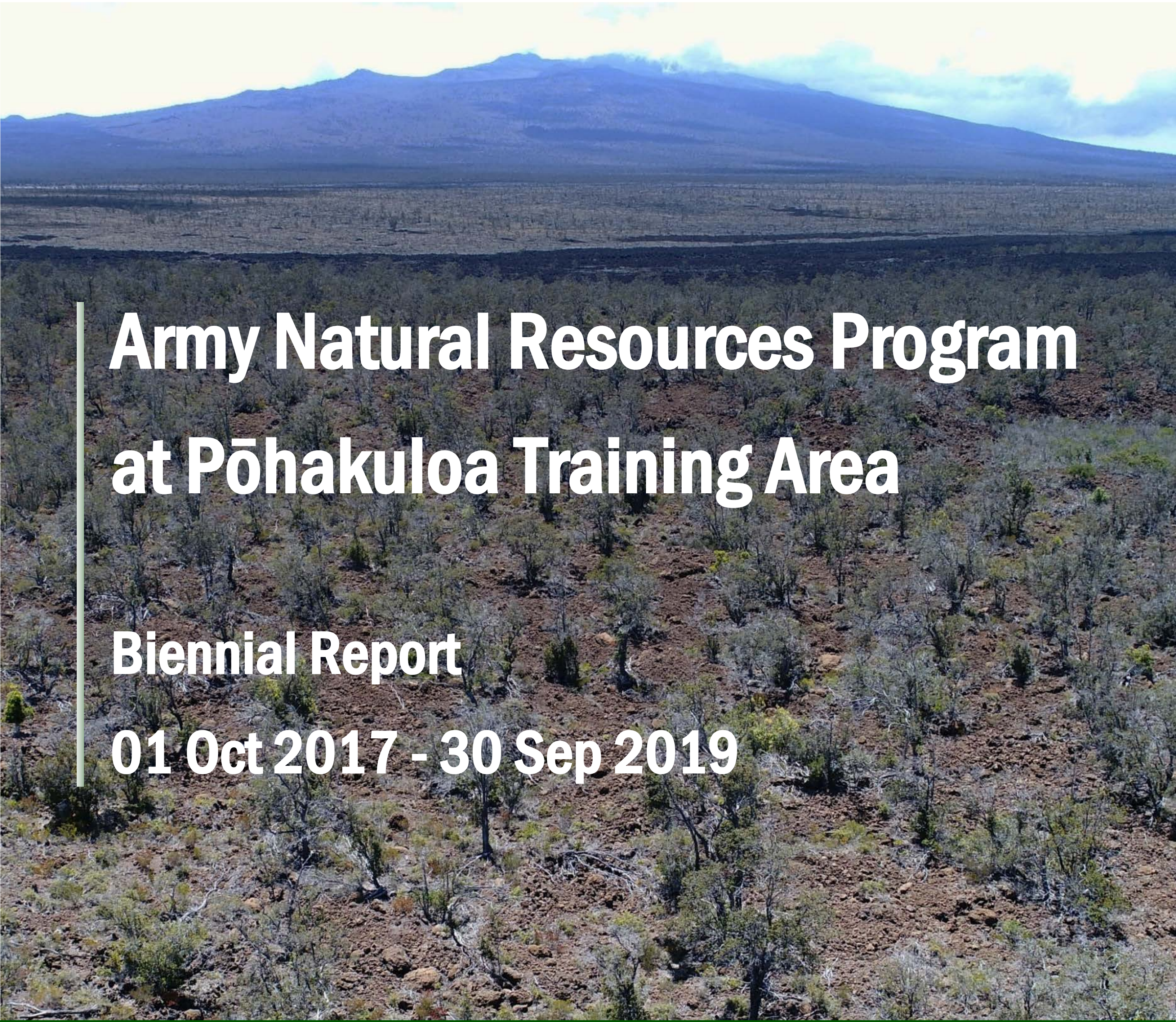

Army Natural Resources Program at Pōhakuloa Training Area

Biennial Report

01 Oct 2017 - 30 Sep 2019

Prepared for

US Army Garrison, Pōhakuloa Training Area

Prepared by

Center for Environmental Management of Military Lands

Colorado State University

Center for Environmental Management
MILITARY LANDS
Colorado State University

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Army Natural Resources Program
at Pōhakuloa Training Area, Island of Hawai‘i

US Army Garrison, Pōhakuloa Training Area

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LIST OF ACRONYMS

ASR	Area of Species Recovery
BA	Biological Assessment
BAAF	Bradshaw Army Airfield
BAX	Battle Area Complex
BO	Biological Opinion
BSTP	Band-rumped Storm Petrel
CEMML	Center for Environmental Management of Military Lands
CSU	Colorado State University
DLNR	Department of Land and Natural Resources
DOD	Department of Defense
DOFAW	Division of Forestry and Wildlife
DPW	Directorate of Public Works
E	Endangered
EA	Environmental Assessment
EDP	Ecological Data Program
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FB	Firebreak/Fuel break
FMC	Fuel Monitoring Corridor
FY	Fiscal Year
GCOS	Genetic Conservation and Outplanting Section
GIS	Geographic Information System
GPS	Global Positioning System
HFNWR	Hakalau Forest National Wildlife Refuge
HHB	Hawaiian Hoary Bat
HRPRG	Hawaiʻi Rare Plant Restoration Group
INRMP	Integrated Natural Resources Management Plan
IPP	Invasive Plants Program
IPSM	Invasive Plants Survey and Monitoring
IWFMP	Integrated Wildland Fire Management Plan
KKEPH	Kīpuka Kālawamauna Endangered Plants Habitat
KMA	Keʻāmuku Maneuver Area
LCTA	Land Condition Trend Analysis
LZ	Landing Zone
MATS	Management Actions Tacking System
MBTA	Migratory Bird Treaty Act
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MPRC	Multi-Purpose Range Complex
MFR	Memorandum for Record

NEPA	National Environmental Policy Act
NVCS	National Vegetation Classification System
OP	Outplanting Site
PS	Priority Species
PSMS	Plant Survey and Monitoring Section
PTA	Pōhakuloa Training Area
REC	Record of Environmental Consideration
ROD	Rapid ʻŌhiʻa Death
SOP	Standard Operating Procedure
T	Threatened
TA	Training Area
TES	Threatened and Endangered Species
USAG	United States Army Garrison
USFWS	US Fish and Wildlife Service
WCB	Weed Control Buffer
WEA	Wildlife Enhancement Area

EXECUTIVE SUMMARY

Introduction

This biennial report documents the work performed jointly by the US Army Garrison, Pōhakuloa Training Area (Army) and the Center for Environmental Management of Military Lands (CEMML) regarding the management of natural resources at Pōhakuloa Training Area (PTA) during the 2-year period of FY 2018–FY 2019 (01 October 2017 through 30 September 2019). It documents CEMML accomplishments toward Statement of Objectives tasks and fulfills the deliverable requirement of Cooperative Agreement W9126G-16-2-0014 to provide a biennial report. The report is also produced to maintain compliance with the installation's Integrated Natural Resources Management Plan (INRMP) and regulatory obligations under the Endangered Species Act (ESA), Migratory Bird Treaty Act (MBTA), and National Environmental Policy Act.

The report is organized into 3 areas: 1) compliance with regulatory mandates and reporting requirements, 2) technical assistance for military initiatives, and 3) assessments after disturbance events. The first section summarizes achievements by the Botanical, Invasive Plants, Wildlife, Game Management, and Ecological Data programs towards the fulfillment of the Army's Natural Resources Program regulatory requirements and promotes the goals of the installation's INRMP and Integrated Wildland Fire Management Plan (IWFMP). The second section highlights military training, operations, and maintenance projects that required technical assistance and support from CEMML. The third section provides a brief review of disturbance events (e.g., wildland fire) for which we provided field assessments, GIS/data analyses, and technical reports.

We produce a comprehensive biennial report every 2 years. The report includes an appendix that satisfies annual reporting requirements for the most recently completed fiscal year. In interim years, a report addressing reporting requirement is produced as a stand-alone document and delivered separately. Annual reporting requirements for FY 2019 (01 October 2018 through 30 September 2019) are contained in Appendix E of this report.

Area 1: Compliance with Regulatory Mandates and Reporting Requirements

Botanical Program

The Botanical Program implements conservation measures for 20 ESA-listed plants at PTA: *Asplenium peruvianum* var. *insulare*, *Exocarpos menziesii, Festuca hawaiiensis, Haplostachys haplostachya*, *Isodendrion hosakae*, *Kadua coriacea*, *Lipochaeta venosa*, *Neraudia ovata*, *Portulaca sclerocarpa*, *Portulaca villosa, Schiedea hawaiiensis*, *Sicyos macrophyllus, Silene hawaiiensis*, *Silene lanceolata*, *Solanum incompletum*, *Spermolepis hawaiiensis*, *Stenogyne angustifolia* var. *angustifolia*, *Tetramolopium arenarium* ssp. *arenarium* var. *arenarium*, *Vigna o-wahuensis*, and *Zanthoxylum hawaiiense.* We also manage the undescribed species *Tetramolopium* sp. 1 due to its rarity and limited distribution even though this plant is not ESA-listed.

The Botanical Program is composed of 2 sections:

1) Plant Survey and Monitoring
2) Genetic Conservation and Outplanting

The purpose of the Plant Survey and Monitoring Section is to delimit listed species distributions, estimate and monitor plant populations, monitor for emerging threats, and monitor vegetation and habitat conditions. Projects in this section include plant surveys, priority species monitoring, and vegetation monitoring. Data collected and its analysis help to guide management actions to create, where possible, favorable conditions for the continued persistence of each ESA-listed plant species.

During the reporting period, information derived from plant surveys met INRMP objectives and compliance obligations as well as provided accurate information on the distribution of ESA-listed plant species. During priority species monitoring, we collected count data from which we can accurately track current population status. In FY 2020, we plan to use the information gained from plant surveys and priority species monitoring to develop new monitoring methods that will allow us to more efficiently and precisely estimate abundance for all ESA-listed plant species at PTA and potentially model future projections of population status.

We are improving our understanding of threats to ESA-listed plant species. Analysis showed that threats are not present at most plots on most visits; threats were detected most often between July and September. In FY 2020, we will examine spatial and temporal patterns. Understanding these types of patterns will help us establish meaningful management triggers and increase our management efficiency and effectiveness. Additionally, we plan to implement vegetation monitoring, as resources allow, to better understand community-level changes that occur following landscape-level management and/or disturbance events.

The purpose of the Genetic Conservation and Outplanting Section is to maintain the genetic diversity of the 20 ESA-listed plant species found at PTA, and to the extent feasible, to increase the distribution and abundance of the ESA-listed plant species. Projects implemented in this section include genetic conservation, propagation and management of the greenhouse, outplanting, and habitat improvement. The overall goal of the Genetic Conservation and Outplanting Section is to increase the distribution and abundance of ESA-listed plant species at PTA through propagating and planting the protected species or by planting common native species to improve habitat at natural populations of ESA-listed plants or outplanting sites.

The *Genetic Conservation and Outplanting Plan* (2017) is an excellent foundation to guide genetic conservation for the 20 ESA-listed plants. The strategy developed in the plan will guide management priorities, collection and propagation targets, and outplanting activities including site selection and the development of site-specific planting plans. These more detailed site-specific plans will establish planting targets and long-term site monitoring plans to evaluate outplanting success and our efforts in relation to our goals and compliance obligations for each ESA-listed plant species.

During the reporting period, we encountered challenges with record keeping and reporting. These challenges prompted in-house scrutiny of processes and procedures for collecting, storing, and propagating propagules, for accessing seedlings to the greenhouse, and for outplanting. We identified several areas to improve accounting and record keeping, to facilitate annual reporting for state and federal threatened and endangered plant permits. We aim to overhaul our database, inventory species and founders in the *ex situ* propagule bank and streamline the accounting process to accurately track seeds from collection and storage to propagation and outplanting.

The botanical portion of this report summarizes methods and general results for plant surveys, priority species monitoring, genetic conservation, and outplanting efforts during the reporting period. Summaries for each ESA-listed species, including the most up-to-date distribution maps, are also provided.

Invasive Plants Program

The Invasive Plants Program is responsible for both invasive plants and fuels control at PTA. This program comprises 3 sections:

1) Vegetation Control
2) Invasive Plants Survey and Monitoring (IPSM)
3) Fuels Management

The purpose of the <u>Vegetation Control and IPSM Sections</u> is to reduce impacts from invasive plants to threatened and endangered species (TES) and their habitats, prevent the introduction and establishment of invasive plants, provide control and minimize ecological impacts, and manage invasive plants for natural resource stewardship. Projects in the IPSM Section include monitoring and control, site-specific survey and control, surveys, trail and road maintenance. Projects in the Vegetation Control Section include Hawaiian Goose management on and off PTA, small-scale fences, trail and road maintenance, and maintenance of weed control buffers (WCBs).

During the reporting period, we made satisfactory progress toward achieving program goals. We plan to use updated WCB geospatial data combined with rare plant monitoring data to assess the efficacy of weed control in Areas of Species Recovery (ASRs) and the benefits to rare plants. All ASRs on the current schedule, except 5, received weed control during the reporting period. We also implemented weed control in 1 new ASR on Puʻu Pāpapa. Overall, there was an approximate net increase of 2.6 ha in WCB area across PTA; we documented 105.7 ha of total WCB area within ASRs.

Several of our WCBs likely reduced direct impacts to ESA-listed plants during a July 2018 fire in Training Areas 18, 19, and 22. The site of ignition was within the Kīpuka Kālawamauna Endangered Plants Habitat (KKEPH), one of the most fire-prone and ecologically significant areas at PTA. Our post-fire assessment results showed that the fire burned right up to the edge of 4 WCBs before it stopped. Thus, these WCBs were effective in preventing fire from impacting the ESA-listed plant species in the area, averting a potential extinction event for the endangered *Tetramolopium arenarium* var. *arenarium*.

A cloud-based relational database was implemented in ArcGIS Online for the Invasive Plant Survey and Monitoring Section. This new system includes a field collection component through Collector for AcrGIS, allowing near real-time updates of data with new data collected in the field. It has proven efficient and effective. However, the system does present some challenges. Since multiple individuals from different natural resources programs enter data directly into the database, the likelihood for errors is high. We believe this issue can be addressed through quality assurance procedures such as more detailed and frequent training for field staff and regular data QC. We are currently developing a more systematic approach to quality control and analysis.

The purpose of the Fuels Management Section is to reduce the threat of wildland fire to TES and their habitats at the installation. Projects implemented to achieve these goals include the implementation and maintenance of firebreaks, fuel breaks, and fuels monitoring corridors.

During the reporting period, all fuel beaks received maintenance to ensure compliance with the standards per the PTA Integrated Wildland Fire Management Plan. In concert with WCBs in fire-prone areas, the fuel breaks proved to be a functional asset for firefighters during the July 2018 fire in the KKEPH. The fire spread westward from the ignition site in TA 19 to TAs 18 and 22, burning approximately 585 ha. Fuel breaks were effective in preventing the westward spread of the fire into additional TES habitat, and significantly aided in fire suppression and containment.

The invasive plants portion of this report summarizes vegetation control efforts in ASRs and outplanting sites, IPSM management actions, and fuels management activities conducted during the reporting period.

Wildlife Program

The Wildlife Program manages for 6 ESA-listed animal species that use habitat at PTA and/or periodically transit the installation: Hawaiian Goose (*Branta sandvicensis*), Hawaiian Hawk (*Buteo solitarius*), anthricinan yellow-faced bee (*Hylaeus anthracinus*), Hawaiian hoary bat (*Lasiurus cinereus semotus*), Band-rumped Storm Petrel (*Oceanodroma castro*), and Hawaiian Petrel (*Pterodroma sandwichensis*). In July 2019, the Blackburn's sphinx moth (*Manduca blackburni*), also an ESA-listed species, was found at PTA. Additionally, 15 bird species protected under the MBTA occur at PTA.

The Wildlife Program comprises 2 sections:

1) Wildlife Management
2) Threat Management

The purpose of the Wildlife Management Section is to manage and protect ESA-listed animal species as required by law, while minimizing impacts from wildlife to military activities that may degrade training realism or quality at PTA. This section is divided into the following projects: Hawaiian Goose management, Hawaiian hoary bat, seabird management, avian monitoring, anthricinan yellow-faced bee, and Blackburn's sphinx moth. Section objectives include surveying to determine presence of species, monitoring activity patterns, identifying habitat use, and reporting incidental take (direct and indirect) for the Hawaiian Goose, Hawaiian hoary bat, and bird species protected under the MBTA.

During the reporting period, we continued to monitor Hawaiian Geese at PTA and to implement management to reduce conflicts with military training. Our management efforts at Hakalau Forest National Wildlife Refuge supported the fledging of 7 goslings in FY 2018 and 20 goslings in FY 2019, which is substantial progress toward our goal of supporting 26 goslings to fledgling age annually in Army-managed areas at the refuge. Following our data analysis of Hawaiian hoary bat monitoring data, we have a better understanding of seasonal activity patterns and the likelihood of occupancy across the installation. Similarly, we continue to improve our knowledge about the Band-rumped Storm Petrel and patterns of colony attendance and breeding activity and success.

With the listing of the anthricinan yellow-faced bee and the recent discovery of Blackburn's sphinx moth, we continue to investigate the presence of these species at PTA. Information on presence and distribution is essential to developing management plans for these species.

The purpose of the Threat Management Section is to reduce or eliminate impacts to TES and their habitats from non-native animals (ungulates, small mammals, and invertebrates), to prevent the introduction and establishment of new invasive animals via military actions, and to monitor and preserve the ungulate exclusion fence units that protect TES and their habitats. Our objectives include detecting and reporting the presence of incipient or previously undocumented invasive animal species, especially reptiles, controlling invasive animal species that threaten TES, and maintaining the integrity of the ungulate exclusion fences. This section is divided into the following projects: ungulate management, small mammal (i.e., predator) management, roadside ant mapping project, early detection and control of invasive animal species, and fence maintenance.

During the reporting period, operational goals were achieved for most projects in the Threat Management Section. Significant program achievements include removing predators prior to the Band-rumped Storm Petrel arrival to the colony, continuing to maintain an ungulate-free status (since 2017) in all of the ungulate exclusion fence units, roadside mapping of invasive ant distribution at PTA, and implementing a new request procedure for the use of off-site aggregate at PTA. In FY 2018 and FY 2019, electronic data collection methods were implemented to improve the process for recording control of small mammals and surveying for invasive invertebrates at PTA and off-site quarries.

The wildlife portion of this report summarizes management actions that were conducted for all projects in the wildlife management and threat management sections.

Game Management

The Game Management Program manages introduced game mammals within designated hunting areas to reduce negative impacts to Palila Critical Habitat (Training Areas 1-4, 10, 11) and to minimize potential ungulate ingress into the PTA ungulate exclusion fence units. The program also provides outdoor recreation and public access to military lands for hunting game mammals and upland game birds on approximately 156 km^2 at the installation. The Game Manager monitors game resources and hunter efficacy to reduce negative impacts to protected natural resources and coordinates access to hunting areas for the public.

During the reporting period, we successfully completed the first steps to understanding the dynamics of resident game populations; namely, we identified potential survey techniques, implemented them in the field, and calculated density estimates. This information acts as a baseline and will be important for future study of methods for the protection of TES and management of critical habitat. As we build on our understanding of game populations and their response to varying levels of harvest, we will be better suited and prepared to respond to changes in the status of TES.

Ecological Data Program

The Ecological Data Program (EDP) provides support to technical programs regarding the development of ecological data collection methodologies, data/GIS management, analysis, reporting, and the effective incorporation of results into management operations. This program develops, implements, and maintains the necessary information technology infrastructure supporting management planning, scheduling, implementation, tracking, and reporting. Additionally, the EDP facilitates the coordination and incorporation of research results from external agencies. This program is organized into 6 sections:

1) Centralized Data Support
2) Data Management Systems
3) Information Technology
4) External Research Support
5) General Support for Army Training Initiatives
6) Administrative Support

The purpose of the <u>Centralized Data Support and Data Management Systems Sections</u> is to provide guidance and support for data collection, management, and analysis to the technical programs. This support function helps ensure operational protocols most efficiently address pre-established questions, including assessments of management efficacy, strategy optimization, and budget tracking and accounting. In addition, this program develops computer information systems to ensure appropriate data management infrastructure exists to enter, store, analyze, and report results from data collected. Data management systems are necessary to facilitate day-to-day operations, planning, accounting, and reporting efforts.

During the reporting period, we took on a significantly greater role in project development to ensure protocols can most efficiently address pre-established questions pertinent to the project purpose and intents, including assessments of management efficacy, strategy optimization, and budget tracking and accounting. In addition, we develop computer information systems (e.g., data input interfaces and databases) to ensure appropriate data management infrastructure exists to enter, store, analyze, and report results from data collected. Data management systems are necessary to facilitate day-to-day operations, planning, accounting, and reporting efforts. Systems are developed, implemented, and managed using established principles and theory of data management and database design.

The purpose of the Information Technology Section is to provide the necessary infrastructure (e.g., computer workstations, printers, central network server, telecommunications) to facilitate day-to-day operations. During the reporting period, we continued work with CEMML, the Army, and representatives from Spectrum Business to bring broadband fiber optic communications (internet and phone) to our facilities. We oversaw upgrades to network infrastructure including workstations, network servers, switches, and printers. We also managed and maintained the centralized network server and backup domain controller, a network-attached storage system, and over 26 individual workstations, including automated backups of data at all levels of the network.

The purpose of the External Research Support Section is to facilitate installation access for outside agencies to conduct ecological research. During the reporting period, researchers from the University of Hawaiʻi and the Institute of Pacific Islands Forestry completed 2 large projects. The first project involved better understanding how the removal of ungulates from PTA's ecosystems affect plant community dynamics. The second project involved the investigation and quantification of impacts non-native predators have on native species and community pollination ecology.

To provide General Support for Army Training Initiatives, we assisted the Army with data collection and development, evaluation, and synthesis, mapping and graphics support, and technical document preparation. We also provided significant support to the PTA Department of Emergency Services using imagery analysis and mapping tools to provide resources to aid in wildland fire suppression efforts. Additional details about support tasks that fell into this category during the reporting period are summarized in the second section (Area 2) of this report.

In the newly consolidated Administrative Section of the EDP, primary functions included planning, implementing, and managing on-site human resources, fiscal actions, facilities, and fleet vehicle maintenance and repair. Effective execution of environmental compliance and safety programs ensured that all federal, state, and Army regulatory and reporting requirements were met.

The ecological data portion of this report summarizes support tasks conducted by staff and efforts toward fulfillment of program objectives during the reporting period.

Area 2: Technical Assistance for Military Initiatives

We provide technical services to the Army in the form of personnel expertise, data acquisition and evaluation, graphics support, and document preparation, for military initiatives for training capacity, for cooperative initiatives with state and federal resource agencies, and to provide for a defense in litigation proceedings. We also review proposed military actions to assess potential effects to TES and other species of concern. During the reporting period, we provided technical assistance in the following areas:

1) ESA and NEPA Projects
2) INRMP
3) Public Outreach
4) Publications and Presentations
5) Technical Reviews
6) Conservation Reimbursable Programs
7) Collaborations with Partner Agencies
8) External Research Support
9) Direct Assistance to Army Biologist
10) On-site Support to PTA Command

Please refer to Section 7.0 (Area 2) of this biennial report for a summary of technical services we provided for each of these projects.

Area 3: Assessments after Disturbance Events

Following disturbance events such as wildland fire, drought, or flooding we provide technical assistance to the Army by assessing the condition of natural resources. Additionally, the Integrate Wildland Fire Management Plan (IWFMP) and 2003 Biological Opinion (BO) require the Army to assess and report all military training-related wildland fires occurring on the installation outside of the Impact Area to determine potential effects to TES and incidental take of Hawaiian hoary bats. During the reporting period, we provided an assessment following 1 wildland fire disturbance event:

July 2018 Wildland Fire Training Areas 18, 19, and 22

On 18 July 2018, at approximately 1800 hours, a wildland fire ignited in Training Area (TA) 19 at PTA. The fire eventually spread to adjacent TAs 18 and 22; it burned 585 ha before it was declared 100% contained on 1 August 2018. The overall impact of the fire was patchy and heterogenous, with the most severe impacts in the northwest portion of TA 22. We conducted a post-fire survey within 2 weeks of the fire being extinguished. Of the 716 plant locations visited during post-fire surveys, 34% were determined to be fully burned, 49% partially burned, and 17% completely unburned. In addition, the fire burned an estimated 149 ha of vegetation considered potential available Hawaiian hoary bat roosting habitat exceeding indirect, incidental take for habitat authorized by the Incidental Take Statement in the 2003 BO. Since the issuance of the 2003 BO, this was the only large training-related fire at PTA to exceed the authorized indirect, incidental Hawaiian hoary bat take amount. Even with surpassing the annual allowance, the Army remains under the cumulative authorized incidental take limit for the loss of 1,345 ha of potential available Hawaiian hoary bat roosting habitat.

Following this initial assessment, we conducted additional rare plant surveys in the area affected by fire during the remainder of 2018 and 2019. See the Plant Survey and Monitoring Section Discussion (Section 2.2.6) for additional information about the impacts of the fire to the ESA-listed plant species.

Conclusion

Ecosystems at PTA are highly complex and the challenges to manage natural resources multi-faceted. Through implementation of the Natural Resources Program at PTA, we work toward fulfilling goals and objectives congruent with the Army and Department of Defense mission to sustain and conserve natural resources on the installation.

By implementing management at ecosystem and landscape scales to control threats (e.g., from ungulates, wildland fire, and invasive weeds), we have reduced many of their negative impacts to ESA-listed species and their habitats. Through these actions, we assume a positive conservation benefit is conferred to the entire ecosystem as well as to TES and their habitats. For example, since feral ungulates were removed from the fence units, some ESA-listed plants have increased in number. However, some critically rare species may need more active management to persist. We recommend additional research into basic life history characteristics and an expanded knowledge of species ecology to better design and implement management to encourage healthy, resilient populations that have a greater chance of persisting under changing climate conditions.

Implementing effective natural resources programs benefits the Army by improving the resiliency of the natural environment to training and other uses, thereby helping to ensure an enduring land-base to maintain future training capacity. To maintain effective natural resources management embedded with a robust military training and operational environment, an integrated approach is essential. The INRMP is a critical planning tool to engage multiple partners, within and external to the Army, to ensure the successful management of the natural environment at PTA. To optimize military training capacity while promoting training sustainability over time, and to meet the demanding training mission of the installation, we continue to maximize conservation benefits to TES and their habitats through the effective implementation of the INRMP and the Army's Natural Resources Program at PTA.

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1.0 INTRODUCTION

1.1 Purpose and Scope

1.1.1 Function of the Report

This biennial report documents the work performed jointly by the US Army Garrison, Pōhakuloa Training Area (Army) and the Center for Environmental Management of Military Lands (CEMML) to manage natural resources at Pōhakuloa Training Area (PTA). It documents CEMML accomplishments toward Statement of Objectives (SOO) tasks and fulfills the deliverable requirement of Cooperative Agreement W9126G-16-2-0014 to provide a biennial report. The report is also produced to maintain compliance with the installation's Integrated Natural Resources Management Plan (INRMP) and regulatory obligations under the Endangered Species Act (ESA), National Environmental Policy Act (NEPA), and Migratory Bird Treaty Act (MBTA). Information is summarized, interpreted, and presented in a manner so that the reader understands the essential purpose of each project in a regulatory and ecological context.

The Army Biologist and Natural Resources Program Manager are the main audiences for this report; however, it is also intended to communicate the Army's Natural Resources Program accomplishments and regulatory compliance at PTA to Army leadership and to the Army's regulators. This report covers the 2-year period of FY 2018–FY 2019 (01 October 2017 through 30 September 2019).

Report purposes include:

- Documenting program progress, accomplishments, and compliance with regulatory obligations during the reporting period;
- Allowing time to summarize and reflect on program operation, direction, and data;
- Synthesizing information about work done and relating the actions back to stated purposes, goals, and objectives;
- Explaining the relevance and biological importance of the actions to the resources and/or to compliance;
- Informing our practices and processes (e.g., what are we doing well, what needs improving?);
- Gathering important program data in a centralized and usable report;
- Allowing us to disseminate our findings to the Army and regulators.

1.1.2 Report Organization

This report is organized into 3 areas:

1) Compliance with regulatory mandates and reporting requirements
2) Technical assistance for military initiatives

3) Assessments after disturbance events

The first section of this report summarizes achievements by the Botanical, Invasive Plants, Wildlife, Game Management, and Ecological Data programs towards the fulfillment of the Army's Natural Resources Program regulatory requirements and promotes the goals of the installation's INRMP and Integrated Wildland Fire Management Plan (IWFMP). The second section highlights military training, operations, and maintenance projects that required technical assistance and support from CEMML. The third section provides a brief review of disturbance events (e.g., wildland fire) for which we provided field assessments, GIS/data analyses, and technical reports.

We produce a comprehensive biennial report every 2 years. The report includes an appendix that satisfies annual reporting requirements for the most recently completed fiscal year. In interim years, a report addressing reporting requirements is produced as a stand-alone document and delivered separately (CEMML 2019b). Annual reporting requirements for FY 2019 (01 October 2018 through 30 September 2019) are contained in Appendix E of this report.

1.2 PTA Natural Resources Program Background

1.2.1 Natural Resources Program Authorities and Regulatory Framework

The Army is committed to environmental stewardship and sustainability in all actions as an integral part of its mission. To this end the Army promulgated Army Regulation 200-1 to implement federal, state, and local environmental laws and Department of Defense policies for preserving, protecting, conserving, and restoring the quality of the environment. The Army's broad land resources management goals are to:

1) Integrate natural resources stewardship and compliance responsibilities with operational requirements to help achieve sustainable ranges, training areas, and other land assets.
2) Develop, initiate, and maintain programs for the conservation, utilization, and rehabilitation of natural resources on Army lands.

Per the Sikes Act Improvement Act (1997), the PTA INRMP (USAG-P 2019a) is the foundational document of the Army's Natural Resources Program at PTA and sets objectives for managing native plant species, including ESA-listed plants (Chapter 5.1.3). The plan also identifies objectives to manage the ecosystem at the landscape scale to protect habitats that are home to 27 ESA-listed threatened and endangered plant and animal species (TES). The US Fish and Wildlife Service (USFWS) considers invasive species and their associated impacts to be major threats to the ESA-listed plants at PTA (USFWS 2003b). Because of the active management of these threats under the PTA INRMP, the USFWS did not designate critical habitat on Army lands at PTA for 12 plant species in 2003[1].

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[1] *Asplenium peruvianum* var. *insulare, Kadua coriacea, Isodendrion hosakae, Neraudia ovata, Portulaca sclerocarpa, Silene hawaiiensis, Silene lanceolata, Solanum incompletum, Spermolepis hawaiiensis, Tetramolopium arenarium* ssp. *arenarium* var. *arenarium, Vigna o-wahuensis*, and *Zanthoxylum hawaiiense.*

The PTA INRMP addresses all aspects of natural resource management at the installation and is the primary driver for budget requests, project development, and compliance reporting. The plan is coordinated with state and federal conservation agencies to ensure alignment between Army, state, and federal conservation efforts. The INRMP is a coordinating document to ensure stewardship projects work toward the conservation of TES in accordance with section 7(a)(1) of the ESA. In addition, the INRMP helps align management actions with regulatory obligations in Biological Opinions (BOs) from formal consultations conducted under section 7(a)(2) of the ESA and regulatory outcomes from NEPA documents. Previous consultations between the Army and USFWS regarding the effects of military actions to TES at PTA have resulted in 3 primary BOs, summarized below.

1.2.2 2003, 2008, and 2013 Biological Opinions

In 2003, the USFWS issued a BO to the Army as part of a formal consultation under section 7(a)(2) of the ESA. In 2008, the Army reinitiated formal consultation to address emergent issues and a subsequent BO was issued. Another BO was issued in 2013 that addressed effects to biological resources from a proposed Infantry Platoon Battle Area and effects to the Hawaiian Goose (*Branta sandvicensis*) from installation-wide military training. Together, these 3 BOs stipulate specific management actions to be implemented by the Army to ensure the continued non-jeopardy status of TES at PTA. Along with the INRMP, the BOs are the primary directive for managing natural resources at the installation. The 2003, 2008, and 2013 BOs are summarized below:

<u>2003 BO</u>

On 23 December 2003 the USFWS issued a BO titled *Routine Training and Transformation of the 2^nd^ Brigade 25^th^ Infantry Division (Light), US Army Installations, Island of Hawaiʻi* as part of formal consultation with the Army regarding military training and related activities at PTA. The consultation included 15 ESA-listed plant species (*Asplenium peruvianum* var. *insulare*, *Haplostachys haplostachya*, *Kadua coriacea*, *Isodendrion hosakae*, *Lipochaeta venosa*, *Neraudia ovata*, *Portulaca sclerocarpa*, *Silene hawaiiensis*, *Silene lanceolata*, *Solanum incompletum*, *Spermolepis hawaiiensis*, *Stenogyne angustifolia* var. *angustifolia*, *Tetramolopium* ssp. *arenarium* var. *arenarium*, *Vigna o-wahuensis*, *Zanthoxylum hawaiiense*); 1 ESA-listed mammalian species, the Hawaiian hoary bat *(Lasiurus cinereus semotus)*; and designated critical habitat for 1 ESA-listed avian species, Palila *(Loxioides bailleui)*. Biological surveys to determine the status and abundance of 3 avian species were also conducted as part of the consultation: Hawaiian Goose, Hawaiian Hawk (*Buteo solitarius*), and Hawaiian Petrel (*Pterodroma sandwichensis*).

The USFWS determined that military training and related activities at PTA were not likely to jeopardize the continued existence of TES or adversely modify or destroy critical habitat. Several conservation measures to offset effects to TES from military activities were identified in the BO. In addition, the 2003 BO included an incidental take statement for the Hawaiian hoary bat. To be exempt from the prohibitions in section 9 of the ESA, the Army must comply with the "terms and conditions", which state the reasonable and prudent measures (2003 BO; p. 180–183).

2008 BO

On 12 December 2008, the USFWS issued a new BO titled *Reinitiation of Formal Section 7 Consultation for Additional Species and New Training Actions at Pōhakuloa Training Area, Hawaiʻi*. Reinitiation of the 2003 BO was necessary to address impacts to *Asplenium peruvianum* var. *insulare*, *Silene hawaiiensis*, and *Solanum incompletum* associated with new construction, training, and conservation actions at PTA. Consultation with USFWS was also reinitiated due to a change in status of the Hawaiian Goose and the Hawaiian hoary bat at the installation.

The USFWS determined that implementation of the proposed action was not likely to jeopardize the continued existence of any species (*Asplenium peruvianum* var. *insulare*, *Silene hawaiiensis*, *Solanum incompletum,* Hawaiian Goose, or Hawaiian hoary bat) covered in the 2008 BO. Conservation measures to offset project impacts to the species were included in the BO. In addition, the 2008 BO included incidental take statements for the Hawaiian Goose and the Hawaiian hoary bat. To be exempt from the prohibitions in section 9 of the ESA, the Army must comply with the "terms and conditions", which state the reasonable and prudent measures (2008 BO; p. 44–45).

2013 BO

On 11 January 2013, the USFWS issued a BO titled *Informal Consultation and Formal Consultation with a Biological Opinion for the Construction, Maintenance, and Operation of an Infantry Platoon Battle Area and Installation-Wide Impacts of Military Training on Hawaiian Geese at Pōhakuloa Training Area, Hawaiʻi*. The BO was divided into 2 parts for analytical purposes. Part I evaluated potential impacts to TES from the construction, maintenance, and operation of a proposed Infantry Platoon Battle Area (IPBA) at PTA. This discrete action is one component in a long-range plan to modernize training ranges and training support infrastructure at PTA. Part II evaluated ongoing military training actions and related activities at PTA that may affect the Hawaiian Goose. The 2008 BO required the Army to reconsult on potential effects to the Hawaiian Goose from general military training actions and propose new conservation measures as necessary.

The USFWS determined that implementation of the proposed actions was not likely to jeopardize the continued existence of any species covered in the 2013 BO (*Asplenium peruvianum* var. *insulare*, *Kadua coriacea*, *Silene hawaiiensis*, *Spermolepis hawaiiensis*, *Zanthoxylum hawaiiense,* and the Hawaiian Goose). Conservation measures to minimize and offset impacts to these species were included in the BO.

The BO included an incidental take statement which allows military training proximate to Hawaiian Geese as long as troops have been educated prior to training. Also, geese may be hazed from ranges under certain conditions. In return, the Army funds an off-site conservation partnership project at Hakalau Forest National Wildlife Refuge. The goal of the project is to produce an average of 26 fledgling geese (21 geese surviving to breeding age) per year, to compensate for an incidental take statement of 20 geese annually at PTA. We are required to monitor Hawaiian Geese and goose nests at PTA and off-site mitigation locations to quantify the level of take. To be exempt from the prohibitions in section 9 of the ESA, the Army must comply with the "terms and conditions", that guide the reasonable and prudent measures (2013 BO; p. 50–51).

Hawaiian Hawk

In the 2013 BO, the USFWS concurred with the Army's 4 January 2013 "no effect" determination for the Hawaiian Hawk for all anticipated military training at PTA. Consequently, the Army is no longer required to survey this species.

1.2.3 Upcoming Sec-7 Consultation

The 2003, 2008, and 2013 BOs established conservation measures for 15 species of ESA-listed plants (*Asplenium peruvianum* var. *insulare*, *Haplostachys haplostachya*, *Isodendrion hosakae*, *Kadua coriacea*, *Lipochaeta venosa*, *Neraudia ovata*, *Portulaca sclerocarpa*, *Silene hawaiiensis*, *Silene lanceolata*, *Solanum incompletum*, *Spermolepis hawaiiensis*, *Stenogyne angustifolia* var. *angustifolia*, *Tetramolopium arenarium* spp. *arenarium* var. *arenarium*, *Vigna o-wahuensis*, and *Zanthoxylum hawaiiense*) and 4 species of ESA-listed animals at PTA: Hawaiian hoary bat (*Lasiurus cinereus semotus*), Hawaiian Goose (*Branta sandvicensis*), Hawaiian Hawk (*Buteo solitarius*), and Hawaiian Petrel (*Pterodroma sandwichensis*).

Since the issuance of these BOs, several species that occur on the installation have subsequently been listed under the ESA. In October 2013, the USFWS listed *Schiedea hawaiiensis* as an endangered plant species. In September 2016, the following species were also listed as endangered: *Exocarpos menziesii*, *Festuca hawaiiensis*, *Portulaca villosa*, *Sicyos macrophyllus*, Band-rumped Storm Petrel (*Oceanodroma castro*), and Anthricinan yellow-faced bee (*Hylaeus anthracinus*). Additionally, in July 2019, Blackburn’s sphinx moth (*Manduca blackburni*), an endangered species, was first detected at PTA. The Army has not yet consulted with the USFWS under section 7(a)(2) of the ESA for these species; therefore, these species lack formal conservation measures.

We are currently assisting the Army with developing a Programmatic Biological Assessment (PBA) for the installation. The PBA is intended to be a comprehensive document that assesses potential impacts from military activities on all TES at PTA (20 plant species and 7 animal species). We anticipate the issuance of a BO from the USFWS in FY 2020.

1.2.4 Cooperative Agreement

The Army funds CEMML to provide technical assistance and to implement natural resources management, including actions to fulfill regulatory requirements at the installation. The current Cooperative Agreement with CEMML was originally awarded in FY 2016 and consists of a base year and 4 option years. Because this report covers FY 2018 to FY 2019, the reporting period roughly corresponds to Cooperative Agreement option years 1 and 2 which spanned July 2017 through July 2019. The SOO for the Cooperative Agreement includes tasks for coordination and natural resources management activities at PTA. Approximately 35 CEMML employees work within the Natural Resources Program at PTA under the cooperative agreement.

1.2.5 CEMML Organizational Structure at PTA

CEMML's structure at PTA was reorganized in FY 2019. Coordination of hunting and outdoor recreation activities was moved from the Wildlife Program into a separate Game Management Program under the direction of a full-time game manager. After the departure of the Administrative Program Manager, some administrative responsibilities were allocated to managers in other programs and primary administrative functions were consolidated under the Ecological Data Program. CEMML currently manages natural resources at PTA in 5 major program areas: Botanical, Invasive Plants, Wildlife, Game Management, and Ecological Data.

1) The <u>Botanical Program</u> implements conservation measures for 20 ESA-listed plant species, including plant surveys, Priority Species 1 monitoring, genetic conservation, outplanting, and habitat improvement.

2) The <u>Invasive Plants Program</u> reduces direct impacts to TES and their habitats from non-native species competition and indirect impacts to native ecosystems from wildland fire. The program strives to create buffers around ESA-listed plants free from non-native plant competition, reduce fine fuels within a prescribed distance in fire-prone habitats, and improve native-dominated habitats near ESA-listed plant locations by reducing non-native plant cover. To control target invasive weed species around selected plant populations, management efforts are focused in a series of weed control buffers located within Areas of Species Recovery (ASRs).

3) The <u>Wildlife Program</u> manages for 7 ESA-listed animal species. Management actions include surveying to determine species presence and monitoring of population trends, and controlling invasive animal species (ungulates, invertebrates, and small mammals) to benefit TES. In addition, regular inspection and maintenance of ungulate exclusion fences at PTA is required by the 2003 and 2008 BOs.

4) The <u>Game Management Program</u> manages and provides outdoor recreation and public access to PTA lands for hunting feral ungulates and upland game birds. This program manages resources for safe, long-term pubic hunting opportunities without degrading military training capacity. Primary functions include coordinating access to hunting areas for the public and monitoring game resources for hunter efficacy.

5) The <u>Ecological Data Program</u> provides guidance and support to the technical programs regarding the development of ecological data collection methodologies, data/GIS management, analysis, reporting, and the effective incorporation of results into management operations. This program is also responsible for developing, implementing, and maintaining the necessary Information Technology infrastructure for the effective execution of management planning, scheduling, implementation, tracking, and reporting. Additionally, this program facilitates the coordination and incorporation of research results from external agencies toward the effective accomplishment of the Army's mission.

Administrative functions performed under the Ecological Data Program include planning, implementing, and managing on-site human resources, fiscal actions, facilities, and fleet vehicle maintenance and repair. Execution of environmental compliance and safety programs ensures that all federal, state, and Army regulatory and reporting requirements are met.

1.2.6 PTA Natural Resources Program Plan

A comprehensive program plan documents the goals, objectives, and methods for fulfilling regulatory requirements to protect and conserve natural resources at the installation. The plan strategically aligns the overall purpose and execution of each component of the Natural Resources Program at PTA. Projects are directly linked to the INRMP, regulatory mandates, and SOO requirements to track compliance. The program plan provides detail regarding how projects are to be implemented and is intended to work in conjunction with documents that guide natural resource management at PTA, including the BOs, INRMP, and IWFMP. The program plan was intended to update the PTA Implementation Plan (2010) required by the 2003 BO. The Army Biologist and USFWS personnel have not yet reviewed/approved the plan completed in 2017. The plan will be updated once every 5 years to be synchronized with the installation's INRMP (USAG-P 2019a). However, if additions or deletions of regulatory requirements or policies are issued to the Army, the plan will be updated to reflect those changes.

The program plan is intended to assist Army leaders at the Garrison, Installation Management Command-Region, and Installation Management Command-Headquarters to coordinate regulatory mandates and actions implemented at the local level. Additionally, the plan aids in systematic project development and justification in an easy-to-review format. The program plan is the basis for annual planning. Annual tasks are prioritized based on funding allocations.

CEMML recently identified a need to improve existing project planning and development processes. To this end, the Army Biologist and CEMML management have been discussing strategies to modify CEMML's organizational structure to more effectively address project planning needs. Specifically, we feel that project planning and development must result in protocols that include details clearly linking all components of project implementation (i.e., tasks and actions) to predetermined project questions, objectives, and goals. Protocols nest within the program plan to meet the functions as described above. We will finalize a restructuring strategy in early 2020 and implement modifications toward the end of the fiscal year. At that time, all new projects will require a detailed protocol prior to implementation, and existing projects will be reviewed to ensure adequately described and detailed protocols are in place.

1.3 Ecosystem Management at PTA

Ecosystem-based management principles are at the core of the Army's natural resources programs and embedded into PTA's INRMP. Over the long-term, the ecosystem management approach maintains and improves the sustainability and resiliency of ecosystems while supporting the environment required for realistic military training.

We implement ecosystem management on a landscape scale to improve the condition of native habitats and to offset effects from military activities identified in ESA consultations. For example, we reduce fire threat via fuels management and control invasive plants and animals. The intent of these management actions is to create conditions where native species, including ESA-listed plant species, can persist and naturally increase their abundance and distribution whenever environmental conditions are favorable (e.g., adequate rainfall).

Most landscape-level actions that we implement are aimed at managing invasive species and their associated negative effects. We have made significant strides toward minimizing some of these negative effects to the native ecosystems at PTA. By 2017, we removed all goats, sheep, and pigs from 15 ungulate exclusion fences that encompass a total of 15,092 ha (CEMML 2019c). Follow-up research by Litton et al. (2018) found that fence construction followed by ungulate removal correlated to a positive increase in TES and mostly insignificant changes to non-native plant distributions. Since 2008, we have consistently managed fuels in accordance with standards in the PTA IWFMPs (USAG-HI 2003, USAG-P 2019b) along a fuel break system. Additionally, for more than 10 years we have managed invasive plants, some of which are fine fuels, in buffers currently totaling about 199 ha around most of the critically rare ESA-listed plant populations. These efforts to reduce fuels positively contributed to firefighting efforts and helped minimize fire impact to ESA-listed plants and Hawaiian hoary bat habitat during 2 wildfire events in 2012 and 2018 (CEMML 2014, CEMML 2018b, CEMML 2019c).

1.4 Installation Description

1.4.1 PTA History

The United States first used the land at Pōhakuloa in 1942 for military maneuvers during World War II; PTA was formally established as an Army installation in 1956. The primary mission of PTA is to enhance the combat readiness of training units by providing a quality joint combined arms facility that offers logistical, administrative and service support for up to regiment or brigade-level combat teams and to operate and maintain a safe, modernized, major training area for military units. As a multi-functional training facility for Pacific Command elements, PTA is the only training area in the Pacific where military units can use all weapons systems at maximum capabilities.

PTA is a primary tactical training area for mission-essential training and contributes to the Army's mission by providing resources and facilities for active and reserve component units that train on the installation throughout the year. The largest live-fire range and training complex belonging to the US Army Pacific is located at PTA. Installation assets are geared toward live-fire range training and maneuvers at ranges, dismounted maneuver training, and artillery live-fire. Artillery units use PTA to conduct the majority of their live-fire training. The installation is administered by the Army and is primarily used by the 25th Infantry Division. Additional users include the Hawaiʻi Army National Guard, US Marine Corps, US Navy, US Air Force, and International Allied Forces.

PTA is the single largest Army holding in the state of Hawaiʻi at approximately 53,500 ha. The majority of the installation was acquired through Governor's Executive Order 1719 (26 January 1956; 307 ha) and Presidential Executive Order 11167 (15 August 1964; 34,017 ha). Another 9,296 ha were added through a 65-year lease with the State of Hawai‘i, which expires on 16 August 2029. Additionally, the Army purchased the 9,340-ha Ke‘āmuku Maneuver Area (KMA) from Parker Ranch in 2006. Included with this purchase was 409 ha of previously-leased maneuver lands.

1.4.2 Location and Physical Description

PTA is located in the saddle region between Mauna Kea, Mauna Loa, and Hualālai volcanoes on the island of Hawai‘i (Figure 1), 40 km south of Waimea and 58 km west of Hilo. The installation is bordered by Mauna Kea State Park, Mauna Kea Forest Preserve, and Parker Ranch to the north, Department of Hawaiian Home Lands to the northeast, the Mauna Loa Forest Reserve to the east and south, and Kamehameha School lands and state lands to the west. PTA is comprised of a cantonment area, Bradshaw Army Airfield, and training areas that include KMA and a centrally-located Impact Area.

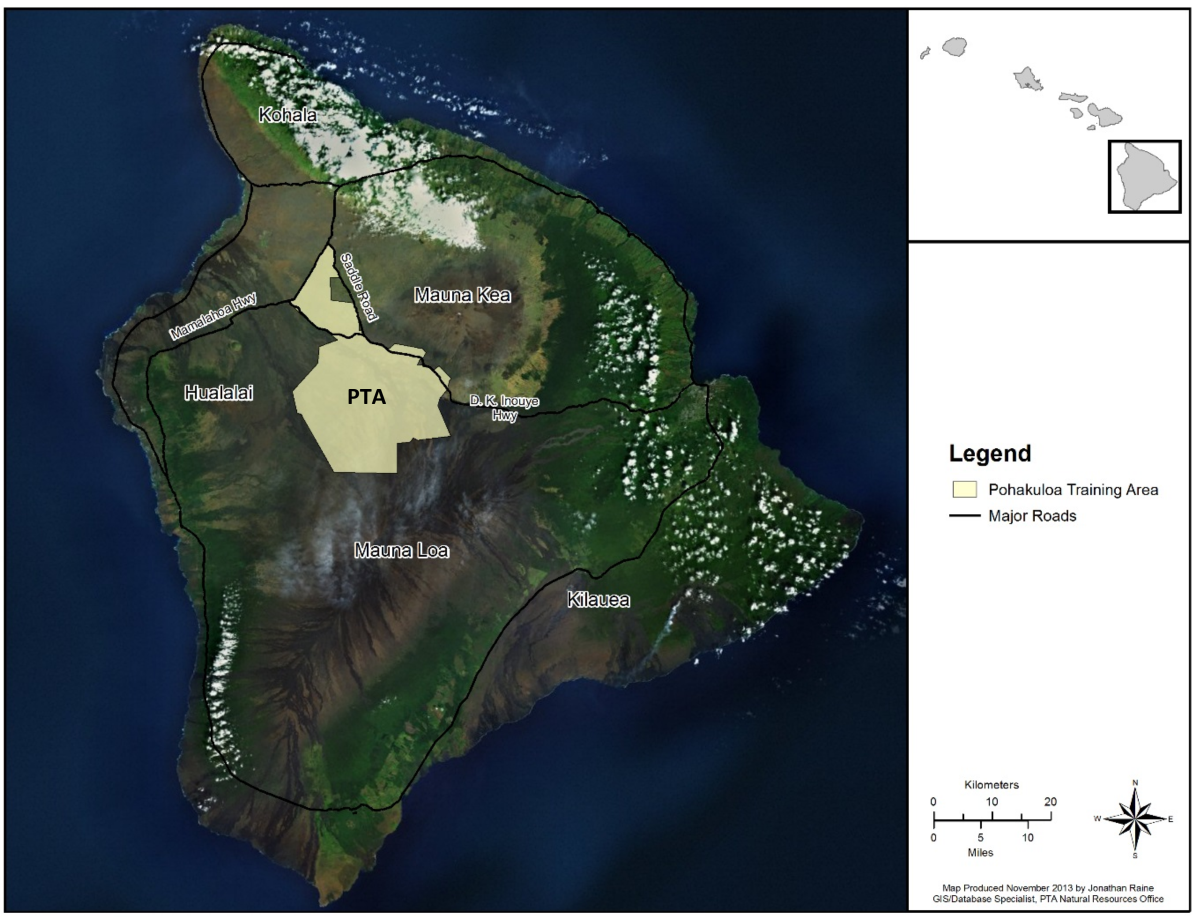

Figure 1. Location of Pōhakuloa Training Area on Hawai‘i Island

The climate of PTA is classified as cool, dry, and tropical. The habitat is dryland forest with an average annual rainfall of 37 cm at Bradshaw Army Airfield (Shaw and Castillo 1997). Statewide rainfall maps indicate average yearly rainfall of 48 cm in KMA (Giambelluca et al. 1986). Annual rainfall can be highly variable across the installation. The highest precipitation rates usually occur during the winter months (November through February) in conjunction with Kona storms. The cool-tropical climate is characterized by a 55° Fahrenheit (13° Celsius) average annual temperature (Shaw and Castillo 1997). The growing season at PTA is essentially year-round, except when inadequate soil moisture due to seasonal influences limits plant growth.

Elevation ranges from 750 m at the western tip of KMA to 2,650 m at the southernmost boundary of the installation on the slopes of Mauna Loa. Approximately 80% of PTA is covered by poorly developed, young volcanic substrate with the greatest soil development in the northern portion of the installation (USDA 1973). In contrast, most of KMA has more developed soils, with younger lava flows covering less than 1% of the area. The majority of KMA is previous pastureland consisting almost entirely of non-native vegetation. Cinder cones are a noticeable topographic feature.

There are no surface streams, lakes or other bodies of water within PTA due to low rainfall, porous soils, and lava substrates. The nearest known stream is Waikahalulu Gulch, an intermittent stream located about 3 km to the southeast of cantonment. The nearest known lake is Lake Waiau near the summit of Mauna Kea. Sparse rainfall, fog drip, and occasional frost are the main sources of moisture that sustain plants and animals in the dryland habitat at the installation.

1.4.3 Climate Change, Habitat Vulnerability Assessment, and Adaptation Planning

In 2016, the Department of Defense issued Directive 4715.21 *Climate Change Adaptation and Resilience* to establish responsibilities and resources to assess and manage risk associated with climate change including helping to safeguard the environment and natural resources. Climate change impacts to natural resources are considered during INRMP development. The 2019 INRMP identifies several ongoing conservation actions that help retain ecosystem resiliency as climate conditions change such as:

- Habitat protection and restoration;
- Genetic conservation of threatened and endangered plants;
- (Re)introduction of species to suitable habitats based on projected climate conditions.

We discuss the progress and outcomes of some these landscape-level actions in Section 1.3 and in later sections of this report. Although these landscape-level actions are aligned and consistent with actions to maintain or restore ecosystem resiliency, this was not a specific aim in implementing these projects. Currently, our projects lack specific goals and measurable objectives to monitor effects of climate-related changes and they also lack specific climate adaptation measures and actions. In FY 2020, we plan to update the INRMP with additional climate change considerations including:

- Identifying information sources to characterize regional climate change and scenarios upon which to base climate change adaptation planning.

- Determining likely ecosystem-level effects of climate change to assess potential impacts including probable complex and indirect changes that are likely to happen in the future.

- Developing or utilizing existing habitat vulnerability assessments and adaptation recommendations (e.g.,EcoAdapt reports) as a framework to develop new and/or improve existing natural resources management strategies to protect species of concern.

- Developing vulnerability assessments and climate adaptation plans for the at-risk, threatened, and endangered species at PTA.

- Developing and updating the INRMP and implementation table to request funding to complete climate change-related projects.

1.4.4 Vegetation Classification

Vegetation at PTA is classified according to the National Vegetation Classification System (NVCS). The NVCS is useful for inventorying and describing plant communities, managing rare plant habitat, and controlling invasive species. Vegetation data are also useful in the planning of infrastructure such as military training ranges and combat maneuver courses. The NVCS provides a thorough understanding of the vegetation communities at PTA and their distribution on the installation, which is essential for effective management of these military training lands. Further, the NVCS provides a standardized structure for developing a consistent classification of vegetation cover across agencies.

Classifications based on the NVCS represent existing vegetation, not potential or climax vegetation. Current PTA vegetation maps reflect extensive changes to plant communities since 1997 that have resulted from a number of large fires, prolonged drought, the increasing presence of invasive species, and natural successional processes. Block et al. (2013) classified and mapped the following vegetation communities at PTA:

1) *Metrosideros polymorpha* Woodland Alliance
2) *Eucalyptus* spp. Semi-natural Woodland Alliance
3) *Olea europaea* Semi-natural Woodland Alliance
4) *Myoporum sandwicense – Sophora chrysophylla* Woodland Alliance
5) *Myoporum sandwicense – Sophora chrysophylla* Shrubland Alliance
6) *Dodonaea viscosa* Shrubland Alliance
7) *Chenopodium oahuense* Shrubland Alliance
8) *Eragrostis atropioides* Herbaceous Alliance
9) *Pennisetum clandestinum* Semi-natural Grassland Alliance
10) *Pennisetum* (*ciliare*, *setaceum*) – Mixed Medium-Tall Ruderal Grassland Alliance

11) Semi-natural Herbland Alliance
12) *Metrosideros polymorpha* Sparsely Vegetated Woodland Alliance
13) Barren or Sparsely Vegetated Semi-natural Herbland Alliance
14) Urban Land Cover

1.5 Threatened and Endangered Species

PTA includes a portion of the last remaining sub-alpine tropical dryland ecosystem in the world. In addition, parts of the installation (Training Area 2 and parts of Training Areas 1, 4, 10 and 11) contain critical habitat for the endangered Palila (*Loxioides bailleui*). The installation provides potential habitat for a total of 27 TES (20 plant species and 7 animal species). Primary threats to ecosystem health, and therefore to TES, at PTA come from direct impacts as well as changes to the landscape as a result of disturbance from feral ungulates, invasive species, and wildland fire.

Refer to Appendix B for summary profiles for each of the installation's TES, including a physical description, habitat, life history, and distribution.

1.5.1 Plants Listed under the Endangered Species Act

There are 20 ESA-listed plant species at the installation. One plant species is undescribed and not ESA-listed but is managed due to its rarity and limited distribution. Several of these plant species occur exclusively on the installation.

1. *Asplenium peruvianum* var. *insulare*
2. *Exocarpos menziesii*
3. *Festuca hawaiiensis*
4. *Haplostachys haplostachya*
5. *Isodendrion hosakae*
6. *Kadua coriacea*
7. *Lipochaeta venosa*
8. *Neraudia ovata*
9. *Portulaca sclerocarpa*
10. *Portulaca villosa*
11. *Schiedea hawaiiensis*
12. *Sicyos macrophyllus*
13. *Silene hawaiiensis*
14. *Silene lanceolata*
15. *Solanum incompletum*
16. *Spermolepis hawaiiensis*
17. *Stenogyne angustifolia* var. *angustifolia*

18. *Tetramolopium arenarium* ssp*. arenarium* var. *arenarium*[2]
19. *Tetramolopium* sp.1 (not ESA-listed)
20. *Vigna o-wahuensis*
21. *Zanthoxylum hawaiiense*

1.5.2 Animals Listed under the Endangered Species Act

One mammal species, 4 bird species, and 2 invertebrate species listed under the ESA may occasionally use habitat at PTA and/or periodically transit the installation. Additionally, 15 bird species protected under the Migratory Bird Treaty Act (MBTA) may use habitat at PTA.

1. Hawaiian hoary bat
2. Band-rumped Storm Petrel
3. Hawaiian Goose
4. Hawaiian Hawk
5. Hawaiian Petrel
6. Anthricinan yellow-faced bee
7. Blackburn's sphinx moth

1.6 MANAGEMENT DEFINITIONS

1.6.1 Ungulate Exclusion Fences

Ungulate exclusion fence units are the principal conservation management units at the installation. Fencing is a conservation measure to protect TES and their habitat at a landscape scale and is a requirement of the 2003 and 2008 BOs issued to PTA by the USFWS. The scope and alignments of fence units were established between 1998–2006 via agreements between Army leadership, CEMML, and the Army's regulators. Construction of the ungulate exclusion fences was completed in FY 2013 at a cost of more than $10 million. There are 15 fence units at PTA that total 138 km in length and protect 15,092 ha of native habitat (Figure 2). One of these fences is located in the southeast portion of KMA and encloses a historical *Sicyos macrophyllus* location.

[2] From here forward *Tetramolopium arenarium* ssp. *arenarium* var*. arenarium* will be abbreviated *T. arenarium* var*. arenarium* in accordance with the Council of Scientific Editors (CSE) guidance for abbreviating intraspecific taxa. The CSE recommends using a trinomial encompassing the genus, the specific epithet, and the name of the lowest rank.

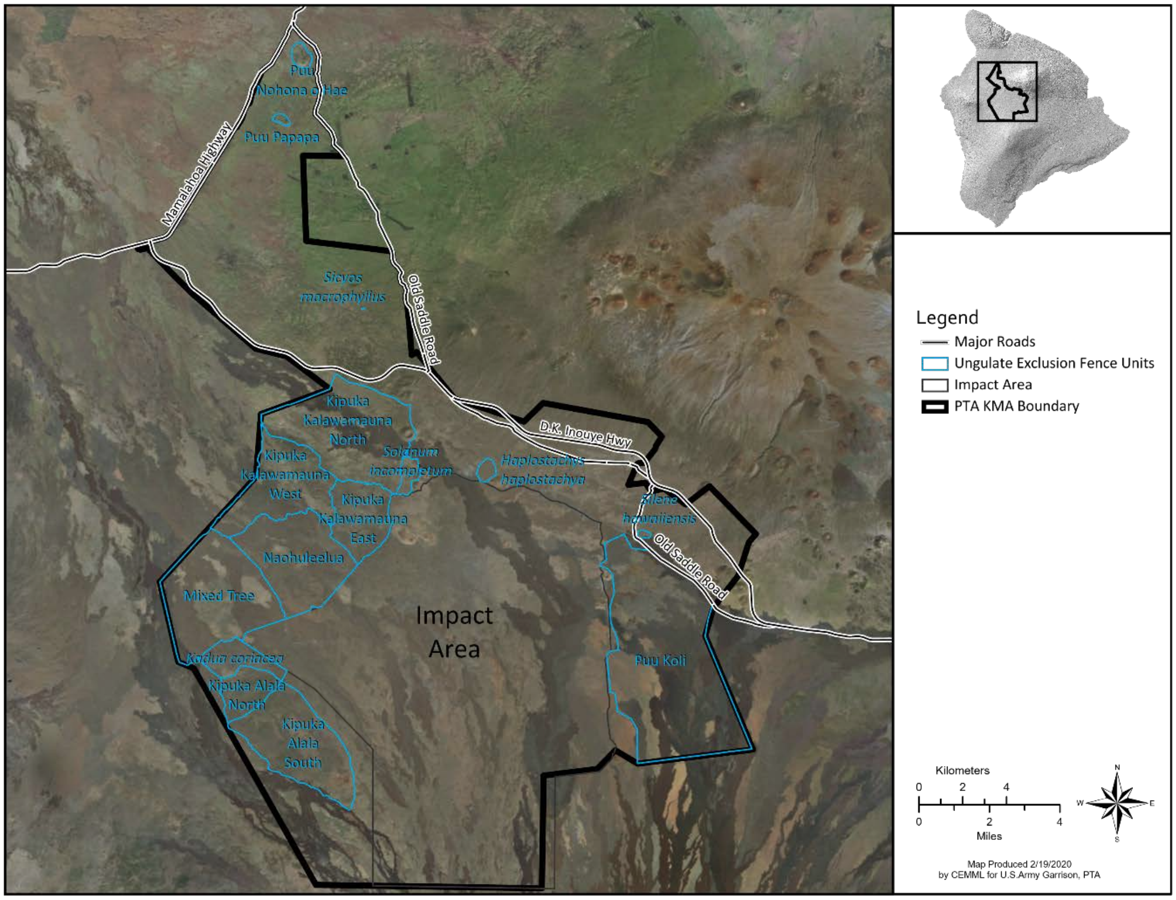

Figure 2. Ungulate exclusion fence units at Pōhakuloa Training Area

As of FY 2017, all the fence units are considered to be ungulate-free. We conduct inspections regularly to monitor the functionality and structural integrity of fence lines and gates. Inspections involve checking the fence lines, making necessary repairs, and controlling vegetation along fence corridors to reduce premature aging of fence material. As fence lines are walked, we check for breaches from man-made or naturally occurring causes, identify objects along fence corridors that could potentially cause damage (e.g., overhanging branches, loose rocks), identify potential ingress points, and monitor fences for degradation. Fence units are monitored regularly from the air and ground for ungulate egress and detected animals are removed. We also ensure all locks are working properly and gates are securely closed and functional.

1.6.2 Areas of Species Recovery

Within the ungulate exclusion fence units are Areas of Species Recovery (ASRs), which are defined as 100-m buffers around known ESA-listed plant populations where management is focused. The 100 m distance was selected based on 3 criteria:

1) Wildland fire flame lengths of 40–50 m

2) An area large enough for ESA-listed plant populations to expand
3) Maximum size that is feasible for sustained management over time

Currently, there are 44 ASRs at PTA that comprise 1,146 ha (AGOL 2020). The ASR boundaries are periodically reviewed and adjusted as population extent and conditions change. The degree of management effort within the ASRs varies based on prioritization criteria such as natural resource value, threats, quality of habitat, and rarity of species. Prioritization allows us to use resources efficiently and to systematically implement management over large-scale areas for multiple species in various habitats.

