I.

MU	Restoration Action	# of plants	Area (m²)	Taxa
Makaha I	Outplanting	535	3,879	*D. viscosa*, *K. affinis*, *P. sandwicensis*, *Eragrostis grandis*, *H. arnottianus* subsp. *arnottianus*, *M. strigosa*, *P. zeylanica*, *P. mariniana*
Outplanting efforts continued this year in three pre-existing restoration sites. Restoration also began at a new site, and continued to expand along this central ridge of Makaha. This year, *S. obovata* was outplanted at the oldest restoration site, "Giant Ohia." With an already well-established native canopy prior to restoration efforts, "Giant Ohia" was able to accommodate the reintroduction of rare plants just a few years post-clearing. For a more detailed discussion on "Giant Ohia", see the results of two-year monitoring in Appendix 3.11.				
Makaha I	SDT	N/A	2,368	*B. torta*, *C. chamissoi*, *M. strigosa*
Seed sows, divisions, and transplants were conducted in three aggressive restoration sites. Staff experimented with optimal planting methods of *M. strigosa* (based purely on casual observation) for distance between transplants, different substrate types, and level of weed growth within the selected area.				

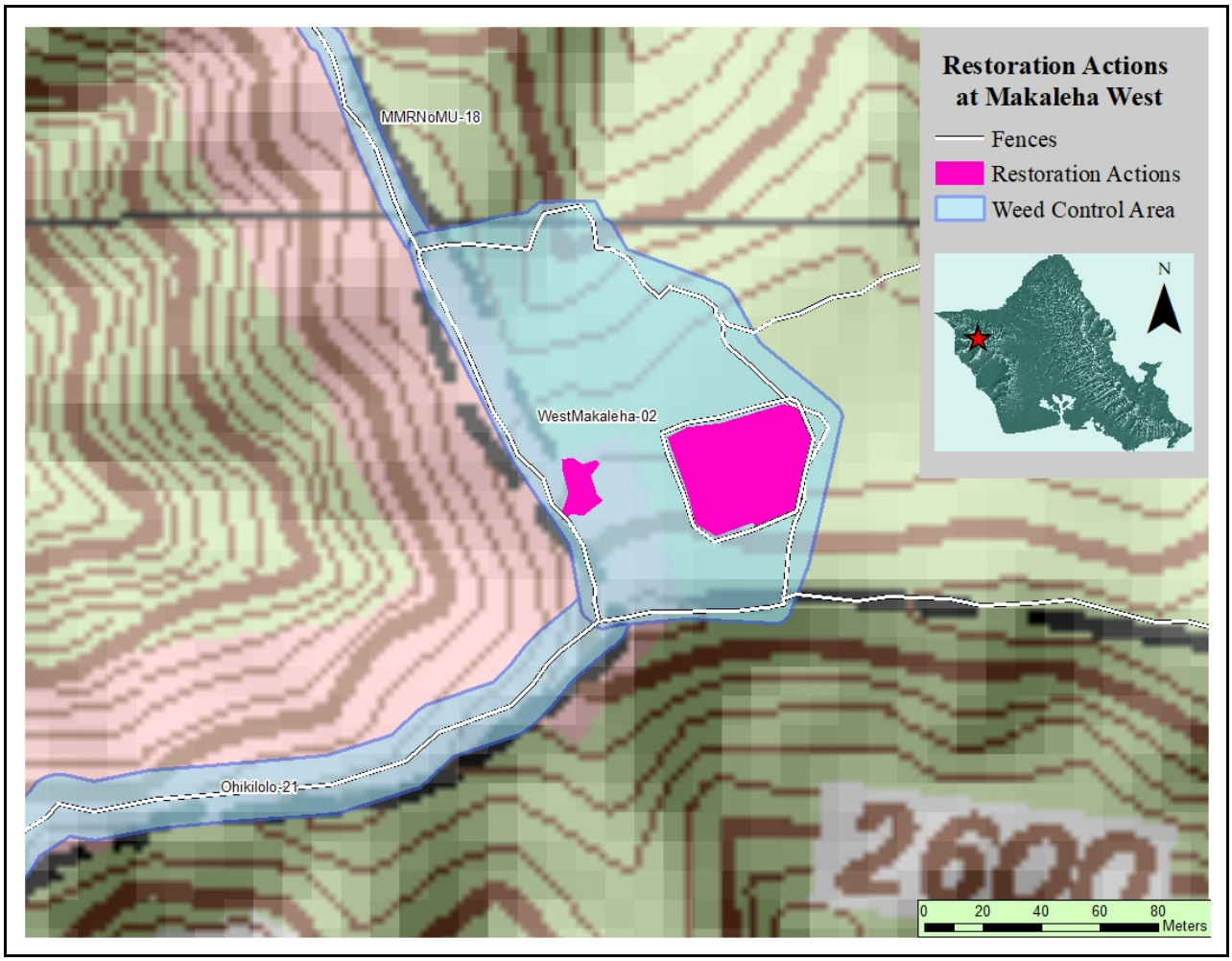

Figure 53. Map of 2019 Restoration Sites in respective WCAs in Makaleha West.

Table 33. Summary of 2019 Restoration Actions in Makaleha West.

MU	Restoration Action	# of plants	Area (m²)	Taxa
Makaleha West	Outplanting-MU restoration	65	198	*D. viscosa*
Volunteers and staff planted *D. viscosa* in a bowl where rigorous weed control efforts had been done recently. The area was previously a *P. cattleianum* stand, and has been the focus of weed control efforts for several years.				
Makaleha West	Outplanting-Snail enclosure	310	1,573	*A. platyphyllum*, *C. longifolia*, *K. affinis*, *M. macropus*, *Metrosideros polymorpha*, *Syzygium sandwicensis*
The Three Points Snail Enclosure was constructed this year; see chapter 5 for more detailed information on this project. Unlike the Palikea North snail enclosure, much of this enclosure is dominated by *M. polymorpha* canopy, but the understory is largely open and bare. The site is not yet ready for large-scale restoration, as it needs to remain somewhat open to facilitate *Euglandina rosea* searches. This year two separate outplanting events were done by volunteers and staff. Outplants were planted inside the Three Points snail enclosure in preparation for the eventual translocation of *Achatinella mustelina*.				

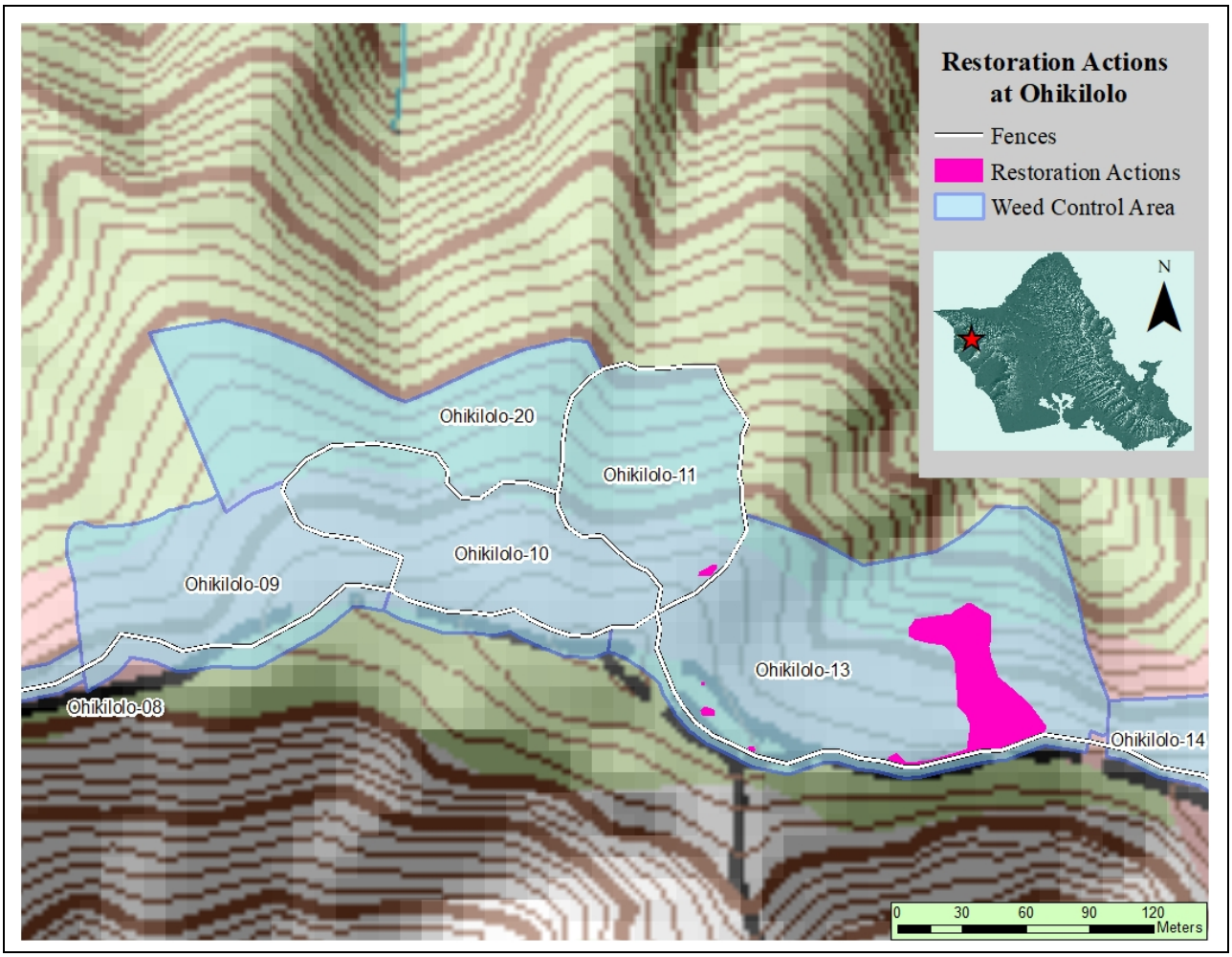

Figure 54. Map of 2019 Restoration Sites in respective WCA in Ohikilolo.

Table 34. Summary of 2019 Restoration Actions in Ohikilolo.

MU	Restoration Action	# of plants	Area (m^2)	Taxa
Ohikilolo	Outplanting	460	2,059	*A. koa*, *Lysimachia hillebrandii*, *M. polymorpha*, *S. chrysophylla*, *Wikstroemia oahuensis* var. *oahuensis*
Outplants were planted within the "Mauka Patch" in the bowl just before the population of *Tetramolopium filiforme*, around the Ohikilolo cabin, and also near the *Pritchardia kaalae* fence. Some plants were planted above an erosion scar and along the fenceline, for the purpose of re-vegetation and slope stabilization. Since these sites remain open, they have a tendency to fill in with weeds and grasses such as *Melinis minutiflora, Erigeron karvinskianus,* and *Rubus rosifolius;* staff continue to monitor these sites and conduct weed control as necessary.				

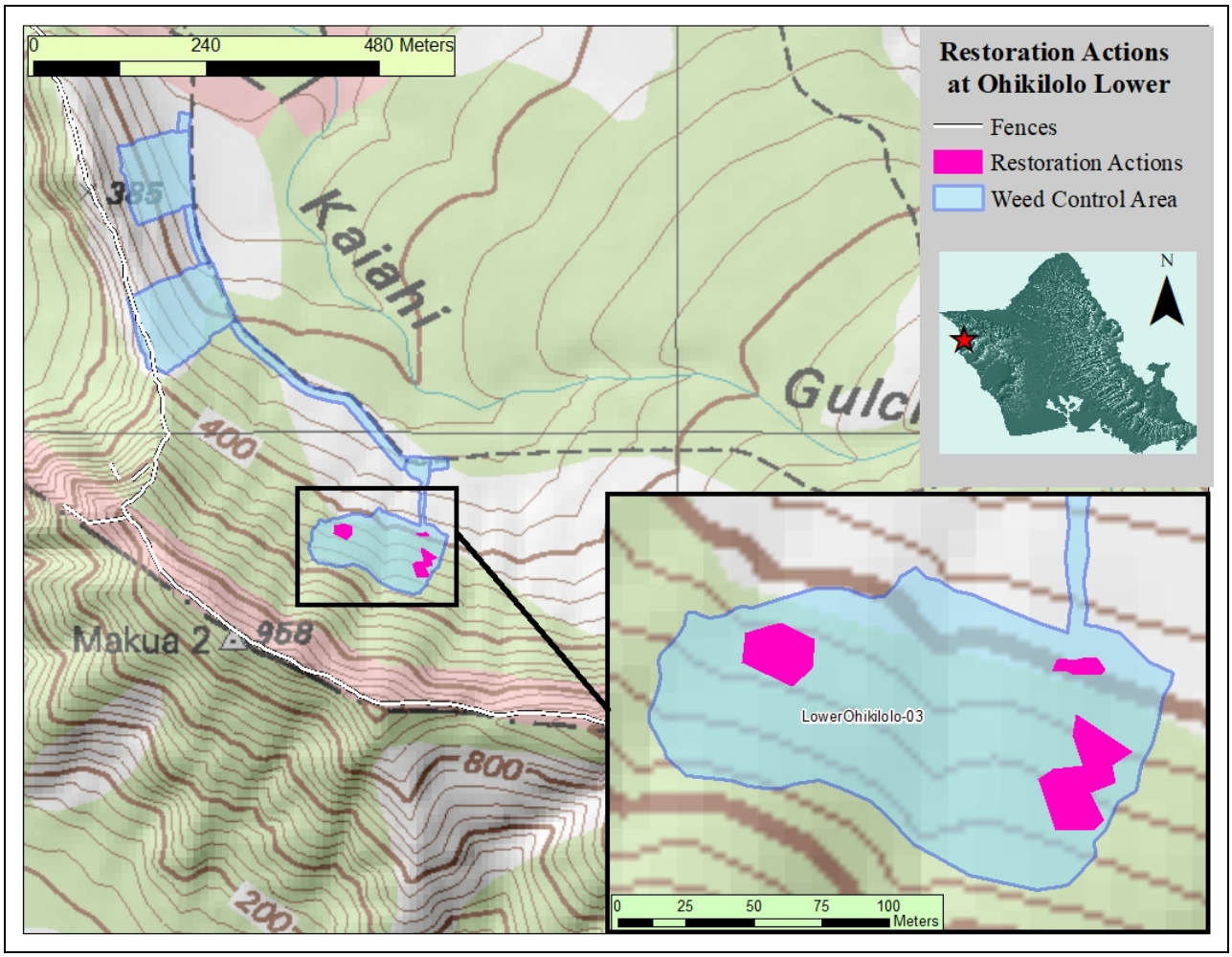

Figure 55. Map of 2019 Restoration Sites in respective WCA in Ohikilolo Lower.

Table 35. Summary of 2019 Restoration Actions in Ohikilolo Lower.

MU	Restoration Action	# of plants	Area (m²)	Taxa
Ohikilolo Lower	Outplanting	513	1,267	*Bidens cervicata*, *D. viscosa*, *E. sandwicensis*, *M. sandwicensis*
This year, restoration efforts continued to focus on the "Hibiscus Patch," with the dual goal of reducing grass cover to minimize fire risk, and improve the overall habitat quality of the site for *H. brackenridgei*. Outplants were placed in a *U. maxima* dominated bowl on the west of the site, in the hopes that they will compete favorably with the grass and suppress it. Other outplants were planted to the east, adjacent to last year's restoration efforts. *Dodonaea viscosa, E. sandwicensis,* and *M. sandwicensis* have proven to be successful in this patch when outplanted in previous years. One new addition to the species list was *B. cervicata*, which was added more so for habitat diversity than for weed suppression. *Myoporum sandwicensis* outplants have especially thrived in this patch, but since Myoporum thrips were detected on Oahu, this will no longer be a selected species for restoration projects.				

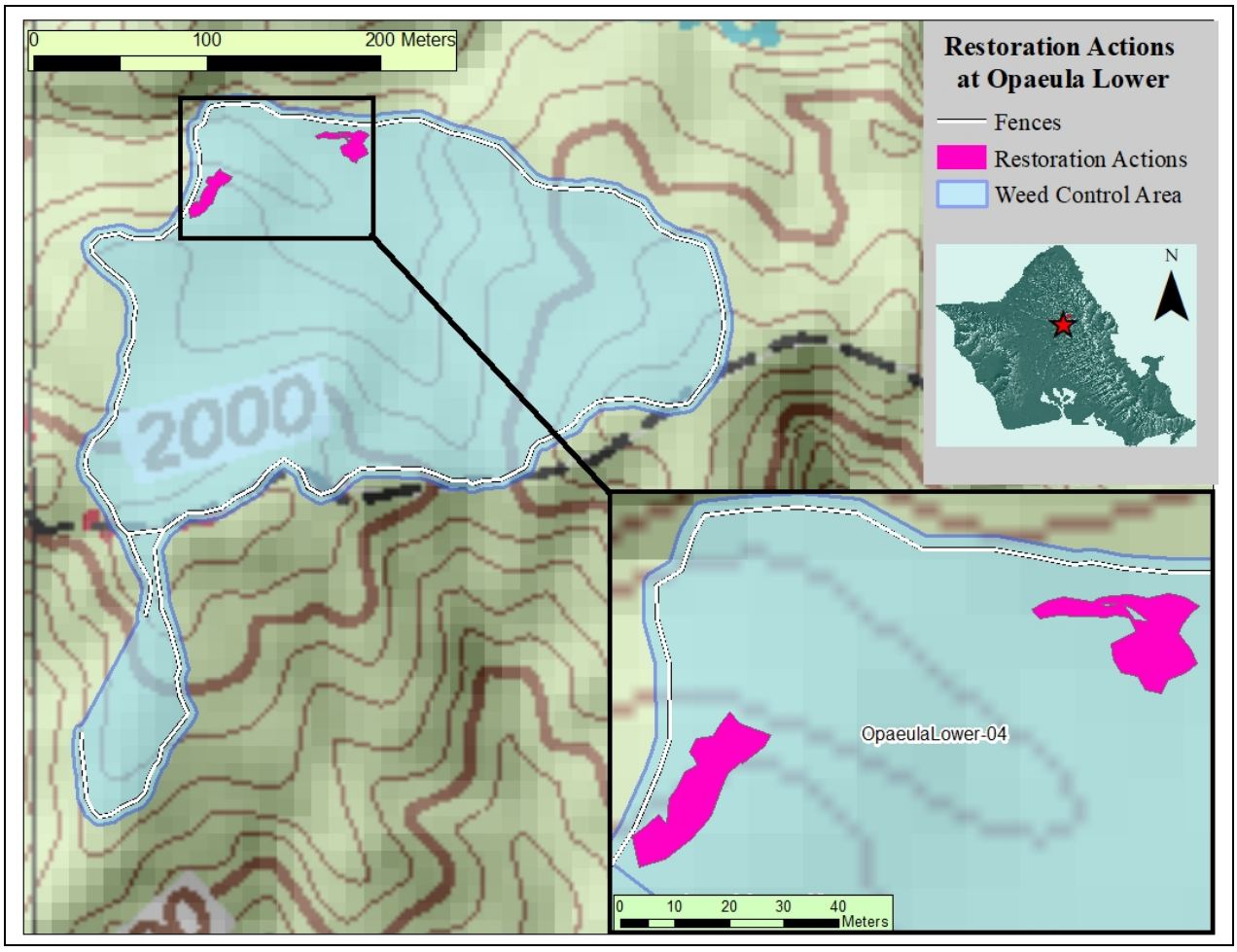

Figure 56. Map of 2019 Restoration Sites in respective WCA in Opaeula Lower.

Table 36. Summary of 2019 Restoration Actions in Opaeula Lower.

MU	Restoration Action	# of plants	Area (m²)	Taxa
Opaeula Lower	Outplanting	121	479	*A. koa*, *Cheirodendron trigynum*, *Clermontia kakaeana*, *Ilex anomala*
Restoration efforts expanded slightly this year, with the addition of a restoration site directly behind the weatherport. This site includes a grassy flat area and a small ridge dominated by *P. cattleianum* and some persistent native trees. Staff cleared and outplanted into this area, and hope to connect to the existing native plants. In addition, staff continued to plant around the *G. mannii* reintroduction site to improve the habitat.				

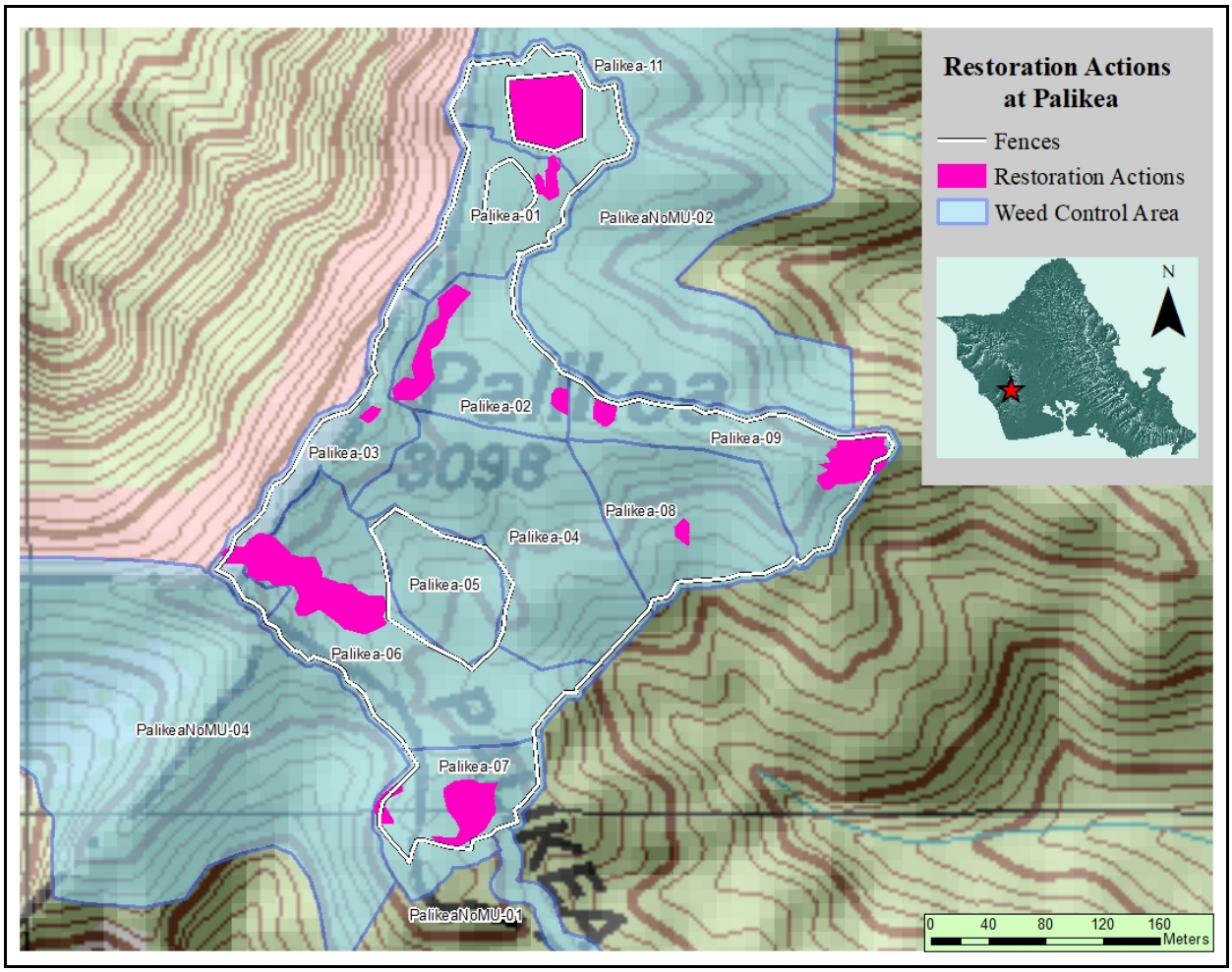

Figure 57. Map of 2019 Restoration Sites in respective WCAs in Palikea.

Table 37. Summary of 2019 Restoration Actions in Palikea.

MU	Restoration Action	# of plants	Area (m²)	Taxa
Palikea	Outplanting - MU restoration	1,064	7,413	*A. koa, B. torta*, *C. wahuensis*, *C. trigynum*, *Clermontia persicifolia*, *C. longifolia*, *D. viscosa*, *K. affinis*, *L. kaalae*, *P. albidus*, *P. confertiflorum*, *P. brunoniana*, *Psychotria hathewayi*, *P. mariniana*, *Scaevola gaudichaudiana*
Restoration efforts continued to expand at Palikea. A large number of outplants were planted at three aggressive restoration sites. At one site, plants were added to an area where a large landslide had recently occurred. The intention was to promote re-vegetation for erosion control. Staff did also notice native recruitment coming up on its own around this area. This particular outplanting event was classified as both MU restoration and *Drosophila* stabilization. At the other two restoration sites, outplantings were expanded on slopes that needed stabilization, and plants were filled in at any gaps where staff felt weeds could thrive. Excess *D. viscosa* plants from the greenhouse were planted at Puu Palikea where the slope used to be covered in *M. minutiflora.* The soil is very loose there and is right above the big landslide. The purpose of re-vegetating Puu Palikea is to prevent more landslides and erosion in the future. *Scaevola gaudichaudiana* was planted below the south Palikea snail exclosure as a field production site for fruit collection. Staff also planted a row of *D. viscosa* nearby as a WCA boundary indicator.				
Palikea	SDT- MU restoration	N/A	3,686	*B. torta*, *C. chamissoi*, *D. sandwicensis*, *N. exaltata* subsp. *hawaiiensis*, *P. albidus*, *P. brunoniana*
Ferns were transplanted in the new *Cyanea superba* subsp. *superba* reintroduction site for understory diversity and weed suppression. Fern transplants and seed sows were conducted at three aggressive restoration sites. Seed sows were often done in areas where grass was recently controlled.				

Table 37 (continued).

MU	Restoration Action	# of plants	Area (m^2)	Taxa
Palikea	Outplanting-Drosophila stabilization	520	1,206	*C. trigynum*, *C. persicifolia*, *C. longifolia*, *D. viscosa*, *K. affinis*, *L. kaalae*, *P. brunoniana*, *P. hathewayi*, *U. glabra*
As mentioned above, this particular outplanting event was classified as both MU restoration and *Drosophila* stabilization. The landslide spot discussed earlier is also *Drosophila* habitat with a large number of existing *U. glabra* and *U. kaalae*. To create shady habitat attractive to *Drosophila*, a variety of woody species were planted.				
Palikea	Outplanting-Snail enclosure	475	2,494	*A. platyphyllum*, *B. torta*, *C. trigynum*, *C. persicifolia*, *C. longifolia*, *Freycinetia arborea*, *I. anomala*, *K. affinis*, *L. kaalae*, *Luzula hawaiiensis*, *M. polymorpha* var. *glaberrima*, *Metrosideros polymorpha* var. *polymorpha*, *Microlepia speluncae*, *M. strigosa*, *Perrotettia sandwicensis*, *P. confertiflorum*, *P. hathewayi*, *P. mariniana*, *U. glabra*
Staff continued to fill in any open spots left after the large outplantings at Palikea North snail enclosure the previous year. One of the goals is to continue to increase native cover to shade out the weedy asters that thrive in open, sunny areas. The primary goal is to gradually create proper snail habitat across the entire enclosure for the future translocation of *Achatinella mustelina.* To this end, this year's efforts included a variety of snail host species; while some of these taxa are slow growing, they are critical to the success of this enclosure.				
Palikea	SDT- Snail enclosure	N/A	2,480	*B. torta*, *D. sandwicensis*, *P. albidus*, *S. gaudichaudiana*
Seeds of various species were scattered throughout the entirety of the Palikea North snail enclosure, particularly in dry, open spots. Divisions of *D. sandwicensis* were also brought in to the snail enclosure from surrounding area, but staff were conscious of the importance of cleaning plants to avoid introducing *E. rosea.*				

Figure 58. Staff member outplanting *D. viscosa* at Puu Palikea.

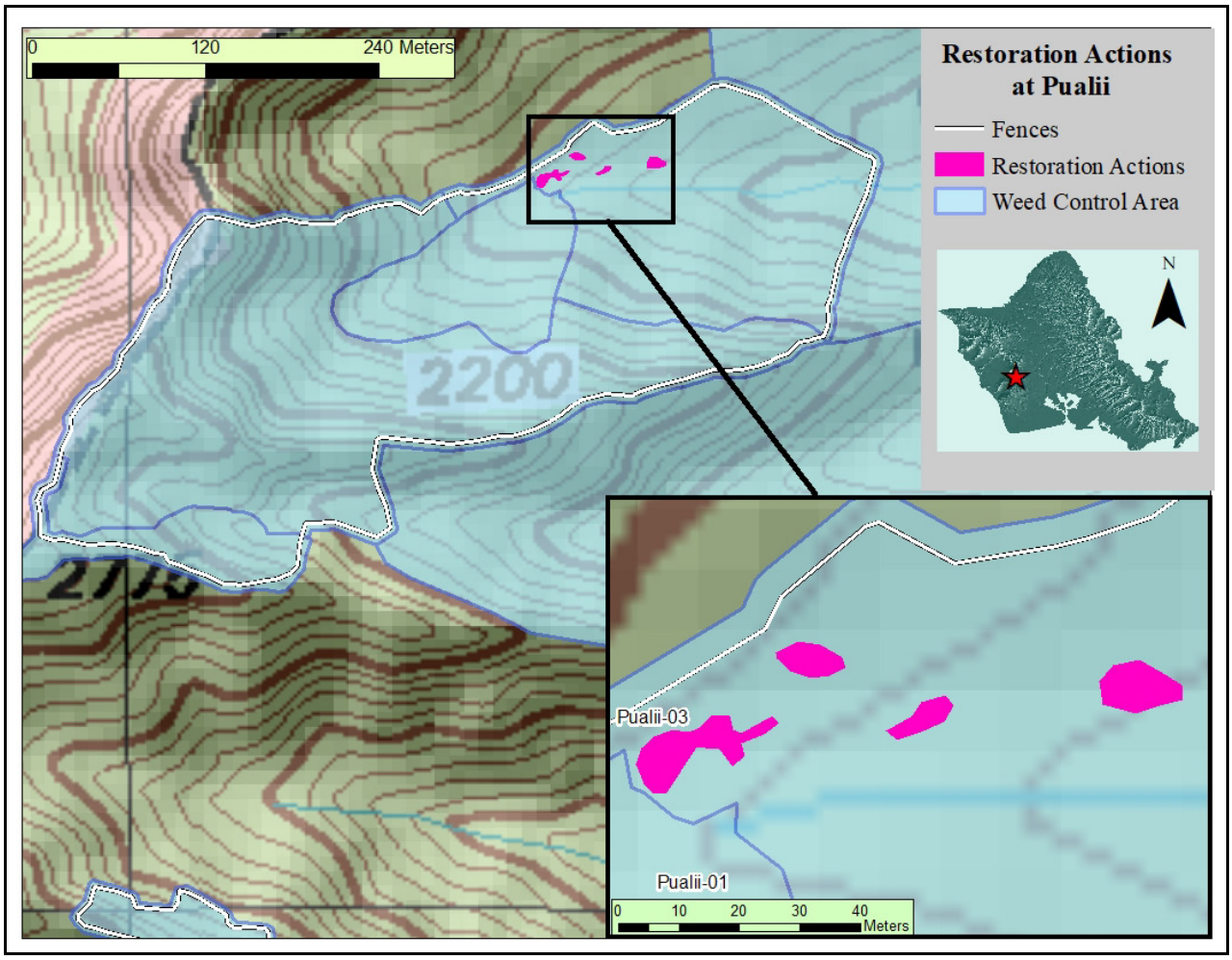

Figure 59. Map of 2019 Restoration Sites in respective WCAs in Pualii.

Table 38. Summary of 2019 Restoration Actions in Pualii.

MU	Restoration Action	# of plants	Area (m²)	Taxa
Pualii North	Outplanting-Drosophila stabilization	98	293	*U. glabra*
Staff and volunteers planted *U. glabra* in a bowl at the very back of the WCA, in an area weeded by staff and volunteers. Outplants were also planted on the rocky slopes below it, in a side drainage, and in an open bowl that formerly had an abundance of *U. maxima* and *N. exaltata* subsp. *hawaiiensis*. Staff will have to monitor the success of these plants as they were planted in very rocky areas, and were also in dibbles and not in the greatest condition at the time of planting.				

3.7.2 Common Native Species Collection

Utilizing genetically appropriate and ecologically adapted native plant materials is essential to successful restoration efforts. However, identifying genetically appropriate plant materials for restoration actions are rather complicated and requires the understanding of genetics of adaptation through reciprocal transplant experiments or common garden studies, used to develop empirical seed zones. A seed zone is an area within which native plants can be transferred with minimal risk of maladaptation to their new location. In many instances restoration practitioners do not have access to seed zones developed through genetic research and must try and match seed source and planting location as closely as possible. In the absence of genetic research to inform seed zones or seed transfer guidelines, provisional seed zones are a useful decision making tool for the movement and use of native plant materials. These provisional zones are delineated by integrating climate and ecological factors known to affect plant adaptation and can be used to guide plant material transfer until species specific genetic research is available to delineate empirical seed zones.

OANRP has adopted the Oahu Seed Zone Map developed by Alex Loomis (Duke University) and Matt Keir (DOFAW). These provisional seed zones were initially demarcated to inform seed collections and use of *Metrosideros* spp. plant materials in response to Rapid Ohia Death (ROD), however, they can also be applied to other common native plant species. The Oahu seed zones were delineated by overlaying Oahu moisture zones, biogeographic regions, HRPRG population reference codes, and by incorporating local expert knowledge (pers. comm., M. Keir). The map includes 14 distinct zones (Figure 60). OANRP is currently utilizing these provisional zones as a tool to guide common native seed collection goals and to inform the appropriate transfer of plant materials to restoration sites until more species specific genetic information or empirical seed zones become available.

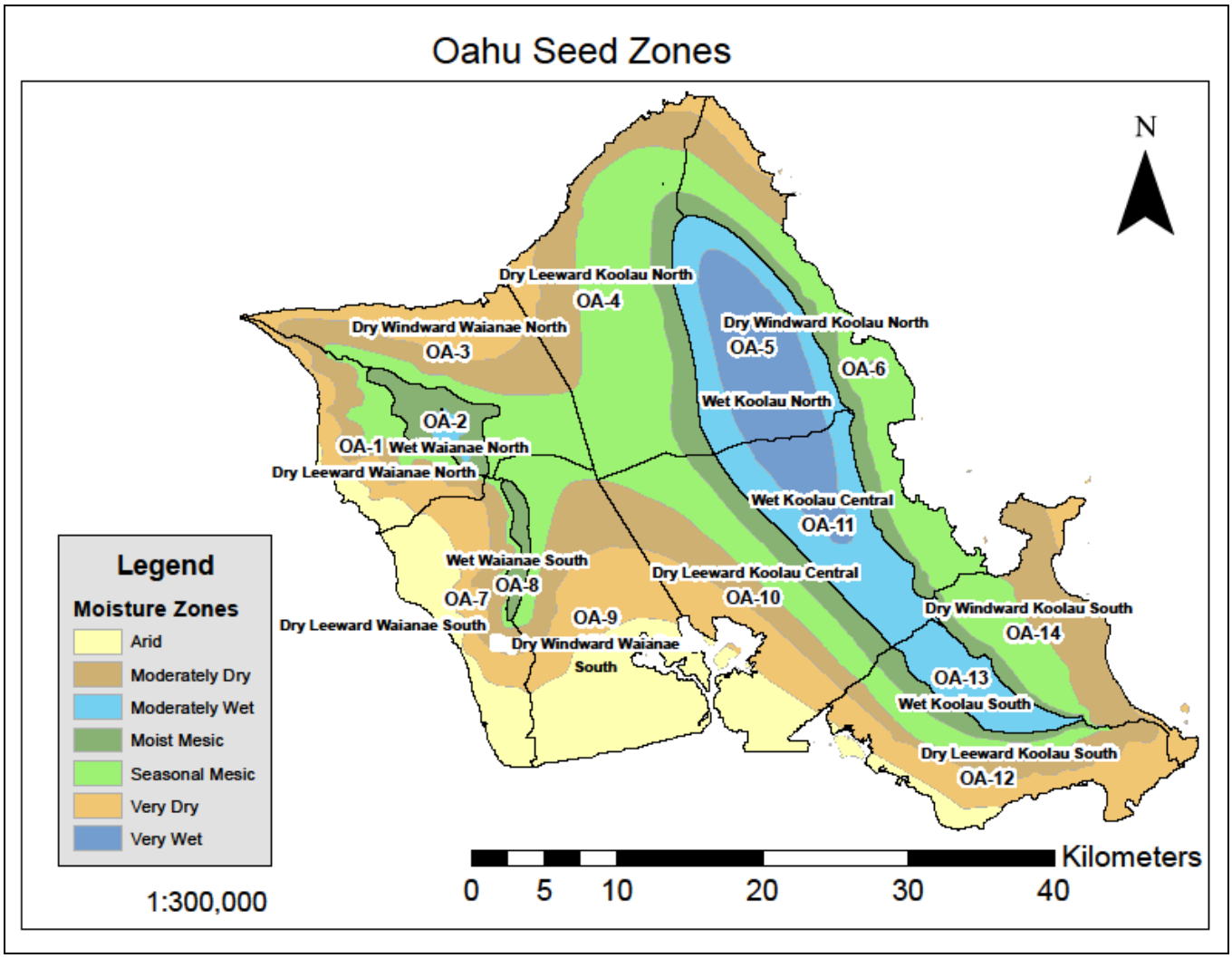

Figure 60. Map of Oahu Seed Zones.