1.6.3 Management Projects

Because management for species other than ESA-listed plants is generally conducted over areas larger in scale than ASRs, management actions for ESA-listed animals, outplanting sites, individual target weed species, or ecosystem-level projects may be tracked by management projects. A management project may extend beyond an ungulate exclusion fence unit or an ASR because of the larger geographical extent of specific projects. We use ASRs and management projects to facilitate natural resource management planning and operations, and to organize the vast amount of data we collect and process for tracking and reporting purposes.

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AREA 1: COMPLIANCE WITH REGULATORY MANDATES AND REPORTING REQUIREMENTS

2.0 BOTANICAL PROGRAM

2.1 INTRODUCTION

The purpose of the Botanical Program is to gain insight and understanding of ESA-listed plant species' distributions, genetics, and ecology, and the factors that impact their long-term survival to develop and implement appropriate and efficient management approaches to ensure long-term persistence of these species and conservation of their genetics in accordance with mandates that guide the Army's natural resources programs. To this end, we assess the distribution and abundance of ESA-listed plant species to inform species management, military training and range development, and report the status of the species. In addition, we implement management to promote conditions that we believe will facilitate increases in distribution and abundance and genetic conservation of ESA-listed plants.

To manage botanical resources at PTA, we implement Statement of Objectives (SOO) tasks 3.2(1)(a) through 3.2(1)(f) to comply with INRMP objectives (Sikes Act Improvement Act), ESA consultation requirements, regulatory outcomes from NEPA documents, and the conditions of federal and state threatened and endangered plant permits.

To meet these requirements, we manage native plant species and their habitats including 20 ESA-listed plant species: *Asplenium peruvianum* var. *insulare* (fragile fern), *Exocarpos menziesii* (Menzie's ballart or heau), *Festuca hawaiiensis* (Hawaiian fescue), *Haplostachys haplostachya* (Hawaiian mint or honohono), *Isodendrion hosakae* (aupaka), *Kadua coriacea* (leather-leaf sweet ear or kioʻele), *Lipochaeta venosa* (nehe)[3], *Neraudia ovata* (spotted nettle bush or maʻaloa), *Portulaca sclerocarpa* (hard fruit purslane or poʻe), *Portulaca villosa* (hairy purslane or ʻihi), *Schiedea hawaiiensis* (māʻoliʻoli), *Sicyos macrophyllus* (Alpine bur cucumber or ʻānunu), *Silene hawaiiensis* (Hawaiian catchfly), *Silene lanceolata* (lance-leaf catchfly), *Solanum incompletum* (Hawaiian prickle leaf or pōpolo kū mai), *Spermolepis hawaiiensis* (Hawaiian parsley), *Stenogyne angustifolia* var. *angustifolia* (creeping mint), *Tetramolopium arenarium* var. *arenarium* (Mauna Kea pāmakani), *Vigna o-wahuensis* (Oʻahu cowpea), and *Zanthoxylum hawaiiense* (Hawaiian yellow wood or aʻe).

In 2003, 2008, and 2013 the USFWS issued the Army BOs with conservation measures for 15 ESA-listed plants[4]. The Army has not consulted with the USFWS under section 7(a)(2) of the ESA for 5 ESA-listed plants found at PTA: *E. menziesii*, *F. hawaiiensis*, *P. villosa*, *S. macrophyllus,* and *Schiedea hawaiiensis*. Without an ESA consultation, these species lack formal conservation measures. We also

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[3] The name for this species was recently changed to *Lipochaeta venosa*, which remains synonymous with *Melanthera venosa* (Edwards et al. 2018).

[4] *A. peruvianum* var. *insulare, H. haplostachya*, *I. hosakae*, *K. coriacea*, *L. venosa*, *N. ovata*, *P. sclerocarpa*, *Silene hawaiiensis*, *S. lanceolata*, *S. incompletum*, *Spermolepis hawaiiensis*, *S. angustifolia*, *T. arenarium* var. *arenarium*, *V. o-wahuensis*, and *Z. hawaiiense.*

manage the undescribed species *Tetramolopium* sp. 1 due to its rarity and limited distribution even though this plant is not ESA-listed.

We are currently preparing documents to formally consult with the USFWS in 2020 under Section 7(a)(2) of the ESA regarding military activities at PTA and the potential effects to ESA-listed plants. We anticipate the issuance of a programmatic BO from the USFWS in 2020.

To work with TES, we obtained state and federal permits authorizing our activities. In 2017, the USFWS issued us an Endangered Species Recovery permit under section 10(a)(1)(A) of the ESA (Federal Fish and Wildlife Permit TE40123A-2, Native Endangered & Threatened Sp. Recovery – E & T Plants; hereafter referred to as the 2017 PTA Recovery Permit). We are negotiating a new threatened and endangered plant permit with the State of Hawaiʻi and anticipate issuance of a permit in late 2019. We also maintain permits that authorize our work on State of Hawaiʻi lands and lands jointly administered by federal and state agencies. Under the authorizations of the permits, we collect, store, propagate, and outplant propagules, including seeds, inflorescences, spores, fruits, cuttings, and leaves, of the 20 ESA-listed plant species to further genetic conservation of these species. Our management complies with permit conditions and separate reports addressing these conditions are provided annually to USFWS and the State of Hawaiʻi.

The Botanical Program is composed of 2 sections:

1) Plant Survey and Monitoring Section (PSMS)
2) Genetic Conservation and Outplanting Section (GCOS)

Each Botanical Program section addresses specific SOO tasks, INRMP objectives, and regulatory requirements, which dictate the goals and objectives within that section. Specifically, projects implemented under the PSMS address SOO tasks 3.2(1)(a) and 3.2(1)(d) and projects implemented under the GCOS address SOO tasks 3.2(1)(e) and 3.2(1)(f). SOO tasks 3.2(1)(b) and 3.2(1)(c) are primarily implemented by the Invasive Plants and Wildlife Programs, respectively, and are addressed in Chapters 3 and 4. For a list of drivers associated with each of the projects and sections in the Botanical Program, please refer to Appendix C.

This report summarizes project methods and general results for each Botanical Program section. This information applies collectively to all managed plant species at PTA. Next, this report provides summaries for each ESA-listed plant species (e.g., survey data and genetic conservation activity). The species sections are arranged by Priority Species (PS) rank (Table 1) and then alphabetically by species. We group PS 2 and PS 3 species because we manage these species similarly. The species-specific summaries include distribution maps for each species. Maps depict species locations recorded during plant surveys completed between 2011 and 2015.

2.1.1 Management of Plant Species Listed under the Endangered Species Act

PTA comprises an extremely heterogeneous landscape with an interacting mosaic of biotic and abiotic variables differentially present at a range of scales, all of which results in highly unpredictable patterns of species presence and persistence. This leads to some ESA-listed plant species with relatively dense but very restricted distributions (e.g., *N. ovata*, *S. incompletum*, *T. arenarium* var. *arenarium*), some species with sparser distributions occurring across many thousands of acres (e.g., *A. peruvianum* var. *insulare*, *P. sclerocarpa*), and some species with a combination of dense and sparse distributions over thousands of hectares (e.g., *H. haplostachya*, *Silene hawaiiensis*, *Z. hawaiiense*). These factors make managing ESA-listed plant species and natural resources at PTA a significant challenge, requiring efficient methods to understand patterns in species distributions and abundances so that natural resources program objectives can be fulfilled.

To guide management across this complex landscape, we assign each rare plant species to 1 of 3 management priority levels based on each species' distribution and abundance (Table 1):

- Priority Species 1 (PS1) – Plant species with fewer than 500 individuals and/or 5 or fewer populations remaining statewide.
- Priority Species 2 (PS2) – Plant species with 500–1,000 individuals and/or 6–10 populations remaining statewide.
- Priority Species 3 (PS3) – Plant species with more than 1,000 and/or more than 10 remaining statewide.

Management activities, such as fencing, monitoring, and invasive plants management, are implemented to varying degrees for each plant species according to assigned priority level.

Table 1. Priority of plant species listed under the Endangered Species Act at Pōhakuloa Training Area

Priority 1	Priority 2	Priority 3
Asplenium peruvianum var. *insulare* (E)	***Zanthoxylum hawaiiense* (E)**	***Exocarpos menziesii* (E)**
Isodendrion hosakae (E)		*Festuca hawaiiensis* (E)
Kadua coriacea (E)		***Haplostachys haplostachya* (E)**
***Lipochaeta venosa* (E)**		***Silene lanceolata* (E)**
***Neraudia ovata* (E)**		***Silene hawaiiensis* (T)**
Portulaca sclerocarpa (E)		*Spermolepis hawaiiensis* (E)
Schiedea hawaiiensis (E)		***Stenogyne angustifolia* (E)**
Sicyos macrophyllus (E)		
***Solanum incompletum* (E)**		
Tetramolopium arenarium var. *arenarium* (E)		
Tetramolopium sp. 1[a]		
***Vigna o-wahuensis* (E)**		

[a] Undescribed, not listed under the Endangered Species Act
E, Endangered; T, Threatened
Underline = species found only at Pōhakuloa Training Area; Bold = most of the statewide population is found at Pōhakuloa Training Area

In 2008, we developed Areas of Species Recovery (ASRs) to prioritize and focus management efforts for ESA-listed species based on a set of criteria including species rarity, fire risk, non-native plant density, and exposure to ungulate browse. The ASRs are defined as 100-m buffers around rare plant populations where we focus management (see Section 1.6.2). There are currently 44 ASRs at PTA; however, we aim to update ASR designations in 2020 to reflect current understanding of ESA-listed plant distributions and changes in other factors.

Because the environment at PTA is variable, investigating the causal relationships between management, environmental factors, and plant responses is challenging. Due to the strong effect of environmental factors and chance events on the ecosystem and species, we cannot directly attribute changes observed in the system or the focal species to our management efforts. Therefore, we report the status of the species and the management that has been implemented for each species. Where applicable, we draw attention to results or observations that suggest positive benefits from management to the ESA-listed plant species, but we cannot draw definitive conclusions that specific management actions caused specific responses.

2.2 PLANT SURVEY AND MONITORING SECTION

2.2.1 Introduction

We implement projects to delimit ESA-listed plant species distributions, estimate and monitor plant populations, monitor for emerging threats, and monitor vegetation and habitat conditions. Our goal is to survey and monitor ESA-listed plant populations and vegetation communities to gather information to guide management actions to create, where possible, favorable conditions for the continued persistence of each ESA-listed plant species.

Annual monitoring is a required conservation measure for most of the ESA-listed plant species at PTA (USFWS 2003). To achieve these monitoring requirements, we implement a multi-faceted approach including: 1) surveys to determine species distribution and derive the minimum plant numbers for Priority Species (PS) 2 and 3 species; 2) monitoring PS 1 species to track abundance, identify emerging threats, and investigate specific management needs; and 3) vegetation monitoring to document landscape-scale conditions. Together, these projects provide information to assess the status of the ESA-listed plant species. Investigating the status of ESA-listed plant populations and vegetation communities is essential to determining if the selected strategies are creating favorable conditions to adequately to sustain each ESA-listed plant species.

The overall operational goals of the PSMS are to:

- Comprehensively survey ungulate exclusion fence units on a 5-year cycle to provide information about species distribution and estimates of population size for PS 2 and PS 3 species.
- Designate ASRs in which to focus management so species have the highest potential for survival and natural recruitment.

- Monitor ESA-listed plant species status throughout their distribution on PTA.
- Monitor selected ESA-listed plant species to guide management.
- Provide short-term protection of ESA-listed plant species directly impacted by military construction projects.
- Monitor vegetation communities over time and, where possible, document changes.

2.2.2 Plant Surveys

Plant surveys within the ungulate exclusion fences are conducted on a 5-year cycle to document distributions of ESA-listed plant species, species at risk of becoming listed, and invasive species. We also collect data to derive a minimum number of PS 2 and PS 3 species. The plant surveys meet SOO task 3.2(1)(a) and INRMP and Army Regulation-100 requirements for Planning Level Surveys. We use survey results to establish or revise ASRs and to plan future management strategies for ESA-listed species. In addition, plant survey data are important for planning military activities, addressing current and future regulatory requirements, and developing long-term management strategies for each ESA-listed plant species.

We completed plant surveys within the ungulate exclusion fences from 2011 to 2015. We began a second cycle of surveys within the fences in 2017. Because a full survey data set is required to refresh the species' distributions and to derive plant numbers, the distributions reported in the species summaries, Sections 2.4 and 2.5, are based on the surveys completed between 2011 and 2015. Also, in Section 2.5 we use the same 2011 to 2015 survey data to report the minimum number of plants present at PTA for PS 2 and PS 3 plants *E. menziesii, F. hawaiiensis, H. haplostachya, Silene hawaiiensis, S. lanceolata, Spermolepis hawaiiensis, S. angustifolia,* and *Z. hawaiiense.*

During the surveys, we collected information about non-native plant species and their distributions. Results from the non-native plant data have not been prepared; therefore, we do not discuss methods or results regarding non-native plants in this report. In 2020, we plan to prepare a technical report to map non-native plant distributions and evaluate management strategies.

Plant Survey Methods

We used square kilometer grids, each comprising 100 transects 1 km in length and spaced 10 m apart, to delineate the area to be surveyed (Figure 3). Transects were created using ArcGIS (ESRI, Redlands CA, USA). We collect a complete species list on every 10th transect, which is further subdivided into four 250 m-long segments. We record all plant species present, excluding ESA-listed plants, separately for each segment to document spatial variation in species compositions across the landscape.

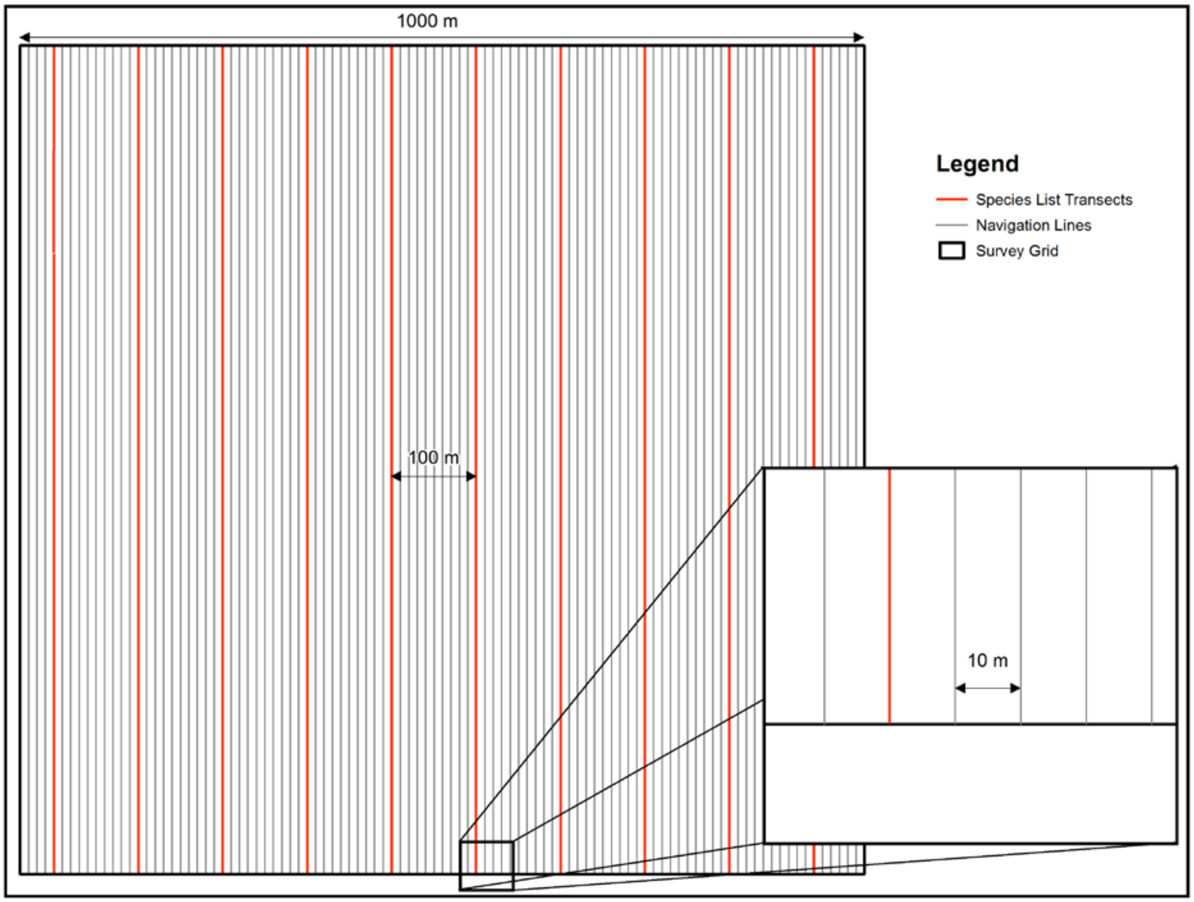

Figure 3. Example of plant survey grid

We refined the survey area for the 2017 survey effort. Because we anticipate that dispersal is limited for most of the ESA-listed plant species, we buffered plant locations from the first survey (2011 to 2015) by 100 m to define the area for the second survey, which resulted in approximately 65 km^2 to survey. We further refined the survey area in summer 2019 after realizing that several transects extended beyond the ungulate exclusion fences and into areas of barren lava. In the GIS, we clipped the survey transects to vegetated areas within the fences, which further reduced the target survey area to 56 km^2 to survey for the second cycle.

During surveys, we use Global Positioning System (GPS)-equipped devices to record spatial coordinates of "priority species" (i.e., ESA-listed, candidates for listing, and species identified by the Botanical Program Manager). Because plants are often found in clusters, we record a single GPS coordinate to represent all individuals within a 5-m radius area. This area is termed a plant “location”. If plants are in larger and continuous groupings, we record location coordinates every 10 m along transects. For each location, we count all individuals up to 25 and then assign a count class[5] based on the number of individuals present within a 5-m radius at each recorded location.

[5] Count classes are defined as 26-50, 51-75, 76-100, and >100.

Plant Survey Results

In FY 2017, we started the second cycle of plant surveys inside the ungulate exclusion fences. During the report period, we surveyed 1,137 linear kilometers and recorded 3,440 plant locations representing at least 21,318 ESA-listed plants.

The most significant find thus far is a new location of *Schiedea hawaiiensis* approximately 110 m from an outplanting site. This is the first new, natural location of this species discovered at PTA since 1995.

Because only a partial dataset was available for the second cycle of surveys, we continue to report the distributions for the ESA-listed plants derived from the complete plant survey dataset collected between 2011 and 2015 (Figure 4). For 2011 to 2015, we recorded approximately 9,597 locations of the 20 ESA-listed plant species.

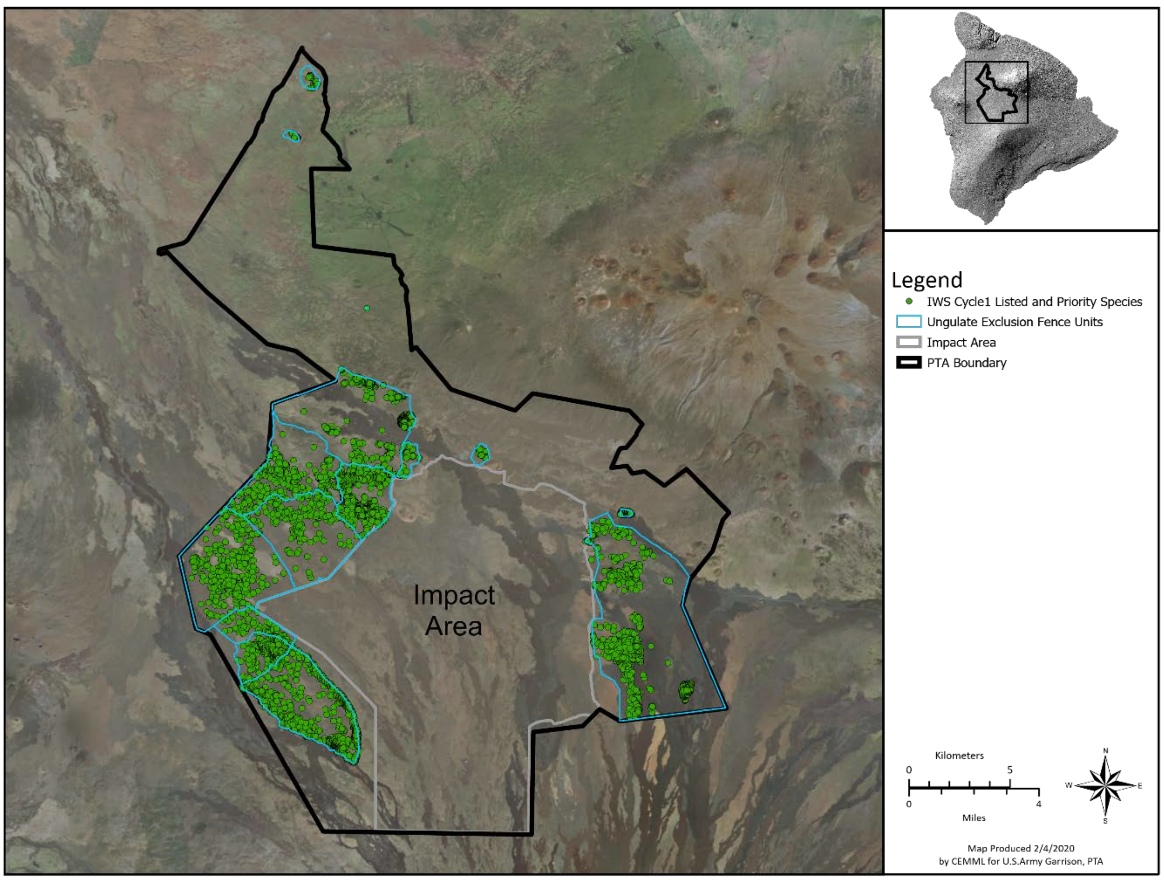

Figure 4. Known distribution of plant species listed under the Endangered Species Act at Pōhakuloa Training Area

For PS 1 species, we report the number of locations found during the first cycle of plant surveys (Table 2), but we do not report the minimum number of plants present because we track detailed abundance information for these species, which is reported in Section 2.2.3. For PS 2 and 3 species, we continue to derive the minimum number of individuals present at PTA from the complete survey dataset (Table

3). The minimum number of individuals reported in Table 3 reflects the use of count classes. Because the distribution of sample abundances may not conform to assumptions associated with count classes, we used the lower boundary of each count class to quantify the minimum number of individuals. For some widely dispersed but abundant species such as *Silene hawaiiensis*, the minimum number of individuals present at PTA per count class data likely under-reports the actual number of individuals present at the installation.

Table 2. Number of plant survey locations for Priority Species 1 plants (2011 to 2015)

Species	Locations Recorded
Asplenium peruvianum var. *insulare*	42
Isodendrion hosakae	42
Kadua coriacea	119
Lipochaeta venosa	21
Neraudia ovata	16
Portulaca sclerocarpa	39
Portulaca villosa	5
Schiedea hawaiiensis	1
Sicyos macrophyllus	1
Solanum incompletum	21
Tetramolopium arenarium var. arenarium	40
Tetramolopium sp. 1	67
Vigna o-wahuensis	75

Table 3. Number of plant survey locations and minimum number of individuals for Priority Species 2 and 3 plants (2011 to 2015)

Species	Locations Recorded	Minimum Number of Individuals[a]
Exocarpos menziesii	1,762	1,802
Festuca hawaiiensis	683	1,083
Haplostachys haplostachya	3,180	24,268
Silene hawaiiensis	1,324	2,344
Silene lanceolata	372	3,882
Spermolepis hawaiiensis	195	595
Stenogyne angustifolia	1,087	2,517
Zanthoxylum hawaiiense	506	536

[a] The minimum number of individuals stated in the table reflects the use of count classes for ESA-listed plant species locations. Because the distribution of sample abundances may not conform to assumptions associated with count classes, we used the lower boundary of each count class to quantify the minimum number of individuals for descriptive purposes only. These values are likely low for most species and therefore underrepresent population size.

Plant Survey Discussion

Our goal for the second cycle of plant surveys is to survey 56 km^2, or roughly 5,634 linear kilometers, within the ungulate exclusion fence units over a 5-year period. From second quarter FY 2017 through fourth quarter FY 2019, we completed 1,487 linear kilometers of survey (26% of the 5-year goal). Achieving quarterly survey goals was challenging due to budget and staff reductions in 2017 and 2019. Additionally, in 2017 high turnover of staff reduced survey efficiency.

The plant survey goals were originally established in 2011 and redefined in 2017. However, considering the current fiscal climate, with past and anticipated budget reductions, we need to examine the current plant survey methodology to determine if this is the most efficient way to monitor species abundance and distribution.

In the FY 2016-2017 Biennial Report (CEMML 2019c), we attempted to summarize changes in species distributions and abundances for areas completed for both plant survey cycles for 6 ESA-listed plant species: *Haplostachys haplostachya, Silene hawaiiensis, Solanum incompletum, Stenogyne angustifolia, Tetramolopium arenarium* var. *arenarium,* and *Zanthoxylum hawaiiense*. However, between survey cycles 1 and 2 we changed how the number of individuals at each location were counted or estimated. This change in methodology created problems for comparing species distributions between the survey cycles, which limited our ability to quantitatively describe changes in species abundance between plant survey cycles[6]. Overall, the strength of the initial plant surveys appears to be in delineating the geographic extent and number of occurrences associated with each taxon. This data will be extremely useful in developing and implementing revised sampling designs for selected listed species in FY 2020.

Because our current methodology limits our ability to detect changes between plant survey cycles, we plan to complete the current survey cycle and then develop a new monitoring approach. However, to support the development of a Programmatic Biological Assessment for PTA, we need better abundance estimates for PS 2 and 3 species before the planned completion of the second survey cycle. Therefore, we plan to adjust our sampling approach in early 2020 to enable us to complete the second survey cycle by March 2020. This revised sampling approach will yield better estimates of abundance for 6 ESA-listed focal species: *E. menziesii, F. hawaiiensis, H. haplostachya, Silene hawaiiensis, S. lanceolata,* and *S. angustifolia.*

Plant surveys are a cornerstone of the natural resources program and directly support INRMP objectives and BO conservation measures. Per Army Regulation-100, Planning Level Surveys should be updated every 5 years. Updating spatial information regarding locations of ESA-listed plants, plants at risk of becoming listed, and invasive plants helps to facilitate natural resources management, identifies potential encroachment issues for the military, and can provide baseline information for land use planning and future military operations. However, a repeat inventory may not be the most efficient method for tracking abundance over time.

[6] See the FY 2016–2017 Biennial Report for the Natural Resources Program for an in-depth discussion of the methods selected to address differences in the plant survey data sets and the challenges of analysis.

<u>Summary of Recovery of *Haplostachys haplostachya* and *Stenogyne angustifolia* following the July 2018 Wildfire in Training Areas 18, 19, and 22</u>

On 18 July 2018, a US Marine Corps H-1 aircraft ignited a wildland fire by inadvertently discharging flares while the aircraft was approximately 500 ft above ground level over Holding Area Wilma in Training Area (TA) 19. The fire burned approximately 585 ha at varying intensities resulting in a patchwork of fully or partially burned and unburned areas.

Following the fire, we produced a Technical Report and Post-Disturbance Assessment (CEMML 2018b) to evaluate the impacts from the fire to TES and their habitats. The fire directly impacted 5 ESA-listed plant species: *H. haplostachya, P. sclerocarpa, Silene hawaiiensis, S. lanceolata,* and *S. angustifolia.* We last collected rare plant survey data for the area burned in 2013, so pre-fire survey numbers may not accurately represent the number of individuals that were actually present just prior to the fire in 2018.

Based on the number of plant locations with 1 or more individuals from 2013 survey data, the fire may have affected 7% of *H. haplostachya* locations, 5% of *P. sclerocarpa* locations, <1% *S. hawaiiensis* and *S. lanceolata* locations, and 43% of *S. angustifolia* locations. To assess fire impacts immediately following the fire (August 2018), we revisited all known ESA-listed plant locations within the fire footprint (CEMML 2018b). We found minimal fire-related impacts to *P. sclerocarpa* at known locations and estimated the loss of only 2 individual plants. Although the fire did impact locations for *Silene hawaiiensis* and *S. lanceolata*, the number of locations affected by the fire was <1% and the estimated number of individuals lost was about 1% of the population of each species (CEMML 2018b). Because the fire affected a larger proportion of individuals for *H. haplostachya* and *S. angustifolia*, we provide an update here of the documented recovery of these species within the 2018 fire footprint[7].

During the first rare plant survey cycle (2011–2015), throughout PTA we documented 3,180 locations of *H. haplostachya* representing a minimum of 24,270 individual plants and 1,087 locations of *S. angustifolia* representing 2,517 individual plants. Of these, 228 locations of *H. haplostachya* (7% of known locations at PTA) and 463 locations of *S. angustifolia* (43% of known locations at PTA) occurred within the 2018 fire footprint (CEMML 2018b).

In 2017, we began a second cycle of rare plant surveys within ungulate exclusion fences. Within the area burned by the fire, a total of 305 transects were surveyed between 2011 and 2015. Of these 305 transects, *H. haplostachya* and/or *S. angustifolia* occurred on 86. Since the fire in 2018, we have

[7] In the *Technical Report and Post-Disturbance Assessment for the July 2018 Fire in Training Areas 18, 19, and 22* (CEMML 2018b), we estimate the number of individuals present at each plant locations using point count class data as opposed to reporting the minimum number of plants present, which we use in this report. During the first cycle of rare plant surveys, the minimum count class was 1 to 10. For species, such as *Silene hawaiiensis*, that often occur in clusters greater than 1, but fewer than 10, providing the minimum number of plants present can greatly underestimate the actual population present. The rationale for estimating the number of plants present in the technical report was to attempt to more accurately evaluate the impacts of the fire. However, for this report, to remain consistent with how we report rare plant survey data, we use the minimum number of plants present to evaluate changes pre- and post-fire.

surveyed 70 out of those 86 transects (81%) and have documented almost twice the number of locations of *H. haplostachya*, representing about an 8-fold increase in the minimum number of plants present post fire (Figure 5 and Table 4). For *S. angustifolia*, we have recorded a slight decrease (5%) in the number of plant locations. However, the minimum number of plants present at the locations more than doubled post fire (Figure 5 and Table 4). Although this is not a comprehensive survey of all the locations that were impacted by the fire, both species appear to be recovering well along the subset of transects we have surveyed to date.

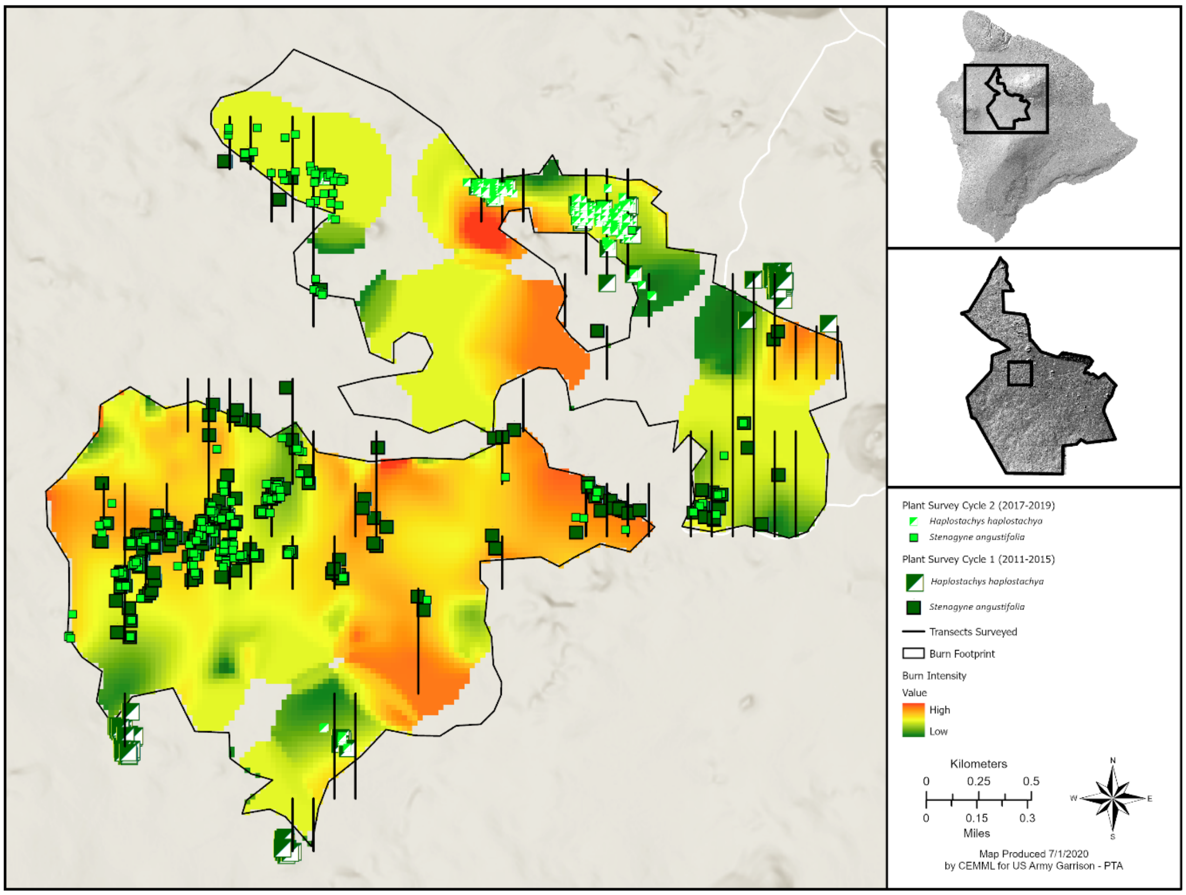

Figure 5. Locations for *Haplostachys haplostachya* and *Stenogyne angustifolia* before and after the fire on 18 July 2018 in Training Areas 18, 19 and 22, Pōhakuloa Training Area

Table 4. Pre- and post-fire comparisons of plants locations and minimum numbers of plants present for *Haplostachys haplostachya* and *Stenogyne angustifolia* along a subset of rare plant survey transects, where one or both species were recorded in 2013, within the 2018 Training Area 18, 19, and 22 fire footprint

Species	Pre-Fire		Post-Fire	
	Plant Locations	Min. Plant No.	Plant Locations	Min. Plant No.
Haplostachys haplostachya	132	562	258	4,493
Stenogyne angustifolia	204	604	193	1,324

Note: Pre-fire survey data were collected in 2013 and post-fire data were collected between August 2018 and December 2020. To date, 81% of the pre-fire transects have been surveyed since the fire.

Following a fire that burned in a similar area in 1994, Shaw et al. (1997) observed post-fire recovery of *H. haplostachya* via resprouting from root crowns in areas lightly impacted by fire and from seed germination in areas more severely burned. In addition, they found that regardless of the severity of the burn, *S. angustifolia* resprouted from underground rhizomes and from seed. Similar to our post-fire findings, Shaw et al. (1997) noted resprouting for both species within 1 month following the fire. However, in 1994 feral ungulates browsed the regrowth of *H. haplostachya and S. angustifolia* negatively impacting the growth of these species. Shaw et al. (1997) state that the browsing "appeared to have a much more negative impact on the overall health of the plants than did the wildfire alone" (p. 264). Unlike in 1994, all locations of *H. haplostachya* and *S. angustifolia* that burned in 2018 are now protected within ungulate-free exclusion fences. Because the regrowth of these species is protected from browsing by feral ungulates, we anticipate that recruitment from seedling to adult age classes will be more directly influenced by natural environmental conditions.

2.2.3 Priority Species 1 Monitoring

Priority Species 1 monitoring meets SOO task 3.2(1)(d). Our monitoring objectives are to document changes in abundance and to identify emerging threats to implement management actions as appropriate. We monitor the following Priority Species 1 quarterly: *A. peruvianum* var. *insulare, K. coriacea, L. venosa, N. ovata, P. sclerocarpa, P. villosa, Schiedea hawaiiensis*, *S. macrophyllus, S. incompletum, T. arenarium* var*. arenarium*, *T*. sp.1, and *V. o-wahuensis.* We use a similar but different monitoring method for *I. hosakae*, which is reported in Section 2.2.4.

Although we aimed to monitor all PS 1 individuals each quarter, our monitoring efforts sometimes extended outside a given quarter. For example, our monitoring efforts took longer than a quarter between May and September 2016 and between April 2017 and June 2018. Because our work did not strictly adhere to quarters, we use the term "census period" to represent the period of time required to complete a full census of the monitoring plots for each PS 1 species. When needed for clarity, a date range is included with the census period.

Methods

We established monitoring plots to encompass all known individuals of each PS 1 species. Monitoring plots are circular with a radius of 5.62 m and total area of 100 m^2. We marked the plot center with a stake. Plots encompassed only one PS 1 species, but multiple individuals of that species were sometimes located within a single plot. If new individuals of a PS 1 species were found outside existing plots, we established new plots for the new occurrences.

Each monitoring period, we visited each plot for each PS 1 species. For most of the report period, we recorded the proportion of total individuals in the plot by life stage in increments of 10%. Beginning in July 2019, we began recording the number of individuals in the plot by life stage. We counted all individuals up to 25 and assigned count classes when the number of individuals exceeded 25 (26–50, 51–100, and >101). When count classes were assigned, we used the minimum values of the count class as a proxy for abundance. This value is summed with counts from other plots to provide a total value for abundance. To detect emerging threats, we visually assessed the PS 1 plants within each plot collectively for impacts and recorded the sources of impact (e.g., ants, birds, disease; Figure 6).

Results

We monitored all PS 1 species over 5 census periods between July 2018 and September 2019, with the exception that we did not collect data for *T. arenarium* var. *arenarium* and *Vigna o-wahuensis* between July and September 2018. We did not monitor PS 1 species between October 2017 and June 2018. Detailed monitoring results for each PS 1 species are presented in the Species Summaries (Section 2.4).

We pooled the census data by age class for all monitoring plots for each species and derived the total number of PS 1 individuals present between July and September 2019 (Table 5).

Table 5. Priority Species 1 monitoring results[a] for the final reporting monitoring period

Species	Number Plants	Adults	Juveniles	Seedlings
Asplenium peruvianum var. *insulare*	708	202	194	312
Kadua coriacea	146	143	3	0
Lipochaeta venosa	95	85	9	1
Neraudia ovata	57	43	14	0
Portulaca sclerocarpa	391	115	174	102
Portulaca villosa	10	6	2	2
Schiedea hawaiiensis	12	6	6	0
Sicyos macrophyllus	0	0	0	0
Solanum incompletum	113	101	12	0
Tetramolopium arenarium var. *arenarium*	420	253	145	22
Tetramolopium s.1	159	79	79	1
Vigna o-wahuensis	180	102	75	3

[a] Monitoring results represent data collected between July and September 2019. All numbers are direct counts of plants by age class.

During census periods from July 2018 through September 2019, we collected information about emerging threats. We pooled the observed threats for all species across all plots for each census period (Figure 6). Between July and September 2018, we made 288 visits to plots and detected threats during 77 of the 288 (27%) plot visits (Figure 6, panels A and B). Between October 2018 and June 2019, we made 391 visits to plots during each census period (Figure 6, panels C through H), and recorded threats during 16 (4%), 13 (3%), and 6 (2%) of the plot visits, during the 3 census periods, respectively. Between July and September 2019, we recorded threats during 55 (22%) out of 401 plot visits (Figure 6, panels I and J). The overall number of threats detected each quarter was relatively low. Water stress was the most frequently detected threat in 3 of 5 census periods (Figure 6, panels B, H, and J), and invasive plants and invertebrates were the most frequently detected in the other 2 census periods (Figure 6, panels D and F, respectively).

Discussion

Quarterly monitoring provides accurate, complete counts of the ESA-listed plants with the lowest population numbers at PTA. With these data, we are learning more about the current age class distributions for these species and how the observed population structure for these species compares to what we expect based on their life history characteristics (e.g., slow growing vs. fast growing species). We are more closely tracking *in situ* reproduction for these species and are building a better understanding of different reproductive strategies for each of the species. In addition, we have identified several species (e.g., *Kadua coriacea*) where reproduction is extremely limited. More detail about population structure and reproduction is provided in the summaries for the PS1 plants. These census data will help us identify gaps in our understanding of the basic biology and ecology of some of these species and will help identify information needed to better manage these species to meet our goals.

We plan to improve our monitoring methods to collect data that will allow us to better characterize population structure and reproduction characteristics. We also plan to improve our methods to collect more detailed phenology data for some species to better understand flowering and fruiting patterns.

We tracked emerging threats at PS 1 monitoring plots. For all quarters from July 2018 to September 2019, most visits to plots did not detect threats to the plants (Figure 6). Threats were most frequently observed during July to September for 2018 and 2019, and water stress was the most frequent threat during those quarters. A further parsing of these data is needed to investigate connections between water stress and the emergence of other threats. Although we cannot directly manage for water stress, we may be able to reduce impacts from related threats. We plan to use this information as a baseline to begin quantifying impacts from these threats to set management triggers.

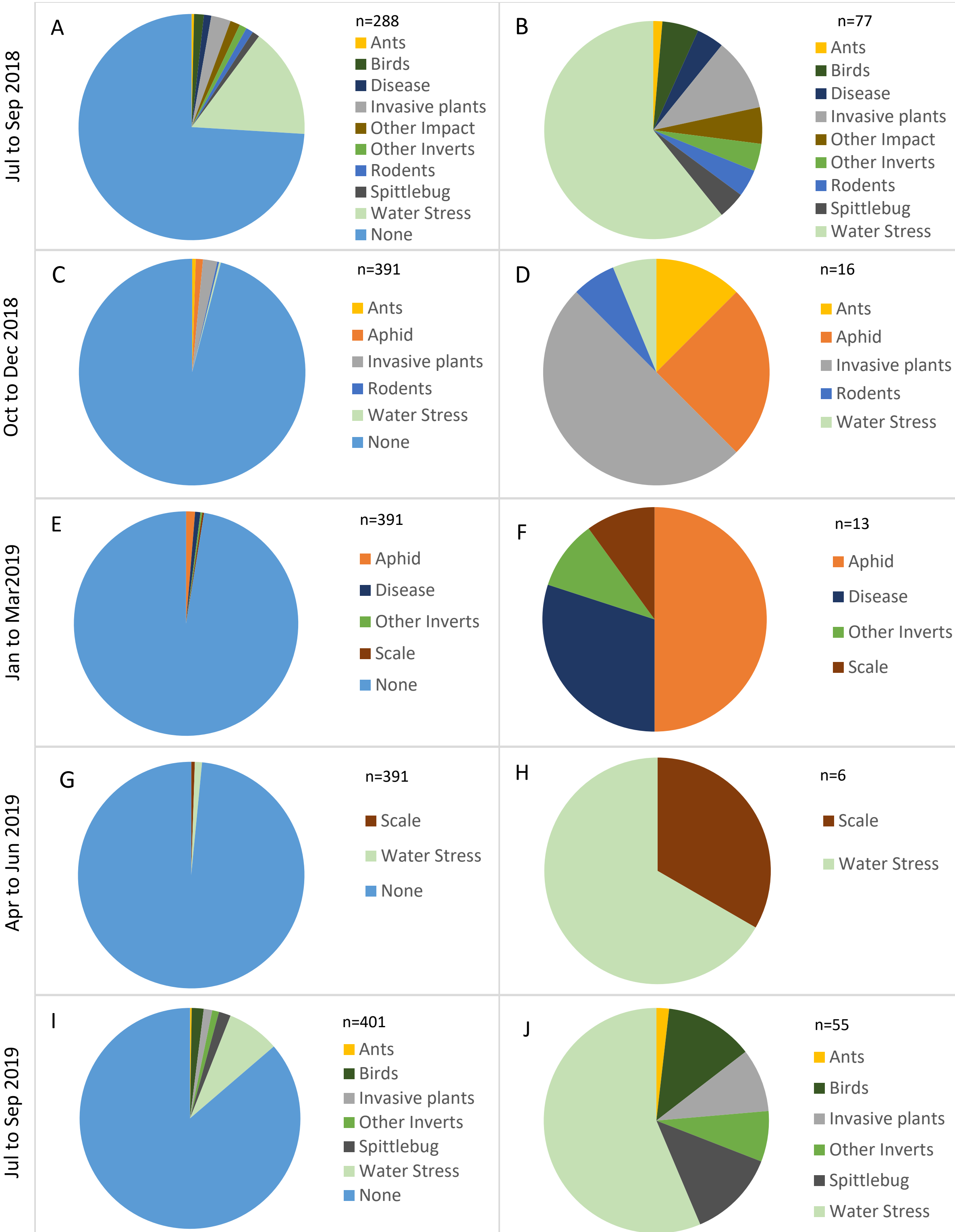

Figure 6. Emerging threats by panel (A–J) detected during census periods at Priority Species 1 monitoring plots between July 2018 and September 2019[a]

[a] Data pooled for all PS 1 monitoring plots. For Panels A, C, E, G and I, n = total number of plot visits, and pie chart shows the proportion of all plot visits that each threat was detected. For Panels B, D, F, H, and J, n = number of plot visits during which a threat was detected, and the pie chart shows the relative number of times each threat was detected.

2.2.4 *Isodendrion hosakae* Habitat Improvement and Demographic Monitoring at Puʻu Pāpapa

In 2018, we initiated a project on Puʻu Pāpapa to improve habitat conditions to enhance natural *in situ* reproduction, recruitment, and survival of *I. hosakae.* Project goals were to 1) facilitate population persistence and expansion of *I. hosakae* by restoring a functioning, native-dominated, plant community and 2) monitor the effect of habitat modification on *I. hosakae* and the surrounding plant community. We conducted demographic monitoring to better understand the ecology of this species and collected vegetation data to assess changes in plant community following weed control.

We are still preparing data for portions of the study. We anticipate presenting these results in a technical report in 2020. For this report, we summarize census data and some demographic data.

Methods

We censused *I. hosakae* quarterly using the PS 1 monitoring method described in Section 2.2.3. In 2016, we established monitoring plots to encompass all known *I. hosakae* and initiated monitoring. In June 2018, we began collecting additional demographic information along with the census data. We tagged all known individuals with a unique number to track survivorship. Also, we categorized individuals as reproductive if flowers or fruit were present but did not quantify the reproductive structures.

Results

Overall abundance of *I. hosakae* individuals at the site increased from 116 in the summer of 2018 to 135 in the summer of 2019. The number of adult plants decreased from 58 to 54, the number of juveniles increased from 32 to 71, and the number of seedlings declined from 26 to 10 individuals. Because not all individual plants are tagged, the net change in numbers of individuals between census periods reflects mortality of individuals, the finding of new individuals (e.g., recent recruits or recovered/reported adults that were previously overlooked), and individuals that cannot be re-located (e.g., dieback). Therefore, we report net change and do not characterize this change as percent survivorship.

We are developing a strategy to mark all known individual plants for future monitoring to better assess mortality versus other factors that drive the net change in number.

The proportion of adult plants that were reproductive (i.e., adult plants with flowers or fruits) varied from 0.26 ± 0.09 (90% CI) during Summer 2018 to 0.71 ± 0.10 during Winter 2019, 0.52 ± 0.11 during Spring 2019, and 0.46 ± 0.10 during Summer 2019 (Figure 7).

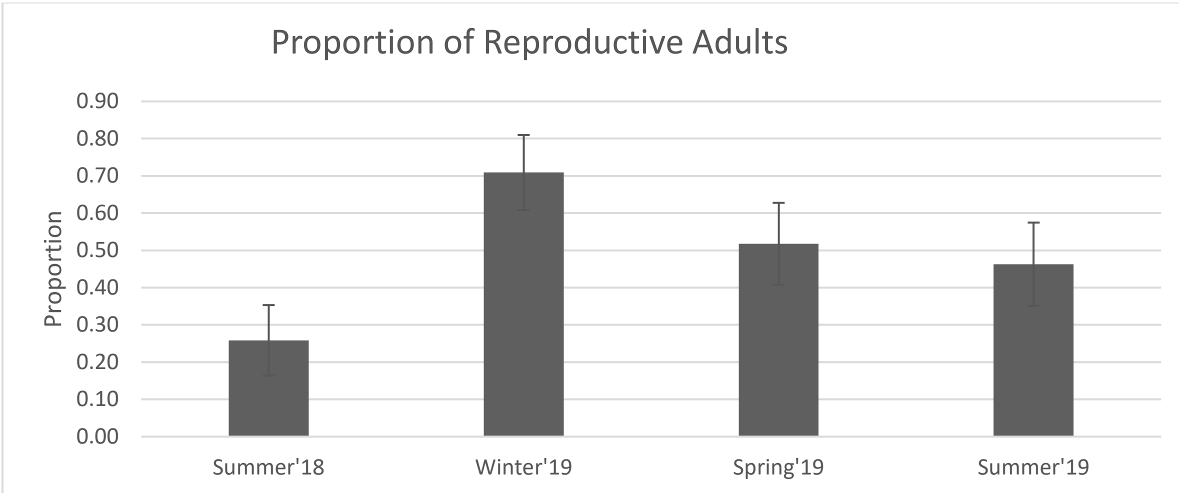

Figure 7. Proportion of *Isodendrion hosakae* reproductive adult plants (+/- 90% confidence intervals) at Puʻu Pāpapa during the summer of 2018, and winter, spring and summer of 2019

Discussion

Our census of *I. hosakae* in June 2016 found only 46 plants (adults and juveniles). In fiscal years 2008, 2009, and 2010, using a slightly different monitoring method, we counted 566, 511, and 267 plants (adults and juveniles), respectively. Other population estimates from Puʻu Pāpapa vary widely over time: 1) Arnett (2002) estimated 870 individuals; 2) USFWS biologists estimated between 25 and 50 individuals (USFWS 1994); and 3) Cuddihy et al. (1982) estimated 300 individuals. Because different methods were used by the different investigators, estimates are not directly comparable among years. Our recent monitoring period from 2016 to 2019 begins to capture the range of variability over time but does not inform whether populations are increasing or declining.

We documented the loss of 8 reproductive adult plants between 2018 and 2019. This loss of reproductive adults was obscured by the addition of 4 previously undetected adult plants to the net total. Considering the small population size (135 plants as of the last monitoring in Summer 2019), the loss of 8 reproductive adults may be significant. However, without more information about the natural life cycle of *I. hosakae* and transition rates between age classes, we cannot accurately describe the impact to the population of the loss of 8 adults.

We are seeing reproduction on site, but it is restricted to only a few plots with high numbers of seedlings. Reproduction data for 2019 suggests that winter may be the peak time for flowering and fruiting, but some plants on site flower year-round. Longer-term data may help elucidate whether phenological patterns are driven by season, precipitation, or both.

We plan to continue monitoring *I. hosakae* and to implement new methods aimed at understanding current and future population status and to gather critical life history information to better manage this extremely rare and restricted species.

2.2.5 Vegetation Community Monitoring

Vegetation monitoring addresses 3 INRMP objectives and contributes toward terms and conditions for the Hawaiian hoary bat in the 2003 BO. Vegetation monitoring may also help meet the SOO task 3.2(1) to implement a botanical program; however, there is no specific SOO task associated with vegetation monitoring.

We have not implemented monitoring of the general vegetation community. However, 2 vegetation monitoring projects were recently completed at PTA. For one project, a CEMML team under a separate Scope of Work completed vegetation monitoring across PTA using the Land Condition Trend Analysis (LCTA) methodology (Tazik et al. 1992). The other project was completed by researchers working under a grant from the Department of Defense Strategic Environmental Research and Development Program.

Long-term Vegetation Monitoring from LCTA Plots

Vegetation was monitored at PTA in 3 regions during 2014–2015: Training Areas 1 through 22, the Keʻāmuku Maneuver Area (KMA), and Kīpuka ʻAlalā in TA 23. A final report was produced in December 2017 (Block and Cook 2017). Methods and key findings are summarized below for each area. We also used the data collected from this monitoring effort to investigate trends in Hawaiian hoary bat treeland roosting habitat (See Section 4.2.4).

Training Areas 1 to 22

Between December 2014 and March 2015, the team monitored 119 LCTA plots established and inventoried between 1989 and 1992. Previous monitoring on these plots was conducted in 1989/1992, 2000, and 2014. Block and Cook (2017) used the LCTA long-term monitoring method on all plots and the LCTA short-term monitoring method to inventory woody plants within belt transects.

Total plant cover declined in all height classes from 1989 to 2014 and invasive species cover increased from 1989 to 2014 (Block and Cook 2017). Woody plants and most native plants declined in abundance. In particular, *Myoporum sandwicense* (naio) decreased from 1,463 live individuals and 395 snags in 1989 to only 474 live individuals and 742 snags in 2014.

The loss of *M. sandwicense* cover was likely driven by an invasive sap-sucking invertebrate called naio thrips (*Klambothrips myopori*). This change in forest composition and structure likely has multi-level ecological impacts to plant and animal communities. For example, *M. sandwicense* is believed to be a primary food source for several anthricinan yellow-faced bees (*Hylaeus* spp.) (Karl Magnacca, personal communication). The reduction in *M. sandwicense* cover appears to be coincidental with a decrease in *Hylaeus* spp. detections at PTA (Karl Magnacca, personal communication).

Keʻāmuku Maneuver Area

In 2010, 100 LCTA plots were established and inventoried in KMA. The plots were monitored in 2015 using the same LCTA methods described above.

Grasslands are the dominant vegetation community at KMA. Total vegetation cover increased from 2010 to 2015. Block and Cook (2017) speculated that the removal of cattle and favorable precipitation influenced the observed pattern. Very few trees are found at KMA and there was no significant change in aerial cover for shrubs and trees between 2010 and 2015. Forb cover increased nearly 10-fold over the same period. These results support general observations that vegetation communities in the KMA continue to be dominated by low-stature grassland and shrublands with interspersed trees following the removal of cattle in 2011.

Dodonaea viscosa shrubland is one of the few remaining native and/or indigenous species found at KMA. Although data show a slight increase in aerial cover of this species, invasive species such as fountain grass (*Cenchrus setaceus*) and fireweed (*Senecio madagascariensis*) showed much larger increases in aerial cover. Overall, woody species declined. The most abundant shrub in both survey years was *D. viscosa* but it declined by 35% between 2010 and 2015. *Sophora chrysophylla* (māmane) declined from 308 to 10 trees. However, the native shrub *Sida fallax* (ʻilima) almost doubled in abundance. Introduced grasses continue to dominate the vegetative canopy and increased significantly between 2010 and 2015. The decline in woody vegetation abundance and increase in grass cover may reflect the continued conversion of KMA to a grass-dominated system.

Kīpuka ʻAlalā in Training Area 23

To enable comparability with previous data collection, in Kīpuka ʻAlalā the team used a vegetation monitoring method developed by Jacobi (2003). The CEMML team monitored 40 plots in 2015 that were initially established and inventoried between 2001 and 2002.

The vegetation communities in Kīpuka ʻAlalā are mostly dominated by *Sophora chrysophylla* and *Myoproum sandwicense* tall shrublands. Vegetation cover increased between 2001 and 2015 in the mid- to lower canopy (≤1 m) but cover above 5 meters decreased. Non-native plants dominate the lower vegetation layers (≤1 m) and native species dominate in the taller layers (≥2 m).

Cover and abundance of *S. chrysophylla* increased between 2001 and 2015. The current *S. chrysophylla* population structure is composed of trees from <1 m to 3 m in height. Trees classified as healthy increased in cover and had stem diameters of 6 to 8 cm or 20 to 28 cm.

M. sandwicense declined in abundance and density. Losses were primarily in the shortest (≤0.5 m) and tallest (>5 m) height classes. The current *M. sandwicense* population is primarily composed of trees from 2 to 3 m in height with stem diameters ranging from 6 to 14 cm. Six percent of the trees were classified as healthy, 12% were unhealthy and 82% were recently dead. Loss of *M. sandwicense* will likely change local environmental conditions (e.g., light and moisture regimes), which can influence changes in vegetation community structure and composition. Some invasive species, such as *Cenchrus setaceus*, may more successfully invade under these altered conditions. In fact, *C. setaceus* cover has increased by 100% since 2001. This has major implications for wildfire risk and the potential accelerated conversion of the native forest to non-native grass-dominated systems via fire.

Overall native species abundance increased, but some native species declined in abundance (e.g., *Myrsine lanaiensis*). As Kīpuka ʻAlalā continues to be stressed by multiple disturbances, we anticipate additional shifts in the vegetation community structure and composition. However, since ungulates were removed in 2007, the observed changes appear to be mostly positive for native species.

Strategic Environmental Research and Development Vegetation Monitoring

Litton et al. (2018) implemented a study from 2014 through 2018 to quantify the impacts of non-native ungulate removal on the biodiversity, structure, and function of the dryland forests at PTA. Ungulate removal is a key first step in conserving and promoting native plant communities. Nonnative plants also benefit from ungulate removal, so control of these species is an important consideration following ungulate removal. The team worked in 3 widespread vegetation types: *Metrosideros* woodland, *Dodonaea* shrubland, and *Eragrosti*s grassland. All study sites were fenced. To investigate vegetation community recovery over time following ungulate removal, study sites were selected based on the number of years the site had been ungulate free. We summarize the results from the vegetation monitoring portion of the study. In addition, Litton et al. (2018) conducted ecological process measurements (except in *Eragrosti*s grassland) and nutrient manipulations in the greenhouse and field. The results from these study aspects are not summarized here.

Litton et al. (2018) identified several general patterns. In all 3 vegetation types, ESA-listed plants increased in abundance over time following ungulate removal, and recovery was highest where a population was present at the time of fencing and ungulate removal. In *Metrosideros* treeland and *Dodonaea* shrubland, common native and non-native plant cover did not change following ungulate removal. In *Eragrosti*s grassland, common native plant cover increased, but non-native plant cover did not change.

This research provides significant insights into the effects of non-native ungulate removal on plant communities and ecological processes and can help us strategize and prioritize management for ESA-listed plants and their habitats.

2.2.6 Plant Survey and Monitoring Section Discussion

Plant surveys are an important aspect of the Army's Natural Resources Program. Information derived from these surveys informs progress towards INRMP objectives and compliance obligations as and provides accurate information on the locations and status of ESA-listed species for installation planning. While surveys are a good method for understanding plant distributions, the initial plant survey data that was collected is not suited to generating accurate estimates of abundance or projecting future population status. For PS 1 monitoring, we collect more accurate count data from which we can accurately track current population status. In 2020, we plan to use the information gained from the plant surveys and PS 1 monitoring to develop new monitoring methods that will allow us to more efficiently and precisely estimate abundance for all ESA-listed species at PTA and potentially model future projections of population status.

We are improving our understanding of threats to ESA-listed species. Analysis of the data showed that threats are not present at most plots on most visits; threats were detected most often between July and September in 2 years. In FY 2020, we will examine spatial and temporal patterns. Understanding these types of patterns will help us establish meaningful management triggers and increase our management efficiency and effectiveness. Additionally, water stress was often the leading threat recorded during plot visits. We are unable to control for water stress at the landscape level, but if other threats, such as invertebrates, are related to water stress, we may be able to manage these related stressors.

We plan to implement further vegetation monitoring as resources allow. Vegetation monitoring is important to understand community-level changes that occur following landscape-level management (i.e., ungulate removal) and natural disturbance events like wildland fire.

2.3 GENETIC CONSERVATION AND OUTPLANTING SECTION

2.3.1 Introduction

Our goal is to maintain the genetic diversity of the 20 ESA-listed plant species found at PTA, and to the extent feasible, to increase the distribution and abundance of the ESA-listed plant species. Genetic conservation and outplanting to increase species distribution and abundance are conservation measures identified in the 2003 and 2013 BOs for 13 of the ESA-listed plant species at PTA (USFWS 2003a, USFWS 2013a). In addition, our 2017 PTA Recovery Permit (TE40123A-2) authorizes genetic conservation and outplanting actions for the 20 ESA-listed species at PTA. Several INRMP objectives for genetic conservation overlap with the BO conservation measures and permitted activities.

To achieve these requirements and objectives, we implement projects under SOO tasks 3.2(1)(e) and 3.2(1)(f): 1) to collect and store propagules of ESA-listed plants and common native plants, 2) to propagate common and rare plants for outplanting to improve habitats, and 3) to increase the distribution and abundances of ESA-listed plants. To conserve and manage the ESA-listed plant genetics we track the provenance of the collected propagules through collection, storage, propagation, and outplanting. In this report, we refer to the plant that propagules are collected from as the “founder”. Monitoring is essential to track success of plantings as well as to track the genetic representation of founders by species at each outplanting site.

Goals of the Genetic Conservation and Outplanting Section (GCOS) are to:

- Increase species distribution and abundance of ESA-listed plant species through outplanting.
- Improve habitat for ESA-listed species.
- Maintain an *ex situ* collection of genetic material for each ESA-listed plant species.
- Maintain the greenhouse.
- Maintain founders in the greenhouse and native garden for collection of seeds, spores, or cuttings.
- Collect propagules from natural locations for propagation and use at outplanting sites.
- Propagate ESA-listed plant species for outplanting or transfer to other agencies and/or organizations.
- Assess the status of outplanted occurrences of ESA-listed species using demographic monitoring on an annual or other appropriate recurring cycle.
- Propagate common native species.

- For ESA-listed plant species directly impacted by military construction projects, preserve genetic variability via propagule collection and propagate plants for outplanting.

To this end, we implement projects to collect propagules from ESA-listed plants and from common native plants for long-term storage and propagation. From these propagules, we grow plants for outplanting.

Genetic Conservation and Outplanting Strategy

To guide management, we developed the *Genetic Conservation and Outplanting Plan* (CEMML 2017). We prioritize genetic conservation according to the PTA priority species ranking (Table 1). To guide implementation efforts, we assigned the ESA-listed plants a genetic conservation implementation priority based on their Priority Species rank and previous outplanting efforts (Table 6). The rarest plants with minimal previous outplanting efforts have the highest implementation priority rank. For the highest priority species, for which even a single small-scale catastrophic event could impact the entire known population or a significant portion of its distribution, we balance the importance of propagule banking (from both naturally occurring plants and living collections), the augmentation of natural populations with plantings, establishment of new locations, and habitat improvement. For more abundant species with lower implementation priorities, we prioritize propagule banking only.

Table 6. Implementation priority for genetic conservation and outplanting of plant species listed under the Endangered Species Act at Pōhakuloa Training Area

Implementation Priority 1 (High)	
Isodendrion hosakae (E)	*Sicyos macrophyllus* (E)
Lipochaeta venosa (E)	*Vigna o-wahuensis* (E)
Implementation Priority 2	
Kadua coriacea	*Portulaca villosa* (E)
Portulaca sclerocarpa (E)	
Implementation Priority 3	
Neraudia ovata (E)	*Solanum incompletum* (E)
Schiedea hawaiiensis (E)	*Tetramolopium arenarium* var. *arenarium* (E)
Implementation Priority 4	
Asplenium peruvianum var. *insulare* (E)	
Implementation Priority 5 (Low)	
Exocarpos menziesii (E)	*Silene lanceolata* (E)
Festuca hawaiiensis (E)	*Spermolepis hawaiiensis* (E)
Haplostachys haplostachya (E)	*Stenogyne angustifolia* (E)
Silene hawaiiensis (T)	*Zanthoxylum hawaiiense* (E)

E, Endangered; T, Threatened

Under previous Recovery Permits, we established 15 outplanting sites (also referred to as ASRs) at PTA and 5 on lands under the jurisdiction of Hawaiʻi County or the State of Hawaiʻi (i.e., outside the PTA installation boundary). Between 2002 and 2014, we planted at sites off-PTA because fenced, ungulate-free areas were not present on the installation. However, there are administrative, regulatory, and spatial constraints to managing plants on lands not under Army authority.

Following animal removal from the ungulate exclusion fences, we now have more areas available for outplanting on PTA, which total about 15,100 ha of fenced, ungulate-free habitat with an elevational gradient from 760 m to 2,200 m. Along with the elevational gradient, a range of conditions exists, including significant moisture and temperature gradients overlaid on a mosaic of substrate textures and ages. The variety of habitats available has made outplanting within PTA borders more feasible.

We plan to focus outplanting sites on Army-controlled lands at PTA. With the goal of establishing self-sustaining populations of ESA-listed plant species, we will develop site-specific planting plans that address natural species assemblages, community structure, and habitat to encourage a more natural diversity and density of ESA-listed plant species and common native species. We may enhance a new planting site by controlling non-native plants and planting common native species to improve community structure and composition.

Although we plan to limit outplanting on non-Army controlled lands (Figure 8), we plan to maintain the existing ASRs where plants remain and/or are self-sustaining. In addition, we will provide seeds, spores, cuttings, and/or plants to other agencies working in conservation. This type of partnership allows agencies to propagate and/or outplant on their own lands and manage the species towards their own conservation goals and contributes toward broader species-level conservation goals.

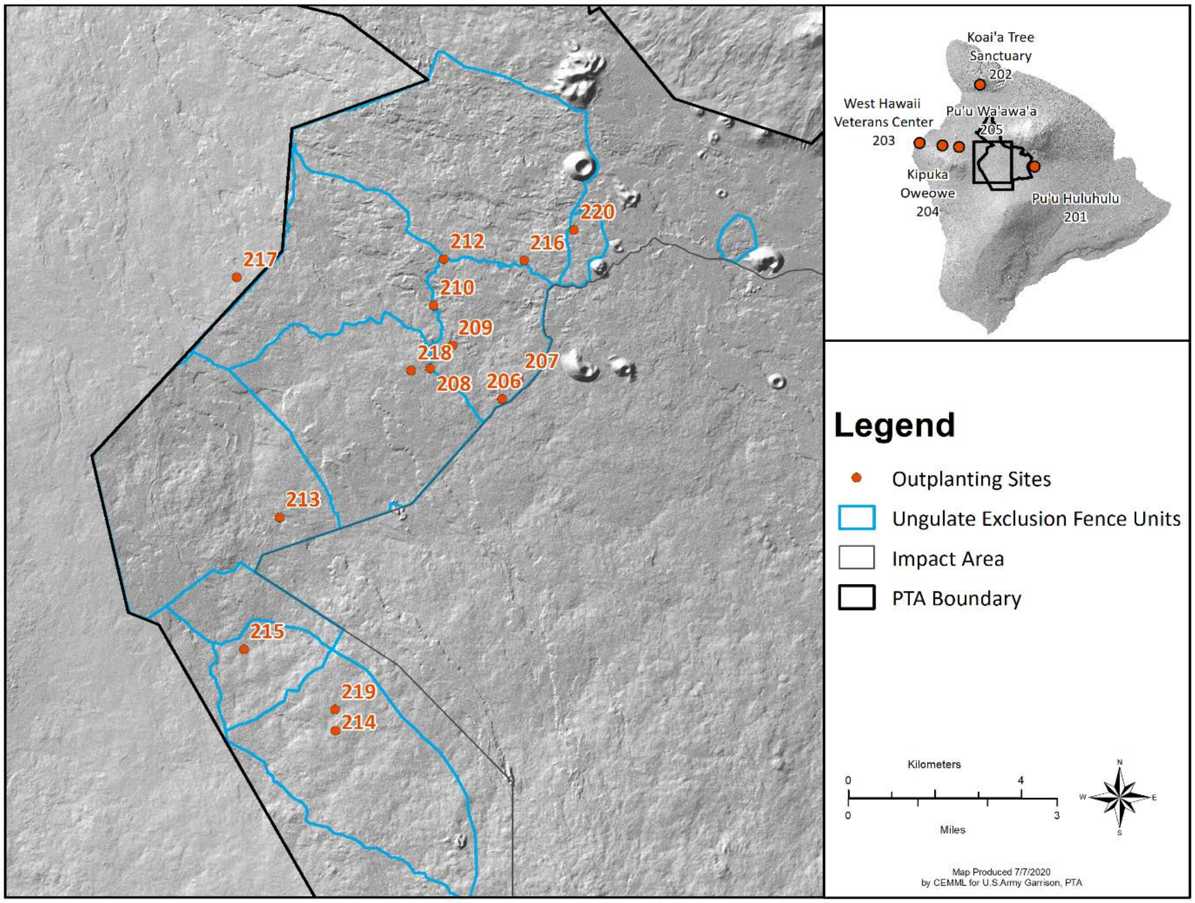

Figure 8. Location of outplanting sites on and off Pōhakuloa Training Area

2.3.2 Genetic Conservation

We implement several genetic conservation projects that meet SOO task 3.2(1)(e) and that address INRMP objectives and conservation measures as required by the 2003 and 2013 BOs. Through seed and propagule collection and storage, we strive to maintain genetic representation of each species in propagule banks (i.e., *ex situ* storage facilities) and to propagate and outplant species in accordance with the *Genetic Conservation and Outplanting Plan* (CEMML 2017). Please refer to Table 8 for a consolidated summary of the number of propagules in storage for all ESA-listed plant species at PTA.

Propagule storage in *ex situ* facilities is an efficient method to conserve species' genetics. Unlike living plant collections, plant material stored in propagule banks is not susceptible to the extreme variability of biotic and abiotic factors. We plan to maintain *ex situ* collections in a primary, on-site propagule bank and in a secondary, off-site propagule bank. The primary propagule bank provides easy access to test seed viability and to propagate plants for outplanting. We plan to establish a secondary off-site propagule bank to serve as an additional safeguard.

We strive to ensure that the *ex situ* collections remain viable by withdrawing and replacing seeds based on seed characteristics of individual species. The frequency of refreshing is determined through viability testing. Plants that result from seed viability testing are outplanted or provided to other agencies.

Propagule Collection Methods

We systematically collect propagules to meet propagation and *ex situ* storage needs in accordance with the 2017 PTA Recovery Permit conditions. Our collection standards are based on: 1) guidelines from the Center for Plant Conservation (1991); 2) recommendations from peer-reviewed literature (Brown and Briggs 1991; Brown and Marshall 1995; Guerrant et al. 2004); and 3) established and accepted practices within the Hawaiʻi conservation community.

For species with limited founders or propagule production, we sometimes maintain living plants in the greenhouse to provide a secure and readily accessible source of propagules. We may keep plants on a long-term basis to facilitate cross-pollination and increased seed collection. Or, we may retain plants on a short-term basis to collect first-generation propagules prior to outplanting. We limit propagule collections from plants in the greenhouse to 1 generation removed from the natural founder to minimize any genetic drift that might result from cultivation practices. Outplanted individuals are another source of genetic material that can be collected and used if needed.

To improve the likelihood of collecting a representative sample of the genetic variation within a species' distribution at PTA, we developed discrete collection areas termed "Plant Groups", which are polygons based primarily on the PTA fuels management system (Figure 9). These groups do not infer any biological meaning, but instead are a tool for potentially maximizing genetic and spatial representation throughout the species' distribution at PTA. To further track plant/founder locations, we designate collection site numbers[8]. Additionally, we track the Plant Population Reference Code provided by the US Fish and Wildlife Service.

[8] A collection site number consists of: 1) the 6-letter species code (**Isohos**502-1802-028-007); 2) the Plant Group number (Isohos**502**-1802-028-007); 3) a UTM coordinate reference to the square kilometer in which the site is located (Isohos502-**1802**-028-007); 4) a number representing each location (defined as a 5-m radius circle) of the species within the kilometer (Isohos502-1802-**028**-007); and 5) a sequential number representing each plant/founder collected from within the 5-m radius circle (Isohos502-1802-028-**007**). For most of the Priority Species 1 plants – *I. hosakae*, *K. coriacea*, *L. venosa*, *N. ovata*, *Schiedea hawaiiensis*, *S. macrophyllus*, *V. o-wahuensis* – the location numbers within the square kilometer and within the 5-m radius circle will always represent the same individual plant/founder. For all other species, the location numbers within the square kilometer and 5-m radius circle represent individual plants, but not necessarily the same individuals from year to year.

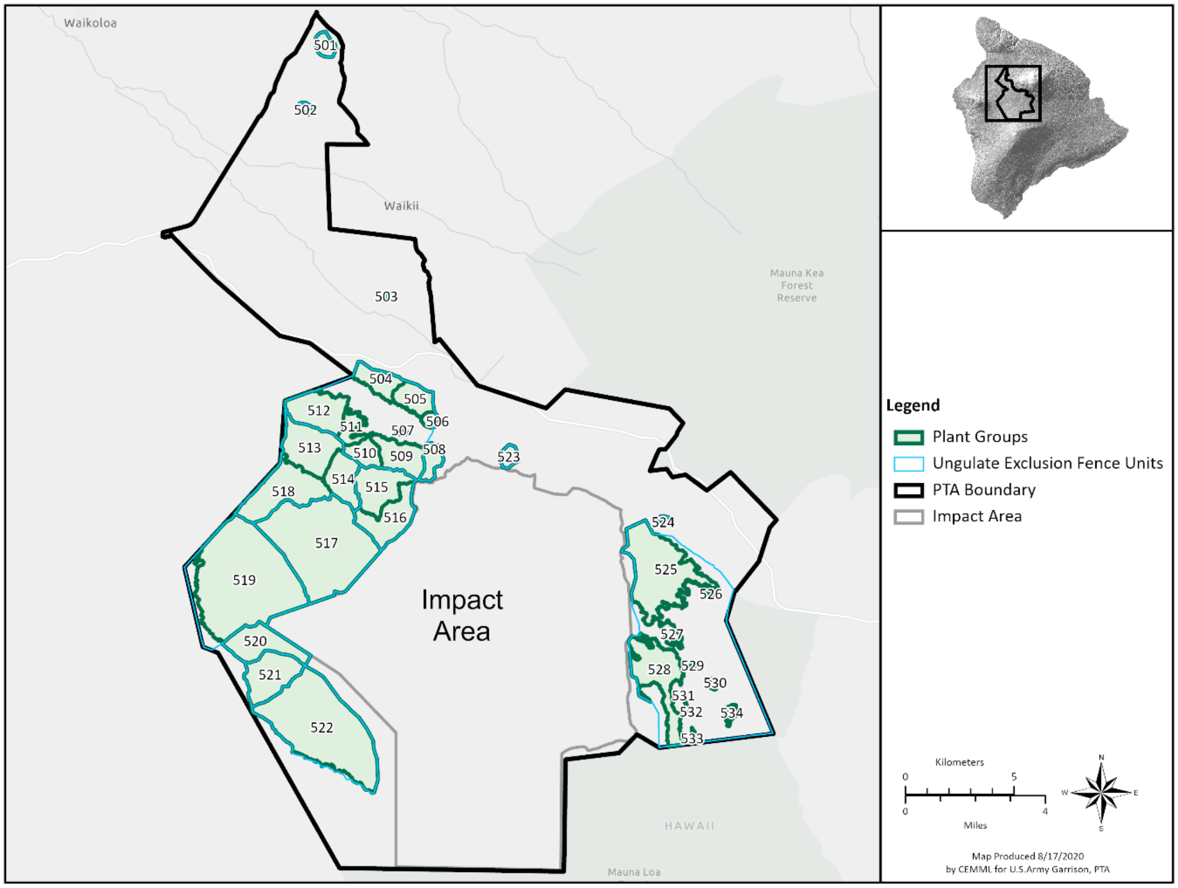

Figure 9. Plant groups to guide propagule collection from plant species listed under the Endangered Species Act and guide to site selection at Pōhakuloa Training Area

We base seed-collection priorities on species abundance, level of natural recruitment, and current representation in storage. Because seed set at PTA is highly variable, we follow guidelines established by Guerrant et al. (2004), which recommends collecting seed from up to 50 populations, and up to 50 individuals per population with less intense, but frequent harvests, over multiple years. Leaving sufficient material to maintain the natural seed bank is extremely important in sustaining *in situ* population numbers and genetic variability. At PTA, we aim to maintain at least 50 propagules per PS 1 founder in both primary and secondary storage.

However, seed availability is highly influenced by environmental conditions. In any given year, the plants from which seeds are collected (i.e., founders) will represent a sub-set of natural occurrences. Thus, periodic visits and collection from various reproducing individuals likely increases the balance and representation of genetic variability over the long-term. Lastly, propagules are collected and stored separately for each founder. The accession number assigned to each collection for each species consists of the species, year collected, and a sequential number (e.g., *I. hosakae* 2018001, 2018002, etc.). The accession number is linked to the collection site number in our database to track founder information. We track and report propagation and outplanting efforts via this accession number.

We limit collections per conditions of the 2017 PTA Recovery Permit. We place the collected seeds or fruits in a labeled coin envelope, which is placed in a sealed plastic bag for transport to the office. Other propagules are transported to the office in appropriate containers following collection.

We collect cuttings for immediate propagation and, at this time, only store fruits and seed for genetic conservation. When collecting cuttings, we record the following information: location coordinates, date, collector, plant identification number (if present), and quantity and type of material collected. We consolidate all cuttings from a single founder into a single collection record. We immediately place the cuttings in water and keep them cool and shaded until processing. Cuttings are prepared per propagation methods described below and survivorship is tracked and reported.

Propagule Storage Methods

We use propagule banks to store seeds and fruits over the short- and long-term. For each collection, we record the following information: location coordinates, date, collector, plant identification number (if present), and quantity and type of material collected. We then assign an accession number to each collection and note in our database which accessions are for primary storage, secondary storage, or available for distribution to other agencies. We annually review the data to ensure adequate propagules and founders are represented and to refresh accessions as needed.

Fruit and seeds are processed as soon as possible following collection. Seeds are cleaned, counted, and dried. We aim to reduce seed moisture to 30% before placing in storage. Seeds destined for short-term storage (1 to 2 years) may be placed in sealed glass or plastic jars. Seed destined for long-term storage are sealed within foil packets. We store all processed seeds inside a refrigerator.

Propagule Collection and Storage Results

To work toward our *ex situ* storage objectives, we collected seeds/spores and/or fruit from 14 ESA-listed species and 1 rare species (Table 7). We made cuttings for immediate propagation from 10 ESA-Listed species.

Collection records for cuttings made between August 2017 and July 2018 are not available. However, based on plants accessioned to the greenhouse and their founder numbers, we assume these plants were propagated from cuttings. Because we have seen minimal success with germinating seeds for *L. venosa,* we assume all plants of this species without propagation records were propagated via cuttings. Based on greenhouse accession records, at least 37 cuttings representing 11 *L. venosa* founders were collected between August 2017 and July 2018 (see Section 2.3.3 for propagation details and Table 12). Generally, it takes several months to germinate *N. ovata* from seed, so we also assume plants of this species accessioned to the greenhouse were propagated from cuttings. At least 45 cuttings representing 14 founders were collected between August 2017 and July 2018 (see Section 2.3.3 for propagation details and Table 12). Loss of these records is problematic in that we do not know how many cuttings were made; therefore, we cannot evaluate the propagation success.

Table 7. Summary of propagule collection of plant species listed under the Endangered Species Act at Pōhakuloa Training Area between August 2017 and July 2018

Species	Type Collected	Founders[a]	Amount Collected	Disposition
Asplenium peruvianum var insulare	Spore	1	1	Storage
Exocarpos menziesii	Seed	9+	766+	Storage/Propagation
Haplostachys haplostachya	Cutting	2	3	Propagation
Haplostachys haplostachya	Seed	31+	7,396+	Storage/Propagation
Isodendrion hosakae	Cutting	2	6	Propagation
Isodendrion hosakae	Seed	43	1,079	Storage
Kadua coriacea	Cutting	2	2	Propagation
Kadua coriacea	Seed	69	28,474	Storage
Lipochaeta venosa	Cutting	23	93	Propagation
Lipochaeta venosa	Seed	6	479	Storage/Propagation
Neraudia ovata	Cutting	32	313	Propagation
Neraudia ovata	Seed	25	3,976	Storage
Portulaca sclerocarpa	Seed	53	32,761	Storage
Portulaca villosa	Cutting	4	9	Propagation
Portulaca villosa	Seed	3	4,833	Storage
Schiedea hawaiiensis	Cutting	4	20	Propagation
Silene lanceolata	Seed	3	8,802	Storage
Solanum incompletum	Cutting	17	103	Propagation
Solanum incompletum	Seed	13	2,223	Storage
Solanum incompletum	Fruit	7	1,864	Storage
Stenogyne angustifolia	Cutting	1	3	Propagation
Tetramolopium arenarium var. *arenarium*	Seed	46	8,043	Storage
Tetramolopium sp. 1	Seed	12	4,342	Storage
Vigna o-wahuensis	Seed	74	2,492	Storage/Propagation
Zanthoxylum hawaiiense	Cutting	1	34	Propagation
Zanthoxylum hawaiiense	Seed	1	108	Storage

[a] Collections with a "+" sign denote a bulk collection where propagules were collected from more than one founder.

Propagule Collection and Storage Discussion

Our aim over the reporting period was to refresh many propagule accessions that are aging (i.e., for *K. coriacea* and *T. arenarium* var. *arenarium*), and that are under-represented by founders from the natural field populations (i.e., for *P. sclerocarpa* and *V. o-wahuensis*).

In 2019, we implemented a new system for tracking plant locations and propagule collection sites (see Footnote 8). We are in the process of translating the previous plant location and propagule number systems to the new system. Because the 2 systems are not currently fully reconciled, we cannot accurately report the number of founders collected during the reporting period. We plan to complete the reconciliation of the numbering systems to get an accurate accounting of stored founders in 2020.

Propagules from all 20 ESA-listed plant species are represented in storage (Table 8). We track the propagule accessions by the source (e.g. natural population, greenhouse, or outplanting site) and by the type of propagule (e.g., seeds vs. fruits). Many of our current propagule accessions in storage are aging and some collections, such as for *N. ovata* and *S. incompletum*, date back to the late 1990's. The viability of these older accessions is unknown.

In addition, we are experiencing challenges with accurately determining founders and propagule totals currently in storage. With the recent change in the plant location numbering system, as well as data entry errors, an accurate accounting of the founders represented in storage is not available currently. In addition, propagule collections and withdrawals from storage between 2017 and 2019 were not consistently recorded in the database. Therefore, we plan to inventory the seed storage to verify the number of founders and seeds physically present and then update the database. Until this inventory is completed, the totals present in Table 8 are the most up-to-date totals.

Table 8. Summary of propagules in *ex situ* storage at Pōhakuloa Training Area as of 31 December 2019

Species	Source	Propagule Type	Total by Propagule Type
Asplenium peruvianum var. *insulare*	Field/Natural Population	Blade	119
	Field/Natural Population	Spore	1
	Greenhouse	Blade	492
Exocarpos menziesii	Field/Natural Population	Fruit	536
Festuca hawaiiensis	Field/Natural Population	Seed	184
	Greenhouse	Seed	198
	Outplanted Population	Seed	47
Haplostachys haplostachya	Field/Natural Population	Fruit	9,274
	Field/Natural Population	Seed	41,850
	Greenhouse	Fruit	25,504
	Greenhouse	Seed	11,768
Isodendrion hosakae	Field/Natural Population	Seed	1,985
Kadua coriacea	Field/Natural Population	Seed	103,331
	Greenhouse	Seed	280
Lipochaeta venosa	Field/Natural Population	Seed	499
	Greenhouse	Seed	37
Neraudia ovata	Field/Natural Population	Seed	6,130
	Greenhouse	Seed	236,474
Portulaca sclerocarpa	Field/Natural Population	Fruit	508
	Field/Natural Population	Seed	32,761
	Greenhouse	Fruit	8,734

Table 8. Summary of propagules in *ex situ* storage at Pōhakuloa Training Area as of 31 December 2019 (cont.)

Species	Source	Propagule Type	Total by Propagule Type
Portulaca villosa	Field/Natural Population	Seed	4,833
Schiedea hawaiiensis	Field/Natural Population	Seed	315
	Greenhouse	Seed	331,418
Sicyos macrophyllus	Field/Natural Population	Fruit	479
Silene hawaiiensis	Field/Natural Population	Seed	11,425
	Greenhouse	Seed	28,520
Silene lanceolata	Field/Natural Population	Seed	473,988
	Greenhouse	Seed	1,043,321
	Outplanted Population	Seed	26,430
Solanum incompletum	Field/Natural Population	Fruit	2,517
	Field/Natural Population	Seed	3,390
	Greenhouse	Fruit	8,363
	Outplanted Population	Fruit	21
Spermolepis hawaiiensis	Field/Natural Population	Seed	3,094
	Greenhouse	Seed	506,320
	Outplanted Population	Seed	5,039
Stenogyne angustifolia	Field/Natural Population	Seed	2,175
	Greenhouse	Seed	1,926
	Outplanted Population	Seed	119
Tetramolopium arenarium	Field/Natural Population	Seed	71,933
	Greenhouse	Seed	3,932
	Outplanted Population	Seed	8,318
Tetramolopium sp1	Field/Natural Population	Seed	19,316
	Greenhouse	Seed	99,497
	Outplanted Population	Seed	65,838
Vigna o-wahuensis	Field/Natural Population	Seed	3,356
	Greenhouse	Seed	32,399
Zanthoxylum hawaiiense	Field/Natural Population	Seed	5,706

In 2020, we plan to refine our annual collection targets and storage goals for each species. This will help improve our tracking and reporting progress toward achieving stated targets and goals. Currently, evaluating progress toward storage goals for PS 1 species is challenging because our stated goals (e.g., to collect from every PS 1 individual) are too general and do not account for changes in PS 1 plant population status. Although our collection targets for PS 2 and PS 3 species are more specific (50 propagules from 50 plants/locations per Plant Group, where possible), we plan to set explicit annual collection targets to meet overall storage goals for each species. We plan to inventory the *ex situ* collection, rectify issues with founder numbers, and determine which collections need to be refreshed, especially for PS 1 species. In addition, we will explore options to collaborate with the

Army’s Natural Resources Program on Oʻahu to test seed viability and dormancy and to curate a second *ex situ* storage collection.

2.3.3 Propagation

We implement several projects that meet SOO task 3.2(1)(f) and address INRMP objectives and regulatory mandates to increase the distribution and abundance for ESA-listed plant species by augmenting wild populations or establishing new occurrences. In addition, we outplant common native species to improve degraded habitat for ESA-listed plant species.

Propagation Strategy and Methods

Our propagation strategy for each ESA-listed plant is described in the *Genetic Conservation and Outplanting Plan* (CEMML 2017). In addition to growing plants for outplanting, or for transfer to other agencies, we propagate plant material to test germination methods and long-term viability of seeds, and to test propagation methods for cuttings and other plant material.

For propagation from seed, we withdraw a predetermined amount of seed from the appropriate accession. Information regarding the accession, the withdrawal, and germination is tracked to establish the provenance of the propagules and the resultant outplants. Prior to sowing, we clean and/or treat seed as needed. Pretreatments may include scarification, soaking, etc. Depending on specific species’ needs, we sow seeds in a variety of sterile media such as wet sand, paper towels, and various combinations of perlite, vermiculite, cinder, and peat. After use, media is discarded and not re-used.

Sown seed trays are kept in various levels of light, depending on the species’ needs. We check seed trays daily for adequate moisture and germination. When germination occurs, we move the seedlings to a shaded (60% shade) bench. Plants are kept in the shaded area for 2–4 weeks, then moved to 30% shade, and finally moved to full sun. Seedlings are transplanted into progressively larger pots as they grow to avoid bound roots. Most plants are outplanted from 4” pots.

To propagate from cuttings, we first prepare the field collections by treating the cuttings with a soapy water solution and thoroughly rinsing with water. We make a new basal cut for each selected cutting ensuring that at least 3 growing nodes remain on the cutting. The basal end of the cutting is dipped in rooting hormone and placed in sterile media. Potted cuttings are kept on a mist bench with a frequent watering schedule. We periodically check for rooting and transfer rooted cutting to new pots with a soil mixture. These re-potted cuttings are moved to different, less frequent watering regimes as the cuttings become more established.

Once seedlings and cuttings reach sufficient size to be transferred to a 4-inch pot, plants are assigned a greenhouse accession number that is used to track the genetic history and the fate of each individual.

Propagation Results

We propagated from seed the common native, *Kadua terminalis* (manono), *Tetramolopium* sp. 1, and 17 ESA-listed plant species (Table 9). Germination success for each ESA-listed species is discussed in the Species Summaries below.

Table 9. Summary of seed germination for plant species listed under the Endangered Species Act at Pōhakuloa Training Area between August 2018 and September 2019

Species	No. Accessions Sown[a]	Total No. Seeds Sown for all Accessions
Asplenium peruvianum var. *insulare*	2	Unknown
Exocarpos menziesii	8	276
Haplostachys haplostachya	11	701
Isodendrion hosakae	34	443
Kadua coriacea	17	545
Lipochaeta venosa	23	466
Neraudia ovata	4	354
Portulaca sclerocarpa	8	546
Portulaca villosa	2	100+
Schiedea hawaiiensis	3	290
Sicyos macrophylla	2	50
Silene hawaiiensis	2	200
Solanum incompletum	17	1,587
Stenogyne angustifolia	1	73
Tetramolopium arenarium	10	1,415+
Vigna o-wahuensis	5	161
Zanthoxylum hawaiiense	2	114

[a] Each accession typically represents a location (5-m radius circle) where one or more individuals may be present but are considered a single founder. More than one seed treatment may be applied to seeds from the same accession.

We attempted to propagate cuttings of 10 species: *H. haplostachya, I. hosakae, K. coriacea, L. venosa, N. ovata, P. villosa, Schiedea hawaiiensis, S. incompletum, S. angustifolia,* and *Z. hawaiiense* (Table 10). We deem cuttings to be successful when they establish roots and grow large enough to be accessioned into the greenhouse (i.e., transferred to a 4-inch pot). However, because we do not record the status of plants until they are accessioned into the greenhouse, there may still be some cuttings alive in the greenhouse that have not reached sufficient size to be accessioned. Therefore, the reported overall success for the cutting trials remains preliminary until all cuttings either die or are accessioned. The success rates for *L. venosa* and *N. ovata* cuttings were relatively low. Success rates for *Schiedea hawaiiensis*, *S. incompletum* and *Z. hawaiiense* cuttings were higher, but even so, overall the percentage of cuttings to be accessioned to the greenhouse so far was low.

Table 10. Propagation from cuttings for plants listed under the Endangered Species Act at Pōhakuloa Training Area between August 2018 and September 2019

Species	No. Trials	Total Cuttings Propagated	Total Seedlings Accessioned
Haplostachys haplostachya	2	3	1
Isodendrion hosakae	2	6	0[a]
Kadua coriacea	2	2	1
Lipochaeta venosa	27	91	5
Neraudia ovata	34	313	40
Portulaca villosa	4	9	4
Schiedea hawaiiensis	6	20	2
Solanum incompletum	22	103	36
Stenogyne angustifolia	1	3	3
Zanthoxylum hawaiiense	1	34	0

[a] Seeds from the *I. hosakae* founder were also propagated and information about the propagation method was not transferred with the seedlings to larger pots. Therefore, we assumed all plants from this founder accession to the greenhouse were germinated from seed.

Many seedlings propagated in 2019 from seeds and cuttings are still growing in the greenhouse and are not large enough to be accessioned to the greenhouse. At this time, we do not track the numbers of these seedlings, so it is difficult to derive overall seedling survivorship until all the plants from a germination or cutting propagation trial either die or are accessioned to the greenhouse. In addition, propagation information was lost for some seedling trays and plants in 4-inch pots, which will skew overall seedling survivorship for those species. However, many species propagated over the reporting period did grow to sufficient size for accession to the greenhouse (Table 11).

We propagated 9 ESA-listed plant species between August 2017 and July 2018; however, propagation records are not available for this time period. Loss of these records is problematic in that we do not know how many seeds were withdrawn from accessions and sown or cuttings propagated; therefore, we cannot evaluate any propagation success. The only propagation information we have is the 2017 Propagation report provided to the USFWS in July 2018 and the founder and accession information on the plants accessioned to the greenhouse (Table 12).

In addition, we propagated 16 common native Hawaiian plant species to support habitat improvement at Puʻu Pāpapa and to plant in the PTA Interpretive garden at the Natural Resources Program buildings on the PTA cantonment (Table 13).

Table 11. Greenhouse inventory of accessioned plants listed under the Endangered Species Act including plants as of September 2019

		Inventory as of September 2019			
Species	Total Plants Accessioned	Outplanted	Dead	Not found	Plants Remaining in GH
Asplenium peruvianum var. insulare	0	0	0	0	0
Exocarpos menziesii	0	0	0	0	0
Festuca hawaiiensis	0	0	0	0	0
Haplostachys haplostachya	0	0	0	0	0
Isodendrion hosakae	64	0	17	2	45
Kadua coriacea	234	201	10	2	18
Lipochaeta venosa	40	16	3		21
Neraudia ovata	86	11	2	7	66
Portulaca sclerocarpa	26	18	0	0	8
Portulaca villosa	33	0	1	0	32
Schiedea hawaiiensis	8	0	0	0	8
Sicyos macrophylla	0	0	0	0.	0
Silene hawaiiensis	4	0	0	0	0
Silene lanceolata	0	0	0	0	0
Solanum incompletum	175	0	8	1	166
Stenogyne angustifolia	3	0	0	0	3
Tetramolopium arenarium var *arenarium*	255	0	159	36	60
Vigna o-wahuensis	31	11	1	0	19
Zanthoxylum hawaiiense	6	0	0	0	6

Note: Total plants accessioned includes all individuals in the greenhouse with accession numbers including plants that may have died, were not found during the final 2019 inventory, or were outplanted. The final column represents the total plants accessioned minus the plants that died, were not found or were outplanted. GH, greenhouse

Table 12. Plants listed under the Endangered Species Act accessioned to the greenhouse without propagation records prior to August 2018

Species	Total Plants Accessioned
Isodendrion hosakae	15
Kadua coriacea	231
Lipochaeta venosa	37
Neraudia ovata	45
Portulaca sclerocarpa	24
Portulaca villosa	29
Schiedea hawaiiensis	6
Solanum incompletum	37
Tetramolopium arenarium var *arenarium*	209
Vigna o-wahuensis	31
Zanthoxylum hawaiiense	6

Table 13. Common native Hawaiian plant species propagated and accessioned to the greenhouse

Species	Common Name	Hawaiian Name	Total Plants Accessioned
Acacia koa	Koa	Koa	100
Bidens menziesii	Manua Loa beggertick	Kokoolau	27
Coprosma ernodeoides	Black-fruited coprosma	Kukaenene	29
Dodonaea viscosa	Hopbush	ʻĀʻaliʻi	75
Eragrostis deflexa	Pacific lovegrass	--	6
Erythrina sandwichesis	Hawaiian coral tree	Wiliwili	2
Heteropogon contortus	Pili grass	Pili	140
Luzula hawaiiensis var. *hawaiiensis*	Hawaiʻi wood-rush	--	68
Metrosideros polymorpha	Ohia lehua	Ohiʻā lehua	540
Osteomeles anthyllidifolia	Hawaiian rose	ʻŪlei	141
Panicum pellitum	Maui panicgrass	--	3
Panicum tenuifolium	Mountain Pili	Konakona	6
Plectranthus parviflours	Cockspur flower	ʻAlaʻala wai nui	2
Santalum paniculatum	Sandalwood	ʻIliahi	1
Sida fallax	Yellow ʻilima	ʻIlima	46
Sophora chrysophylla	Mamane	Māmane	101
Wikstoemia phillyreifolia)	Hawaiʻi false ohelo	ʻĀkia	117

Propagation Discussion

We continue to experience variable success with seed and cutting propagation. We suspect that some of the differences in germination and establishment are attributable to species life history strategies and specific species-related seed characteristics such as physical seed dormancy to delay germination until environmental conditions are favorable. In addition, natural variability in seed quality among plant founders and among accessions acquired under differing environmental conditions likely contributes to differences in germination success. Although we have made substantial progress with germinating several ESA-listed plant species, there is still more to learn to reliably and consistently germinate all species. In FY 2020, we plan to investigate procedural changes to better plan and track germination trials to investigate which seed treatments are influencing seed germination. Because we lack laboratory facilities and expertise, we recommend leveraging the resources and experts at the Army's Natural Resources Program on Oʻahu to investigate seed dormancy issues and to assist with developing propagation protocols.

2.3.4 Outplanting

Outplanting Strategy and Methods

Once selected, an outplanting site is designated as an Area of Species Recovery (ASR). We evaluate the ASR management needs (weed control, habitat improvement, and ESA-listed species outplanting) and develop a site-specific plan with site-specific goals. We implement management in phases: Phase 1) control weeds as needed and collect seeds to meet project goals; Phase 2) propagate plants, usually common species, to improve the habitat; Phase 3) plant the propagated plants from Phase 2; and Phase 4) plant ESA-listed plant species. We control invasive plants during all phases of management.

The common plant species we select for habitat improvement are site-specific and determined by historical records, herbarium records, species distribution models, and species lists from plant survey data. We also plan to consider future climate conditions when selecting species.

We inspect all plants before transporting them to the field and only healthy plants are outplanted. We typically outplant to take advantage of fall and winter weather conditions (i.e., greater likelihood of rain). We select beneficial site conditions such as sun/shade balance, topography, winds, and proximity to common native species to locate planting holes. We follow Standard Operating Procedures (SOPs) to ensure successful transfer of plants from pots to the planting holes and to guide post-planting soil amendments and watering. Each outplant is tagged at the base of the plant. Outplants are watered weekly for a period of 4-6 weeks. We inspect plants weekly and manage emerging problems as appropriate.

Monitoring survivorship and individual plant performance provides essential feedback to adjust site-specific planting plans and to improve outplanting methods and SOPs. We last monitored our previous plantings on PTA and at off-site locations in 2016. We plan to count the number of individuals of each species present at each planting location in 2019. We are also developing a more robust monitoring protocol to better track survivorship of individuals and to better document the genetic lineage of the plants present at each site. We anticipate this new monitoring approach to be completed in 2020.

Outplanting Results

We planted a total of 161 endangered plants, representing 6 species, at 9 new planting locations on PTA lands (Table 14 and Figure 10), and in the PTA Interpretive Garden on the cantonment. The permanent ASR numbers for these new planting locations have not been assigned; therefore, we report our progress using temporary site numbers.

Table 14. Number of individuals planted by species in each planting location between February and April 2019, and monitoring results from November and December 2019[a]

	Training Area 23		Training Area 22		Pu'u Pāpapa	Training Area 21		
Species	**Temp 2019 001**	**Temp 2019 002**	**Temp 2019 003**	**Temp 2019 004**	**Temp 2019 005**	**Temp 2019 006-008**	**Temp 2019 009**	**Total**
Kadua coriacea	18	20	21	24	-	20	4	**107**
Neraudia ovata	-	-	-	-	-	-	9	**9**
Lipochaeta venosa	-	-	-	-	15	-	-	**15**
Portulaca sclerocarpa	-	-	18	-	-	-	-	**18**
Schiedea hawaiiensis	-	-	-	-	-	-	2	**2**
Vigna o-wahuensis	-	-	-	-	11	-	-	**11**
Total Planted	18	20	39	24	26	20	17	**161**

Temp, temporary site number

[a] Planting locations are identified by temporary site numbers. Data for sites Temp 2019-006 to -008 are combined

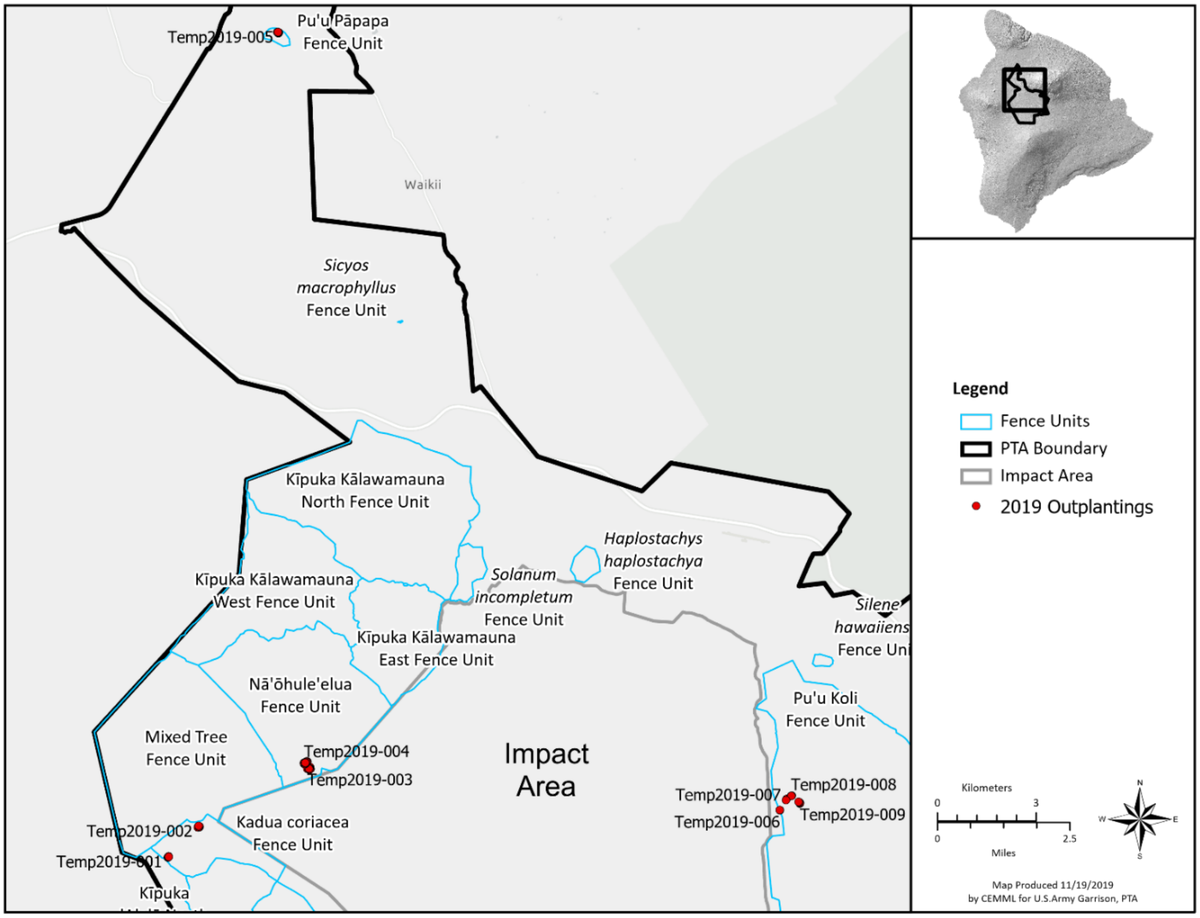

Figure 10. Locations of endangered species plantings established in 2019 at Pōhakuloa Training Area[a]

[a] Sites are identified by temporary site numbers until permanent Area of Species Recovery numbers are assigned

Garden

We also planted several species and individuals in the PTA Interpretive Garden located on the PTA cantonment behind the Natural Resources Program buildings. We planted 94 *K. coriacea* and 2 *N. ovata* during 2019. In addition, we planted several ESA-listed plants in the interpretive garden during 2018 and 2019. We planted several individuals of *N. ovata* and *S. incompletum* that were held in the greenhouse as living collections for many years. Other species in the garden include: *L. venosa, S. lanceolata,* and *S. angustifolia.*

Outplanting Discussion

We plan to explore options for establishing new planting areas at PTA. Per the strategy developed in the *Genetic Conservation and Outplanting Plan* (CEMML 2017), our focus for 2020 will be on establishing planting locations in KMA for *I. hosakae, L. venosa,* and *V. o-wahuensis.* Per our initial trial outplanting at Puʻu Pāpapa in KMA (Planting Site Temp 2019-005), the survivorship for *L. venosa* (79%)

was relatively high after 9 months, but survivorship for *V. o-wahuensis* (1%) was poor. We will continue to explore options to plant common native species to restore native habitats at KMA sites. However, before we initiate additional work, we need to develop a process to vet and receive approval for all planting sites from the Army, especially when ESA-listed plants will be planted. Additionally, we will continue to develop site-specific planting plans that outline planting targets for common and ESA-listed species and to ensure we consider the genetic makeup of plants included at a particular location.

2.3.5 Genetic Conservation and Outplanting Discussion

The *Genetic Conservation and Outplanting Plan* (CEMML 2017) is an excellent foundation to guide genetic conservation for the 20 ESA-listed plants. The strategy developed in the plan will guide management priorities, collection and propagation targets, and outplanting activities including site selection and the development of site-specific planting plans. These more detailed site-specific plans will establish planting targets and long-term site monitoring plans to evaluate outplanting success and our efforts in relation to our goals and compliance obligations for each ESA-listed plant species.

Ex situ storage of propagules in banks is an effective and efficient means to safeguard the genetics of ESA-listed plant species against catastrophic loss of individuals in the natural population due to natural or human-caused disturbances (e.g., wildland fire). Thousands of seeds can be stored per species inside refrigerators (short-term) or freezers (long-term). However, for this to be a viable conservation strategy, research into seed characteristics, such as dormancy, viability, and germination requirements, is needed to ensure stored seeds are of high quality and that they can be germinated reliably for reintroduction back to natural populations or newly established outplanting sites. Many of the propagules in the current *ex situ* storage at PTA were stored under less than ideal conditions for long-term storage. Many seeds were left inside fruits, seeds were not dried prior to storage, and most seed have been stored in the refrigerator. In addition, many of these collections are aging. During the reporting period, we implemented new procedures for seed processing and now all seeds are removed from the fruit and dried to about 30% moisture and sealed in foil packets prior to storage. However, we have limited capacity to freeze seeds, so most are placed in a refrigerator. We recommend partnering with the Army's Natural Resources Program on Oʻahu to leverage their seed lab resources to investigate seed viability, dormancy, germination requirements, and for long-term storage in freezers under optimal conditions.

We encountered challenges with record keeping and reporting during the reporting period. These challenges prompted in-house scrutiny of processes and procedures for collecting, storing, and propagating propagules, for accessing seedlings to the greenhouse, and for outplanting. We identified several areas to improve accounting and record keeping facilitating annual reporting for state and federal threatened and endangered plant permits. We aim to overhaul our database, inventory species and founders in the *ex situ* propagule bank, and streamline the accounting process to accurately track seeds from collection and storage to propagation and outplanting.

2.4 PRIORITY SPECIES 1 SUMMARIES

We present the species summaries arranged by priority species rank (Table 1) and then alphabetically by species. For all species we report the number of locations found during the second cycle of plant surveys (2017 to present), and we present the distribution of the species in a series of maps based on the complete dataset from plant surveys completed between 2011 and 2015. For PS 1 plants, abundance is derived from quarterly monitoring data. The genetic conservation implementation rank is reported for each species and efforts to achieve the objectives are reported for each species. We discuss how our activities implemented under SOO tasks meet INRMP objectives and BO requirements.

2.4.1 *Asplenium peruvianum* var. *insulare* (Endangered)

As a PS 1, we monitor all known *A. peruvianum* var. *insulare* individuals quarterly. For genetic conservation, *A. peruvianum* var. *insulare* is ranked as implementation priority 4 (low) and propagule collection and storage are the primary genetic conservation tools.

Plant surveys

During the reporting period, we surveyed a subset of transects and encountered 9 locations of *A. peruvianum* var. *insulare* representing at minimum 123 individuals. Because we are still surveying the full set of transects, our findings represent progress for the reporting period and do not represent actual changes in species abundance or distribution.

From previous survey work (2011 to 2015), there were 42 locations of *A. peruvianum* var. *insulare* at PTA. The abundance of this species is tracked quarterly and is reported below. The distribution for *A. peruvianum* var. *insulare*, including outplanting sites, is shown in Figure 11.

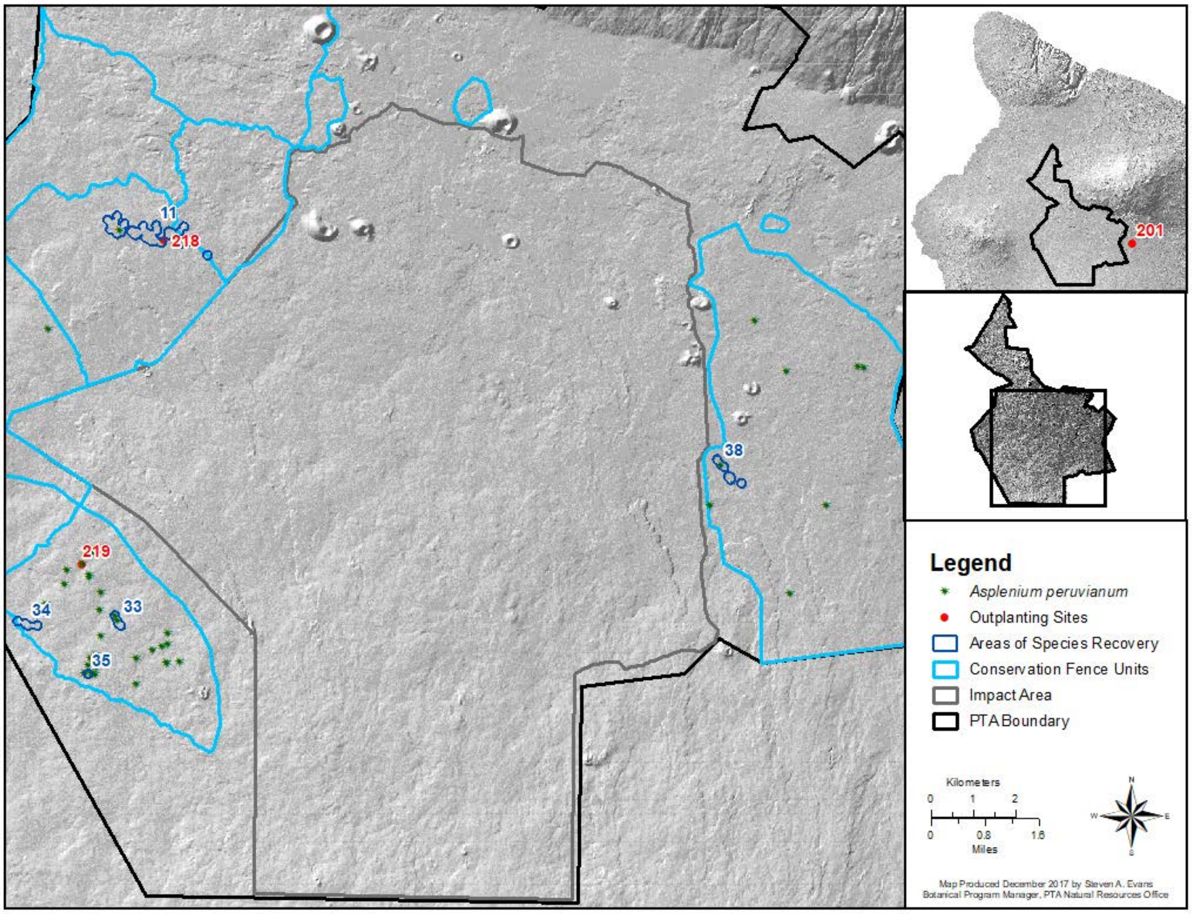

Figure 11. Current known distribution of *Asplenium peruvianum* var. *insulare*[a]

[a] Distribution data were collected between 2011 and 2015.

PS 1 Monitoring

We counted *A. peruvianum* var. *insulare* over 8 census periods between April 2016 and September 2019. Ferns steadily increased over the census periods from a low of 150 juveniles and adults counted between April and September 2016 to 396 ferns counted between August and October 2019 (Figure 12). The number of young ferns present on the plots varied over the census periods but was highest in September 2019. The increase in the number of ferns present appears to be influenced by the recruitment of juvenile ferns; the number of adults remained relatively steady over the last 3 census periods. Gametophytes were present in all census periods.

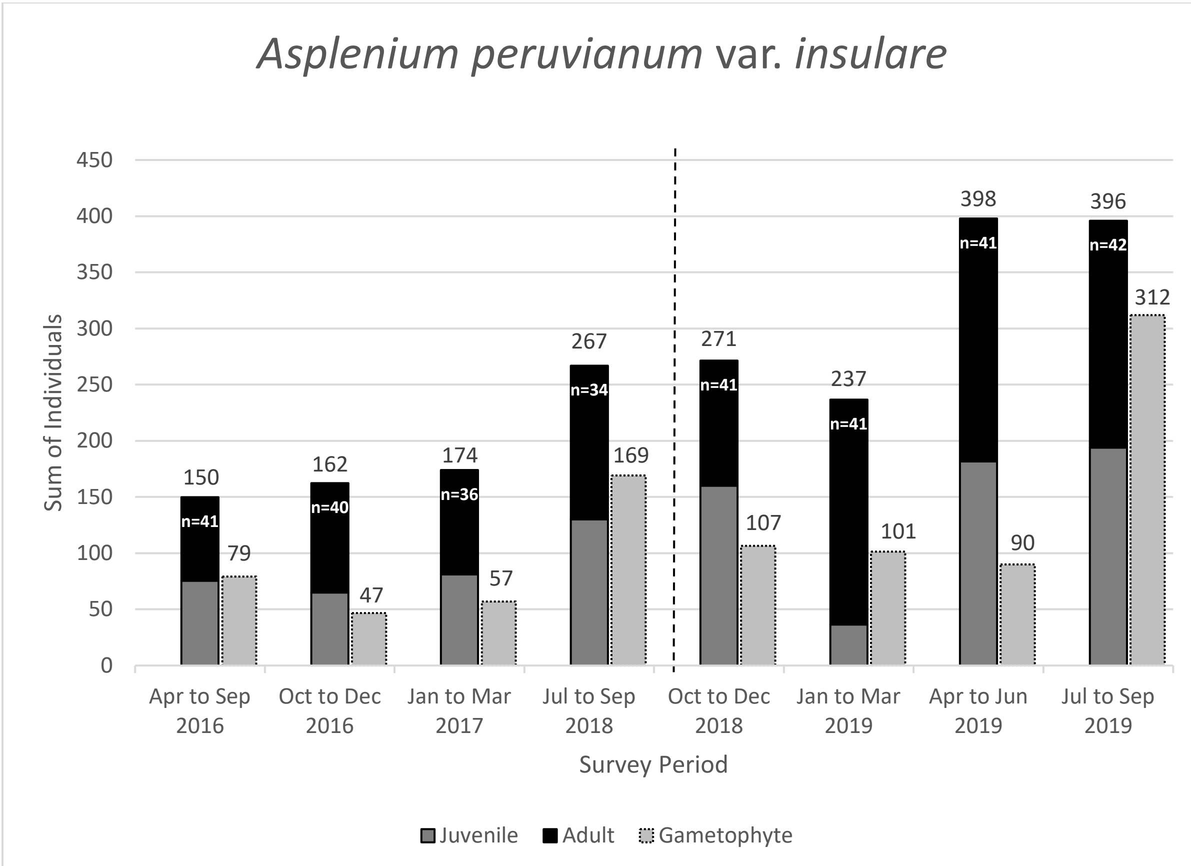

Figure 12. Quarterly monitoring results for *Asplenium peruvianum* var. *insulare* from April 2016 through September 2019[a]

[a] For census periods left of the dotted line, we estimated life stage composition using proportion and to the right we counted each plant present by life stage (n=number of plots read). For census periods right of the dotted line, totals may include count class data. When this occurs the minimum value of the count class is summed with the counts from other plots to provide the total value for abundance. Therefore, these numbers represent the minimum number of individuals present during the census period.

We visually assessed threats at every plot each monitoring period, then pooled all threat detections for every *A. peruvianum* var. *insulare* monitoring plot for the period of July 2018 through September 2019. Over this time, we detected threats during only 8 of the 200 visits completed (Figure 13). Invasive plants were the most frequently recorded threat to *A. peruvianum* var. *insulare* (7 out of 8 threat detections). No management actions were implemented to manage the observed threats due to the relatively few observations.

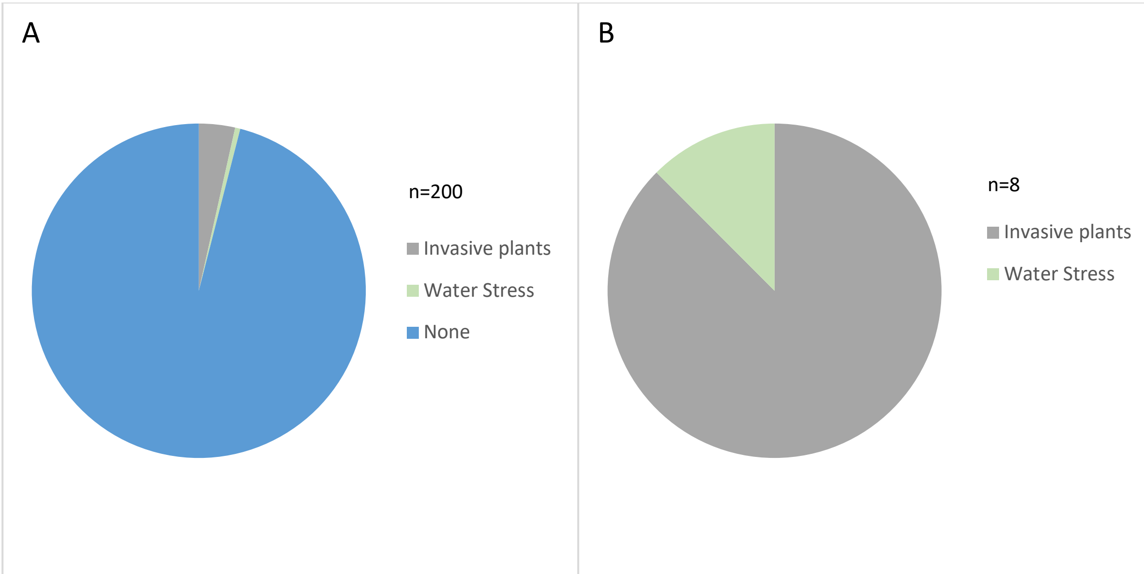

Figure 13. Emerging threats to *Asplenium peruvianum* var*. insulare* recorded between July 2018 and September 2019[a]

[a] Data are pooled for all *A. peruvianum* var. *insulare* monitoring plots for all monitoring periods. We made a total of 200 visits to the monitoring plots during this time period and threats were present on 8 occasions. Panel A shows the threats recorded for every plot visit (n=200). Panel B shows the the number of times each threat was recorded for every plot visit when threats were detected (n=8).

Genetic Conservation

Propagule Collection

Botanical staff aim to collect from all founders from Plant Groups currently underrepresented in collections. Primary and secondary collections will be maintained and refreshed. Collections will be refreshed on a 10-year cycle with collections conducted during peak rainfall periods.

We collected from one *A. peruvianum* var. *insulare* founder during the reporting period. Please refer to Table 8 for a complete summary of genetic conservation status for *A. peruvianum* var. *insulare.*

Propagation

We attempted to propagate spores of *A. peruvianum* var. *insulare* from 2 accessions (Table 9). One accession was collected during the reporting period (2019) and the other collected in 2015. The number of spores sown is unknown due to their microscopic size. As of September 2019, no ferns germinated; however, several pots inoculated with fern spores remained in the seed-growing chamber. Because no ferns germinated, no ferns were accessioned into the greenhouse.

Outplanting and Monitoring

We did not outplant *A. peruvianum* var. *insulare* during the reporting period. In previous years, we planted *A. peruvianum* var. *insulare* at ASRs 201, 218, and 219 (Figure 11). At last monitoring in 2016, 18 of the ferns planted were living and 4 ferns recruited at ASR 218 (Table 15). We plan to monitor all outplanting sites in FY 2020.

Table 15. Monitoring summary for *Asplenium peruvianum* var. *insulare* outplanted prior to FY 2018

			Surviving Outplants			Recruits	
Location	**Outplanting Site**	**Total Outplanted**	**Adult**	**Juvenile**	**Net Survivorship**	**Adult**	**Juvenile**
On PTA	218	15	9	4	87%	4	0
	219	23	9	0	39%	0	0
Off PTA	201	10	0	0	0%	0	0

PTA, Pōhakuloa Training Area

Discussion

Our efforts to survey, monitor, and conserve genetics for *A. peruvianum* var. *insulare* address SOO tasks 3.2(1)(a, d–f) as well as several INRMP objectives and conservation measures from the 2003 and 2013 BO.

The greatest distribution and abundance of *A. peruvianum* var. *insulare* occurs within the Puʻu Koli and Kīpuka ʻAlalā South Fence Units but it is also found within the Nāʻōhuleʻelua Fence Unit (Figure 11). *A. peruvianum* var. *insulare* is currently found predominantly outside of the ASRs designated for the species (Figure 11). We are evaluating where management is most needed and if current ASR designations need to be changed to reflect these needs.

Quarterly counts of *A. peruvianum* var. *insulare* steadily increased from April 2016 through September 2019. Gametophytes were present each census period. Although our monitoring was not designed to directly track transition from one life stage to another, there are patterns in the quarterly count numbers that suggest that transition from gametophyte and juvenile life stages supported gains in the adult life stage (Figure 12). There is little known about optimal *A. peruvianum* var. *insulare* population structures and/or ratios between the life stages that support healthy and resilient populations. In addition, we do not know which, if any, of the life stages is most vulnerable and/or may regulate population dynamics. These life history attributes are key to designing management actions to increase the abundance and distribution of this species, especially with changing climate conditions.

Our quarterly monitoring indicated that threats to *A. peruvianum* var. *insulare* are infrequent. Invasive plants were the most common threat detected. This result is not surprising since we have not implemented invasive plant control for most *A. peruvianum* var. *insulare* locations. When invasive plant management for PS 1 plants was first implemented, *A. peruvianum* var. *insulare* was ranked as a PS 2 and, therefore, did not receive management at the same time as other PS 1 species. In 2018 we changed the rank of *A. peruvianum* var. *insulare* to PS 1 because the ferns at PTA now represent a larger proportion of the state-wide population following a population decline in Hawaiʻi Volcanoes National Park. With this change to a rank of PS 1, we plan to further parse quarterly monitoring information to see if invasive plants are a threat at specific sites or if weeds presence is otherwise innocuous. From this additional analysis, we plan to develop further management actions for *A. peruvianum* var. *insulare*.

We have made progress towards genetic conservation targets for *A. peruvianum* var. *insulare*. Although we made only 1 collection this reporting period, the propagule bank contains 119 blades each with multiple fertile sori attached. We attempted to propagate *A. peruvianum* var. *insulare* from spores, but no gametophytes were in evidence by September 2019. Past attempts to propagate ferns were successful, but since the propagation records are not available, we are not sure of the propagation methods used and if the propagules were cuttings or spores.

Progress toward compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects from military activities to *A*. *peruvianum* var. *insulare*, the 2003 and 2013 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browse pressure, maintenance of genetic stock *ex situ*, outplanting, reproduction *in situ*, non-native plant control, annual monitoring, and protection from construction activities and/or genetic recovery of affected species.

To address these conservation measures for *A*. *peruvianum* var. *insulare*, we implement landscape-level projects to reduce fire risk and ungulate browse for all known *A*. *peruvianum* var. *insulare* individuals at PTA (see Section 1.3). In addition, we actively conserve *A*. *peruvianum* var. *insulare* genetics; the propagule bank contains 119 blades from the natural population and 492 blades from individuals grown in the greenhouse. To date, we have outplanted 48 ferns at 3 ASRs (201, 218, and 219). As of 2016, 18 outplanted ferns survived and we observed recruitment of 4 ferns at ASR 218. Propagation and finding suitable outplanting sites remain limiting factors for this species. We have not implemented weed control buffers specifically for *A*. *peruvianum* var. *insulare* (Table 63). Between 2016 and 2019, we documented *in situ* reproduction at 17 of the 43 (40%) quarterly monitoring plots. Although we monitor *A*. *peruvianum* var. *insulare* quarterly to assess population patterns, we are unable to attribute changes in numbers to effects from training or management.

For a discussion regarding how ongoing management benefits Army operations at PTA and the importance of continuing management efforts, see the final summary discussion for the Botanical Program (Section 2.6).

2.4.2 *Isodendrion hosakae* (Endangered)

As a PS 1, we monitor all known *I. hosakae* individuals each quarter. For genetic conservation, *I. hosakae* is an implementation priority 1 (high). We plan to collect propagules for storage and propagation and to outplant to augment the existing population and to establish new populations.

Plant surveys

No locations of *I. hosakae* were recorded during the reporting period. This outcome is not surprising since we did not survey within the known distribution of this species.

From previous survey work (2011 to 2015), there were 42 locations of *I. hosakae* at PTA. The abundance of this species is tracked quarterly and reported below. The distribution for *I. hosakae*, including outplanting sites, is shown in Figure 14.

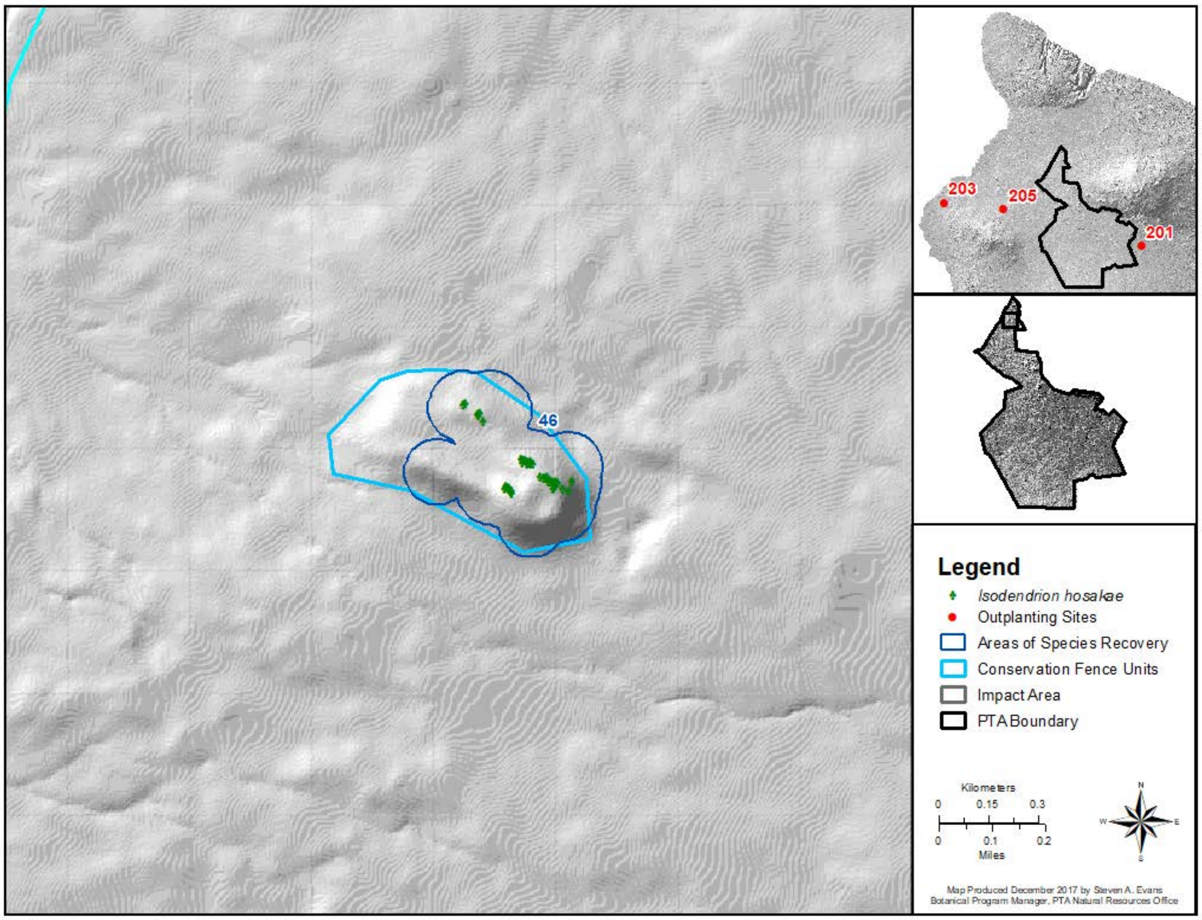

Figure 14. Current known distribution and outplanting sites for *Isodendrion hosakae*

[a] Distribution data were collected between 2011 and 2015.

Priority Species 1 Monitoring

We monitored *I. hosakae* over 9 census periods between April 2016 and September 2019. Overall, the numbers of juvenile and adult *I. hosakae* increased between the first and last census period (Figure 15). Larger flushes of seedlings were present between April and June 2018 and between January and March 2019. The flush between January to March 2019 preceded an increase in juveniles and adults in the final 3 census periods.

We use a modified approach to monitor *I. hosakae* and did not collect the same threats data as for other PS 1 species. All known *I. hosakae* locations are protected by ungulate exclusion fence and we control invasive plants around all individuals. Observed threats included erosion on steep slopes where some *I. hosakae* are located and anecdotal reports of water stress.