This year efforts continued to target and collect seed from an increased diversity of common native species and populations in support of ongoing restoration actions in high priority weed control areas. Collection targets were informed by the list of 57 restoration species developed in 2017 (Table 39). This list includes species commonly used in OANRP restoration outplantings and seed sows, as well as species not used in past actions, but which exhibit traits beneficial to OANRP restoration goals. Common native seed collections are processed and curated in the OANRP Seed Lab until they are withdrawn for the propagation of restoration plant materials or to develop seed storage and/or propagation protocols for those species where this information is lacking. The "Propagation Protocol Developed" column lists "S" or "V" if successful protocols for seed and vegetative propagation are being used and "No" if propagation protocols are unknown.

Table 39. Summary of taxa for OANRP restoration projects.

Taxa	Family	Seed Storage Possible	Propagation Protocol Developed	Total # of Seeds in Storage	Total Seed Accessions Currently in Storage	# of Seed Accessions Collected in 2019	Seed Zones Represented
Acacia koa	Fabaceae	Yes	S	29527	33	11	OA- 1,2,5,8
Alyxia stellata	Apocynaceae	Yes	S	502	5	7	OA-1,2,8
Antidesma platyphyllum	Phyllanthaceae	Yes	S,V	1495	3	1	OA-2
Asplenium kaulfussii [a]	Aspleniaceae	Unknown[b]	No[c]	NA	1	1	OA-2
Bidens torta	Asteraceae	Yes	S,V	499403	17	2	OA-1,2,8
Carex meyenii [a]	Cyperaceae	Yes	No	20303	4	1	OA-2
Carex wahuensis	Cyperaceae	Yes	S	88021	13	6	OA-1,2,8
Cheirodendron trigynum	Araliaceae	Yes	S	10122	5	0	OA-5,8
Chenopodium oahuense	Chenopodiaceae	Yes	S	134560	6	1	OA-1,3
Cibotium spp.[a]	Dicksoniaceae	Unknown[b]	S	NA	2	1	OA-2,5
Coprosma foliosa[a]	Rubiaceae	Yes	S	75	1	0	OA-2
Coprosma longifolia	Rubiaceae	Yes	S	27136	10	6	OA-2,8
Cyperus hillebrandii var. *hillbrandii* [a]	Cyperaceae	Unknown	No	0	0	0	----------
Cyperus polystachyos [a]	Cyperaceae	Unknown[b]	No[c]	155535	2	1	OA-2,8
Deparia prolifera[a]	Athyriaceae	Unknown	V	NA	0	0	----------
Dianella sandwicensis	Xanthorrhoeaceae	Yes	S,V	25310	9	4	OA-2,8
Diplazium sandwichianum [a]	Athyriaceae	Unknown	No	NA	0	0	----------
Dodonaea viscosa	Sapindaceae	Yes	S	220529	24	6	OA-1,2,3,8
Doodia kunthiana[a]	Blechnaceae	Unknown[b]	S	NA	2	0	OA-2
Eragrostis grandis	Poaceae	Yes	S	15922	4	1	OA-2,8
Eragrostis variabilis	Poaceae	Yes	S	7088	1	0	OA-3
Erythrina sandwicensis	Fabaceae	Yes	S	290	4	1	OA-1
Freycinetia arborea [a]	Pandanaceae	Yes	S		5	1	OA-8
Gahnia beecheyi [a]	Cyperaceae	Yes	No[c]	14601	6	1	OA-2,8
Hibiscus arnottianus subsp. *arnottianus*	Malvanceae	Yes	V,S	364	2	4	OA-2
Ilex anomala	Aquifoliaceae	Yes	S	7697	6	0	OA-2,5,8
Kadua acuminata	Rubiaceae	Yes	S	0	0	0	----------
Kadua affinis	Rubiaceae	Yes	S	50317	19	5	OA-2,8
Labordia kaalae	Loganiaceae	Yes	S	1515	2	0	OA-8
Luzula hawaiiensis	Juncaceae	Yes	S,V	158	1	0	OA-2
Machaerina angustifolia [a]	Cyperaceae	Yes	No	0	0	0	----------

Table 39 (continued).

Taxa	Family	Seed Storage Possible	Propagation Protocol Developed	Total # of Seeds in Storage	Total Seed Accessions Currently in Storage	# of Seed Accessions Collected in 2019	Seed Zones Represented
Melicope oahuensis [a]	Rutaceae	Unknown	No	0	0	0	----------
Metrosideros polymorpha	Myrtaceae	Yes	S	2816655	68	10	OA-1,2,5,8
Microlepia speluncae [a]	Dennstaedtiaceae	Unknown[b]	S,V	NA	2	2	OA-8
Microlepia strigosa var. *strigosa*	Dennstaedtiaceae	Yes	V,S	NA	7	5	OA-2,8
Myoporum sandwicense	Scrophulariaceae	Yes	S,V	5174	4	3	OA-1,3
Myrsine lessertiana	Primulaceae	Yes	S	114	2	5	OA-2,8
Nephrolepis exaltata subsp. *hawaiiensis* [a]	Nephrolepidaceae	Unknown	No	NA	0	0	----------
Nestegis sandwicensis	Oleaceae	Yes	S,V	0	0	2	OA-2
Perrottetia sandwicensis	Dipentodontaceae	Yes	V,S	915	01	1	OA-8
Pipturus albidus	Urticaceae	Yes	S,V	155106	4	2	OA-2,8
Pisonia brunoniana	Nyctaginaceae	No	S,V	0	0	0	----------
Pisonia sandwicensis [a]	Nyctaginaceae	No	V,S	0	0	0	----------
Pisonia umbellifera	Nyctaginaceae	No	V,S	0	0	0	----------
Planchonella sandwicensis	Sapotaceae	No	S	0	0	1	OA-2
Plumbago zeylanica	Plumbaginaceae	Unknown	V	0	0	0	----------
Polyscias sandwicensis [a]	Araliaceae	Yes	S	0	0	0	----------
Psychotria hathewayii	Rubiaceae	Yes	S	544	7	3	OA-2,8
Psychotria mariana	Rubiaceae	Yes	S	147	1	1	OA-2
Psydrax odorata [a]	Rubiaceae	Yes	S	596	2	2	OA-1,2
Pteris excelsa [a]	Pteridaceae	Unknown[b]	S	NA	1	1	OA-8
Rumex albescens	Polygonaceae	Yes	S	4260	3	0	OA-8
Santalum spp.[a]	Santalaceae	Yes	S	340	4	4	OA-2,8
Scaevola gaudichaudii [a]	Goodeniaceae	Yes	S	0	0	1	OA-8
Scaevola gaudichaudiana	Goodeniaceae	Yes	V,S	0	0	3	OA-2,8
Scaevola taccada	Goodeniaceae	Yes	S,V	0	0	0	----------
Sida fallax [a]	Malvaceae	Yes	S,V	4632	5	3	OA-1,2,8
Sophora chrysophylla	Fabaceae	Yes	S	3878	7	0	OA-1,2
Urera glabra	Urticaceae	Yes	S,V	2938	9	2	OA-8

[a] Native species targets for future restoration efforts

[b] Research underway to develop seed storage protocols

[c] Research underway to develop propagation protocols

3.7.3 Seed Production Plots Update

In September 2017, 1,498 *B. torta* individuals representing 30 founders from the upper elevations of the southern Waianae Mountains, seed zone OA-8 (Wet Waianae South), were planted from dibble pots at Kahua. There were some minor setbacks in plot establishment and growing conditions in the first year of production including compacted soil, hot and dry conditions, and pest infestations. However, most plants fared well and seed collection efforts have taken place from 2018 April 26 through 2019 May 22 from the plants that set fruit, totaling 240.25 grams of seed, approximately 187,665 seeds. This equates to 22,078 seeds per ounce. In the second year of production plants showed significant signs of decline following flowering and seed production, suggesting this species is a short-lived perennial or can only be established as a short term field crop.

In July 2018, 550 *C. wahuensis* dibbles representing 68 individual founders were also planted at Kahua. Seeds were harvested on 2019 April 17 and 2019 June 4, totaling 93.16 grams or 3.28 ounces of seed, approximately 61,312 seeds. This equates to 18,692.68 seeds per ounce. It is expected that the second year harvests will significantly surpass the first year harvest. Germination tests for both *B. torta* and *C. wahuensis* are currently underway and will be reported in the 2020 annual report.

In March and April 2019, 108 *S. gaudichaudiana* plants representing 50 individual founders were planted directly below the Palikea South snail enclosure to establish a field seed production plot for this species. Planting at this plot will continue until 100 individual founders are represented. Plans are also underway to establish a *B. torta* seed production plot at Kahanahaiki. Planting is scheduled for early November at the Black Wattle site.

Figure 61. Left: *C. wahuensis* seed production plot May 2019. Right: Processed seed harvested from Kahua.

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CHAPTER 4: RARE PLANT MANAGEMENT

4.1 PROJECT HIGHLIGHTS

During this reporting period, the Oahu Army Natural Resource Program (OANRP) outplanted a total of 1,499 rare plants representing 12 MIP and OIP taxa at Manage for Stability (MFS) reintroduction sites. In the last year, OANRP made 415 observations at *in situ* and outplanting sites of IP taxa. For a detailed taxon status summary see Appendix 4-1. Some of this year's highlights include:

- *Kadua degeneri* subsp. *degeneri* was outplanted into the Makaha and Ohikilolo Management Units (MU), where it was not historically present, to test the sites as new Population Units (PU) for this species. The stock for these outplantings was from the Central Makaleha and West Branch of East Makaleha PU. Each site was planted with 25 plants and initial monitoring showed 90% of outplants survived after six months. More plants will be added to these sites in the next few years.

- The Makaha outplanting site for *Dubautia herbstobatae* was expanded to include new habitat, with some individuals planted near established trails that do not require rappelling to access. This will allow for observation of outplants throughout the year while rodent, ungulate, and weed management actions are being carried out. Additionally, new founders and seed were collected from Ohikilolo *in situ* populations. Building on past efforts to determine the extent of self-incompatibility in this taxon and whether nursery stock can produce enough seed to meet genetic storage goals, multiple inter-population hand pollinations were conducted in June 2018 at the Kahua *inter situ* site using fresh pollen: WAI-A-3xMAK-B-1, MAK-B-55x WAI-A-4, MAK-B-50xWAI-A-4, and MAK-B-4xWAI-A-4. All seed collected from these crosses in July 2018 were tested for viability and all tests resulted in 0% germination. In addition, cut-tests were performed on seed collected from open pollinated flowers. Of the 415 seed sampled only 0.7% had filled seeds. A 2007 pollination study in the OANRP greenhouse (Keir and Weisenberger 2007) resulted in 5.95% germination for inter-population crosses and 0% for open pollinated flowers. The results of these pollination studies would suggest that this species is strongly self-incompatible, especially given that the founders (MAK-A and B and WAI-A) currently in the living collection are likely genetically similar being that these Population Reference Sites (PRS) are in close proximity to one another. Future pollination efforts will include more founders from more geographically distant PU sites to increase the chance of viable seed production.

- Following the fire that burned most of the Keaau Hibiscus MU, surveys of the *Hibiscus brackenridgei* subsp. *mokuleianus* population revealed eight new founders from which OANRP was able to collect seed and cuttings.

- The *Hesperomannia oahuensis* reintroduction site in Pualii North MU had many individuals with high flower set, some with over 60 flowering heads and/or buds per tree. Hand pollinations were moderately successful, as staff were able to collect 116 filled seeds based on the initial "press" test. However, tracking pollination crosses at each individual by labeling buds remains challenging. In the future, staff plans to use water resistant jeweler's tags versus the bird bands used in the past.

- *Nototrichium humile* plants at Kahua *inter situ* site continue to produce abundant flowers and fruit. Staff were able to make seed collections well in excess of 50 viable seeds, from nine founders representing ALI-C and one founder representing IMU-A. These results are not yet

reflected in the database as initial germination tests are still ongoing, currently with a minimum viability of 66%. In addition, staff were able to make multiple bulk collections for use in developing processing protocol and for storage and longevity research.

- Access to Ohikilolo and Lihue MU, and Makua Valley, was restricted in the past year due to the presence of unexploded ordnance, which limited monitoring and collections for some species.

- An endophyte trial was conducted to test the effect of a microbial slurry of an endophytic mycoparasitic yeast, *Moeziomyces aphidis*, to control *Neoerysiphe galeopsidis* (powdery mildew) on two species of endangered plants, *Phyllostegia kaalaensis* and *Plantago princeps* var. *princeps*. This trial was not successful at controlling powdery mildew, as both the control and test plants had over 90% mortality after one month.

- *Alectryon macrococcus* var. *macrococcus* outplantings at Kahua and Koko Crater Botanical Garden *inter situ* sites are producing new growth and over 90% of plants have survived. OANRP plans to add more plants from the excess living collection this season.

- Included in the appendices are five-year Management Plans for *K. degeneri* subsp. *degeneri* and *Kadua parvula* (Appendices 4-2 and 4-3). In addition, Five-year Genetic Storage Management Plans, to address the current status of living collections and strategies to meet genetic storage goals in the future, for *Eugenia koolauensis*, *Flueggea neowawraea*, and *Gardenia mannii* are included (Appendices 4-4, 4-5, and 4-6).

- The Executive Summary Appendix ES-2 contains instructions for utilizing the database to generate reports on each species explaining Taxon Status, Threat Control, and Genetic Storage Summary Tables.

4.2 THREAT CONTROL SUMMARY

The Threat Control Summary for each Implementation Plan (IP) taxon is included as Appendix 4-7 and shows the current status of fence construction and removal of pigs and goats from Management Units, invasive plant, rat and slug control, and preventing wildfire. “Yes,” “No,” or “Partial” is used to indicate the level of threat management. Additionally “Partial” management includes a percentage based upon the number of mature plants being protected.

Ungulate threat control and fence repairs are ongoing, and all areas known to be free of ungulates are listed as “Yes.” Population Units (PU) where ungulates have been seen inside the fence or where it is uncertain if they are still present are listed as “Partial” for threat control until it is confirmed that ungulates have been removed.

Weed control continues at most MU, and weeds are a threat to all taxa in all PU. See Chapter 3 for a more detailed description of weeding efforts and long term plans. The weed control status was determined by overlaying weed control efforts with IP taxa population sites in GIS. A 50m radial buffer around IP taxa sites was created. If weed control efforts covered the entire buffer for a particular population reference code, it was counted as full management, and assigned a ‘Yes. If only part of the buffer was weeded, it was assigned a ‘Partial’. Of the 129 MFS PU, 104 PU receive ‘Partial’ weed control status. This is an increase of 15% from the previous year.

Rats are considered a potential threat to most IP taxa, as they consume fruit, as well as damage stems and seedlings of plants. Rat control continued around many PU in the last year in large grids around entire

MU and in smaller grids targeting individual populations. Although rats potentially threaten 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 20 of the 39 taxa in the MIP and OIP and are partially or fully controlled at 46% of population sites. This is an increase of 5% from the previous year. Much of the rat threat management has included the addition of more GoodNature A24 automatic resetting traps which improves time efficiency and control of rats around rare taxa.

Slugs are a threat to seedling survival and recruitment of many native plants and they are noted as a threat to 25 of the 39 MIP and OIP taxa. Slugs are currently controlled at 37% of population sites, which is unchanged from the prior year (49 PU). Decisions on where to initiate control are based on site accessibility, slug impact on recruitment, and the presence or absence of native snails. These variables will be taken into account when planning future outplantings and site selection for IP taxa (see Chapter 9 for more discussion of slug control).

4.3 GENETIC STORAGE SUMMARY

The Genetic Storage Summary for each IP taxon is included in Appendix 4-8. Every year, OANRP collects propagules from IP taxa for *ex situ* genetic storage. The amount of propagules needed to meet these goals was pre-determined in the MIP and OIP (Adamski and Chambers 2018). In general, each wild plant (up to 50 plants from each PU) needs: 50 viable seeds (as estimated at the time of collection), three ex-plants/plants held in tissue culture, or a living collection in the nursery. This year, OANRP reported only the collections that have not expired, *i.e.* have not been stored for longer than the species re-collection interval.

This year there were 72 PU that reached their storage goal, representing 1201 founder plants and 29 taxa. This is an increase of six PU and 211 plants from last year. Among PU where goals are not 100% complete, there has been progress with an additional 1,386 founder plants in 125 PU. There were no significant declines in genetic storage goals between 2018 and 2019. This year's increase in PU meeting storage goals is owed largely to cloning efforts for the living collection, which resulted in an increased number of founders with three clones. Also, the *Hibiscus brackenridgei* subsp. *mokuleianus* Keaau PU met its genetic storage goal with the addition of eight founders in 2019.

4.4 LITERATURE CITED

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CHAPTER 5: *ACHATINELLA MUSTELINA* MANAGEMENT

5.1 BACKGROUND

In this chapter, *Achatinella mustelina* management by the Oahu Army Natural Resources Program (OANRP) is outlined for the next three years: July 2019-June 2020, July 2020-June 2021, and July 2021-June 2022. *A. mustelina* across the Waianae mountain range are divided into Evolutionary Significant Units (ESUs) based on genetic differences and are each managed separately. There are a total of eight managed populations within the six ESUs (Figure 1). ESU-B and ESU-D have two managed populations each because of their large geographic spread. The Makua Implementation Plan (MIP) set a goal of 300 snails in each of the eight managed populations. The snail populations within the ESUs are divided into Population Reference Sites (PRSs). Each PRS is a discrete grouping of snails. There are many PRSs in each ESU given the fragmented status of the populations.

5.1.1 Threat Control

In PRSs designated as Manage for Stability (MFS) threats such as predators, ungulates, and weeds are controlled. Predators include black rats (*Rattus rattus*), rosy wolf snails (*Euglandina rosea*), and Jackson's chameleons (*Trioceros jacksonii xantholophus*). Tables in this chapter show the Threat Control Summary for each MFS PRS and the current status of fence construction and removal of ungulates from Management Units (MUs), weed, rat, *E. rosea,* and Jackson's chameleon control. The terms "Yes," "No," or "Partial" are used to indicate the level of threat management.

Ungulate threat control and fence repairs are ongoing, and all areas known to be free of ungulates are listed as "Yes." PRSs where ungulates have been seen inside the fence or where it is uncertain if they are still present are listed as "Partial" for threat control until it is confirmed that ungulates have been removed.

Weed control continues at most MUs and weeds are a threat to all taxa in all PUs. See Chapter 3 for more detailed description of weeding efforts and long term plans. For wild PRSs weed control status was determined by overlaying weed control efforts with *A. mustelina* population reference sites in GIS. A 50 meter radius buffer around PRSs were created. If weed control efforts covered the entire buffer for a particular population reference code, it was counted as full management and assigned a 'Yes.' If only part of the buffer was weeded, it was assigned a 'Partial'. If none of the buffer was weeded, it was assigned a 'No.' All snail enclosures were listed as 'Yes' as weed control has implemented across the entire enclosure.

Rats are considered a potential threat to all PRS, as they are known to prey on native snails. Rat control continued around many PRSs in the last year, in large grids around entire MUs and in smaller grids targeting individual populations. In all ESUs rat control is ongoing. See ESU tables in each section for the threat control status at individual PRSs. Much of the rat threat management has included the addition of more GoodNature A24 automatic resetting traps (A24s) which improves time efficiency and control of rats.

There is no control for *E. rosea* or Jackson's chameleons. At the snail enclosures, these predators are excluded from the enclosures by physical barriers and quarterly searches are conducted therefore, the threat control is 'Yes' and quarterly sweeps for predators are conducted at all enclosures. At all wild populations, there is no threat control therefore is listed as 'No.'

5.1.2 Progress towards MIP Goals

OANRP has made significant progress toward MIP goals. At six of the eight managed populations in the ESUs, the goal of 300 snails is met (Table 1). In ESU-E, most snails have been removed from the wild and are currently in captive rearing or have been released into the Palikea North snail enclosure. Although more than 200 snails from ESU-E are currently held in captive rearing, there are less than 300 snails left in the wild, therefore the MIP goal is not met for this population. At three ESUs (ESU-A, D, and F) snail enclosures are used to protect PRSs from all threats. Populations within all snail enclosures are stable or increasing.

At MFS PRSs snails are monitored on a regular basis by Timed Count Monitoring (TCM) and Ground Shell Plot (GSP) surveys. TCM is used to quantify long-term population trends and assess if the population is self-sustaining over time. During a TCM, staff search a specified area for a specified number of person-hours. This will ensure that data is comparable across surveys. At the enclosures, TCM is conducted quarterly while wild PRSs are monitored every one to two years. TCM data represents a subsample of the population, as not all snails are detectable at any one time. For GSP surveys, the ground is searched in a designated plot and all shells are collected and counted to detect mortality. This method also ensures comparable data across surveys, and is used to assess trends in mortality.

Construction is complete for the enclosure at Palikea North for ESU-E although the native habitat has not yet been fully restored. A temporary enclosure has been constructed within the larger enclosure and snails have been introduced. The rest of the enclosure is continuing to undergo ecosystem restoration. Construction of the enclosure at Makaleha West for ESU-B was completed in September 2018 and snail reintroductions are planned for November 2019. Plans are being developed for an additional enclosure at Kaala for ESU-C and the re-building of the Kahanahaiki enclosure. With the completion of these additional enclosures and successful translocation efforts, all six ESUs will be protected from predators.

Figure 1. Map of Six ESUs, current and historic *A. mustelina* sites, and snail enclosures locations The two enclosures within the Palikea MU are shown zoomed in the box on the left due to their close proximity to each other.

Table 1. Recent counts of ESU wild populations and snail enclosure status 2019.

ESU	# Snails in MFS PRS	# Snails in No Mgmt. PRS	# Total Snails	# Snails in Enclosures	Current or Future Enclosure Location
A	285	42	327	232 (Kahanahaiki) 53 (Pahole)	Kahanahaiki/Pahole
B1	309	11	320	0	West Makaleha†
B2	502	188	690	0	West Makaleha†
C	302	10	312	0	Kaala†
D1	761	41	802	761	Hapapa
D2	254	10	264	0	Hapapa
D*	0	391	391	0	Hapapa
E	86	21	107	33	Palikea North✯
F	332	11	343	284	Palikea South

*Snails from this portion of the ESU are not managed for stability in the MIP
†Enclosure not yet constructed or not yet ready for snail introductions
✯Snails were released into a temporary enclosure within the larger enclosure until the entire enclosure is ready for snail introductions

5.2 ESU-A

Figure 2. *Achatinella mustelina* from ESU-A.

Figure 3. Map of ESU-A.

5.2.1 Management History and Population Trends

Spanning parts of Kahanahaiki Gulch and Pahole Natural Area Reserve, there are 14 PRSs at ESU-A (Figure 3). Two snail enclosure sites (Kahanahaiki and Pahole) are designated as Manage For Stability (MFS) (Table 2) and the remaining PRSs are No Management (NM) (see OANRP 2017a for a list of No Management sites). The MFS PRSs have 285 counted snails and almost all the NM PRS snails have been moved into one of the two snail enclosures. OANRP manages the snail enclosure at Kahanahaiki (MMR-A), and the State of Hawaii's Department of Land and Natural Resources' Snail Extinction Prevention Program (SEPP) manages the Pahole snail enclosure (PAH-B).

Euglandina rosea are assumed to be ubiquitous across the habitat and quarterly sweeps are conducted inside the enclosure to ensure that *E. rosea* have not breached the enclosure walls. Two rat tracking tunnels and two A24s have been installed inside the Kahanahaiki enclosure and are maintained at four month intervals. A24s and Ka Matesnap traps (Ka Mate Traps Ltd) are used both inside and outside of the Pahole enclosure. *Trioceros jacksonii xantholophus* are not common in this area and none have been since 1999 at the camp grounds at Peacock Flats.

Table 2. ESU-A population structure and threat control summary for MFS PRSs.

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control				
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina rosea	Jackson's Chameleon
Achatinella mustelina												
ESU: A	**Pahole to Kahanahaiki**											
MMR-A Kahanahaiki Exclosure	Manage for stability	232	2019-04-17	182	33	17	0	Yes	Yes	Yes	Yes	No
PAH-B Pahole Exclosure	Manage for stability	53	2019-05-28	24	16	13	0	Yes	Partial	Yes	Yes	No
	ESU Total:	285		206	49	30	0					

Size Class Definitions

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

*= Snails (past or current) have been Trans-Located to another wild site.

= 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.

MMR-A Kahanahaiki Enclosure PRS: The 76m² enclosure at Kahanahaiki is the focus of OANRP's management within ESU-A, and all of the observed snails in Kahanahaiki have been translocated to the enclosure to maximize threat protection. Monitoring of the *A. mustelina* population within the enclosure occurs quarterly, and includes TCM and GSP monitoring. Results are shown in Figure 4 below.

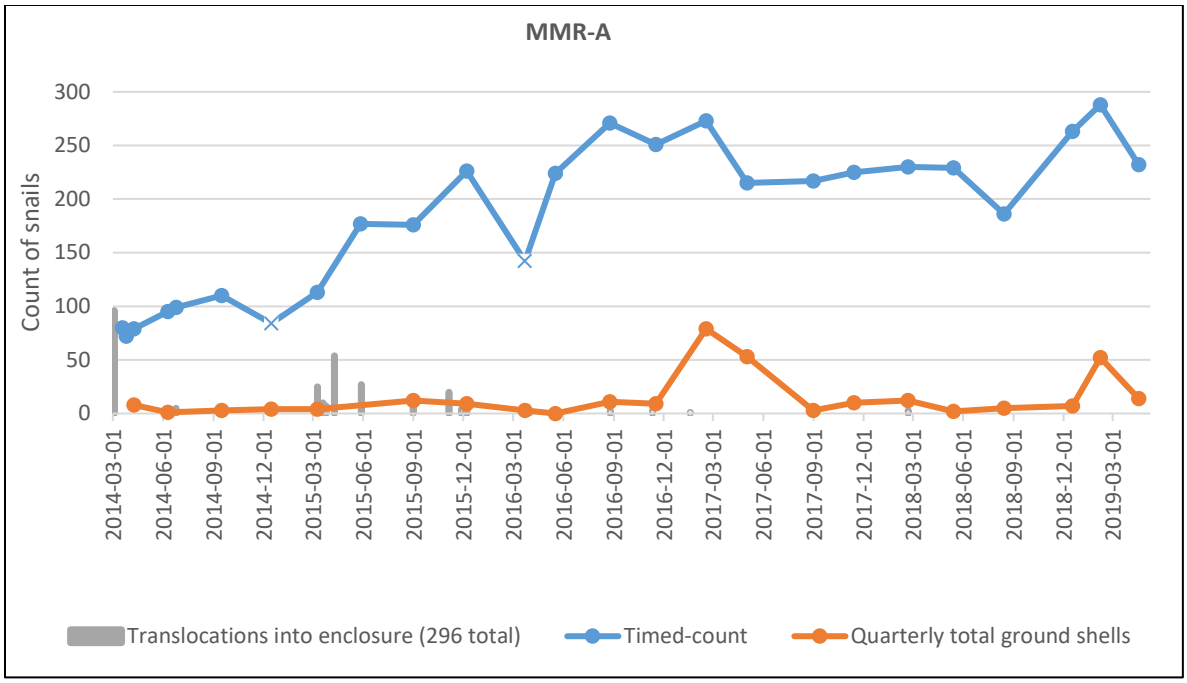

Figure 4. Quarterly timed-count monitoring (TCM) and ground shell counts for *A. mustelina* in the Kahanahaiki snail enclosure from the first quarter of 2014 to the second quarter of 2019, with numbers of snails translocated into the enclosure over time. "X" indicates low confidence data points (poor weather, binoculars not used, inconsistent observer skill).

On 9 January 2019 a rat carcass was found under an A24 inside the enclosure. Upon inspection of the enclosure, two potential entry points were found: a rat tunnel under the wall and a split in the corner of a wall. The rat was dissected and no *A. mustelina* shells were found inside the stomach. The two holes were repaired. One possible rat eaten shell was recovered from inside the enclosure.

Also on 9 January 2019 during an *E. rosea* sweep of the enclosure, staff found a large number of empty *A. mustelina* shells throughout the enclosure and around the outside perimeter (Table 3) and live snails on the ground. The average number of shells found within a quarter is eight shells, but 24 shells were found in one day. These shells did not have evidence of rat predation. This is similar to the event that occurred in January 2017 (OANRP 2017a). Staff continued to find fresh shells for the next few weeks; searches ceased in March after we stopped finding ground shells. As with the event in 2017, there is no known cause for the die-off. No *E. rosea* were found inside the enclosure although one could have gotten in through the rat tunnel or the split in the wall mentioned above. The timed-count on February 2nd had the highest number of snails observed at 288 so it does not appear that this event had a negative impact on the population.

Table 3. Number of fresh shells found between January and March of 2019. Does not include old shells found during the search.

Date	# of Small Shells	# of Medium Shells	# of Large Snails	Total Shells
2019-01-09	5	3	16	24
2019-01-15	2	3	5	10
2019-01-30	0	4	1	5
2019-02-06	1	2	3	6
2019-03-07	1	1	5	7
2019-03-25	0	0	0	0
Total	**9**	**13**	**30**	**52**

PAH-B Pahole Enclosure PRS: The enclosure at Pahole is the focus of SEPP's management in this area. Construction of the new enclosure has been completed and *E. rosea* removal is underway. Monitoring results of the PAH-B enclosure population are shown below in Figure 5.

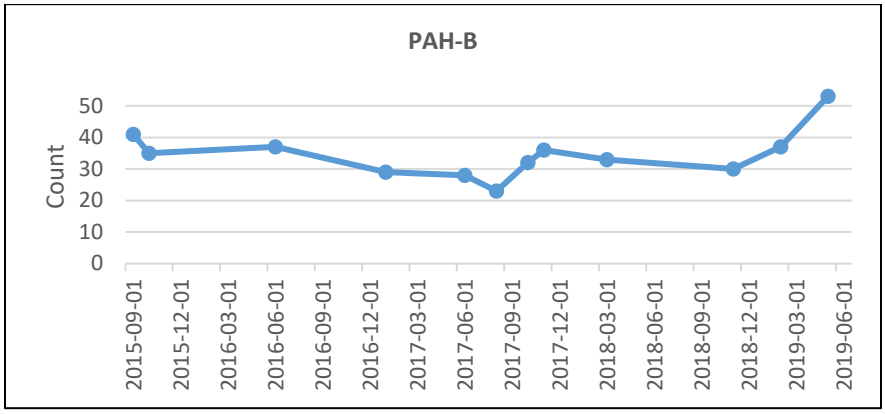

Figure 5. Quarterly timed-count monitoring (TCM) conducted by SEPP for *A. mustelina* in the Pahole snail enclosure since 2015.

5.2.2 Future Management

OANRP will continue to work according to the monitoring plan (Table 4) for MMR-A. Monitoring will be completed as outlined in the Three-Year Action Plan below (Table 5). Any snails remaining outside will be moved to the enclosure. Threat control will continue inside and around the existing enclosures, including tracking tunnels and A24s for *R. rattus*, and searches for *E. rosea* and *T. jacksonii xantholophus*. Weed control and habitat improvements will continue cautiously to ensure there are no impacts on the snails. Staff continue to note and repair structural damages to the enclosure that could potentially allow predators access to *A. mustelina*. Plans are being developed to rebuild the enclosure within the next two years.

Table 4. ESU-A Monitoring Plan for MFS PRS.

PRS	Monitoring Type	Monitoring Interval	Survey Years	Comments
MMR-A Kahanahaiki Enclosure	TCM	quarterly	all	Conduct night TCM with 2 personnel 2 hours each, for 4 person-hours total; quarterly
	GSP	quarterly	all	Search the ground inside the entire enclosure and around outside perimeter where canopy from trees inside hang over the wall.

Table 5. Three Year Action Plan for ESU-A.

PRS	MIP YEAR 16 July 2019 – June 2020	MIP YEAR 17 July 2020 – June 2021	MIP YEAR 18 July 2021 – June 2022
MMR-A Kahanahaiki Enclosure	• Implement monitoring plan • Rat control • Install Intelesense Remote Monitoring system for electric barrier • Maintain enclosure and monitor for predators • Improve habitat via weed control	• Implement monitoring plan • Rat control • Maintain enclosure and monitor for predators • Improve habitat via weed control and restoration planting • Re-build enclosure	• Implement monitoring plan • Rat control • Maintain enclosure and monitor for predators • Improve habitat via weed control and restoration planting

5.3 ESU-B

Figure 6. *Achatinella mustelina* from ESU-B.

ESU-B covers a large geographic area and is therefore divided into two units: ESU-B1 along the north-facing slopes of the southern Makua rim and ESU-B2 along the north-facing rim of the Mokuleia Forest Reserve. The subdivision of ESU-B has a genetic basis (see Makua Implementation Plan 2001). Management of ESU-B1 is focused at Ohikilolo. ESU-B2 includes the gulches in Makaleha. Management of ESU-B2 is focused at Makaleha West.

Figure 7. Map of ESU-B1 and the 3 Points snail enclosure at Makaleha West.

5.3.1 ESU-B1 Management History and Population Trends

There are two MFS PRSs within ESU-B1: MMR-E (Ohikilolo Mauka) and MMR-F (Ohikilolo Makai) (Figure 7 and Table 6). A combined total of 309 snails were observed during the most recent TCM at these PRSs.

The Ohikilolo MU remains unique in that *E. rosea* have never been recorded in the area. *Trioceros jacksonii xantholophus* have also never been seen. Rats are controlled across the known snail habitat with an A24 trap grid.

Table 6. ESU-B1 population structure and threat control summary for MFS PRSs.

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control				
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina rosea	Jackson's Chameleon
Achatinella mustelina												
ESU: B1 Ohikilolo												
MMR-E Ohikilolo Mauka	Manage for stability	57	2018-05-09	37	14	6	0	Yes	Partial	Yes	No	No
MMR-F Ohikilolo Makai	Manage for stability	252	2016-07-20	160	68	24	0	Yes	Partial	Yes	No	No
	ESU Total:	309		197	82	30	0					

Size Class Definitions

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

*= Snails (past or current) have been Trans-Located to another wild site.

= 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.

MMR-E Ohikilolo Mauka PRS: No monitoring of this population was conducted this year. The next scheduled monitoring will be in the second quarter of 2020. The last monitoring of the PRS was in May 2018 when 57 live snails were counted and three ground shells found. (Figure 8).