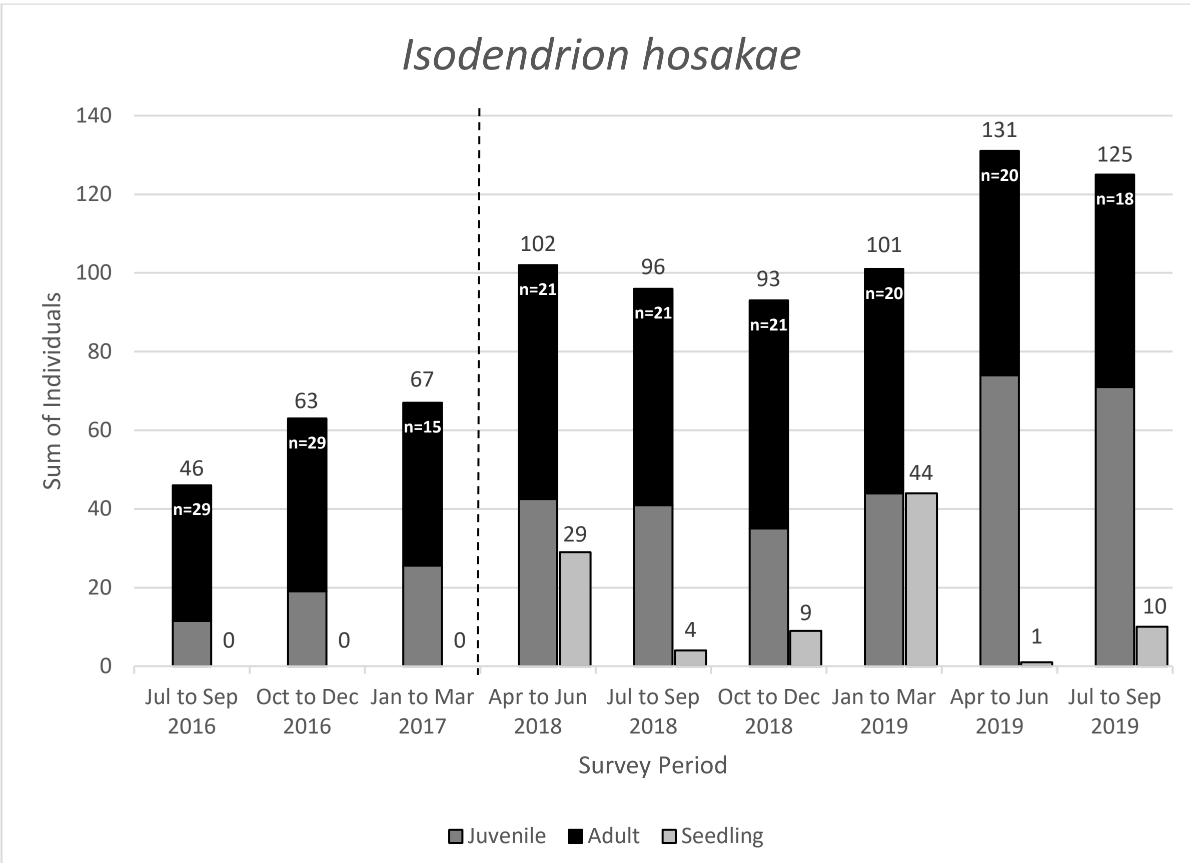

Figure 15. Monitoring results for *Isodendrion hosakae* from April 2016 through September 2019[a]

[a] For census periods left of the dotted line, we estimated life stage composition using proportion and to the right we counted each plant present by life stage (n=number of plots read).

Genetic Conservation

Propagule Collection

We aim to collect from all known extant, reproductive *I. hosakae* individuals. To this end, we collected a total of 1,079 seeds representing 40 founders during the reporting period. In addition, we collected a total of 6 cuttings, 3 cuttings from each of 2 founders. Currently, several founders in storage are no longer extant in the field. Please refer to Table 8 for a complete summary of genetic conservation status for *I. hosakae*.

Propagation

Propagation records between October 2017 and July 2018 were incomplete or missing and do not align with the greenhouse accession records and plants in the facility. The greenhouse accession records indicate that seed from 5 founders collected in 2009 was propagated and 15 seedlings grew to sufficient size to be transferred to 4-inch pots and accessioned to the greenhouse (Table 16). Based on the dates of the greenhouse accessions (6 February 2019), the cuttings were likely propagated in early 2018.

In addition, 1 seed accession was missing from the propagule bank for each of 7 founders. All the missing seeds were collected in 2009. Due to the lack of propagation records, we are not certain if these seeds were not viable and were removed from storage or if propagation attempts yielded no seedlings. We aim to improve tracking processes to better track seed withdrawals from the seed bank.

Table 16. *Isodendrion hosakae* accessioned to the greenhouse without propagation records as of September 2019

New Founder No.	Other Founder No.	Date Accessioned to Greenhouse	Greenhouse Accession No.
None	130720X1	2/6/2019	130
None	13072000	2/6/2019	127, 128 (NF)
None	130720A2001	2/6/2019	129
None	130720G1003	2/6/2019	116,117,118 (D), 119, 120 (D)
None	130720H1001	2/6/2019	121 (D), 122, 123, 124, 125 (D), 126

NF, Not found; D, Dead at last greenhouse monitoring

After August 2018, more detailed propagation records were kept (Table 17). We attempted 40 germination trials and sowed 443 seeds. We anticipated that seeds would germinate at different rates and some would not germinate at all due to natural variation and quality among seeds in an accession. To better understand the range of time some seeds need to germinate, we monitored some germination trials for several months and recorded germination up to 279 days after seeds were sown. However, we cannot easily discern germination patterns for *I. hosakae* from the data. Some accessions from 2009 had 100% germination in as little as 28 days and some accessions from 2018 took 128 days to reach 100% germination. Based on this preliminary information, we need to know more about seed characteristics prior to sowing and the influence of these characteristics on germination outcomes. Without more basic information about seed quality and viability, we will likely continue to experience variability in seed germination success.

Germination success from seed for *I. hosakae* was 52% for germination trials with known outcomes and 223 seedlings were reported. Although some seedlings propagated in 2019 may still be growing and are not large enough to be accessioned to the greenhouse, 49 *I. hosakae* propagated since August 2018 were accessioned to the greenhouse. These plants will be held in the greenhouse until a planting plan is developed and approved by the Army.

Table 17. Seed germination trials for *Isodendrion hosakae* August 2018 through September 2019

New Founder No.	Other Founder No.	Prop. Accession	Media	Seed Treatment	Trial Days	No. Seed Sown	No. Seeds Germ.	% Germ.	No. plants GH Acc.
502-1802-028-007	None	2018031	V + GHM	None	182	14	13	93%	0
502-1802-028-008	None	2018030	V + GHM	1d HW Soak	189	7	4	57%	0
502-1802-033-100	None	2018033	V + GHM	None	110	21	14	67%	4
502-1802-033-101	None	2018029	V + GHM	None	279	17	2	12%	1
502-1802-069-001	None	2018032	V + GHM	None	182	8	8	100%	0
502-1802-101	130460C1007	2018022	V + GHM	1d HW Soak	226	8	1	13%	0
502-1802-101	13046C1004	2018023	V + GHM	None	182	3	1	33%	0
502-1802-101	13046C1005	2018024	V + GHM	1d HW Soak	226	18	1	6%	0
502-1802-105	130720I1001	2009029	Filter paper	None	91	12	9	75%	
502-1802-105	130720I1001	2009029	Filter paper	100ppm GA3	56	12	11	92%	0
502-1802-105	130720I1014	2009030	V + GHM	None	132	21	5	24%	0
None	130720N1014	2009002	Filter paper	None	64	9	7	78%	
None	130720N1014	2009002	Filter paper	100ppm GA3	56	9	3	33%	0
None	130720Q1002	2009003	V + GHM	1d HW Soak	238	12	5	42%	0
None	130720G1004	2009004	V + GHM	None	201	26	20	77%	19
None	130720F1001	2009005	V + GHM	None	132	15	5	33%	4
None	130720L1007	2009006[a]	Filter paper	None	0	17	0	0%	0
None	130720B1041	2009007	Filter paper	None	25	12	0	0%	0
None	130720B1056	2009009	Filter paper	None	91	9	3	33%	0
None	130720O1010	2009013	Filter paper	None	64	4	2	50%	0
None	130720P1037	2009015	Filter paper	None	99	13	9	69%	
None	130720P1037	2009015	Filter paper	50ppm GA3	31	13	10	77%	
None	130720P1037	2009015	Filter paper	100ppm GA3	31	13	13	100%	0
None	130720X1021	2009016	V + GHM	None	132	13	7	54%	7
None	130720B1016	2009018	Filter paper	None	64	5	5	100%	0
None	130720J1003	2009036	Filter paper	None	99	8	8	100%	0
None	130720L1006	2009039	Filter paper	None	100	14	2	14%	0
None	130720N1011	2009042	V + GHM	None	201	12	6	50%	4
None	130720N1015	2009043	V + GHM	1d HW Soak	201	16	5	31%	5
None	130720S1005	2009051	Filter paper	None	73	8	6	75%	2
None	130720S1004	2009052	Filter paper	None	22	2	0	0%	0
None	130720W1021	2009053	Filter paper	None	31	6	6	100%	0
None	130720X1039	2009054	Filter paper	None	80	10	9	90%	
None	130720X1039	2009054	Filter paper	100ppm GA3	28	10	10	100%	0

GA3, gibberellin A3; GH, greenhouse; GHM, greenhouse media; UNK, unknown; V, vermiculite

Table 17. Seed germination trials for *Isodendrion hosakae* August 2018 through September 2019 (cont.)

New Founder No.	Other Founder No.	Prop. Accession	Media	Seed Treatment	Trial Days	No. Seed Sown	No. Seeds Germ.	% Germ.	No. plants GH Acc.
None	130720X1034	2009056	Filter paper	None	44	9	2	22%	
None	130720X1034	2009056	Filter paper	100ppm GA3	25	8	2	25%	0
None	130720Z1025	2009062	Filter paper	None	44	7	7	100%	0
None	130720C2002	2009067	Filter paper	None	56	4	2	50%	0
None	130720B1013	2009008	UNK	UNK	0	6	0	0%	0
None	130460X11H018	2018021	UNK	UNK	161	4	UNK	--	--

GA3, gibberellin A3; GH, greenhouse; GHM, greenhouse media; UNK, unknown; V, vermiculite

We propagated 6 cuttings, 3 cuttings from each of 2 founders (502-1820-033-100, propagule accession 181023001 and 520-1820-049-101, propagule accession 181023002). Based on the propagule accession numbers for the cuttings, no plants were accessioned to the greenhouse.

Outplanting and Monitoring

We did not outplant *I. hosakae* during the reporting period. In previous years, we planted *I. hosakae* at ASRs 201, 203, 205, and 214 (Figure 14). At last monitoring in 2016, we found 29 adult and 2 juvenile outplants living and 1 juvenile plant recruited at ASR 205 (Table 18). We plan to monitor all outplanting sites in FY 2020.

Table 18. Monitoring summary for *Isodendrion hosakae* outplanted prior to FY 2018

			Surviving Outplants			Recruits	
Location	Outplanting Site	Total Outplanted	Adult	Juvenile	Net Survivorship	Adult	Juvenile
On PTA	214	7	4	2	86%	0	0
Off PTA	201	3	2	0	67%	0	0
	203	4	4	0	100%	0	0
	205	44	19	0	45%	0	1

PTA, Pōhakuloa Training Area

Discussion

Our efforts to survey, monitor, and conserve genetics for *I. hosakae* address SOO tasks 3.2(1)(a, d–f) as well as several INRMP objectives and conservation measures from the 2003 and 2013 BO.

The current distribution of *I. hosakae* is scattered and patchy across approximately 7 ha on Puʻu Pāpapa (Figure 14). The distribution of *I. hosakae* has contracted since 1982 when it was reported from three cinder cones in South Kohala (Cuddihy et al. 1982). Two of these cinder cones, Puʻu Pāpapa and Puʻu Nohona o Hae, were purchased by the Army in 2006 as part of the Keʻāmuku Maneuver

Area. In addition to range contraction, the population of *I. hosakae* has declined from 870 individuals in 2002 to 46 individuals in 2016 (a 95% reduction). Although this decline is extreme, similar population declines followed by rebounds have been recorded in the past (see Section 2.2.4). Over the last 36 years, the *I. hosakae* population has experienced large fluctuations in the number of plants present (25 to 870). Because we have been using consistent methods to count individuals for a relatively short period of time (2016 to 2019), we cannot accurately discern natural fluctuations in population size from a precipitous decline. Although such declines are concerning and warrant management attention, swings in population numbers may be a natural response of this species to environmental conditions. Future monitoring strategies will seek to address these questions.

The number of *I. hosakae* more than doubled between April 2016 and September 2019, but abundance is still low with 125 individuals (juveniles and adults) reported during the final census period (August to September 2019). Life history characteristics of *I. hosakae* are poorly understood and nothing is known about growth rates, age at reproductive maturity, or longevity of plants in the natural population (USFWS 1994). Although our monitoring was not designed to directly track transition from one life stage to another, we did consistently record juveniles and adults present and we documented several flushes of seedlings. In addition, patterns in the quarterly count numbers suggest that plants are transitioning from seedlings to juvenile and adult life stages. Nothing is known about *I. hosakae* population structures that support healthy and resilient populations (USFWS 1994). We do not know which, if any, of the life stages is most vulnerable and/or may regulate population sustainability. Knowing these life history attributes is important for designing management actions to maximize the likelihood that *I. hosakae* will persist, and potentially increase in abundance, especially with changing climate conditions. We recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species.

Because of the low numbers and limited distribution of *I. hosakae*, we recommend augmenting the natural population with outplants and establishing new populations away from Puʻu Pāpapa. We recommend planting enough *I. hosakae* to establish at least 25 new individuals at the natural plants (preferably from founders no longer extant at the site) and 50 individuals for new sites.

We continue to make progress with genetic conservation of *I. hosakae*. Many of the accessions in storage were collected in 2009 and are aging. We do not know how aging affects the viability of the seed, but we had moderate germination success from older seed lots in 2019 (Table 17). Germinating these seeds is critical to conserving genetics because many of the founders are no longer extant and as the seeds age we may have less success recovering these genetics via seed propagation. During FY 2018-2019, we collected propagules from 28 founders, which is about 25% of our goal to collect from all individuals in the populatin (n=125). There are 144 *I. hosakae* accessioned to the greenhouse. In 2020, we plan to complete a planting plan focused on Puʻu Pāpapa and *I. hosakae.*

Progress toward compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects from military activities to *I. hosakae*, the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browse pressure, maintenance of genetic stock *ex situ*, outplanting, reproduction *in situ*, non-native plant control, and annual monitoring.

To address these conservation measures for *I. hosakae*, we implement landscape-level projects to reduce fire risk and ungulate browse for all known individuals at PTA (see Section 1.3). In addition, we actively conserve *I. hosakae* genetics; the propagule bank contains 2,974 seeds from the natural population. To date, we have outplanted 58 individuals at 4 ASRs (201, 203, 205, and 214). In 2016, 31 outplanted adults and juveniles were alive and we observed recruitment of 1 plant at ASR 205. In 2018, we implemented an extensive weed control project specifically designed to minimize negative impacts to *I. hosakae* from rapid changes in environmental conditions that can result from grass removal. Non-native plants are controlled in approximately 2.6 ha for *I. hosakae* (Table 62). Between 2016 and 2019, we documented *in situ* reproduction at 1 of the 36 (3%) quarterly monitoring plots. Although we monitor *I. hosakae* quarterly to assess population patterns, we are unable to attribute changes in numbers to effects from training or management.

For a discussion regarding how ongoing management benefits Army operations at PTA and the importance of continuing management efforts, see the final summary discussion for the Botanical Program (Section 2.6).

2.4.3 *Kadua coriacea* (Endangered)

As a PS 1, we monitor all known *K. coriacea* individuals each quarter. For genetic conservation, *K. coriacea* is an implementation priority 2 (high). We plan to collect propagules for storage and propagation and to outplant to augment the existing population and to establish new populations.

<u>Plant surveys</u>

During the reporting period, we found 38 locations of *K. coriacea* representing at minimum 41 individuals. Because we are still surveying the full set of transects, our findings represent progress for the reporting period and do not represent actual changes in species abundance or distribution.

From previous survey work (2011 to 2015), there were 119 locations of *K. coriacea* at PTA. The abundance of this species is tracked quarterly and reported below. The distribution for *K. coriacea*, including outplanting sites, is shown in Figure 16.

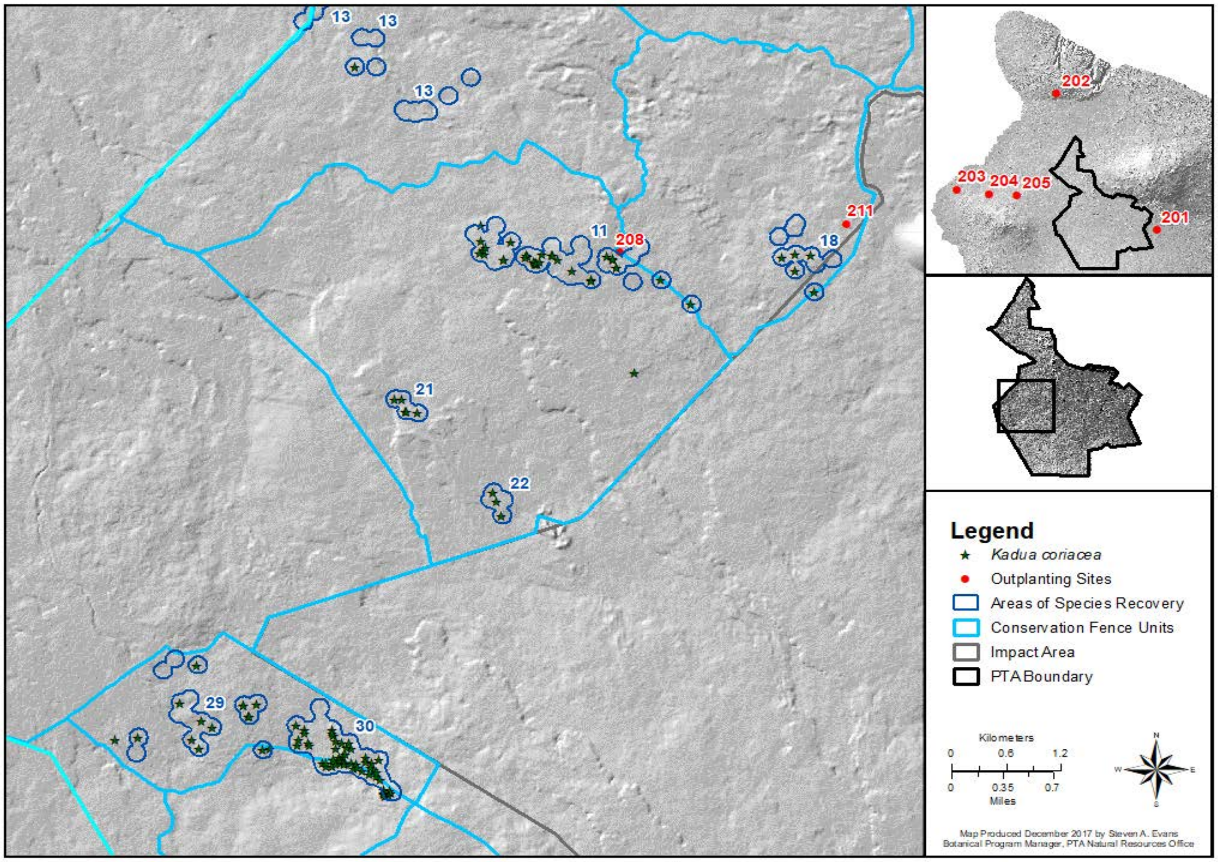

Figure 16. Current known distribution and outplanting sites for *Kadua coriacea*[a]

[a] Distribution data were collected between 2011 and 2015

Priority Species 1 Monitoring

We counted *K. coriacea* individuals over 8 census periods between April 2016 and September 2019. The number of plants remained relatively stable over the census periods with slight fluctuations in the number of juveniles present (Figure 17). We observed very little natural recruitment for *K. coriacea,* and most individuals are mature adults that have been alive for over 15 years.

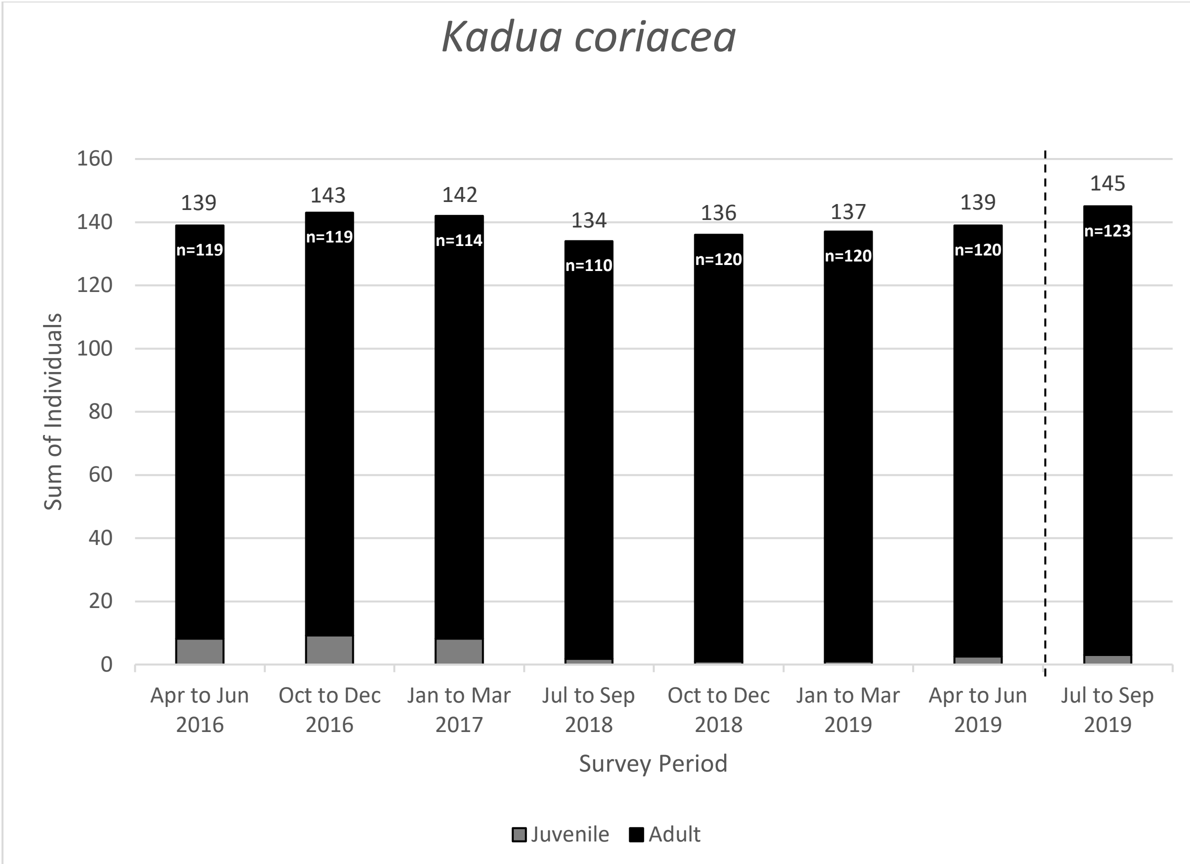

Figure 17. Monitoring results for *Kadua coriacea* from April 2016 through September 2019[a]

[a] For census periods left of the dotted line, we estimated life stage composition using proportion and to the right we counted each plant present by life stage (n= number of plots read).

We visually assessed threats at every plot each census period. We pooled all threat detections for every *K. coriacea* monitoring plot for the period of July 2018 through September 2019. Over this time, we made 596 visits to the monitoring plots and detected threats on 56 visits (Figure 18). Water stress was the most frequently recorded threat to *K. coriacea* (39 out of 56 threat detections).

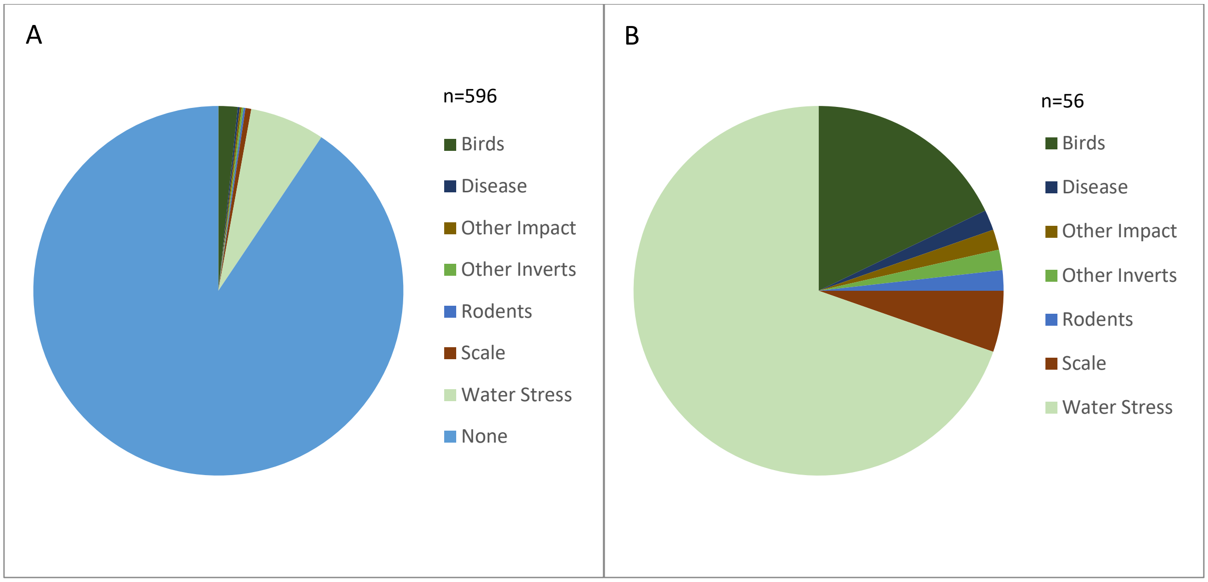

Figure 18. Emerging threats to *Kadua coriacea* recorded between July 2018 and 2019[a]

[a] Data are pooled for all *K. coriacea* monitoring plots for all monitoring periods. We made a total of 596 visits to the monitoring plots during this time period and threats were present on 56 occasions. Panel A shows the threats recorded for every plot visit (n=596). Panel B shows the frequency each threat was recorded for every plot visit when threats were detected (n=56).

Genetic Conservation

Propagule Collection

We aim to collect from all known extant, reproductive *K. coriacea* individuals. To this end, we collected a total of 28,474 seeds representing 68 founders during the reporting period. We collected a total of 2 cuttings, 1 from each of 2 founders.

Currently, several founders in storage are no longer extant in the field and we are exploring options to propagate the propagules of these founders and return their genetics to natural populations over the next 3 to 5 years. Please refer to Table 8 for a complete summary of genetic conservation status for *K. coriacea.*

Propagation

Propagation records between October 2017 and July 2018 were incomplete or missing and do not align with the greenhouse accession records and plants in the facility. The greenhouse accession records indicate that seed from 5 *K. coriacea* founders was propagated and 231 seedlings grew to sufficient size to be transferred to 4-inch pots and accessioned to the greenhouse. Of these, 10 died, 201 were outplanted, 15 remain in the greenhouse, and 4 were not located during the inventory (Table 19). Based on the dates of the greenhouse accessions (6 February 2019), the cuttings were likely propagated in early 2018.

Table 19. ***Kadua coriacea*** **accessioned to the greenhouse without propagation records as of September 2019**

New Founder No.	Other Founder No.	Date Accessioned to Greenhouse	Greenhouse Accession No.	Accessions in Greenhouse
516-2283-019-001	06018001001	2/6/2019	291-319	297 (D), 303
517-1881-006-001	05021006001	2/6/2019	233-290	233, 241, 242, 245, 252, 258, 281
520-1577-009-001	03029009001	2/6/2019	320-332	320(D), 323, 328(D), 329
521-1776-001-001	02030001001	2/6/2019	24-27, 29-44, 47-53, 55-60, 62, 63, 65-87, 334, 345, 350, 363, 382 986,969	86 (D) 334, 345, 350, 363, 382
521-1776-001-002	02030001002	2/6/2019	28, 45,46, 54, 61, 64, 333,335-344, 346-349, 351-381, 383-397	337 (NF), 346 (D), 355 (D), 366 (NF), 368 (D), 375 (D) 378 (NF)

NF, Not found at last greenhouse monitoring; D, Dead at last greenhouse monitoring

Note: All *Kadua coriacea* greenhouse accessions were outplanted in 2019 unless the number is listed in the last column.

After August 2018, more detailed propagation records were kept (Table 20). We attempted 17 germination trials and sowed over 545 seeds from 17 founders. We ranged between 17 and 100 seeds per germination trial. We anticipated that seeds would germinate at different rates and some would not germinate at all due to natural variation and quality among seeds in an accession. The percent germination for trials with known outcomes was moderate to high (44% to 100%). Germination appeared to increase with the number of days after sowing the seed. The lowest percent germination also corresponded to the fewest days seeds had to germinate.

From the germination trials with known inputs and outcomes, overall germination success was 71% (323 seedlings from 452 seeds sown). As of September 2019, none of the seeds sown after August 2018 were large enough be accessioned to the greenhouse and there were 16 *K. coriacea* accessioned in the greenhouse. In addition, there were over 100 seedlings in the greenhouse that were germinated without propagation records; however, none of these seedlings were large enough to accession to the greenhouse.

The number of plants that grew large enough to be accessioned to the greenhouse was low compared to the number of seedlings germinated. This result is similar to past work at PTA with *K. coriacea*. Previously we achieved good germination success, but seedling mortality exceeded 50% (USAG-HI 2006). The surviving seedlings grew slowly and required up to 12 months before reaching a sufficient size for outplanting (USAG-HI 2006). We do not understand the underlying factors driving the poor performance of seedlings, but poor seedling performance may also influence low recruitment in the natural populations.

In October 2018, we collected 1 cutting from each of 2 founders for a total of 2 cuttings. One seedling from founder 516-2082-052-001 was accessioned to the greenhouse.

Table 20. Seed germination trials for *Kadua coriacea* August 2018 through September 2019

New Founder No.	Other Founder No.	Prop. Accession	Media	Seed Treatment	Trial Days	No. Seed Sown	No. Seeds Germ.	% Germ	No. plants GH Acc.
516-2282-004-001	060618002001	181022001	Filter paper	GC	54	100	70	70%	4
517-1982-037-001	05011037001	2013057	Filter paper	GC	44	35	35	100%	4
520-1577-002-001	03029002001	2004002	Filter paper	GC	65	35	25	71%	1
520-1677-094-001	03030094001	181119015	Filter paper	GC	67	50	32	64%	3
520-1776-025-001	Unclear	181105017	UNK	UNK	174	60	UNK	--	0
520-1776-089-001	03030089001	2009131	Filter paper	GC	55	35	17	49%	0
None	IG 000	2002001	UNK	UNK	UNK	UNK	UNK	UNK	42
None	99604001001	2014001	Filter paper	GC	44	20	20	100%	3
None	99604003001	2014003	Filter paper	GC	41	20	9	45%	0
None	99604004001	2014004	Filter paper	GC	55	20	16	80%	1
None	99604005001	2014005	Filter paper	GC	49	20	10	50%	1
None	99604006001	2014006	Filter paper	GC	65	17	15	88%	2
None	99604007001	2014007	Filter paper	GC	65	25	21	84%	2
None	99604007002	2014008	Filter paper	GC	55	25	21	84%	1
None	99604008001	2014009	Filter paper	GC	65	25	21	84%	1
None	99604009001	2014010	Filter paper	GC	65	25	11	44%	0
Unclear	021776004001	2016051	UNK	UNK	161	33	UNK	--	0

GC, growth chamber; GH, greenhouse; UNK, unknown

Outplanting and Monitoring

We planted 107 *K. coriacea* at 8 sites on PTA and 94 plants, representing 5 founders, in the interpretive garden near the natural resources program buildings on cantonment (See Section 2.3.4). Four sites were located in TA 22 and 23 near existing natural *K. coriacea* populations. Sites 2019 Temp 006-009 are all clustered within TA 21. Although TA 21 is outside the known or modeled distribution of *K. coriacea*, it allows us to evaluate this species' performance at higher elevations. In the past, we attempted high elevation plantings at Puʻu Huluhulu (ASR 201), but no outplanted individuals remained at the last monitoring in 2016 (Figure 16 and Table 21).

Our greenhouse inventory indicates that 204 *K. coriacea* were outplanted, but our outplanting records account for only 201 outplants. It is likely that the 3 other plants were planted in the PTA Interpretative garden.

In previous years, we planted *K. coriacea* at ASRs 201, 202, 203, 204, 205, 208 and 211 (Figure 16). At last monitoring in 2016, we found 60 adult outplants living and we documented recruitment of 2 adult and 3 juvenile plants at ASR 205 (Table 21). We plan to monitor all outplanting sites in FY 2020.

Table 21. Monitoring summary for *Kadua coriacea* outplanted prior to FY 2018

Location	Outplanting Site	Total Outplanted	Surviving Outplants Adult	Surviving Outplants Juvenile	Surviving Outplants Net Survivorship	Recruits Adult	Recruits Juvenile
On PTA	208	5	0	0	0%	0	0
	211	20	1	0	5%	0	0
Off PTA	201	75	0	0	0%	0	0
	202	63	0	0	0%	0	0
	203	19	3	0	16%	0	0
	204	85	1	0	1%	0	0
	205	316	55	0	17%	2	3

PTA, Pōhakuloa Training Area

Discussion

Our efforts to survey, monitor, and conserve genetics for *K. coriacea* address SOO tasks 3.2(1)(a, d-f) as well as several INRMP objectives and conservation measures from the 2003 and 2013 BO.

Kadua coriacea is found in the *Metrosideros* woodlands on the west side of the installation and found in the *Kadua coriacea*, Nāʻōhuleʻelua, and Kīpuka Kālawamauna East and West Fence Units (Figure 16). The population is dominated by mature adults, many of which are 15 years or older. Reproduction *in situ* remains a problem for this species. Factors limiting natural seedling recruitment remain unknown. We have worked with University of Hawaiʻi students to investigate pollination services as limiting factors, but neither study was conclusive. Nothing is known about what *K. coriacea* population age distributions support healthy and resilient populations. In addition, we do not know which, if any, of the life stages is most vulnerable and/or may regulate population dynamics. Knowing these life history attributes is important for designing management actions to maximize the likelihood that *K. coriacea* will persist, and potentially increase, especially with changing climate conditions. We recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species.

We found a *K. coriacea* seedling in ASR 30 in March 2019. Because we have observed so few seedlings, we know very little about additional threats to young plants. To maximize survival of this seedling, we emplaced a small fence covered with netting to deter game birds. To protect against possible rodent impacts, we deployed 4 self-resetting traps (Goodnature® A24 rat + stoat traps, Goodnature Limited, Wellington, New Zealand, here after referred to at A24) at 25 m from the plant and 4 rat-sized snap traps. After a month, mice repeatedly ate the bait in the snap traps, so we removed them and deployed an additional A24. We initially deployed 4 cameras to monitor wildlife interactions with the seedling and to test camera settings. By June, we removed 3 cameras leaving a single camera aimed at the seedling.

Beginning in March 2019, we checked the seedling and serviced the traps and cameras weekly. We reduced our checks in April to once every 2 weeks, in May to monthly, and in August to quarterly. The seedling measured 13 cm in March 2019 and at last monitoring in September 2019, the plant grew to 17 cm tall with a 7 cm crown and had branched to 2 stems.

We did not detect any negative wildlife interactions with the seedling, but did record mongoose (*Herpestes javanicus*), rat (*Rattus rattus*), mouse (*Mus musculus*), Erckel's Francolin (*Pternistis erckelii)*, California Quail (*Callipepla californica*), Northern Mockingbird (*Mimus polyglottos*), and skink (*Emoia* sp.). We did not detect birds inside the small fence with netting. Rats and mice were detected inside the fence with the netting but did not interact with the seedling. We found at least 2 mouse carcasses near the A24 traps and integrated trip counters indicated that the A24 kill mechanism fired multiple times. Because scavengers often take the carcasses from the base of the A24 traps, we are uncertain how many rodents were removed from the area.

We continue to make progress with genetic conservation of *K. coriacea*. Many of the accessions in storage are aging and we do not know how aging affects the viability of the seed. Germination rates for *K. coriacea* were high, but we had less success growing seedlings to a sufficient size for accession to the greenhouse. During FY 2018–2019, we collected propagules from about 63 founders, which is about 43% of the *K. coriacea* population (n=145). There are 130 *K. coriacea* accessioned to the greenhouse. We are developing planting strategies and plan to continue investigating outplant performance and planting site characteristics in 2020 to maximize the successful establishment of new self-sustaining groupings.

Progress toward compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects from military activities to *K. coriacea*, the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browse pressure, maintenance of genetic stock *ex situ*, outplanting, reproduction *in situ*, non-native plant control, and annual monitoring.

To address these conservation measures for *K. coriacea*, we implement landscape-level projects to reduce fire risk and ungulate browse for all known individuals at PTA (See Section 1.3). In addition, we actively conserve *K. coriacea* genetics; the propagule bank contains 103,331 seeds from the natural population and 280 seeds from individuals grown in the greenhouse. To date, we have outplanted 583 individuals at several ASRs; however, only 32 individuals recruited across all sites since 2004 and only a few of those recruits survived to become reproductive. We control invasive plants at all known locations of *K. coriacea* in an area of approximately 33 ha (Table 62). We first managed invasive plants for *K. coriacea* in 2005 at 4 sites and continued to add new weed management locations as new plants were found. We have not observed *in situ* reproduction for *K. coriacea.* Although we monitor *K. coriacea* quarterly to assess population patterns, we are unable to attribute changes in numbers to effects from training or management.

For a discussion regarding how ongoing management benefits Army operations at PTA and the importance of continuing management efforts, see the final summary discussion for the Botanical Program (Section 2.6).

2.4.4 *Lipochaeta venosa* (Endangered)

As a PS 1, we monitor all known *L. venosa* individuals each quarter. For genetic conservation, *L. venosa* is an implementation priority 1 (high). We plan to collect propagules for storage and propagation and outplant to augment the existing population and to establish new populations.

Plant surveys

No locations of *L. venosa* were recorded during the reporting period. This outcome is not surprising since we did not survey within the known distribution of this species.

From previous survey work (2011 to 2015), there were 21 locations of *L. venosa* at PTA. The abundance of this species is tracked quarterly and reported below. The distribution for *L. venosa*, including outplanting sites, is shown in Figure 19. This species is restricted to a single pu'u at PTA.

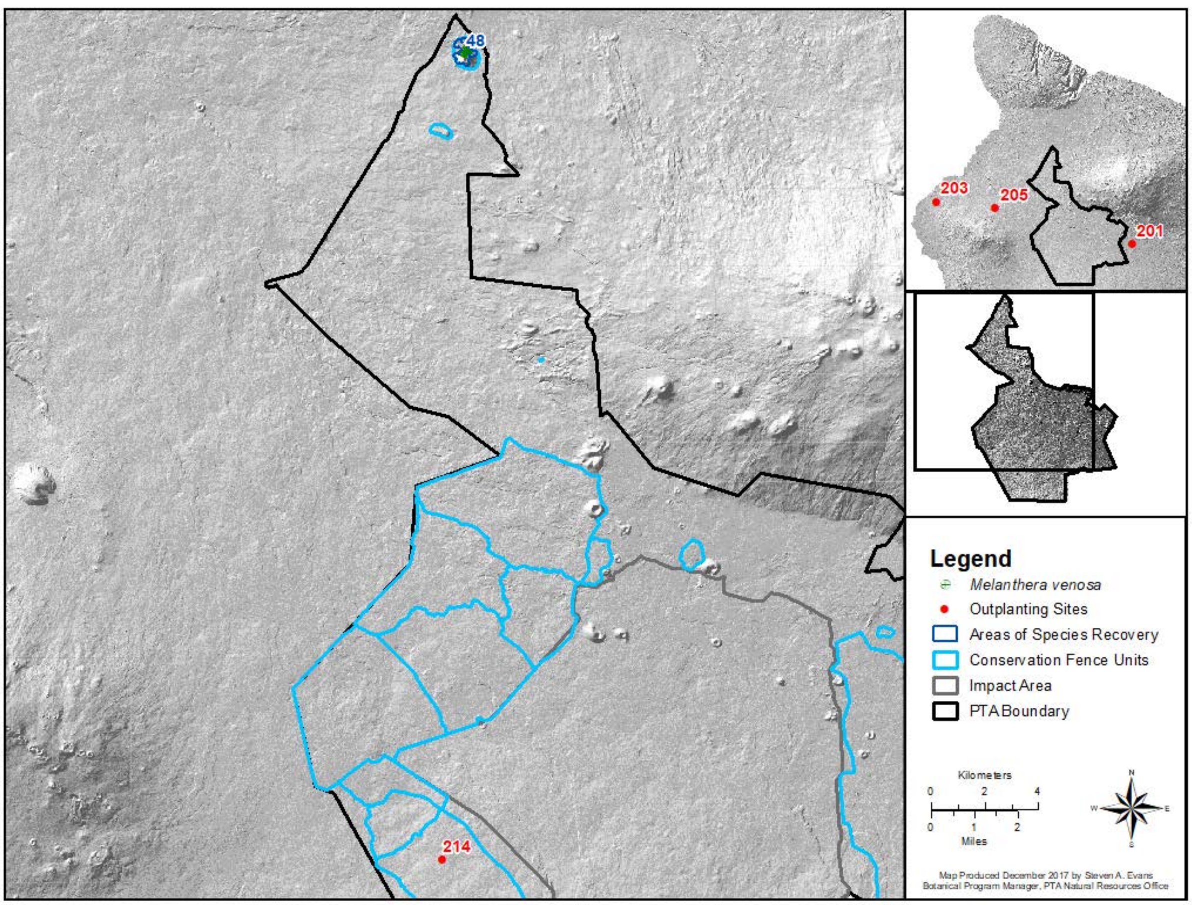

Figure 19. Current known distribution and outplanting sites for *Lipochaeta venosa*[a]

[a] Distribution data were collected between 2011 and 2015

Priority Species 1 Monitoring

We counted all known *L. venosa* individuals over 9 census periods between April 2016 and September 2019. Although there is some fluctuation in the number of adults present over the census periods, changes in the numbers of juveniles appears to drive overall fluctuations in abundance (Figure 20). Between January and March 2017, a large number of juvenile plants recruited; following this event, the number of adult plants present in the population remained higher from April 2018 through September 2019 compared to the number of adults present prior to January 2017. Seedlings were only observed between April 2018 and December 2018 and between July 2019 and September 2019. The seedling flushes do not appear to significantly influence the numbers of adults and juveniles present in subsequent census periods.

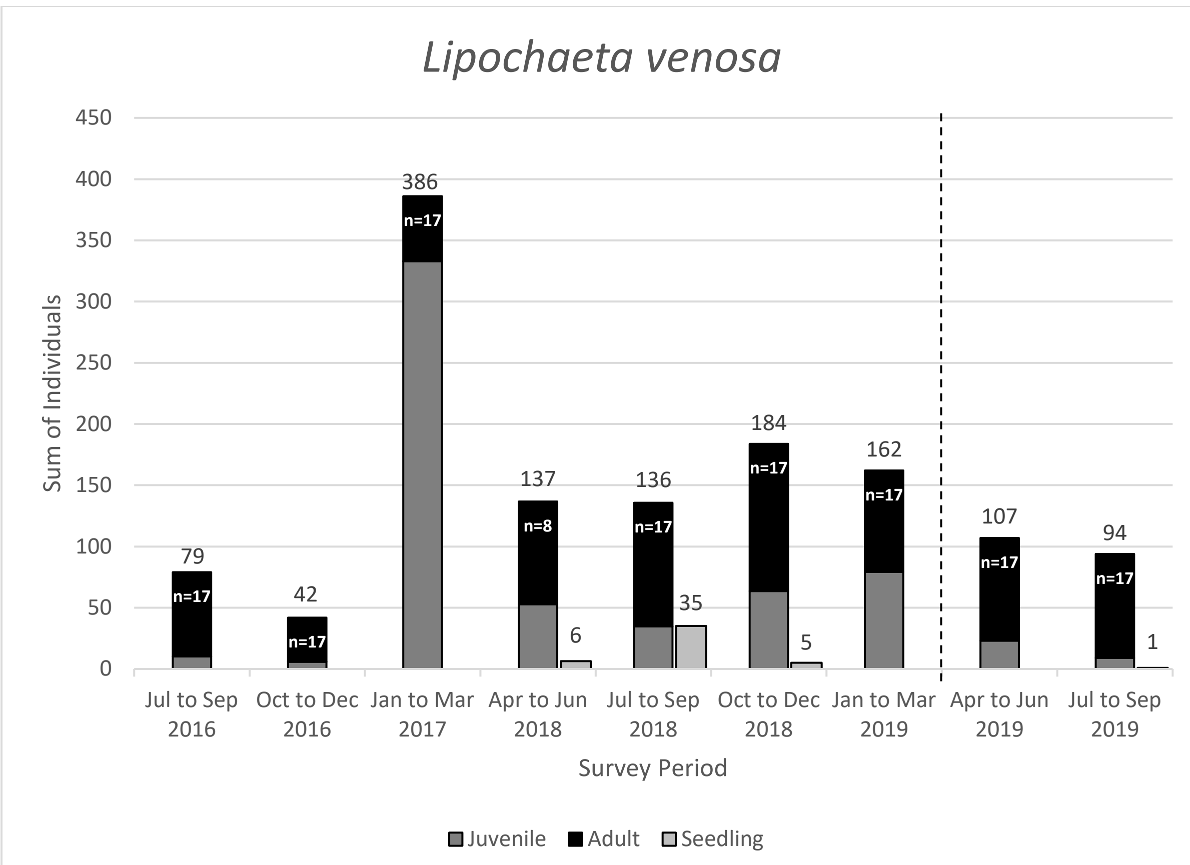

Figure 20. Monitoring results for *Lipochaeta venosa* from April 2016 through September 2019[a]

[a] For census periods left of the dotted line, we estimated life stage composition using proportion and to the right we counted each plant present by life stage (n= number of plots read). For census periods right of the dotted line, totals may include count class data. When this occurs the minimum value of the count class is summed with the counts from other plots to provide the total value for abundance. Therefore, these numbers represent the minimum number of individuals present during the census period.

We visually assessed threats at every plot each census period. We pooled all threat detections for every *L. venosa* monitoring plot for the period of July 2018 through September 2019. Over this time, we made 77 visits to the monitoring plots and detected threats on 18 visits (Figure 21). Water stress was the most frequently recorded threat to *L. venosa* (8 out of 16 threat detections).

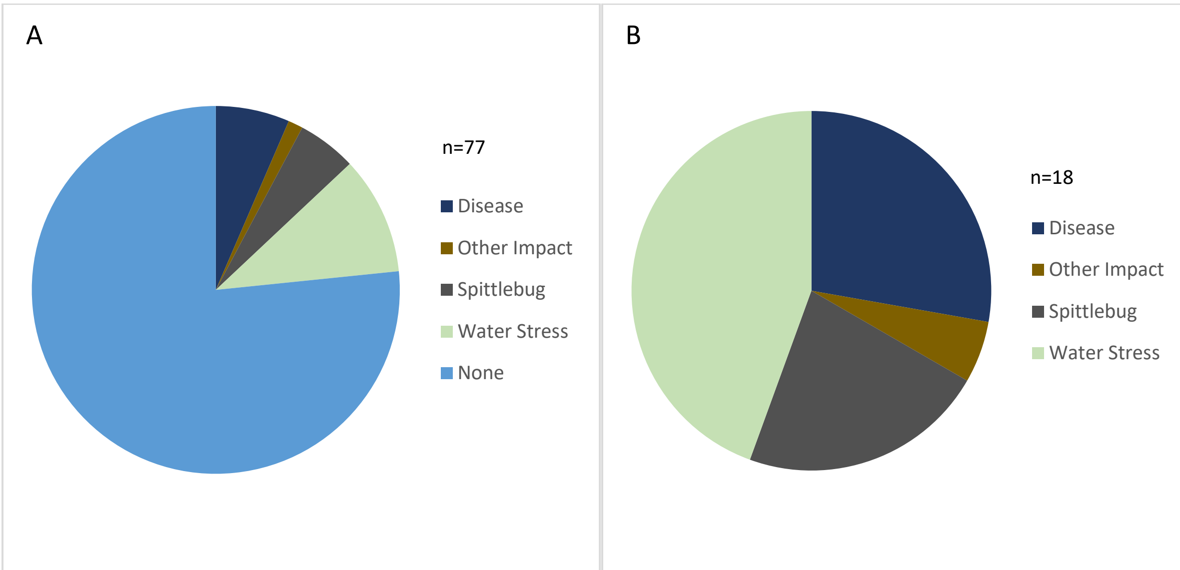

Figure 21. Emerging threats to *Lipochaeta venosa* recorded between July 2018 and 2019[a]

[a] Data are pooled for all *L. venosa* monitoring plots for all monitoring periods. We made a total of 77 vistis to the monitoring plots during this time period and threats were present on 18 occasions. Panel A shows the threats recorded for every plot visit (n=77). Panel B shows the frequency each threat was recorded for every plot visit when threats were detected (n=18).

Genetic Conservation

Propagule Collection

Because of the low abundance of this species, we aim to collect from all extant individuals in the natural population. To this end, we collected a total of 479 seeds representing 6 founders during the reporting period. In addition, we collected 93 cuttings from 23 founders (3 to 5 cuttings per founder). Please refer to Table 8 for a complete summary of genetic conservation status for *L. venosa.*

Propagation

Propagation records between October 2017 and July 2018 were incomplete or missing and do not align with the greenhouse accession records and plants in the facility. The greenhouse accession records indicate that propagules, likely cuttings, from 11 *L. venosa* founders were propagated and 37 seedlings grew to sufficient size to be transferred to 4-inch pots and accessioned to the greenhouse (Table 22). Because propagation efforts from seed for *L. venosa* in 2019 were not successful, we assume these plants were propagated from cuttings, which may also explain the lack of propagule accession numbers. Based on the dates of the greenhouse accessions (6 February 2019), the cuttings were likely propagated in early 2018.

Table 22. *Lipochaeta venosa* accessioned to the greenhouse without propagation records as of September 2019

New Founder No.	Other Founder No.	Date Accessioned to Greenhouse	Greenhouse Accession No.
501-1905-003-001	Unclear	2/6/2019	207
501-1905-015-001	Unclear	2/6/2019	208, 209
501-1905-070-001	Unclear	2/6/2019	210, 211
501-1905-115-001	Unclear	2/6/2019	**97**
501-1905-115-004	Unclear	2/6/2019	**95**
501-1905-119-001	Unclear	2/6/2019	96 (D), 212, 213
501-1905-154-001	Unclear	2/6/2019	**88, 89, 90** ,**91**,214, 215, 216
501-1905-155-001	Unclear	2/6/2019	204, 205 (D), 206
501-1905-155-002	Unclear	2/6/2019	**92, 93**, **94**, 217, 218, 219
501-1905-179-001	Unclear	2/6/2019	**98**
501-1905-189-001	Unclear	2/6/2019	99(D), **100, 101 ,102, 103, 104, 105,** 220, 221, 222

D, dead at last greenhouse inventory in 2019

Note: Bold indicates founders and accession numbers that were outplanted in 2019

After August 2018, more detailed propagation records were kept (Table 23). We attempted to propagate 18 batches of seed. The number of seeds sown from each accession varied and was determined by the number of seeds in the original accession. We ranged between 1 and 59 seeds per germination trial. We anticipated that seeds would germinate at different rates and some would not germinate at all due to natural variation and quality among seeds in an accession. However, we did not observe any germination at 133 and 158 days after the seeds were sown. Based on these preliminary results, we need to know more about seed characteristics and the influence of these characteristics on germination outcomes. Without more basic information about seed quality and viability, we may continue to get poor seed germination.

Ten accessions were removed from storage because the seed was not viable.

Table 23. Seed germination trial results for *Lipochaeta venosa* from August 2018 to September 2019

New Founder No.	Other Founder No.	Prop. Accession	Media	Seed Treatment	Trial Days	No. Seed Sown	No. Seeds Germ.	% Germ	No. plants GH Acc.
501-000-000-000	14072	190321001	Filter paper	GA3 100ppm	133	20	0	0%	0
501-000-000-000	14072	190321001	Filter paper	GA3 200ppm	133	20	0	0%	0
501-000-000-000	14072	190321001	Filter paper	GA3 300ppm	133	20	0	0%	0
501-000-000-000	14072	190321001	Filter paper	GA3 400ppm	133	20	0	0%	0
501-000-000-000	14072	190321001	Filter paper	GA3 500ppm	133	20	0	0%	0
501-000-000-000	14072	190321001	Filter paper	None	133	20	0	0%	0
501-1905-155-006	14072	190314001	Filter paper	None	156	11	0	0%	0
501-1905-155-034	14072	190314002	Filter paper	None	157	32	0	0%	0
None	14071172001	2008002	UNK	Not viable	0	12	0	0%	0
None	14071000000	2008004	UNK	Not viable	0	2	0	0%	0
None	14071157001	2008021	UNK	Not viable	0	18	0	0%	0
None	14071104001	2009002	UNK	Not viable	0	6	0	0%	0
None	14071119001	2009005	UNK	Not viable	0	25	0	0%	0
None	14071002001	2009010	UNK	Not viable	0	10	0	0%	0
None	14071003001	2009011	UNK	Not viable	0	8	0	0%	0
None	14071154001	2009012	UNK	Not viable	0	32	0	0%	0
None	14071155001	2009013	UNK	Not viable	0	8	0	0%	0
None	14071189001	2009014	UNK	Not viable	0	1	0	0%	0

GA3, gibberellin A3; GH, greenhouse; UNK, unknown

We propagated 91 cuttings from 24 founders. Of these cuttings, 5 cuttings from 4 founders survived to sufficient size to be accessioned to the greenhouse (Table 24).

Table 24. *Lipochaeta venosa* cuttings accessioned to the greenhouse

New Founder No.	Other Founder No.	Date of Cutting	Prop. Accession No.	Greenhouse Accession. No.
501-1905-112-002	Unclear	10/17/2018	181017002	398, 399
501-1905-155-059	Unclear	10/17/2018	181017005	400
501-1905-155-103	Unclear	03/14/2019	190314005	1245
501-1905-155-023	Unclear	11/19/2018	181119009	1246

Outplanting and Monitoring

We planted 15 *L. venosa* on Puʻu Pāpapa in the Keʻāmuku Maneuver Area in 2019. The plants represented 6 founders. Although historically known from Puʻu Pāpapa, *L. venosa* has had not been found on the cinder cone since 2002 (Arnett 2002). Reintroduction of *L. venosa* to Puʻu Pāpapa was established as a goal in the *Genetic Conservation and Outplanting Plan* (CEMML 2017).

In previous years, we planted *L. venosa* at ASRs 201, 203, 205, and 214. Except for the plantings at ASR 205 (Puʻu WaʻaWaʻa), as of 2016 all outplants were dead (Table 25). At ASR 205, the plants established well and grew so intertwined we could not accurately count the number of individuals present.

Table 25. Monitoring summary for *Lipochaeta venosa* outplanted prior to FY 2018

			Surviving Outplants			Recruits	
Location	Outplanting Site	Total Outplanted	Adult	Juvenile	Net Survivorship	Adult	Juvenile
On PTA	214	1	0	0	0%	0	0
Off PTA	201	2	0	0	0%	0	0
	203	28	0	0	0%	0	0
	205	234	Present	--	--	--	--

PTA, Pōhakuloa Training Area

Discussion

Our efforts to survey, monitor, and conserve genetics for *L. venosa* address SOO tasks 3.2(1)(a, d–f) as well as several INRMP objectives and conservation measures from the 2003 and 2013 BO.

Lipochaeta venosa is restricted to 0.5 ha on Puʻu Nohona o Hae in the KMA. Since 2002, the *L. venosa* population has declined and its distribution contracted. Prior to 2002, *L. venosa* was believed to be present on 6 puʻu in Parker Ranch lands including Puʻu Nohona o Hae and Puʻu Pāpapa (Arnett 2002). In 2002, *L. venosa* was estimated at 1,250 plants on Puʻu Nohona o Hae and no plants were found on Puʻu Pāpapa (Arnett 2002). Since 2002, *L. venosa* decreased by 97% to 42 plants in 2017 (Figure 19). Additionally, the distribution on Puʻu Nohona o Hae contracted from 225 ha to 0.5 ha (99%).

The plants known from PTA are believed to represent a large proportion of the statewide population and are the only natural plants occurring on public lands and that are actively managed with public funds. The limited distribution and low population number make managing the threats to this species extremely important to ensure its continued existence on Puʻu Nohona o Hae.

In response to the decline, in 2016 we initially removed *Cenchrus setaceus* from about 1.7 ha in ASR 48 on Puʻu Nohona o Hae to reduce resource competition, to improve community structure, and to promote favorable microsite conditions likely to support the persistence of *L. venosa*. Following grass removal and a period of increased precipitation, the common native species increased in size and we observed recruitment of common native plants from the seed bank. In addition, *L. venosa* numbers increased coincidentally with the pulse in moisture. The number of extant adults was relatively stable for FY 2017–2019 (census periods 5 through 9 in Figure 20).

Little is known about *L. venosa* population age distributions that support healthy and resilient populations. In addition, we do not know which, if any, of the life stages is most vulnerable and/or may regulate population dynamics. Knowing these life history attributes is important for designing management actions to maximize the likelihood that *L. venosa* will persist, and potentially increase, especially with changing climate conditions. We recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species.

We continue to make progress with genetic conservation of *L. venosa*; however, many of the accessions we attempted to germinate in 2019 had no viable seed. In addition, none of the seed sown germinated. Based on this preliminary information, we need to know more about seed characteristics prior to sowing and the influence of these characteristics on germination outcomes. Without more basic information about seed quality and viability, we will likely continue to experience variability in seed germination success. During FY 2018–2019, we collected seeds from about 28 founders and cuttings from at least 23 founders and up to 38 founders. There are 30 *L. venosa* accessioned to the greenhouse. We are developing planting strategies and plan to continue investigating outplant performance and planting site characteristics in 2020 to maximize the successful establishment of new self-sustaining groupings.

Progress toward compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects from military activities to *L. venosa,* the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browse pressure, maintenance of genetic stock *ex situ*, outplanting, reproduction *in situ*, non-native plant control, and annual monitoring.

To address these conservation measures for *L. venosa*, we implement landscape-level projects to reduce fire risk and ungulate browse for all known individuals at PTA (See Section 1.3). In addition, we actively conserve *L. venosa* genetics; the propagule bank contains 336 seeds from the natural population and 37 seeds from individuals grown in the greenhouse. In 2019, we planted 15 *L. venosa* on Puʻu Pāpapa, representing 6 founders. In addition, prior to 2019, we outplanted 265 individuals at 4 ASRs, but *L. venosa* has only persisted at ASR 205 (Puʻu Waʻawaʻa) where it has spread vegetatively to cover large areas. We consider this group of *L. venosa* to be self-sustaining because of its persistence, the suite of founders planted, and successful vegetative reproduction. We continue weed management in ASR 48 (Table 62). Between 2016 and 2019, we observed *in situ* reproduction in 6 of 17 (35%) monitoring plots for *L. venosa.* Although we monitor *L. venosa* quarterly to assess population patterns, we are unable to attribute changes in numbers to effects from training or management.

For a discussion regarding how ongoing management benefits Army operations at PTA and the importance of continuing management efforts, see the final summary discussion for the Botanical Program (Section 2.6).

2.4.5 *Neraudia ovata* (Endangered)

As a PS 1, we monitor all known *N. ovata* individuals each quarter. For genetic conservation, *N. ovata* is an implementation priority 3 (moderate). We plan to collect propagules for storage and propagation and to outplant judiciously to establish new populations.

<u>Plant surveys</u>

During the reporting period, we did not find any natural occurrences of *N. ovata.* This outcome is not surprising since we did not survey within the known distribution of this species. However, we did encounter 1 outplanted location representing 2 *N. ovata* individuals.

From previous survey work (2011 to 2015), there were 16 locations of *N. ovata* at PTA. The abundance of this species is tracked quarterly and reported below. The distribution for *N. ovata*, including outplanting sites, is shown in Figure 22.

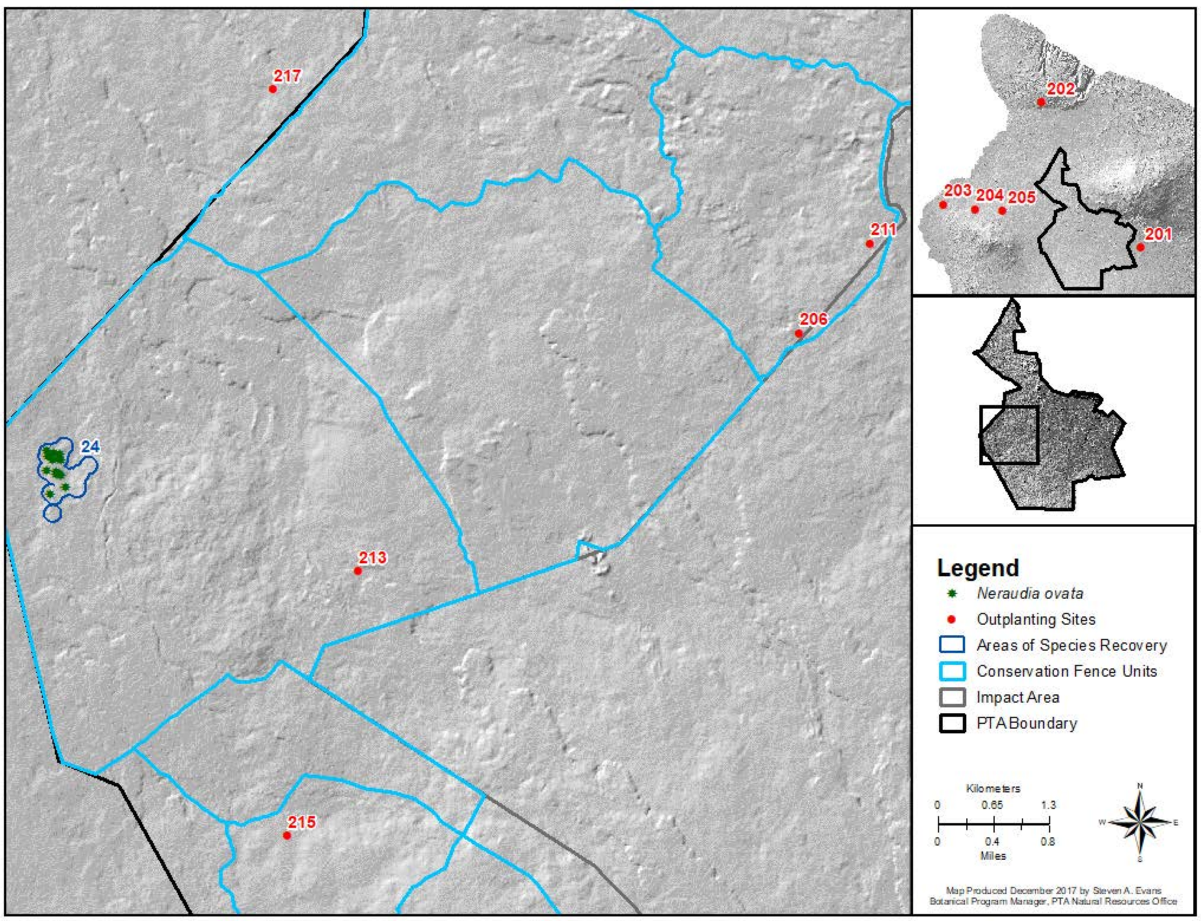

Figure 22. Current known distribution and outplanting sites for *Neraudia ovata*[a]

[a] Distribution data were collected between 2011 and 2015

Priority Species 1 Monitoring

We counted *N. ovata* over 8 census periods between July 2016 and September 2019. The number of plants was relatively stable over the period (Figure 23). Losses from juveniles and adult age classes, as well as transition from the juvenile to the adult age class, appear to drive patterns in the numbers of plants present. Seedlings were present for 4 of the 8 census periods, but the influence of these flushes on the number of juveniles and adults present is not readily apparent.

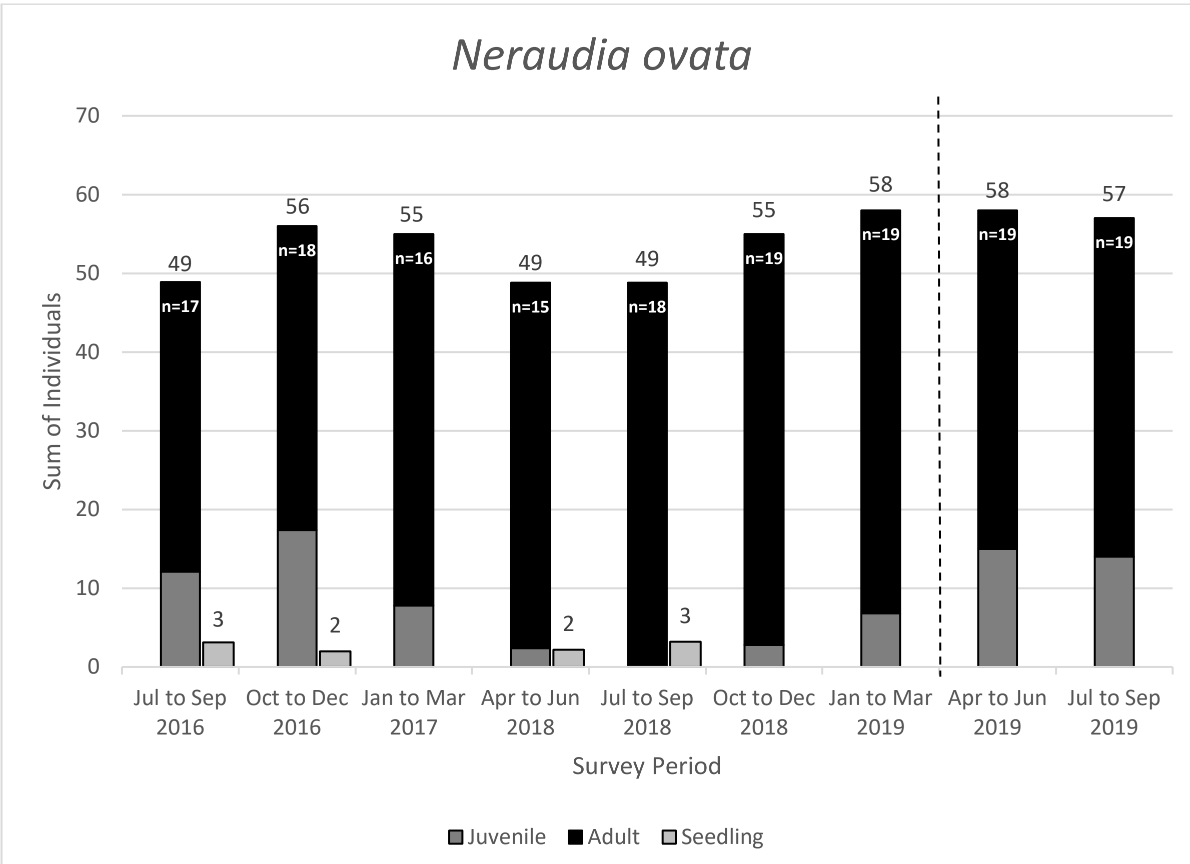

Figure 23. Monitoring results for *Neraudia ovata* from April 2016 through December 2019[a]

[a] For census periods left of the dotted line, we estimated life stage composition using proportion and to the right we counted each plant present by life stage (n= number of plots read).

We visually assessed threats at every plot each census period. We pooled all threat detections for every *N. ovata* monitoring plot for the period of July 2018 through September 2019. Over this time, we made 88 visits to the monitoring plots and detected spittlebug on 1 visit (Figure 24).

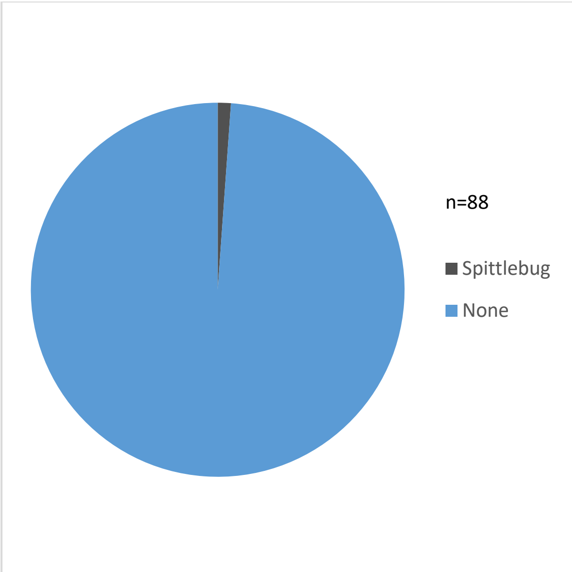

Figure 24. Emerging threats to *Neraudia ovata* recorded between July 2018 and 2019[a]

[a] Data pooled for all *N. ovata* monitoring plots for all monitoring periods. We made a total of 88 visits (n) to the monitoring plots during this time period and spittlebug was present on 1 visit.

<u>Genetic Conservation</u>

Propagule Collection

We aim to collect from all known extant, reproductive *N. ovata* individuals. To this end, we collected a total of 2,976 seeds representing 25 founders during the reporting period. We also collected 160 cuttings from 32 founders (5 per founder) and 148 cuttings from founder 519-1380-014-001, for a total of 308 cuttings. Currently, several founders in storage are no longer extant in the field and we are exploring options to propagate the seeds of these founders and return their genetics to the natural population over the next 3 to 5 years. Please refer to Table 8 for a complete summary of genetic conservation status for *N. ovata.*

Propagation

Propagation records between October 2017 and July 2018 were incomplete or missing and do not align with the greenhouse accession records and plants in the facility. The greenhouse accession records indicate that propagules, likely cuttings, from 14 *N. ovata* founders were propagated and 45 seedlings grew to sufficient size to be transferred to 4-inch pots and accessioned to the greenhouse (Table 26). We assume these plants were propagated from cuttings taken from plants in the greenhouse, which may also explain the lack of propagule accession numbers. Based on the dates of the greenhouse accessions (6 February2019), the cuttings were likely propagated in early 2018.

Table 26. *Neraudia ovata* cuttings accessioned to the greenhouse without propagation records as of September 2019

New Founder No.	Other Founder No.	Date Accessioned to Greenhouse	Greenhouse Accession No.
518-1585-001-001	05014001001	2/6/2019	**106**, 107, **108**
518-1685-001-001	05014001001	2/6/2019	196
518-1685-001-402	05014001402	2/6/2019	195, 197
518-1685-003-402	05014003402	2/6/2019	**113** ,198, 199, 200, 201 (NF)
519-1380-001-402	04024001402	2/6/2019	169, 170, 171
519-1380-003-401	04024003401	2/6/2019	**112**, 172, 173, 174 (NF), 175, 176 (D), **202**
519-1380-005-001	04024005001	2/6/2019	177, 178,
519-1380-007-001	04024007402	2/6/2019	179
519-1380-008-001	04024008001	2/6/2019	**114**, **115**, 180, 181, 182
519-1380-009-001	04024009001	2/6/2019	183, 184, 185
519-1380-010-401	04024010401	2/6/2019	186, 187, 188, **203**
519-1380-010-402	04024010402	2/6/2019	189
519-1380-013-401	04024013402	2/6/2019	190,191
519-1380-013-402	04024013402	2/6/2019	**109**, **110**, **111**, 192, 193, 194

NF, not found at last greenhouse monitoring; D, dead at last greenhouse monitoring

Note: Bold indicates founders and accession numbers that were outplanted in 2019

After August 2018, more detailed propagation records were kept (Table 27). We attempted to propagate 4 batches of seed from accessions made between 2001 and 2005. The number of seeds sown from each accession varied and was determined by the number of seeds in the original accession. We ranged between 54 and 100 seeds per germination trial. We anticipated that seeds would germinate at different rates and some would not germinate at all due to natural variation and quality among seeds in an accession. We observed very low germination rates even after more than 240 days had elapsed since the seeds were sown. From past work with *N. ovata,* we have recorded the emergence of seedlings in as little as 3 weeks (2017 Propagation SOP). However, germination rates tend to be low and average about 16% over 24 months. From past germination trials, we learned that drying and wetting the seeds can renew germination activity.

Table 27. Seed germination trial results for *Neraudia ovata* August 2018 to September 2019

New Founder No.	Other Founder No.	Prop. Accession	Media	Seed Treatment	Trial Days	No. Seed Sown	No. Seeds Germ.	% Germ	No. plants GH Acc.
519-1380-001-401	04024001401	2005001	V + GHM	No clean + GC Dark	177	54	1	2%	1
519-1380-004-001	04024004001	2001001	V + GHM	No clean + GC Dark	247	100	1	1%	0
519-1380-004-001	04024004001	2003002	V + GHM	Clean + GC Dark	248	100	1	1%	0
519-1380-005-001	04024005001	2001002	V + GHM	Clean + GC Dark	246	100	2	2%	1

GH, greenhouse; GHM, greenhouse media; GC, growth chamber; V, vermiculite

We propagated 313 cuttings from 33 founders. As of September 2019, 39 cuttings from 19 founders survived to sufficient size to be accessioned to the greenhouse (Table 28) and at least 5 seedlings were growing but were not large enough for a greenhouse accession number.

Table 28. *Neraudia ovata* cuttings accessioned to the greenhouse

New Founder No.	Other Founder No.	Date of Cutting	Prop. Accession No.	Greenhouse Accession. No.
518-1685-003-402	05014003402	5/15/2019	190515014	786, --
519-1380-003-002	Unclear	3/20/2019	190320002	663
519-1380-003-401	04024003	5/15/2019	190515010	788
519-1380-004-001	04024004001	1/2/2019	190102015	664, 665, 666
519-1380-005-001	04024005001	5/15/2019	190515006	792, 990
519-1380-008-001	04024008001	5/15/2019	190320011	672, 673, 793
519-1380-008-003	Unclear	3/20/2019	190320006	667, 668
519-1380-008-004	None	3/20/2019	190320012	669, 670, 671
519-1380-009-002	Unclear	3/20/2019	190320008	674, 675
519-1380-010-401	04024010	5/15/2019	190515012	--
519-1380-010-402	04024010	5/15/2019	190515011	794, 795,
519-1380-011-001	Unclear	3/20/2019	190320010	676
519-1380-011-106	None	1/2/2019	190102014	677
519-1380-012-016	Unclear	3/20/2019	190320004	679, 680, 681
519-1380-012-106	None	1/2/2019	190102013	796, 797,
519-1380-014-001	Unclear	3/20/2019	190330015	682, 683, 684
519-1380-001-402	04024001	5/15/2019	190515009	785,
519-1380-022-001	Unclear	1/2/2019	190102012	685, 686
519-1380-034-001	Unclear	3/20/2019	190320001	687, 798, 799

Outplanting and Monitoring

In 2019, we outplanted 6 *N. ovata*, representing 5 founders, at a new planting location Temp 2019-009 in TA 21 (Figure 10). The 9 plants were propagated from cuttings from founders that were established in the greenhouse. Although TA 21 is outside the historical or projected range of *N. ovata*, we continue to explore the upper elevational range of this species using founder clones. In past years, we have documented survivorship of *N. ovata*, but no recruitment, at Puʻu Huluhulu (ASR 201), which is higher in elevation than the new planting location in TA 21. We have documented survivorship and recruitment at ASR 213, which is outside the historical and projected range for *N. ovata*, but lower in elevation than the new planting site.

We also planted 19 *N. ovata* in the PTA interpretive garden in FY 2018–2019. Two of the plants were cuttings propagated in 2019 (greenhouse accession number 202 and 203). The other plants were original founders recovered from the natural population in 2004. These founders were maintained in the greenhouse for seed collection and for cuttings. These founders are well represented in the *ex* *situ* propagule bank and have been cloned. Therefore, to make room in the greenhouse for other living collections, we planted the *N. ovata* founders in the garden.

In addition, we planted *N. ovata* at ASRs 201, 202, 203, 204, 205, 206, 211, 213, 215, and 217 (Table 29). As of 2016, 65 planted adults were living. In addition, we documented adults, juveniles, and seedlings that recruited at ASRs 203, 204, 205, 206, and 213. Although *N. ovata* appears to have a higher survivorship and recruitment at lower elevations sites (ASRs 202–205), we documented some survival and recruitment at sites outside this species' historical and projected range (ASRs 201 and 213).

Table 29. Monitoring summary for *Neraudia ovata* prior to FY 2018

			Surviving Outplants			Recruits	
Location	Outplanting Site	Total Outplanted	Adult	Juvenile	Net Survivorship	Adult	Juvenile
On PTA	206	4	2	0	50%	0	1
	211	3	0	0	0%	0	0
	213	54	2	0	4%%	0	0
	215	12	1	0	8%	0	0
	217	8	0	0	0%	0	0
Off PTA	201	117	17	0	15%	0	0
	202	16	0	0	0%	0	0
	203	31	22	0	71%	12	1
	204	42	0	0	0%	0	10
	205	132	21	0	16%	2	0

PTA, Pōhakuloa Training Area

Discussion

Our efforts to survey, monitor, and conserve genetics for *N. ovata* address SOO tasks 3.2(1)(a, d–f) as well as several INRMP objectives and conservation measures from the 2003 and 2013 BO.

N. ovata naturally occurs as solitary individuals or small isolated groups only within ASR 24 at PTA (Figure 24). In 1997, *N. ovata* was reduced to 10 mature individuals at PTA. Since then, extensive management at ASR 24 has included small- and large-scale fencing to protect the plants from ungulate browse, invasive plant control and rodent management. *N. ovata* recruits from the seed bank in an episodic manner, with large recruitment events occurring during favorable environmental conditions. Quarterly monitoring shows a relatively stable adult population with periodic flushes of seedlings and juvenile plants. As of the last quarterly monitoring between July and September 2019, 58 *N. ovata* adults and juveniles were present. However, we know little about *N. ovata* age distributions that support healthy and resilient populations. In addition, we do not know which, if any, of the life stages is most vulnerable and/or may regulate population dynamics. Knowing these life history attributes is important for designing management actions to maximize the likelihood that *N. ovata* will persist, and potentially increase, especially with changing climate conditions. We recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species.

We continue to make progress with genetic conservation of *N. ovata.* Many of the accessions in storage are aging and we do not know how aging affects the viability of the seed. Seed gemination remains low and success with cuttings is moderate. We need to know more about seed characteristics prior to sowing and the influence of these characteristics on germination outcomes. Without more basic information about seed quality and viability, we will likely continue to experience variability in seed germination success. There are 74 *N. ovata* accessioned to the greenhouse. We are developing planting strategies and plan to continue investigating outplant performance and planting site characteristics in 2020 to maximize the successful establishment of new self-sustaining groupings.

Progress toward compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects from military activities to *N. ovata,* the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browse pressure, maintenance of genetic stock *ex situ*, outplanting, reproduction *in situ*, non-native plant control, and annual monitoring.

To address these conservation measures for *N. ovata*, we implement landscape-level projects to reduce fire-risk and ungulate browse for all known individuals at PTA (See Section 1.3). In addition, we actively conserve *N. ovata* genetics; the propagule bank contains 6,130 seeds from the natural population and 236,474 seeds from individuals grown in the greenhouse as living collections. To date, we have outplanted 419 individuals at 10 ASRs and *N. ovata* has persisted at 6 ASRs. However, *N. ovata* outplants appear to perform better and recruit offspring at lower elevation sites. We continue invasive plant management in ASR 24 (Table 64). Between 2016 and 2019, we observed *in situ* reproduction in 5 of 19 (26%) monitoring plots for *N. ovata.* Although we monitor *N. ovata* quarterly to assess population patterns, we are unable to attribute changes in numbers to effects from training or management.

For a discussion regarding how ongoing management benefits Army operations at PTA and the importance of continuing management efforts, see the final summary discussion for the Botanical Program (Section 2.6).

2.4.6 *Portulaca sclerocarpa* (Endangered)

As a PS 1, we monitor all known *P. sclerocarpa* individuals each quarter. For genetic conservation, *P. sclerocarpa* is an implementation priority 3 (moderate). We plan to collect propagules for storage and propagation and to outplant judiciously to establish new populations.

Plant Surveys

During the reporting period, we found 12 locations of *P. sclerocarpa* representing at least 59 individuals. Because we are still surveying the full set of transects, our findings represent progress for the reporting period and do not represent actual changes in species abundance or distribution.

From previous survey work (2011 to 2015), there were 39 locations of *P. sclerocarpa* at PTA. The abundance of this species is tracked quarterly and reported below. The distribution for *P. sclerocarpa*, including outplanting sites, is shown in Figure 25.

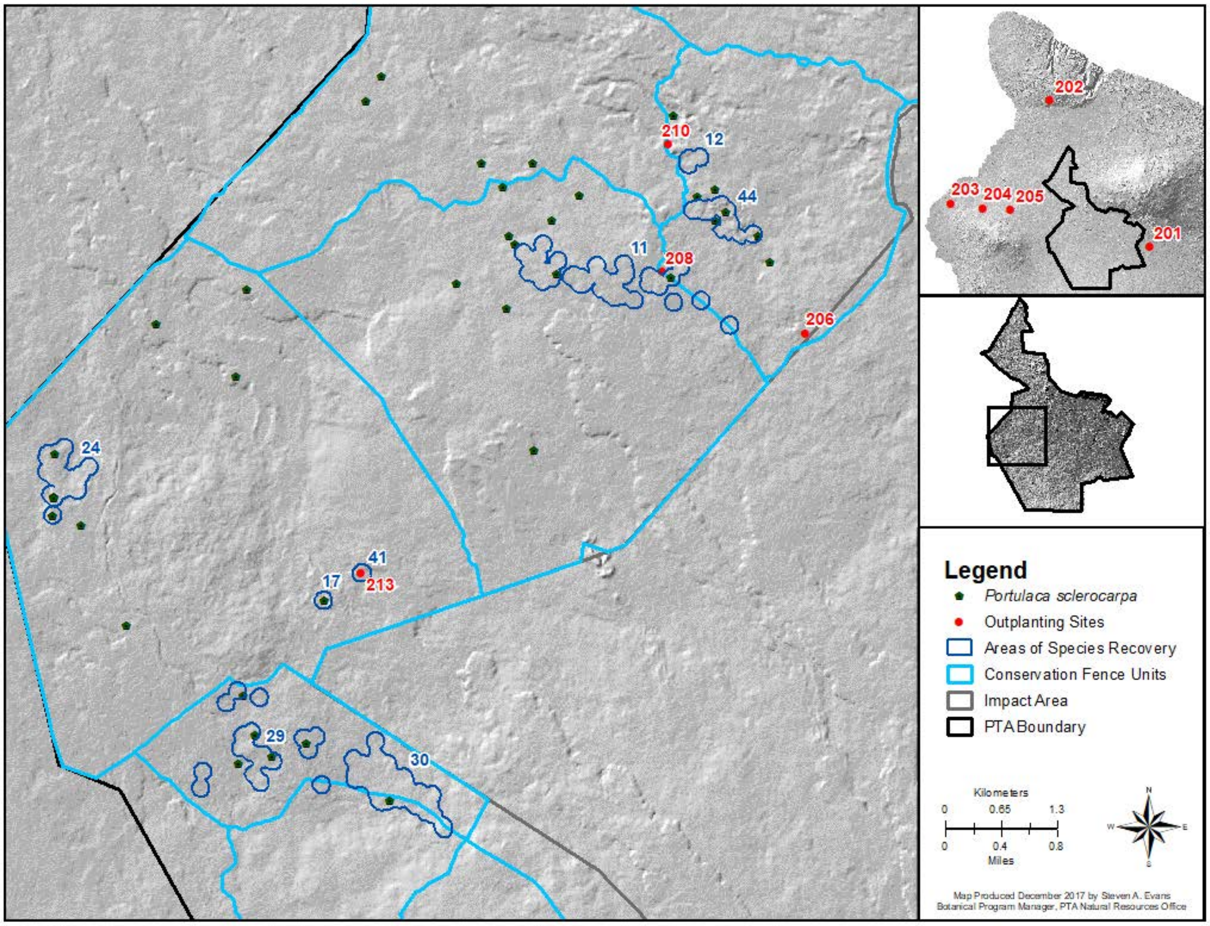

Figure 25. Current known distribution of *Portulaca sclerocarpa*[a]

[a] Distribution data were collected between 2011 and 2015

<u>Priority Species 1 Monitoring</u>

We monitored *P. sclerocarpa* over 9 census periods between April 2016 and September 2019. The overall numbers of *P. sclerocarpa* increased between May 2016 and September 2019. The increase appears to be driven by flushes of seedlings between July 2018 through August 2019 and eventual transition of seedlings to juveniles. The number of adults remained relatively stable and ranged from 78 to 121 plants over the census periods (Figure 26).

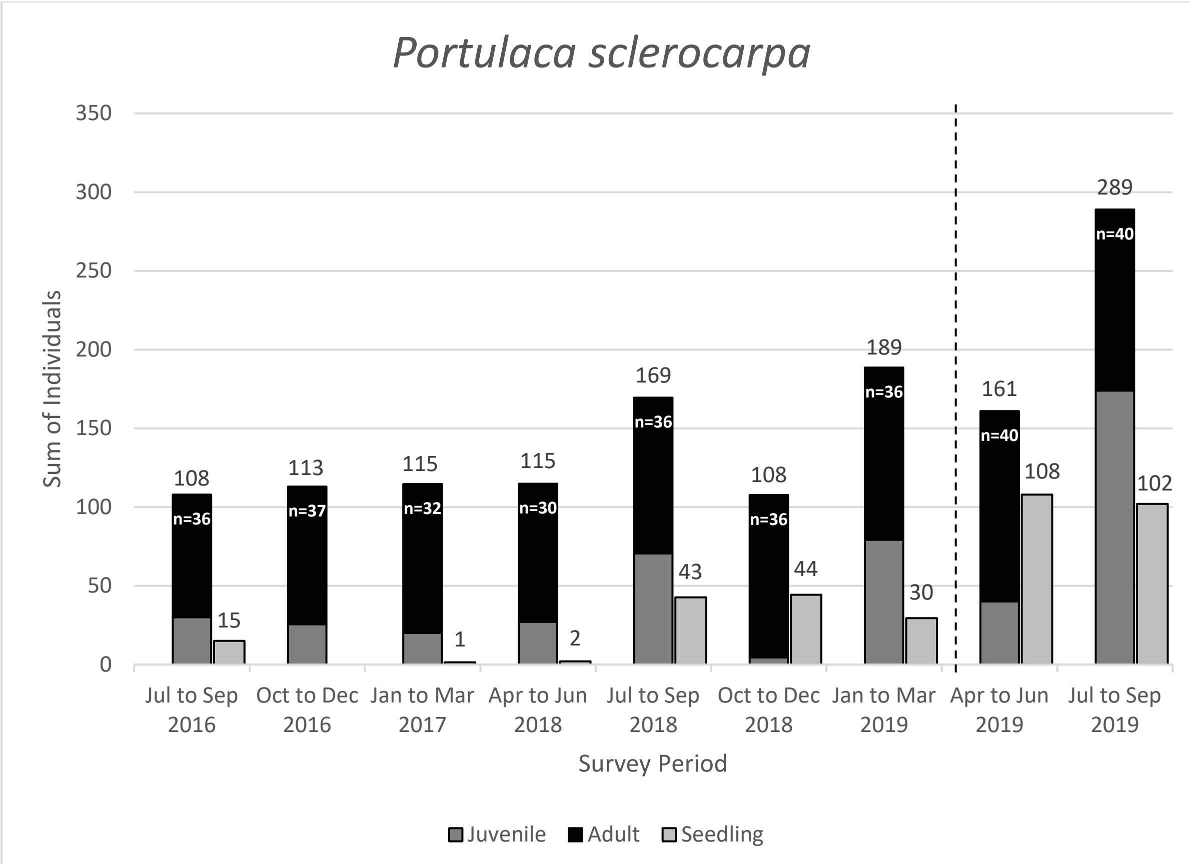

Figure 26. Monitoring results for *Portulaca sclerocarpa* from April 2016 through September 2019[a]

[a] For census periods left of the dotted line, we estimated life stage composition using proportion and to the right we counted each plant present by life stage (n=number of plots read). For census periods right of the dotted line, totals may include count class data. When this occurs the minimum value of the count class is summed with the counts from other plots to provide the total value for abundance. Therefore, these numbers represent the minimum number of individuals present during the census period.

We visually assessed threats at every plot each census period. We pooled all threat detections for every *P. sclerocarpa* monitoring plot for the period of July 2018 through September 2019. Over this time, we made 179 visits to the monitoring plots and detected threats on 30 visits (Figure 27). Water stress was the most frequently recorded threat for *P. sclerocarpa* (20 out of 30 threat detections).

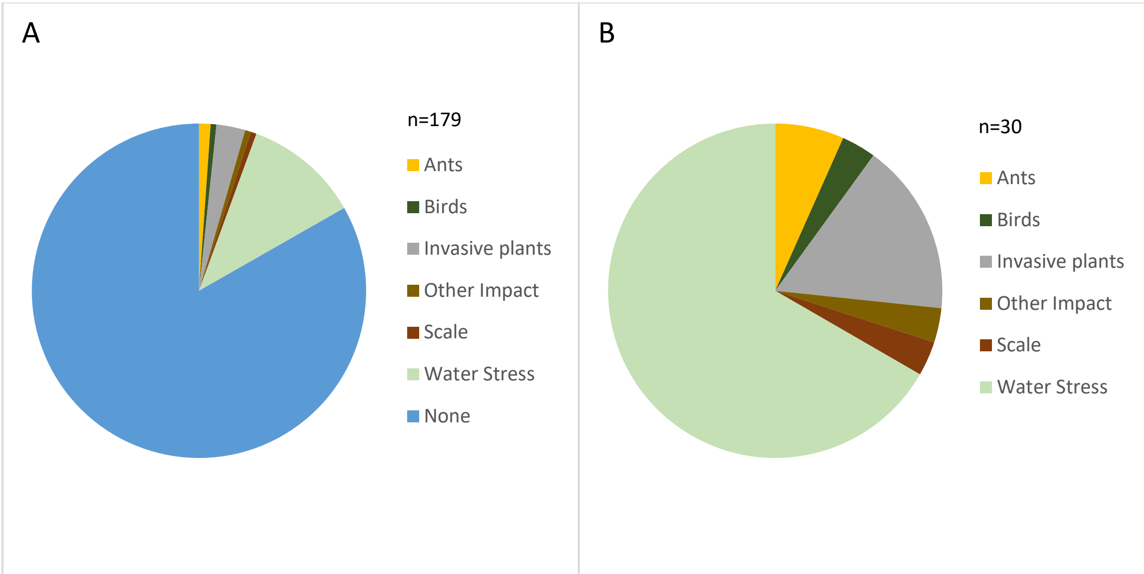

Figure 27. Emerging threats to *Portulaca sclerocarpa* recorded between July 2018 and 2019[a]

[a] Data pooled for all *P. sclerocarpa* monitoring plots for all monitoring periods. We made a total of 179 vistis to the monitoring plots during this time period and threats were present on 30 occasions. Panel A shows the threats recorded for every plot visit (n=179). Panel B shows the frequency each threat was recorded for every plot visit when threats were detected (n=30).

Following a wildland fire that ignited on 18 July 2018 and burned approximately 585 ha, we produced a *Technical Report and Post-Disturbance Assessment* (CEMML 2018b) to assess the impacts from the fire to ESA-listed species and habitats. There was one location of *P. sclerocarpa* within the burn footprint. At the site impacted by the fire, we counted 4 individuals of *P. sclerocarpa* on 12 January 2017. Immediately following the fire, we revisited the location impacted by the fire on 30 August 2018 and counted 3 individuals of *P. sclerocarpa.* The individual "lost" between census periods was a juvenile. Subsequently, at that location we had as many as 4 adult individuals (28 January 2019 and 1 May 2019), but only 2 remained as of our last monitoring (29 October 2019).

<u>Genetic Conservation</u>

Propagule Collection

We aim to collect from all known extant, reproductive *P. sclerocarpa* individuals. To this end, we collected about 32,761 seeds representing 53 founders during the reporting period. Refer to Table 8 for a complete summary of genetic conservation status for *P. sclerocarpa.*

Propagation

Propagation records between October 2017 and July 2018 were incomplete or missing and do not align with the greenhouse accession records and plants in the facility. The greenhouse accession records indicate that propagules from 2 *P. sclerocarpa* founders were propagated and 24 seedlings grew to sufficient size to be transferred to 4-inch pots and accessioned to the greenhouse (Table 30). Based on the dates of the greenhouse accessions (6 February2019), the cuttings were likely propagated in early 2018.

Table 30. *Portulaca sclerocarpa* accessioned to the greenhouse without propagation records as of September 2019

New Founder No.	Other Founder No.	Date Accessioned to Greenhouse	Greenhouse Accession No.	Accessions in Greenhouse
516-2083-014-001	Unclear	2/6/2019	139-154	140, 146, 147, 149, 150, 154
520-1577-007-001	Unclear	2/6/2019	131-138	--

Note: *Portulaca sclerocarpa* listed in the "Greenhouse Accession No." column were outplanted in 2019, except for individuals listed in the "Accessions in the Greenhouse" column.

After August 2018, more detailed propagation records were kept (Table 31). We attempted to propagate 8 batches of seed from accessions made between 1998 and 2018. The number of seeds sown from each accession varied and was determined by the number of seeds in the original accession. We ranged between 16 and 100 seeds per germination trial. We anticipated that seeds would germinate at different rates and some would not germinate at all due to natural variation and quality among seeds in an accession. We observed very high germination rates from some accessions, even as old as 2001. Other accessions show no or very low germination, thus, underscoring that seed viability differs among collections. Because we do not have information about the quality and viability of our accessions, we cannot definitively conclude that age affects germinations rates. However, we may want to pursue the effect age has on germination under more controlled conditions.

Table 31. Seed germination trial results for *Portulaca sclerocarpa* from August 2018 to September 2019

New Founder No.	Other Founder No.	Prop. Accession	Media	Seed Treatment	Trial Days	No. Seed Sown	No. Seeds Germ.	% Germ	No. plants GH Acc.
517-1884-033-001	None	181120002	Filter paper	GC	67	50	29	58%	0
519-1380-002-000	04024002000	2012001	V + GHM	None	118	60	0	0%	0
519-1380-008-001-1102	040240080011201	2013028	Filter paper	GC	75	100	81	81%	8
519-1679-001-001	04017001000101	2001001	Filter paper	GC	33	100	91	91%	7
519-1679-001-001	04017001000401	2006004	Filter paper	GC	48	100	95	95%	8
520-1577-007-001	03029007001	2013001	V + GHM	None	118	16	2	13%	1
Unclear	051983001002	2016032	Filter paper	GC	48	100	95	95%	6
Unclear	02030001003	1998001	V + GHM	None	118	20	0	0%	0

GC, growth chamber; GH, greenhouse; GHM, greenhouse media; UNK, unknown; V, vermiculite

From the germination trials with known inputs and outcomes, overall germination success was 75% (393 seedlings from 546 seeds sown). No seedlings from these germination trials grew to sufficient size to be accessioned to the greenhouse. Seedlings from these germination trials are still growing. However, the numbers of seedlings that transitioned from the germination trials to seedlings in the greenhouse (~23 remaining out of 393 germinates) may indicate that transition from seedling to young plant is critical to successful cultivation of *P. sclerocarpa.*

Outplanting and Monitoring

In 2019, we outplanted 18 *P. sclerocarpa*, representing 2 founders, in TA 22 at planting site Temp 2019-003 (Figure 10). Although *P. sclerocarpa* is not a high implementation priority for outplanting per the 2017 Genetic and Outplanting Plan, several plants were ready for planting and we continue to investigate appropriate planting site characteristics.

In previous years, we planted *P. sclerocarpa* at ASRs 201, 202, 203, 204, 205, 206, 208, 210, 213, and 214 (Table 32). As of 2016, only 4 of 271 planted adults were living, 2 each at ASR 213 and 214. No recruits were found at any site. This low success with outplanting survivorship warrants continued investigation into planting site characteristics for this species.

Table 32. Monitoring summary for *Portulaca sclerocarpa* outplanted prior to FY 2018

			Surviving Outplants			Recruits	
Location	Outplanting Site	Total Outplanted	Adult	Juvenile	Net Survivorship	Adult	Juvenile
On PTA	206	7	0	0	0%	0	0
	208	4	0	0	0%	0	0
	210	6	0	0	0%	0	0
	213	2	2	0	100%	0	0
	214	13	2	0	15%	0	0
Off PTA	201	8	0	0	0%	0	0
	202	59	0	0	0%	0	0
	203	11	0	0	0%	0	0
	204	25	0	0	0%	0	0
	205	136	0	0	0%	0	0

PTA, Pōhakuloa Training Area

Discussion

Our efforts to survey, monitor, and conserve genetics for *P. sclerocarpa* address SOO tasks 3.2(1)(a, d–f) as well as several INRMP objectives and conservation measures from the 2003 and 2013 BO.

At PTA, *P. sclerocarpa* occurs in small clusters of plants and is widely distributed with several kilometers between plant clusters, which typically range from 1 to 5 plants. Most *P. sclerocarpa* locations are outside designated ASRs (Figure 25). We plan to designate ASR for *P. sclerocarpa* in 2020. In addition, due to a decline in the *P. sclerocarpa* population at Hawaiʻi Volcanoes National Park (estimated at 200 individuals in 2010), the population at PTA now represents a large proportion of the state-wide population (USFWS 2010). At last quarterly monitoring, we counted 269 *P. sclerocarpa* (adults, juveniles and seedlings). In 2010, the USFWS estimated the statewide population to be about

200 natural individuals, underscoring the importance of the *P. sclerocarpa* at PTA to the persistence of this species globally.

Although our quarterly monitoring is not designed to specifically track transition between life stages, patterns in the quarterly counts suggest that seedling flushes support recruitment to juvenile and adult classes. However, we know little about *P. sclerocarpa* age distributions to support healthy and resilient populations. In addition, we do not know which, if any, of the life stages is most vulnerable and/or may regulate population dynamics. Knowing these life history attributes is important for designing management actions to maximize the likelihood that *P. sclerocarpa* will persist, and potentially increase, especially with changing climate conditions. We recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species.

We continue to make progress with genetic conservation for *P. sclerocarpa.* Many of the accessions in storage are from plants growing in the greenhouse. Over FY 2018–2019, we were able to make valuable collections of fruits and seeds from 51 founders within the natural population. These collections add needed diversity to the propagules already in storage. Seed gemination was variable and ranged from none to 100%. We need to know more about seed characteristics prior to sowing and the influence of these characteristics on germination outcomes. Without more basic information about seed quality and viability, we will likely continue to experience variability in seed germination success. In addition, we noted that relatively few seedlings successfully transition to established plants. More investigation is needed to understand this critical step to improve cultivation success. There are 42 *P. sclerocarpa* accessioned to the greenhouse. We are developing planting strategies and plan to continue investigating outplant performance and planting site characteristics in 2020 to maximize the successful establishment of new self-sustaining groupings.

Portulaca sclerocarpa is not self-sustaining at any of the outplanting sites; plants are relatively short-lived, and no recruitment occurs. We plan to monitor the most recent outplants in 2020 to evaluate performance.

Progress toward compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects from military activities to *P. sclerocarpa,* the 2003 BO conservation measures include fuels management to reduce fire risk and fencing and ungulate control to reduce browse pressure. From these actions, USFWS assumed *in situ* reproduction would happen.

To address these conservation measures for *P. sclerocarpa*, we implement landscape-level projects to reduce fire risk and ungulate browse for all known individuals at PTA (See Section 1.3). Between 2016 and 2019, we observed *in situ* reproduction in 19 of 41 (46%) monitoring plots for *P. sclerocarpa.* Although not specifically mentioned in the 2003 BO, as part of the INRMP objectives we actively conserve *P. sclerocarpa* genetics; the propagule bank contains 32,761 seeds from founders in the field and 9,242 fruits from founders in the greenhouse. To date, we have outplanted 271 individuals at 10 ASRs, but *P. sclerocarpa* has only persisted at ASRs 213 and 214. In addition, per INRMP objectives, *P. sclerocarpa,* in conjunction with *S. lanceolata,* receives the benefits of weed management in ASR 44.

Although we monitor *P. sclerocarpa* quarterly to assess population patterns, we are unable to attribute changes in numbers to effects from training or management.

For a discussion regarding how ongoing management benefits Army operations at PTA and the importance of continuing management efforts, see the final summary discussion for the Botanical Program (Section 2.6).

2.4.7 *Portulaca villosa* (Endangered)

As a PS 1, we monitor all known *P. villosa* individuals each quarter. For genetic conservation, *P. villosa* is an implementation priority 3 (moderate). We plan to collect propagules for storage and propagation and to outplant judiciously to establish new populations.

Plant surveys

No locations of *P. villosa* were recorded during the reporting period. This outcome is not surprising since we did not survey within the known distribution of this species.

From previous survey work (2011 to 2015), there were 5 locations of *P. villosa* at PTA. The abundance of this species is tracked quarterly and reported below. The distribution for *P. villosa* is shown in Figure 28.

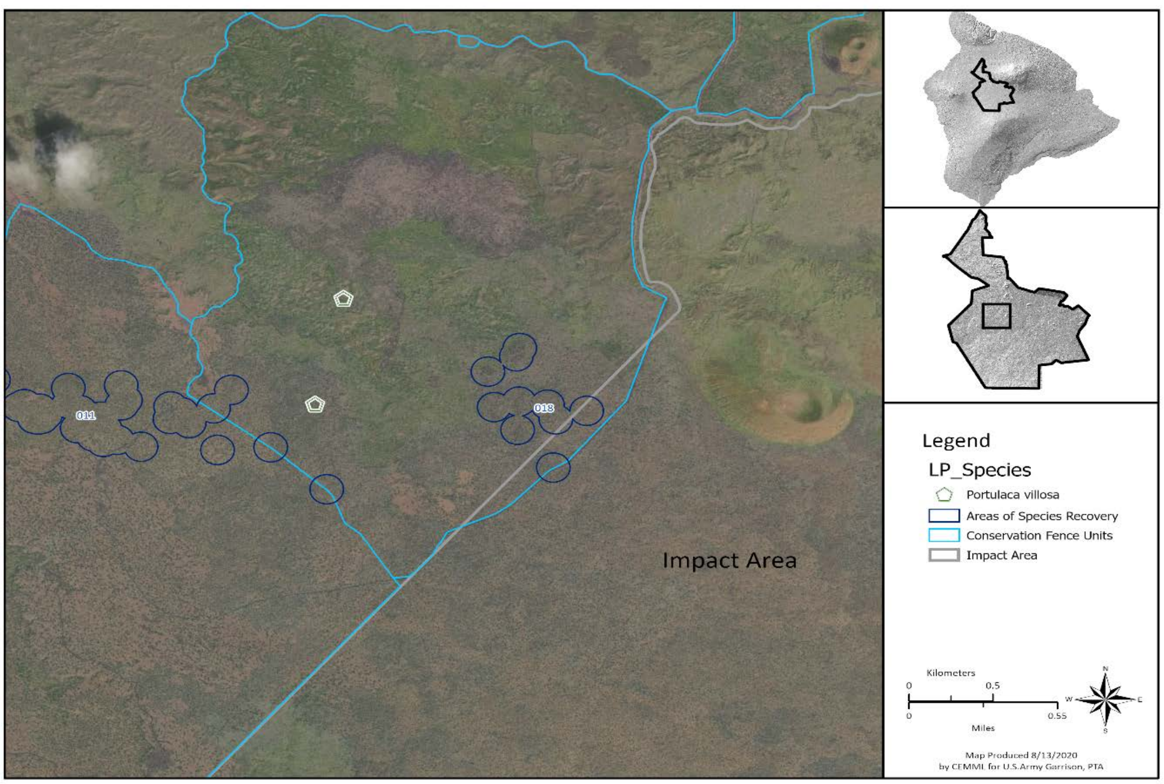

Figure 28. Current known distribution of *Portulaca villosa*[a]

[a] Distribution data were collected between 2011 and 2015

Priority Species 1 Monitoring

We counted *P. villosa* over census periods between April 2016 and September 2019. There was a large seedling flush between July and September 2018, followed by lesser flushes in subsequent census periods. Some of these seedlings appear to transition to the juvenile and adult age classes between October and March 2019. There were also lesser seedling flushes between October and December 2018 and between March and August 2019. Between January 2019 and September 2019, the number of adults and juveniles remained constant; however, some juveniles transitioned to the adult age class between April 2019 and September 2019, changing the overall ratio of adults to juveniles (Figure 29).

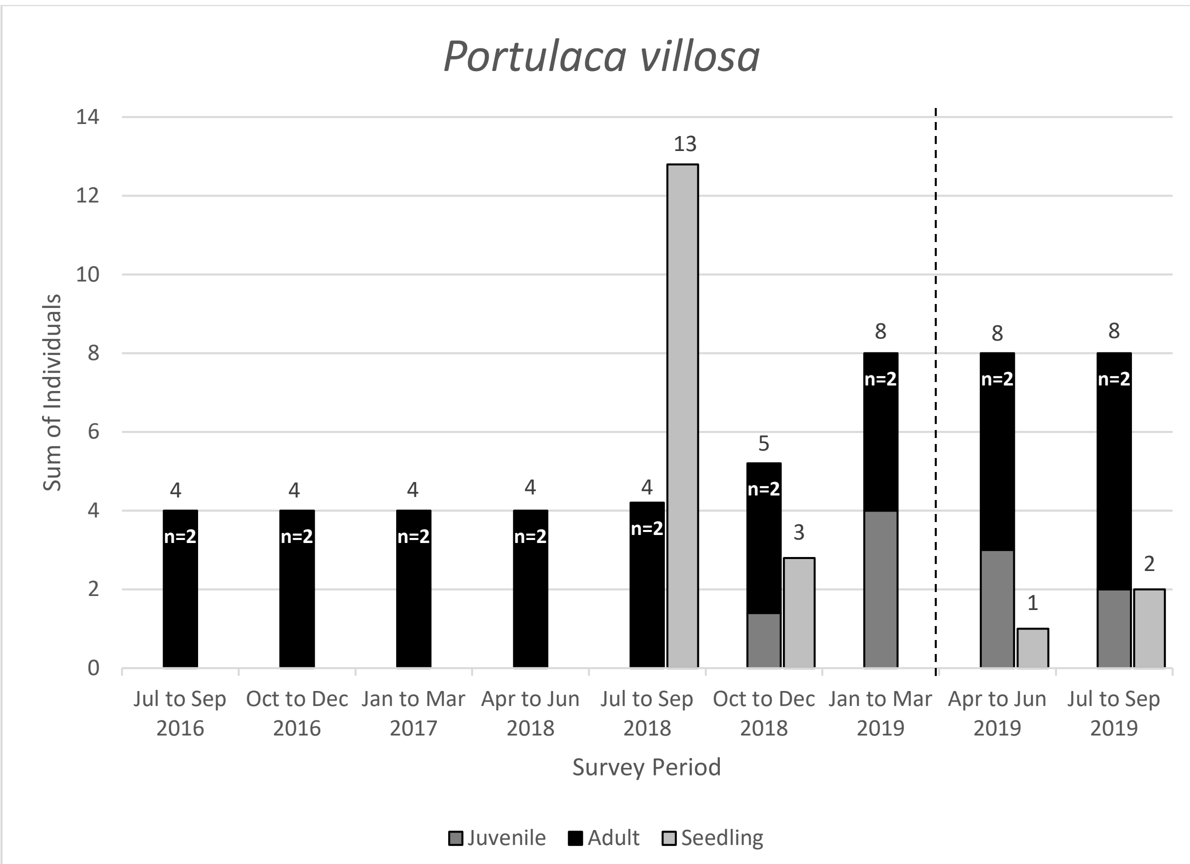

Figure 29. Monitoring results for *Portulaca villosa* from April 2016 through September 2019[a]

[a] For census periods left of the dotted line, we estimated life stage composition using proportion and to the right we counted each plant present by life stage (n=number of plots read).

We visually assessed threats at every plot each census period. We pooled all threat detections for every *P. villosa* monitoring plot for the period of July 2018 through September 2019. Over this time, we made 12 visits to the monitoring plots and detected water stress on 1 visit (Figure 30).

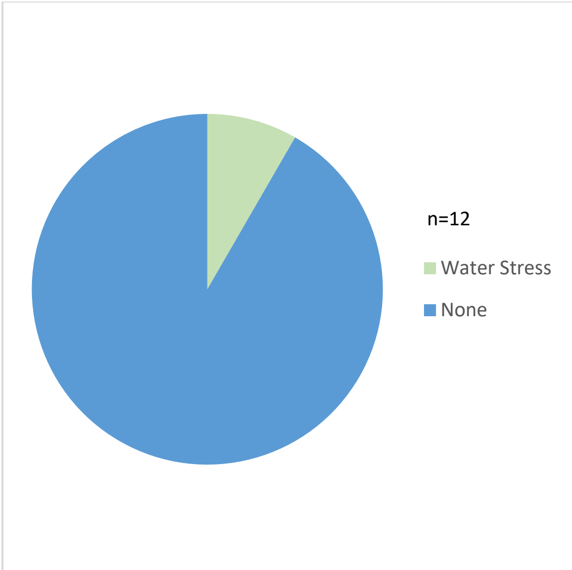

Figure 30. Emerging threats to *Portulaca villosa* recorded between July 2018 and 2019[a]

[a] Data pooled for all *P. villosa* monitoring plots for all monitoring periods. We made a total of 12 visits (n) to the monitoring plots during this time period and detected water stress on 1 visit.

<u>Genetic Conservation</u>

Propagule Collection

We aim to collect from all known extant, reproductive *P. villosa* individuals. To this end, we collected a total of 4,833 seeds representing 3 founders during the reporting period. In addition, we collected 1 cutting from each of 3 founders and 6 cuttings from an additional founder. A living collection will be maintained in the greenhouse to collect seed. Only seed from first generation plants will be collected. The seed will be placed in primary and secondary banks when enough seed has been collected for eventual use in propagation and outplanting. Please refer to Table 8 for a complete summary of genetic conservation status for *P. villosa.*

Propagation

Propagation records between October 2017 and July 2018 were incomplete or missing and do not align with the greenhouse accession records and plants in the facility. The greenhouse accession records indicate seeds from a single *P. villosa* founder were propagated and 29 seedlings grew to sufficient size to be transferred to 4-inch pots and accessioned to the greenhouse (Table 33). There are no propagation records associated with the plants. Database records for seed withdrawal indicate these plants were propagated in July 2018 and were collected from founder 516-2183-001-001.

Table 33. *Portulaca villosa* accessioned to the greenhouse without propagation records as of September 2019

New Founder No.	Other Founder No.	Date Accessioned to Greenhouse	Greenhouse Accession No.	Accessions in Greenhouse
515-2183-001-001	Unclear	2/6/10 and 6/12/19	223-226, 689-709	223-226, 689-704, 705(D), 706-709

D, dead

After August 2018, more detailed propagation records were kept (Table 34). We attempted to propagate 1 batch of seed from 1 accession made in 2018 from a single founder. One hundred seeds were sown and only 2 had germinated after 173 days.

Table 34. Seed germination trial results for *Portulaca villosa* from August 2018 to September 2019

New Founder No.	Other Founder No.	Prop. Accession	Media	Seed Treatment	Trial Days	No. Seed Sown	No. Seeds Germ.	% Germ	No. plants GH Acc.
515-2183-001-001	None	181029003	Filter paper	GC + GA3 100ppm	173	100	2	2%	4[a]

GA3, gibberellin A3; GC, growth chamber; GH, greenhouse; UNK, unknown

[a] The total number of plants accessioned in August 2019 exceeds the number of seedlings that germinated from this seed trial. We assume that 2 additional seedlings from this founder that resulted from a germination trial prior to August 2018 grew to sufficient size to be accessioned to the greenhouse.

In 2018, we propagated 1 cutting each from 3 founders (516-2183-002-001, 516-2183-002-002, 516-2183-002-003) and each cutting grew to sufficient size to be accessioned to the greenhouse (greenhouse accession numbers 563, 564, and 565). The 6 cuttings taken from founder 519-1578-004 have not been accessioned to the greenhouse and may still be growing in the greenhouse. However, an additional cutting was accessed to the greenhouse (#726) and was assigned to founder 516-2183-002-002. Collection records indicated that only 1 cutting was collected from this founder so one of the 2 plants in the greenhouse is mislabeled.

Outplanting and Monitoring

We did not outplant *P. villosa* during the reporting period and we have not planted this species in previous years.

Discussion

Our efforts to survey, monitor, and conserve genetics for *P. villosa* address SOO tasks 3.2(1)(a, d–f) as well as several INRMP objectives.

At PTA, *P. villosa* occurs in small clusters within the Kīpuka Kālawamauna East Fence Unit and the plant clusters are widely distributed with several kilometers between the clusters (Figure 28). At last quarterly monitoring, we counted 8 adults and juveniles and 2 seedlings.

Although our quarterly monitoring is not designed to specifically track transition between life stages, patterns in the quarterly counts suggest that seedling flushes support recruitment to juvenile and adult classes. However, we know little about *P. villosa* age distributions to support healthy and resilient populations. We recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species.

We continue to make progress with genetic conservation for *P. villosa.* Over FY 2018-2019, we collected seeds from 3 of the 6 extant adults. Because the USFWS listed *P. villosa* as an endangered species under the ESA in 2016, we have not worked extensively with germination or planting requirements for this species. Also, we know little about the ecological requirements of *P. villosa* at the high elevations of PTA. We aim to gather basic life history information for *P. villosa* as we continue to monitor and manage this species. There are 32 *S. P. villosa* accessioned to the greenhouse. We are developing planting strategies and plan to continue investigating outplant performance and planting site characteristics in 2020 to maximize the successful establishment of new self-sustaining groupings.

We are preparing to initiate a formal consultation with the USFWS under the ESA to analyze the potential effects from military activities to *P. villosa.* Therefore, we implement management of this species under the INRMP objectives that minimize threats to Hawaiian plants from wildfire and introduced ungulates. In addition, we strive to conserve the genetics of *P. villosa*.

To manage threats proactively for *P. villosa*, we implement landscape-level projects to reduce fire risk and ungulate browse for all known individuals at PTA (See Section 1.3). Between 2016 and 2019, we observed *in situ* reproduction in 2 of 3 monitoring plots for *P. villosa.* We actively conserve *P. villosa* genetics and have 4,833 seeds representing 3 natural founders in the propagule bank. Although we monitor *P. villosa* quarterly to assess population patterns, we are unable to attribute changes in numbers to effects from training or management.

For a discussion regarding how ongoing management benefits Army operations at PTA and the importance of continuing management efforts, see the final summary discussion for the Botanical Program (Section 2.6).

2.4.8 *Schiedea hawaiiensis* (Endangered)

As a PS 1, we monitor all known *Schiedea hawaiiensis* individuals each quarter. For genetic conservation, *Schiedea hawaiiensis* is an implementation priority 3 (moderate). We plan to collect propagules for storage and propagation and to outplant judiciously to establish new populations.

Plant Surveys

During the reporting period, we found 2 locations of *Schiedea hawaiiensis* representing 27 individuals. Because we are still surveying the full set of transects, our findings represent progress for the reporting period and do not represent actual changes in species abundance or distribution.

From previous survey work (2011 to 2015), there was 1 location of *Schiedea hawaiiensis* at PTA. The abundance of this species is tracked quarterly and reported below. The distribution for *Schiedea hawaiiensis*, including outplanting sites, is shown in Figure 31.

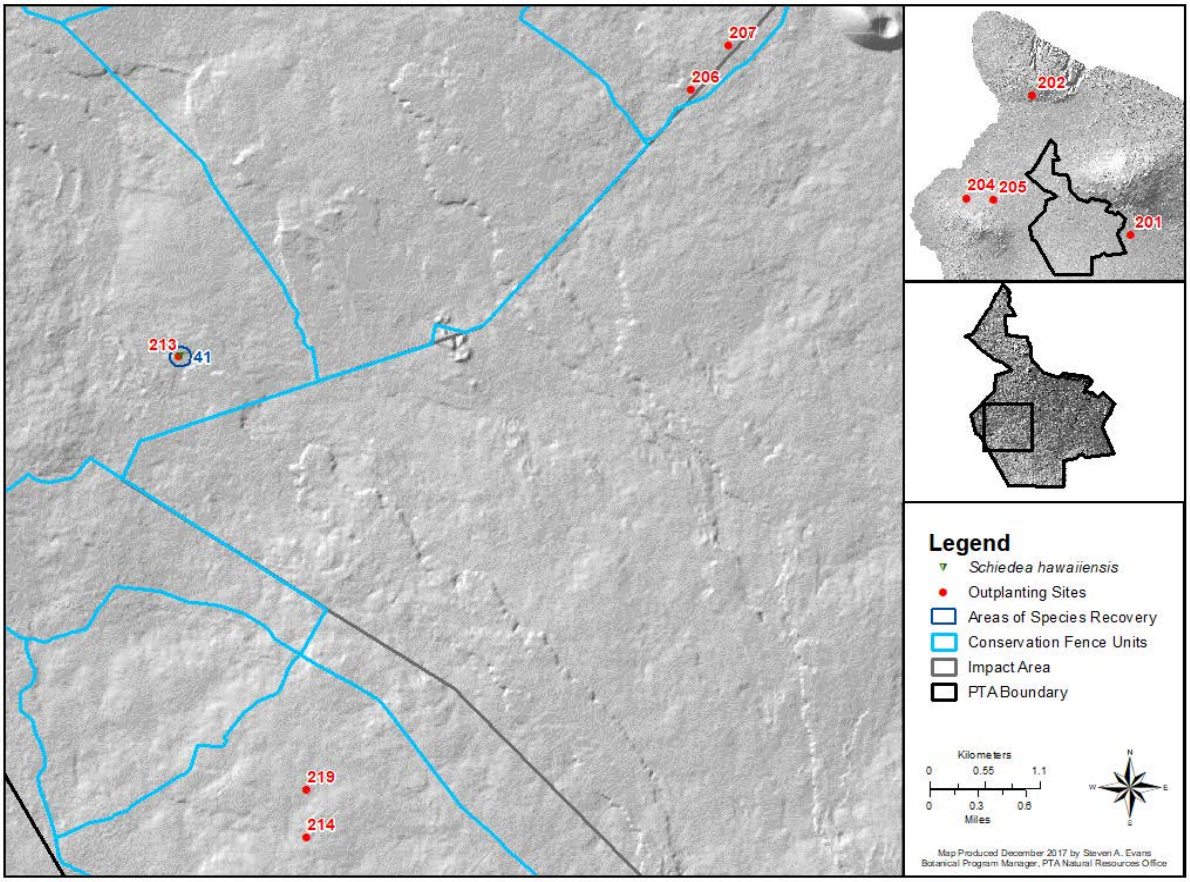

Figure 31. Current known distribution and outplanting sites for *Schiedea hawaiiensis*[a]

[a] Distribution data were collected between 2011 and 2015

Priority Species 1 Monitoring

We counted *Schiedea hawaiiensis* over 7 census periods between January 2017 and September 2019. The number of adults ranged between 3 and 6 over the census periods. The overall numbers of *Schiedea hawaiiensis* are low and loss and transition from the juvenile age class appears to heavily influence observed patterns in abundance (Figure 32).

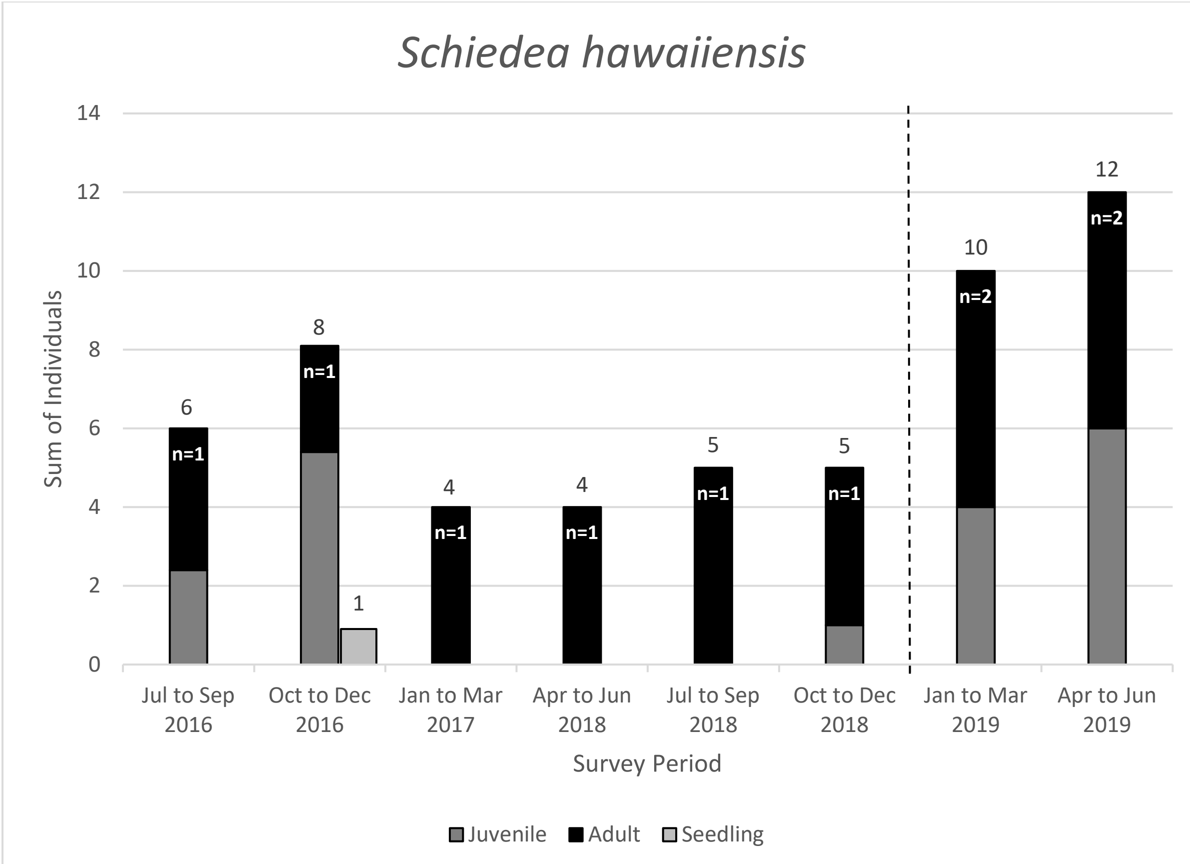

Figure 32. Monitoring results for *Schiedea hawaiiensis* from April 2016 through September 2019[a]

[a] For census periods left of the dotted line, we estimated life stage composition using proportion and to the right we counted each plant present by life stage (n=number of plots read).

We visually assessed threats at every plot each census period. We pooled all threat detections for every *Schiedea hawaiiensis* monitoring plot for the period of July 2018 through September 2019. Over this time, we made 6 visits to the monitoring plots and detected threats on 3 visits (Figure 33). We recorded rodent damage on 2 visits and water stress on one visit.

In addition, we monitored the plants via camera at ASR 206, an outplanted group of *Schiedea hawaiiensis* that is not monitored quarterly like the natural population. We captured images of black rats (*Rattus rattus*) climbing on the plants (Figure 34). We documented Erckel's Francolins foraging near plants (Figure 35) and, although we have yet to capture direct feeding on camera, we suspect the birds are clipping branches and leaves. We documented for the first time at PTA damage caused by an introduced species of leaf cutter bee (*Megachile* sp.). This species extracted large semi-circular cuts from the leaves of *Schiedea hawaiiensis* (Figure 36). Leaf cutter bees are typically found at lower elevations in Hawai'i, but some species have been documented from elevations similar to PTA.

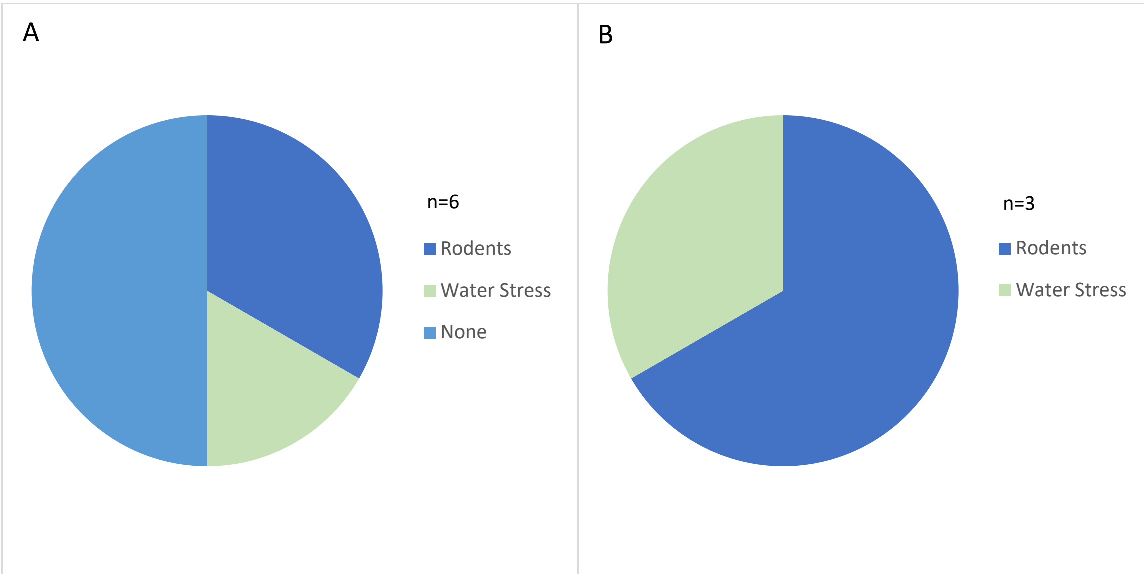

Figure 33. Emerging threats to *Schiedea hawaiiensis* recorded between July 2018 and 2019[a]

[a] Data pooled for all *Schiedea hawaiiensis* monitoring plots for all monitoring periods. We made a total of 6 visits to the monitoring plot during this time period and threats were present on 6 occasions. Panel A shows the threats recorded for every plot visit (n=6). Panel B shows the frequency each threat was recorded for every plot visit when threats were detected (n=3).

Figure 34. Rodent damage to *Schiedea hawaiiensis* documented via camera[a]

[a] Panel A shows rodent browse damage to an outplanted individual at ASR 217. Panel B shows a black rat (*Rattus rattus*) climbing a natural plant at ASR 41.

Figure 35. Erckel's Francolins (*Pternistis erckelii*) foraging near *Schiedea hawaiiensis* in ASR 207

Figure 36. Damage to *Schiedea hawaiiensis* leaves caused by an introduced leaf cutter bee species (*Megachile* sp.)

<u>Genetic Conservation</u>

Propagaule Collection

We aim to collect from all known extant, reproductive *Schiedea hawaiiensis* individuals. To this end, during the reporting period we collected a total of 40 cuttings: 10 from founder 519-1679-001-001, 16 from funder 519-1679-001-002, 12 from founder 519-1679-001-003, 2 from founder 519-1679-001-004. Refer to Table 8 for a complete summary of genetic conservation status for *Schiedea hawaiiensis.*

Propagation

Propagation records between October 2017 and July 2018 were incomplete or missing and do not align with the greenhouse accession records and plants in the facility. The greenhouse accession records indicate that seed from a single *Schiedea hawaiiensis* founder (519-1679-001-001-201) was propagated and 6 seedlings grew to sufficient size to be transferred to 4-inch pots and accessioned to the greenhouse (greenhouse numbers 155, 156, 157, 158, 159, and 160). Based on the founder number associated with the plants, the seeds propagated were collected in 2001 from a founder in the greenhouse.

After August 2018, more detailed propagation records were kept (Table 35). We attempted to propagate 3 batches of seed from accessions made in 2002, 2006, and 2008. We ranged between 90 and 100 seeds per germination trial. We anticipated that seeds would germinate at different rates and some would not germinate at all due to natural variation and quality among seeds in an accession. We observed very low germination rates up to 139 days after seeds were sown. In past germination trials, seedlings emerged in as little as 3 weeks and the percent germination ranged from 15–50%. We have no information on the long-term viability of *Schiedea hawaiiensis* seed. We cannot definitively conclude that age affects germinations rates; however, we may want to pursue the effect of age on germination under more controlled conditions. None of seedlings grew large enough to accession to the greenhouse.

Table 35. Seed germination trial results for *Schiedea hawaiiensis* from August 2019 to September 2019

New Founder No.	Other Founder No.	Prop. Accession	Media	Seed Treatment	Trial Days	No. Seed Sown	No. Seeds Germ.	% Germ	No. plants GH Acc.
519-1679-001-001-201	04041001001201	2002001	Filter paper	GC + GA3 100ppm	139	100	3	3%	0
519-1679-001-001-501	04041001001501	2006001	Filter paper	GC + GA3 100ppm	139	100	5	5%	0
519-1679-001-001	04041001001	2008001	Filter paper	GC	55	90	0	0%	0

GA3, gibberellin A3; GC, growth chamber; GH, greenhouse

We propagated a total of 20 cuttings from 4 founders. One of 5 cuttings from founder 519-1679-001-001 and 1 of 8 cuttings from founder 519-1679-001-002 grew to sufficient size to be accessioned to the greenhouse. No cuttings from founders 519-1679-001-003 and 519-1679-001-004 were accessioned to the greenhouse. Although some cuttings may still be growing without accession numbers in the greenhouse, the successful establishment of plants sufficient to be accessioned was relatively low (2 out of 20 or 10%).

Outplanting and Monitoring

In 2019, we outplanted 2 individuals of *Schiedea hawaiiensis* in TA 21 at planting site Temp 2019-009 (Figure 10). Very little is known about the historical, natural range of *Schiedea hawaiiensis*. Because *Schiedea hawaiiensis* planted at Puʻu Huluhulu (ASR 201) in past years performed relatively well, we anticipate that *Schiedea hawaiiensis* will do well at this high elevation site as well.