MMR-F Ohikilolo Makai PRS: No monitoring of this population was conducted this year. A full census monitoring of the PRS will be conducted every four years because a 46 person-hour effort is required. The last full census monitoring of the PRS was conducted in July 2016 and 252 live snails were counted. (Figure 8). The next monitoring is scheduled for 2020. A shorter eight person-hour TCM will be conducted every two years between the full censuses and was last conducted on 9 May, 2018 and 99 snails were counted.

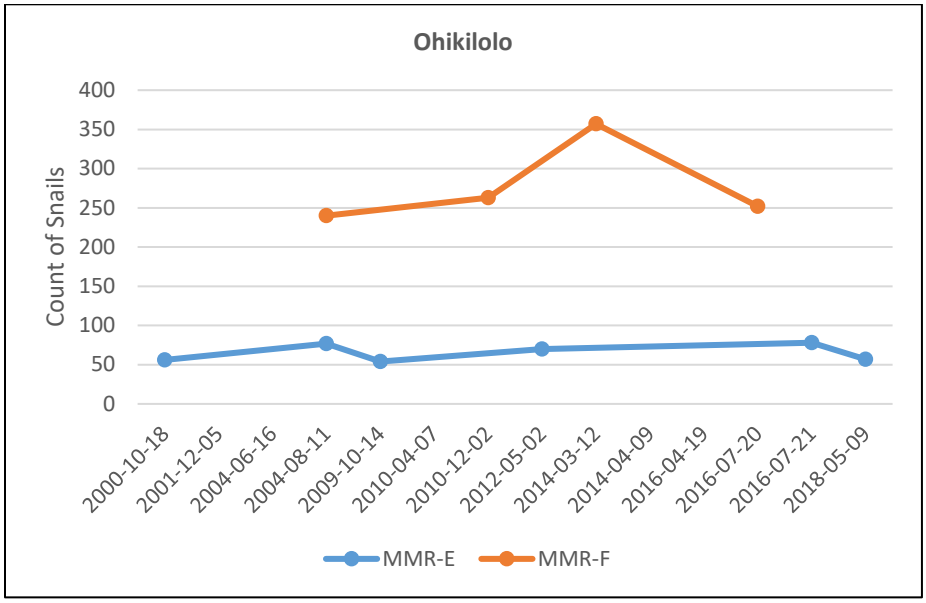

Figure 8. Timed counts of MMR-E and MMR-F during the day.

No Management PRS: At MMR-H (Ohikilolo Koiahi) staff plan to make a fifth and final trip next year to search for any remaining snails that will be translocated to MMR-F. The MMR-J Lower Makua camp population will be surveyed again when staff is allowed access to the area. All other NM PRSs are not a management priority as numbers are low and previous monitoring data are old.

5.3.2 ESU-B1 Future Management

OANRP will continue monitoring as indicated below (Table 7). Rat control and the use of tracking tunnels will continue across the MU (Table 8). Searches for *E. rosea*, and *T. jacksonii xantholophus* during other work will also continue. Fifty snails from MMR-F will be moved into the enclosure at West Makaleha along with snails from ESU-B2 to increase the genetic diversity of the population within the enclosure (Appendix 5-1).

Table 7. ESU-B1 monitoring plan for MFS PRS.

PRS	Monitoring Type	Monitoring Interval	Survey Years	Comments
MMR-E Ohikilolo Mauka	TCM	Every 2 years	2020, 2022	Eight person-hours day survey with binoculars
	GSP	Annual	all	GSP MMR-E-1
MMR-F Ohikilolo Makai	TCM	Every 2 years	2022	TCM during the day with binoculars.
	TCM	Every 4 years	2020	46 person-hours day TCM with binoculars
	GSP	Annual	all	GSP MMR-F-4

Table 8. Three Year Action Plan for ESU-B1.

PRS	MIP YEAR 16 July 2019 – June 2020	MIP YEAR 17 July 2020 – June 2021	MIP YEAR 18 July 2021 – June 2022
MMR-E Ohikilolo Mauka	• Implement monitoring plan • Rat control	• Implement monitoring plan • Rat control	• Implement monitoring plan • Rat control
MMR-F Ohikilolo Makai	• Implement monitoring plan • Rat control • Translocate 50 snails to enclosure at Makaleha West	• Implement monitoring plan • Rat control	• Implement monitoring plan • Rat control
MMR-H Ohikilolo Koiahi	• Survey for remaining snails • Translocate to MMR-F		
MMR-J Lower Makua camp		• Survey for remaining snails • Consider translocation to MMR-F	

5.3.3 ESU-B2 Management History and Population Trends

Figure 9. Map of ESU-B2.

There are two MFS PRSs within ESU-B2, both located below the Kaala Road: LEH-C (Culvert 69) and LEH-D (Culvert 73) (Figure 9 and Table 9). Together these PRSs have 502 observed snails. There are ten NM-PRSs, many of which have not been surveyed for many years. Numbers have likely declined at these sites. Currently rats are controlled with A24s at LEH-C along the ridge crest and also at LEH-D. While *E. rosea* are assumed present throughout ESU-B2, *T. jacksonii xantholophus* have not been observed. The goat population and accompanying habitat damage has increased over the last several years. With the recent completion of the Kaala Road fence, and additional strategic fencing currently in construction for the upper Makaleha area, aggressive goat and pig control is needed to eliminate populations as their impacts will now be in a more concentrated area.

Table 9. ESU-B2 population structure and threat control summary for MFS PRSs.

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**											
LEH-C	Manage for stability	378	2016-12-31	267	99	12	0	No	Partial	Yes	No	No
East Branch of East Makaleha (culvert 69)												
LEH-D	Manage for stability	124	2019-04-18	83	36	5	0	No	No	Yes	No	No
East Branch of East Makaleha (culvert 73)												
	ESU Total:	502		350	135	17	0					

Size Class Definitions

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

*= Snails (past or current) have been Trans-Located to another wild site.

= 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.

LEH-C East Branch of East Makaleha Culvert 69 PRS: The last monitoring of this population was conducted by OANRP staff in 2016 and 378 snails were observed. There is not a suitable site here for a GSP because most of the snails are found while on rappel and the area in general is very steep. A subset of snails from this population will be translocated to the Makaleha West enclosure (see Appendix 5-1).

LEH-D East Branch of East Makaleha Culvert 73 PRS: This area is also very steep with a predominant *Dicranopteris linearis* understory and thus is determined to be inappropriate for GSP monitoring. TCM will be performed annually. The last monitoring of the population occurred in April 2019 and a total of 124 snails were observed (Figure 10). A subset of snails from this population will be translocated to the Makaleha West enclosure.

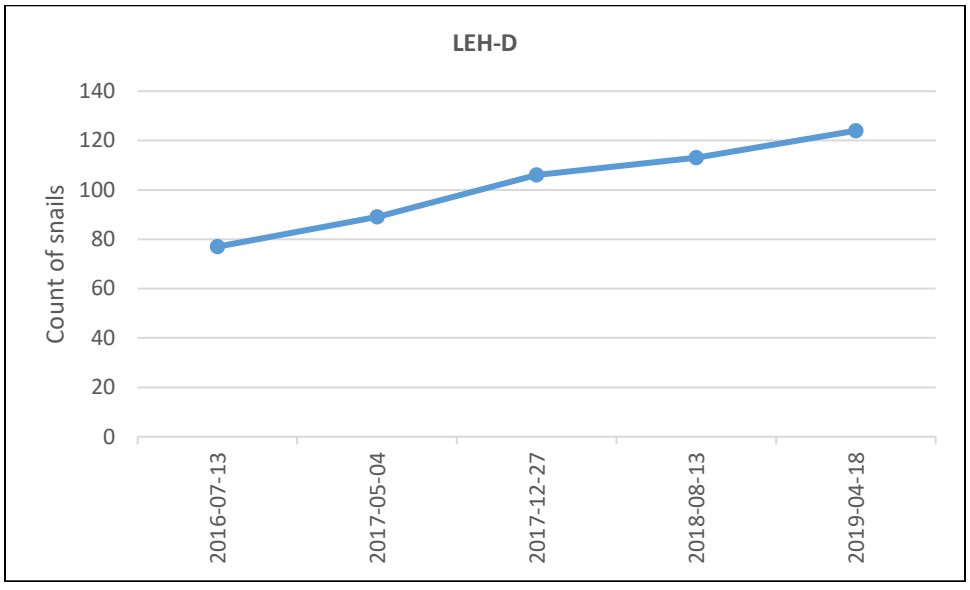

Figure 10. Timed counts at LEH-D.

LEH-L 3 Points PRS: The Makaleha West snail enclosure at 3 Points was completed, and a translocation plan was prepared (Appendix 5-1). Restoration actions were initiated with a number of common taxa outplants in April 2019. *Euglandina rosea* removal efforts are underway. Baseline vegetation monitoring was completed (Appendix 5-2) to track progress towards vegetation cover goals in the restoration plan (OANRP 2018a). A study was completed to address concerns that a few of the trees in the enclosure were dying as a result of soil compaction (Appendix 5-3). The 3 Points PRS will be designated as an MFS PRS once translocations begin. There are no *A. mustelina* inside of the enclosure currently.

No Management PRS: All snails from the ten NM PRSs will be moved into the Makaleha West enclosure. These sites will be visited prior to translocation to get an updated population size which will aid in the planning of future translocations.

5.3.4 ESU-B2 Future Management

Translocations to the Makaleha West enclosure will begin as early as November 2019 pending the removal of all *E. rosea* from within the enclosure. Since June 2018, a total of 202 person hours have been spent removing 66 *E. rosea* from inside the enclosure. The enclosure will be considered clear of *E. rosea* after seven consecutive searches with no *E. rosea* found inside the enclosure, per *E. rosea* search protocol detailed in the restoration plan.

OANRP will conduct monitoring as outlined below (Table 10). Rat control will continue at LEH-C (Culvert 69) and LEH-D (Culvert 73) (Table 11).

Table 10. ESU-B2 Monitoring Plan for MFS PRS.

PRS	Monitoring Type	Monitoring Interval	Survey Years	Comments
LEH-C East Culvert 69	TCM	Every 2 years	2020, 2022	Conduct night TCM for 5 person-hours, and day TCM for 18 person-hours in steep areas of site.
LEH-D East Culvert 73	TCM	Annual	All	Conduct day TCM for 4 person-hours.
LEH-L 3 Points	TCM	Quarterly	All	Conduct day TCM for 2-person hours
	GSP	Quarterly	All	

Table 11. Three Year Action Plan for ESU-B2.

PRS	MIP YEAR 16 July 2019 – June 2020	MIP YEAR 17 July 2020 – June 2021	MIP YEAR 18 July 2021 – June 2022
LEH-C East Culvert 69	• Implement monitoring plan • Rat control • Translocate snails to 3 Points enclosure	• Implement monitoring plan • Rat control • Translocate snails to 3 Points enclosure	• Implement monitoring plan • Rat control • Translocate snails to 3 Points enclosure
LEH-D East Culvert 73	• Implement monitoring plan • Rat control • Translocate snails to 3 Points enclosure	• Implement monitoring plan • Rat control	• Implement monitoring plan • Rat control
LEH-L 3 Points	• Begin snail re-introductions into the enclosure • Implement monitoring plan • Rat control	• Implement monitoring plan • Rat control	• Implement monitoring plan • Rat control
NM PRS	• Translocate snails to 3 Points enclosure		

5.4 ESU-C

Figure 11. *Achatinella mustelina* from ESU-C.

Figure 12. Map of ESU-C.

5.4.1 ESU-C Management History and Population Trends

There are two MFS PRSs with 335 observed snails at ESU-C: SBW-A (North Haleauau Hame Ridge) and SBW-W (Skeet Pass) (Table 12). There are several NM PRSs that have very few total observed snails and have not been monitored recently. OANRP conducts rat control at both MFS PRSs. *Euglandina rosea* are present across the ESU. *Trioceros jacksonii xantholophus* are not often seen across the Lihue MU, however, distribution is not well known.

Table 12. ESU-C population structure and threat control summary.

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: C	**Schofield Barracks West Range, Alaiheihe and Palikea Gulches**											
SBW-A	Manage for stability	37 *	2019-01-23	16	18	3	0	Yes	Partial	Yes	No	No
North Haleauau Hame Ridge												
SBW-W	Manage for stability	265	2018-10-22	36	63	166	0	Partial	No	Yes	No	No
Skeet Pass												
	ESU Total:	302		52	81	169	0					

Size Class Definitions

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

*= Snails (past or current) have been Trans-Located to another wild site.

= 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.

SBW-A North Haleauau-Hame Ridge PRS: SBW-A is located in the UXO area. After staff observed a population decline between 2013 and 2015, the IT agreed with the decision to move translocate snails from SBW-A (OANRP 2017b). In January 2019, 37 snails were collected from SBW-A and translocated to SBW-W. All snails were released at one site within SBW-W.

SBW-W Skeet Pass PRS: This population was last monitored in October 2018 and 265 snails were counted. Rat control occurs on the ridge with A24s which are monitored every four months.

5.4.2 ESU-C Future Management

OANRP will conduct monitoring of the MFS PRSs (Table 13) and construction of the enclosure at Kaala will be pursued as outlined below (Table 14). Searches for *E. rosea* and *T. jacksonii xantholophus* in the course of other work will also continue. Weed and ungulate control will also be ongoing.

OANRP plans to construct an enclosure at the top of Kaala (Figure 12) by the Fall of 2020. The snail enclosure site has yet to be finalized but several potential sites have been selected. A translocation plan will be developed once enclosure construction is underway.

Ungulate control for pigs and goats is ongoing. Goats are occasionally observed along the ridgeline between the Manuwai fence and Lihue MU near the historic snail populations. Low numbers of pigs are still present in the Lihue fence.

Table 13. ESU-C Monitoring Plan for MFS PRSs.

PRS	Monitoring Type	Monitoring Interval	Survey Years	Comments
SBW-A North Haleauau	TCM	annual	all	Conduct night TCM for 6 person-hours.
SBW-W Skeet Pass PRS	TCM	every 2 years	2020, 2022	Conduct night TCM for 9.25 person-hours

Table 14. Three Year Action Plan for ESU-C.

PRS	MIP YEAR 16 July 2019 – June 2020	MIP YEAR 17 July 2020 – June 2021	MIP YEAR 18 July 2021 – June 2022
SBW-A North Haleauau	• Implement monitoring plan • Rat control • Translocate to Skeet Pass	• Implement monitoring plan • Rat control • Translocate to Skeet Pass • Begin construction of enclosure at Kaala	• Implement monitoring plan • Rat control
SBW-W Skeet Pass PRS	• Implement monitoring plan • Monitor snails translocated from SBW-A • Rat control	• Implement monitoring plan • Rat control • Monitor snails translocated from SBW-A	• Implement monitoring plan • Rat control • Translocate snails to Kaala enclosure
Kaala Snail Enclosure	•	• Begin construction of enclosure	• Begin snail introductions
NM PRS			• Translocate snails to Kaala enclosure

5.5 ESU-D

Figure 13. *Achatinella mustelina* from ESU-D.

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

5.5.1 ESU-D1 Management History and Population Trends

Figure 14. Map of ESU-D1.

There is one MFS PRS at KAL-G (Puu Hapapa Snail Enclosure) (Figure 14 and Table 15). During TCM, 761 snails were observed and the population appears to be stable or increasing. The 12 NM PRSs contain few to no snails as most have been translocated into the enclosure. Habitat restoration efforts in the Puu Hapapa Enclosure are largely complete with a nearly continuous sub-canopy of native host plants now established to facilitate genetic communication of snails across the enclosure. Weed control is ongoing. Staff will continue to opportunistically survey the 12 NM PRSs, and if found, translocate snails into the Puu Hapapa Snail Enclosure. Threats are abundant outside of the enclosure with *E. rosea* and *T. jacksonii xantholophus* commonly seen. Pigs occasionally disturb snail habitat in the unfenced area of PRS SBS-B.

Table 15. ESU-D1 Population Structure and Threat Control Summary.

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control				
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina rosea	Jackson's Chameleon
Achatinella mustelina												
ESU: D1	**North Kaluaa, Waieli, Puu Hapapa, and Schofield Barracks South Range**											
KAL-G	Manage for stability	761 *	2019-06-12	509	172	80	0	Yes	Yes	Yes	Yes	Yes
Puu Hapapa snail enclosure												
	ESU Total:	761		509	172	80	0					

Size Class Definitions

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

*= Snails (past or current) have been Trans-Located to another wild site.

= 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.

KAL-G Puu Hapapa Snail Enclosure PRS: A total of 761 snails were observed during the TCM in June 2019 (Figure 15). Though TCM counts oscillate, the population appears to be generally increasing. This trend is most strongly supported by data between July 2014 and February 2018, as numbers rose over time while new translocations were minimal. Though subsequent counts have been variable, the population appears to remain stable. Staff continue to conduct TCM at Hapapa on a quarterly basis. The habitat continues to improve and the snails were observed spreading out into new vegetation as outplanted trees grow larger. No *T. jacksonii xantholophus* or *E. rosea* have been known to breach the enclosure barriers.

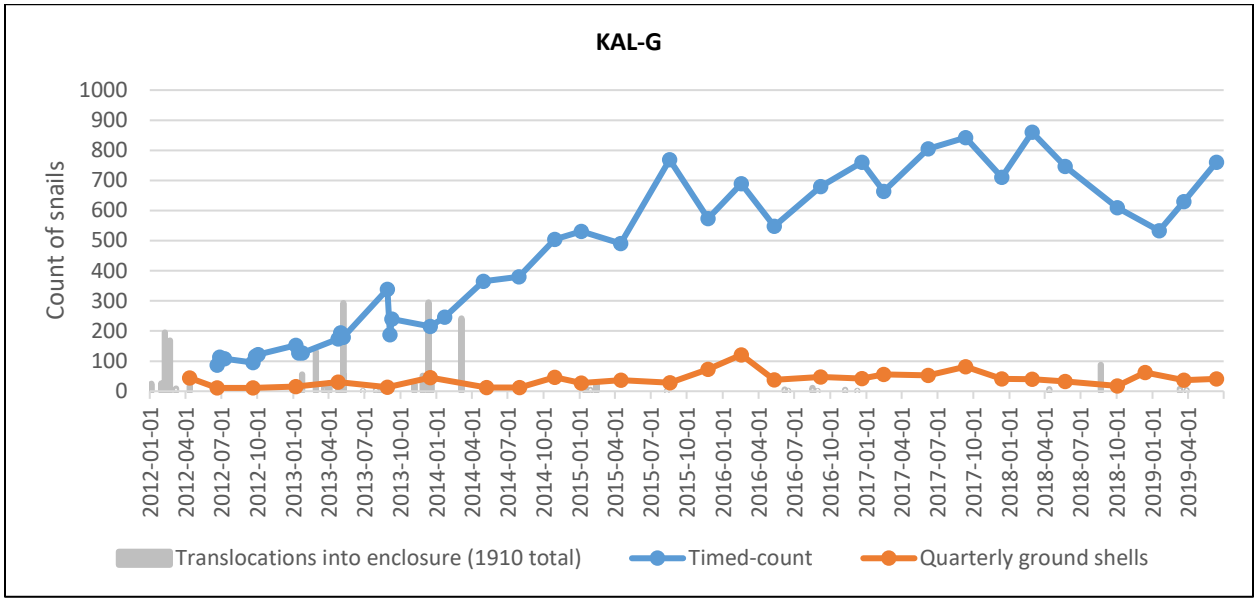

Figure 15. Timed-counts and ground shell counts for *A. mustelina* in Hapapa snail enclosure from June 2012 to June 2019, with numbers of snails translocated into the enclosure over time.

No Management PRS: The 12 NM PRS are not monitored regularly. With a high abundance of threats, these sites will likely continue to decline. OANRP staff opportunistically translocate the few snails

remaining into the Hapapa enclosure. Table 16 shows the number of snails for each population that were translocated into the snail enclosure in the past year. Table includes translocations from SBW-M and SBW-L which are part of ESU-D and are no managed.

Table 16. Translocations of *A. mustelina* into KAL-G Hapapa Enclosure 2018-2019.

Translocation Date	Population Reference Site	Small	Medium	Large	Total
2018-08-21	SBW-M	0	6	16	22
2018-08-21	SBW-L	15	14	37	66
2019-03-11	SBS-B	0	3	5	8
2019-03-28	KAL-B	0	2	2	4
Total		15	25	60	100

5.5.2 ESU-D1 Future Management

OANRP staff will continue monitoring KAL-G (Puu Hapapa Snail Enclosure) (Table 17) and management will continue as described in Table 18. Threat control will continue around the existing enclosure, including tracking tunnels and A24s for *R. rattus*, and searches for *E. rosea*- and *T. jacksonii xantholophus*. Weed control and habitat improvements will continue. Habitat improvements will continue in the area surrounding the enclosure. Pig control at the SBS-B population will be done as needed as well as any further translocations from this PRS.

Two non-managed PRSs, ELI-A and SBS-D, will be surveyed again within the next year. Both sites were last surveyed in 2016 and a few remaining snails were observed. These PRSs will be surveyed and any snails found translocated to the Puu Hapapa enclosure

Table 17. ESU-D1 Monitoring Plan for MFS PRS.

PRS	Monitoring Type	Monitoring Interval	Survey Years	Comments
KAL-G Puu Hapapa Snail Enclosure	TCM	quarterly	all	Conduct night TCM with 4 personnel for 8 person-hours total.
	GSP	quarterly	all	GSP KAL-G-1

Table 18. Three Year Action Plan for ESU-D1.

PRS	MIP YEAR 16 July 2019 – June 2020	MIP YEAR 16 July 2019 – June 2020	MIP YEAR 18 July 2021 – June 2022
KAL-G Puu Hapapa Snail Enclosure	• Implement monitoring plan • Rat control • Maintain enclosure and monitor for predators	• Implement monitoring plan • Rat control • Maintain enclosure and monitor for predators	• Implement monitoring plan • Rat control • Maintain enclosure and monitor for predators
NM PRSs	• Survey for remaining snails • Translocate to Hapapa enclosure		

5.5.3 ESU-D2 Management History and Population Trends

Figure 16. Map of ESU-D2**.**

There are seven MFS PRS in ESU-D2 with a total of 254 observed snails (Figure 16 and Table 19). Rat control occurs at all PRSs except MAK-F and MAK-G. *Euglandina rosea* are found across the MU, and while *T. jacksonii xantholophus* occur at the Kaneaki Heiau at the residential/forest boundary, they are not frequently detected in the Management Unit. Overall, the *A. mustelina* snail population is quite fragmented, with snails commonly occurring only in small numbers in isolated trees and shrubs. In past years staff have observed a retraction in the distribution of snails in the Makaha Unit I fence area. A significant decline of snails is likely to have occurred across this ESU over the last several years. A large grid of A24s are maintained in the Makaha Unit I fence area.

Table 19. ESU-D2 Population Structure and Threat Control Summary.

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	12 *	2018-07-17	6	5	1	0	Yes	Partial	Yes	No	No
MAK-B Kumaipo ridge crest	Manage for stability	9	2018-07-17	7	2	0	0	Yes	Partial	Yes	No	No
MAK-C Near pinnacle rocks. Includes Hesarb ridge.	Manage for stability	11	2017-10-16	7	3	1	0	Yes	Partial	Yes	No	No
MAK-D On ledge below ridge crest above MAK-A site.	Manage for stability	43	2018-07-17	31	11	1	0	Yes	Partial	Yes	No	No
MAK-E Ridge east of Cyasup exclosure	Manage for stability	63	2017-10-16	47	14	2	0	Yes	Partial	Yes	No	No
MAK-F Waianae Kai trail to Kaala	Manage for stability	50	2018-07-18	40	10	0	0	No	Partial	No	No	No
MAK-G Upper Makaha 3850 ft.	Manage for stability	66	2017-11-02	57	4	5	0	No	Partial	No	No	No
	ESU Total:	254		195	49	10	0					

Size Class Definitions

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

*= Snails (past or current) have been Trans-Located to another wild site.

= 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.

MAK-A Kumaipo Isolau Ridge PRS: This PRS was last surveyed in July 2018 and 12 snails were counted. Incidental observations indicate that there have been declines since the last TCM. Snails will be translocated to Puu Hapapa enclosure.

MAK-B Kumaipo Ridge Crest PRS: Many of the trees at this site that used to harbor snails have died and snail numbers have since declined. In July 2018 only 9 snails were counted while 14 snails were counted during the previous survey in February 2017. Snails will be translocated to Puu Hapapa enclosure.

MAK-C Near Pinnacle Rocks PRS: During the survey on 16 October 2017 a total of eleven snails were counted. The next survey will be conducted in 2019. Snails will be translocated to Puu Hapapa enclosure.

MAK-D On Ledge Below Ridge Crest Above MAK-A PRS: In July 2018, 31 snails were counted. A steady decline has been observed since 2014 when 127 snails were counted. A decline in host trees has also been observed. Snails will be translocated to Puu Hapapa enclosure.

MAK-E Ridge East of Cyasup Exclosure PRS: During the survey on 16 October 2017 a total of 63 snails were counted. The next survey will be conducted in 2019. Snails will be translocated to Puu Hapapa enclosure.

MAK-F Waianae Kai Trail PRS: In July 2018, 50 snails were counted. Although less than half the amount of snails were counted since the 19 September 2016 count when a total of 145 snails were counted, the aid of ropes and three rappellers was not utilized in the most recent count as it was in the previous count. There is still more area that needs to be explored to understand the full extent of the PRS. It is a difficult and steep area with thick vegetation.

MAK-G Upper Makaha PRS: This is a new site discovered by state staff while searching for rare plants in November 2015. OANRP staff surveyed the site on 02 November 2017 and found 66 snails (5 small, 4 medium and 57 large). OANRP staff will return to the PRS this year to further explore the area and determine the extent of the PRS. This PRS is located just 46 m lower than the summit bog at 3850 ft. and is the highest elevation site known for *A. mustelina*.

5.5.4 ESU-D2 Future Management

OANRP staff will continue monitoring MAK-F and MAK-G (Table 20) and management will continue as described in Table 21. Rats are controlled in all but two of the MFS PRSs; at these two sites control would be challenging due to steep terrain. OANRP will continue to explore higher elevation areas in the next year to determine numbers and consider possible threat control options. A steady decline in snail populations has been observed in Makaha. At the February 2019 IT meeting, OANRP proposed translocating all snails in MAK-A, MAK-C, MAK-D, and MAK-E to the Puu Hapapa enclosure and is in the process of formalizing a translocation plan.

Table 20. ESU-D2 Monitoring Plan for MFS PRS.

PRS	Monitoring Type	Monitoring Interval	Survey Years	Comments
MAK-F Waianae Kai	TCM	every 2 years	2020, 2022	Conduct night TCM for 4 total person-hours. Conduct day TCM on rope for 4 person-hours.
MAK-G Upper Makaha	TCM	every 2 years	2019, 2021	Conduct night TCM for 4 total person-hours. Conduct day TCM on rope for 4 person-hours.

Table 21. Three Year Action Plan for ESU-D2.

PRS	MIP YEAR 16 July 2019 – June 2020	MIP YEAR 17 July 2020 – June 2021	MIP YEAR 18 July 2021 – June 2022
MAK-A Isolau Ridge	• Translocate to Puu Hapapa enclosure • Rat control		
MAK-C Near Pinnacle Rocks	• Translocate to Puu Hapapa enclosure • Rat control		
MAK-D On Ledge	• Translocate to Puu Hapapa enclosure • Rat control		
MAK-E Ridge East of Cyasup	• Translocate to Puu Hapapa enclosure • Rat control		
MAK-F Waianae Kai	• Implement monitoring plan • Assess rat control • Determine PRS extent	• Implement monitoring plan • Implement rat control	• Implement monitoring plan • Rat control
MAK-G Upper Makaha	• Implement monitoring plan • Assess rat control • Determine PRS extent	• Implement monitoring plan • Implement rat control	• Implement monitoring plan • Rat control

5.5.5 ESU-D No management PRS

Figure 17. Map of ESU-D.

ESU-D consists solely of NM PRS (Figure 17). In August 2018, SBW-L and SBW-M were surveyed and all snails found were collected and translocated to the Puu Hapapa enclosure as planned (see Appendix 5-2 in the 2017 Status Report for the Makua and Oahu Implementation Plans). Sixty-six snails were collected from SBW-L and 22 snails collected from SBW-M.

5.6 ESU-E

Figure 18. *Achatinella mustelina* from ESU-E.

Figure 19. Map of ESU-E.

5.6.1 ESU- E Management History and Population Trends

There are five MFS PRSs which include 86 observed snails (Table 22) and eight NM PRSs with 21 observed snails at ESU-E (Figure 19). The larger PRSs were surveyed during the past year. Most of the PRSs are included in the larger rat control grid in the Ekahanui MU except for the four Huliwai PRSs which are not managed. *Trioceros jacksonii xantholophus* have been seen once in Ekahanui but do not seem prevalent. *Euglandina rosea* are common and thought to be the major cause of *A. mustelina* decline at these PRSs. ESU-E is an area of considerable management focus given steep declines in snail numbers. Plans were made with the IT in 2015 to translocate snails to a permanent enclosure at Palikea. A total of 201 snails were collected and given to the SEPP lab to rear in captivity. The snail population in the lab had reproduced at a rate that was projected to surpass the holding capacity of the incubators by November 2018 resulting in the need for temporary relocation of lab snails to a highly protected site until the Palikea North enclosure is ready for reintroductions. Fifty-two snails from the lab were released into two sites: the Ekahanui Temporary enclosure (box) and a temporary enclosure built within the Palikea North enclosure. The Ekahanui box was considered a failure after the population began to decline immediately. Use of the box was discontinued and one live snail was returned to the lab. The temporary enclosure at Palikea North was considered a success. The death rate was minimal with only five shells found and a new baby was found during TCM. A second introduction into the temporary enclosure occurred in April 2019 with 21 wild snails from Ekahanui.

Table 22. ESU-E Population Structure and Threat Control Summary.

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control				
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina rosea	Jackson's Chameleon
Achatinella mustelina												
ESU: E Puu Kaua / Ekahanui												
EKA-A	Manage for stability	25 *	2019-04-03	10	13	2	0	Yes	Partial	Yes	No	No
Mamane Ridge and Near Plapripri EKA-A												
EKA-B	Manage for stability	0 *	2019-04-03	0	0	0	0	Yes	Partial	Yes	No	No
Below north population of Tetlep. Between Plapri EKA-A, EKA-B and EKA-C												
EKA-C	Manage for stability	12 *	2019-04-03	6	5	1	0	Yes	Partial	Yes	No	No
At Plapripri EKA-C site												
EKA-D	Manage for stability	0	2019-04-03	0	0	0	0	Yes	No	No	No	No
Puu Kaua												
EKA-H	Manage for stability	16	2018-03-01	5	10	1	0	Yes	No	Yes	No	No
South Ekahanui North Branch												
EKA-S	Manage for stability	0	2019-02-25	0	0	0	0	Yes	No	Yes	Yes	Yes
Spirizona snail enclosure												
PAK-T	Manage for stability	33	2019-06-30	25	4	4	0	Yes	Yes	Yes	Yes	Yes
ESU-E snails in Palikea North Enclosure												
	ESU Total:	86		46	32	8	0					

Size Class Definitions

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

*= Snails (past or current) have been Trans-Located to another wild site.

= 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.

EKA-A Mamane Ridge PRS: On 3 April 2019, OANRP staff returned to the site and collected a total of 25 snails (2S, 13M, 10L). The 10 adults were taken to the lab and the remaining 15 snails were introduced into the Palikea North snail enclosure.

EKA-B Below Tetlep PRS: During a survey in April 2019, no snails were observed.

EKA-C Plapri PRS: Staff returned in April 2019 and collected a total of 12 snails (1S, 5M, 6L). The six adults were taken to the lab and the remaining six were introduced into the Palikea North snail enclosure.

EKA-D Puu Kaua PRS: OANRP staff re-surveyed the site in April 2019 and found no snails.

EKA-S Spirizona PRS Temporary Snail Enclosure: Use of the EKA-S Sprizona temporary enclosure (box) was originally discontinued in 2016 because of high mortality rates due to unknown reasons. After spending two years in the field, the box had weathered and the vegetation had grown denser. The site also remained fully enclosed and predator proof. For these reasons, it was considered to be a feasible site for a reintroduction. In December 2018, 26 captive reared subadults were released into the *Spirizona* enclosure. An immediate and steady decline was observed within the first month (Figure 20). The decision was

made to discontinue use of the box and return snails to the lab. Only one live snail was recovered from the box in January. No *E. rosea* or rats were detected inside the enclosure.

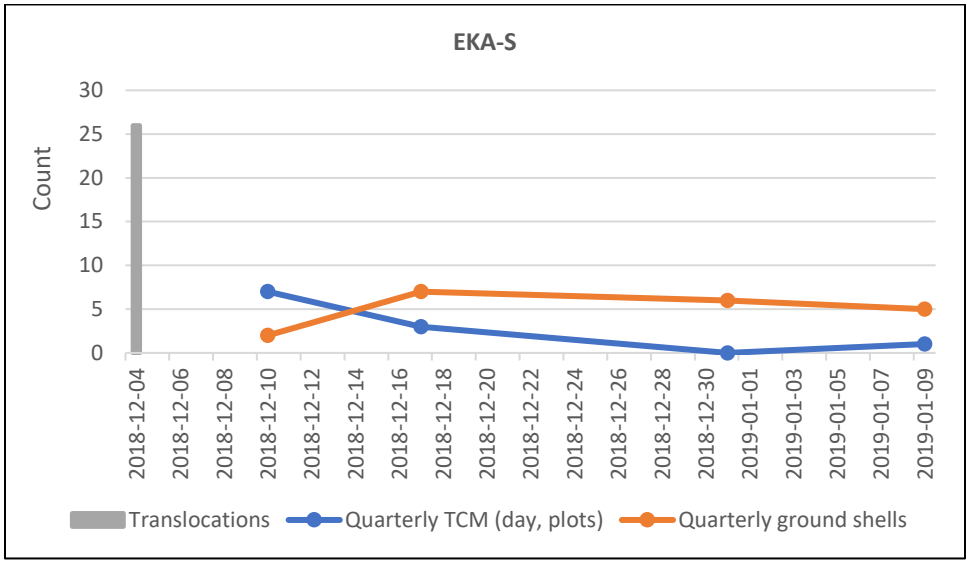

Figure 20. Monitoring results of lab reared snails introduced into the temporary enclosure. After introduction, a steady decline in live snails was observed.

PAK-T Palikea North Enclosure: The Palikea North snail enclosure is currently undergoing habitat restoration but sections of the enclosure have adequate vegetation for snails (Figure 21, and see vegetation monitoring results, Appendix 5-4). One area was selected and a temporary enclosure was built in November 2018 (Figure 22). A total of 26 captive reared sub-adults were introduced into the temporary enclosure in December 2018. The population remained stable and only three ground shells were recovered within the first four months. A baby snail born in the temporary enclosure was observed in February. In April 2019, 21 wild snails from Ekahanui were translocated to the temporary enclosure (Table 23). The population continues to remain stable with low mortality rates. A total of five shells were found since the initial release in December 2018 (Figure 23).

Figure 21. Aerial view of Palikea North enclosure in February 2019. Temporary enclosure is shown on the left (east) side of the wall.

Figure 22. Temporary enclosure site within the Palikea North enclosure, showing 2.5 foot high walls and shade cloths installed over the two *F. arborea* patches. A drip emitter system (not shown) was installed to provide moisture to the enclosure. A non-lethal electric barrier (also not shown) was installed on the wall interior to prevent snails from escaping.

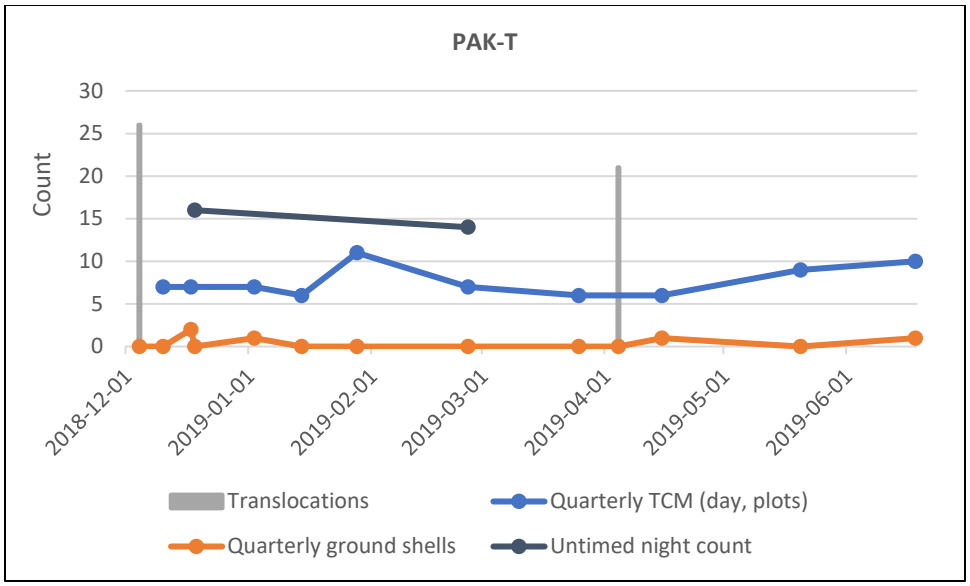

Figure 23. Monitoring results of snails in Palikea North's temporary enclosure. The timed-count is conducted during the day, but more snails are found during the incidental observations at night. The population remains stable and ground shells remain low.

Table 23. Translocations for 2018-2019 into Palikea North temporary enclosure.

Date	# of Snails translocated into temporary enclosure
12-4-2018	26
04-04-2018	21
Total	**47**

No Management PRS: Most of these sites have few snails surviving and all snails will be translocated to the Palikea North snail enclosure.

Captive-reared population: Sixteen large snails were collected from the wild (EKA-A and EKA-C) and taken to the lab this year. The total number of snails given to the lab since 2017 is 201. Fifty-two snails were released from the lab into two locations (EKA-S and PAK-T). Following the failure at EKA-S, one snail was returned to the lab. As the lab population grows, snails will continue to be released into PAK-T. Table 24 shows the current population of ESU-E snails in the lab.

Table 24. SEPP Lab Population of Ekahanui *A. mustelina,* as of June 2019.

	Juvenile	Sub-adult	Adult	Total
Number of snails	152	35	37	**224**

5.6.2 ESU-E Future Management Plans

Monitoring of snails released into the Palikea North temporary enclosure will occur quarterly (Table 25). Future management will focus on translocating snails from Ekahanui to the temporary enclosure inside Palikea North (Table 26). Due to the success of the snail population in the temporary snail enclosure at Palikea North and the positive trend in habitat restoration efforts, OANRP plans to start translocations of wild snails in November of 2019 instead of November 2020 as originally planned (OANRP 2018b). Two more lab sub-adult snail releases are scheduled for Fall 2019 and Spring 2020. New temporary enclosure sites will be constructed in appropriately vegetated areas. There are no plans to reintroduce any snails into the Ekahanui box and it will be dismantled.

Table 25. ESU-E Monitoring Plan for MFS PRS.

PRS	Monitoring Type	Monitoring Interval	Survey Years	Comments
PAK-T Palikea North temporary enclosure	TCM	quarterly	all	Conduct day TCM within temporary enclosure for 1 person-hour.
	GSP	quarterly	all	Search entire temporary enclosure for ground shells

Table 26. Three-Year Action Plan for ESU-E.

PRS	MIP YEAR 16 July 2019 – June 2020	MIP YEAR 17 July 2020 – June 2021	MIP YEAR 17 July 2021 – June 2022
EKA-A Mamane Ridge	• Translocate to Palikea North temporary enclosure		
EKA-B Below Tetlep	• Translocate to Palikea North temporary enclosure		
EKA-C Plapri	• Translocate to Palikea North temporary enclosure		
EKA-D Puu Kaua	• Translocate to Palikea North temporary enclosure		
EKA-H South Ekahanui	• Translocate to Palikea North temporary enclosure		
PAK-T Palikea North temporary enclosure	• Release lab and wild snails into temporary enclosure • Implement monitoring plan • Rat control	• Release lab snails into temporary enclosure • Implement monitoring plan • Rat control • Construct new temporary enclosure	• Release lab snails into enclosure • Implement monitoring plan • Rat control • Construct new temporary enclosure

5.7 ESU-F

Figure 24. *Achatinella mustelina* from ESU-F.

Figure 25. Map of ESU-F. *The Palikea North Enclosure, although located within ESU-F, will house ESU-E snails.

5.7.1 Management History and Population Trends

There are 13 MFS PRSs in ESU-F (Figure 25) which includes 332 observed snails (Table 27). Small snail populations are still occasionally found within the Palikea MU fence and those populations have been brought into the snail enclosure due to *E. rosea* presence throughout the MU. All PRSs in the Palikea fence are within the large rat control grid. Only two *T. jacksonii xantholophus* have been observed within the MU thus far but larger numbers have been observed along Palehua Road.

Table 27. ESU-F Population Structure and Threat Control Summary.

Population Reference Site	Management Designation	Total Snails	Date of Survey	Size Classes				Threat Control				
				Large	Medium	Small	Unk	Ungulate	Weed	Rat	Euglandina rosea	Jackson's Chameleon
Achatinella mustelina												
ESU: F Puu Palikea												
PAK-A Puu Palikea-Ohia spot	Manage for stability	9*	2015-09-28	5	2	2	0	Yes	Partial	Yes	No	No
PAK-B Iele Patch	Manage for stability	2*	2018-04-11	2	0	0	0	Yes	Partial	Yes	No	No
PAK-C Steps spot	Manage for stability	0*	2017-05-23	0	0	0	0	Yes	Partial	Yes	No	No
PAK-D Joel Lau's site	Manage for stability	0*	2017-08-01	0	0	0	0	No	Partial	Yes	No	No
PAK-E Exogau site	Manage for stability	1*	2018-01-17	0	1	0	0	Yes	Partial	Yes	No	No
PAK-F Dodonaea site	Manage for stability	6*	2016-10-25	4	2	0	0	Yes	Partial	Yes	No	No
PAK-G Hame and Alani site just above Cyagri fence	Manage for stability	6*	2018-08-01	6	0	0	0	Yes	Partial	Yes	No	No
PAK-H Mike Hadfield's study site at Puu Palikea	Manage for stability	1*	2018-08-02	0	1	0	0	Yes	Partial	Yes	No	No
PAK-I One ridge truck side of E and F	Manage for stability	3*	2017-04-25	3	0	0	0	No	Partial	Yes	No	No
PAK-K Pilo site	Manage for stability	0*	2018-08-02	0	0	0	0	Yes	Partial	Yes	No	No
PAK-L Olapa site north of Puu Palikea	Manage for stability	8*	2019-06-18	7	1	0	0	Yes	Partial	Yes	No	No
PAK-M Middle Site	Manage for stability	7*	2019-06-19	2	5	0	0	Yes	Partial	Yes	No	No
PAK-P Palikea snail exclosure	Manage for stability	284	2019-06-18	210	54	20	0	Yes	Yes	Yes	Yes	Yes
PAK-Q outside snail enclosure	Manage for stability	1*	2018-01-17	1	0	0	0	Yes	Partial	Yes	No	No
PAK-R 4 Trail Junction	Manage for stability	4*	2019-05-08	4	0	0	0	Yes	Partial	Yes	No	No
	ESU Total:	332		244	66	22	0					

Size Class Definitions

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

*= Snails (past or current) have been Trans-Located to another wild site.

= 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.

PAK-G Hame and Alani site just above Cyagri fence PRS: This PRS was surveyed on 01 August 2019 and six large snails were collected and moved to the enclosure.

PAK-H Mike Hadfield's study site at Puu Palikea PRS: OANRP staff found one medium-sized snail while passing through the site in August 2018. The snail was collected and moved into the enclosure.

PAK-K Pilo site PRS: The site was surveyed in August and no snails were found.

PAK-L Olapa site north of Puu Palikea PRS: The site was surveyed on 18 June 2019 and eight snails were collected and moved to the enclosure.

PAK-M Middle Site PRS: After seeing a decline in the population and finding E. rosea at the site, OANRP began to translocate PAK-M snails to the enclosure. A total of 203 snails have been translocated to date (Table 28). The site was visited on eight separate occasions and each time snails were collected.

Table 28. The number of PAK-M snails collected and translocated to the Palikea South (PAK-P) enclosure.

Date	Number of snails translocated to enclosure
2018-07-02	55
2018-07-10	57
2018-07-12	11
2018-07-23	10
2018-07-30	17
2018-08-01	4
2018-12-04	42
2019-06-19	7
Total	**203**

PAK-P Enclosure PRS: OANRP staff continue to translocate snails into the Palikea South snail enclosure and to conduct TCM during the day on a quarterly basis (Figure 26). During the most recent daytime TCM, 50 snails were counted. Once a year, a night TCM is performed for 4-person hours covering the entire enclosure, and on 18 June 2019 staff counted 284 *A. mustelina*, which is 114 more snails counted than last year, likely due to the translocations during the past year (Table 29).

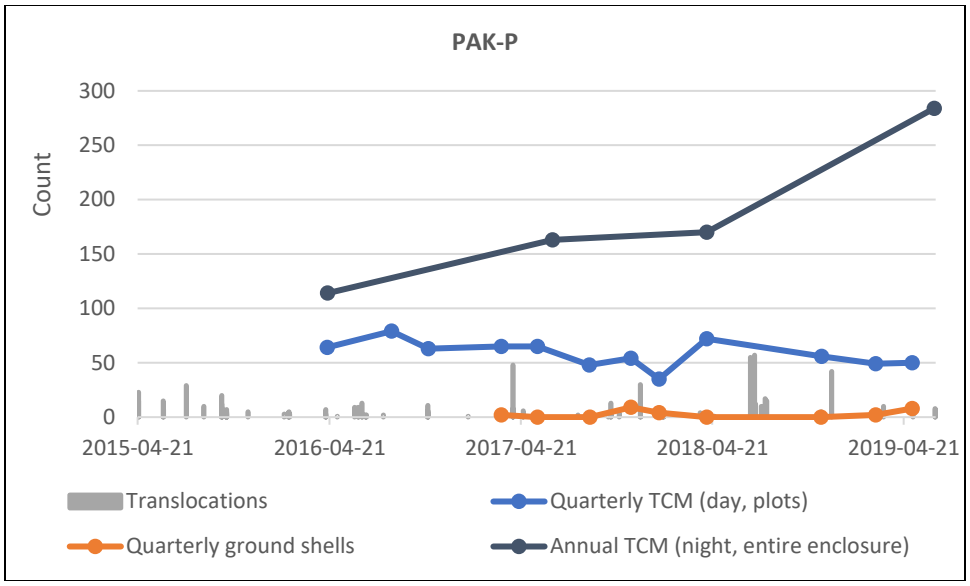

Figure 26. Quarterly and annual timed-counts and quarterly ground shell counts for *A. mustelina* in Palikea South snail enclosure from April 2016 to June 2019, with numbers of snails translocated into the enclosure over time since April 2015. Note: Snail detection is much greater at night than during the day, and the entire enclosure is searched at night, but subsampled in plots during the day.

Table 29. Translocations of *A. mustelina* into PAK-P Palikea South Snail Enclosure between July 2018 and June 2019.

# of Translocation Events	PRS Translocation Source	Small	Medium	Large	Total
1	PAK-G	0	0	6	6
1	PAK-H	0	1	0	1
1	PAK-K	2	3	9	14
2	PAK-L	0	2	11	13
8	PAK-M	21	65	117	203
4	PAK-R	1	4	11	16
Total		**24**	**75**	**154**	**253**

5.7.2 ESU-F Future Management

OANRP will continue monitoring and managing as described in Tables 30 and 31. Staff has been actively translocating snails from PAK-M to the enclosure. OANRP will continue to translocate snails from small declining NM PRSs. Each of these sites will be visited a minimum of three times. After each site has been visited three times with no live snails observed its status will be changed from Manage For Stability to No Management.

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

Table 30. ESU-F Monitoring Plan for MFS PRS.

PRS	Monitoring Type	Monitoring Interval	Survey Years	Comments
PAK-P Palikea Enclosure	TCM	quarterly	all	Conduct day TCM in plots for 4 person-hours.
	GSP	quarterly	al	Search plots for all ground shells
	TCM	annual	all	Conduct night TCM across entire enclosure and perform

Table 31. Three Year Action Plan for ESU-F.

PRS	MIP YEAR 16 July 2019 – June 2020	MIP YEAR 17 July 2020 – June 2021	MIP YEAR 18 July 2021 – June 2022
PAK-A Puu Palikea-Ohia	• Translocate to enclosure • Rat control	• Rat control	• Rat control
PAK-B Ieie Patch	• Translocate to enclosure • Rat control	• Rat control	• Rat control
PAK-E	• Translocate to enclosure • Rat control	• Rat control	• Rat control
PAK-F Dodonea Site	• Translocate to enclosure • Rat control	• Rat control	• Rat control
PAK-G Hame	• Translocate to enclosure • Rat control	• Rat control	• Rat control
PAK-H	• Translocate to enclosure • Rat control	• Rat control	• Rat control
PAK-I One Ridge Truck side of E and F	• Translocate to enclosure • Rat control	• Rat control	• Rat control
PAK-K Pilo	• Translocate to enclosure • Rat control	• Rat control	• Rat control
PAK-L Olapa	• Translocate to enclosure • Rat control	• Rat control	• Rat control
PAK-M Middle	• Translocate to enclosure • Rat control	• Rat control	• Rat control
PAK-P Palikea Enclosure	• Implement monitoring plan • Rat control • Maintain enclosure and monitor for predators	• Implement monitoring plan • Rat control • Maintain enclosure and monitor for predators	• Implement monitoring plan • Rat control • Maintain enclosure and monitor for predators

5.8 LITERATURE CITED

OANRP. 2017a. Chapter 5: *Achatinella* Species Management, subsection 5.2.1.1 MMR-A Kahanahaiki Enclosure PRS *in* 2017 Status Report for the Makua and Oahu Implementation Plans. https://pcsuhawaii.org/projects/oanrp/reports/2017/05.pdf

OANRP. 2017b. Appendix 5-1 Management Actions to Prevent the Continued Decline of ESU-C *Achatinella mustelina* in Haleauau Gulch in Schofield Barracks West Range *in* 2017 Status Report for the Makua and Oahu Implementation Plans. https://pcsuhawaii.org/projects/oanrp/reports/2017/A5-1.pdf

OANRP. 2018a. Appendix 5.2 3-Points Enclosure Restoration Plan *in* 2018 Status Report for the Makua and Oahu Implementation Plans. http://manoa.hawaii.edu/hpicesu/DPW/2018_YER/A5-2.pdf

OANRP. 2018b. Appendix 5.1 Management Plan for Achatinella mustelina ESU-E Initial Release of Excess Laboratory Snails at the Ekahanui Temporary Enclosure and the Palikea North Enclosure *in* 2017 Status Report for the Makua and Oahu Implementation Plans. http://manoa.hawaii.edu/hpicesu/DPW/2018_YER/A5-1.pdf

CHAPTER 6: RARE VERTEBRATE MANAGEMENT

The Oahu Army Natural Resource Program (OANRP) manages or monitors two vertebrate species, the Hawaiian Monarch Flycatcher (Oahu Elepaio) and the Hawaiian Hoary Bat (Opeapea). Results of our management and monitoring efforts for Oahu Elepaio and Opeapea are presented below.

6.1 OIP ELEPAIO MANAGEMENT 2019

6.1.1 Background

In 2000, the U.S. Fish and Wildlife Service (USFWS) granted the Oahu Elepaio (*Chasiempis ibidis*) endangered species status under the Federal Endangered Species Act and designated critical habitat on Oahu for the Elepaio in 2001. Under the terms of the Biological Opinion for Routine Military Training and Transformation dated 2003 (USFWS 2003), OANRP is required to conduct threat control for a minimum of 75 Oahu Elepaio pairs. On-site management is required to be conducted 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. Staff has conducted rodent control and Elepaio monitoring at SBW (1998-present), Ekahanui Gulch in the Honouliuli Forest Reserve (2005-present), Moanalua Valley (2005-2017, 2019), Palehua (2007-present), Palikea (2018) (OANRP 2018), Makaha Valley (2005-2009), and Waikane Valley (2007-2008). Along with rodent control, monitoring is conducted to determine nesting success and adult survivorship which are indicators of the effectiveness of rodent control. This chapter summarizes Elepaio reproduction results at each of the sites currently 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.

6.1.2 Methods

Monitoring

Throughout the nesting season, from early January to late July, each managed Elepaio territory was visited at one or two-week intervals depending on breeding activity (excluding SBW). Single male and paired territories without rodent control 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 rate 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 are 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 20 minutes.

Figure 1. Army Natural Resources staff, Jevis Sojot (left) and Philip Taylor (right), with an adult Oahu Elepaio. The population at Schofield Barracks West Range has shown great success over the years despite their close proximity to daily live fire training and UXO detonations. *Photo by Mike Donaldson*

Rodent Control

OANRP staff completed the conversion to GoodNature auto-resetting (A24) rat traps at all Elepaio MUs in 2019. Use of A24s provides cost effective year-round protection from rodents. These traps only require monitoring/rebaiting every three months as opposed to every 1-2 weeks with conventional snap traps and baits. Staff were unable to conduct another wide scale aerial rodenticide broadcast of the entire MU at SBW this breeding season. Instead, A24 trap lines were installed throughout Mohiakea and Banana gulches giving protection to 26 pairs. Both Ekahanui and Palehua continued with their large-scale A24 trapping grids. Road construction in Moanalua Valley was completed in the fall of 2018 giving staff access to Elepaio territories after a one year hiatus. Small-scale A24 trapping grids consisting of nine traps each were installed in ten territories. Difficult terrain and territories spread farther apart at Moanalua does not allow for the use of large-scale grids, so traps are placed within the individual territories. Eight of those territories consisted of breeding pairs, while the other two had a single male in each territory.

Figure 2. An adult female Elepaio feeding her two nestlings. It is uncommon for Oahu Elepaio to nest in native trees, but this pair at Ekahanui successfully nested in a *Pisonia umbellifera*.

6.1.3 Results

With rodent control occurring in 100 Elepaio pair territories during the 2019 breeding season, the OANRP fulfilled the required 75 pairs for species management. The results of management conducted for each area during the 2019 breeding season are compiled below. The results from each area are presented in two ways. First, a map presents a compilation of all Elepaio territories benefiting from rodent control (managed) within each Elepaio MU. Second, the number of pairs receiving rodent control and the ratio of fledglings observed/managed pairs is presented in a graph.

Schofield Barracks West Range

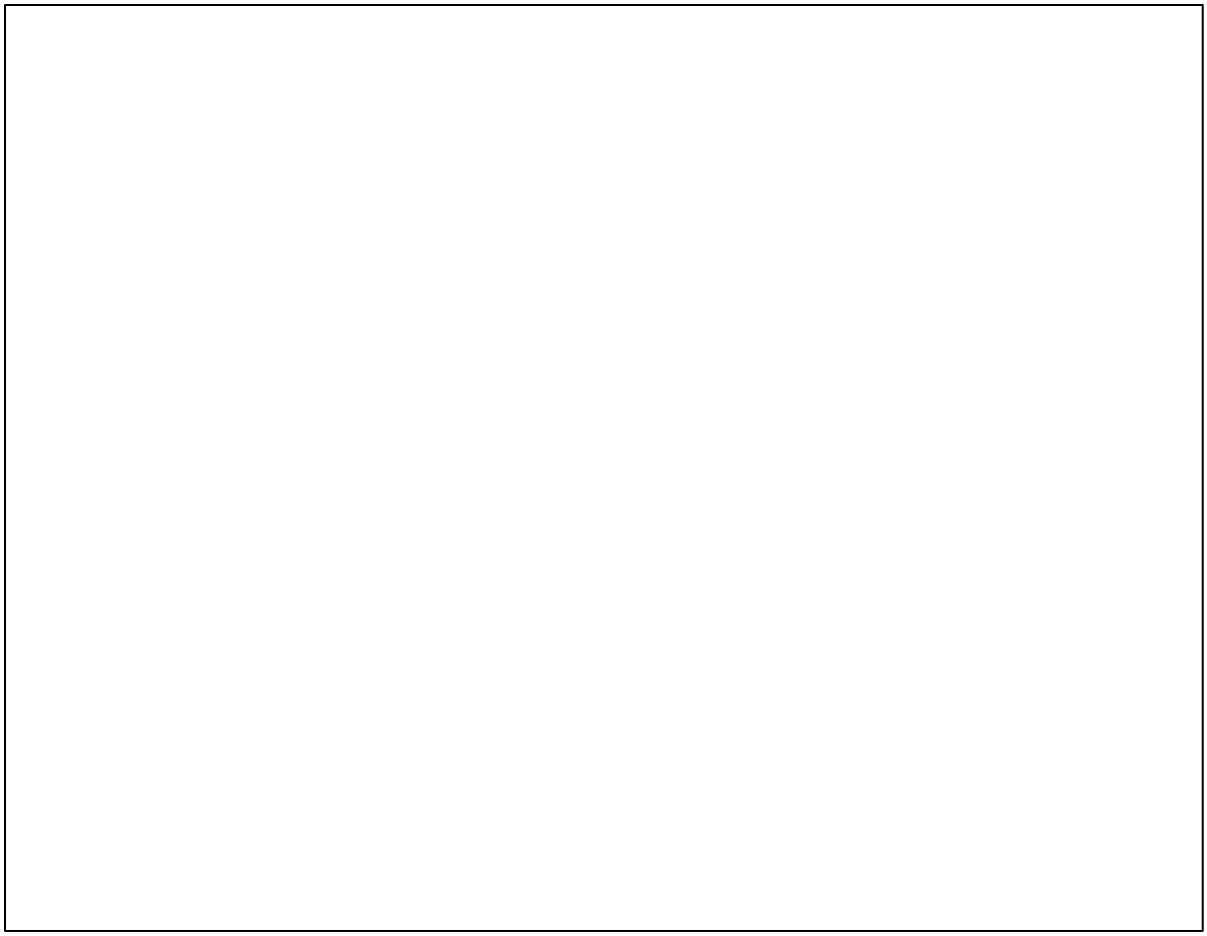

Figure 3. Schofield Barracks West Range Territory Occupancy Status and Rat Control 2019.

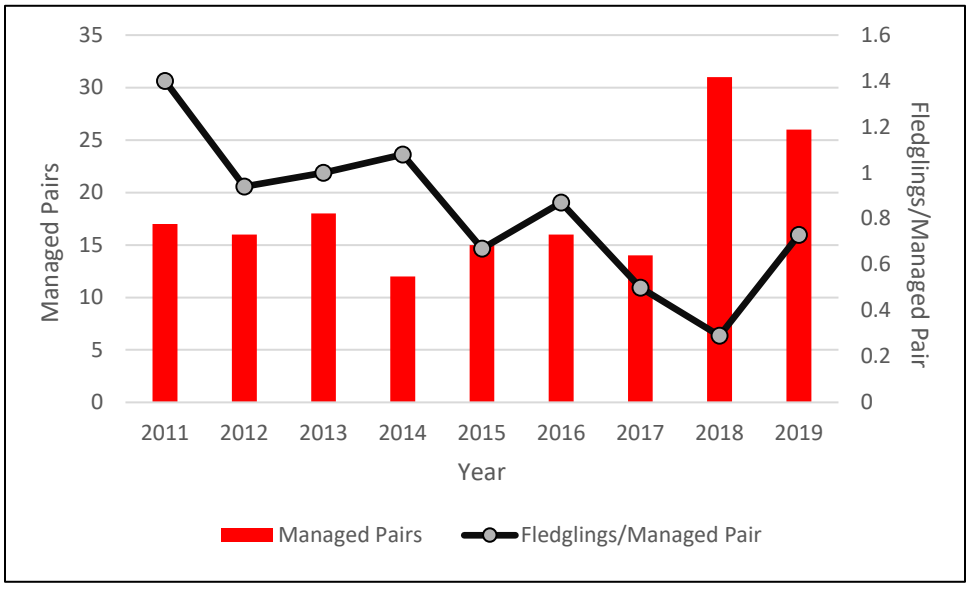

Figure 4. SBW managed pairs and fledglings observed/managed pair since 2011.

Reproductive Results

Of the active nests monitored, 78% (7/9) were successful, producing eight fledglings, and 22% (2/9) of active nests failed. Eleven fledglings were found in nine managed pairs where no nesting had been observed (family groups). A total of 19 fledglings were observed in territories benefiting from rodent control management.

Figure 5. A mist-net placed in the shadows of the forest canopy is the perfect trap for a territorial Elepaio. After carefully extracting the bird, it will be fitted with leg identification bands and released.

Summary

With the limited amount of time that OANRP staff were allowed access to SBW and the large gaps between access, our focus for monitoring was the two gulches of Mohiakea and Banana. The time allowed for monitoring both gulches was limited to a maximum of four consecutive days per month. Between these access days was a 3-4 week gap where monitoring of nesting activity was unable to take place, which allows for greater uncertainty in the outcomes of nests. The total amount of time for monitoring was 22 days. This is a significant increase in monitoring days compared to last year, but still fewer than previous years. Knowing that access would be limited and OANRP would not have the option of using aerial rodenticide drops, we installed A24 rat trap lines through Elepaio territories in both gulches. This allowed for active rodent control throughout the entire breeding season. Twenty-six pairs benefited from rodent control in both Mohiakea and Banana gulches, with 19 fledglings observed.

Honouliuli Forest Reserve – Ekahanui

Figure 6. Ekahanui Territory Occupancy Status and Rat Control 2019.

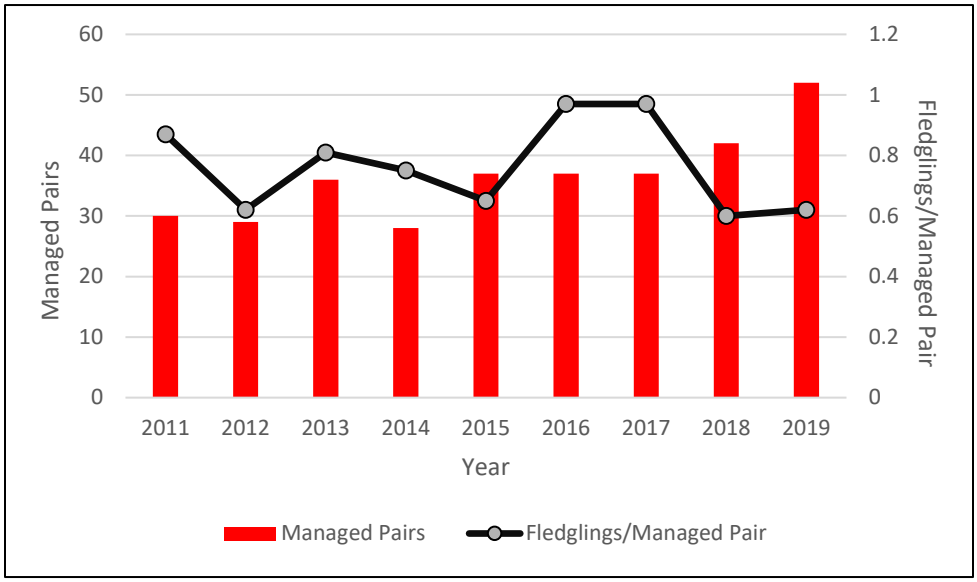

Figure 7. Ekahanui managed pairs and fledglings observed/managed pair since 2011.

Reproductive Results

Of the active nests monitored, 58% (7/12) were successful, producing nine fledglings, and 42% (5/12) of active nests failed. Twenty-three fledglings were found in 21 managed pairs where no nesting had been observed (family groups). A total of 32 fledglings were observed in territories benefiting from rodent control management. One fledgling was observed in a territory not protected from rodents.

Summary

For the fifth straight year the population of managed and unmanaged Oahu Elepaio at Ekahanui increased with a new record high of 118 birds, adding ten managed pairs. Thirty-two fledglings were also observed this breeding season. As the population continues to increase and now with a total of 52 managed pairs, staff is unable to reach all of these pairs on a consistent basis in order to monitor breeding activity. This is reflected in the low fledglings /managed pair ratio shown in Figure 7. Starting with the 2020 breeding season staff will select a segment of the population at Ekahanui that will be monitored more frequently and allow for more time to determine the outcome of nesting activity.

Figure 8. A young Elepaio has just fledged from the nest and quietly waits for its parents to return with a meal.

Palehua

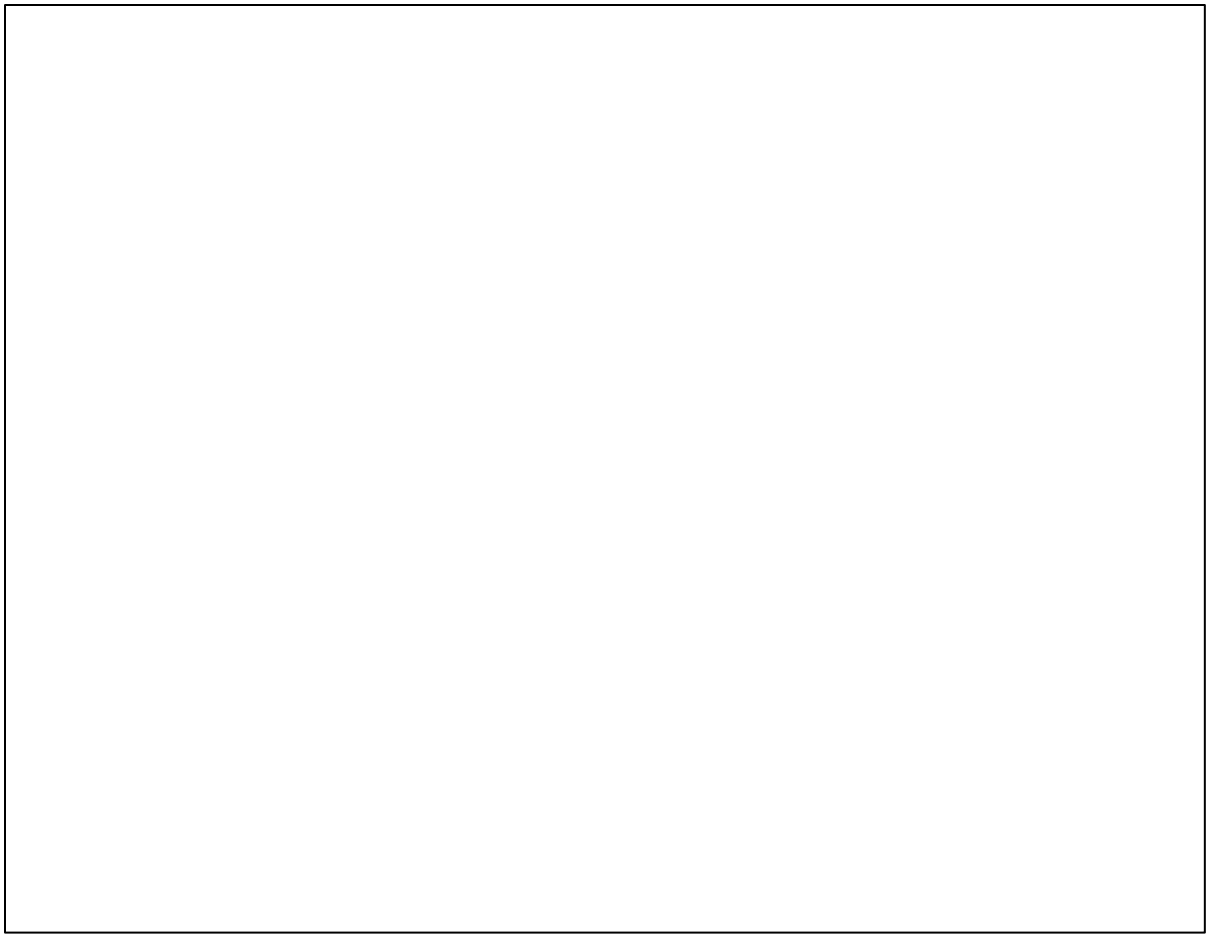

Figure 9. Palehua Territory Occupancy Status and Rat Control 2019.

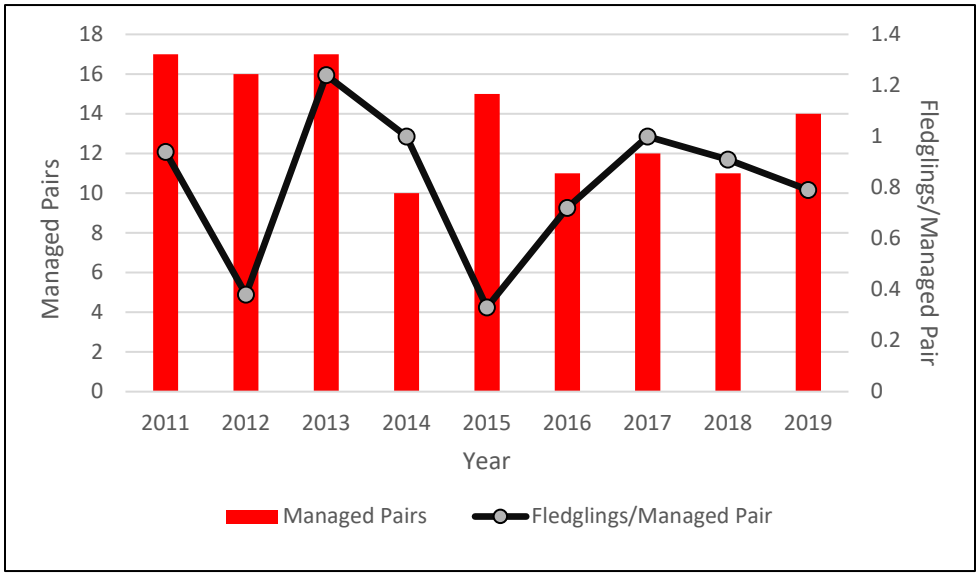

Figure 10. Palehua managed pairs and fledglings observed/managed pair since 2011.

Reproductive Results

Of the active nests monitored, 70% (7/10) were successful and produced a total of seven fledglings, while 30% (3/10) of the nests failed. Four fledglings were found with three managed pairs where no nesting had been observed (family groups). A total of 11 fledglings were observed in territories benefiting from rodent control management.

Summary

Palehua's population increased to 32 birds in 2019, the MU's highest since 2013. Breeding pairs grew from 11 to 15 with one more fledgling observed over the previous breeding season. The number of active nests found was also the highest since 2013. Seventy percent of those nests went on to have at least one fledgling. The large-scale A24 trapping grid continues to run year-round with OANRP staff and volunteers assisting in rebaiting the grid every three months.