In previous years, we planted *Schiedea hawaiiensis* at ASRs 201, 202, 204, 205, 206, 207, 213, 214 and 219 (Table 36). As of 2016, at least 73 of the planted adults were living. Outplants did not persist and no recruitment occurred at ASR 202 and 204. These sites are lower in elevation than PTA and may not be optimal for this species. *Schiedea hawaiiensis* established self-sustaining groups at ASRs 206 and 207 on PTA and has recruited at ASRs 201, 205, 213, and 214. Because the natural population of *Schiedea hawaiiensis* is limited to one small area with only a few individuals, the establishment of plants in new areas with successful recruitment is an important achievement towards the conservation of this species. Continuing to investigate planting site characteristics and the performance of the outplants will help us to better select new planting sites and improve the likelihood of establishing successful plantings.

Table 36. Monitoring summary for *Schiedea hawaiiensis* outplanted prior to FY 2018

			Surviving Outplants			Recruits	
Location	Outplanting Site	Total Outplanted	Adult	Juvenile	Net Survivorship	Adult	Juvenile
On PTA	206	24	Present	--	--	Yes	--
	207	5	0	0	0%	Yes	--
	213	14	8	0	57%	Yes	--
	214	69	19	0	27%	37	0
	219	5	4	0	80%	--	--
Off PTA	201	259	34	0	13%	6	6
	202	40	0	0	0%	0	0
	204	204	0	0	0%	0	0
	205	374	8	0	2%	2	0

PTA, Pōhakuloa Training Area

Discussion

Our efforts to survey, monitor, and conserve genetics for *Schiedea hawaiiensis* address SOO tasks 3.2(1)(a, d–f) as well as several INRMP objectives.

Schiedea hawaiiensis has the most restricted distribution of any ESA-listed plant species at PTA. The main grouping of plants is restricted to approximately 1 m^2 (Figure 31). Our most significant find during the second cycle of the rare plant surveys, thus far, was a new location of *Schiedea hawaiiensis* approximately 110 m from an outplanting site with *Schiedea hawaiiensis* present. This is the first new location of a natural plant of this species discovered at PTA since 1995.

Very little is documented about the ecological requirements or life history of *Schiedea hawaiiensis*. This species was known only from a single collection made near Waimea, Hawaiʻi, circa 1850. The species was apparently not collected or documented again until rediscovered at PTA in 1995. Like other *Schiedea* species, *Schiedea hawaiiensis* appears to successfully self-pollinate and produce viable seeds (Sakai et al. 2006). However, we poorly understand the relationship between vegetative reproduction (i.e., clones) and germination from seed and the relative contributions to healthy populations. We have no information about what *Schiedea hawaiiensis* age distributions support healthy and resilient populations. In addition, we do not know which, if any, of the life stages is most vulnerable and/or may regulate population dynamics. Knowing these life history attributes is important for designing management actions to maximize the likelihood that *Schiedea hawaiiensis* will persist, and potentially increase, especially with changing climate conditions. We recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species.

We continue to investigate wildlife threats to *Schiedea hawaiiensis*. Deployment of A24 traps appears to effectively reduce observed damage from rodent browse. We are still investigating interactions between game birds and the plants. Although we suspect that the birds directly damage the plants by clipping branches and leaves, photographs suggest that, at a minimum, the birds disturb the soil around plants as they forage. This disturbance could affect root health and the establishment of seedlings. We continue to monitor the impact of leaf cutter bees on *Schiedea hawaiiensis*. Based on the biology of leaf cutter bees and the current level of observed damage to *Schiedea hawaiiensis,* we do not plan to control the bees. If the level of damage rises and poses a threat to the survival of the plants, we can investigate control options.

Schiedea hawaiiensis has successfully established at several ASRs. *Schiedea hawaiiensis* has been so successful at ASR 206 that quantifying individuals is difficult. *Schiedea hawaiiensis* has successfully established at ASRs 201, 207, 213, and 214, although to a lesser degree. We plan to continue to investigate planting site characteristics to improve our success at establishing self-sustaining groups. There are 9 *Schiedea hawaiiensis* accessioned to the greenhouse. We are developing planting strategies and plan to continue investigating outplant performance and planting site characteristics in 2020 to maximize the successful establishment of new self-sustaining groupings.

The USFWS listed *Schiedea hawaiiensis* as an endangered species under the ESA in 2013. We have not initiated a formal consultation with the USFWS under the ESA to analyze the potential effects from military activities on *Schiedea hawaiiensis.* Therefore, we implement management of this species under the INRMP objectives that minimize threats to Hawaiian plants from wildfire and introduced animals. In addition, we strive to conserve the genetics of *Schiedea hawaiiensis*.

To manage threats proactively for *Schiedea hawaiiensis*, we implement landscape-level projects to reduce fire-risk and browse and damage from ungulates, rodents, and game birds for all known individuals at PTA (See Section 1.3). Between 2016 and 2019, we observed *in situ* reproduction in 1 of 2 monitoring plots for *Schiedea hawaiiensis.* We actively conserve *Schiedea hawaiiensis* genetics; the propagule bank contains 315 seeds from the natural population and 331,418 seeds from individuals grown in the greenhouse. Although we monitor *Schiedea hawaiiensis* quarterly to assess population patterns, we are unable to attribute changes in numbers to effects from training or management.

For a discussion regarding how ongoing management benefits Army operations at PTA and the importance of continuing management efforts, see the final summary discussion for the Botanical Program (Section 2.6).

2.4.9 *Sicyos macrophyllus* (Endangered)

As a PS 1, we monitor all known *S. macrophyllus* individuals each quarter. For genetic conservation, *S. macrophyllus* is an implementation priority 1 (high). We plan to collect propagules for storage and propagation and to outplant to augment the existing population and to establish new populations.

Plant Surveys

No locations of *S. macrophyllus* were recorded during the reporting period. This outcome is not surprising since we did not survey within the known distribution of this species.

From previous survey work (2011 to 2015), there was 1 location of *S. macrophyllus* at PTA. The plant at this location died in 2017. We monitor the site periodically for regeneration but have not detected new plants to date. The distribution for *S. macrophyllus* is shown in Figure 37.

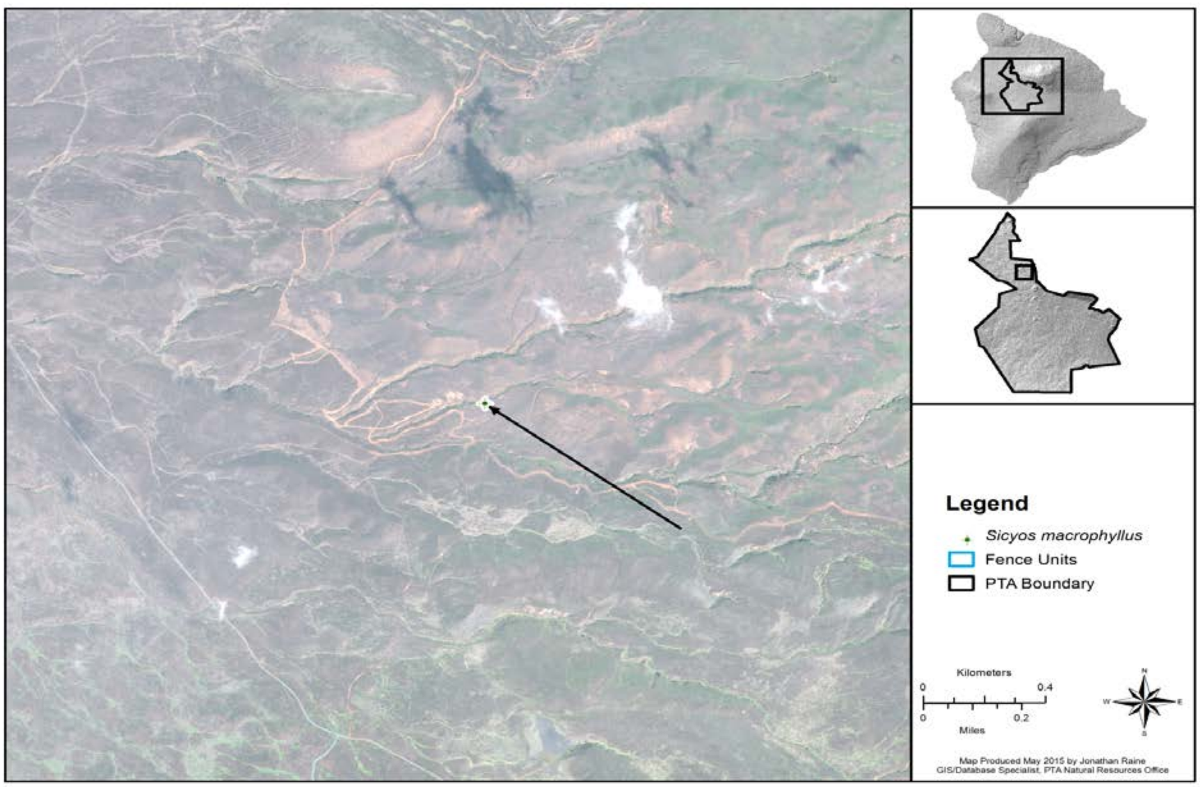

Figure 37. Current known distribution of *Sicyos macrophyllus*[a]

[a] Distribution data were collected between 2011 and 2015

Priority Species 1 Monitoring

Although the only known *S. macrophyllus* plant at PTA died in 2017, we monitored the plot where it previously occurred in March, June, and September 2019. We did not see any regeneration at the plot.

Genetic Conservation

Propagule Collection

In 2016, approximately 479 fruits were collected from the single known founder of *S. macrophyllus*. The plant died in 2017 and there are no extant individuals of *S. macrophyllus* at PTA currently.

Propagation

We attempted germination trials with 2 batches of 25 seeds (Table 37). We did not observe any germination even 270 days after seeds were sown. Based on this preliminary information, we need to know more about seed characteristics prior to sowing and the influence of these characteristics on germination outcomes. Without more basic information about seed quality and viability, we will likely continue to experience variability in seed germination success. A botanist at the USFWS speculates that *S. macrophyllus* seeds are short-lived and are most viable within a year of collection (Lauren Weisenberger, personal communication, November 2019). The seeds in our storage are over 2 years old. We may partner with Lyon Arboretum in 2020 to assess the feasibility of seed embryo rescue or tissue culture from some of the *S. macrophyllus* seed in our *ex situ* collection.

Table 37. Seed germination trial results for *Sicyos macrophyllus* from August 2018 to September 2019

New Founder No.	Other Founder No.	Prop. Accession	Media	Seed Treatment	Trial Days	No. Seed Sown	No. Seeds Germ.	% Germ	No. plants GH Acc.
503-2193-001-001	15049001001	2016001	V + GHM	Clip	272	25	0	0%	0
503-2193-001-001	15049001001	2016001	V + GHM	None	273	25	0	0%	0

GH, Greenhouse

Outplanting and Monitoring

No outplanting of *S. macrophyllus* occurred during the reporting period and we have not planted this species in previous years.

Discussion

Our efforts to survey, monitor, and conserve genetics for *S. macrophyllus* address SOO tasks 3.2(1)(a, d-f) as well as several INRMP objectives.

S. macrophyllus occurs as a single individual in a highly degraded gulch in KMA in 2015 (Figure 37). We constructed a small fence (~0.5 ha) around the plant in 2016. We continue to maintain the fence, but do not control the vegetation within the fence and the grass has formed a dense mat. Based on past observations and collections of fruits, we assume there is a seed bank in the soil. However, the thick grass may impede natural regeneration at the site. Because seeds are relatively short-lived, we recommend actively managing the grass within the fence for 2020. We recommend working in partnership with the USFWS and seed researchers to investigate the viability of the seeds and tissue last collected from *S. macrophyllus* in 2016.

The USFWS listed *S. macrophyllus* as an endangered species under the ESA in 2016. We have not initiated a formal consultation with the USFWS under the ESA to analyze the potential effects from military activities to *S. macrophyllus.* Therefore, we implement management for this species under INRMP objectives. We constructed a fence to prevent ungulate browse to the only known location of *S. macrophyllus.* We actively conserve *S. macrophyllus* genetics; the propagule bank contains 479 seeds from the single founder.

For a discussion regarding how ongoing management benefits Army operations at PTA and the importance of continuing management efforts, see the final summary discussion for the Botanical Program (Section 2.6).

2.4.10 *Solanum incompletum* (Endangered)

As a PS 1, we monitor all known *S. incompletum* individuals each quarter. For genetic conservation, *S. incompletum* is an implementation priority 3 (moderate). We plan to collect propagules for storage and propagation and to outplant judiciously to establish new populations.

Plant surveys

No locations of *S. incompletum* were recorded during the reporting period. This outcome is not surprising since *S. incompletum* is restricted to 3 widely disbursed locations and we did not survey within the known groupings of this species.

From previous survey work (2011 to 2015), there were 21 locations representing 21 individuals of *S. incompletum* at PTA. The abundance of this species is tracked quarterly and reported below. The distribution for *S. incompletum*, including outplanting sites, is shown in Figure 38.

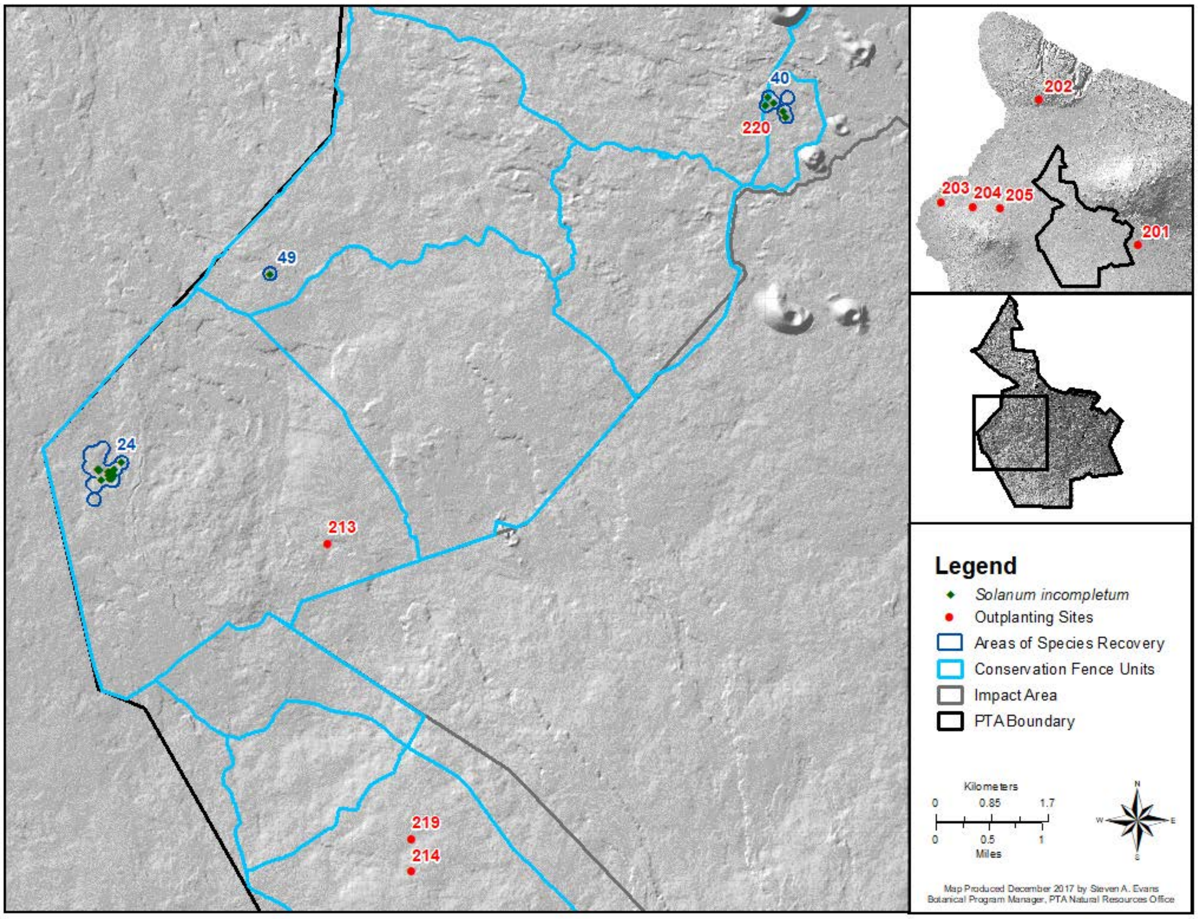

Figure 38. Current known distribution and outplanting sites for *Solanum incompletum*[a]

[a] Distribution data were collected between 2011 and 2015

<u>Priority Species 1 Monitoring</u>

We counted *S. incompletum* over 9 census periods between April 2016 and September 2019. The number of adults present over the period remained relatively stable and ranged from 73 to 101 adults (Figure 39). A low number of seedlings was present between July 2018 and March 2018 and between July and September 2019. A transition from seedlings to juveniles between January 2019 and June 2019 likely supported the increase in the number of adults present between July to September 2019.

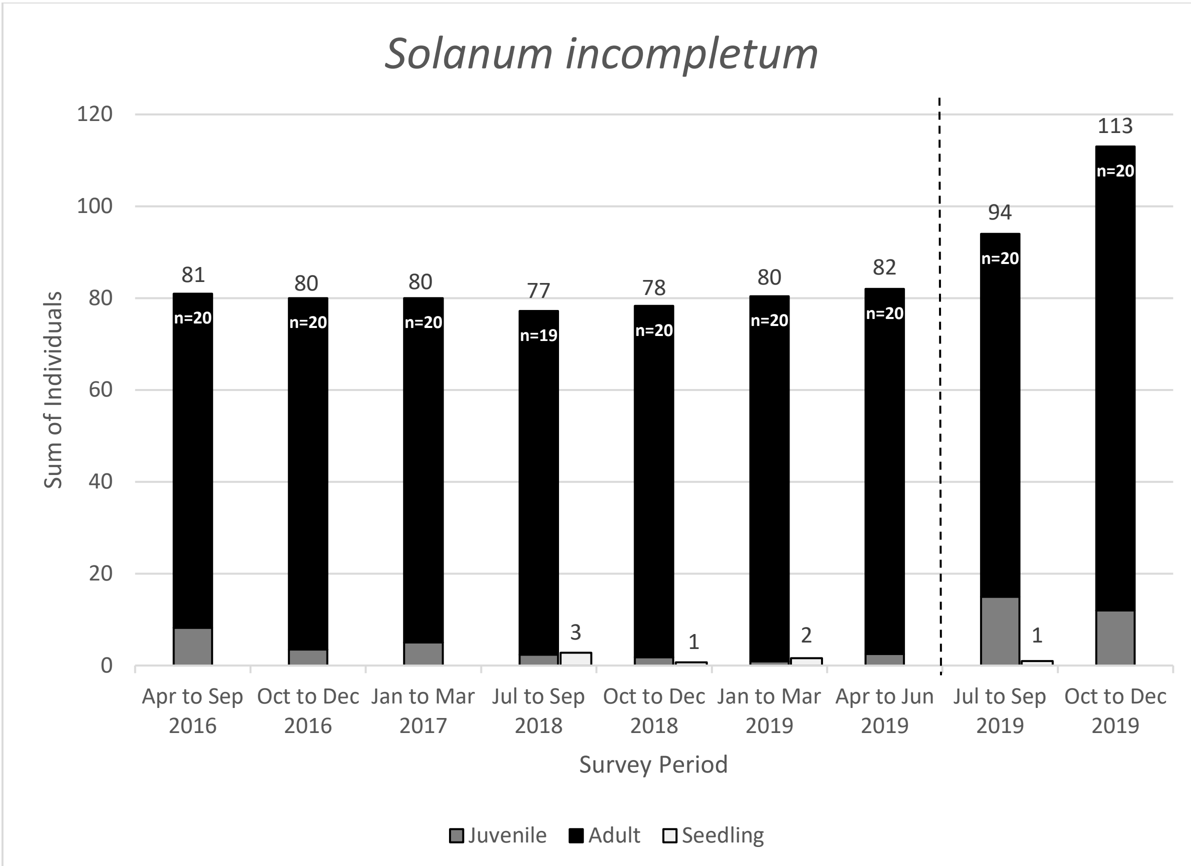

Figure 39. Monitoring results for *Solanum incompletum* from April 2016 through September 2019[a]

[a] For census periods left of the dotted line, we estimated life stage composition using proportion and to the right we counted each plant present by life stage (n=number of plots read).

We visually assessed threats at every plot each census period. We pooled all threat detections for every *S. incompletum* monitoring plot for the period of July 2018 through September 2019. Over this time, we made 99 visits to the monitoring plots and detected threats on 5 visits (Figure 40). We recorded invasive plants as a threat on 2 visits and all other threat on one visit each. In all, threats were detected on 5 of 99 visits.

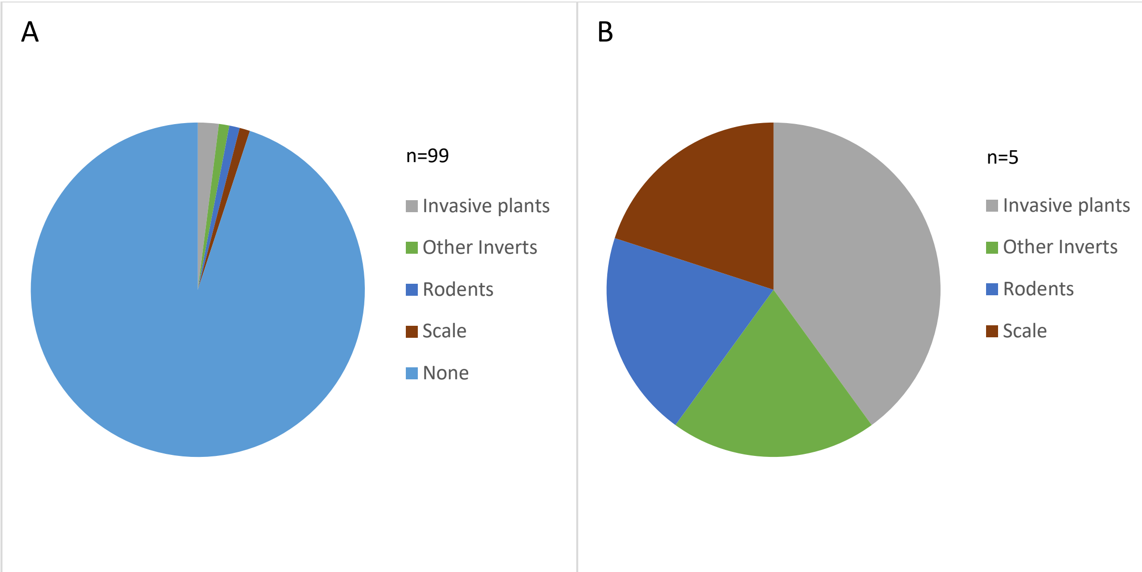

Figure 40. Emerging threats to *Solanum incompletum* recorded between July 2018 and 2019[a]

[a] Data pooled for all *S. incompletum* monitoring plots for all monitoring periods. We made a total of 99 visits to the monitoring plot during this time period and threats were present on 5 occasions. Panel A shows the threats recorded for every plot visit (n=99). Panel B shows the frequency each threat was recorded for every plot visit when threats were detected (n=5).

Genetic Conservation

Propagule Collection

We aim to collect from all known extant, reproductive *S. incompletum* individuals. To this end, we collected a total of 1,864 fruits representing 7 founders and 2,226 seeds representing 13 founders during the reporting period. In addition, we collected a total of 103 cuttings from 17 founders, taking 3 to 5 cuttings per founder. Refer to Table 8 for a complete summary of genetic conservation status for *S. incompletum.*

Propagation

Propagation records between October 2017 and July 2018 were incomplete or missing and do not align with the greenhouse accession records and plants in the facility. The greenhouse accession records indicate that propagules from 3 *S. incompletum* founder were propagated and 37 seedlings grew to sufficient size to be transferred to 4-inch pots and accessioned to the greenhouse (Table 38).

Table 38. ***Solanum incompletum*** **accessioned to the greenhouse without propagation records as of September 2019**

New Founder No.	Other Founder No.	Date Accessioned to Greenhouse	Greenhouse Accession No.	Accessions in Greenhouse
519-1380-006-001	Unclear	6/15/2019, 7/9/2019, and 8/8/2019	605-607, 777-784, 977-979	605-607, 777-784, 977-979
519-1380-009-000	Unclear	7/9/2019	733, 734, 735	733, 734, 735
519-1380-009-001	Unclear	5/15/2019 and 8/8/2019	609-620, 727-732, 980, 981	609-619, 727-732, 980, 981

After August 2018, more detailed propagation records were kept (Table 39). We attempted to propagate 29 batches of seed from accessions made between 1999 and 2018. We ranged between 22 and 168 seeds per germination trial. We anticipated that seeds would germinate at different rates and some would not germinate at all due to natural variation and quality among seeds in an accession. To try and better understand the range of time some seeds need to geminate, we monitored some germination trials for several months and recorded germination up to 301 days after seeds were sown. However, we cannot easily discern germination patterns for *S. incompletum* from the data. Some accessions from 2018 had 0% germination after 301 days and other accessions from the same year had over 50% germination.

Based on this preliminary information, we need to know more about seed characteristics prior to sowing and the influence of these characteristics on germination outcomes. Without more basic information about seed quality and viability, we will likely continue to experience variability in seed germination success.

Table 39. Seed germination trial results for *Solanum incompletum* from August 2018 to September 2019

New Founder No.	Other Founder No.	Prop. Accession	Media	Seed Treatment	Trial Days	No. Seed Sown	No. Seeds Germ.	% Germ	No. plants GH Acc.
519-1380-000-000	04024000000	2006007	V + GHM	None	176	100	7	7%	
519-1380-000-000	04024000000	2007003	V + GHM	None	176	100	21	21%	27
519-1380-100-000	04024001000	1999001	V + GHM	None	176	100	6	6%	5
519-1380-100-001	04024001000	2000002	UNK	UNK	UNK	UNK	UNK	--	--
519-1380-001-003	04024001003	2002002	V + GHM	None	176	65	0	0%	0
519-1380-008-001	4024008001	2015004	V + GHM	1d Soak + GC	190	30	3	10%	2
519-1380-010-002	04024010002	2015006	V + GHM	1d Soak + GC	190	30	4	13%	4
508-2386-002-002	08040002002	2009009	V + GHM	None	176	81	0	0%	0
508-2386-003-001	08040003001	2015009	V + GHM	1d Soak	195	84	1	1%	0
519-1380-001-001	040240101001	2001005	V + GHM	None	78	25	1	4%	0
519-1380-001-010-001	04024001010001	2001005	V + GHM	None	78	25	1	4%	
519-1380-001-001	04024001010001	2001005	V + GHM	300ppm GA3	78	25	3	12%	
519-1380-001-001	04024001010001	2001005	V + GHM	300ppm GA3	78	25	4	16%	
519-1380-001-001	04024001010001	2001005	V + GHM	500ppm GA3	78	25	8	32%	
519-1380-001-001	04024001010001	2001005	V + GHM	500ppm GA3	78	25	2	8%	
519-1380-001-001	04024001010001	2001005	V + GHM	Water	78	25	0	0%	
519-1380-001-001	04024001010001	2001005	V + GHM	Water	78	25	0	0%	
519-1380-001-001	04024001010001	2001005	V + GHM	None	176	100	23	23%	
519-1380-001-001	04024001010001	2002003	V + GHM	None	176	100	6	6%	
519-1380-001-001	04024001010001	2005013	V + GHM	None	176	60	0	0%	
519-1380-001-001	04024001010001	2010009	V + GHM	None	176	168	9	5%	62
519-1380-002-001-310	04024002001301	2008009	V + GHM	None	153	51	4	8%	1
519-1380-008-008	04024008	2018002	V + GHM	4mo GH + GC	301	30	7	23%	0
519-1380-010	04024010	2018003	V + GHM	1d Soak + GC	190	100	27	27%	0
519-1380-013-001	04024013001	180927001	Filter paper	None	63	22	2	9%	0
519-1380-013-001	04024013001	180927001	Filter paper	GA3 100ppm	63	22	3	14%	0
519-1380-013-001	04024013001	180927001	Filter paper	GA3 300ppm	63	22	13	59%	0
519-1380-013-001	04024013001	180927001	Filter paper	GA3 500ppm	63	22	11	50%	0
519-1380-024-001	None	2018001	V + GHM	4mo GH + GC	301	100	0	0%	0

GA3, gibberellin A3; GC, growth chamber; GH, greenhouse; GHM, greenhouse media; UNK, unknown; V, vermiculite

We propagated 103 cutting from 17 founders. Of these cuttings, 41 cuttings from 13 founders survived to sufficient size to be accessioned to the greenhouse (Table 40). Some cuttings may still be growing in the greenhouse, so it is difficult to assess overall success rates. From the data we have, at least 47% of the *S. incompletum* cuttings were accessioned to the greenhouse.

Table 40. *Solanum incompletum* cuttings accessioned to the greenhouse

New Founder No.	Other Founder No.	Date of Cutting	Prop. Accession No.	Greenhouse Accession. No.
508-2386-003-001	08040003001	5/16/2019	190516003	1033
508-2386-005-001	Unclear	5/16/2016	190516004	1023
519-1380-001-006	Unclear	1/2/2019	190102029	1202, 1204
519-1380-001-054	Unclear	1/2/2019	1901020021	630, 631, 687, 688
519-1380-002-001	Unclear	1/2/2019	190102030	632, 633, 774, 775, 773
519-1380-005-100	Unclear	1/2/2019	190102019	1174
519-1380-007-001	04024007001	1/2/2019	190102022 / 190101025	634, 635, 636, 637, 638, 638, 1173
519-1380-008-001	04024008001	1/2/2019	190102024	640, 641, 642, 643, 644
519-1380-011-001	Unclear	1/2/2019	190102020	642
519-1380-013-001	Unclear	1/2/2019	190102027	649, 650, 651, 988, 993, 1175
519-1380-016-001	Unclear	1/2/2019	190102018	652, 653, 654, 655
519-1380-021-001	Unclear	1/2/2019	190102026	656, 657, 658
519-1380-024-001	None	1/2/2019	190102028	659, 660, 661, 1172

Outplanting and Monitoring

We did not outplant *S. incompletum* during the reporting period.

In previous years, we planted *S. incompletum* at 11 ASRs (Table 41). Although we outplanted several hundred plants between 2004 and 2014, *S. incompletum* persisted at very few sites and only successfully recruited in low numbers at 3 ASRs. Due to the limited success at establishing self-sustaining groupings, we plan to continue to investigate planting site characteristics and other ecological requirements to maximize our chances of success.

Table 41. Monitoring summary for *Solanum incompletum* outplanted prior to FY 2018

			Surviving Outplants			Recruits	
Location	Outplanting Site	Total Outplanted	Adult	Juvenile	Net Survivorship	Adult	Juvenile
On PTA	209	40	28	4	80%	0	0
	211	14	1	0	7%	0	0
	213	21	15	6	100%	0	0
	214	170	51	24	51%	12	1
	219	4	0	4	100%	0	0
	220	3	2	1	20%	0	0
Off PTA	201	455	162	0	36%	0	0
	202	78	0	0	0%	0	0
	203	11	3	0	27%	0	0
	204	225	4	0	2%	4	0
	205	406	49	0	12%	0	1

PTA, Pōhakuloa Training Area

Discussion

Our efforts to survey, monitor, and conserve genetics for *S. incompletum* address SOO tasks 3.2(1)(a, d–f) as well as several INRMP objectives and conservation measures from the 2003 and 2013 BO.

At PTA, *S. incompletum* naturally occurs in soil and rocky substrates in 3 habitat types: *Dodonaea* shrubland, *Myoporum* shrubland, and *Metrosideros* treeland. It occurs in ASRs 24, 40, and 49 (Figure 38). The population of *S. incompletum* is comprised mostly of adults with a low, but consistent number of juvenile plants. We documented periodic recruitment during quarterly monitoring and the data suggests some level of transition between life stages. However, we do not know which, if any, of the life stages is most vulnerable and/or may regulate population dynamics. Knowing these life history attributes is important for designing management actions to maximize the likelihood that *S. incompletum* will persist, and potentially increase, especially with changing climate conditions. We recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species.

We continue to make progress with genetic conservation for *S. incompletum.* Many of the accessions in storage are aging and we do not know how long seeds or fruit will store. Seed germination was variable and generally low (range 0% to 59%). We need to know more about seed characteristics prior to sowing and the influence of these characteristics on germination outcomes. Without more basic information about seed quality and viability, we will likely continue to experience variability in seed germination success.

Although we have outplanted over 1,000 *S. incompletum* individuals between 2004 and 2014, outplants do not persist in high numbers. In 2016, we documented recruitment at three ASRs, 2 at lower elevation (ASRs 204 and 205) and 1 at higher elevation (ASR 214). There are 125 *S. incompletum* accessioned to the greenhouse. We are developing planting strategies and plan to continue investigating outplant performance and planting site characteristics in 2020 to maximize the successful establishment of new self-sustaining groupings.

Progress toward compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects from military activities to *S. incompletum,* the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browse pressure, maintenance of genetic stock *ex situ*, outplanting, reproduction *in situ*, non-native plant control, and annual monitoring.

To address these conservation measures for *S. incompletum*, we implement landscape-level projects to reduce fire-risk and ungulate browse for all known individuals at PTA (See Section 1.3). In addition, we actively conserve *S. incompletum* genetics; the propagule bank contains 2,622 fruit and 6,957 seeds from the natural populations and another 8,384 fruit from individuals grown in the greenhouse or from individuals outplanted. To date, we have outplanted 1,427 individuals at 9 ASRs, but *S. incompletum* has not persisted at any. We manage weeds in 3 ASRs, with all areas totaling about 2.7 ha for *S. incompletum* (Table 62). Between 2016 and 2019, we observed *in situ* reproduction in 3 of 20 (15%) monitoring plots for *S. incompletum.* Although we monitor *S. incompletum* quarterly to assess population patterns, we are unable to attribute changes in numbers to effects from training or management.

For a discussion regarding how ongoing management benefits Army operations at PTA and the importance of continuing management efforts, see the final summary discussion for the Botanical Program (Section 2.6).

2.4.11 ***Tetramolopium arenarium*** **var.** ***arenarium*** **(Endangered)**

As a PS 1, we monitor all known *T. arenarium* var. *arenarium* individuals each quarter. For genetic conservation, *T. arenarium* var. *arenarium* is an implementation priority 3 (moderate). We plan to collect propagules for storage and propagation and to outplant judiciously to establish new populations.

Plant surveys

No locations of *T. arenarium* var. *arenarium* were found during the reporting period. This result is not surprising since we did not survey within the known distribution of this species.

From previous survey work (2011 to 2015), there were 40 locations of *T. arenarium* var. *arenarium* at PTA. The abundance of this species is tracked quarterly and reported below. The distribution for *T. arenarium* var. *arenarium*, including outplanting sites, is shown in Figure 41.

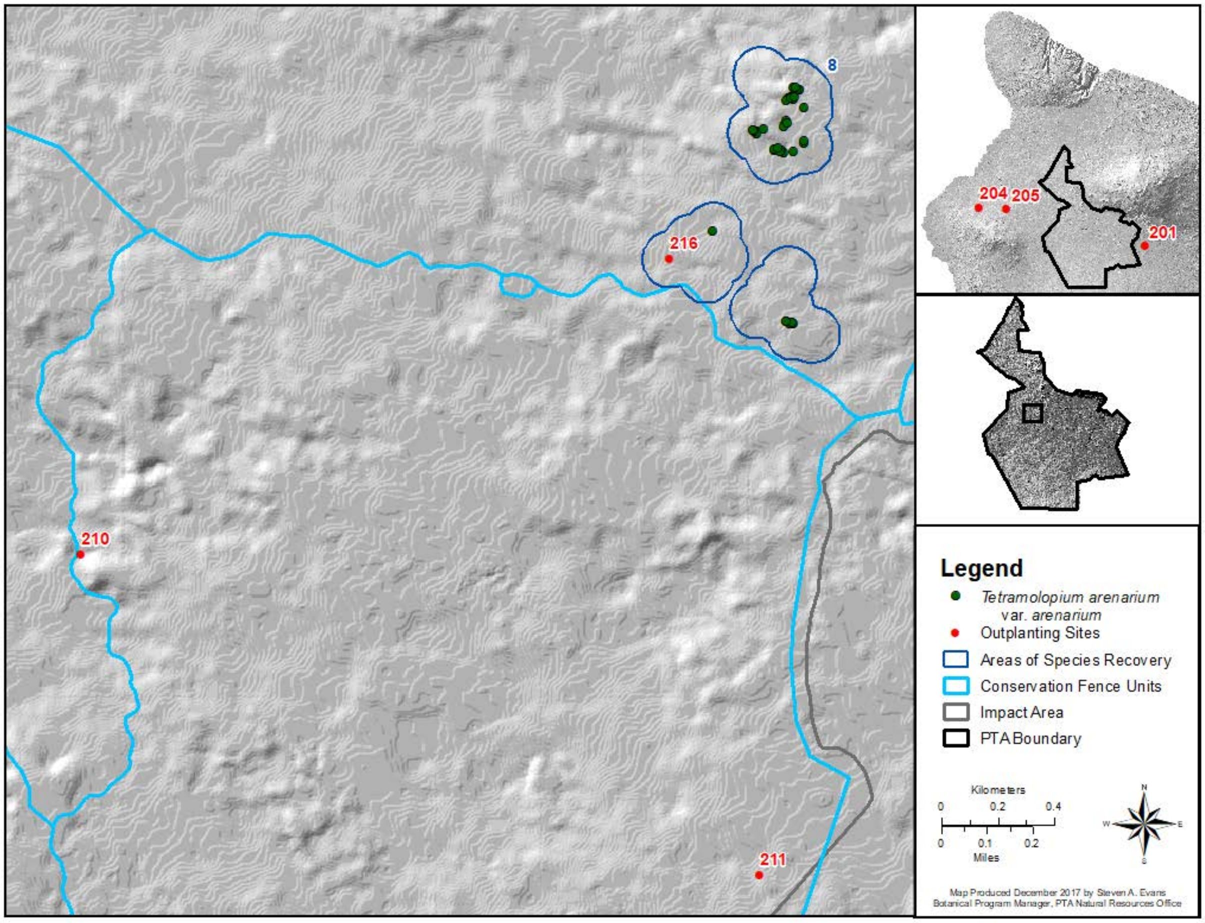

Figure 41 . Current known distribution and outplanting sites for *Tetramolopium arenarium* var. *arenarium*[a]

[a] Distribution data were collected between 2011 and 2015

Priority Species 1 Monitoring

We counted *T. arenarium* var. *arenarium* over 8 census periods between April 2016 and September 2019 (Figure 42). Between October 2016 and March 2017, seedlings recruited in large numbers. Although the numbers of seedlings greatly decreased between census periods September 2018 and March 2019, many of these seedlings transitioned to juvenile and adult age classes and numbers of juveniles and adults remained relatively stable from October 2018 through September 2019. Lesser seedling flushes from April through September 2019 appeared to support continual transition to juvenile and adult age classes.

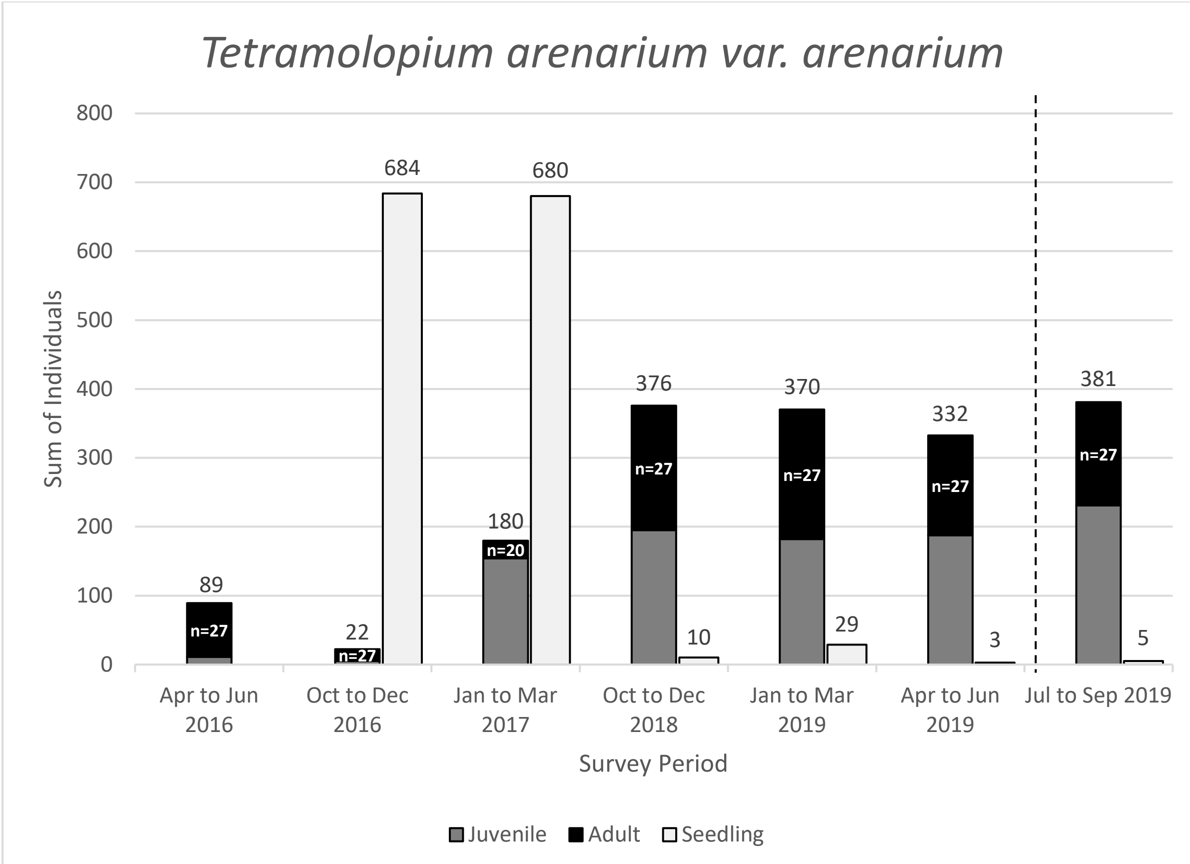

Figure 42. Monitoring results for *Tetramolopium arenarium* var. *arenarium* from April 2016 through September 2019[a]

[a] For census periods left of the dotted line, we estimated life stage composition using proportion and to the right we counted each plant present by life stage (n=number of plots read). For census periods right of the dotted line, totals may include count class data. When this occurs the minimum value of the count class is summed with the counts from other plots to provide the total value for abundance. Therefore, these numbers represent the minimum number of individuals present during the census period.

We visually assessed threats at every plot each census period. We pooled all threat detections for every *T. arenarium* var. *arenarium* monitoring plot for the period of July 2018 through September 2019. Over this time, we made 297 visits to the monitoring plots and detected threats on 14 visits (Figure 43). Water stress and aphids were the most frequently recorded threats for *T. arenarium* var. *arenarium* (20 out of 30 threat detections).

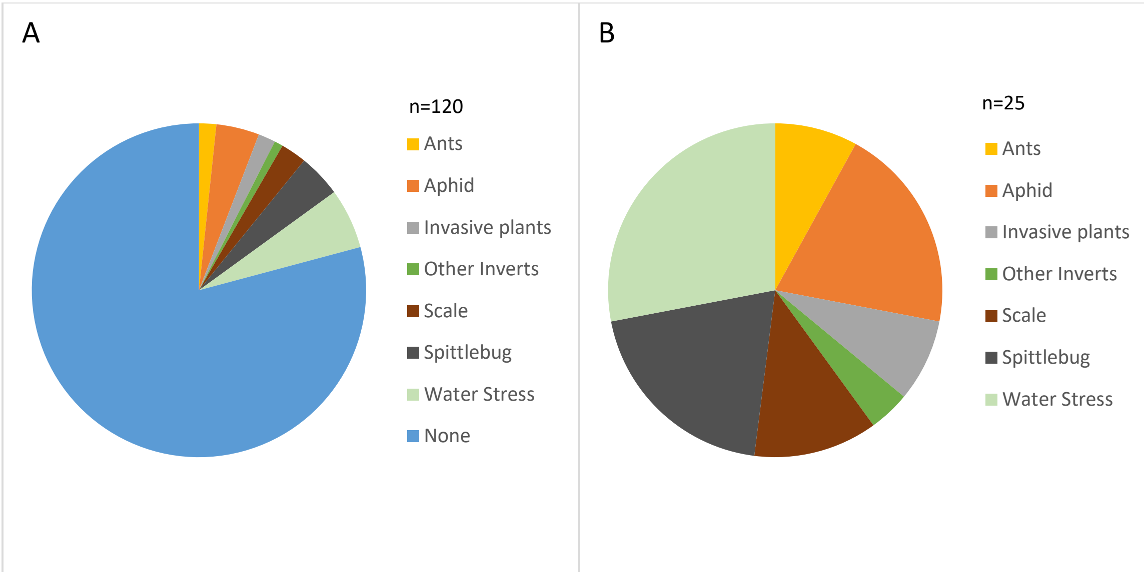

Figure 43. Emerging threats to *Tetramolopium arenarium* var. *arenarium* recorded between July 2018 and 2019[a]

[a] Data pooled for all *T. arenarium* var. *arenarium* monitoring plots for all monitoring periods. We made a total of 120 visits to the monitoring plots during this time period and threats were present on 25 occasions. Panel A shows the threats recorded for every plot visit (n=120). Panel B shows the frequency each threat was recorded when threats were detected (n=25).

Genetic Conservation

In the *Genetic Conservation and Outplanting Plan* (CEMML 2017), *T. arenarium* var. *arenarium* is an implementation priority 3 (low). The propagule storage goal is to represent as many reproductive individuals from the natural population as possible. Currently, the propagule bank holds material from 563 founders with an average of 200 seed per founder. *T. arenarium* var. *arenarium* often seed at the same time, which facilitates collecting seed from a large proportion of the reproductive population.

Propagule Collection

We aim to collect from all known extant, reproductive *T. arenarium* var. *arenarium* individuals. To this end, we collected a total of 8,043 seeds representing 46 founders. Please refer to Table 8 for a complete summary of genetic conservation status for *T. arenarium* var. *arenarium.*

Propagation

Propagation records between October 2017 and July 2018 were incomplete or missing and do not align with the greenhouse accession records and plants in the facility. The greenhouse accession records indicate that seeds from a single *T. arenarium* var. *arenarium* founder were propagated and 209 seedlings grew to sufficient size to be transferred to 4-inch pots and accessioned to the greenhouse (Table 42). Based on the dates of the greenhouse accessions (6 February 2019), the cuttings were likely propagated in early 2018.

Table 42. *Tetramolopium arenarium* var. *arenarium* accessioned to the greenhouse without propagation records as of September 2019

New Founder No.	Other Founder No.	Date Accessioned to Greenhouse	Greenhouse Accession No.	Accessions in Greenhouse
509-2385-002-002	Unclear	4/2/2019, and 8/8/2019	434-558, 884-967	884-892, 894, 895, 987-900, 902, 903, 906-908, 910-915, 917-921, 925, 926, 928-930, 932-938, 941-943, 945-948, 954-958, 960-962, 964, 966

Note: All *Tetramolopium arenarium* var. *arenarium* greenhouse accessions not listed in the last column died (n=159) or were not found (n=36).

We attempted to propagate 10 batches of seed from accessions made between 2007 and 2018 (Table 43). Some germination trial information was not recorded, and we are unable to assess the success of those trials. For trials with known inputs and outcomes, we ranged between 40 and 100 seeds per germination trial. We anticipated that seeds would germinate at different rates and some would not germinate at all due to natural variation and quality among seeds in an accession. To try and better understand the range of time some seeds need to geminate, we monitored some germination trials for several months and recorded germination up to 149 days after seeds were sown. In general germination rates were good with only one trial of older seeds not resulting in seedlings.

Table 43. Seed germination trial results for *Tetramolopium arenarium* var. *arenarium* from August 2018 to September 2019

New Founder No.	Other Founder No.	Prop. Accession	Media	Seed Treatment	Trial Days	No. Seed Sown	No. Seeds Germ.	% Germ	No. plants GH Acc.
509-2386-024-101	Unclear	181205017	Filter paper	GC	34	52	22	42%	1
509-2386-198-100	Unclear	181205014	Filter paper	GC	19	50	33	66%	1
Unclear	080080S1003	2008006	Filter paper	None	26	40	25	63%	0
Unclear	080080I1001	2008008	Filter paper	None	26	40	14	35%	0
Unclear	080080M2002	2008009	V + GHM	None	149	100	1	1%	1
Unclear	080080B3001	2011001	UNK	UNK	UNK	636	UNK	--	--
Unclear	08008LMN055	2012106	V + GHM	None	31	100	53	53%	0
Unclear	080080A3006	2014005	V + GHM	None	31	100	31	31%	0
Unclear	08008CDE061	2014079	UNK	UNK	UNK	297	UNK	--	--

GC, growth chamber; GH, greenhouse; GHM, greenhouse media, UNK, unknown; V, vermiculite

Outplanting and Monitoring

We did not outplant *T. arenarium* var. *arenarium* during the reporting period.

In previous years, we planted a total of 1,427 *T. arenarium* var. *arenarium* individuals at several ASRs (Table 44). Only 18 recruits, 2 juveniles, and 16 adults were present during the last monitoring in 2016.

We plan to investigate further site suitability and species requirements needed to successfully establish self-sustaining populations.

Table 44. Monitoring summary for *Tetramolopium arenarium* var. *arenarium* outplanted prior to FY 2018

			Surviving Outplants			Recruits	
Location	Outplanting Site	Total Outplanted	Adult	Juvenile	Net Survivorship	Adult	Juvenile
On PTA	210	96	0	0	0%	0	0
	211	48	0	0	0%	0	0
	216	85	0	0	0%	0	0
Off PTA	201	32	0	0	0%	0	0
	204	18	0	0	0%	0	0
	205	231	0	0	0%	280	110

PTA, Pōhakuloa Training Area

Discussion

Our efforts to survey, monitor, and conserve genetics for *T. arenarium* var. *arenarium* address SOO tasks 3.2(1)(a, d–f) as well as several INRMP objectives and conservation measures from the 2003 and 2013 BO.

At PTA, *T. arenarium* var. *arenarium* naturally occurs in the *Dodonaea* shrubland. It occurs in 3 clusters distributed over fewer than 2 ha within the Kīpuka Kālawamauna North Fence Unit in ASR 8 (Figure 41). *Tetramolopium arenarium* var. *arenarium* can fluctuate in numbers, sometimes dramatically, especially in the seedling life stage. We documented a large decline in adults and juveniles in census period 2 (October 2016 to December 2016). In census periods 2 and 3 (January 2017 to March 2017), we recorded high numbers of seedlings, of which some number of seedlings recruited into the juvenile and adult life stages in subsequent census periods. We have documented similar declines in juveniles and adults in 2007 and 2010/2011 with a similar population rebound driven by a large flush of seedlings (CEMML 2010; CEMML 2011).

Other monitoring and research projects have also documented high mortality in adults (Laven et al. 1991; Aplet et al. 1994), but did not document subsequent recruitment of seedlings. Laven et al. (1991) described the size frequency distribution (substituting size as a proxy for age) as bell-shaped indicating either an even-aged population or a multi-aged population with few young plants. In addition, Aplet et al. (1994) concluded that the level of seedling recruitment compared to the level of adult mortality documented during their project could not sustain the *T. arenarium* var. *arenarium* population over the long-term. In fact, we have observed a drastic reduction in the numbers of *T. arenarium* var. *arenarium* in the areas where Aplet et al. conducted their study (i.e., ASR 8 southeast and southwest groups).

Because we have collected data over several years, we have captured more environmental variation in our dataset and have documented 2 to 3 large flushes of seedlings between 2007 and 2019, which supported the establishment of juveniles and adults that sharply increased the population numbers. In between these large flushes of seedlings, periodic recruitment does occur, but the effect of sustaining or increasing the numbers of adults is less clear.

Laven et al. (1991) suggest that one possible life history strategy for *T. arenarium* var. *arenarium* to sustain populations may be episodic recruitment during favorable environmental conditions. We have documented this type of phenomenon over the longer monitoring period. However, this episodic recruitment strategy typically works for long-lived species, which *T. arenarium* var. *arenarium* is not likely to be. Laven et al. (1991) suggest 2 other life history strategies that may help sustain *T. arenarium* var. *arenarium* – “r strategy” life history characteristics (i.e., rapid establishment vs. long-lived) and/or colonization of disturbed sites. Faulkner et al. (1997) found that *T. arenarium* var. *arenarium* germinates and grows better under high light intensity (characteristics associated with the r strategy). They also found that soil moisture strongly influenced germination. In addition, *T. arenarium* var. *arenarium* is not a strong competitor and had no effect on, but was affected by, other plant species when grown in competition in a greenhouse (Aplet and Laven 1993). Low competitive ability and delaying germination until favorable conditions exist (e.g., high soil moisture) are both consistent with r strategies, which in turn are consistent with life history characteristics of early-successional plants (Huston and Smith 1987).

To date, we have applied general management actions to the *T. arenarium* var. *arenarium* population. However, we plan to improve and adapt our management to align better with the early-successional (r strategy) life history characteristics of this species.

Until recently, we knew little about the pollinators for *T. arenarium* var. *arenarium*. Aslan et al. (2019) documented several native and non-native insects visiting *T. arenarium* var. *arenarium* flowers and likely providing pollinator services. The most frequent visitor to the flowers was a native Cambrid month (*Orthomecyna* sp.). Other visitors included the non-native honeybee (*Apis mellfifera*), hover flies (*Syrphid* spp.), unspecified moths, unspecified wasps, and a keyhole wasp (*Pachodynerus nasidens*).

We are continuing to learn about other threats to this species. Of the threats detected during quarterly monitoring, invertebrates (combined) comprised more than half of the threats observed during the reporting period. This is similar to observations made in between 2007 and 2009, when scales and/or aphids were documented on 22% to 27% of all tagged *T. arenarium* var. *arenarium* adults. Monitoring data from this period suggests that plants infested with scales had a higher mortality rate (Table 45). Although we cannot be sure whether aphids and scales are attacking weakened plants or plants are weakened due to the infestation, there is some correlation between plant performance and the presence of invertebrates. Water stress may also be a contributing factor. We plan to continue monitoring for infestations and plan to implement invertebrate control sparingly and strategically because this action is resource intensive.

Table 45. Mortality rates for tagged adult *Tetramolopium arenarium* var. *arenarium* infested with aphid and/or scale monitored at ASR 8 between 2007 and 2009

	2007	2008	2009
Number of Tagged Adults	463	199	142
Percent with Scale/Aphid Recorded	22%	20%	27%
Overall Mortality Rate (%)	--	59%	34%
Mortality Rate without Scale/Aphid Present (%)	--	58%	26%
Mortality Rate with Scale/Aphid Present (%)	--	62%	62%

We continue to make progress with genetic conservation of *T. arenarium* var. *arenarium*. Many of the accessions in storage are aging. We do not know how aging affects the viability of the seed, but we had moderate germination success this reporting period. There are 63 *T. arenarium* var. *arenarium* accessioned to the greenhouse. We are developing planting strategies and plan to continue investigating outplant performance and planting site characteristics in 2020 to maximize the successful establishment of new self-sustaining groupings.

Progress toward compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects from military activities to *T. arenarium* var. *arenarium,* the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browse pressure, maintenance of genetic stock *ex situ*, outplanting, reproduction *in situ*, non-native plant control, and annual monitoring.

To address these conservation measures for *T. arenarium* var. *arenarium*, we implement landscape-level projects to reduce fire risk and ungulate browse for all known individuals at PTA (See Section 1.3). In addition, we actively conserve *T. arenarium* var. *arenarium* genetics; the propagule bank contains 71,933 seeds from the natural population and another 12,250 seeds from individuals grown in the greenhouse or from individuals outplanted. To date, we have outplanted 1,427 individuals at 9 ASRs, but *T. arenarium* var. *arenarium* has not persisted at any. We manage weeds in several buffers within ASR 8 totaling about 12.3 ha for *T. arenarium* var. *arenarium* (Table 64). Between 2016 and 2019, we observed *in situ* reproduction in 3 of 20 (15%) monitoring plots for *T. arenarium* var. *arenarium.* Although we monitor *T. arenarium* var. *arenarium* quarterly to assess population patterns, we are unable to attribute changes in numbers to effects from training or management.

For a discussion regarding how ongoing management benefits Army operations at PTA and the importance of continuing management efforts, see the final summary discussion for the Botanical Program (Section 2.6).

2.4.12 *Tetramolopium* sp. 1 (Not ESA-listed)

Tetramolopium sp. 1 is undescribed and not ESA-listed, but per INRMP objectives we manage the species due to its rarity and limited distribution. As a PS 1, we monitor all known *Tetramolopium* sp.

1 individuals each quarter. For genetic conservation, *Tetramolopium* sp. 1 is a priority, but was not included in the *Genetic Conservation and Outplanting Plan* (CEMML 2017) because it is not ESA-listed. We plan to collect propagules for storage and propagation and to outplant to augment the existing population and to establish new populations.

Plant surveys

During the reporting period, we found 45 locations of *Tetramolopium* sp. 1 representing at least 95 individuals. Because we are still surveying the full set of transects, our findings represent progress for the reporting period and do not represent actual changes in species abundance or distribution.

From previous survey work (2011 to 2015), there were 39 locations of *Tetramolopium* sp. 1 at PTA. The abundance of this species is tracked quarterly and reported below. The distribution for *Tetramolopium* sp. 1, including outplanting sites, is shown in Figure 44.

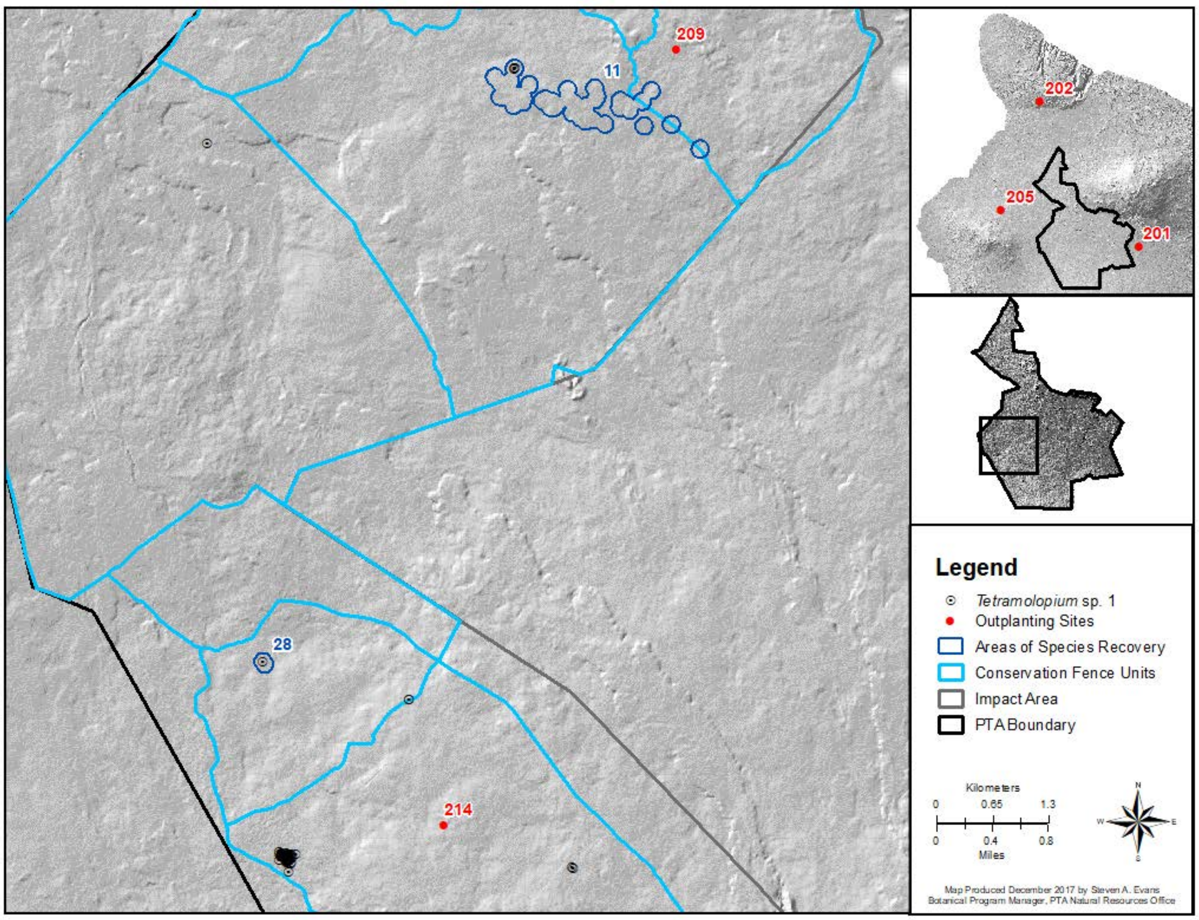

Figure 44. Current known distribution and outplanting sites for *Tetramolopium* sp. 1[a]

[a] Distribution data were collected between 2011 and 2015

Priority Species 1 Monitoring

We counted *T.* sp. 1 over 9 census periods between April 2016 and September 2019 (Figure 45). Between the census periods of July through September 2016 and October through December 2016 the number of plants present appears to have doubled; however, we installed and monitored twice the number of plots between October and December 2016, which accounts for the apparent increase in plant numbers. Between October and December 2016 and October and December 2018 there is a decline the numbers, but the overall pattern of change is difficult to interpret because the number of plots read in each period differs. Seedlings are present for most census periods, but in low numbers. The highest count of seedlings (43) occurs between July to August 2018. However, it is difficult to discern how the presence of seedlings supports recruitment into the later life stages. For example, for the 3 census periods between January 2019 and September 2019 there were 40, 67, and 74 juveniles recorded, respectively. However, in the preceding census periods, between October 2018 and June 2019, there are not sufficient numbers of seedlings present to support that level of change in the juvenile class. The data suggest that seedlings are germinating and growing to a large enough size to be considered a juvenile in between quarterly visits, this appearing like recruitment directly to the juvenile life stage in the graph.

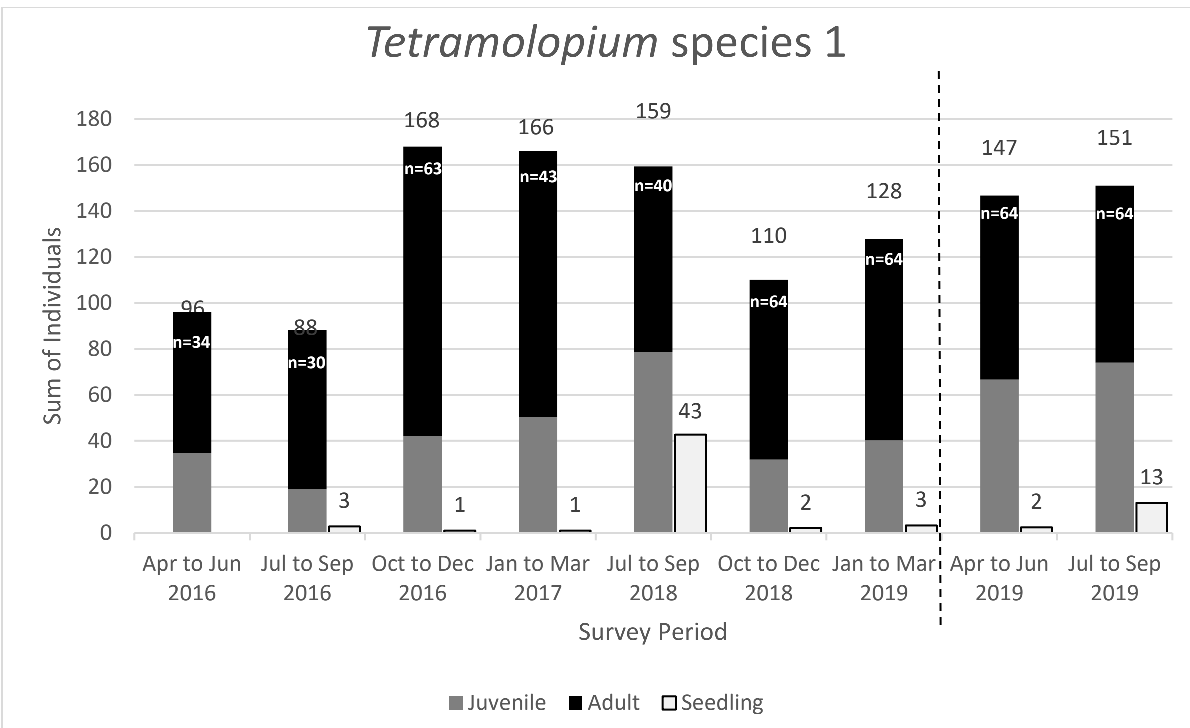

Figure 45. Monitoring results for *Tetramolopium* species 1 from April 2016 through September 2019[a]

[a] For census periods left of the dotted line, we estimated life stage composition using proportion and to the right we counted each plant present by life stage (n=number of plots read). For census periods right of the dotted line, totals may include count class data. When this occurs the minimum value of the count class is summed with the counts from other plots to provide the total value for abundance. Therefore, these numbers represent the minimum number of individuals present during the census period.

We visually assessed threats at every plot each census period. We pooled all threat detections for every *Tetramolopium* sp. 1 monitoring plot for the period of July 2018 through September 2019. Over this time, we made 279 visits to the monitoring plots and detected threats on 14 visits (Figure 46). Invertebrates (aphids and other invertebrates combined), detected on 7 visits, and water stress, detected on 4 visits, were the most frequently recorded threats for *Tetramolopium* sp. 1 (20 out of 30 threat detections).

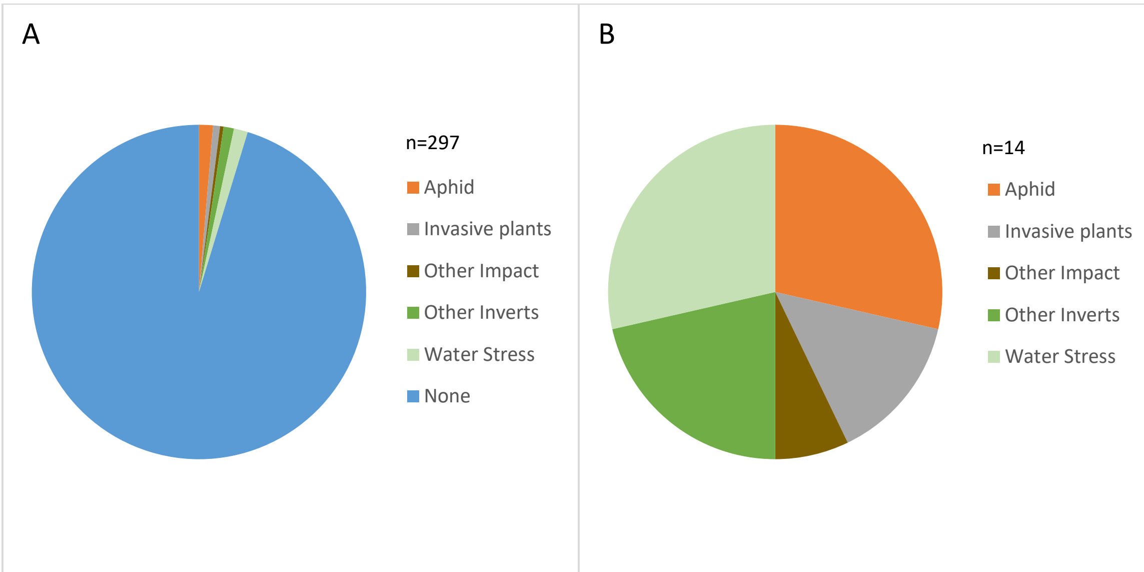

Figure 46. Emerging threats to *Tetramolopium* species 1 recorded between July 2018 and 2019[a]

[a] Data pooled for all *Tetramolopium* sp. 1 monitoring plots for all monitoring periods. We made a total of 297 visits to the monitoring plot during this time period and threats were present on 14 occasions. Panel A shows the threats recorded for every plot visit (n=297). Panel B shows the frequency each threat was recorded for every plot visit when threats were detected (n=14).

Genetic Conservation

Propagule Collection

We aim to collect from all known extant, reproductive *Tetramolopium* sp. 1 individuals. To this end, we collected a total of 4,342 seeds representing 12 founders during the reporting period. Please refer to Table 8 for a complete summary of genetic conservation status for *Tetramolopium* sp. 1.

Propagation

We attempted to propagate 3 batches of seed from accessions made in 2018 (Table 46). We sowed 100 seeds per trial. We anticipated that seeds would germinate at different rates and some would not germinate at all due to natural variation and quality among seeds in an accession. Germination was relatively good over a short period of time (20 to 35 days).

Table 46. Seed germination trial results for *Tetramolopium* species 1 from August 2018 to September 2019

New Founder No.	Other Founder No.	Prop. Accession	Media	Seed Treatment	Trial Days	No. Seed Sown	No. Seeds Germ.	% Germ	No. Plants GH Acc.
517-1983-029-001	Unclear	181018001	Filter paper	GC	20	100	3	20%	0
517-1983-029-002	Unclear	181018002	Filter paper	GC	35	100	16	35%	0
522-1674-127-001	Unclear	181127001	Filter paper	GC	34	100	19	34%	0

GC, growth chamber; GH, greenhouse

Outplanting and Monitoring

We did not outplant *Tetramolopium* sp. 1 during the reporting period.

In previous years, we planted a total 357 *Tetramolopium* sp. 1 individuals at 4 sites (Table 47). At ASR 214, *Tetramolopium* sp. 1 established well and plants have been self-sustaining for 14 years. Recruitment occurs annually and the occupied area continues to expand, especially in areas where grass is managed.

Table 47. Monitoring summary for *Tetramolopium* species 1 outplanted prior to FY 2018

			Surviving Outplants			Recruits	
Location	Outplanting Site	Total Outplanted	Adult	Juvenile	Net Survivorship	Adult	Juvenile
On PTA	209	66	0	0	0%	1	0
	214	139	6	0	4%	491	347
Off PTA	201	83	0	0	0%	0	0
	205	69	0	0	0%	0	0

PTA, Pōhakuloa Training Area

Discussion

Our efforts to survey, monitor, and conserve genetics for *Tetramolopium* sp. 1 address SOO tasks 3.2(1)(a, d–f) as well as several INRMP objectives and conservation measures from the 2003 and 2013 BO.

At PTA, *Tetramolopium* sp. 1 naturally occurs in the Nāʻōhuleʻelua Fence unit and in the Kīpuka ʻAlalā North and South Fence units (Figure 44). The species grows in the *Metrosideros polymorpha* Woodland alliance and the *Myoporum sandwicense - Sophora chrysophylla* Shrubland alliance. This species remains undescribed and therefore does not have a scientifically accepted specific epithet. Because this plant is not scientifically accepted as a species, it has no protections under the law. However, this plant is only known from PTA, and due to its apparent rarity, we manage this species similar to other PS 1 ESA-listed plant species.

Quarterly monitoring data show a population mostly of juvenile and adult plants with few seedlings present. There is evidence of recruitment to the juvenile life stage in numbers greater than the recorded number of seedlings, suggesting rapid growth and establishment of seedlings between census periods (about a 3-month interval).

Little is known about the life history characteristics of this species, but it likely shares some characteristics with other congeners. *Tetramolopium* sp. 1 likely has some life history characteristics in common with early-successional species (r strategists) and with *T. arenarium* var. *arenarium*. Based on lessons learned with *T. arenarium* var. *arenarium*, we plan to investigate monitoring and management approaches suited for early-successional species. However, we recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species. Knowing these attributes is important for designing management actions to maximize the likelihood that *Tetramolopium* sp. 1 will persist, and potentially increase, especially with changing climate conditions. Because *Tetramolopium* sp. 1 is an undescribed and unlisted species, we implement management for *Tetramolopium* sp. 1 under INRMP objectives that minimize threats to Hawaiian plants from wildfire and invasive species. In addition, we strive to conserve the genetics of *Tetramolopium* sp. 1.

To manage threats for *Tetramolopium* sp. 1, we implement landscape-level projects to reduce fire risk and browse from ungulates all known individuals at PTA (See Section 1.3). Between 2016 and 2019, we observed *in situ* reproduction in 17 of 64 (27%) monitoring plots for *Tetramolopium* sp. 1. We actively conserve *Tetramolopium* sp. 1 genetics; the propagule bank contains 19,316 seeds from the natural population and 165,335 seeds from individuals grown in the greenhouse or from outplanted individuals. Although we monitor *Tetramolopium* sp. 1 quarterly to assess population patterns, we are unable to attribute changes in numbers to effects from training or management.

For a discussion regarding how ongoing management benefits Army operations at PTA and the importance of continuing management efforts, see the final summary discussion for the Botanical Program (Section 2.6).

2.4.13 *Vigna o-wahuensis* (Endangered)

As a PS 1, we monitor all known *V. o-wahuensis* individuals each quarter. For genetic conservation, *V. o-wahuensis* is an implementation priority 1 (high). We plan to collect propagules for storage and propagation and to outplant to augment the existing population and to establish new populations.

Plant surveys

No locations of *V. o-wahuensis* were recorded during the reporting period. This outcome is not surprising since we did not survey within the known distribution of this species.

From previous survey work (2011 to 2015), there are 75 locations of *V. o-wahuensis* at PTA. The abundance of this species is tracked quarterly and reported below. The distribution for *V. o-wahuensis*, including outplanting sites, is shown in Figure 47.

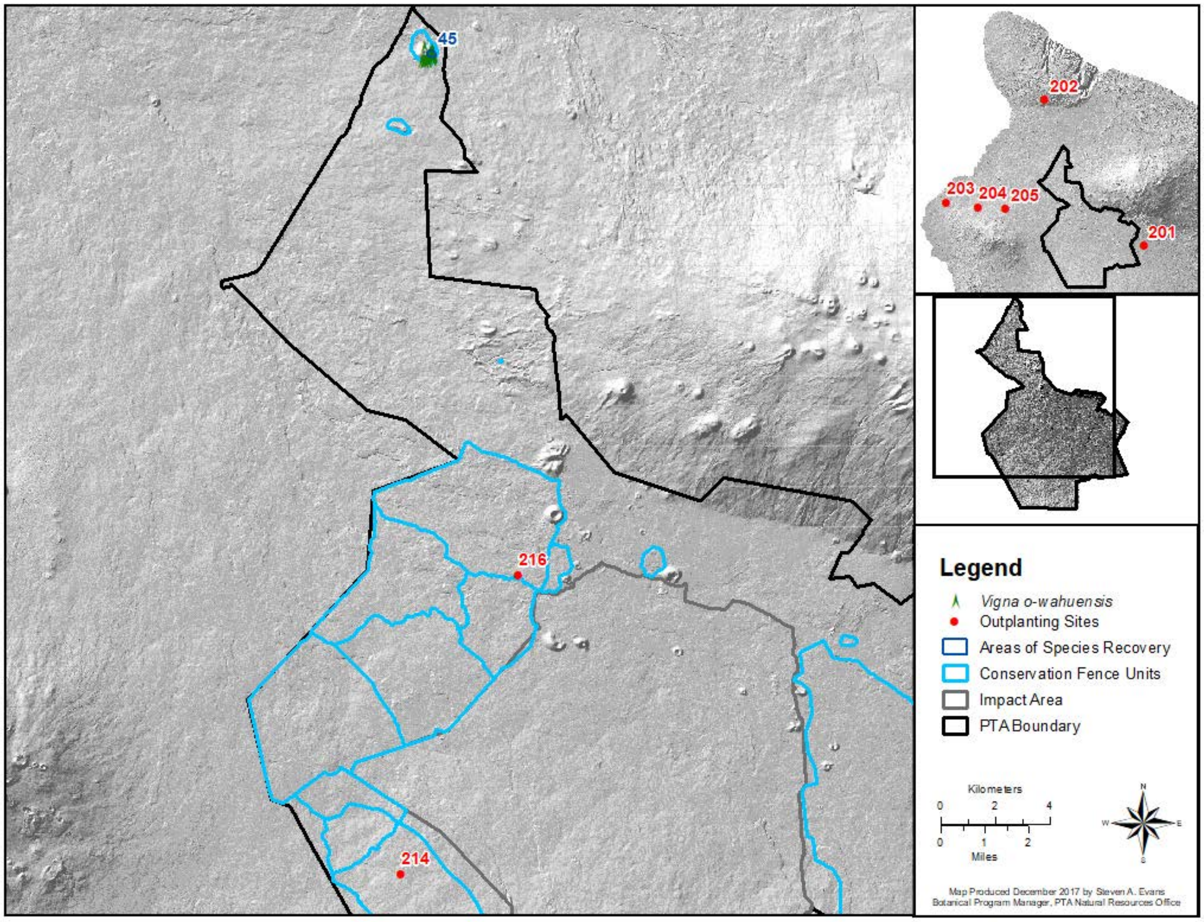

Figure 47. Current known distribution and outplanting sites for *Vigna o-wahuensis*[a]

[a] Distribution data were collected between 2011 and 2015

Priority Species 1 Monitoring

We counted *V. o-wahuensis* over 7 census periods between April 2016 and September 2019 (Figure 48). There was a large gap in data collection between December 2016 and October 2018. Clearly, we missed collecting data during a significant recruitment event as evidenced by the number of adults present in the plots when we resumed monitoring between September and December 2018. In addition, *V. o-wahuensis* recruited in large numbers in all age classes between September and December 2018. In subsequent census periods, the overall number of *V. o-wahuensis* declined with losses in the adult class driving the overall pattern. Seedlings were present between September 2018 and September 2019 and likely supported the increased number of juveniles present from April 2019 through September 2019.

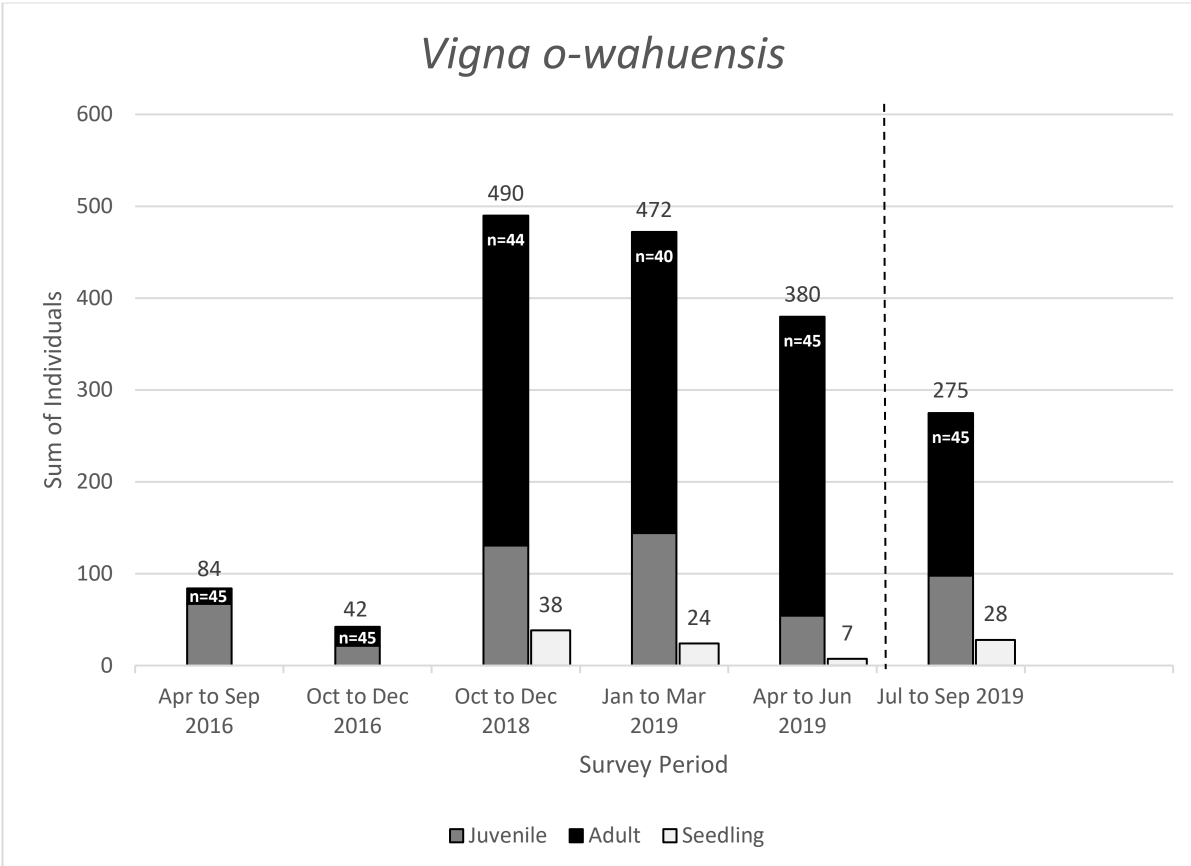

Figure 48. Monitoring results for *Vigna o-wahuensis* from April 2016 through September 2019[a]

[a] For census periods left of the dotted line, we estimated life stage composition using proportion and to the right we counted each plant present by life stage (n=number of plots read). For census periods right of the dotted line, totals may include count class data. When this occurs the minimum value of the count class is summed with the counts from other plots to provide the total value for abundance. Therefore, these numbers represent the minimum number of individuals present during the census period.

We visually assessed threats at every plot each census period. We pooled all threat detections for every *V. o-wahuensis* monitoring plot for the period of July 2018 through September 2019. Over this time, we made 187 visits to the monitoring plots and detected threats on 8 visits (Figure 49). Water stress was the most frequently recorded threat to *V. o-wahuensis* (20 out of 30 threat detections).

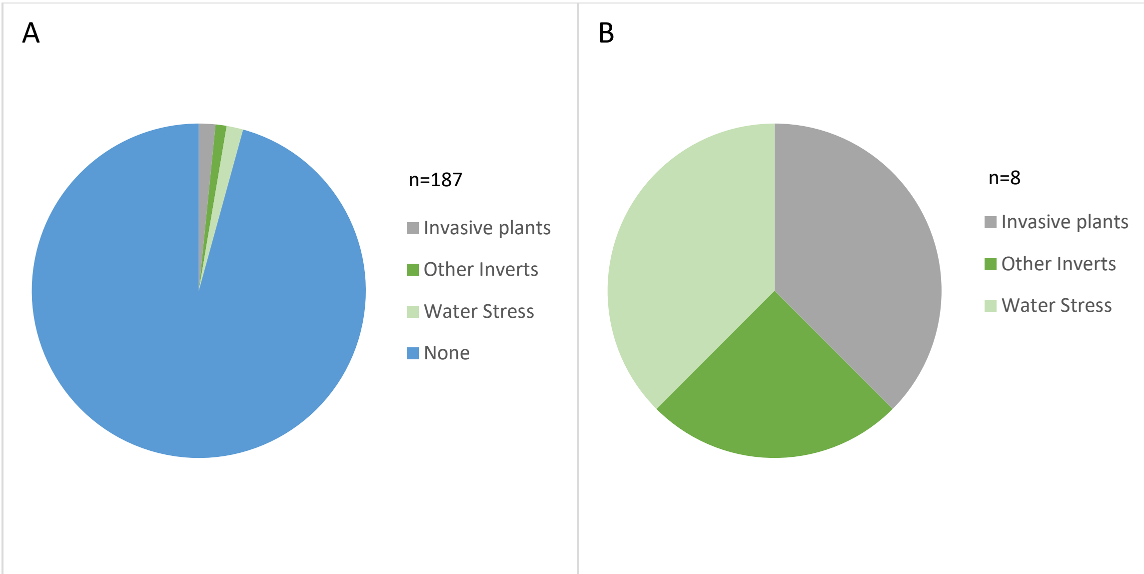

Figure 49. Emerging threats to *Vigna o-wahuensis* recorded between July 2018 and 2019[a]

[a] Data pooled for all *V. o-wahuensis* monitoring plots for all monitoring periods. We made a total of 187 visits to the monitoring plot during this time period and threats were present on 8 occasions. Panel A shows the threats recorded for every plot visit (n=187). Panel B shows the frequency each threat was recorded for every plot visit when threats were detected (n=8).

<u>Genetic Conservation</u>

Propagule Collection

We aim to collect from all known extant, reproductive *V. o-wahuensis* individuals. To this end, we collected a total of 2,492 seeds representing 74 founders during the reporting period. Please refer to Table 8 for a complete summary of genetic conservation status for *V. o-wahuensis.*

Propagation

Propagation records between October 2017 and July 2018 were incomplete or missing and do not align with the greenhouse accession records and plants in the facility. The greenhouse accession records indicate that propagules from 2 *V. o-wahuensis* founders were propagated and 31 seedlings grew to sufficient size to be transferred to 4-inch pots and accessioned to the greenhouse (Table 48). Based on the dates of the greenhouse accessions (6 February 2019), the cuttings were likely propagated in early 2018.

Table 48. *Vigna o-wahuensis* accessioned to the greenhouse without propagation records as of September 2019

New Founder No.	Other Founder No.	Date Accessioned to Greenhouse	Greenhouse Accession. No.
501-1905-001-005	Unclear	2/6/2019	**1**, 4, 16, 17, 18, 19, 23, 161-168
501-1905-059-001	Unclear	2/6/2019	**2**, 3, **5, 6,** 7, 8, 9, **10**, 11, **12,** 13 (D), **14, 15, 20, 21, 22**

D, dead at last greenhouse monitoring

Note: Bold indicates founders and accession numbers that were outplanted in 2019

After August 2018, more detailed propagation records were kept (Table 49). We attempted to propagate 8 batches of seed from accessions made between 2003 and 2019. We sowed about 20 seeds per germination trial. We anticipated that seeds would germinate at different rates and some would not germinate at all due to natural variation and quality among seeds in an accession. To better understand the range of time some seeds need to geminate, we monitored some germination trials for several months and recorded germination up to 92 days after seeds were sown. Germination rates appear higher for younger seed. However, we need to know more about seed characteristics and the influence of these characteristics on germination outcomes. We cannot definitively conclude that age affects germinations rates; however, we may want to pursue the effect of age on germination under more controlled conditions.

The seedling propagated after 2018 are still growing but none of the plants grew large enough to be accessioned to the greenhouse as of September 2019.

Table 49. Seed germination trial results for *Vigna o-wahuensis* from August 2018 to September 2019

New Founder No.	Other Founder No.	Prop. Accession	Media	Seed Treatment	Trial Days	No. Seed Sown	No. Seeds Germ.	% Germ	No. plants GH Acc.
501-1904-000-000	14071000000	2018001	V + GHM	Boil	92	21	8	38%	0
501-1904-000-000	14071000000	2003001-1	Filter paper	8h Water	50	20	10	50%	2
501-1904-000-001	14071000000	2003001-1	Filter paper	None	50	20	3	15%	3
501-1904-000-002	14071000000	2003001-2	Filter paper	8h Water	50	20	1	5%	0
501-1904-000-003	14071000000	2003001-2	Filter paper	None	50	20	3	15%	3
501-1904-000-004	14071000000	2003001-3	Filter paper	8h Water	50	20	1	5%	0
501-1904-000-005	14071000000	2003001-3	Filter paper	None	50	20	0	0%	
501-1904-004-102	None	190703003	Filter paper	3h Water	50	20	9	45%	8

GH, greenhouse; GHM, greenhouse media; V, vermiculite

Outplanting and Monitoring

We planted 11 *V. o-wahuensis,* representing a single founder, on Puʻu Pāpapa in the Keʻāmuku Maneuver Area in 2019. In 2002, Arnett (2002) found 3 *V. o-wahuensis* plants Puʻu Pāpapa. Reintroduction of *V. o-wahuensis* to Puʻu Pāpapa was established as a goal in the *Genetic Conservation* *and Outplanting Plan* (CEMML 2017). We plan to monitor the performance of the outplants in FY 2020.

In previous years, we planted *V. o-wahuensis* at ASRs 201, 203, 205, 214, and 216 (Table 50). In addition, we broadcast seed at 4 ASRs. Except for the plantings at ASR 205 (Puʻu Waʻawaʻa), as of 2016 all outplants were dead. At ASR 205, the plants established well and grew so entwined we could not accurately count the number of individuals present.

Table 50. Monitoring summary for *Vigna o-wahuensis* outplanted prior to FY 2018

			Surviving Outplants			Recruits	
Location	Outplanting Site	Total Outplanted	Adult	Juvenile	Net Survivorship	Adult	Juvenile
On PTA	214	2	0	0	0%	0	0
	216	11	0	0	0%	0	0
Off PTA	201	7 Broadcast	0	0	0%	0	0
	202	7	0	0	0%	0	0
	203	11 Broadcast	0	0	0%	0	0
	204	0 Broadcast	--	--	--	0	0
	205	47 Broadcast	1	0	2%	7	3

PTA, Pōhakuloa Training Area

Discussion

Our efforts to survey, monitor, and conserve genetics for *V. o-wahuensis* address SOO tasks 3.2(1)(a, d–f) as well as several INRMP objectives and conservation measures from the 2003 and 2013 BO.

At PTA, *V. o-wahuensis* naturally occurs on Puʻu Nohona o Hae and is short-lived and ephemeral (Figure 47). Quarterly monitoring shows that the abundance of *V. o-wahuensis* fluctuates over time. Seedlings were present in census periods 3 to 6, but at low levels. However, the numbers of juveniles and adults steadily decrease over the same period, suggesting the level of recruitment did not compensate for the level of juvenile and adult mortality. Unfortunately, we missed documenting a significant recruitment event for *V. o-wahuensis* because we had suspended monitoring for a short period. Like *T. arenarium* var. *arenarium, V. o-wahuensis* may rely on episodic recruitment during favorable environmental conditions to sustain the population. Like many other species that occur at PTA, we know very little about the life history characteristics of *V. o-wahuensis*. Knowing these life history attributes is important for designing management actions to maximize the likelihood that *V. o-wahuensis* will persist, and potentially increase, especially with changing climate conditions. We recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species.

We continue to make progress with genetic conservation of *V. o-wahuensis*. Many of the accessions in storage were collected prior to 2015. We do not know how aging affects the viability of the seed, but we had similar levels of germination between seed collected in 2014 and seed collected in 2019. We have had minimal success in outplanting *V. o-wahuensis*. We are unsure why plants are not persisting at certain sites. We plan to continue to investigate planting site characteristics and ways to improve our success in establishing outplants. In 2020, we plan to complete a planting plan focused on Puʻu Pāpapa and *Isodendrion hosakae*. There are 24 *V. o-wahuensis* accessioned to the greenhouse. We are developing planting strategies and plan to continue investigating outplant performance and planting site characteristics in 2020 to maximize the successful establishment of new self-sustaining groupings.

Progress toward compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects from military activities to *V. o-wahuensis,* the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browse pressure, maintenance of genetic stock *ex situ*, outplanting, reproduction *in situ*, non-native plant control, and annual monitoring.

To address these conservation measures for *V. o-wahuensis*, we implement landscape-level projects to reduce fire-risk and ungulate browse for all known individuals at PTA (See Section 1.3). In addition, we actively conserve *V. o-wahuensis* genetics; the propagule bank contains 3,491 seeds from the natural population and 32,244 seeds from individuals grown in the greenhouse. To date, we have outplanted 86 individuals at 6 ASRs; plants established and recruited only at ASR 205. Due to challenges on steep slopes and degraded habitat on Puʻu Nohona o Hae, we have not managed invasive plants for *V. o-wahuensis.* Between 2016 and 2019, we observed *in situ* reproduction in 23 of 46 (50%) monitoring plots for *V. o-wahuensis.* Although we monitor *V. o-wahuensis* quarterly to assess population patterns, we are unable to attribute changes in numbers to effects from training or management.

For a discussion regarding how ongoing management benefits Army operations at PTA and the importance of continuing management efforts, see the final summary discussion for the Botanical Program (Section 2.6).

2.5 Priority Species 2 and 3 Summaries

We present the species summaries arranged by Priority Species rank (Table 1) and then alphabetically by species. We present PS 2 and PS 3 species together as these species receive similar management. We delineate the distributions and estimate abundances for these species via plant survey data. These surveys are repeated within the ungulate exclusion fence units every 5 years and at the completion of a 5-year survey cycle, we update plant distribution and abundance estimates generated from the most recent rare plant survey cycle. For the current survey cycle (2017 to present), we are 26% completed with the 5-year goal. Therefore, in this report, we continue to use the distribution and abundance estimates we derived from the plant survey data set completed between 2011 and 2015 until we complete the next survey effort. In addition, we report our survey results, to include the numbers of locations and the minimum numbers of individuals for all PS 2 and 3 plants, found during the reporting period (October 2017 through September 2019). These reported results are to show our survey progress and, because the data represent a partial dataset, are not intended for comparison to the reported distribution and abundance from the 2011 to 2015 survey results. The genetic conservation implementation rank is reported for each species and efforts to achieve objectives are reported for each species. We discuss how our activities implemented under SOO tasks meet INRMP objectives and BO requirements.

2.5.1 *Exocarpos menziesii* (Endangered)

As a PS 3, we survey and monitor a portion of the known *E. menziesii* distribution each year. However, we derive distribution and estimate abundance for each species within the ungulate exclusion fences from the completed 5-year data set (2011 to 2015). For genetic conservation, *E. menziesii* is an implementation priority 5 (low). We plan to collect propagules for storage with little to no outplanting.

Plant surveys

During plant surveys for the reporting period, we recorded 860 locations representing at least 945 individuals of *E. menziesii.* Because we are still surveying the full set of transects, our findings represent progress for the reporting period and do not represent actual changes in species abundance or distribution.

From previous survey work (2011 to 2015), there were 1,762 locations representing at least 1,802 individuals of *E. menziesii* at PTA. The distribution for *E. menziesii*, including outplanting sites, is shown in Figure 50.

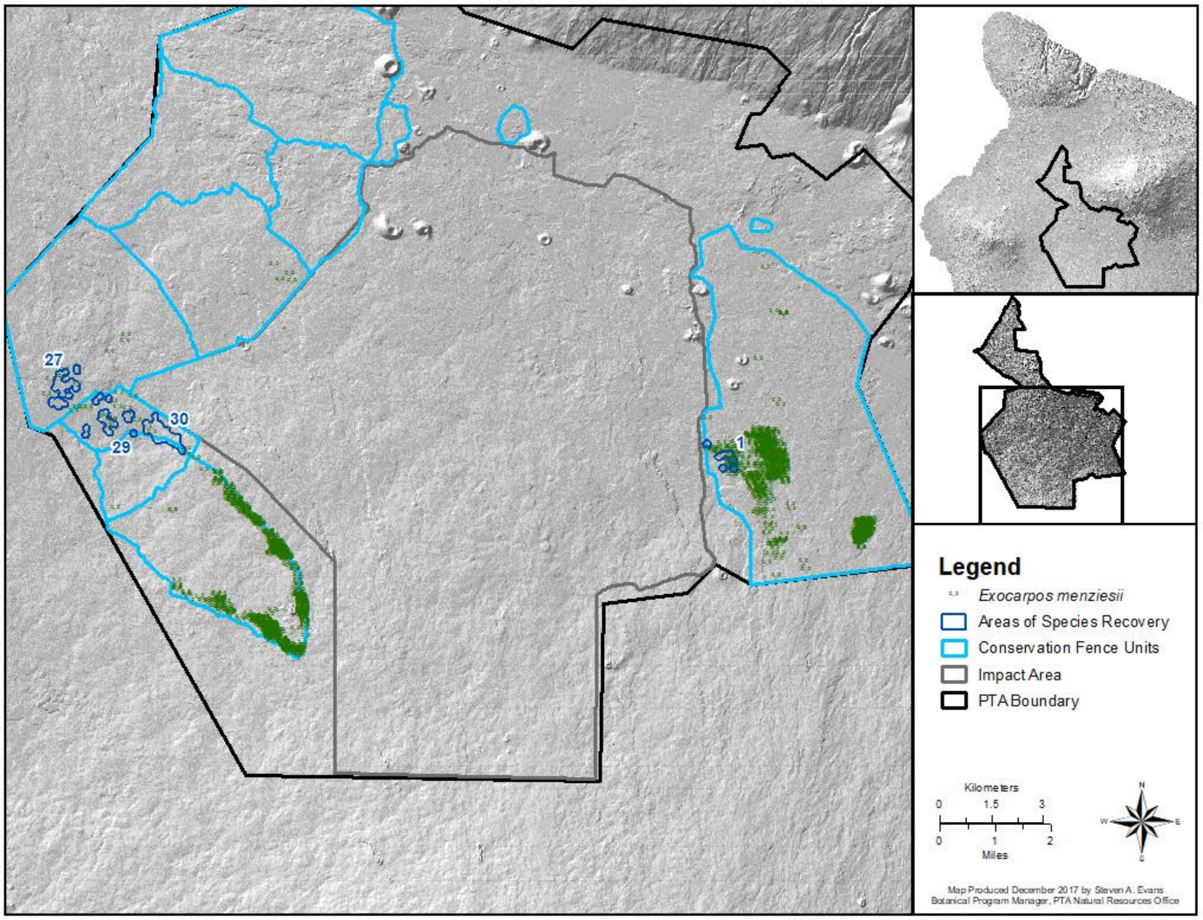

Figure 50. Current known distribution of *Exocarpos menziesii*[a]

[a] Distribution data were collected between 2011 and 2015

Genetic Conservation

Propagule Collection

We collected 776 propagules in TA 23 (Plant Group 22) and TA 22 (Plant Group 17) representing more than 9 founders. Some collections were made in bulk from each area; therefore, the exact number of founders represented in the collections is not known. Seeds from 5 collections were accessioned to the propagule bank (621 seeds) and later 121 seeds withdrawn for propagation. So, 536 seeds remain in storage. In addition, seeds from 4 collections (155 seeds) were immediately propagated bringing the total number of seeds propagated during the reporting period to 276 (Table 51). Please refer to Table 8 for a complete summary of genetic conservation status for *E. menziesii.*

Propagation

We attempted to propagate 16 batches of seeds, totaling 276 seeds, from accessions made between 2018 and 2019 (Table 51). We sowed between 10 to 37 seeds per germination trial. We anticipated that seeds would germinate at different rates and some would not germinate at all due to natural variation and quality among seeds in an accession. To try and better understand the range of time some seeds need to geminate, we monitored some germination trails for several months and recorded germination up to 276 days after seeds were sown. Only 2 trials resulted in good germination after about 162 days after the seeds were sown. These trials were some of the first efforts to germinate this species at PTA. We will continue to monitor these trials to better understand germination requirements.

Plants from the germination trials are still growing but none were large enough to be accessioned to the greenhouse as of September 2019.

Table 51. Seed germination trial results for *Exocarpos menziesii* from August 2018 to September 2019

New Founder No.	Other Founder No.	Prop. Accession	Media	Seed Treatment	Trial Days	No. Seed Sown	No. Seeds Germ.	% Germ	No. plants GH Acc.
522-0000-000-000	None	181114001	V + GHM	Hot Water 24h	276	37	2	5%	0
522-0000-000-000	None	181128999	Filter paper	Topped	164	10	0	0%	0
522-2070-000-000	None	190123999	Filter paper	GA3 100ppm	154	20	0	0%	0
522-2070-000-000	None	190123999	Filter paper	GA3 300ppm	162	20	8	40%	0
522-2070-000-000	None	190123999	Filter paper	GA3 500ppm	162	15	9	60%	0
522-2171-000-000	None	190212999	Filter paper	GA3 100ppm + Clip	162	10	3	30%	0
522-2171-000-000	None	190212999	Filter paper	None	164	20	0	0%	0
522-2171-000-000	None	190212999	Filter paper	Topped	165	20	0	0%	0
522-2171-000-000	None	190212999	Filter paper	Clip	155	20	0	0%	0
517-2181-000-001	None	190311999	Filter paper	GA3 100ppm	162	10	5	50%	0
521-1776-005-001	None	190507001	V + GHM	None	71	19	0	0%	0
521-1776-005-001	None	190507001	V + GHM	100ppm GA3	71	19	0	0%	0
522-1975-004-001	None	190605001	V + GHM	None	71	16	0	0%	0
522-1975-004-001	None	190605001	V + GHM	100ppm GA3	71	16	0	0%	0
552-1975-003-001	None	190611001	V + GHM	None	71	12	0	0%	0
552-1975-003-001	None	190611001	V + GHM	100ppm GA3	71	12	0	0%	0

GA3, gibberellin A3; GH, greenhouse; GHM, greenhouse media; V, vermiculite

Outplanting and Monitoring

We did not outplant *E. menziesii* during the reporting period and have not planted this species in previous years.

Discussion

Our efforts to survey, monitor, and conserve genetics for *E. menziesii* address SOO tasks 3.2(1)(a, d–f) as well as several INRMP objectives.

At PTA, *E. menziesii* naturally occurs primarily in sparse *Metrosideros* treeland and *Dodonaea* shrubland habitat types. The species was most abundant in the Kīpuka ʻAlalā South and Puʻu Koli Fence Units, and was also found in the Kīpuka ʻAlalā North, *Kadua coriacea*, Mixed Tree, and Nāʻōhuleʻelua Fence Units (Figure 50). It is currently found in 4 ASRs, but these ASRs were designated for other primary species and may not be well suited to address management needs of *E. menziesii.* We anticipate completing a sampling of plant survey transects by March 2020 and data collected will allow us to more accurately estimate the abundance of *E. menziesii.*

Because *E. menziesii* was recently listed as endangered, we have not investigated threats that may be limiting this species. We have observed little *in situ* reproduction of *E. menziesii* and the population appears to be dominated by adults with thick stems suggesting that the population may be skewed toward older adults. We also noted many fruits and seeds under the adult shrubs were eaten, likely by rodents (Figure 51). However, we have observed substantial fruit set over several years.

Figure 51 . Damage, presumably rodent, to *Exocarpos menziesii*[a]

[a] Panel A shows consumed seeds under the plant. Panel B shows consumed seeds on the plant.

We know very little about the life history characteristics of *E. menziesii.* Although the population of *E. menziesii* appears relatively robust in terms of numbers, we know little about the age distribution that will support healthy and resilient populations. In addition, with high levels of fruit and seed depredation and low levels of recruitment observed, this population may be at risk of rapid decline if adult mortality increases. Currently, we have ranked this species as a PS 3 due to its relatively high numbers. However, the time to evaluate threats to the plants and investigate factors affecting recruitment is now while population numbers remain robust. Because thousands of individuals are present at PTA, we can experimentally test assumptions and threat control methods. Implementing these types of experiments will help us to better design science-based, targeted management approaches for *E. menziesii.*

Because *E. menziesii* is an implementation priority 5 (low) for genetic conservation, propagule collection and storage are our primary conservation actions. We collected 776 seeds representing more than 9 founders and propagated 276 seeds, which resulted in 27 seedlings of which a single plant grew to sufficient size to be accessioned to the greenhouse. Because we have not worked extensively with *E. menziesii* in past years, there is still much to learn about germination requirements and seedling establishment and care. There is 1 *E. menziesii* accessioned to the greenhouse.

We are preparing to initiate a formal consultation with the USFWS under the ESA to analyze the potential effects from military activities to *E. menziesii*. Therefore, we implement management of this species under the INRMP objectives that minimize threats to Hawaiian plants from wildfire and introduced ungulates. In addition, we strive to conserve the genetics of *E. menziesii*.

To manage threats proactively for *E. menziesii*, we implement landscape-level projects to reduce fire risk and ungulate browse for all known individuals at PTA (See Section 1.3). We actively conserve *E. menziesii* genetics; the propagule bank contains 536 seeds from the natural population. Although we monitor *E. menziesii* via rare plant surveys to estimate abundance, we are unable to attribute changes in numbers to effects from training or management.

For a discussion regarding how ongoing management benefits Army operations at PTA and the importance of continuing management efforts, see the final summary discussion for the Botanical Program (Section 2.6).

2.5.2 *Festuca hawaiiensis* (Endangered)

As a PS 3, we survey and monitor a portion of the known *F. hawaiiensis* distribution each year. However, we derive distribution and estimate abundance for each species within the ungulate exclusion fences from the completed 5-year data set (2011 to 2015). For genetic conservation, *F. hawaiiensis* is an implementation priority 5 (low). We plan to collect propagules for storage with little to no outplanting.

Plant surveys

During plant surveys for the reporting period, we recorded 358 locations representing at least 2,055 individuals of *F. hawaiiensis*. Because we are still surveying the full set of transects, our findings represent progress for the reporting period and do not represent actual changes in species abundance or distribution.

From previous survey work (2011 to 2015), there were 863 locations representing at least 1,083 individuals of *F. hawaiiensis* at PTA. The distribution for *E. menziesii*, including outplanting sites, is shown in Figure 52.

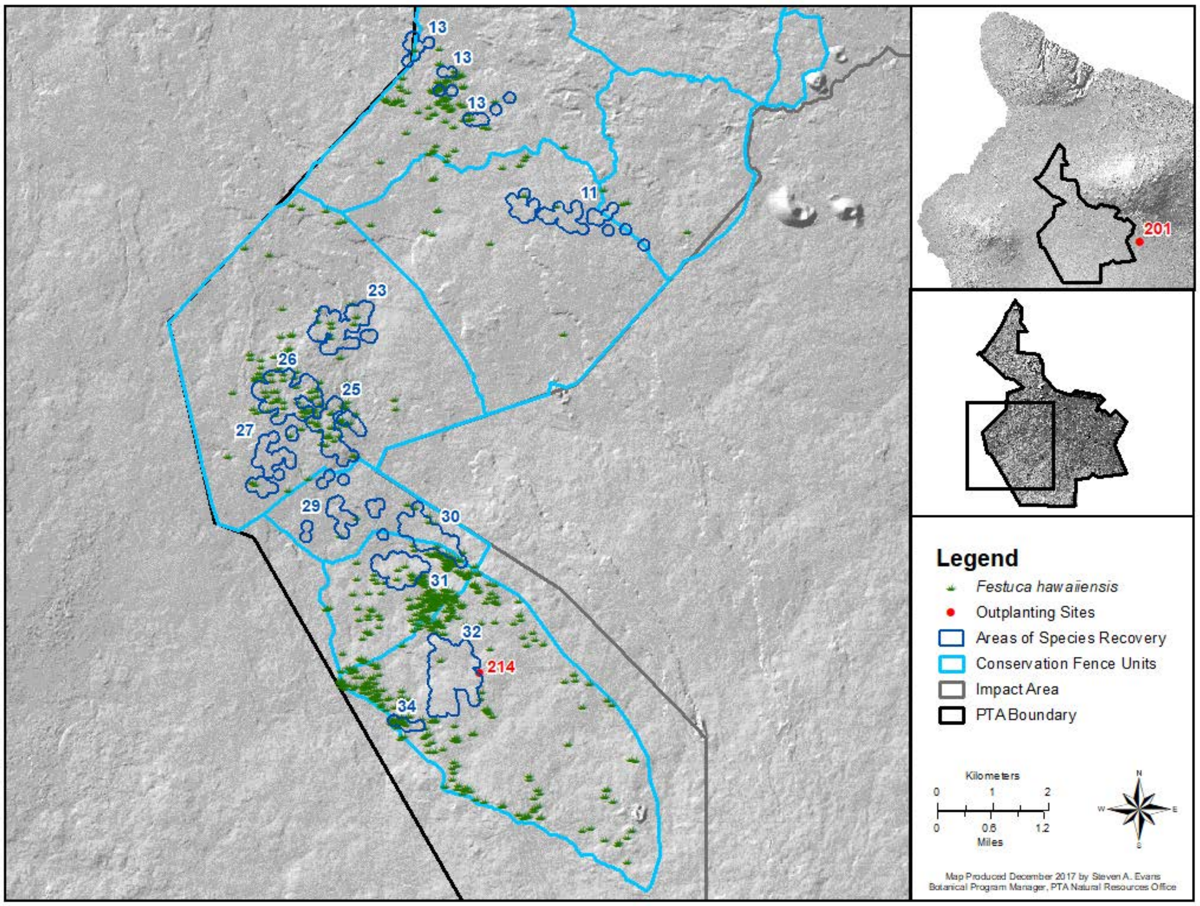

Figure 52. Current known distribution and outplanting sites for *Festuca hawaiiensis*[a]

[a] Distribution data were collected between 2011 and 2015

<u>Genetic Conservation</u>

During this reporting period, we did not collect propagules, propagate or outplant *F. hawaiiensis.* Please refer to Table 8 for a complete summary of genetic conservation status for *F. hawaiiensis.*

In previous years, we planted a total 11 *F. hawaiiensis* individuals at ASRs 201 and 214 (Table 52). *F. hawaiiensis* did not establish at either site, and no recruitment was noted during the last monitoring in 2016.

Table 52. Monitoring summary for *Festuca hawaiiensis* outplanted prior to FY 2018

Location	Outplanting Site	Total Outplanted	Surviving Outplants Adult	Surviving Outplants Juvenile	Surviving Outplants Net Survivorship	Recruits Adult	Recruits Juvenile
On PTA	214	7	--	--	--	--	--
Off PTA	201	4	0	0	0%	0	0

PTA, Pōhakuloa Training Area

Discussion

Our efforts to survey, monitor, and conserve genetics for *F. hawaiiensis* address SOO tasks 3.2(1)(a, d–f) as well as several INRMP objectives.

At PTA, *F. hawaiiensis* naturally occurs primarily in the Kīpuka Kālawamauna East, Kīpuka Kālawamauna West, Nāʻōhuleʻelua, Mixed Tree, *Kadua coriacea*, Kīpuka ʻAlalā North, and Kīpuka ʻAlalā South Fence Units (Figure 52). Although it is difficult to compare distribution and abundance between rare plant survey cycles, we encountered *F. hawaiiensis* in new locations not previously recorded. Although we have only surveyed a portion of the total survey for the second survey cycle, the number of individuals for the second cycle (2,055) is already almost double the number of individuals recorded between 2011 and 2015 (1,083). We anticipate completing a sampling of plant survey transects by March 2020 and data collected will allow us to more accurately estimate the abundance of *F. hawaiiensis.*

We plan to designate ASRs for *F. hawaiiensis* in 2020. This species was recently listed as endangered, and we know little about its life history characteristics or threats that may be limiting this species. Therefore, in 2020, we plan to investigate a monitoring method to track population numbers to determine which management actions may best support a healthy and resilient *F. hawaiiensis* population at PTA.

We did not engage in genetic conservation activities for *F. hawaiiensis* during the reporting period because this species is an implementation priority 5 (low) and efforts were directed towards high priority species. However, because we have not worked extensively with *F. hawaiiensis* in past years, there is still much to learn about germination requirements and seedling establishment and care. There is 1 *F. hawaiiensis* accessioned to the greenhouse.

We are preparing to initiate a formal consultation with the USFWS under the ESA to analyze the potential effects from military activities to *F. hawaiiensis*. Therefore, we implement management of this species under the INRMP objectives that minimize threats to Hawaiian plants from wildfire and introduced ungulates. In addition, we strive to conserve the genetics of *F. hawaiiensis*.

To manage threats proactively for *F. hawaiiensis*, we implement landscape-level projects to reduce fire risk and ungulate browse for all known individuals at PTA (See Section 1.3). We actively conserve *F. hawaiiensis* genetics; the propagule bank contains 184 seeds from the natural population and 245 seeds from individuals grown in the greenhouse or from individuals outplanted. Although we monitor *F. hawaiiensis* via rare plant surveys to estimate abundance, we are unable to attribute changes in numbers to effects from training or management.

For a discussion regarding how ongoing management benefits Army operations at PTA and the importance of continuing management efforts, see the final summary discussion for the Botanical Program (Section 2.6).

2.5.3 *Haplostachys haplostachya* (Endangered)

As a PS 3, we survey and monitor a portion of the known *H. haplostachya* distribution each year. However, we derive distribution and estimate abundance for each species within the ungulate exclusion fences from the completed 5-year data set (2011 to 2015). For genetic conservation, *H. haplostachya* is an implementation priority 5 (low). We plan to collect propagules for storage with little to no outplanting.

Plant Surveys

Based on the completed plant survey data set (2011 to 2015), there were 3,180 locations representing at least 24,270 individuals of *H. haplostachya* at PTA (Figure 53). *H. haplostachya* is the most abundant species at PTA and accounts for approximately 33% of all locations and 64% of all individuals of all species.

During plant surveys for the reporting period, we recorded 960 locations representing at least 8,992 individuals of *H. haplostachya*.

In June 2018, about 228 locations *H. haplostachya* in TA 18, 19, and 22 were impacted by a wildfire. In August 2018, we visited all known *H. haplostachya* locations within the burned area and found varying degrees of fire-related impacts to *H. haplostachya* and documented some post-fire recovery including germination of plants from the seed bank (CEMML 2018b). To assess on-going recovery, we compared the pre- and post-fire numbers of locations of *H. haplostachya* (see Section 2.2.2 for details). We surveyed 70 out of 86 transects (81%) within the burned area where *H. haplostachya* and/or *Stenogyne angustifolia* were found during the first cycle of rare plant surveys (2011–2015). Along transects that were occupied by the plants prior to the fire, we documented 258 locations of *H. haplostachya*, almost twice the pre-fire number, representing about an 8-fold increase in the minimum number of plants present (562 plants vs. 4,493 plants) after the fire.

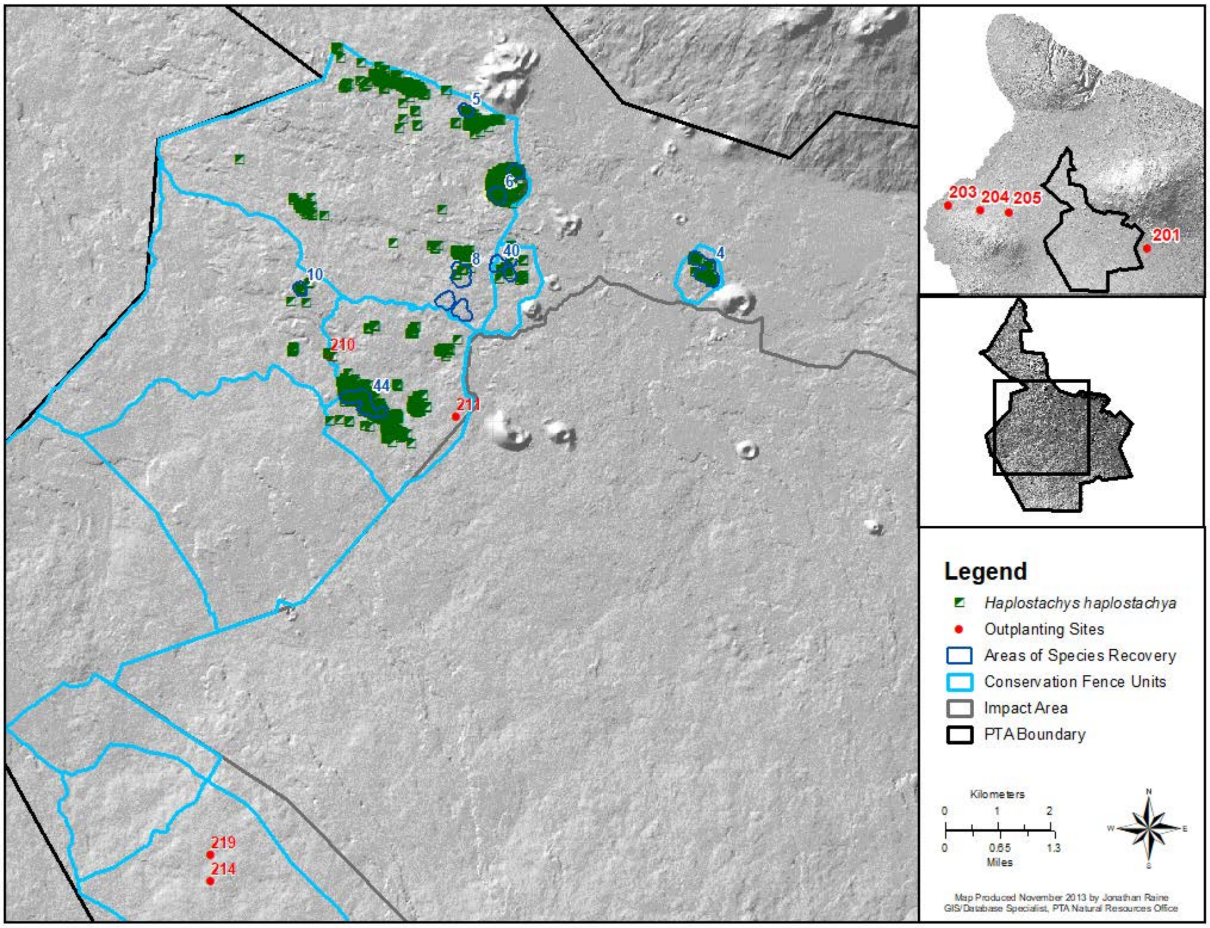

Figure 53. Current known distribution and outplanting sites for *Haplostachys haplostachya*[a]

[a] Distribution data were collected between 2011 and 2015

Genetic Conservation

Propagule Collection

We collected a total of 7,396 seeds from more than 31 founders. Because some collections were made in bulk and represented more than a single founder, we cannot accurately determine the exact number of founders. In addition, we collected a total of 3 cuttings representing 2 founders. Please refer to Table 8 for a complete summary of genetic conservation status for *H. haplostachya.*

Propagation

We attempted to propagate 16 batches of seed from accessions made between 1998 and 2019 (Table 53). We ranged between 20 and 51 seeds per germination trial. We anticipated that seeds would germinate at different rates and some would not germinate at all due to natural variation and quality among seeds in an accession. To better understand the range of time some seeds need to geminate, we monitored some germination trials for several months and recorded germination up to 216 days after seeds were sown. We still experience very low germination rates from seed for *H. haplostachya.*

In fact, we recorded almost the same germination rate for seed collected in 1999 as for seed collected in 2019. We need to know more about seed characteristics and the influence of these characteristics on germination outcomes. Without more basic information about seed quality and viability, we will likely continue to experience variability in seed germination success.

None of the plants from the germination trials grew large enough to be accessioned to the greenhouse by September 2019.

Table 53. Seed germination trial results for *Haplostachys haplostachya* from August 2018 to September 2019

New Founder No.	Other Founder No.	Prop. Accession	Media	Seed Treatment	Trial Days	No. Seed Sown	No. Seeds Germ.	% Germ	No. plants GH Acc.
507-000-000-000	None	190124001	Filter paper	1% Liquid Smoke	121	25	0	0%	0
507-000-000-000	None	190124001	Filter paper	1000ppm GA3	121	25	1	4%	0
507-000-000-000	None	190124001	Filter paper	500ppm GA3	121	25	0	0%	0
507-000-000-000	None	190124001	Filter paper	300ppm GA3	121	25	0	0%	0
515-2183-000-000	None	190306999	V + GHM	10min @ 200F	155	50	0	0%	0
515-2183-000-000	None	190306999	Filter paper	Clip	155	20	0	0%	0
515-2183-000-000	None	190312999	Filter paper	100% Liquid Smoke	141	25	0	0%	0
515-2183-000-000	None	190312999	Filter paper	50% Liquid Smoke	141	25	0	0%	0
515-2183-000-000	None	190312999	Filter paper	2.5% Liquid Smoke	141	25	0	0%	0
515-2183-000-000	None	190312999	Filter paper	10min @ <200F	141	25	0	0%	0
None	08006000000	1998001	V + GHM	Hammer	206	51	0	0%	0
None	08006000000	1999004	V + GHM	4ds + GC	216	42	2	5%	0
None	08006000000	1999004	V + GHM	7ds + GC	216	42	0	0%	0
None	060160D11538	2015265	V + GHM	Hammer	206	50	0	0%	0
None	060160E11537	2015266	V + GHM	GC	216	27	0	0%	0
None	060160E11537	2015266	V + GHM	GC	216	27	0	0%	0
Unclear	090040A1003	2008011	UNK	UNK	252	20	UNK	--	--
Unclear	090040H1006	2008024	UNK	UNK	252	24	UNK	--	--
Unclear	9004033001	2008031	UNK	UNK	252	32	UNK	--	--
Unclear	060440F1	181029008	UNK	UNK	--	116	0	--	--

GA3, gibberellin A3; GC, growth chamber; GH, greenhouse; GHM, greenhouse media; UNK, unknown; V, vermiculite

In December 2018, we propagated 3 cuttings collected from 2 founders (08006050-000 and 0804002-000). One of the 2 cuttings made from founder 08006050-000 grew to sufficient size to be accessioned to the greenhouse by September 2019.

Outplanting and Monitoring

We did not outplant *H. haplostachya* during the reporting period.

In previous years, we planted a total 531 *H. haplostachya* individuals at 8 ASRs (Table 54). Although several outplanted *H. haplostachya* were alive at the 2016 monitoring, *H. haplostachya* did not establish in self-sustaining numbers at any site. In 2016, recruitment was noted at ASRs 204, 205, and 210.

Table 54. Monitoring summary for *Haplostachys haplostachya* outplanted from August 2018 to September 2019

			Surviving Outplants			Recruits	
Location	**Outplanting Site**	**Total Outplanted**	**Adult**	**Juvenile**	**Net Survivorship**	**Adult**	**Juvenile**
On PTA	210	10	0	0	0%	2	0
	211	32	1	0	3%	0	0
	214	95	11	0	12%	0	0
	219	15	11	0	73%	0	0
Off PTA	201	51	7	0	14%	0	0
	203	69	0	0	0%	0	0
	204	8	0	0	0%	0	2
	205	251	16	0	6%	2	2

PTA, Pōhakuloa Training Area

Discussion

Our efforts to survey, monitor, and conserve genetics for *H. haplostachya* address SOO tasks 3.2(1)(a, d–f) as well as several INRMP objectives.

At PTA, *H. haplostachya* naturally occurs primarily in the *Haplostachys haplostachya, Solanum incompletum,* Kīpuka Kālawamauna East, Kīpuka Kālawamauna West, and Kīpuka Kālawamauna North Fence Units (Figure 53). We anticipate completing a sampling of plant survey transects by March 2020 and data collected will allow us to more accurately estimate the abundance of *H. haplostachya.*

Although *H. haplostachya* was one of the first endangered plants documented at PTA in the late 1970's, we still know relatively little about its life history and ecology. Flower morphology of *H. haplostachya* suggest the plant is pollinated by insects (Lindqvist and Albert 2002). Work in Hawaiʻi Volcanoes National Park by Pratt et al. (2012) with *Phyllostegia stachyoides*, a relative of *H. haplostachya,* identified several potential pollinators – a native yellow-faced bee (*Hylaeus difficilis*), the Hawaiian blue butterfly (*Udara blackburni*), the non-native honeybee (*Apis mellfifera*), and introduced hover flies (*Allograpta obliqua* and *Toxomerus marginatus*) – all of which have also been recorded at PTA. However, pollinator studies at PTA found that no native insects visited *H. haplostachya* (Aslan et al. 2019). Aslan et al. (2019) also documented flower visits by honeybees and hover flies, but the most frequent visitor to *H. haplostachya* flowers was a keyhole wasp (*Pachodynerus nasidens*). No *Hylaeus* were seen visiting *H. haplostachya* flowers. We recommend further investigation into pollinators and the effectiveness of the services they provide (native vs. non-native insects) and potential management actions that may support native pollinators, such as *Hylaeus* spp., proximate to *H. haplostachya* populations.

Although we do not know the agent(s) pollinating *H. haplostachya,* we find viable seed in the natural population. We also observe seedlings in the natural populations, sometimes in very high numbers, but our success with seed germination in the greenhouse is low. In addition, genetic variation among plants is higher in larger groups possibly making smaller groups, with less genetic variation, more vulnerable to changes in environmental conditions (Morden and Loeffler 1999). We plan to incorporate this information into genetic conservation plans for collections and potential augmentation of small natural populations. We recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species. Knowing these life history attributes is important for designing management actions to maximize the likelihood that *H. haplostachya* will persist, and potentially increase, especially with changing climate conditions.

We continue to make progress with genetic conservation of *H. haplostachya*. We need to better understand germination requirements of *H. haplostachya* so that we can reliably germinate the many seeds in storage and effectively retrieve the stored genetics. We recommend partnering with the Army's Natural Resources Program on O'ahu to leverage their expertise to establish reliable germination procedures. In addition, we have had minimal success in outplanting *H. haplostachya*. We are unsure why plants are not persisting at certain sites. We plan to continue to investigate planting site characteristics and ways to improve our success in establishing outplants. There is 1 *H. haplostachya* accessioned to the greenhouse.

Progress toward compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects from military activities to *H. haplostachya,* the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browse pressure, maintenance of genetic stock *ex situ*, outplanting, reproduction *in situ*, non-native plant control, and annual monitoring.

To address these conservation measures for *H. haplostachya*, we implement landscape-level projects to reduce fire-risk and ungulate browse for all known individuals at PTA (See Section 1.3). In addition, we actively conserve *H. haplostachya* genetics; the propagule bank contains 41,850 seeds and 9,274 fruits from the natural population and 11,768 seeds and 25,504 fruit from individuals grown in the greenhouse or individuals outplanted. To date, we have outplanted more than 500 individuals at 7 ASRs and plants established and recruited only at ASR 210. We managed invasive plants for *H. haplostachya* in about 2.1 ha in ASR 4 (Table 64). This species also receives benefit from invasive plant management where it occurs in weed control buffers that were implemented for other species. Although we do not currently monitor for *H. haplostachya in situ* reproduction annually, in 2008 and 2009 we noted *H. haplostachya* seedlings in all 9 ASRs where we had monitoring plots. No seedlings were present at any of the 9 ASRs in 2007 and 2010. We monitor a portion of the *H. haplostachya* distribution annually and estimate abundance based on rare plant survey data. However, we are unable to attribute changes in numbers to effects from training or management.

For a discussion regarding how ongoing management benefits Army operations at PTA and the importance of continuing management efforts, see the final summary discussion for the Botanical Program (Section 2.6).

2.5.4 *Silene hawaiiensis* (Threatened)

As a PS 3, we survey and monitor a portion of the known *Silene hawaiiensis* distribution each year. However, we derive distribution and estimate abundance for each species within the ungulate exclusion fences from the completed 5-year data set (2011 to 2015). For genetic conservation, *Silene hawaiiensis* is an implementation priority 5 (low). We plan to collect propagules for storage with little to no outplanting.

<u>Plant Surveys</u>

During plant surveys for the reporting period, we recorded 410 locations representing at least 1,769 individuals of *Silene hawaiiensis.* Because we are still surveying the full set of transects, our findings represent progress for the reporting period and do not represent actual changes in species abundance or distribution.

From previous survey work (2011 to 2015), there were 1,324 locations representing at least 2,344 individuals of *Silene hawaiiensis* at PTA. The distribution for *Silene hawaiiensis*, including outplanting sites, is shown in Figure 54.

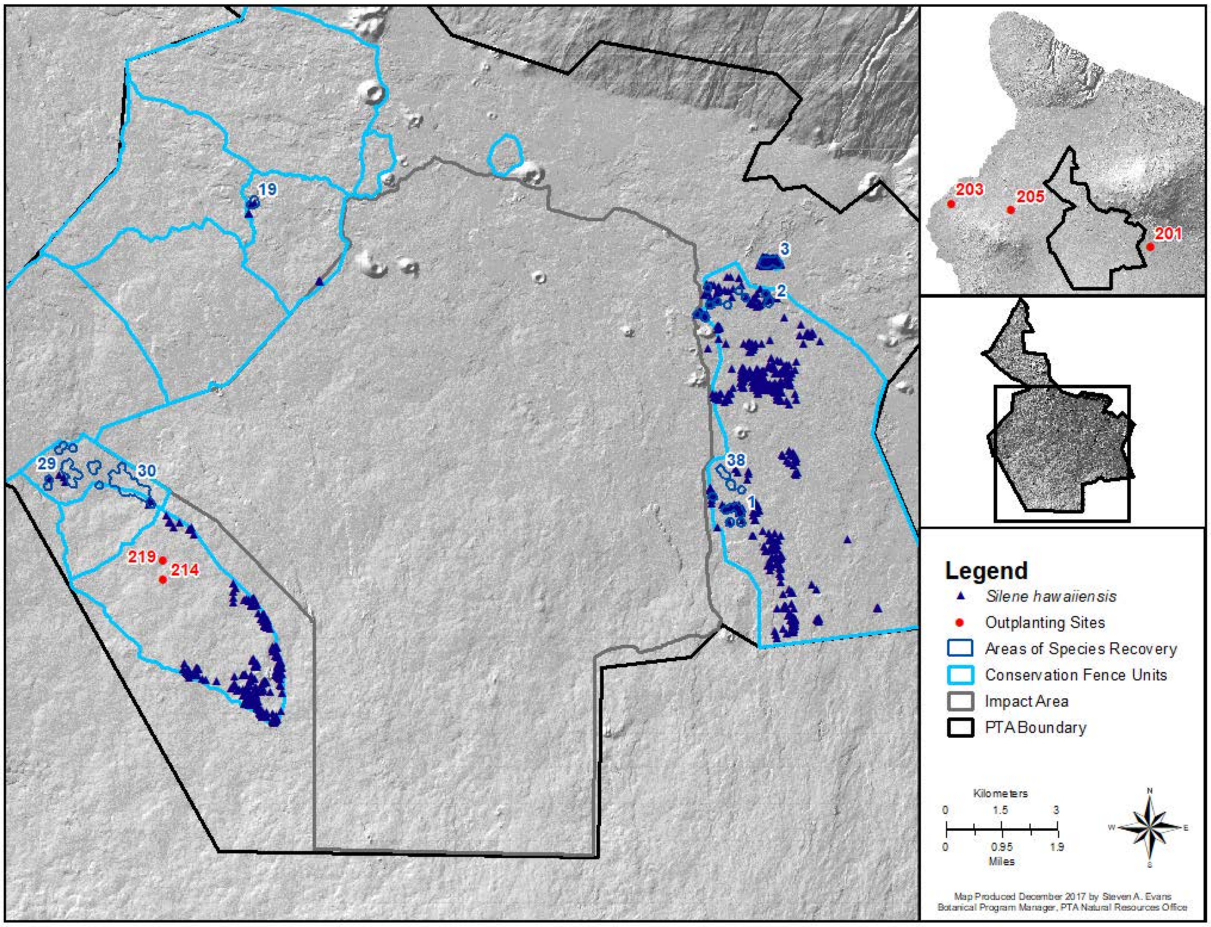

Figure 54. Current known distribution and outplanting sites for *Silene hawaiiensis*[a]

[a] Distribution data were collected between 2011 and 2015

Genetic Conservation

Propagule Collection

We did not collect propagules from *Silene hawaiiensis* during the reporting period. Please refer to Table 8 for a complete summary of genetic conservation status for *Silene hawaiiensis.*

Propagation

We attempted to propagate 2 batches of seed from accessions made in 1999 and 2001 (Table 55). Although the seed was over 10 years old, the germination rate was relatively high for both batches. We plan to continue testing the viability of seed over time.