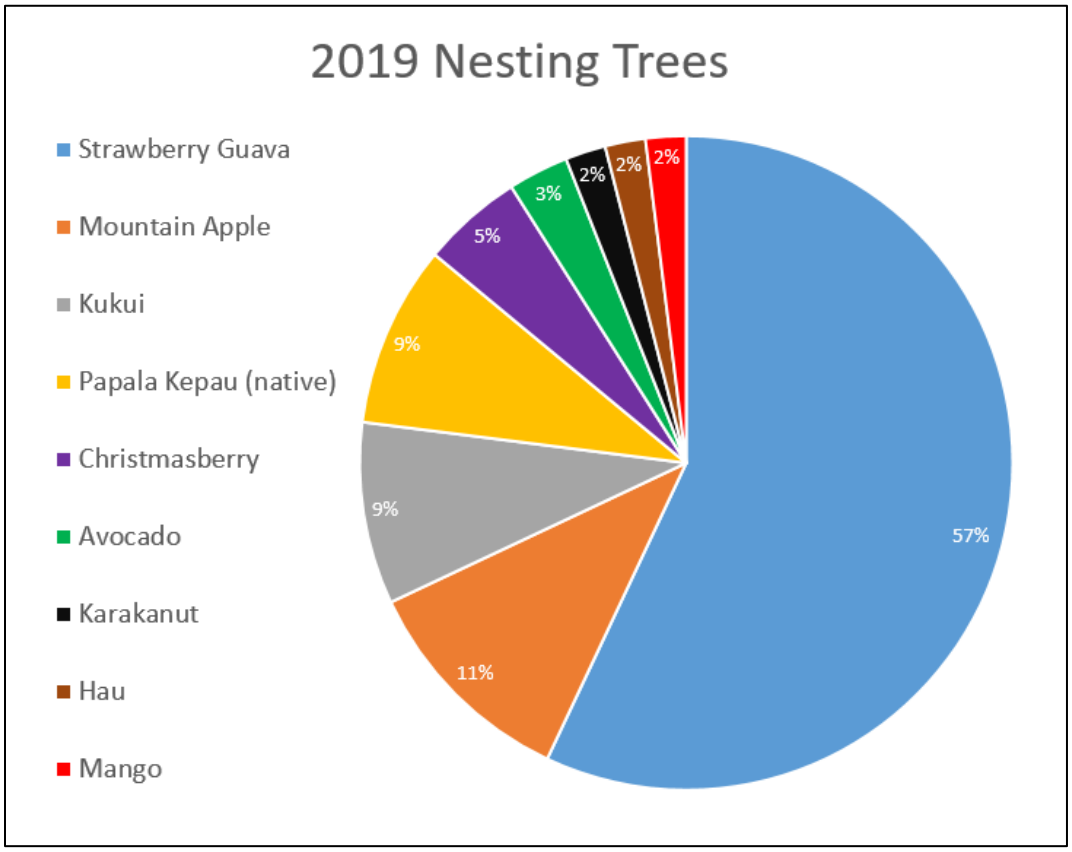

Figure 11. These are the nine tree species used for nesting during the 2019 breeding season. Strawberry guava (*Psidium cattleianum*) is the dominant tree occupying gulch bottoms and valleys where Oahu Elepaio are found, therefore they are utilized the most.

Moanalua Valley

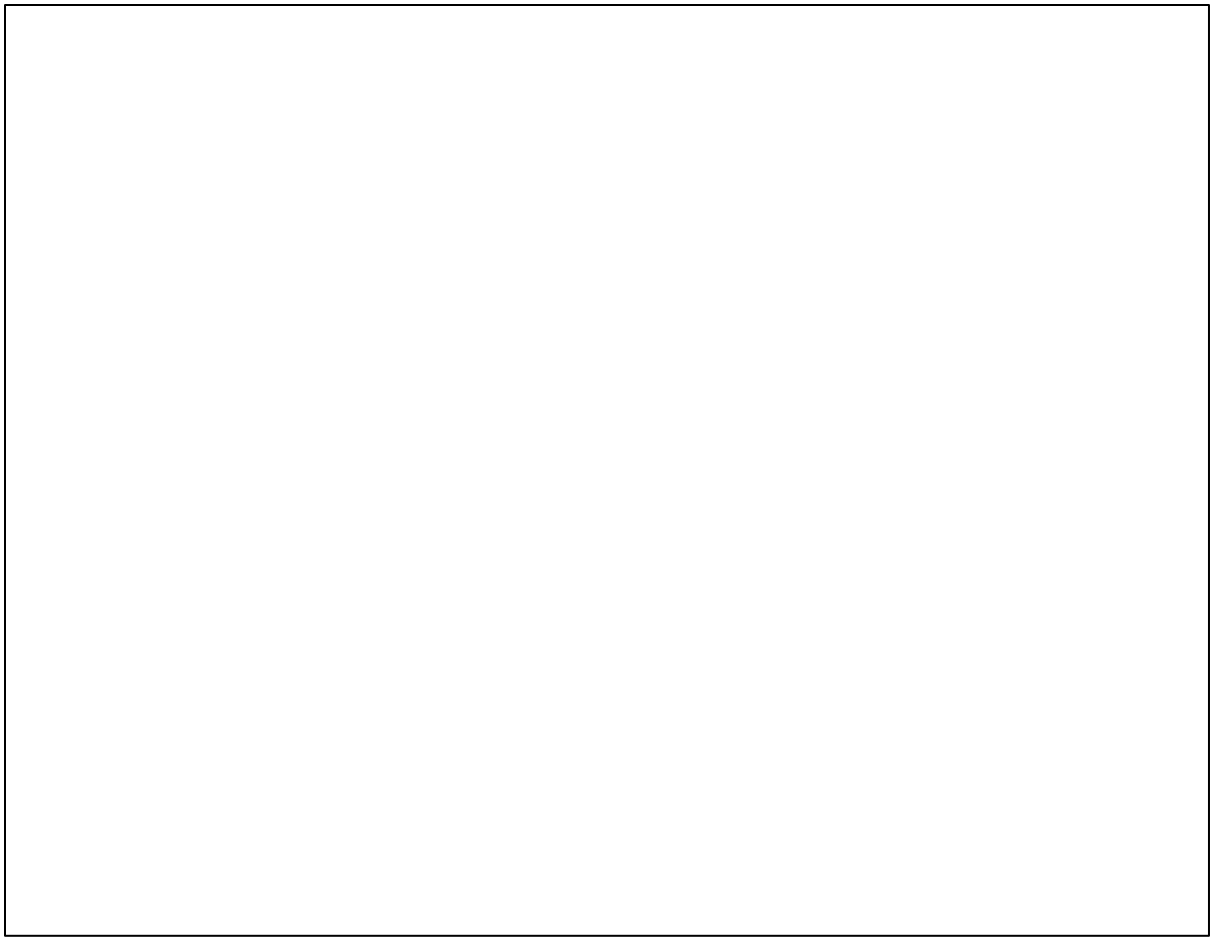

Figure 12. Moanalua Valley Territory Occupancy Status and Rat Control 2019.

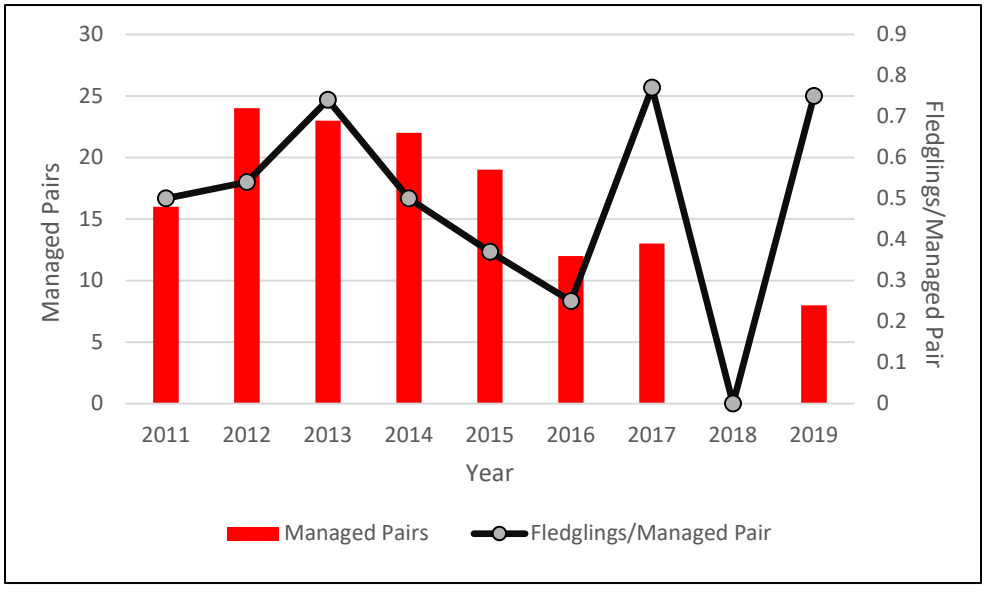

Figure 13. Moanalua Managed Pairs and fledglings/managed pairs since 2011.

Reproductive Results

Of the active nests monitored, 55% (6/11) were successful in producing six fledglings, and 45% (5/11) failed. All six fledglings were observed in territories benefiting from rodent control management.

Summary

Rodent control and monitoring resumed in Moanalua Valley this year after no mangement was conducted in 2018. Road improvemnts allowed staff to access Elepaio pairs and install small-scale A24 trap grids in eight pair territories. Beginning in 2016 OANRP staff began managing pairs lower in the valley with easier access from the road. Territories managed between 2011-2015 that were further up the valley are no longer accessible due to the collapse of the the main road and overgrown vegetation. Each trap grid in the territories managed this year included nine A24 traps. Two single male territories that had previously been pairs in 2017 also had trap grids installed in their territories. With eight pairs managed this year, that is the fewest since management began in 2006. With the OANRP already exceeding the required goal of 75 managed pairs, it is likely that ten pairs will be the maximum number that will be monitored and provided with rodent control going forward.

Figure 14. A portion of the newly paved road in Moanalua Valley. Improvements to the road and stream crossings have allowed our program to return to Moanalua and continue rodent control and monitoring of Elepaio pairs.

6.1.4 OIP Summary

Management Action Highlights 2019

- Conducted rodent control in a total of 100 territories with pairs at four management sites.
- All Elepaio MUs are now using A24 traps providing year-round rodent control.
- The population and number of managed pairs reached an all-time high at Ekahanui. Density of pairs has been able to increase from year to year despite no expansion to the amount of rodent control effort at this MU.
- Table 1 below summarizes the number of managed pairs and reproductive output since 2006. In 2018, a large number of paired territories at SBW were baited using an aerial drop, but staff were not able to monitor them all for breeding activity. This is reflected in the unusually low fledglings/managed pairs and high number of managed pairs.

Table 1. Summary of Elepaio Management.

Year	Managed Pairs	Success Active Nests	Family Groups	Fledglings	Fledglings/ Managed Pair
2019[1]	100	27	35	68	0.68
2018[2]	151	20	22	50	0.33
2017[1]	89	26	36	73	0.82
2016[1]	88	21	36	68	0.77
2015[1]	97	27	20	50	0.52
2014[1]	81	24	28	62	0.77
2013[1]	105	51	38	95	0.90
2012[1]	97	38	22	65	0.67
2011[1]	94	47	34	96	1.02
2010[1]	87	18	15	39	0.45
2009[3]	81	29	24	60	0.74
2008[4]	74	25	20	56	0.76
2007[4]	78	18	26	46	0.59
2006[5]	69	11	17	33	0.48

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

Management Actions 2020

- Conduct rodent control and Elepaio monitoring at Ekahanui, SBW, Palehua, and Moanalua to meet required 75 managed pairs.
- With the OANRP reaching 100 managed pairs in 2019 and exceeding the required 75 pairs, we will see a reduction in monitoring at the Ekahanui population in 2020. Rat control will continue for all territories at this MU, but with fewer pairs being monitored for breeding activity. This will bring the number of managed pairs closer to our required total and increase the quality of monitoring in those territories.
- Continue to mist-net and band all adult and juvenile Elepaio within the MUs to improve yearly demographic monitoring. In the process, record songs and calls in order to expand our collection of Oahu Elepaio vocalizations at all MUs.

6.1.5 Terms and Conditions for Implementation

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

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

[No high explosive rounds landed above the firebreak road]

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

[No fires affected any known Elepaio territories during the 2019 breeding season]

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

[No training actions have occurred above the firebreak road]

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

[No specimens were collected by ANRP staff]

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

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

[This report documents all of the above requirements]

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

[All training was conducted in accordance with the WFMP]

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

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

[This report documents all of the above requirements]

2. *The Army, Service, and ornithological experts will formally reassess all impacts to Oahu Elepaio and Elepaio critical habitat that have occurred during the first five years following completion of this biological opinion. This formal review will occur before the end of calendar year 2008 and its purpose will be to reassess impacts from training exercises and, if necessary, correct any outstanding issues that are still impacting Elepaio and resulting in the loss suitable Elepaio habitat at SBMR. The feasibility of restoring critical habitat areas that have been lost also will be reassessed during this formal review.*

[Completed]

Figure 15. This subadult Elepaio will display a pale coloration on its lower bill for the first year after fledging the nest. As it matures the bill will turn completely black and a plumage transformation lasting 3 years will occur before reaching adulthood.

6.2 MIP ELEPAIO MANAGEMENT 2019

6.2.1 Background

The initial Biological Opinion (BO) that triggered the development of the Makua Implementation Plan (MIP) was issued in 1999 (USFWS 1999). At that time, the Oahu Elepaio 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 (USFWS 2004), the USFWS issued another BO that covered newly designated critical habitat within the Makua AA for plants and Elepaio. This BO outlined additional requirements related to this critical habitat. The most recent BO issued in 2007 required the protection of all Elepaio pairs within the Makua AA. A term and condition in this 2007 BO was to construct ungulate-proof fencing around Makua Military Reservation and control rodents using aerially broadcast rodenticide when authorized.

6.2.2 MIP Summary

Management Actions 2019

- Unfortunately, due to safety concerns regarding UXO, we were unable to access Makua Valley in 2019. We have not had access since 2017 when two adult males were found defending separate territories in gulches deep within the valley. A breeding pair of Elepaio has not been observed in Makua Valley since 2009.

Management Actions 2020

- If the OANRP is able to regain access we hope to continue with yearly territory occupancy surveys at all territories and surrounding gulches within the Makua AA as well as monitoring and banding.

6.3 OPEAPEA MANAGEMENT 2019

6.3.1 Background

The OANRP originally conducted acoustic monitoring for the Hawaiian Hoary bat (*Lasiurus cinereus semotus*) or Opeapea from 2010 to 2013 on all Oahu Army Training Areas: Dillingham Military Reservation (DMR), Kahuku Training Area (KTA), Kawailoa Training Area (KLOA), Makua Military Reservation (MMR) and Schofield Barracks Military Reservation (SBMR). The surveys were conducted for over 301 nights in order to establish bat presence or absence and if possible document potential seasonal use of habitats by the Opeapea. Acoustic monitoring confirmed the presence of Opeapea on all Oahu Training Areas (Figure 16) but seasonality of habitat use could not be determined. 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. Pinzari pers. comm.).

Figure 16. Acoustic monitoring sites on Army Training lands from 2010-2013.

6.3.2 Opeapea Management Summary

The OANRP secured funding in FY 15 to conduct more intensive acoustic monitoring surveys across 12 Army installations on Oahu, including cantonment areas. The Pacific Island Ecosystems Research Center of the U. S. Geological Survey were contracted to conduct these intensive surveys. A total of 30 monitoring stations were run nightly from one hour before local sunset until one hour after local sunrise from January 2015 to March 2016. Figure 17 shows all of the locations that the bat acoustic recorders were placed throughout the duration of the study.

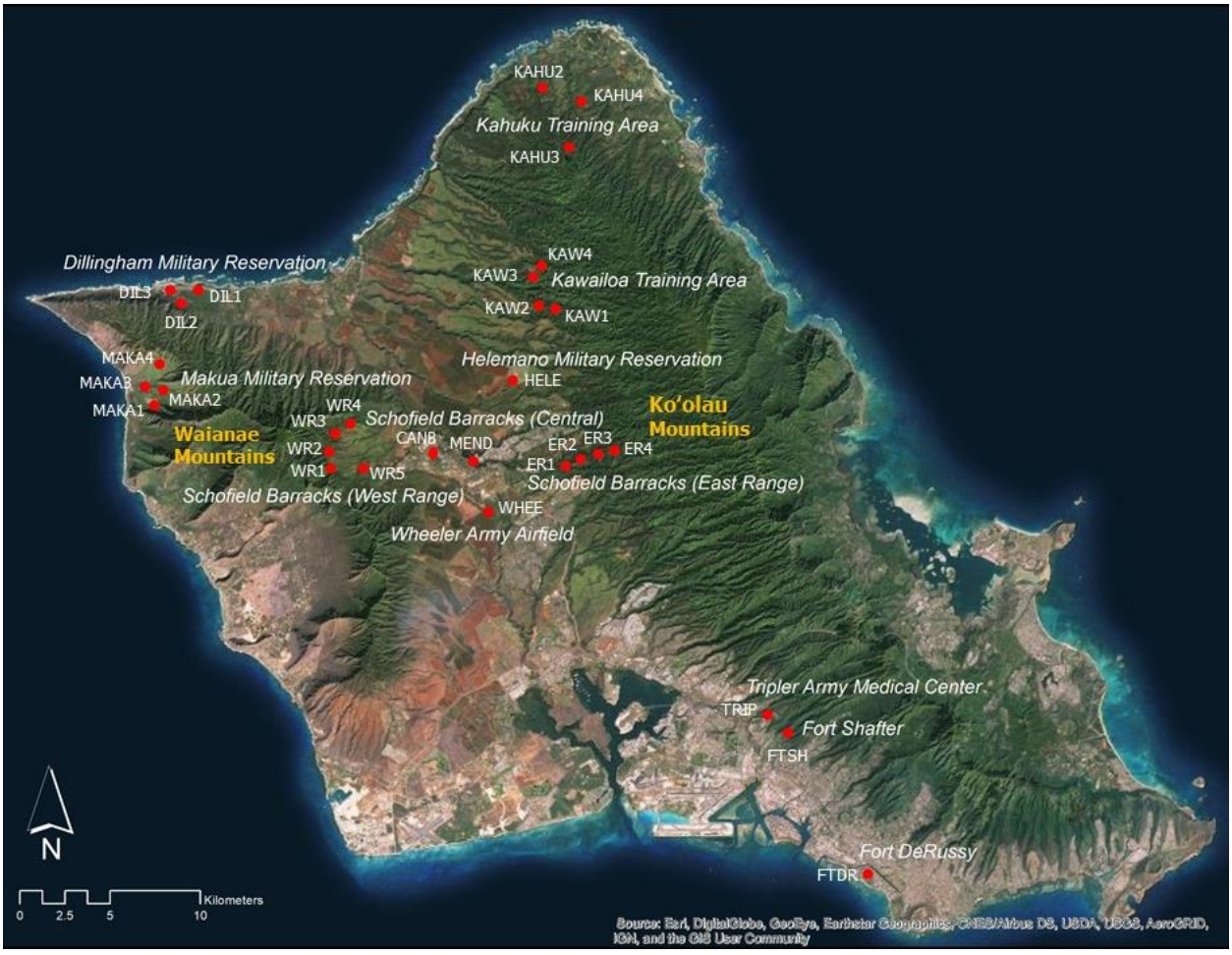

Figure 17. USGS survey sites for Opeapea on Army controlled lands, from Technical Report HCSU-089.

A brief synopsis of the results from the study show that 20 out of the 30 sites had bat presence, but the detection rates were very low (Figure 18). The highest frequency of detections were recorded from one station at Dillingham Airfield and three of the stations at West Range. Foraging activity was only recorded at West Range and East Range in Schofield Barracks. Refer to Appendix 6-1 for a full copy of Technical Report HCSU-089, Hawaiian Hoary Bat Acoustic Monitoring on U. S. Army Oahu Facilities.

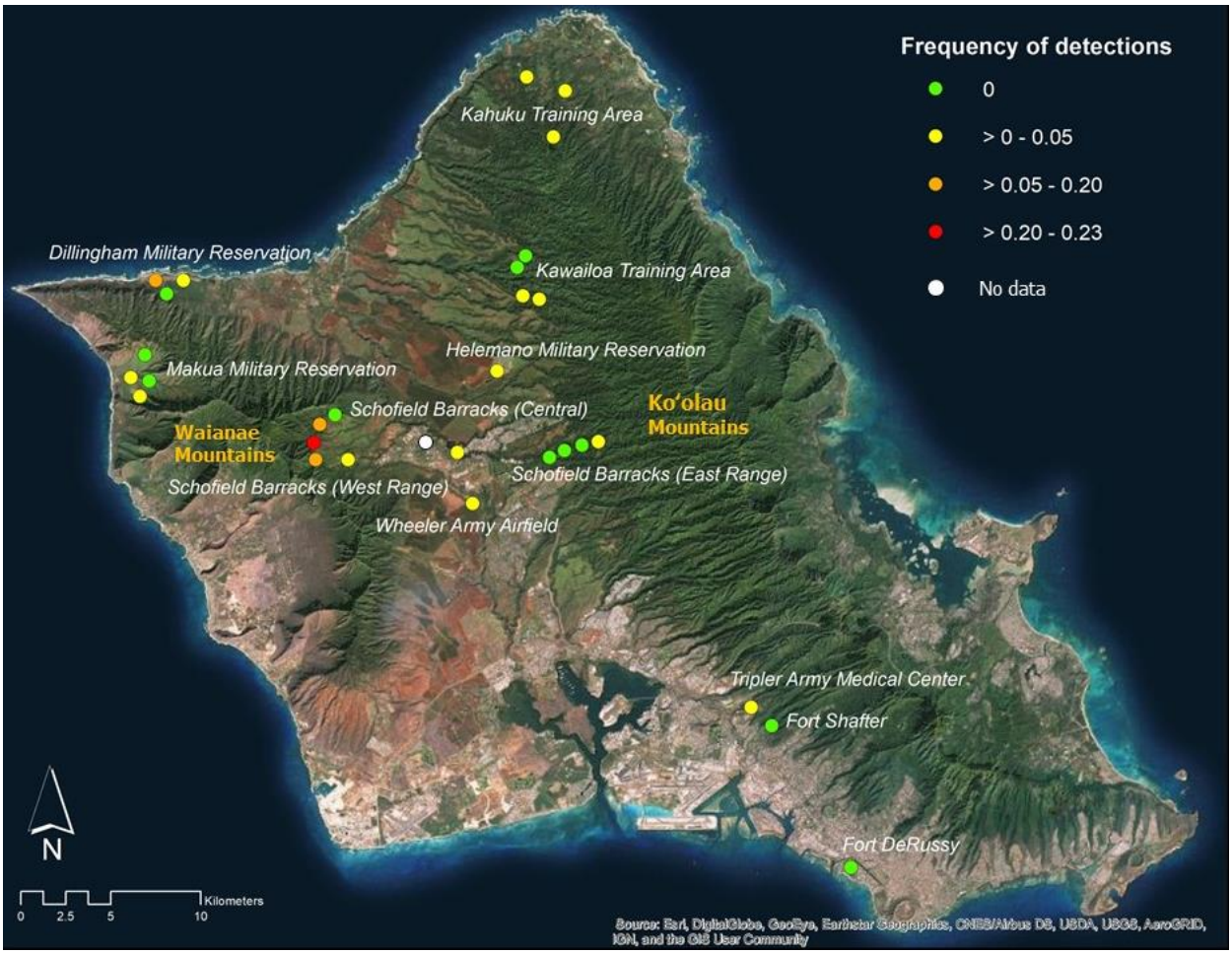

Figure 18. USGS survey sites with frequency of detections from Technical Report HCSU-089.

The Army continues to abide by tree cutting limits during the Opeapea pupping season from 1 June to 15 September. The USFWS provided these parameters to minimize impacts to roosting bat pups through an informal consultation. Refer to the 2016 Army's Natural Resources Program on Oahu YER for further details on the restrictions. This is a difficult situation as Federal contracts for grounds maintenance are executed using year-end funding just prior to the pupping season restrictions. Typically this makes it impractical to get all tree trimming and removal projects completed prior to 1 June. To ensure the completion of these contracts and cover any emergency tree removal actions, thermal surveys are conducted prior to any tree trimming or removal activities during the pupping season. All surveys are performed prior to sunrise on the morning of the scheduled tree trimming. During the 2019 pupping season there were 49 requests for bat pup surveys. Three were conducted by OANRP staff and 46 were completed by an outside contractor, Tree Solutions and Environmental Consulting Services. The Contractor has had training and past experience in bat pup surveys. The Contractor employed the use of a FLIR Scout III thermal imager to conduct its surveys. OANRP continued to employ a combination of acoustic monitoring (Echo meter Touch) and thermal imager (Fluke Ti400) surveys to determine if bats were utilizing the trees for roosting and if pups were present. Both the Contractor and Army Natural Resource Staff recorded whether any other wildlife was observed during the surveys. Survey reports produced are included as Appendix 6-2 and 6-3, respectively. Table 2 shows the results of the 49 surveys conducted by both OANRP and the Contractor. All totaled, ~43 hours were spent conducting these surveys (not including transportation time) in 728 trees. There were 24 species of trees surveyed but the

majority (439) were coconut palms (*Cocos nucifera*). Zero roosting or flying bats were detected during the course of the thermal surveys.

The Opeapea Acoustic/Thermal Survey summary table below shows the total number of roosting bat surveys throughout the 2019 pupping season. From the left, column 1 shows the date of each survey. Column 2 lists the surveyor, either Army Natural Resource staff or Tree Solutions and Environmental Consulting Services (TSECS). Column 3 is the type of survey. Column 4 shows the time of the survey. Columns 5 and 6 show whether there were any detections, bat or other wildlife. Column 7 lists the Army installation. Finally, columns 8-21 present the different species of trees that were surveyed.

6.3.3 Literature Cited

OANRP. 2018. Chapter 8: Rodent Management *in* 2018 Status Report for the Makua and Oahu Implementation Plans. http://manoa.hawaii.edu/hpicesu/DPW/2018_YER/08.pdf

U.S. Fish and Wildlife Service. 2004. Reinitiation of the 1999 Biological Opinion of the USFWS for Routine Military Training at Makua Military Reservation Island of Oahu. 190 Pages http://manoa.hawaii.edu/hpicesu/DPW/BO/2004BO_edited.pdf

U.S. Fish and Wildlife Service. 2003. Biological Opinion of the U.S. Fish and Wildlife Service for Routine Military Training and Transformation of the 2nd Brigade 25th Infantry Division (Light) U.S. Army Installation Island of Oahu. 356 pages. http://manoa.hawaii.edu/hpicesu/DPW/BO/2003BO_edited.pdf

U.S. Fish and Wildlife Service. 1999. Biological Opinion of the USFWS for Routine Military Training at Makua Military Reservation. 47 Pages. http://manoa.hawaii.edu/hpicesu/DPW/BO/1999BO.pdf

Table 2. 2019 Opeapea Acoustic/Thermal Surveys, showing number of trees by species surveyed.

Date	**Surveyor**	**Thermal or Acoustic Survey**	**Time**	**Bat Detected (T/A)**	**Wildlife Detected**	**Army Installation**	***Adonidia merrillii***	***Araucaria columnaris***	***Caryota spp***	***Cassia fistula***	***Cocos nucifera***	***Cordia subcordata***	***Cyrtostachys renda***	***Delonix regia***	***Dypsis lutescens***	***Eucalyptus spp.***	***Ficus sp.***	***Mangifera indica***	***Pandanus veitchi***	***Phoenix dactylifera***	***Ptychosperma macarthurii***	***Ravenala madagascariensis***	***Roystonea oleracea***	***Roystonea regia***	***Samanea saman***	***Spathodea campanulata***	***Swietenia mahagoni***	***Syagrus romanzoffiana***	***Tabebuia heterophylla***	***Wodyetia bifurcate***
7-Jun	TSECS	Thermal	05:00-06:00	No	Yes	AMR								1											3					
10-Jun	TSECS	Thermal	05:30-06:00	No	No	WAAF												1												
12-Jun	TSECS	Thermal	05:30-06:00	No	Yes	WAAF												1												
20-Jun	TSECS	Thermal	05:00-06:00	No	Yes	SBMR											1													
24-Jun	TSECS	Thermal	05:00-05:30	No	Yes	FSMR																			1					
27-Jun	TSECS	Thermal	05:30-06:00	No	Yes	SBMR											1													
27-Jun	TSECS	Thermal	05:15-05:45	No	No	HKH					22																			
28-Jun	TSECS	Thermal	05:20-05:50	No	No	HKH					25																			
29-Jun	MDB	Both	04:30-06:00	No	Yes	SBMR											1									1				
1-Jul	TSECS	Thermal	05:30-06:00	No	Yes	SBMR																					1			
1-Jul	TSECS	Thermal	05:15-06:00	No	No	HKH					33																			
2-Jul	TSECS	Thermal	05:10-06:00	No	No	HKH					20													9						
3-Jul	TSECS	Thermal	05:05-06:10	No	No	HKH					23													8						
9-Jul	TSECS	Thermal	05:00-06:30	No	No	HKH					25													8						
10-Jul	TSECS	Thermal	05:00-06:15	No	No	HKH					26									10										
11-Jul	TSECS	Thermal	05:05-06:05	No	No	HKH					22						1													
11-Jul	MDB	Both	04:30-06:30	No	Yes	FSMR												3							6		3			
12-Jul	TSECS	Thermal	05:00-06:00	No	No	HKH					1	4																		

Table 2 (continued).

Date	Surveyor	Thermal or Acoustic Survey	Time	Bat Detected (T/A)	Wildlife Detected	Army Installation	*Adonidia merrillii*	*Araucaria columnaris*	*Caryota spp*	*Cassia fistula*	*Cocos nucifera*	*Cordia subcordata*	*Cyrtostachys renda*	*Delonix regia*	*Dypsis lutescens*	*Eucalyptus spp.*	*Ficus sp.*	*Mangifera indica*	*Pandanus veitchi*	*Phoenix dactylifera*	*Ptychosperma macarthurii*	*Ravenala madagascariensis*	*Roystonea oleracea*	*Roystonea regia*	*Samanea saman*	*Spathodea campanulata*	*Swietenia mahagoni*	*Syagrus romanzoffiana*	*Tabebuia heterophylla*	*Wodyetia bifurcate*
15-Jul	TSECS	Thermal	05:00-06:00	No	No	HKH				2	12																			
16-Jul	TSECS	Thermal	05:10-05:45	No	No	HKH					13						1													
17-Jul	TSECS	Thermal	05::30-06:00	No	No	SBMR																				1				
17-Jul	TSECS	Thermal	05:10-06:00	No	No	HKH					22						1													
18-Jul	TSECS	Thermal	05:45-06:15	No	No	SBMR											1													
18-Jul	TSECS	Thermal	05:10-05:45	No	No	HKH											1													
19-Jul	TSECS	Thermal	05:05-05:55	No	No	HKH					17						1													
22-Jul	TSECS	Thermal	06:00-06:30	No	Yes	SBMR		1								1														
22-Jul	TSECS	Thermal	05:10-06:00	No	No	HKH					7						1								1					
23-Jul	TSECS	Thermal	05:10-06:00	No	No	HKH					7														1					
24-Jul	TSECS	Thermal	05:15-05:45	No	No	HKH					5						1													
25-Jul	TSECS	Thermal	05:05-06:10	No	No	HKH					19						1													
26-Jul	TSECS	Thermal	05:10-05:50	No	No	HKH					4						1													
29-Jul	TSECS	Thermal	05:45-07:00	No	Yes	SBMR/ WAAF					7						1													
29-Jul	TSECS	Thermal	05:00-06:00	No	No	HKH					30																			
30-Jul	TSECS	Thermal	05:45-07:00	No	Yes	SBMR/ WAAF										1	1												1	
31-Jul	TSECS	Thermal	05:45-06:15	No	Yes	SBMR																				1				
31-Jul	TSECS	Thermal	05:05-05:50	No	No	HKH					5													1						
1-Aug	TSECS	Thermal	05:10-05:55	No	No	HKH					36																			

Table 2 (continued).

Date	Surveyor	Thermal or Acoustic Survey	Time	Bat Detected (T/A)	Wildlife Detected	Army Installation	*Adonidia merrillii*	*Araucaria columnaris*	*Caryota spp*	*Cassia fistula*	*Cocos nucifera*	*Cordia subcordata*	*Cyrtostachys renda*	*Delonix regia*	*Dypsis lutescens*	*Eucalyptus spp.*	*Ficus sp.*	*Mangifera indica*	*Pandanus veitchi*	*Phoenix dactylifera*	*Ptychosperma macarthurii*	*Ravenala madagascariensis*	*Roystonea oleracea*	*Roystonea regia*	*Samanea saman*	*Spathodea campanulata*	*Swietenia mahagoni*	*Syagrus romanzoffiana*	*Tabebuia heterophylla*	*Wodyetia bifurcate*
2-Aug	TSECS	Thermal	05:15-06:00	No	No	HKH					19																			
8-Aug	TSECS	Thermal	05:00-05:30	No	No	AMR																				1			1	
19-Aug	TSECS	Thermal	05:30-06:15	No	No	HKH					17																			
20-Aug	TSECS	Thermal	05:15-06:00	No	No	HKH					9																			
28-Aug	TSECS	Thermal	05:15-06:00	No	No	HKH													1											
29-Aug	TSECS	Thermal	05:05-06:00	No	No	HKH													1											
09-Sep	TSECS	Thermal	05:15-06:00	No	Yes	HKH				5																				
10-Sep	MDB	Both	04:00-06:00	No	Yes	SBMR	11		32		13		3		38						19	2	3					31		5
10-Sep	TSECS	Thermal	05:00-05:45	No	No	HKH				5																				
11-Sep	TSECS	Thermal	05:00-05:45	No	No	HKH				1																				
12-Sep	TSECS	Thermal	05:00-06:00	No	No	HKH				21				1											2					
13-Sep	TSECS	Thermal	05:30-06:15	No	Yes	HKH				20																				

CHAPTER 7: RARE INSECT MANAGEMENT

7.1 *DROSOPHILA* MANAGEMENT

7.1.1 BACKGROUND

Fourteen species of Hawaiian picture wing *Drosophila* flies are currently listed as threatened or endangered, and many more are equally rare. Six listed species are endemic to Oahu, and three – *D. montgomeryi*, *D. obatai*, and *D. substenoptera* – are currently known to occur on Army lands. OANRP work on *Drosophila* began in March 2013, focusing on monitoring known populations, surveying for new ones, and restoring habitat. Winter and spring 2019 saw a second year of moderately high numbers (by recent standards) of both common and rare species in mesic forests. However, both endangered species at Palikea (*D. substenoptera* and *D. hemipeza*) have been at even lower levels than in 2016–17, despite high numbers of common species there.

7.1.2 SURVEY METHODS

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

Known, significant populations of *D. montgomeryi* at Kaluaa MU and *D. substenoptera* at Palikea MU, where flies occur relatively consistently, are monitored monthly in order to determine approximate population trends through the year. For *D. montgomeryi*, Pualii (designated as a management site for *D. montgomeryi*) and Waianae Kai (not a managed population, but the largest known population) were designated to be monitored quarterly; however, due to apparent loss of the population at Pualii due to a demographic gap in the host plant, and higher priorities elsewhere, no monitoring visits were made there this year (see below for other actions). Other known populations (Kaala and Lower Opaeula for *D. substenoptera*, Lihue and Manuwai for *D. obatai*) are visited periodically through the year, typically quarterly or less. New populations of endangered *Drosophila* were searched for by looking in similar habitat both in areas suggested by other staff as having host plants, at historic collecting localities, and in new sites where surveys have been minimal. Due to various access difficulties, both monitoring of secondary sites and surveys for new populations were reduced this year.

7.1.3 RESULTS

7.1.3.1 *Drosophila montgomeryi*

Drosophila montgomeryi is a small yellow-brown species that breeds in rotting bark of *Urera kaalae* and *Urera glabra* (opuhe). While *U. glabra* occurs widely across the Waianae range, it often occurs as

scattered clumps of one or a few individuals, unsuited for survival of *D. montgomeryi* and probably not viable for long-term survival of this dioecious, wind-pollinated tree. *Urera kaalae* is critically endangered and only a handful of wild plants remain, although several hundred have been outplanted. *Drosophila montgomeryi* 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). Kaluaa (all three sites collectively), Pualii, and Palikea are designated as MFS PUs. It has not been found at the Pualii PU in over five years, and the Lihue PU has not been surveyed recently due to access issues. However, three individuals were found this year at Palikea PU, 17 months after the previous sighting. Field work this year has focused on monitoring known populations rather than searching for new sites (Table 1).

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 150 survey days. Abundance of *D. montgomeryi* generally follows a distinct seasonal pattern, increasing dramatically over the winter months to a peak between January and May, more or less in synchrony with several common *Drosophila* species (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. During the El Nino of 2015–17, there was no such winter pulse in *D. montgomeryi*. Numbers largely recovered in 2017–18 and 2018–19, but with

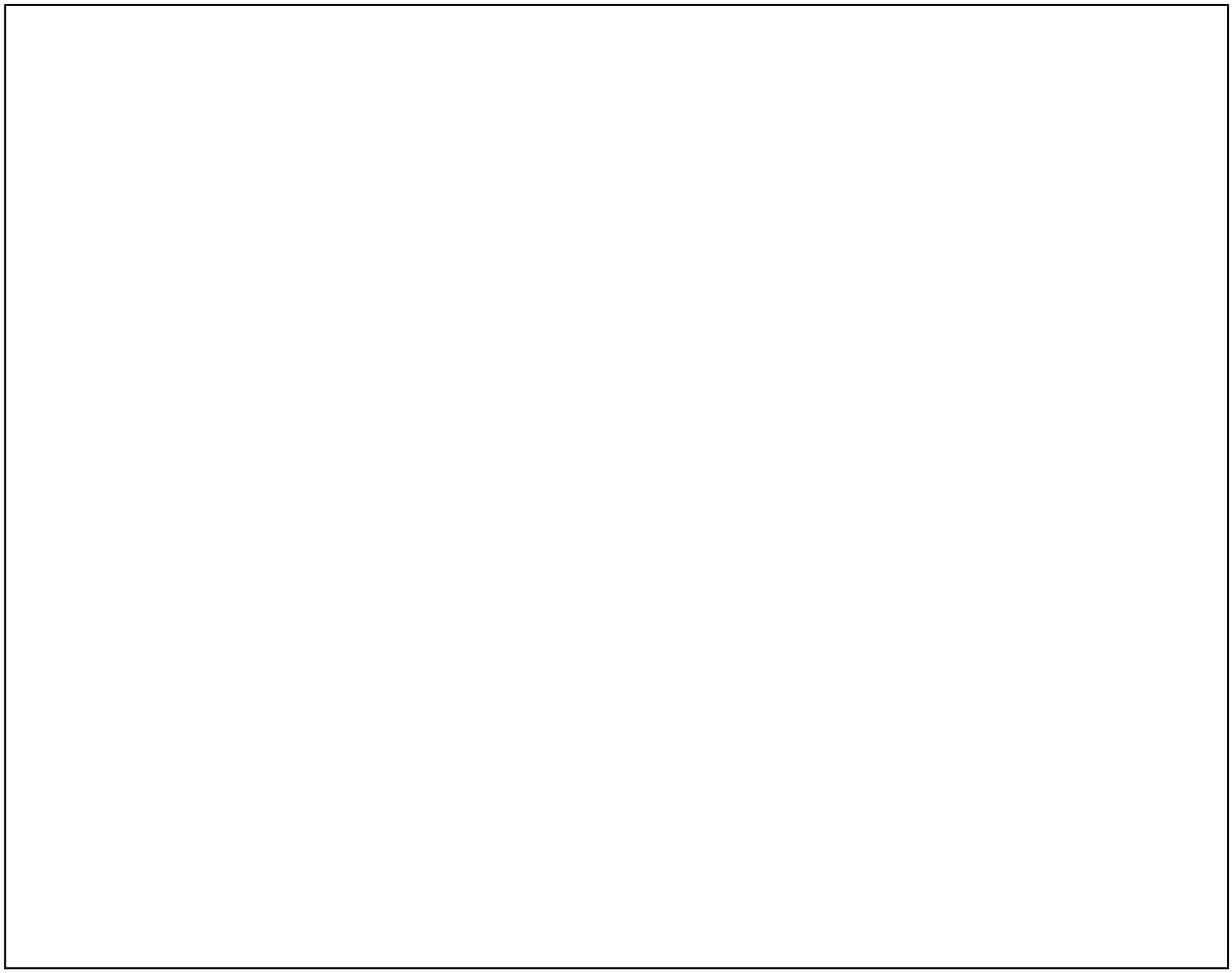

Figure 1. Distribution of *Drosophila montgomeryi* observations in the 2018–19 reporting year and earlier records from 2009–18, with known *Urera* spp. sites and all survey points in the Waianae range.

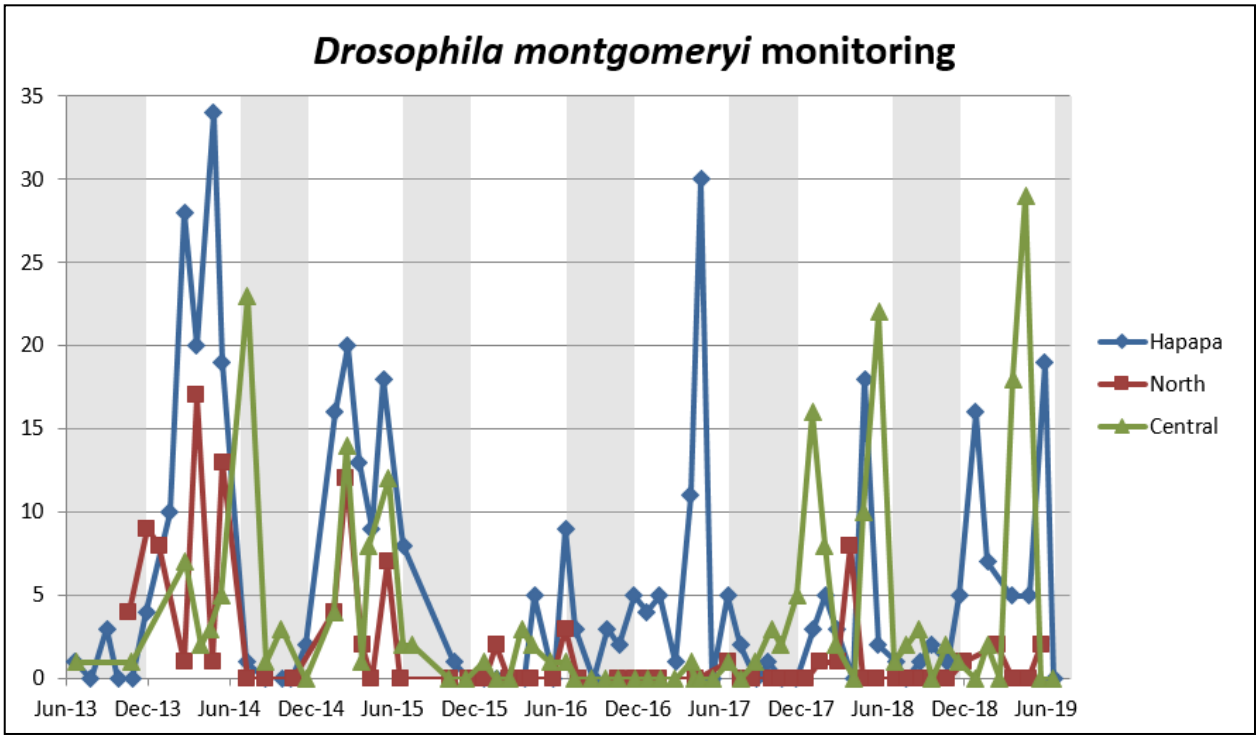

Figure 2. *Drosophila montgomeryi* numbers during monthly monitoring at three sites in Kaluaa PU (Puu Hapapa, North Kaluaa, and Central Kaluaa). Y axis is the maximum number observed across the entire site on the survey day (see Survey Methods, section 7.2). Gray shading indicates the summer low season.

less consistency across the season. The population at North Kaluaa has also declined due to a loss of host plants, but recent outplants should help the population there in the future.

Table 1. Survey effort for *D. montgomeryi* across all potential sites in the 2018–19 reporting period, in survey days. "Max No." is the highest number of flies observed in a single day.

Site	Days	Max No.
Kaluaa - Central	12	29
Kaluaa - North	10	2
Puu Hapapa	12	19
Palikea	12	2
Waianae	2	51

Pualii

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

Ongoing monitoring and control of the big-headed ant (*Pheidole megacephala*) population in the gulch suggests that their range expands and contracts with vegetation and microclimate changes, as they avoid darker and moister sites. Currently, several large portions of the gulch are open and dry, and susceptible to invasion of ants from adjacent alien-dominated areas. We expect that increased cover as outplants and other native trees expand will reduce the area of suitable habitat for ants in the future.

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. Five of the seven records here have been of single individuals, indicating that the population remains low. After a year of occasional sightings it disappeared, possibly due in part to drying of the site from canopy clearing. Since that time, *Urera glabra* has increased naturally as weed control reduced alien cover, and outplanting has significantly boosted the population. Outplanted *U. glabra* here have done exceptionally well – after four years, many of them are large sprawling trees 8–10 feet tall. Continuous treefalls of *Schinus terebinthefolius* and other larger trees have damaged some *Urera* and slowed growth, but also provide breeding habitat for *D. montgomeryi*. *Urera kaalae* have also been planted here by Oahu PEPP, and are thriving. Weed control is ongoing as some parts of the restoration area currently lack canopy cover and are susceptible to heavy invasion by weeds such as *Rubus rosifolius*, *Buddleia asiatica*, and *Erechtites valerianifolia*. In May 2019, one *D. montgomeryi* was seen at the outplant site for the first time since the single sighting in October 2017, and two more in June, suggesting the vigorous growth of outplants there (Figure 3) is benefiting them.

Waianae Kai

The largest known population of *D. montgomeryi* occurs in the northeastern subgulches of Kumaipo stream, Waianae Valley. Four sites have been discovered so far, all at the base of Mt. Kaala and

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

consisting of small patches (~0.5 ha) of diverse native forest constrained by alien-dominated vegetation above and below. All are located on or just below steep slopes that are vulnerable to landslides, which may preclude fencing as a matter of practicality. The largest has been surveyed repeatedly and had a very large population of flies, but this has been severely reduced by damage from falling boulders and subsequent weed invasion over the past several years. Although still degraded from the condition it was originally discovered in, numbers of *D. montgomeryi* were found to have rebounded to their previous high level during the most recent survey. Much of the area further east in Hiu and Honua drainages, as well as the western half of Kumaipo, remains to be surveyed and may contain additional sites.

Habitat restoration

This was the fifth year of active habitat management for *Drosophila montgomeryi*. Since fall 2014, approximately 350 *U. glabra* and 300 *U. kaalae* have been planted at North Kaluaa, Central Kaluaa, Pualii, and Palikea (summarized in the 2017 Year End Report). This year, an additional 98 *U. glabra* were planted at Pualii, where a large treefall opened up a light gap and weeds were removed. This site has unusually shallow soil underlaid by solid, unweathered rock. This is also the first time planting seedlings of *U. glabra* rather than cuttings. The combination of these factors has probably contributed to the lower survivorship seen at this outplanting compared to others (about 50% compared to >80% in cuttings planted in soil or talus), but hopefully the surviving plants will be better adapted to the conditions in the long run. Extensive planting of *U. glabra* as part of general restoration plantings, many near existing *D. montgomeryi* populations, should also aid recovery efforts. In the coming year, additional plantings are planned for Pualii and at Ekahanui, a potential reintroduction site where *D. montgomeryi* was historically most abundant but it has not been detected recently, and only a handful of *Urera* currently remain.

7.1.3.2 *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* spp. (olapa) and *Polyscias* (=*Tetraplasandra*) *oahuensis* (ohe mauka), a habitat which is relatively uncommon since these trees tend to occur most abundantly in boggy, short-stature forest near summit crestlines. Compared to other islands, *Cheirodendron* is rather uncommon on Oahu relative to available habitat, and a large proportion occurs on steep slopes or in the bottom of drainages that are weedy and difficult to access. Currently, there are three PUs for *D. substenoptera* – Palikea, Kaala-Kalena, and Opaeula (Figure 4). PU trends are only graphed for Palikea; the other two PUs are only occasionally monitored and *D. substenoptera* is highly sporadic at them, typically occurring as single individuals observed only once during a day. This rarity has undoubtedly hampered our ability to detect it at new sites. Management currently consists of general habitat maintenance and improvement, since it does not appear to be host-limited and other factors in its rarity remain unknown. *Cheirodendron* has been extensively outplanted at Palikea for general habitat restoration which should help *D. substenoptera*.

Waianae Range

Monthly monitoring in the northern portion of Palikea MU has been ongoing since May 2013 (69 survey days total, 12 in the current reporting period; Table 2). Aside from a large flush in late May 2013, numbers of *D. substenoptera* and another endangered species, *D. hemipeza*, have been consistently low to modest, but they have almost always been present. In contrast to *D. montgomeryi*, abundance of *D. substenoptera* tends to increase in the summer rather than winter, somewhat correlated with *D. hemipeza* and the common *D. crucigera* but not with the most abundant species at the site, *D. punalua* (Figure 5), indicating differences in host availability. At the Kaala-Kalena PU, three sites were surveyed (Kaala west face, east face, and transect); no flies were found in this area.

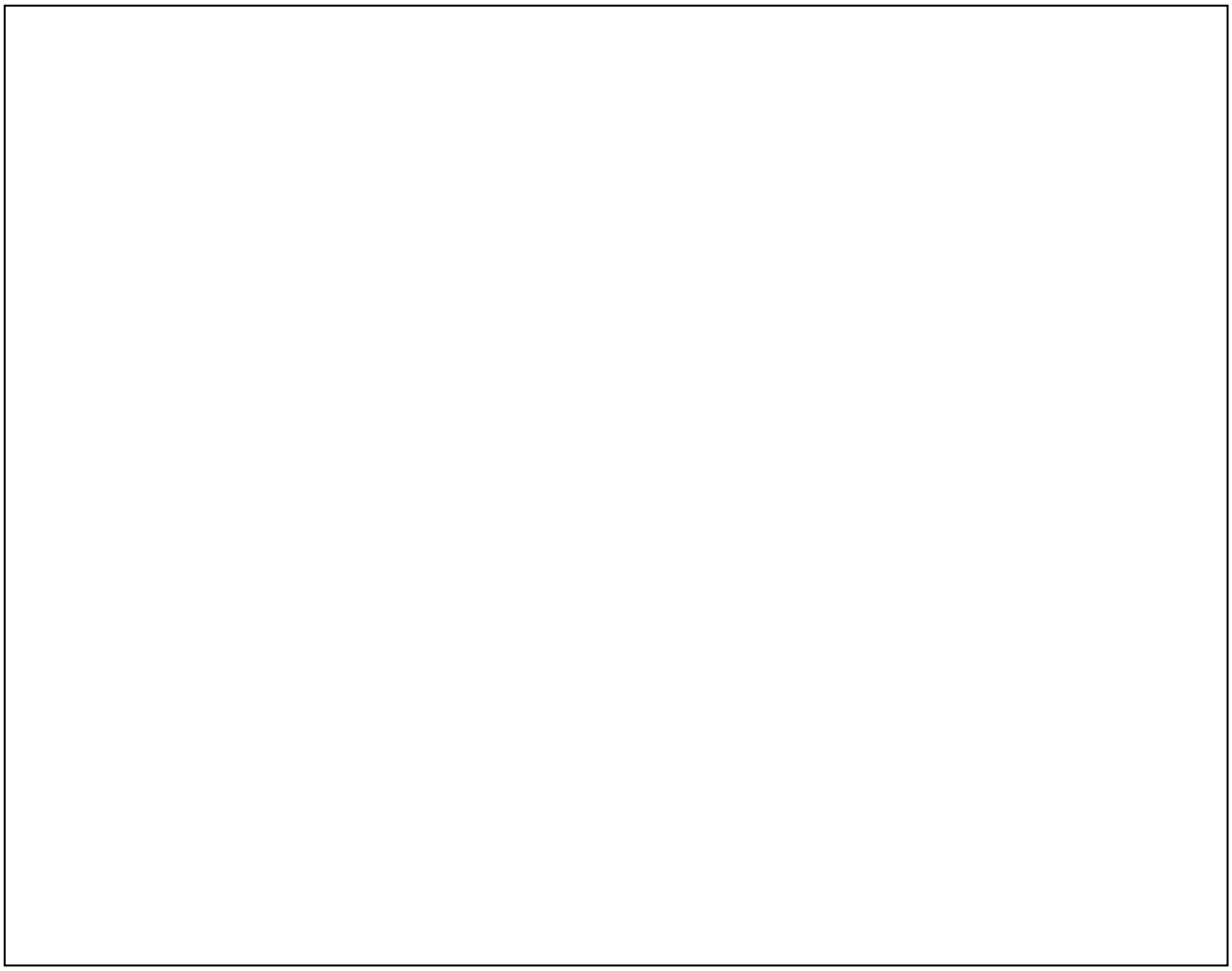

Figure 4. Distribution of *Drosophila substenoptera* observations in the 2018–19 reporting year and earlier records from 2009–18, with selected *Cheirodendron* spp. sites and all survey points.

Koolau Range

In December 2013, a single *D. substenoptera* was observed at Opaeula Lower MU, the first record of the species in the Koolau range since 1972. In early 2015, it was sighted again in the same area. Historically, *D. substenoptera* was more widespread and abundant on this side than in the Waianae range. However, collection effort has been limited due to the difficulty in accessing areas of intact habitat for this species. OANRP survey trips in the Koolaus are now relatively few due to higher priorities elsewhere, and concentrated in only a few sites. In 2018–9, only Koloa was visited once for two days; none were found. Finding additional Koolau populations is a high priority for this species; Helemano, Poamoho, Kaluanui, 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.

Table 2. Survey effort for *D. substenoptera* and number of flies found across all potential sites in the 2017-18 reporting period, in survey days. "Max No." is the highest number of flies observed in a single day.

Site	Days	Max No.
Palikea	12	4
Kaala	5	0
Koloa	2	0

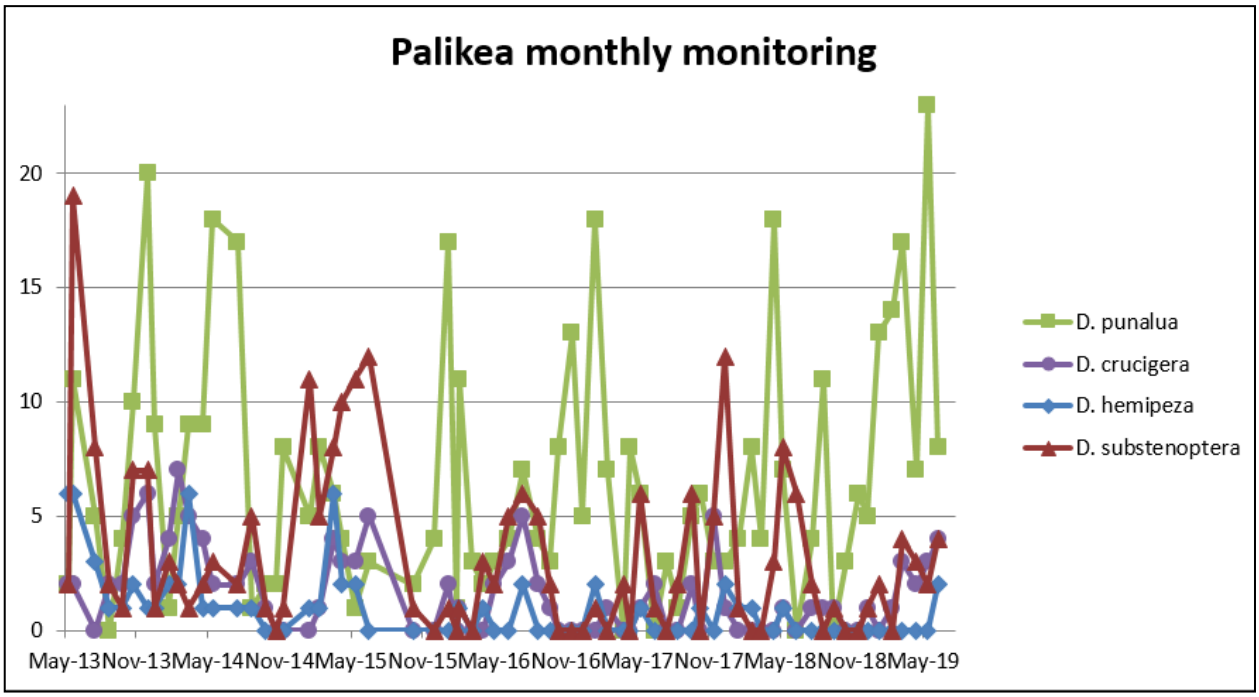

Figure 5. Monthly monitoring results for all picture-wing *Drosophila* species at Palikea, from May 2013 to June 2019.

7.1.3.3 *Drosophila obatai*

Table 3. Survey effort for *D. obatai* across all potential sites in 2018–19 reporting period, in survey days.

Site	Days	Max No.
Lihue – Pulee	1	0
Ohikilolo	1	0

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. *Drosophila obatai* is currently known from seven sites in four potential PUs (Makaleha, Manuwai, Palikea Gulch, and Pulee), although three of these are within 1,200 m of each other and could potentially form one contiguous population (Figure 6). While the populations were almost certainly contiguous until recently, native forest in general and *Chrysodracon* in particular is now much more fragmented, and moving between patches of host trees is more difficult for the flies.

Surveys for *D. obatai* have been few since 2017 due to difficulty accessing SBW (Pulee) and Manuwai, limited survey time available, and focus on monitoring *D. montgomeryi* (Table 3). Access to both areas has recently been restored and the former is a high priority to survey. In late 2017 and early 2018, A24 rat traps were installed at two sites in Pulee and one in Manuwai in hopes of increasing *Chrysodracon* recruitment, but we have not been able to service them regularly. Only two sites were surveyed for *D. obatai* this year, one in Pulee (SBW) and one at Ohikilolo, and no *D. obatai* were seen. Manuwai is the only site with *D. obatai* consistently present and the only currently known site for several other extremely rare species, but may be threatened by expansion of yellow crazy ants (*Anoplolepis gracilipes*) as noted in the 2018 YER.

7.1.3.4 Other Rare *Drosophila*

During the course of surveys, five additional rare but non-listed *Drosophila* were found in management units (Table 4). Many of the rare species that were found in 2014 (*D. kinoole*, *D. paucicilia*, *D. reynoldsiae*, *D. sobrina*, *D. spaniothrix*, and *D.* n. sp. nr. *truncipenna*) have not been seen since then.

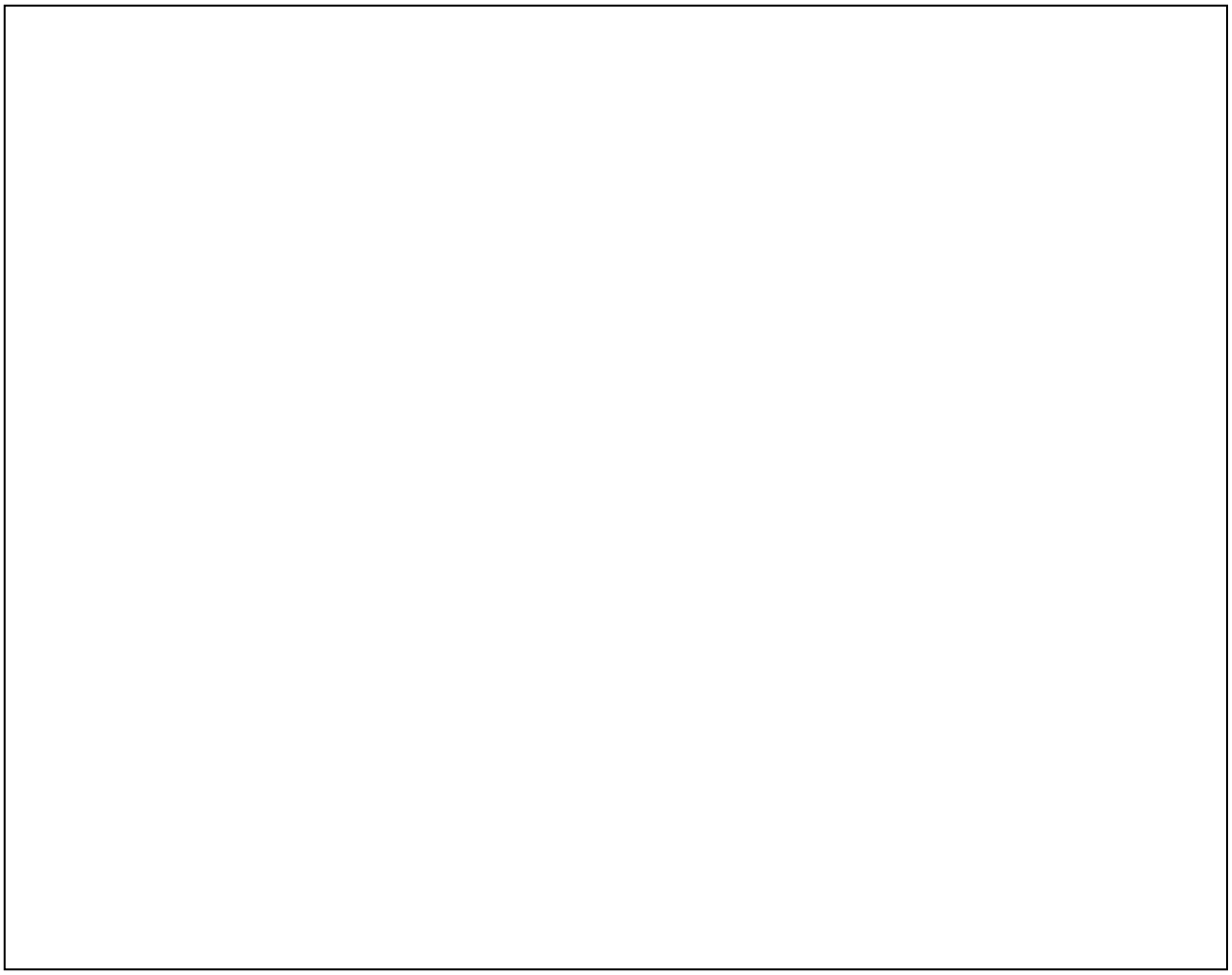

Figure 6. Distribution of *Drosophila obatai* observations in the 2018–19 reporting year and earlier records from 2013–18, with known *Chrysodracon* spp. sites and all survey points in the Waianae range.

Table 4. Non-target rare *Drosophila* observed during surveys, July 2017–June 2018.

Species	Sites	Total Observed	Max. No.
D. divaricata	Kaluaa, Hapapa	41	11
D. hemipeza	Palikea, Hapapa	2	2
D. hexachaetae	Pulee	1	1
D. nigribasis	Kaala	1	1
D. oahuensis	Kaala	7	3

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 is generally rare, but has been observed regularly in Kaluaa Gulch. It was considerably more abundant than previously at Central Kaluaa during the months of the winter and spring peak, but only a few appeared at North Kaluaa where it had been more regular.

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 for

several years but always in low numbers; in 2014–2015 occasional individuals showed up at Puu Hapapa as well. It was absent for nearly all of the current report period, reappearing at Palikea only in June 2019.

Drosophila hexachaetae is a small species similar in appearance to *D. montgomeryi*, but not closely related. It breeds in *Charpentiera* spp. (papala, Amaranthaceae) and *Pisonia* spp. (papala kepau, Nyctaginaceae). Although moderately common prior to 2013, it has been rare since then. A single individual was found at Pulee (Guava Gulch).

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. Only one was seen this year, but surveys in those areas were fewer than previously.

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. Surveys at its preferred sites were relatively few this year; a total of seven were found this year.

Drosophila hexachaetae, similar to *D. montgomeryi* but not closely related.

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

7.1.3.5 *Vespula pensylvanica*

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

Ten traps baited with heptyl butyrate are monitored monthly at Palikea and Puu Hapapa. Traps were replaced with a different style in February 2017, so the numbers for 2017–19 may not be directly comparable to those for 2015–16. *Vespula* numbers were similar at the two sites in 2015, but have been moderate to high at Palikea every year since while Hapapa has not had any since that time (Figure 7). Even numbers at Palikea are modest compared to montane areas of Hawaii or Maui. There is no discernable relationship between the peak of *Vespula* and *Drosophila* observed; in summer 2017, the unusually high *Vespula* peak occurred at a time when *D. substenoptera* numbers were moderate and steady, while in 2018 the brief spike of *Vespula* occurred after *D. substenoptera* dropped to low levels.

Since *Vespula* do not appear to be a serious threat, monitoring was discontinued at Palikea and Hapapa in February 2019. Monitoring may be resumed if populations are observed to increase in the future. However, based on the work of Krushelnycky et al. (Biol. Cons. 215:254–259, and 2016 YER Appendix ES-7), it appears that *Solenopsis papuana* ants may be a more serious threat.

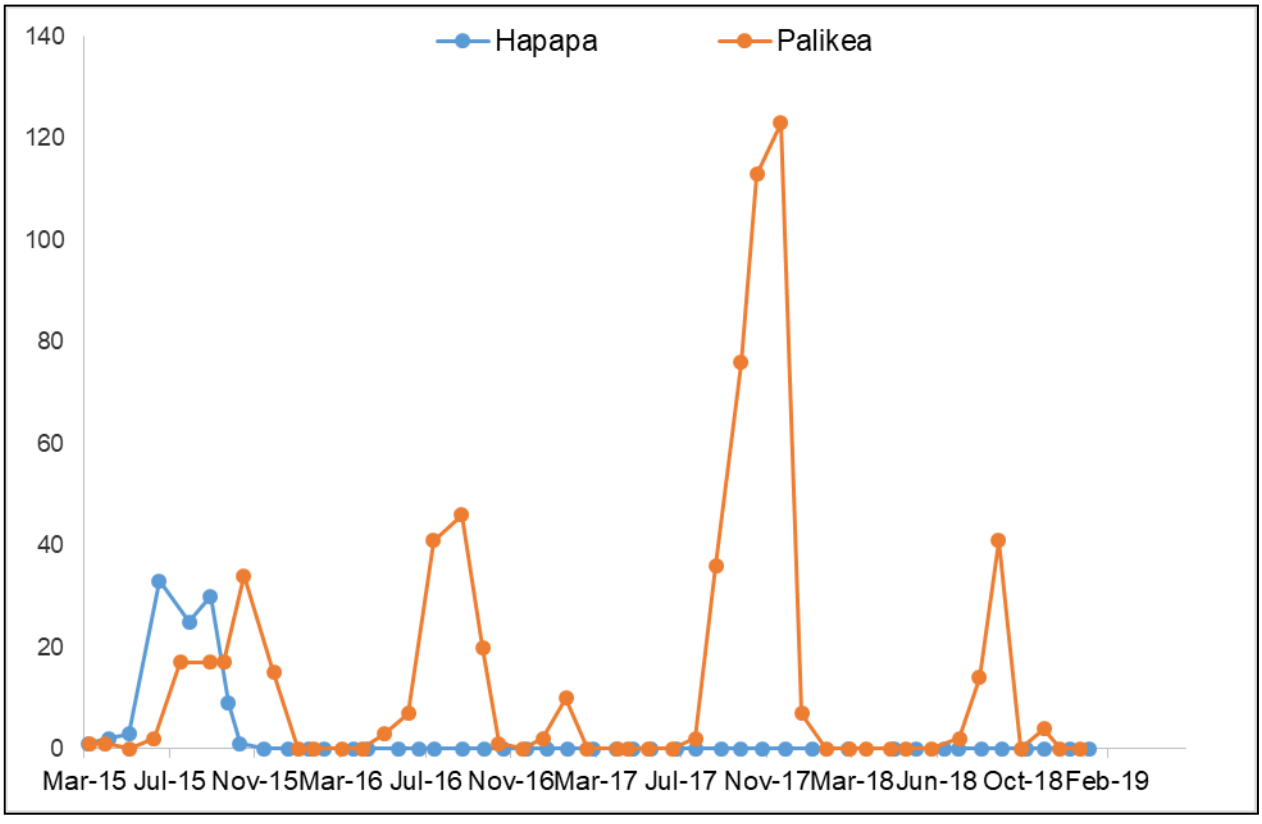

Figure 7. *Vespula pensylvanica* numbers at Palikea and Puu Hapapa (monthly total across 10 traps at each site).

7.2 *MEGALAGRION XANTHOMELAS* REINTRODUCTION

7.2.1 Background

Megalagrion xanthomelas is an endemic damselfly, formerly widespread and common in the lowlands of all islands but now extremely rare; the aquatic naiads are highly vulnerable to predation by alien mosquitofish and topminnows, which are nearly ubiquitous in Hawaiian water bodies. After the last collection from springs around Pearl Harbor in 1977, it was thought to be extirpated from Oahu. In 1995, it was rediscovered on the grounds of Tripler Army Medical Center (TAMC). 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 sporadically prior to that, by Bishop Museum personnel under contract. During this time the population has stayed relatively stable, though the number of individuals observed fluctuates widely between visits.

Establishing additional populations has long been a priority for management of the species. 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. In 2016, the state Division of Forestry and Wildlife established an insectary facility that allows rearing of large number of damselfly naiads, enabling a less disruptive and potentially more effective method of establishing new populations than capturing adults from Tripler and releasing them at the new site. Due to the limited carrying capacity of the Tripler stream, there is a large surplus of *M. xanthomelas* eggs that can be removed without affecting the population, and damselflies are more likely to have affinity for sites they emerged from as adults than translocated mature adults.

7.2.2 Site Selection

Two sites were identified for reintroductions (Figure 8). The top priority was at Lyon Arboretum, which has three artificial, ornamental ponds. These previously had alien fish in them, so they were drained and re-seeded with aquatic plants and microfauna. A secondary site was found at Waianae Kai Forest Reserve, where a small permanently-flowing stream exists, fed by groundwater below Kaala; the stream normally dries up well above the main stream channels, keeping it free of fish.

7.2.3 Release Timeline

The rearing and release was done by DOFAW, with assistance from OANRP, Lyon Arboretum, and other partners. Below is the timeline of the release at the two sites.

Nov. 26, 2018 – Ten *Paederia scandens* (maile pilau) stems (< 1 m) were collected from locations spread out over the length of the Tripler population. Over the next several weeks, 1380 naiads hatched from six of the samples (only four had egg scars visible under the microscope).

Dec. 7, 11, & 21 – Excess early-instar naiads (900) released back at Tripler in batches. Remaining naiads matured faster than expected.

Jan. 10, 2019 – All the ponds at Lyon are drained, and relined with concrete the next week. Amphipods, mosquitos, and chironomids quickly colonized them. The pH of the smaller pond remained high (alkaline) through February but declined with flushing.

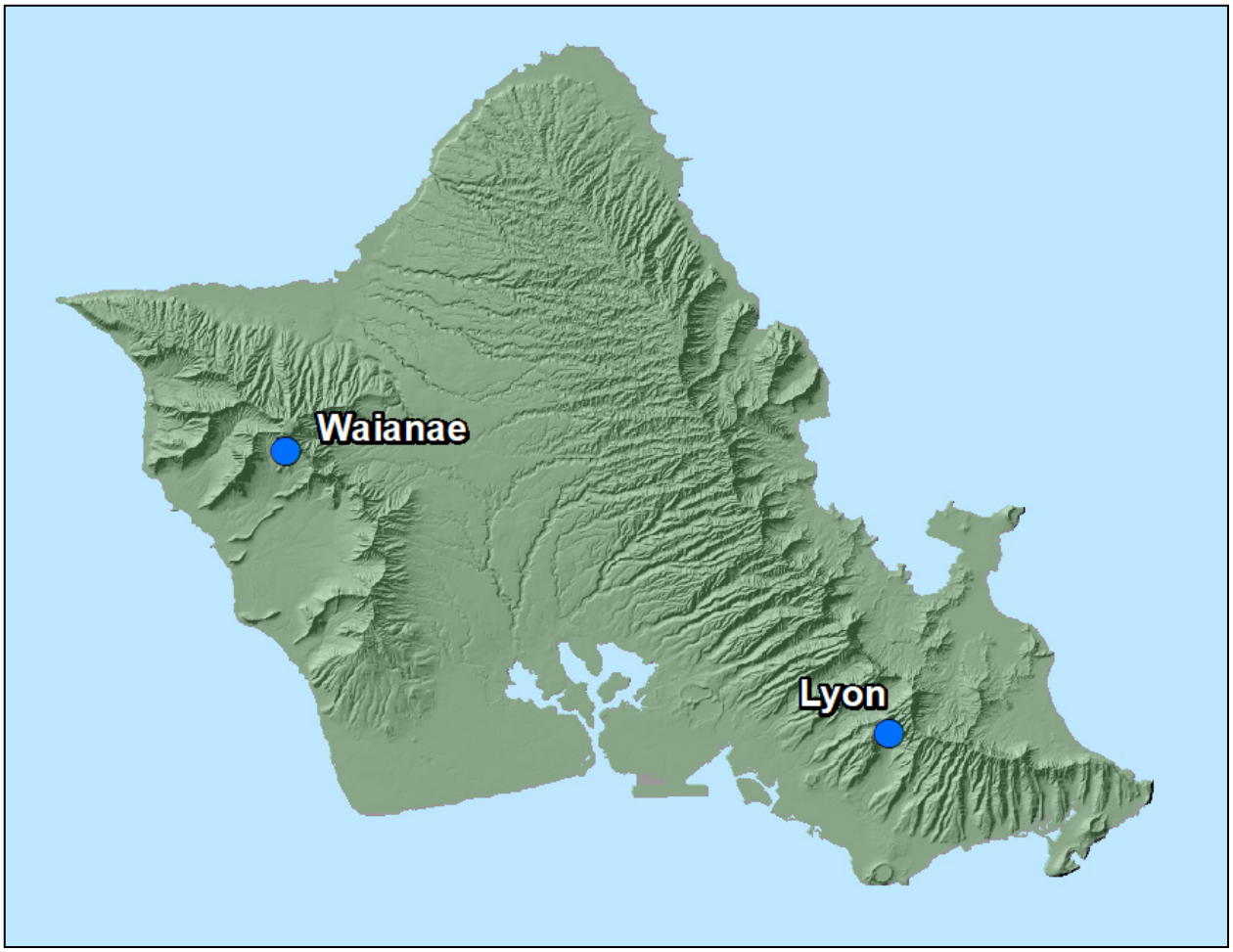

Figure 8. 2019 *Megalagrion xanthomelas* reintroduction sites.

Jan. 22 – First batch of 111 last-instar naiads released at Waianae Valley site. We found that floods had dramatically altered the stream compared to its state when previously visited in October, filling the lower section with tons of rock talus and making the water much colder (Figure 9). A total of 396 naiads and 8 adults were released over the next month (Jan. 22–Feb. 20).

Feb. 21 – Second batch of vegetation collected at Tripler. Collected 4 stems with visible egg scars (total of 795 eggs counted).

Feb. 27 – Vines placed as "oviposition bait" in stream at Tripler and observed a female ovipositing in one vine, which was collected (138 eggs counted). Naiads (133) hatched from these eggs in 14–16 days.

Feb. 22–Mar. 21 – A total of 527 naiads hatched from vegetation samples.

Mar. 1 – One vegetation sample returned to Tripler, due to 248 naiads hatching from that sample already.

Mar. 4 – Excess early-instar naiads (167) released at Waianae Valley site.

Apr. 30 – First batch of 86 last-instar naiads released at Lyon (Figure 10).

May 6 – Second batch of 54 naiads released at Lyon. At least 22 molted skins observed around the first pond.

Figure 9. Waianae Kai release site. Left: October 2018. Above: January 2019, with OANRP biologist Kapua Kawelo and DOFAW entomologist Cynthia King. Both photos taken at approximately the same spot.

Figure 10. Release of *M. xanthomelas* at Lyon Arboretum, with DOFAW entomologists Cynthia King (center left, in blue jacket) and Will Haines (center), and DOFAW, Lyon, and USFWS staff.

May 28 – Final naiad release at Lyon; a total of 295 naiads and 14 adults were released here and 92 molted skins were observed.

May–June – Adults and tandem pairs are frequently seen around the arboretum's taro loi (which contain fish), but only infrequently at the fish-free ponds. Vegetation from loi with eggs removed to rear additional naiads. No adults were ever seen at Waianae.

7.2.4 Results

Although the release at Lyon was successful in producing adults, the presence of a more-attractive water source meant that they did not establish at the ponds as we had hoped. We had not expected them to go as far as the loi when the ponds were available and had been their emergence site. No adults have been seen at either the ponds or the loi since the adults from the released naiads died out (they only live 4–6 weeks as adults), indicating that they have not reproduced there. It appears likely that the Waianae site is also unsuitable due to low water temperatures for at least part of the year. We plan to continue looking for additional sites.

CHAPTER 8: RODENT MANAGEMENT

The Oahu Army Natural Resource Program (OANRP) has managed Makua Implementation Plan (MIP) and Oahu Implementation Plan (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 8.1 provides an overview of the current rodent control program and discusses recent changes; Section 8.2 introduces tracking tunnel results from large scale grids; Section 8.3 describes results from a slug repellent Automatic Lure Pump (ALP) study; Section 8.4 discusses a trial with game cameras to monitor rodent activity at Kahanahaiki MU; and Section 8.5 lays out future plans for rodent control.

8.1 RODENT CONTROL PROGRAM SUMMARY

In the past, our program managed rats seasonally or year-round, depending on rare taxa protection needs. For example, *Chasiempis ibidis* (Oahu Elepaio) were only protected during the nesting season, while *Achatinella mustelina* were protected from predation year-round. Other grids were 'rapid response' to address threats to endangered plant resources. In the history of our program methods of rodent control included: kill-traps (Victor snap traps, Ka Mate traps, and GoodNature A24 traps (A24s)), Diphacinone bait (including Ramik and D-50), ContraPest birth control used for trials, and predator-proof fences.

Our program has been using A24s since 2013 at several Management Units (MUs) and has conducted numerous trials of the traps and bait. There have been some mechanical issues involving leaking seals and gaskets that have reduced the efficacy of these traps. GoodNature has addressed these malfunctions and now produces a trap that has very few issues. Bait longevity and attractiveness are also key to trapping success. Several reasons for decreased longevity/attractiveness include mold, ants, and slugs. It is not uncommon to see slugs remove all of the bait within weeks of placement. The old bait system used a "static" lure that would only last from one to four weeks at our MUs. GoodNature has produced an Automatic Lure Pump (ALP) baiting system that provides continuous attractive bait for up to 4-6 months.

In 2017-2019 our program transitioned all trapping grids from older methods to A24s with Automatic Lure Pumps (ALPs). OANRP now has 31 rodent control areas consisting of 1,421 A24s managed year-round (Table 1). Because of the success of the Citric Acid Slug Repellent ALP, the standard re-baiting interval for all grids will now be every 6 months. Beginning late 2019 and early 2020 we will be implementing citric acid ALPs at all sites. We have also been working to optimize trap spacing. Currently, we are deploying traps in larger areas with 100 by 50 meter grids but will continue to investigate this design. This method of control is now our primary way to reduce rodents for the benefit of our managed species. We plan to limit changes to the grids for the next three years while we evaluate this approach.

Table 1. Rat control areas in 2018-2019.

MU (Area)	Primary Spp. Protected	Description	# A24 Traps
Ekahanui	*Chasiempis ibidis*, *Achatinella mustelina*, *Cyanea grimesiana* subsp. *obatae*, *Schiedea kaalae*, *Delissea waianaeensis*	Large-scale grid	306
Kaala Army	*Labordia cyrtandrae*	One small grid	33
Kahanahaiki	*A. mustelina*	Predator-proof fence	2

Table 1 (continued).

MU (Area)	Primary Spp. Protected	Description	# A24 Traps
Kahanahaiki	*A. mustelina*, *C. superba* subsp. *superba*	Large-scale grid	77
Kahanahaiki	*A. mustelina*	Predator-proof fence	2
Kaluaa & Waieli	*D. waianaeensis*, *C. grimesiana* subsp. *obatae*	One small grid	30
Kaluaa & Waieli (Hapapa bench)	*A. mustelina*	One small grid	12
Kaluaa & Waieli (Hapapa)	*A. mustelina*	Predator-proof fence	4
Kaluaa & Waieli (North gulch)	*C. grimesiana* subsp. *obatae*	One small grid	6
Kamaohanui (in Lihue)	*A. mustelina*	One small grid	25
Keawapilau (in Kapuna Upper)	*Hesperomannia oahuensis*, *Schiedea nuttallii*, *Cyanea longiflora*	One small grid	17
Lihue (Coffee and Guava)	*Drosophila obatai*	Two small grids	17
Lihue (Mohiakea and Haleauau)	*C. ibidis*	Two large grids	219
Lihue (Haleauau)	*A. mustelina*	Two small grids	24
Lihue (Haleauau)	*H. oahuensis*	One small grid	4
Lihue (Mohiakea)	*D. waianaeensis*	One small grid	10
Makaleha East	*A. mustelina*	Two small grids	20
Makaleha West	*C. grimesiana* subsp. *obatae*	One small grid	15
Makaleha West	*A. mustelina*	Predator-proof fence	12
Makaha I	*A. mustelina, H. oahuensis, C. superba*	Large-scale grid	98
Makaha II	*C. grimesiana* subsp. *obatae, C. longiflora, H. oahuensis, S. nuttallii*	Many small grids	51
Manuwai	*D. waianaeensis*	One small grid	8
Manuwai	*D. obatai*	One small grid	6
Moanalua	*C. ibidis*	Large-scale grid	92
Ohikilolo	*A. mustelina*, *Pritchardia kaalae*	Large-scale grid	61
Opaeula Lower	*Cyrtandra dentata*	One small grid	50
Palehua	*C. ibidis*	Large-scale grid	92
Palikea South	*A. mustelina*	Predator-proof fence	4
Palikea	*A. mustelina*	Large-scale grid	108
Palikea North	*A. mustelina*	Predator-proof fence	4
Pualii North	*H. oahuensis*	One small grid	12
Total:			**1,421**

8.2 TRACKING TUNNEL RESULTS FROM LARGE-SCALE GRIDS

For this report and future reports, a graph of tracking tunnel results will be provided for all of our large-scale grids (Kahanahaiki, Ekahanui, Palikea, Makaha, and Ohikilolo) (see Figures 1-5). At most sites, there is historical tracking data for as far back as 2009, however, only data collected since the conversion of these grids to 100% A24 traps will be presented . These graphs can be used to look at the differences

between years or between control and treatment sites. Small changes of ~20% or less between or within grids cannot be assessed accurately. At Kahanahaiki, there is an associated reference site at Kapuna Upper MU where no rodent control is being conducted. At other grids, OANRP staff collected reference data from a nearby location where no rodent suppression was conducted for one year after the grid was installed. The goal of our program's rat control is to keep tracking levels at 10% or less throughout the year. This number is based on goals developed in New Zealand.

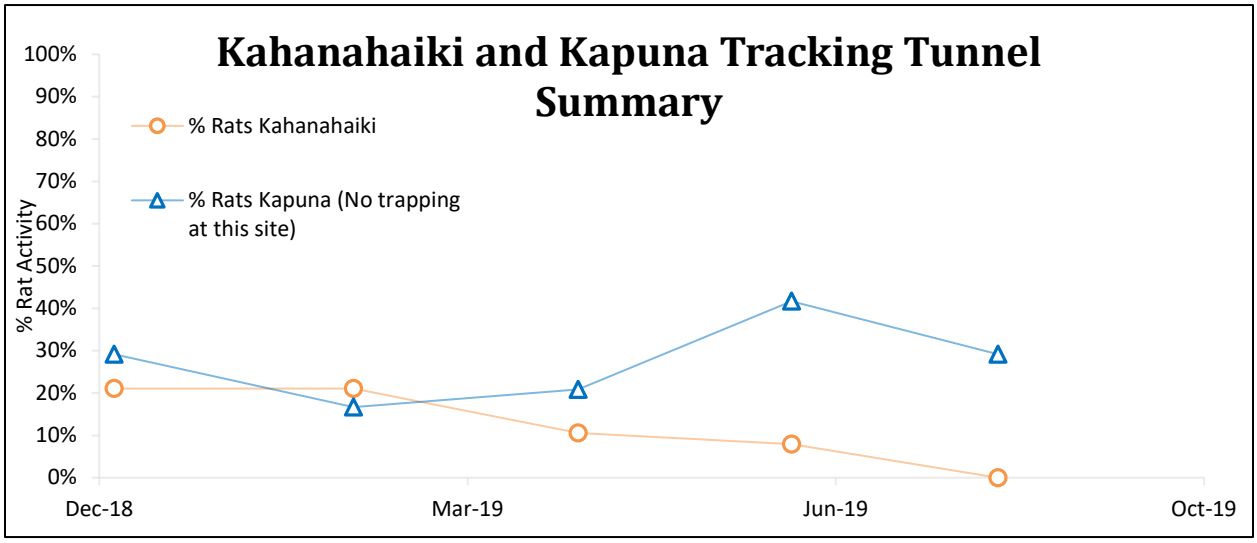

Figure 1. Percent of rat activity at Kahanahaiki 38 tunnels and Kapuna 24 tunnels (reference site).

A grid of 76 A24 traps were installed at Kahanahaiki MU in October 2018. This site had a grid of A24 traps installed previously that were pulled in May 2017 mainly due to mechanical issues. Many methods have been used over the years with varying results. Since installation in 2018 it appears the tracking at this site is showing a steady decline and below the reference site.

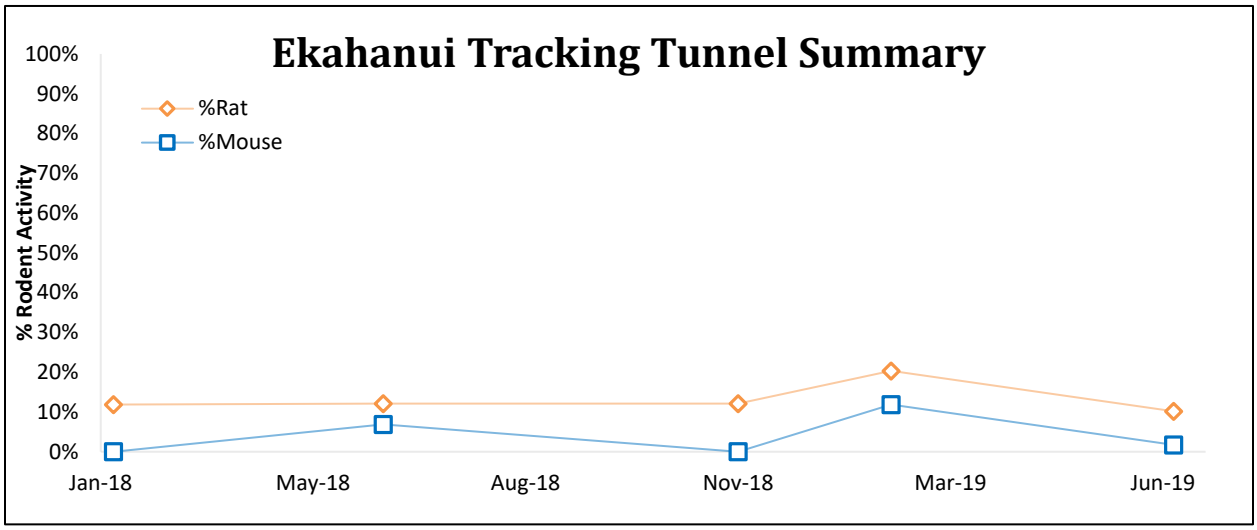

Figure 2. Percent of rodent activity at Ekahanui 59 tunnels.

From February 2011 to September 2017, the Ekahanui grid consisted of ~600 Victors with a few A24s installed around *A. mustelina* areas Rat tracking had a relatively stable trend with a high of 30% in June 2015, while most tracking events showed rates around the 10% goal (see 2018 Status Report). This grid

was very labor intensive with a two week re-baiting interval such that control was only conducted during the Oahu Elepaio breeding season (December to June). Because of advancements in the performance of the GoodNature A24s the Victor grid was removed and 306 A24s were installed at a 100 by 50 meter spacing in September 2017. Since A24 installation, tracking at this site has generally been around 12%, with one month in February 2019 tracking at 20% (Figure 2). It should be noted that the tracking tunnels at this site are mostly set within the gulches and it is believed that these areas have higher rat activity than ridges. A better approach that our program has adopted at other sites is to deploy tracking tunnels in a stratified random grid throughout the trapping areas. OANRP has no plans to change the Ekahanui tracking grid at this time but will continue to monitor it.

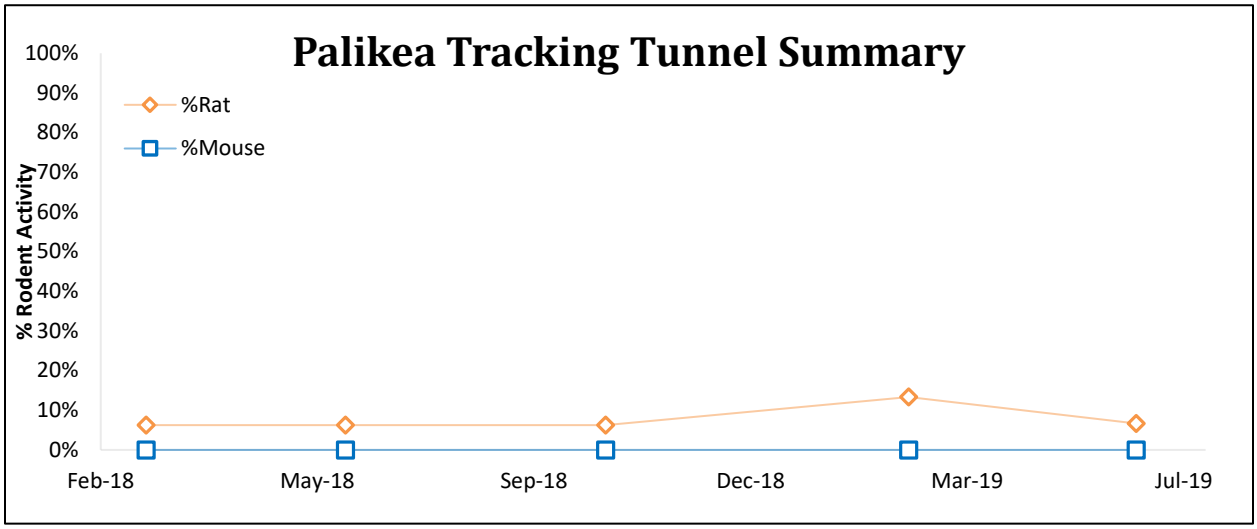

Figure 3. Percent of rodent activity at Palikea.

The Palikea grid formerly consisted of ~200 KaMate traps (August 2010 to October 2017). Rat tracking had a relatively stable trend with a high of 53% in June of 2011. In October 2017 all KaMate traps were removed and 108 A24s were installed. Since installation rat tracking has been below 13% (Figure 3).

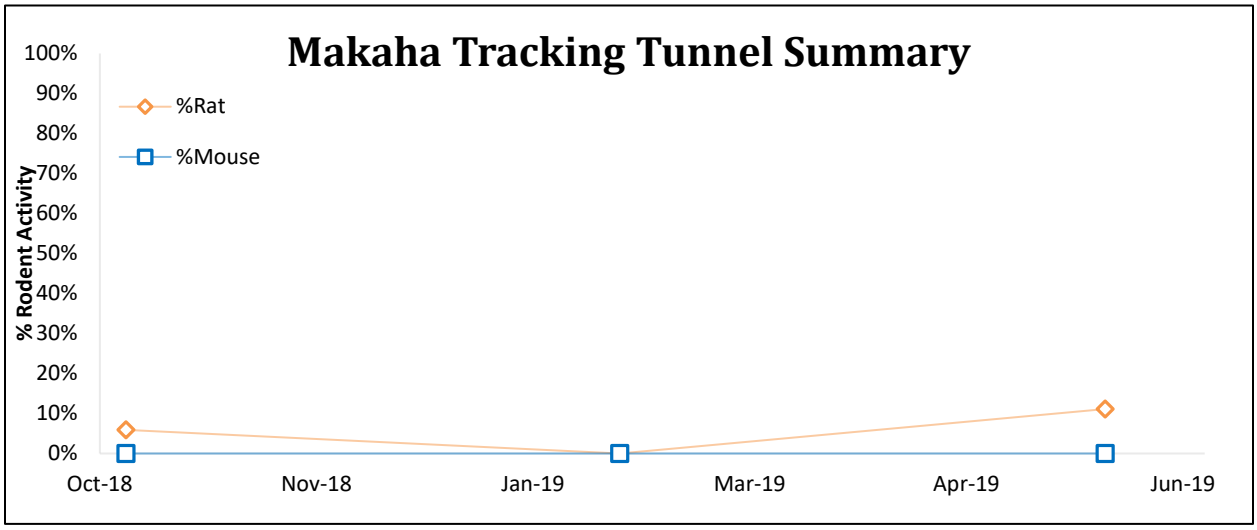

Figure 4. Percent of rodent activity at Makaha inside and outside of the A24 grid.

In May 2018 the grid was modified due to concerns that the grid was small and did not protect all resources within the MU. The entire MU is now gridded with 113 A24s at a 100 by 50 meter spacing. Since installation in 2018, rodent activity has been very low, with a high of 11% in May of 2019 (Figure 4).

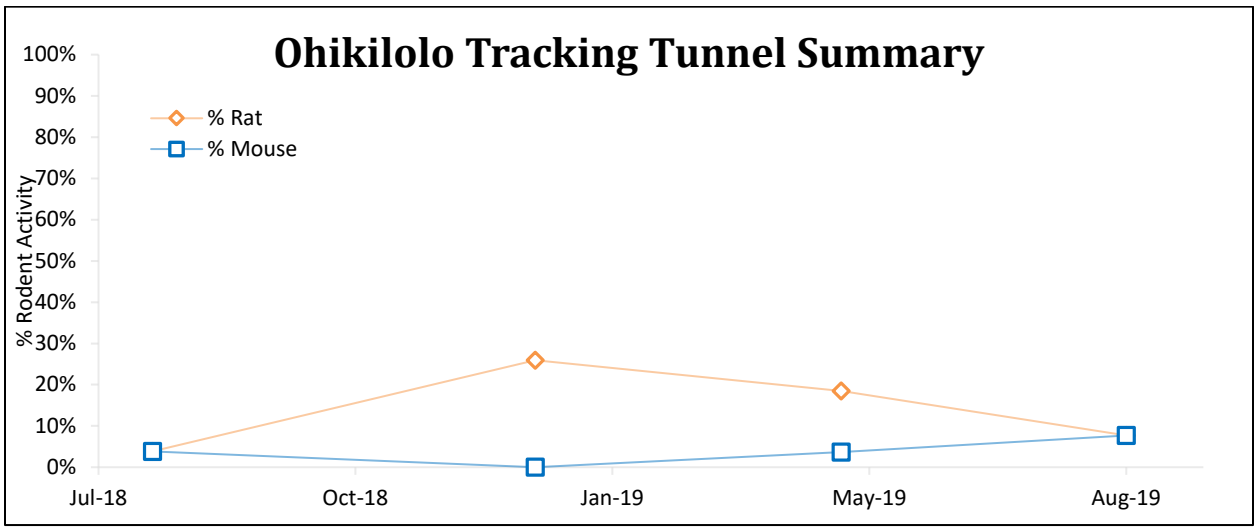

Figure 5. Percent of rodent activity at Ohikilolo.

In April 2018 the A24 grid was expanded to a total of 61 traps. The tracking trends generally indicate successful rodent suppression over the past year with all but one event under 20% (Figure 5). This grid may illustrate some issues with using tracking tunnels as a monitoring system for a three hectare area. At this site traps are spaced very closely together and many of the tunnels are on the edge of the "grid". Considerations are being made for a better monitoring system for small areas.

8.3 Slug Repellent Automatic Lure Pump Study

Bait consumption by slugs has always been a significant issue in the longevity of bait in our rodent control devices (Figure 6). Traditionally snap traps were baited every two weeks so longevity was not as much of a concern. The transition to a self-resetting trap and four month re-baiting interval exacerbated the effect of slugs on bait longevity. In 2016, OANRP began trials on bait palatability to slugs in the lab to determine if adding citric acid (CA) to rat lure deters slug consumption (Joe 2016). The following year, these trials were expanded in order to test more CA concentrations (Joe 2017). The results from these bait trials revealed that the addition of 5% CA to the GoodNature rat lure repels slugs and did not deter rodents in a lab trial in Fort Collins, CO. In 2018-2019 we also conducted two field trials, one looking at effect on rodents in Hawaii and one on longevity of bait within ALPs.

Figure 6. *Limax maximus* in A24 trap after consuming bait.

One field trial was conducted from January 8th to 22nd 2019 at Pahole Natural Area Reserve to examine rat preference among lures with and without 5% CA. A total of 65 paired sites were used for a total of 130 Victor Snap traps. Sites were spaced 20 meters apart. At each site snaps were set on or near the ground and tied to a tree with a small piece of cord. Traps were placed approximately 1–2 m apart and in similar localized environments. The treatment lure containing 5% CA was used on all of the traps on the left and the control lure consisting of standard GoodNature Chocolate lure with no additive was used on all of the traps on the right along the trail. The same amount of bait was applied each time (~3grams). Traps were checked for bait status (present/absent) and presence of rat carcass or hair; if present, all hair was cleaned off with a wire brush. Bait was refreshed each check. A total of 74 rats were captured in 14 days, 35 on the control bait and 39 on the treatment bait. Captures did not differ by bait type, $X^2(1, N = 74) = 0.28$, $p = .0597$. A total of 36 control traps were recorded without bait during the trial when checked, compared to 6 treatment traps without bait. These results suggested that the treatment bait had greater persistence, presumably due to reduced slug consumption.

A second field trial was conducted (July 2018-July 2019) to examine bait longevity in GoodNature ALPs with and without 5% CA added to the standard chocolate rat lure. ALPs are a bait delivery system designed for the A24 trap comprised of a gas and bait chamber; the gas pushes a controlled amount of bait through an opening in the bait chamber neck of the ALP over time (see https://goodnature.co.nz/collections/all/products/alp for more information). This system requires that the bait be added during the making of the unit therefore the citric acid was added to the bait by GoodNature. A24 traps used in the trial were previously installed and in operation at 19 field sites. Number of traps at each site varied from 10 to 306. Traps were generally spaced 50 m apart and 12 cm high on vertical trees. Baits were alternated throughout each site, with the treatment bait (5% CA) used at every odd-numbered trap and the control bait used at every even-numbered trap at each site. Traps were checked for the presence/absence of bait remaining within the ALP in each trap. If the aluminum foil from the gas pouch was visible the ALP was considered to be out of bait. At each check the baits were all replaced regardless

of bait status. A target check interval was 110-140 days since last re-baiting, and some traps were checked sooner or later due to logistics.

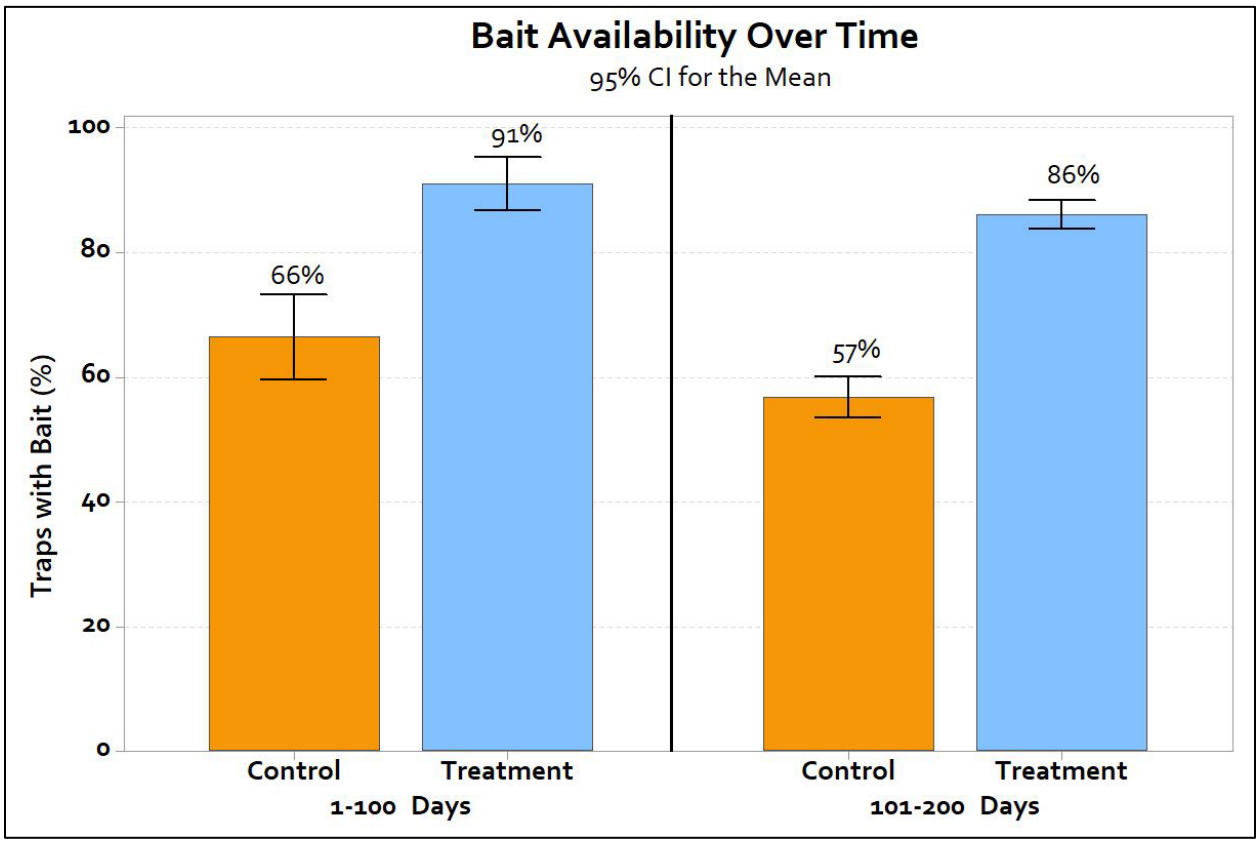

Figure 7. Percent of traps with control and treatment (5% CA) bait remaining over time.

Looking across all sites, the traps with the treatment bait (5% CA) had more bait available relative to the control group. For those traps checked between 1-100 days (left side of Figure 7)) 91% of traps with citric still had bait compared to only 66% of the control group. As time progressed more traps overall lost bait from 101 to 200 days (right side of Figure 7). The citric bait remained available in more traps than in the control group. The data was analyzed using a logistic regression which found that the 5% CA bait had significantly increased bait longevity. Results from these trials showed that adding citric acid to the bait can extend the checking interval to 6 months at all sites. The program is working with GoodNature to purchase the 5% CA bait ALPs and will install them all sites in late 2019.

8.4 Evaluation of Game Cameras as an Alternative Rodent Monitoring Method

In order to ensure that our rodent control methods are effective, our program employs independent monitoring systems. The monitoring system that has been employed for the past several years has taken the form of tracking tunnels and inked tracking cards baited with peanut butter. Tracking tunnels are effective at determining rodent activity, they are cheap, and they are more sensitive than other methods such as chew tabs. However, the disadvantages of tracking cards include their susceptibility to wet weather, two consecutive days of labor are required to place and collect the cards, and they are also

targeted by bait-stealing diurnal species. The reading process of tracking cards can also cause inaccurate data by the misidentification of tracks by staff. With the above considerations in mind, our program decided to look into other techniques that can overcome some drawbacks of tracking cards.

Figure 8. Spy-point Force 10 at tracking site.

This project has four main goals: to evaluate the logistics of a camera trap grid, to compare the sensitivity of camera traps and tracking tunnels, to determine if camera traps are able to detect rats to a species level and to determine the cost effectiveness compared to tunnels. The Spy-point Force 10 (Figure 8) was chosen as the most ideal game camera based on its low cost and suitable specifications comparable to much more expensive models. Cameras were placed at pre-existing tracking tunnels sites in Kahanahaiki MU (62), which has rodent control present, and at Kapuna Upper MU which does not. Cameras were affixed to trees at each site at a height of 50 cm. They faced tracking tunnels at a 20-degree angle from 150 cm away. Cameras were set to take a 3 shot burst of pictures at each motion detection with a 10 second "cool down" between each possible trigger. A 3 shot burst was chosen in order to have more pictures to differentiate between species of rodents. The pictures captured are divided in two categories: overnight, which was the same time that baited tracking cards were present, and multi-month, which was a 2-month period with no bait. OANRP staff focused on the overnight set because it compared the cameras directly to the baited tracking cards. Activity for both game cameras and tracking tunnels was recorded as presence/absence. Multiple tracks or pictures of the same species was recorded as one event for the overnight period.

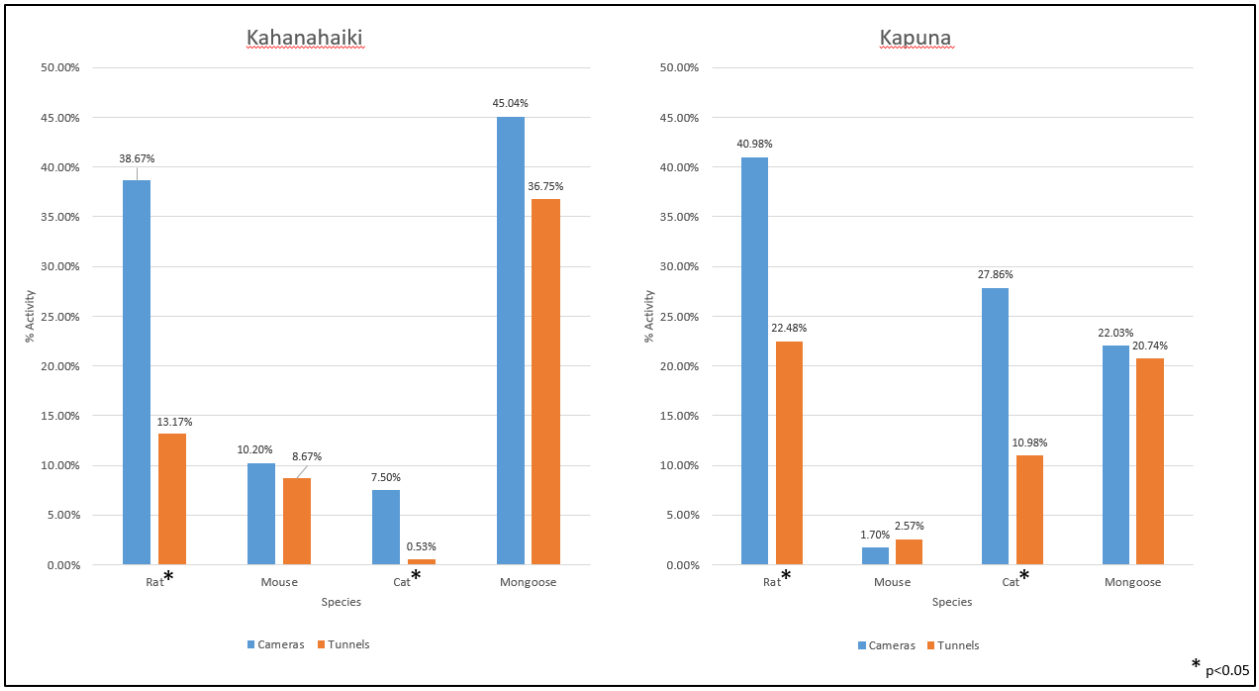

Figure 9. Percent activity of four species at Kahanahaiki MU and Kapuna Upper MU measured via game cameras and tracking tunnels. A chi square analysis was performed and significant differences are denoted with an asterisk.

Data was collected from tunnels/cameras on the first night after baiting, repeated every 2 months over a duration of 10 months. Significant results were found for two of four species recorded (Figure 9). At both Kahanahaiki MU and Kapuna Upper MU rat and cat activity was significantly higher in the game cameras versus the tracking tunnels. One possible reason for higher detections in the cameras could be the larger sampling area of the camera versus tunnels. Many photos were captured of rats walking by with no interest in the tunnel. Rat detections in the tunnels also could be lower because of diurnal bait stealing primarily by mongoose and possible aversion to going in the tracking tunnels. Without bait in the tunnels rats may be less likely to actually go in the tunnel and step on the ink tracking plate. More cats were captured on the game cameras than the tracking tunnels most likely due to the small size of the tracking tunnels. Most of the cats we observed entering the tunnels were not adults. For both mice and mongooses at both sites the differences between cameras and tunnels was not significant.

This was the first time deploying so many game cameras at a site for monitoring. Observations made from this pilot study are quite numerous. Even though a standardized methodology for camera placement was applied, specific site selection was important to success due to vegetation, slope and exposure to wind. In a few instances, cameras were positioned where the tracking tunnel was just out of the frame of the picture. Cameras were manually aimed at the tunnels but it was difficult to confirm whether the tunnel was in frame or not. In the future, a camera that uses a laser or similar method of alignment could improve set up. We recorded approximately a 10% failure rate in the cameras over the 10-month period which was lower than anticipated due to initial concerns about the quality of the battery tray seal.

Figure 10. Various photos of *Rattus rattus* at tunnel sites.

One of the main goals of this trial was to determine if this method would reduce costs associated with rodent monitoring. A cost analysis was also conducted to compare the cost of materials and labor for the two methods. While cameras have a much higher up front material cost, they can reduce labor by 50% per check. After 9 monitoring checks at a site, the reduced cost of labor for the camera method outweighs the initial upfront costs and becomes cheaper to implement than tracking tunnels. The reduced labor benefit is realized by not having to return to the site the day after setting. Instead of the day after tunnels are set, the camera SD card would be replaced the next time a monitoring event occurs. This would cause a delay in receiving the information; however, since management strategies are not adjusted on a month to month basis this would be acceptable.

In the future it is a priority to explore the multi-month photos to determine if baited tracking tunnels are necessary (Figure 10). At this time, to analyze the amount of photos taken in the two month periods would require excessive labor hours. The use of artificial intelligence to analyze photos could greatly expedite the process. In addition, a power analysis study is needed to determine the minimum number of set nights required for this method. Since the camera method was more sensitive than tracking cards it is possible that a reduced number of devices could be deployed over the MUs and still achieve accurate monitoring. Eventually this streamlining of monitoring grids could further decrease overall costs.

8.5 Future Plans

Continue to work with the A24 traps and bait to maximize this method's full potential. In 2020 we plan to conduct trials looking at bait additives that deter ants. Ants are believed to deter rats from entering A24s and decrease bait longevity. Physical barriers such as Tanglefoot and Vaseline have been suggested. However, we would prefer to find a bait additive that will deter ants like the citric acid lure deters slugs but does not change the attractiveness to rats. Additives will be trialed with the existing 5% CA, our new standard lure.

It is worth evaluating if MU grids should be installed at some sites that have isolated or Elepaio territory-based grids. At this time we do not have an adequate way to measure rodent activity and trapping success at small sites. Camera traps and bio markers could be a tool that would allow us to more accurately monitor rodent activity and trapping success at small sites in the future.

8.6 LITERATURE CITED

Joe, S. 2016. Chapter 9, subsection 9.2 Development of a rat bait with slug-repellent properties *in* 2016 Status Report for the Makua and Oahu Implementation Plans. http://manoa.hawaii.edu/hpicesu/DPW/2016_YER/11.pdf.

Joe, S. 2017. Chapter 9, subsection 9.3: Development of a rat bait with slug-repellent properties *in* 2017 Status Report for the Makua and Oahu Implementation Plans. https://pcsuhawaii.org/projects/oanrp/reports/2017/09.pdf.

CHAPTER 9: ALIEN INVERTEBRATE CONTROL PROGRAM

Summary

This chapter outlines alien invertebrate control actions over the past reporting year. In addition to the research presented here, work was completed on the efficacy of non-electric barriers to repel *Euglandina rosea* (Appendix 9-1). It is notable that a new invertebrate threat, the naio thrips (*Klambothrips myopori*), arrived to Oahu in late 2018 (OISC 2018). We began widespread surveys of wild naio (*Myoporum sandwicense*) in May 2019 after the discovery of the thrips infecting ornamental plants at our Schofield Baseyard. These plants were removed and we are no longer outplanting *M. sandwicense* at any restoration site. To date, naio thrips has not been found attacking wild plants, but their rapid spread through ornamental naio suggests wild plants will affected within the next year. Seed collection continues, both to preserve genetic diversity, and ensure propagules are available for future research, as well as to repopulate areas, when and if, the threat passes. A broader discussion of the status of this pest on Oahu will be available in next year's report, once more data is available.

9.1 SUMMARY OF SLUG CONTROL ACTIONS JULY 1, 2018 – JUNE 30, 2019

There have been no changes to the number of plant populations undergoing slug control (Table 1). As in the previous year, 49 rare plant populations covering a total area of 12.75 acres receive slug control. No new detections of rare snails falling within slug control sites have been identified.

Currently all high priority, vulnerable plant populations are protected from slugs with the exception of seven populations (Table 2) where the presence of rare snails precludes the use of molluscicide. Two surveys at the *Schiedea nuttallii* PAH-E population failed to show rare snails remain in the area. We may resume slug control at that site this year.

Due to its longer field efficacy, FerroxxAQ (EPA Reg No. 67702-49) is the molluscicide used in all of our management units (MUs) except for Makaha where the landowner (Board of Water Supply) has approved only the use of Sluggo (EPA Reg. No. 67702-3-34704) (Table 1).

Table 1. List of rare plant species undergoing slug control. An asterisk (*) marks remote plant populations which, due to the difficulty of access, receive slug control at a reduced rate.

MU	Plant species treated (Population Reference Code [PRC] in parentheses)	Treatment area (m^2)	Product used/rate of application
Ekahanui	*Cyanea grimesiana* subsp. *obatae* (EKA-C) *, Delissea waianaeensis* (EKA-D), *Schiedea kaalae* (EKA-D)	3,000	FerroxxAQ/6 weeks
Kahanahaiki	*Cyanea superba* subsp. *superba* (MMR-E & MMR-H), *S. nuttallii* (MMR-E), *S. obovata* (MMR-C & MMR-G)	2,300	FerroxxAQ/6 weeks
Kaluaa & Waieli	*Delissea waianaeensis* (KAL-C), *S. kaalae* (KAL-B)	3,500	FerroxxAQ/6 weeks
Lihue	*Labordia cyrtandrae* (ALA-S), *Phyllostegia hirsuta* (ALA-A)	2,800	FerroxxAQ/6 weeks
Makaha	*Cyanea longiflora* (MAK-B), *C. grimesiana* subsp. *obatae* (MAK-B), *S. obovata* (MAK-A), *S. nuttallii* (MAK-B)	2,450	Sluggo/4 weeks
Opaeula Lower	*Cyrtandra dentata* (OPA-F)	1,500	FerroxxAQ/12 weeks*

Table 1 (continued).

MU	Plant species treated (PRC in brackets)	Treatment area (m^2)	Product used/rate of application
Pahole	*Cyanea longiflora* (PAH-A, PAH-I, PAH-J), *C. grimesiana* subsp. *obatae* (PAH-D), *Delissea waianaeensis* (PAH-C), *Euphorbia herbstii* (PAH-G, PAH-R & PAH-S), *Schiedea kaalae* (PAH-C), *S. nuttallii* (PAH-A, PAH-D, PAH-E,), *S. obovata* (PAH-E),	23,630	FerroxxAQ/6 weeks
Palikea	*Cyanea grimesiana* subsp. *obatae* (PAK-A & PAK-B), *C. superba* subsp. *superba* (PAK-A), *Phyllostegia hirsuta* (PAK-A), *C. grimesiana* subsp. *obatae* (PAK-C)	5,097	FerroxxAQ/6 weeks
Upper Kapuna	*Schiedea kaalae* (KAP-A), *Cyanea longiflora* (PIL-B, PIL-C, PIL-E & PIL-F), *S. kaalae* (KAP-A), *S. nuttallii* (PIL-B)	3,427	FerroxxAQ/6 weeks
West Makaleha	*Cyanea longiflora* (LEH-B), *S. obovata* (LEH-A, LEH-C & LEH-B), *C. grimesiana* subsp. *obatae* (LEH-A &LEH-B)	2,461	FerroxxAQ/6 weeks
Manuwai	*Delissea waianaeensis* (ANU-A)	1,441	FerroxxAQ/12 weeks*

Table 2. List of rare plant species exempt from slug control due to the presence of native snails.

Rare plant species	MU	PRC	Snail species present	Notes
Cyanea superba subsp. *superba*	Kahanahaiki	MMR-H, MMR-G, MAK-A	*Leptachatina* spp., *Achatinella mustelina*	No slug control
Cyanea superba subsp. *superba*	Pahole	PAH-A	*Achatinella mustelina*	No slug control
Cyanea grimesiana subsp. *obatae*	Palikea	PAK-C	*Achatinella mustelina*	Partial slug control
Schiedea nuttallii	Pahole	PAH-E	*Achatinella mustelina*	Partial slug control

9.2 FERROXXAQ PERSISTENCE IN A FIELD SETTING

9.2.1. INTRODUCTION

Two molluscicides, both with the same active ingredient (iron phosphate), are registered for use in natural areas for the control of invasive slugs and snails: FerroxxAQ (EPA Reg No. 67702-49) and Sluggo (EPA Reg. No. 67702-3-34704). They are not contact poisons, but must be ingested to take effect. Extensive research shows while they are effective at eliminating pests, they pose a risk to native snails and should never be applied within 20 m of an endangered or rare snail species (Joe 2016, 2009, 2007, 2006). They differ in two ways: 1). FerroxxAQ contains 3% of the active ingredient (AI) compared to 1% in Sluggo and therefore must be applied in lesser amounts. It also means that it takes less of the product to deliver a lethal dose. 2). FerroxxAQ has a water proof coating on the pellets making them more water resistant. Research confirms FerroxxAQ controls slugs up to six weeks after application despite instructions on the label to apply every two weeks (Joe 2017).

The West Makaleha snail enclosure was recently built for the protection of *Achatinella mustelina*, however presently it contains no snails (Figure 1). There are reasons why one might want to apply molluscicide prior to native snail reintroduction. Molluscicide application controls or eradicates alien slug

and snail pests which feed on native plants and eliminates or reduces the prey base for the predatory snail, *E. rosea*. In order to safely reintroduce native snails, it was necessary to determine the persistence of FerroxxAQ to ensure sufficient time has elapsed from the last application.

Figure 1. Location of the West Makaleha snail enclosure study site.

Here we describe a field experiment where we investigated the persistence of FerroxxAQ at the West Makaleha snail enclosure.

9.2.2. METHODS

On March 21st 2019 we placed 10 teabags each containing 20 grains (2 $\pm$ 0.23g) of FerroxxAQ inside the enclosure where they would be exposed to ambient environmental conditions. Bags were kept in place using pin flags and were separated from one another by at least 5 m. The bags themselves were made of natural wood pulp filter paper and measured 7 cm^2 (SGTA tea filter bags, Amazon.com). Following placement, we subsequently recorded the number of FerroxxAQ grains left in each bag 35, 62 and 95 days later (Figure 2).

Figure 2. Teabag with 20 pellets at the start of the trial (a., b.). Teabag with partially degraded pellets on day 35. Teabag at the end of the trial on day 95.

9.2.3. RESULTS AND DISCUSSION

Results are shown in Figure 3.

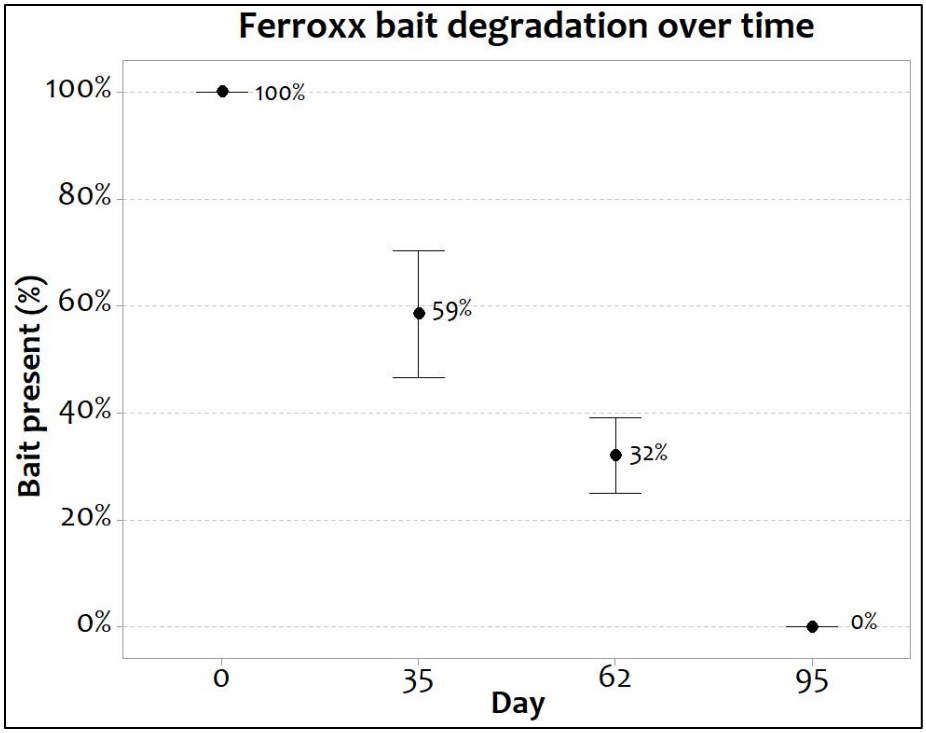

Figure 3. FerroxxAQ bait persistence in West Makaleha March – June 2019. Bars are one standard error from the mean.

When exposed to natural conditions FerroxxAQ completely degraded (as determined using a visual inspection) three months post-application and had a half-life of 41 days. It is unknown whether the bags hindered, or accelerated, degradation by protecting the bait or holding in moisture. During the wet season, bait is expected to degrade more rapidly.

We had no way for testing for residues on or in the soil. Due to its classification as a biochemical pesticide, generally regarded as safe, no environmental fate data is required or was provided by the manufacturer (EPA 2001). Iron phosphate occurs naturally in soil so it would be difficult to identify what portion is attributable to FerroxxAQ. Once applied, iron becomes part of soil compounds, sticks to soil particles, and acts as a bridge to bind particles together. Bacteria can turn iron into forms that dissolve readily in water. Phosphate is readily taken up by plants and can be used alone as a fertilizer. Due to its low toxicity and mobility, groundwater concerns have not been identified (NPIC 2003).

Based on these results, following a three month interval after the last application of FerroxxAQ, reintroduction of native snails may proceed safely.

9.3 *EUGLANDINA ROSEA* RESPONSE TO FERROXXAQ TREATMENT

9.3.1. INTRODUCTION

Euglandina rosea (rosy wolfsnail) is an introduced carnivorous molluscavore thought to have caused the extinction of 134 native island snail species on the 234 islands where it was introduced (Régnier *et al*. 2009). On Oahu, *E. rosea* is largely responsible for the precipitous decline of the native Hawaiian treesnail *Achatinella mustillina* (Hadfield & Mountain 1980). No effective means of control for *E. rosea*

has been identified. The two main methods of control are collection and removal by hand, and biological control (Gerlach 1994). Though the use of collection is incredibly labor-intensive and time-consuming, it remains the only tool available to our program. Generally this method is not used in open systems but is only employed to eradicate *E. rosea* from an area where reinvasion is impossible such as within a predator proof enclosure.

Chemical control, involving the application of molluscicide, is another possible consideration. Two products, both with the same active ingredient, are registered for use in natural areas for the control of invasive slugs and snails FerroxxAQ (EPA Reg No. 67702-49) and Sluggo (EPA Reg. No. 67702-3-34704). They are not contact poisons, but must be ingested to take effect. Extensive research demonstrating the safety and efficacy of both products in natural areas has been established, including their risk to native snails (Joe 2007, 2009, 2010, 2011, 2012a, 2013, 2014 and 2017). Our program has transitioned to FerroxxAQ as it is more water resistant and therefore can be applied less frequently than Sluggo. We therefore selected FerroxxAQ for use in this experiment.

Euglandina rosea has extremely complex feeding and hunting behaviors (Cook 1985a & 1985b; Gerlach 2001; Shaheen *et al*. 2005; Davis-Berg 2012) which would prohibit ingestion of FerroxxAQ. They are susceptible, however, to starvation when prey density drops below nutritional requirements (Gerlach 1994). We investigated whether reduction of prey using FerroxxAQ reduced *E. rosea* numbers either by starvation or by secondary poisoning via the ingestion of contaminated prey. Though the lethal dose of FerroxxAQ has not been determined for *E. rosea*, the manufacturer doubts secondary poisoning could occur because the active ingredient degrades rapidly upon consumption (Moore *pers. comm*.).

9.3.2. METHODS

Euglandina rosea density was recorded as the number of snails trapped under metal flashing measuring 160 m in length placed at an angle to the ground (angle trap) around the West Makaleha enclosure (Figure 4). This enclosure is intended to serve as a predator free refuge for *A. mustillina*, however, none were present within 20 m of the treatment zone at the time of the trial (February-June 2019). The angle trap was divided into two sections, half which (80 m length) received FerroxxAQ to a distance of 10 m on two occasions (February 21 and March 14, 2019)(Figure 5). This required application of 2.5 lbs. FerroxxAQ to an 800 m^2 plot. Following treatment, the number of *E. rosea* found in the treated vs. control (untreated) plots were recorded approximately every two weeks for five months. All snails were removed when discovered. Counts of snails at each time were statically analyzed using a Kruskal Wallace Test of Medians (Minitab 19).

Figure 4. Map of West Makaleha enclosure where trial occurred.

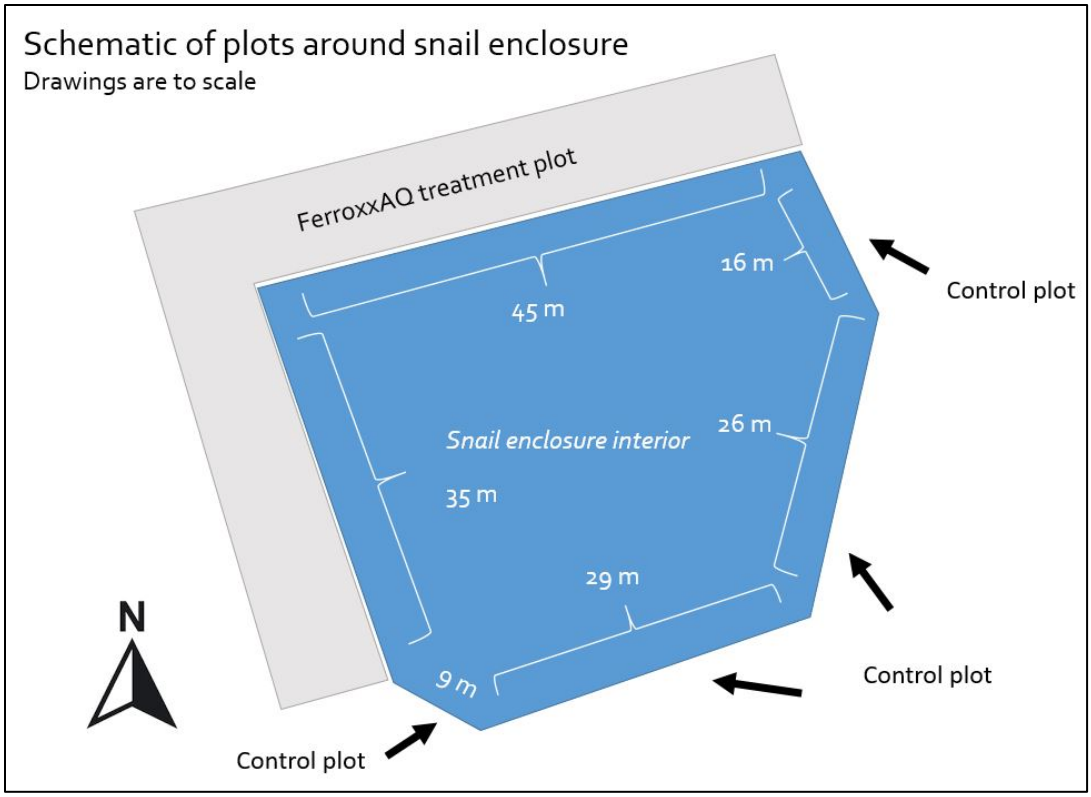

Figure 5. Schematic showing orientation of plots around the exterior of the enclosure. The control site included all the angle traps on the southeast face of the enclosure while the treatment site included all the angle traps to the northwest.

9.3.3. RESULTS

A total of 20 *E. rosea* were found in the angle traps between March and June 2019. Snail counts were roughly evenly split between the treatment and control (Figure 6).

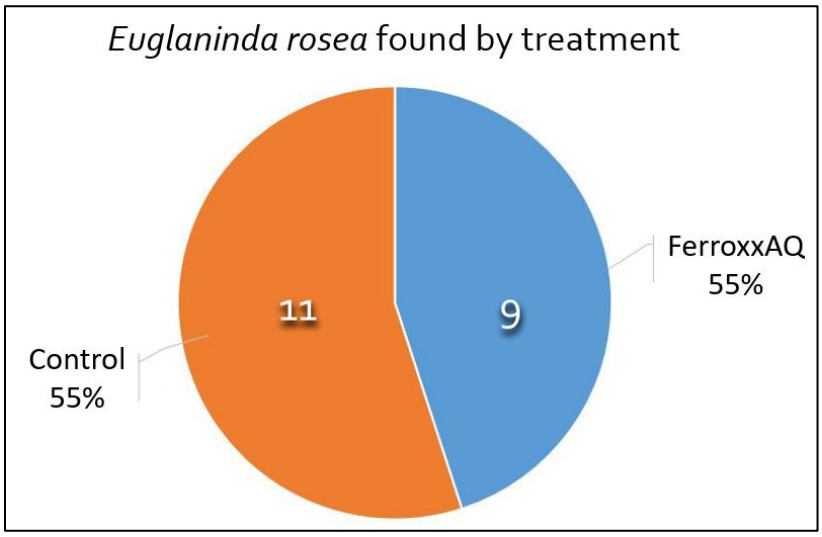

Figure 6. Proportion of total *E. rosea* found in the treatment vs. control March-June 2019.

Mean snail counts recorded at each two week interval are shown in Figure 7. There was no significant difference in *E. rosea* density due to FerroxxAQ application (Kruskal Wallace: H=0.78, p=0.376).

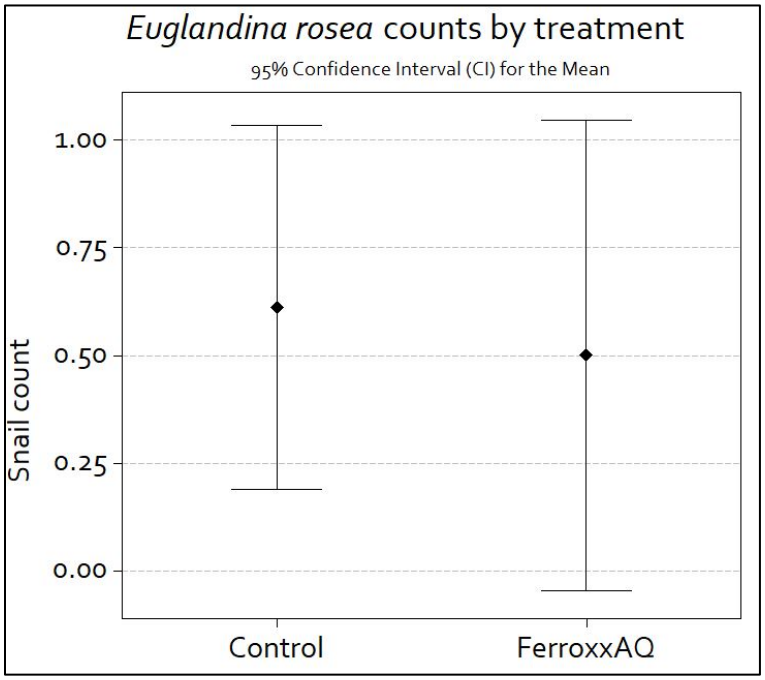

Figure 7. Mean count of snails found across 9 sampling events by treatment. There was no difference due to treatment.

9.3.4. DISCUSSION

We failed to find evidence that *E. rosea* is negatively affected by FerroxxAQ. Caution should be used when making conclusions using our results, however, because the study design had serious flaws. Firstly, only one treatment and control plot were used with no replication (though it was replicated over time) and even these were not independent, being immediately adjacent to each other (Figure 5). The treatment plot had a width of only 10 m and likely needed to be much larger. Even when starving, *E. rosea* travel 1 m every 3.5 hours (Gerlach 1994) meaning a hunting snail, finding no prey could leave the treatment area in less than two days. Since these animals commonly subsist on one prey item every 45 days, finding no prey in two days would be of little importance. There were no pretreatment counts for comparison. Lastly, we do not know whether our method of determining *E. rosea* abundance, via counting snails at angle traps reflects actual numbers in nature. For these reasons our results are highly suspect. Despite these shortcomings, however, we hope our experience can help inform future research.

9.4 INVASIVE ANT SURVEYS AND MANAGEMENT

There are no native ants in Hawaii. Of the approximately 45 species present, all were accidental introductions by humans. The result has been widespread colonization of disturbed and occasionally predominantly native areas by generalist ants that can utilize a number of resources (Krushelnycky *et al*. 2005). Ants can damage managed resources directly or indirectly. They consume rare native insects directly, as is the case with *Solenopsis papuana,* which was found to reduce picture wing fly (*Drosophila*) survival by 58% (Krushelnycky *et al.* 2017). Ants affect plants indirectly by reducing pollinators (Sahli *et al.* 2016) and by farming plant pests such as scales and aphids.

The program aims for early detection of problem species, delineation of infestations of those species, and when possible, eradication. In order to accomplish this, we have carried out annual standardized surveys since 2004 across areas with a high risk of ant introduction (Figure 8). Ants in these areas are sampled using baited index cards left out for one hour.

Ants found within MUs are shown in Table 3.

Treatment of an ant infestation is only considered when one or all of the following criteria are met:
1. The infestation is <3 acres
2. The ant species present is not widespread in adjacent locations
3. The ant species present is known to harm native species.
4. The site is an area of high traffic where materials are staged prior to transport into a predominantly native area.

Figure 8. Map showing locations of ant sampling sites.

Table 3. Recent and historical ant occurrence in 12 Management Units (MUs). Species in red are considered a high threat by the Invasive Species Specialist Group (2019).

Management Unit (MU)	Current species (detected within the last 3 years)	Species detected prior to Jan. 2016
Ekahanui	*Solenopsis papuana*	*Plagiolepis alluaudi, Technomyrmex albipes*
Kaluaa and Waieli (Trailhead & Puu Hapapa)	*Pheidole megacephala, Plagiolepis alluaudi, Solenopsis papuana, Brachymyrmex obscuror*	*Pheidole fervens, Technomyrmex albipes*
Kaala Army and Kaala NAR (Boardwalk & Campsite)	*Cardiocondyla kagutsuchi, C. venustula, Plagiolepis alluaudi, Solenopsis papuana, Tetramorium simillimum*	*Cardiocondyla minutior, C. wroughtoni, Ochetellus glaber*
Kahanahaiki (Snail Enclosure & Fenceline)	*Anoplolepis gracilipes, Ochetellus glaber, Pheidole megacephala, Plagiolepis alluaudi, Solenopsis papuana*	*Cardiocondyla emeryi, C. kagutsuchi, C. obscurior, C. venustula, C. wroughtoni, Leptogenys falcigera, Solenopsis geminata*
Koloa	No ants	No ants
Opaeula Lower	*Solenopsis papuana*	Not sampled prior to 2016
Makaha I and Makaha II (Trailhead & Kumaipo LZ)	*Anoplolepis gracilipes*, Solenopsis papuana*	*Technomyrmex albipes*
Ohikilolo	*Pheidole megacephala, Plagiolepis alluaudi, Solenopsis papuana*	*Anoplolepis gracilipes, Ochetellus glaber*
Pahole (Snail Enclosure)	*Anoplolepis gracilipes, Ochetellus glaber, Plagiolepis alluaudi, Paratrechina bourbonica, P. vaga, Technomyrmex albipes, Tetramorium bicarinatum, Tet. simillimum, Solenopsis papuana*	*Anoplolepis gracilipes, Leptogenys falcigera, Cardiocondyla emeryi, C. obscurior, Solenopsis geminata*
Pualii North	*Pheidole megacephala, Solenopsis papuana*	Not sampled prior to 2016
Kapuna Upper (Trailhead & Cabin)	*Pheidole megacephala, Solenopsis papuana*	*Solenopsis papuana*

*Only present at the parking lot, not in the forested areas.

Ants are not surveyed in all MUs. Those in the Koolau's (Opaeula, Helemano) where ants have not been found for three years are not typically sampled, nor are MUs likely to have high numbers of invasive ants being at elevations below 1,500 ft. and with predominantly non-native vegetation (Kahuku Training Area).

Anoplolepis gracilipes has become extremely common in the Pahole and Kahanahaiki MUs. Unfortunately, our only success with this species has been when controlling small populations ~1 acre around buildings using Provaunt (EPA Reg. No. 100-1487) (Joe 2012b, 2018). Not only is the infestation well beyond our 3 acre limit, but Provaunt is not registered for forest use.

Quarterly ant control is carried out at the East and West Baseyards to prevent transport of ants into management areas, however, as adjacent areas remain infested, ants inevitably recolonize over time. Four baits are used in rotation: AmdroPro (EPA Reg. No. 241-322), Provaunt, and Terro PCO (EPA Reg. No. 149-8-64405). No other ant control is being attempted at this time.

Since its first record on Oahu in December 2013, we have surveyed areas on base (Schofield and Wheeler Air Force Base) as well as pesticide and soil providers to prevent *Wasmannia auropunctata* (the Little Fire Ant or LFA) from establishment. No LFA was detected during these surveys (Table 4).

Table 4. LFA survey details July 2017-June 2018.

Location	Date surveyed	Ants detected
BEI Chemicals and Fertilizers 311 Pacific St # B, Honolulu	September 17, 2018	No ants
Airdrome Road Parking Lot, Wheeler	February 12, 2019	*Ochetellus glaber, Solenopsis geminata, Plagiolepis alludi*
Garden store PX, 903 Cadet Sheridan Road, Schofield Barracks	April 9, 2019	*Pheidole megacephala*
Hawaii Earth Products 65-1101 Wilikina Dr, Wahiawa	May 15, 2019	*Pheidole megacephala, Technomyrmex albipes, Ochetellus glaber*

9.5 Rapid Ohia Death Detection

Rapid Ohia Death (ROD) is a disease caused by two fungal pathogens, *Ceratocystis lukuohia* and *Ceratocystis huliohia*. Both of these fungal pathogens kill ohia (*Metrosideros polymorpha*), Hawaii's most abundant native tree. Both fungi are widespread on the Big Island and were found on Kauai in 2018. *Ceratocystis huliohia* was confirmed on Oahu in July 2019. Since that time, our program has adopted decontamination guidelines recommended by the State (CTAHR 2016) and ramped up sampling efforts. Ten samples from ailing trees were collected between July 2018 and June 2019 from the Makaha, Kahanahaiki, Pahole and Koloa MU's. All tested negative for the disease. The Program remains vigilant to the threat ROD poses and staff have been briefed on the signs and symptoms of ROD.

9.6 Coconut Rhinoceros Beetle Detection and Trapping

Oryctes rhinoceros (Coconut Rhinoceros Beetle [CRB]) was first detected on Oahu in December 2013. Adults attacks palms, agave, sugarcane, banana and pineapple (USDA-APHIS 2019). It is therefore a threat to agriculture and to the native palms in the genus *Pritchardia*. Our program currently maintains 18 CRB traps spread throughout Wheeler, Schofield and Wahiawa, with a single trap at Dillingham (Figure 9). These are placed near palms and at mulch sites and are checked once every two weeks. Lures are

replaced every two months. We have maintained these traps since February 2014. No CRB have been detected at any traps during this period. All information is relayed to Hawaii Department of Agriculture (HDOA) and integrated into CRB distribution maps on Oahu. A detection of CRB at Wheeler in July 2019 by HDOA led us to greatly increase traps in that area. Our actions in response to this detection will be discussed in next year's report.

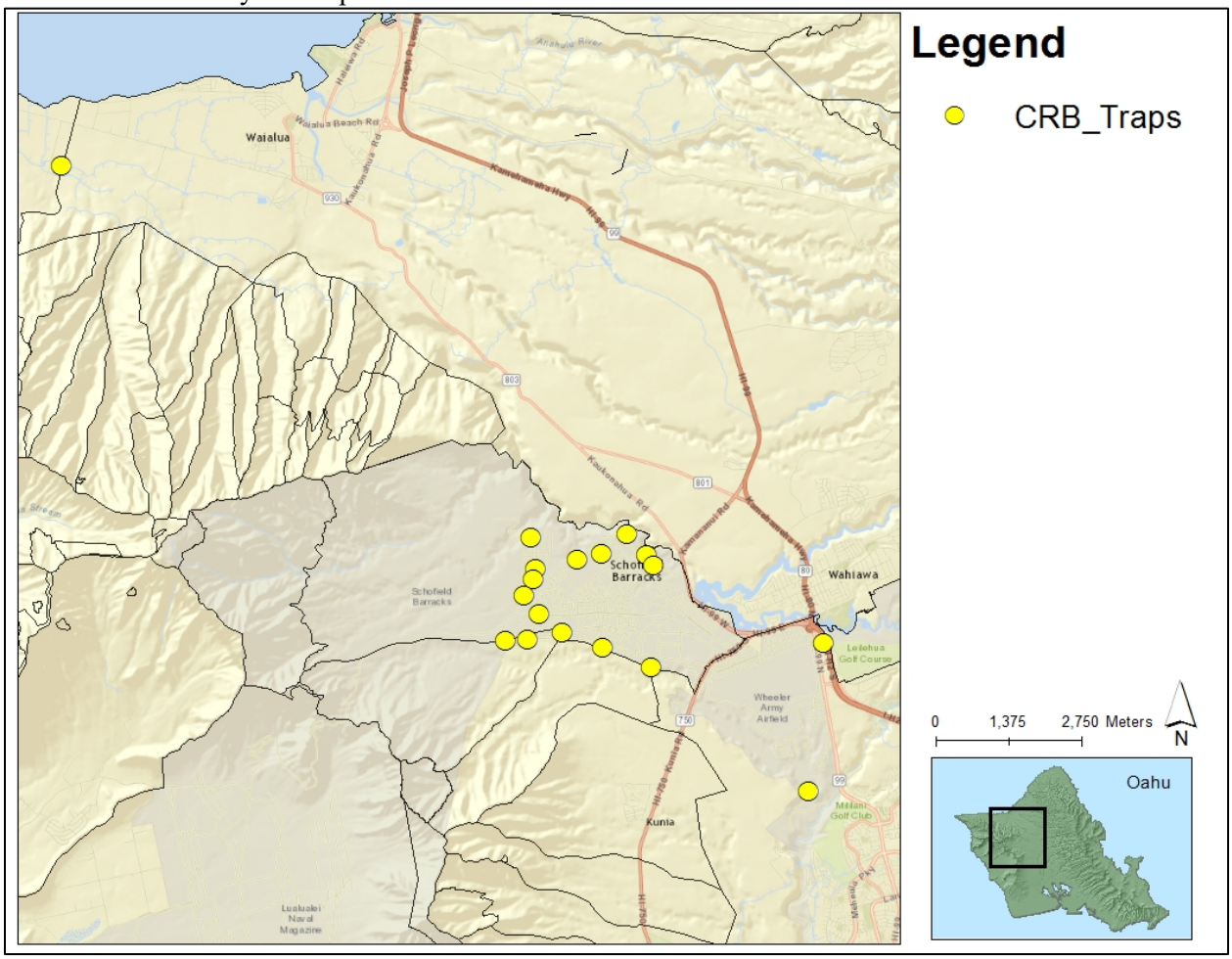

Figure 9. Map of CRB traps maintained by our program.

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