Table 55. Seed germination trial results for *Silene hawaiiensis* from August 2018 to September 2019

New Founder No.	Other Founder No.	Prop. Accession	Media	Seed Treatment	Trial Days	No. Seed Sown	No. Seeds Germ.	% Germ	No. plants GH Acc.
524-3483-003-000-001	10003000000	1999001	Filter paper	GC	34	100	69	69%	0
524-3483-003-000-001	10003000001	2001001	Filter paper	GC	42	100	85	85%	4

GC, growth chamber; GH, greenhouse

Outplanting and Monitoring

We did not outplant *Silene hawaiiensis* during the reporting period.

In previous years, we planted a total 83 *Silene hawaiiensis* individuals at ASRs 201, 203, 205, 214, and 2019 (Table 56). Survivorship was variable at the sites and although some adults were found at the last monitoring in 2016, we documented recruitment of only a single adult at ASR 205.

Table 56. Monitoring summary for *Silene hawaiiensis* outplanted prior to FY 2018

			Surviving Outplants			Recruits	
Location	Outplanting Site	Total Outplanted	Adult	Juvenile	Net Survivorship	Adult	Juvenile
On PTA	214	10	10	0	100%	0	0
	219	2	2	0	100%	0	0
Off PTA	201	31	9	0	29%	0	0
	203	18	0	0	0%	0	0
	205	22	1	0	4%	1	0

PTA, Pōhakuloa Training Area

Discussion

Our efforts to survey, monitor, and conserve genetics for *Silene hawaiiensis* address SOO tasks 3.2(1)(a, d–f) as well as several INRMP objectives.

At PTA, *Silene hawaiiensis* naturally occurs primarily in the *Silene hawaiiensis*, Kīpuka Kālawamauna East, *Kadua coriacea*, Kīpuka ʻAlalā North, Kīpuka ʻAlalā South, and Puu Koli Fence Units (Figure 54). We limit our plant surveys to areas within the ungulate exclusion fences; however, *Silene hawaiiensis* has been documented in previous years outside the ungulate exclusion fences in TA 23. We anticipate completing a sampling of plant survey transects by March 2020 and data collected will allow us to more accurately estimate the abundance of *Silene hawaiiensis.*

Pratt et al. (2012) studied several life history characteristics and ecological traits of *Silene hawaiiensis* for 2 populations within Hawaiʻi Volcanoes National Park. The researchers describe size frequency distributions for a stable population with low mortality and an unstable population with high mortality. Flowers can be present year-round, but the researchers found a peak in flowering during summer months. They documented pollination events from 2 species of native yellow-faced bees, *Hylaeus difficilis* and *Hylaeus volcanicus*, both of which occur at PTA. They also observed an introduced hover fly (*Allograpta exotica)* enter the flowers. *Allograpta exotica* is part of the species group *Allograpta obliqua* and the 2 species are closely related (Mengual et al. 2009). Although the species *A. exotica* has not been documented at PTA, *A. obliqua*, has. The team also found that unfenced plants were browsed, but there was no statistical difference in survivorship for protected and unprotected plants, at least over the short-term. Although this work was conducted at Hawaiʻi Volcanoes National Park, we assume that many of the documented traits will be similar to plants at PTA, but this information should be used to guide local investigations as there may be seasonal shifts in phenology due to differences in climate and environmental conditions.

Between 2007 and 2010, we monitored *Silene hawaiiensis* in 5 ASRs and collected demographic information (CEMML 2010). Although we did not observe seedlings at any of the ASRs, we did note recruitment into the juvenile and adult life stages presumably from plants that germinated between monitoring periods. We plan to use life history information to design monitoring and management strategies for *Silene hawaiiensis* to support healthy and resilient populations under changing climate conditions.

We continue to make progress with genetic conservation of *Silene hawaiiensis.* Although we did not collect propagules this reporting period, we did propagate 2 batches of seed that were over 20 years old. We had relatively high germination success with each batch and several plants are accessioned to the greenhouse. In 2020, we plan to develop site-specific planting plans for *Silene hawaiiensis* and to monitor the performance of the outplants under the different planting conditions. There are 39 *Silene hawaiiensis* accessioned to the greenhouse. We are developing planting strategies and plan to continue investigating outplant performance and planting site characteristics in 2020 to maximize the successful establishment of new self-sustaining groupings.

Progress toward compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects from military activities to *Silene hawaiiensis,* the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browse pressure, maintenance of genetic stock *ex situ*, outplanting, reproduction *in situ*, non-native plant control, and annual monitoring.

To address these conservation measures for *Silene hawaiiensis*, we implement landscape-level projects to reduce fire-risk and ungulate browse for all known individuals at PTA (See Section 1.3). In addition, we actively conserve *Silene hawaiiensis* genetics; the propagule bank contains 11,425 seeds from the natural population and 28,520 seeds from individuals grown in the greenhouse. To date, we have outplanted about 81 individuals at 4 ASRs; however, we have not observed enough reproduction to consider *Silene hawaiiensis* self-sustaining at any of the ASRs. We managed invasive plants for *Silene hawaiiensis* in about 13.4 ha in ASR 3 (Table 64). This species also benefits from invasive plant management where it occurs in weed control buffers that were implemented for other species. Although we do not currently monitor for *Silene hawaiiensis in situ* reproduction annually, previous monitoring in 5 ASR for *Silene hawaiiensis* documented increases of plants (presumably from seedlings that germinated between monitoring periods). We monitor a portion of the *Silene* *hawaiiensis* distribution annually and estimate abundance based on rare plant survey data. However, we are unable to attribute changes in numbers to effects from training or management.

For a discussion regarding how ongoing management benefits Army operations at PTA and the importance of continuing management efforts, see the final summary discussion for the Botanical Program (Section 2.6)

2.5.5 *Silene lanceolata* (Endangered)

As a PS 3, we survey and monitor a portion of the known *S. lanceolata* distribution each year. However, we derive distribution and estimate abundance for each species within the ungulate exclusion fences from the completed 5-year data set (2011 to 2015). For genetic conservation, *S. lanceolata* is an implementation priority 5 (low). We plan to collect propagules for storage with little to no outplanting.

<u>Plant Surveys</u>

Based on the completed plant survey data set (2011 to 2015), there were 372 locations representing at least 3,478 individuals of *S. lanceolata* at PTA. The distribution for *S. lanceolata*, including outplanting sites, is shown in Figure 55.

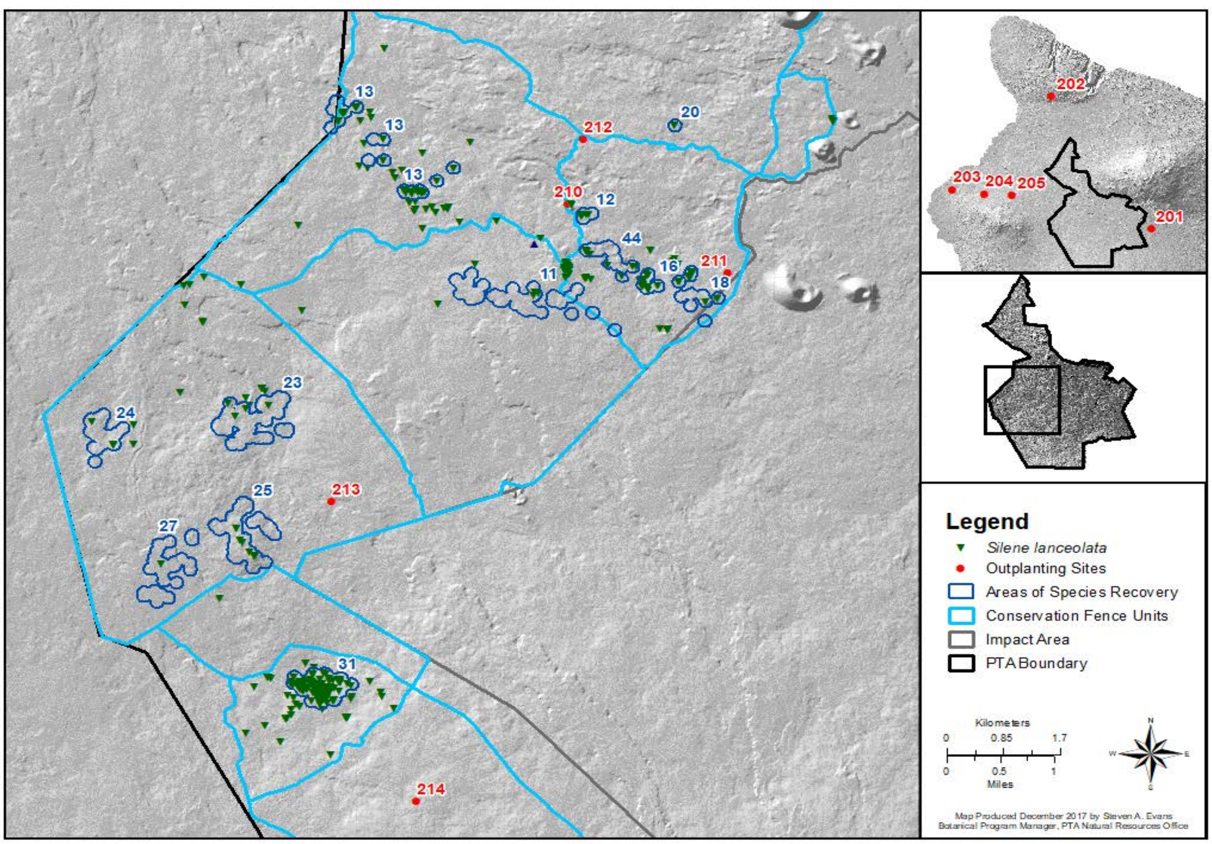

Figure 55. Current known distribution and outplanting sites for *Silene lanceolata*[a]

[a] Distribution data were collected between 2011 and 2015

During plant surveys for the reporting period, we recorded 380 locations representing at least 5,744 individuals of *S. lanceolata.* Because we are still surveying the full set of transects, our findings represent progress for the reporting period and do not represent actual changes in species abundance or distribution.

Genetic Conservation

Propagule Collection

We collected a total of 8,802 seeds representing 3 founders during the reporting period. Please refer to Table 8 for a complete summary of genetic conservation status for *S. lanceolata*.

Propagation

In August 2019, we attempted to propagate 250 seeds from founder 060160A11533 that were collected in 2015. Results for these trials are not available.

Outplanting and Monitoring

We did not outplant *S. lanceolata* during the reporting period.

In previous years, we planted a total 817 *S. lanceolata* individuals at 10 ASRs (Table 57). *Silene lanceolata* established in relatively high numbers, compared the numbers planted, at 2 ASRs on PTA. At ASR 205, *S. lanceolata* recruited in similar numbers to the original number outplanted. We noted lower recruitment levels at ASR 201 and 210. Outplants did not persist and did not recruit at 5 of the ASRs.

Table 57. Monitoring summary for *Silene lanceolata* outplanted prior to FY 2018

			Surviving Outplants			Recruits	
Location	Outplanting Site	Total Outplanted	Adult	Juvenile	Net Survivorship	Adult	Juvenile
On PTA	210	125	0	0	0%	19	22
	211	59	0	0	0%	357	35
	212	26	0	0	0%	0	0
	213	3	0	0	0%	0	0
	214	75	1	0	1%	700	40
Off PTA	201	51	9	0	18%	0	20
	202	27	0	0	0%	0	0
	203	12	0	0	0%	0	0
	204	199	0	0	0%	0	0
	205	340	3	0	<1%	383	38

PTA, Pōhakuloa Training Area

Discussion

Our efforts to survey, monitor, and conserve genetics for *S. lanceolata* address SOO tasks 3.2(1)(a, d–f) as well as several INRMP objectives.

At PTA, *S. lanceolata* naturally occurs primarily in the Kīpuka Kālawamauna North, Kīpuka Kālawamauna East, Kīpuka Kālawamauna West, *Solanum incompletum*, Nāʻōhuleʻelua, Mixed Tree, *Kadua coriacea*, and Kīpuka ʻAlalā North, Fence Units (Figure 55). Although we have not completed the second cycle of plants surveys, preliminary observations suggest that the number of locations of *S. lanceolata* increased. We anticipate completing a sampling of the plant survey transects by March 2020 and data collected will allow us to more accurately estimate the abundance of *S. lanceolata.*

Although we have had some outplanting and management success with *S. lanceolata*, we still know relatively little about life history characteristics and population dynamics. We are still learning about ecological interactions between this species and animals. Aslan et al. (2019) found that no native insects visited *S. lanceolata* flowers and all pollination services were performed by non-native insects including honeybees, hover flies, fly species (*Diptra* spp.), and sweat bees (*Lasioglossum impavidum*). In addition, researchers concluded that ants, Argentine (*Linepithema humile*) in particular, are a threat to endangered plants (Christina Liang, personal communication, May 2018). We recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species. Knowing these life history attributes and potential threats is important for designing management actions to maximize the likelihood that *S. lanceolata* will persist, and potentially increase, especially with changing climate conditions.

We continue to make progress with genetic conservation of *S. lanceolata*. Many of the accessions in storage are aging and we do not know how aging affects the viability of the seed. Typically, we have good success propagating *S. lanceolate*, so it is a lower priority for germination and dormancy research. We have also been successful at establishing outplantings that have persisted at more than one location, outperforming most other species we have outplanted. Because the natural *S. lanceolata* population at PTA is relatively robust and we have been successful with germination and outplanting, we plan to investigate if seed broadcast is an effective, less resource-intensive means to establish plants at new sites.

Progress toward compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects from military activities to *S. lanceolata,* the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browse pressure, maintenance of genetic stock *ex situ*, outplanting, reproduction *in situ*, non-native plant control, and annual monitoring.

To address these conservation measures for *S. lanceolata*, we implement landscape-level projects to reduce fire risk and ungulate browse for all known individuals at PTA (See Section 1.3). In addition, we actively conserve *S. lanceolata* genetics; the propagule bank contains 473,998 seeds from the natural population and 1,069,751 seeds from individuals grown in the greenhouse or from individuals outplanted. To date, we have outplanted 817 individuals at 10 ASRs and we consider *S. lanceolata* self-sustaining at 3 of the ASRs. We manage weeds in 10 ASRs where *S. lanceolata* occurs alone or with 1 or more PS 1 plant species. Within these 10 ASRs, we manage weeds in 31 ha for *S. lanceolata* and other PS 1 plants co-located in the control buffers (Table 64). This species also benefits from invasive plant management where it occurs in weed control buffers that were implemented for other species. Although we do not currently monitor for *S. lanceolata in situ* reproduction annually; in 2008 and 2009 we noted past *S. lanceolata* seedlings in all 10 ASRs monitored. No seedlings were recorded in 2007 or 2010, suggesting that *in situ* reproduction is not constant but occurs when environmental conditions are favorable. We monitor a portion of the *S. lanceolata* distribution annually and estimate abundance based on rare plant survey data. However, we are unable to attribute changes in numbers to effects from training or management.

For a discussion regarding how ongoing management benefits Army operations at PTA and the importance of continuing management efforts, see the final summary discussion for the Botanical Program (Section 2.6).

2.5.6 *Spermolepis hawaiiensis* (Endangered)

As a PS 3, we survey and monitor a portion of the known *Spermolepis hawaiiensis* distribution each year. However, we derive distribution and estimate abundance for each species within the ungulate exclusion fences from the completed 5-year data set (2011 to 2015). For genetic conservation, *Spermolepis hawaiiensis* is an implementation priority 5 (low). We plan to collect propagules for storage with little to no outplanting.

<u>Plant Surveys</u>

During plant surveys for the reporting period, we recorded 13 locations representing at least 63 individuals of *Spermolepis hawaiiensis*. Because we are still surveying the full set of transects, our findings represent progress for the reporting period and do not represent actual changes in species abundance or distribution.

Based on the completed plant survey data set (2011 to 2015), there were 195 locations representing at least 595 individuals of *Spermolepis hawaiiensis*.at PTA. The distribution for *S. lanceolata*, including outplanting sites, is shown in Figure 56.

<u>Genetic Conservation</u>

Propagule Collection

We did not collect *Spermolepis hawaiiensis* during the reporting period. Currently, 60 founders are represented in storage for this species. Please refer to Table 8 for a complete summary of genetic conservation status for *Spermolepis hawaiiensis.*

Propagation

We did not propagate or outplant *Spermolepis hawaiiensis* during the reporting period.

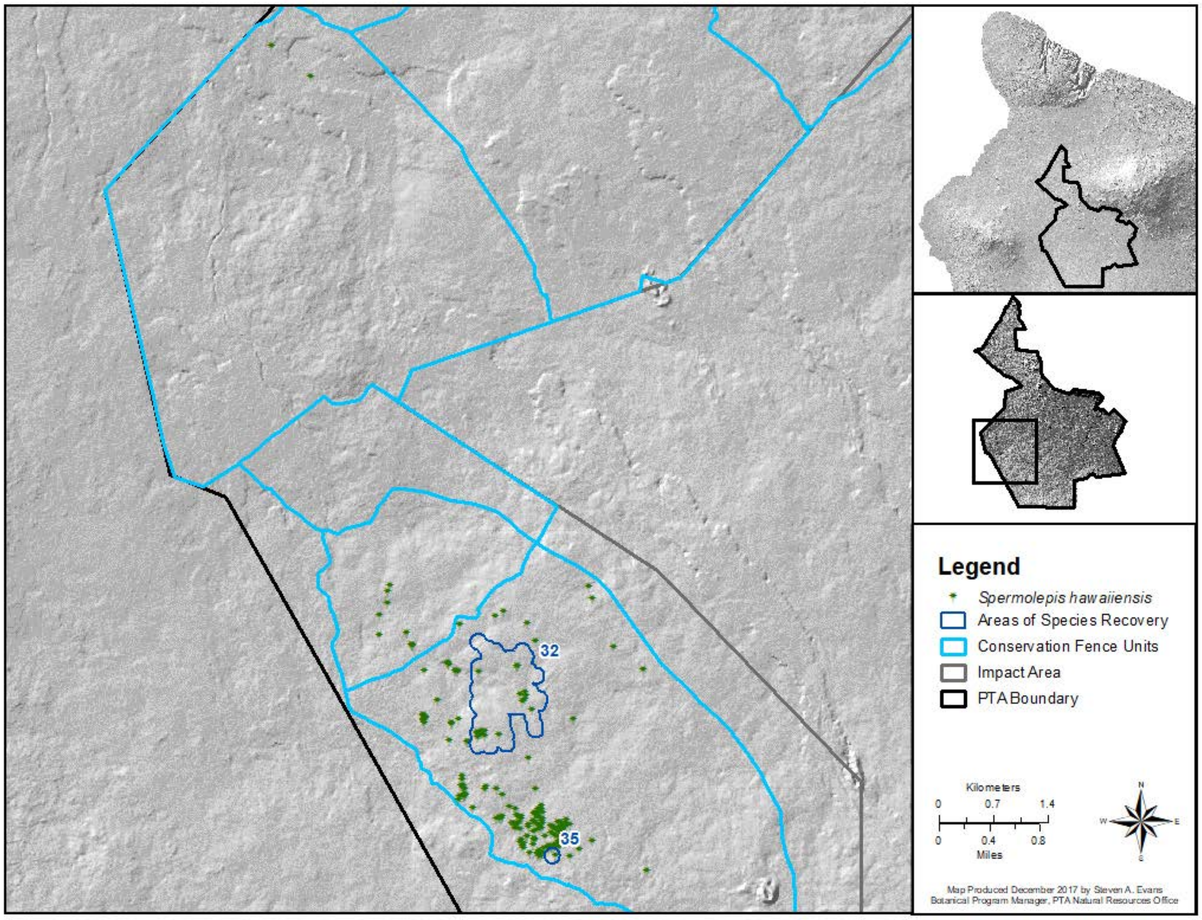

Figure 56. Current known distribution of *Spermolepis hawaiiensis*[a]

[a] Distribution data were collected between 2011 and 2015

Outplanting and Monitoring

In previous years, *Spermolepis hawaiiensis* was directly seeded at 6 ASRs. As of monitoring in 2016, *Spermolepis hawaiiensis* successfully recruited at ASR 201 (95 adults) and ASR 205 (163 adults and 70 juveniles). Recruitment had been limited at ASR 214, although we detected no plants during the 2016 monitoring.

Discussion

Our efforts to survey, monitor, and conserve genetics for *Spermolepis hawaiiensis* address SOO tasks 3.2(1)(a, d–f) as well as several INRMP objectives.

At PTA, *Spermolepis hawaiiensis* naturally occurs primarily in the Kīpuka ʻAlalā North and South Fence Units with 2 additional locations within the Mixed Tree Fence Unit (Figure 56). *Spermolepis hawaiiensis* is an ephemeral species and although it is an annual it may not always be present throughout its entire range unless environmental conditions are favorable. Because of its ephemeral nature, we did not include *Spermolepis hawaiiensis* in the sampling methods for the plant surveys.

Until we develop a monitoring approach more targeted to the unique life history characteristics of *Spermolepis hawaiiensis*, we will continue to use the abundance estimate developed from the first cycle of plant surveys (2011 to 2015).

We know very little about the life history characteristics of *Spermolepis hawaiiensis.* Its short-lived nature and episodic germination and recruitment make this a difficult species to study. We have made some progress with genetic conservation for *Spermolepis hawaiiensis*, but collection from the natural population can be unreliable due to its ephemeral nature. We recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species.

Progress toward compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects from military activities to *Spermolepis hawaiiensis,* the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browse pressure.

To address these conservation measures for *Spermolepis hawaiiensis*, we implement landscape-level projects to reduce fire-risk and ungulate browse for all known individuals at PTA (See Section 1.3). In addition, we actively conserve *Spermolepis hawaiiensis* genetics; the propagule bank contains 3,094 seeds from the natural population and 511,629 seeds from individuals grown in the greenhouse or from individuals outplanted. We have direct seeded *Spermolepis hawaiiensis* at 6 outplanting site ASRs and *Spermolepis hawaiiensis* has successfully recruited at ASR 214.

For a discussion regarding how ongoing management benefits Army operations at PTA and the importance of continuing management efforts, see the final summary discussion for the Botanical Program (Section 2.6).

2.5.7 *Stenogyne angustifolia* (Endangered)

As a PS 3, we survey and monitor a portion of the known *S. angustifolia* distribution each year. However, we derive distribution and estimate abundance for each species within the ungulate exclusion fences from the completed 5-year data set (2011 to 2015). For genetic conservation, *S. angustifolia* is an implementation priority 5 (low). We plan to collect propagules for storage with little to no outplanting.

Plant Surveys

During plant surveys for the reporting period, we recorded 380 locations representing at least 5,744 individuals of *S. angustifolia.* Because we are still surveying the full set of transects, our findings represent progress for the reporting period and do not represent actual changes in species abundance or distribution.

Based on the completed plant survey data set (2011 to 2015), there were 1,087 locations representing at least 2,517 individuals of *S. angustifolia* at PTA. The distribution for *S. angustifolia*, including outplanting sites, is shown in Figure 57.

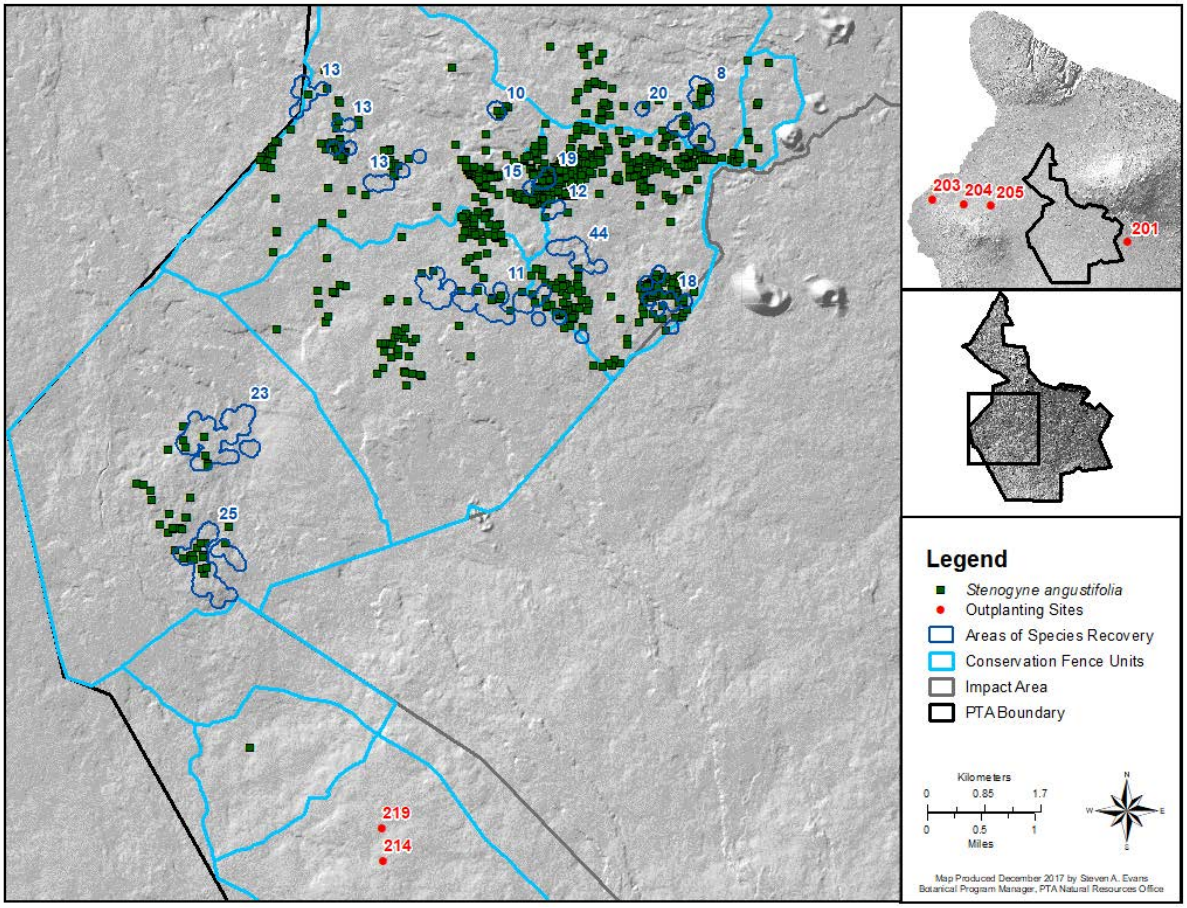

Figure 57. Current known distribution and outplanting sites for *Stenogyne angustifolia*

[a] Distribution data were collected between 2011 and 2015

In June 2018, about 463 locations of *S. angustifolia* in TA 18, 19, and 22 were impacted by a wildfire. In August 2018, we visited all known *S. angustifolia* locations within the burned area and found varying degrees of fire-related impacts to *S. angustifolia* and documented some post-fire recovery including germination of plants from the seed bank (CEMML 2018b). To assess on-going recovery, we compared the pre- and post-fire numbers of locations of *S. angustifolia* (see Section 2.2.2 for details). We surveyed 70 out of 86 transects (81%) within the burned area where *Haplostachys haplostachya* and/or *S. angustifolia* were found during the first cycle of rare plant surveys (2010–2015). Along transects that were occupied by these plants prior to the fire, we documented 197 locations of *S. angustifolia,* which was less than the 204 pre-fire locations. However, we recorded at least 1,324 plants at these 197 locations, which is almost double the pre-fire minimum number of plants (604 plants at 204 locations). So, although there were fewer locations found, there were more individuals at each location following the fire.

Genetic Conservation

Propagule Collection

We collected 3 cuttings from 1 founder during the reporting period. Please refer to Table 8 for a complete summary of genetic conservation status for *S. angustifolia*.

Propagation

We attempted to propagate 5 batches of seed from an accession made in 2007 (Table 58). The seed was over 10 years old and we did not observe any germination after 141 days.

Table 58. Seed germination trial results for *Stenogyne angustifolia* from August 2018 to September 2019

New Founder No.	Other Founder No.	Prop. Accession	Media	Seed Treatment	Trial Days	No. Seed Sown	No. Seeds Germ.	% Germ	No. plants GH Acc.
None	06000000001	2007003	Filter paper	GA3 100ppm	141	15	0	0%	0
None	06000000001	2007003	Filter paper	GA3 300ppm	141	15	0	0%	0
None	06000000001	2007003	Filter paper	GA3 500ppm	141	15	0	0%	0
None	06000000001	2007003	Filter paper	50% Liquid Smoke	141	15	0	0%	0
None	06000000001	2007003	Filter paper	2.5% Liquid Smoke	141	13	0	0%	0

GA3, gibberellin A3; GH, greenhouse

We propagated 3 cuttings from a single founder. By May 2019, 3 cuttings grew to sufficient size to be accessioned to the greenhouse, but by August all had died. In addition, a single plant was accessioned to the greenhouse, but propagation records and the propagule accession information were separated from this plant.

Outplanting and Monitoring

We did not outplant *S. angustifolia* during the reporting period.

In previous years, we planted a total 126 *S. angustifolia* individuals at ASRs 201, 203, 204, 205, 214 and 2019 (Table 59). Because *S. angustifolia* grows in mat-like clusters and establishes clones vegetatively, we did not count the number of individuals of *S. angustifolia* remaining at the sites in 2016. We documented the presence of *S. angustifolia* at 3 of the 5 ASRs. However, we learned that *S. angustifolia* can take over large areas within an outplanting site and smother other ESA-listed outplanting species. Therefore, we plan to be more strategic with outplanting this species, especially when planting it with multiple species in a limited area.

Table 59. Monitoring summary for *Stenogyne angustifolia* outplanted prior to FY 2018

			Surviving Outplants			Recruits	
Location	Outplanting Site	Total Outplanted	Adult	Juvenile	Net Survivorship	Adult	Juvenile
On PTA	214	30	Present	--	--	Clone	--
	219	1	Present	--	100%	Clone	--
Off PTA	201	121	Present	--	--	0	0
	203	8	0	0	0%	0	0
	204	8	0	0	0%	0	0
	205	78	Present	--	--	Clone	--

PTA, Pōhakuloa Training Area

Discussion

Our efforts to survey, monitor, and conserve genetics for *S. angustifolia* address SOO tasks 3.2(1)(a, d–f) as well as several INRMP objectives.

The distribution of *S. angustifolia* is nearly continuous across approximately 2,430 ha of the *Solanum incompletum*, Kīpuka Kālawamauna North, Kīpuka Kālawamauna East, Kīpuka Kālawamauna West, and Nāʻōhuleʻelua Fence Units (Figure 57). It is also scattered in the Mixed Tree Fence Unit and an isolated location in the Kīpuka ʻAlalā North Fence Unit. We anticipate completing a sampling of the plant survey transects by March 2020 and data collected will allow us to more accurately estimate the abundance of *S. angustifolia.*

We know relatively little about life history characteristics and population dynamics of *S. angustifolia*. We are still learning about ecological interactions between this species and animals. Aslan et al. (2019) found that in a year of observations, only 1 potential pollinator, an introduced sweat bee (*Lasioglossum impavidum*), visited *S. angustifolia* flowers. Little is known about native pollinators for *S. angustifolia.* Its floral characteristics, including a flower with a reduced lower lip and longer-tubed, red/pink corolla, and abundant nectar production, suggest bird pollination (Lindqvist and Albert 2002). Hawaiian ʻAmakihi (*Hemignathus virens*), ʻApapane (*Himatione sanguinea*), and Japanese White-eye (*Zosterops japonicus*) are potential pollinators and often sip nectar from other tubular native flowers such as *Sophora chrysophylla* (māmane). Recent research conducted on Oʻahu showed that attracting birds with audio lures to native plants, including endangered plants, increased fruit consumption (MacDonald 2019). To reduce the likelihood of ecological extinction of *S. angustifolia* (Aslan et al. 2018), the use of audio lures to attract potential bird pollinators to *S. angustifolia* may be an effective tool to increase pollination services. In addition, researchers concluded that ants, Argentine (*Linepithema humile*) in particular, are a threat to *S. angustifolia* (Christina Liang, personal communication, May 2018). We recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species. Knowing these life history attributes and potential threats is important for designing management actions to maximize the likelihood that *S. angustifolia* will persist, and potentially increase, especially with changing climate conditions.

We continue to make progress with genetic conservation of *S. angustifolia.* However, we need to better understand germination requirements of *S. angustifolia* so that we can reliably germinate seeds and effectively retrieve the stored genetics. We recommend partnering with the Army's Natural Resources Program on O'ahu to leverage their expertise to establish reliable germination procedures. There are 4 *S. angustifolia* accessioned to the greenhouse.

Progress toward compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects from military activities to *S. angustifolia,* the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browse pressure, maintenance of genetic stock *ex situ*, outplanting, reproduction *in situ*, non-native plant control, and annual monitoring.

To address these conservation measures for *S. angustifolia*, we implement landscape-level projects to reduce fire-risk and ungulate browse for all known individuals at PTA (See Section 1.3). In addition, we actively conserve *S. angustifolia* genetics; the propagule bank contains 2,175 seeds from the natural population and 4,220 seeds from individuals grown in the greenhouse or from individuals outplanted. To date, we have outplanted 126 individuals at 6 ASRs and we consider *S. angustifolia* self-sustaining at 4 of the ASRs. We have not implemented weed management specifically for *S. angustifolia*; however, this species benefits from invasive plant management where it occurs in weed control buffers that were implemented for other species. Although we do not currently monitor for *S. angustifolia in situ* reproduction annually, we have observed *in situ* reproduction of *S. angustifolia*, most recently in TAs 18, 19, and 22 in the area burned by the July 2018 fire. We monitor a portion of the *S. angustifolia* distribution annually and estimate abundance based on rare plant survey data. However, we are unable to attribute changes in numbers to effects from training or management.

For a discussion regarding how ongoing management benefits Army operations at PTA and the importance of continuing management efforts, see the final summary discussion for the Botanical Program (Section 2.6).

2.5.8 *Zanthoxylum hawaiiense* (Endangered)

As a PS 2, we survey and monitor a portion of the known *Z. hawaiiense* distribution each year. However, we derive distribution and estimate abundance for each species within the ungulate exclusion fences from the completed 5-year data set (2011 to 2015). For genetic conservation, *Z. hawaiiense* is an implementation priority 5 (low). We plan to collect propagules for storage with little to no outplanting.

Plant Surveys

Based on the completed plant survey data set (2011 to 2015), there were 506 locations representing at least 536 individuals of *Z. hawaiiense* at PTA. The distribution for *Z. hawaiiense*, including outplanting sites, is shown in Figure 58.

During plant surveys for the reporting period, we recorded 34 locations representing at least 40 individuals of *Z. hawaiiense*. Because we are still surveying the full set of transects, our findings represent progress for the reporting period and do not represent actual changes in species abundance or distribution.

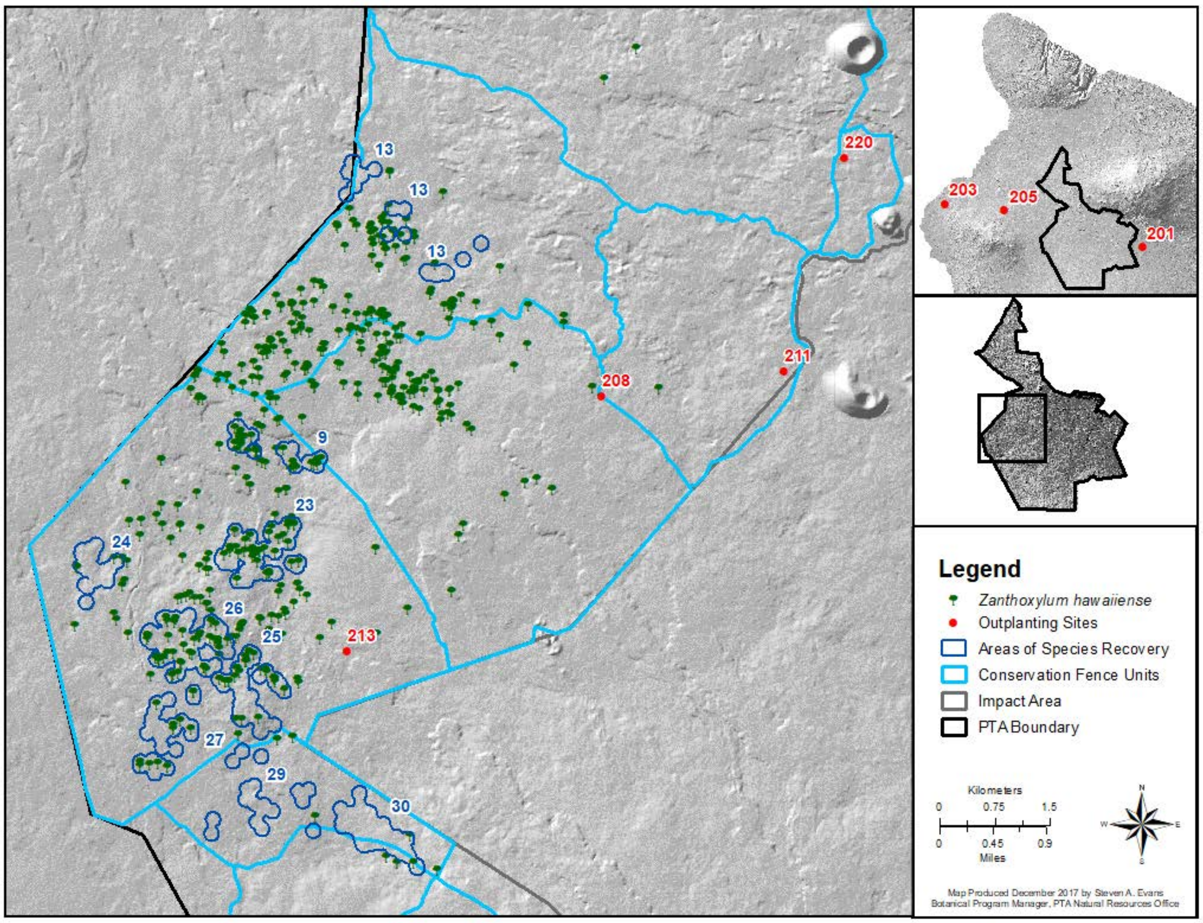

Figure 58. Current known distribution and outplanting sites for *Zanthoxylum hawaiiense*[a]

[a] Distribution data were collected between 2011 and 2015

Genetic Conservation

Propagule Collection

During the reporting period, we collected 108 seeds and made 34 cuttings from a single founder. Please refer to Table 8 for a complete summary of genetic conservation status for *Z. hawaiiense.*

Propagation

Propagation records between October 2017 and July 2018 were incomplete or missing and do not align with the greenhouse accession records and plants in the facility. The greenhouse accession records indicate that propagules from a single *Z hawaiiense* founder were propagated and 6 seedlings grew to sufficient size to be transferred to 4-inch pots and accessioned to the greenhouse (Table 60). Based on the dates of the greenhouse accessions (6 February2019), the cuttings were likely propagated in early 2018.

Table 60. *Zanthoxylum hawaiiense* accessioned to the greenhouse without propagation records

New Founder No.	Other Founder No.	Date Accessioned to Greenhouse	Greenhouse Accession No.
508-2486-001-001	04025045	2/6/2019	227, 228, 229, 230, 231, 232

After August 2018 more detailed propagation records were kept (Table 61). We attempted to propagate 6 batches of seed from an accession made in 2009 and 2015. One seedling germinated after 82 days from seed that was about 10 years old. The seedling grew large enough to be accessioned to the greenhouse.

Table 61. Seed germination trial results for *Zanthoxylum hawaiiense* from August 2018 to September 2019

New Founder No.	Other Founder No.	Prop. Accession	Media	Seed Treatment	Trial Days	No. Seed Sown	No. Seeds Germ.	% Germ	No. plants GH Acc.
None	08007001001	2009050	Filter paper	None	82	20	0	0%	
None	08007001001	2009050	Filter paper	300ppm GA3	82	20	1	5%	
None	08007001001	2009050	Filter paper	500ppm GA3	82	20	0	0%	
None	08007001001	2009050	Filter paper	700ppm GA3	82	20	0	0%	1
None	041578001001	2015001	Filter paper	500ppm GA3	166	17	0	0%	0
None	041578001001	2015001	Filter paper	700ppm GA3	166	17	0	0%	0

GA3, gibberellin A3; GH, greenhouse

In July 2019, we propagated 34 cuttings from 1 founder. The cuttings are likely still growing in the greenhouse but did not reached the size to be accessioned to the greenhouse by September 2019. From preliminary data, our success rate with the cuttings appears low and may warrant further investigation to improve practice and success.

Outplanting and Monitoring

We did not outplant *Z. hawaiiense* during the reporting period.

In previous years, we planted a total 40 *Z. hawaiiense* individuals at ASRs 201, 203, 205, 208, 211, 213, and 220 (Table 62). During the last monitoring of the outplanting sites in 2016, we documented 11 *Z. hawaiiense* alive (3 juveniles and 8 adults).

Table 62. Monitoring summary for *Zanthoxylum hawaiiense* outplanted prior to FY 2018

			Surviving Outplants			Recruits	
Location	Outplanting Site	Total Outplanted	Adult	Juvenile	Net Survivorship	Adult	Juvenile
On PTA	208	5	0	0	0%	0	0
	211	2	0	1	50%	0	0
	213	4	0	0	0%	0	0
	220	3	0	2	67%	0	0
Off PTA	201	2	1	0	50%	0	0
	203	2	0	0	0%	0	0
	205	22	7	0	32%	0	0

PTA, Pōhakuloa Training Area

Discussion

Our efforts to survey, monitor, and conserve genetics for *Z. hawaiiense* address SOO tasks 3.2(1)(a, d–f) as well as several INRMP objectives.

The distribution of *Z. hawaiiense* is nearly continuous across approximately 2,000 ha of the Kīpuka Kālawamauna West, Nāʻōhuleʻelua, and Mixed Tree Fence Units (Figure 58). Scattered individuals also occur in the Kīpuka Kālawamauna North, Kīpuka Kālawamauna East, *Kadua coriacea*, and Kīpuka ʻAlalā North Fence Units. Because *Z. hawaiiense* occurs in small clusters widely dispersed over many thousands of acres, we did not include this species in the sampling approach to plant surveys that will be completed in March 2020. In addition, since *Z. hawaiiense* is a slow growing tree and recruitment of young trees has been low, we expect abundance estimates generated from the first cycle of plant surveys to be representative of the current abundance. We anticipate developing a new monitoring approach for *Z. hawaiiense* based on its specific life history characteristics in 2020.

Like many other species that occur at PTA, we know very little about the life history characteristics of *Z. hawaiiense*. Knowing these life history attributes is important for designing management actions to maximize the likelihood that *Z. hawaiiense* will persist, and potentially increase, especially with changing climate conditions. We recommend exploring opportunities for basic research into life history characteristics to support science-based management of this species. We continue to make progress with genetic conservation of *Z. hawaiiense*. Many of the accessions in storage are aging and we do not know how aging affects the viability of the seed. We had minimal success with seed germination and cutting establishment this reporting period. Also, because *Z. hawaiiense* is a tree, outplants may take years to mature and fruit. Therefore, assessing success in terms of recruitment at outplanting sites may take years. There are 8 *Z. hawaiiense* accessioned to the greenhouse. We are developing planting strategies and plan to continue investigating outplant performance and planting site characteristics in 2020 to maximize the successful establishment of new self-sustaining groupings.

Progress toward compliance with Endangered Species Act Biological Opinion Conservation Measures

To offset effects of military activities on *Z. hawaiiense,* the 2003 BO conservation measures include fuels management to reduce fire risk, fencing and ungulate control to reduce browse pressure, maintenance of genetic stock *ex situ*, outplanting, reproduction *in situ*, non-native plant control, and annual monitoring.

To address these conservation measures for *Z. hawaiiense*, we implement landscape-level projects to reduce fire risk and ungulate browse for all known individuals at PTA (See Section 1.3). In addition, we actively conserve *Z. hawaiiense* genetics and have 5,706 seeds from the natural population in the propagule bank. To date, we have outplanted 40 individuals at 7 ASRs. Eleven trees were alive in 2016 during the last monitoring. Because *Z. hawaiiense* is a slow growing tree, it has not yet established self-sustaining populations. We have not implemented weed management specifically for *Z. hawaiiense*; however, this species benefits from invasive plant management where it occurs in weed control buffers that were implemented for other species. Currently, we do not monitor for *Z. hawaiiense in situ* reproduction annually. We have observed very few young trees and *in situ* reproduction was very low. However, since the removal of the animals from the fence units, we anticipate that seedlings will have a better chance to establish without ungulate browse pressure. We plan to develop a targeted monitoring approach specifically designed for *Z. hawaiiense* in 2020. Currently, we monitor a portion of the *Z. hawaiiense* distribution annually and estimate abundance based on rare plant survey data. However, we are unable to attribute changes in numbers to effects from training or management.

For a discussion regarding how ongoing management benefits Army operations at PTA and the importance of continuing management efforts, see the final summary discussion for the Botanical Program (Section 2.6).

2.6 OVERALL SUMMARY DISCUSSION

Implementation of a Botanical Program is an essential component of the Army's Natural Resources Program at PTA to ensure the continued persistence of valued resources and training lands. Through the implementation of our SOO tasks, we continue to work towards our program goals, INRMP objectives, and maintaining compliance with several regulatory obligations, including conservation measures from several BOs issued by the USFWS. We track the distribution and abundance of 20 ESA-listed plant species at the installation, and based on our findings, we design and implement management actions to maximize the likelihood of maintaining healthy and resilient populations that retain potential to persist under changing climate conditions.

Implementing ecosystem management coupled with a species-specific approach for protected plants supports a holistic approach to natural resources conservation. Many aspects of the Hawaiian ecosystem have changed since the arrival of people and the introduction of non-native plants and animals. We continue to witness the cascading effects of these ecosystem disruptions, sometimes years later (e.g., change in fire-regime from introduced grasses). Often, we are unaware of the negative cascading effects across trophic levels until there is a problem, such as introduced ants negatively impacting native pollinators and possibly disrupting or changing pollination services for endangered plants. This slow, or sometimes rapid, erosion of ecological relationships can reduce community resilience to additional invasions or changes in climate (Suding et al. 2004; Suding 2011). By managing elements in the environment, we reduce or eliminate some stressors from the ecosystem and from individual species, particularly endangered or rare species (e.g., the removal of feral ungulates). Managing at the ecosystem scale helps to maintain ecological relationships that support ESA-listed plants and affords the opportunity to investigate means to ensure these species persist.

Implementing Botanical Program projects supports Army readiness by helping to establish, document, and maintain robust baseline populations of ESA-listed plants. This may seem counterintuitive, but with high population numbers of ESA-listed plants, there is a reduced risk that military operations at PTA will impact a large proportion of a species' population and jeopardize its continued existence. With higher population numbers, it may be possible during formal ESA consultations to negotiate reduced restrictions on military activities and operations and to reduce regulatory-mandated management requirements. In addition, our ecosystem management efforts benefit other common and rare species and help to keep populations stable and to help minimize the potential that these species will need to be listed under the ESA in the future. Also, effective implementation of the INRMP to protect plant habitats at the landscape level demonstrates that the Army's Natural Resources Programs are well managed and executed. In future analyses to designate critical habitat for ESA-listed species, the demonstrated outcomes and conservation benefits to the species from implementation of the INRMP objectives will likely contribute toward continued exemptions from legal designation of Critical Habitat on Army lands for newly designated species (e.g., plants listed in 2016).

In the 2003 BO, we committed to implementing several conservation measures to offset military training impacts to 15 ESA-listed plants. For 13[9] of these 15 plant species, a suite of conservation measures was aimed at setting conditions to allow for reproduction to occur in natural populations (i.e., *in situ* reproduction). Because we cannot control whether seeds will naturally germinate, we managed other aspects of the environment so that when seeds germinated, the seedlings had a chance to survive. Therefore, we view *in situ* reproduction as an indication that our management is providing a conservation benefit to the species.

From 2016 to 2019, we tracked the presence of seedlings for all PS 1 plants. *Portulaca villosa, Sicyos macrophyllus,* and *Tetramolopium* sp. 1 were not included in the 2003 BO, but we report *in situ* reproduction for these species as well (Table 61). In addition, there are 5 ESA-listed plants that were included in the 2003 BO but are not PS 1 species. We discuss reproduction for the PS 2 and 3 species in the Species Summaries (see Section 2.5).

[9] *A. peruvianum* var. *insulare, H. haplostachya*, *I. hosakae*, *K. coriacea*, *L. venosa*, *N. ovata*, *Silene hawaiiensis*, *S. lanceolata*, *S. incompletum*, *S. angustifolia*, *T. arenarium* var. *arenarium*, *V. o-wahuensis*, and *Z. hawaiiense.*

Most PS 1 species are reproducing in the field at most of the monitoring plots (Table 63). This time span is relatively short and may not have captured the full extent of environmental conditions present at all monitoring plots. For example, we documented no reproduction of *Kadua coriacea* and *S. macrophyllus*. We believe factors other than the ones we are managing for, such as low genetic variability or loss of pollinators, are limiting natural reproduction of these 2 species. In addition, reproduction for *Isodendrion hosakae* was limited to a single monitoring plot during this time period. However, we had a gap in monitoring for *I. hosakae* from March 2017 through May 2018 and several individuals recruited to the population on various plots during this period (see Section 2.2.4 for details). Although data show that most PS 1 plants are reproducing naturally, and are receiving conservation benefit from our management, our current monitoring methods do not allow us to accurately track how this reproduction contributes to population structure over time.

Table 63. Priority Species 1 monitoring plots with documented *in situ* recruitment at least once between 2016 and 2019 during quarterly monitoring

Species	No. of Plots	No. of Plots w/ reproduction[a]	Percent of plots w/ reproduction[a]
Asplenium peruvianum var. *insulare*	43	17	40%
Isodendrion hosakae	36	1	3%
Kadua coriacea	124	0	0%
Lipochaeta venosa	17	6	35%
Neraudia ovata	19	5	26%
Portulaca sclerocarpa	41	19	46%
Portulaca villosa	2	3	100%
Sicyos macrophyllus	1	0	0%
Schiedea hawaiiensis	2	1	50%
Solanum incompletum	20	3	15%
Tetramolopium arenarium var. *arenarium*	27	19	70%
Tetramolopium sp. 1	64	17	27%
Vigna o-wahuensis	46	23	50%

[a] The number of plots with seedlings observed at least once between 2016 and 2019. This number is used to derive the percent of total plots with reproduction documented at least once.

As a learning organization, we have many challenges ahead of us in 2020. To fulfill the purpose of the Botanical Program – to gain insights into the ecology of ESA-listed plants and to use that information to effectively manage the plants for long-term persistence – we plan to reexamine many of our approaches. To maximize our effectiveness at integrating management at the ecosystem and localized scale, we need to reexamine how landscape-level management dovetails with species-specific management needs (e.g., rodent or invertebrate control). To this end, we plan to begin development of species-specific management plans based on known life history characteristics, to develop basic research needs and seek partnerships to implement projects, and to use science-based information to adjust on-going management of ESA-listed plants. In addition, we plan to overhaul the survey and monitoring programs to better estimate population numbers and trends for the ESA-listed plants to better track compliance with regulatory commitments and, where possible, to assess the effectiveness of our management.

3.0 INVASIVE PLANTS PROGRAM

3.1 INTRODUCTION

The Invasive Plants Program (IPP) encompasses both invasive plant and fuels control and has 2 purposes: 1) to reduce threats to TES (including plants and animals) from invasive plants and wildland fire, and 2) to protect TES and their habitats from habitat modification/degradation due to competition from invasive non-native plants, wildfires, and changes in fire regime. To manage invasive plants and fuels at PTA, we implement Statement of Objectives (SOO) tasks 3.2(1)(b) and 3.2(3)(a) through 3.2(3)(d) to comply with INRMP objectives (Sikes Act Improvement Act), ESA consultation requirements, regulatory outcomes from NEPA documents, and the IWFMP (USAG-P 2019b).

Most SOO tasks and INRMP objectives overlap with regulatory outcomes from ESA consultations and the NEPA process. In 2003, 2008, and 2013 the USFWS issued the Army BOs with conservation measures for 15 threatened and endangered plants[10]. The Army has not consulted with the USFWS under section 7(a)(2) of the ESA for 5 endangered plants found at PTA: *Exocarpos menziesii*, *Festuca hawaiiensis*, *Portulaca villosa*, *Schiedea hawaiiensis,* and *Sicyos macrophyllus*. Without an ESA consultation, these species lack formal conservation measures. We also manage the undescribed species *Tetramolopium* sp. 1 due to its rarity and limited distribution even though this plant is not ESA-listed.

We are currently preparing documents to formally consult with the USFWS in 2020 under Section 7(a)(2) of the ESA regarding military activities at PTA and the potential effects to TES. We anticipate the issuance of a programmatic BO from the USFWS in 2020.

The IPP comprises 3 sections:

1) Vegetation Control
2) Invasive Plants Survey and Monitoring (IPSM)
3) Fuels Management

Each program section addresses specific SOO tasks, INRMP objectives, and regulatory requirements, which dictate the goals and objectives within that section. Specifically, projects implemented under the Vegetation Control Section and IPSM address SOO tasks 3.2(1)(b) and 3.2(3)(a) and projects implemented under Fuels Management Section address SOO tasks 3.2(3)(b) and 3.2(3)(c). SOO task 3.2(3)(d) is implemented by the Fire Ecologist at the CEMML office in Fort Collins, CO. For a list of drivers associated with each of the projects and sections in the IPP, please refer to Appendix C.

This report summarizes project methods and general results for each IPP section and documents our progress with SOO tasks.

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[10] *A. peruvianum* var. *insulare, H. haplostachya*, *I. hosakae*, *K. coriacea*, *L. venosa*, *N. ovata*, *P. sclerocarpa*, *Silene hawaiiensis*, *S. lanceolata*, *S. incompletum*, *Spermolepis hawaiiensis*, *S. angustifolia*, *T. arenarium* var. *arenarium*, *V. o-wahuensis*, and *Z. hawaiiense.*

3.2 VEGETATION CONTROL IN AREAS OF SPECIES RECOVERY (ASRS) AND OUTPLANTING SITES (OPS)

3.2.1 Introduction

Projects implemented under the Vegetation Control Section address SOO tasks 3.2(1)(b) and 3.2(3)(a). Our mission is to improve habitat by reducing impacts from invasive plants to TES, primarily ESA-listed plants, and their habitats by implementing INRMP objectives and BO conservation measures. We strive to create areas around ESA-listed plant species relatively free from invasive plant competition, reduce fine fuels within a prescribed distance in fire-prone habitats, and improve native-dominated habitats in proximity to ESA-listed plant locations by reducing invasive plant cover.

Additionally, we support the Hawaiian Goose habitat improvement project at Hakalau Forest National Wildlife Refuge (HFNWR) by mowing and cutting grass in Army-managed areas frequented by geese.

To develop an effective strategy that efficiently controls invasive plant species and improves native habitat, we must balance many factors including invasiveness of species, proximity of invasive species to TES, native vegetation density and habitat quality, and site accessibility. These factors are highly variable between sites, requiring adjustments to control methods. Weather, specifically precipitation, is an uncontrollable factor that requires us to adjust our methods and strategies.

Operational goals to address issues and problems are as follows:

- Assess Weed Control Buffers (WCBs) in ASRs per the annual schedule to determine the need for weed control and schedule appropriately (e.g., quarter/month/week). See Section 1.6.2 for details about ASR establishment.
- Perform management actions appropriate to the site and conditions (e.g., hand pull, follow-up cutting or spraying), monitor weather conditions for effective herbicide application timing.
- Assess efficacy of management actions (e.g., response to herbicide application).
- Communicate with Botanical Program on results of monitoring to inform management.
- Ensure less than 20% weed cover is maintained in WCBs.

3.2.2 Weed Control in Delineated Areas of Species Recovery and Outplanting Sites

Weed control in ASRs meets SOO tasks 3.2(1)(b) and 3.2(3)(a). To accomplish these tasks for ESA-listed plant species, we focus invasive plant management in a series of WCBs within ASRs (Figure 59). WCBs are defined as areas that have had some form of weed control implemented. We aim to maintain WCBs at less than 20% weed cover as determined by visual inspection as to when a site approached the 20% threshold. Generally, we initially establish WCBs by controlling weeds within 25 m from plant locations (i.e., species for which the ASR was designated). Once a maintenance phase is established, we may expand the WCBs. However, only a few WCBs have been expanded to a maximum of 50 m as logistics, resources, new challenges and threats (e.g., new/expanding invasions) limit operational management capacity.

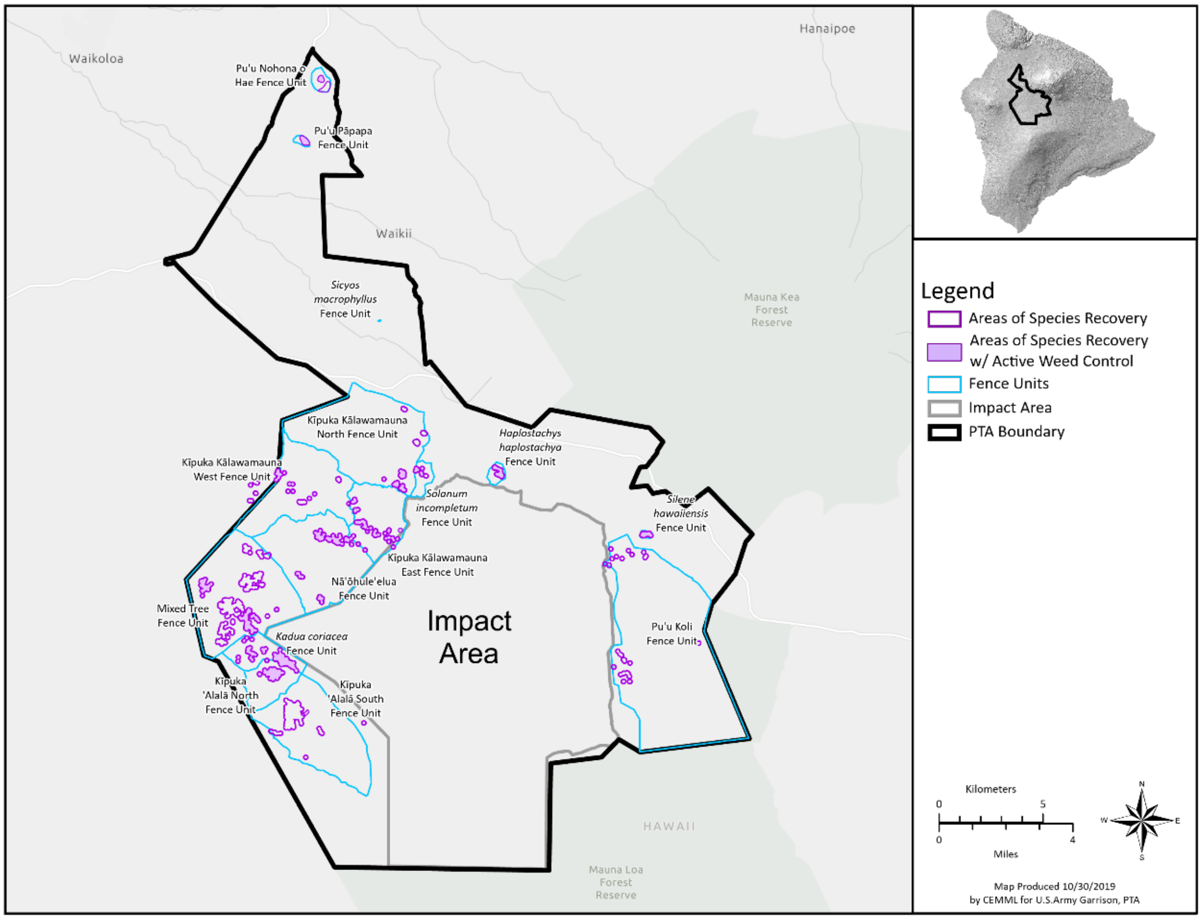

Figure 59. Areas of species recovery with and without active weed control at Pōhakuloa Training Area

In the last biennial report, we reported on ASRs and outplanting sites (OPs) separately. Outplanting sites are areas where ESA-listed plant species were planted to increase their distributions and abundances (see Section 2.3). ASRs were originally areas with naturally occurring ESA-listed plant species. Some outplanting sites were established within or adjacent to existing ASRs. Because we control and manage weeds the same way in outplanting sites as in ASRs, we now refer to outplanting sites as ASRs. Some outplanting sites were implemented within an ASR and assigned a 200-series number but were later combined with the ASR in which they occurred (e.g., OP 213 is now part of ASR 41). Moving forward, outplanting sites near an existing ASR may be combined with that ASR as an additional WCB (e.g., OP 207 will be WCB 207 within ASR 18 beginning in FY 2020).

To control weeds over time, we repeat weed control treatments within WCBs. The frequency of weed control in any ASR depends on recent, local environmental conditions (e.g., precipitation) that influence the rate at which weeds grow in each area, and thus the need for weed control at any given time. We schedule each actively managed ASR to assess each actively managed ASR for percent weed cover ranging from quarterly to every 18 months, depending on site characteristics and historical management data, and implement weed control as needed.

Mechanical removal and herbicide application are the primary methods for weed control and fuels reduction in WCBs, with hand clearing conducted within 1 m of ESA-listed plant species. The 4-step approach to weed control in ASRs is: 1) hand-pull or cut weeds within 1 m of ESA-listed plant species, 2) cut weeds in WCB with weed whackers, 3) apply herbicides to re-growth of target weeds in the WCB, and 4) continue hand-clearing, cutting and spraying as needed to achieve and maintain less than 20% weed cover. The primary targets for weed control in ASRs are fountain grass (*Cenchrus setaceus)* and fireweed (*Senecio madagascariensis*) due to their invasiveness, habitat altering-nature, and, for *C. setaceus,* production of fine fuels. The term "primary target weed" is used to describe these species to distinguish them from secondary target weeds described in the IPSM Section of this report.

We prioritize ASRs for weed control using several criteria: priority level of ESA-listed plant species (see Section 2.1.1), number of ESA-listed plant species present, level of threats present, site access, recovery potential, and density of weeds. We schedule weed control in ASRs at frequencies based on projected need (e.g., quarterly for areas with dense weeds) and management actions data from the recent past (e.g., last 1 to 2 years). In general, ASRs containing the rarest plants, with dense weed cover and adequate access tend to receive higher priority and therefore more frequent management. We manage ASRs with lower priority plants and difficult or costly access less frequently. Further, some ASRs require more frequent weed control than others depending on the community type, substrate, level of previous disturbance, and invasion by primary and/or secondary target weeds. For example, ASRs with sparse vegetation do not typically need as much weed control as do ASRs within shrubland and grassland communities invaded by *C. setaceus*. We conduct weed control and other management actions (e.g., plant monitoring) in remote ASRs with high priority TES during camp trips to maximize mobilization of resources and reduce overall costs.

There are typically 1 or 2 high priority, or primary, ESA-listed plant species for which an ASR is designated. Additional or secondary ESA-listed plant species may fall within the 100-m boundary of an ASR. Although we typically initiate WCBs around the primary ESA-listed plant species within an ASR, if a secondary ESA-listed plant species is in proximity to a primary species, it may also benefit from weed control if it occurs within the WCB.

During the reporting period, we delineated a total of 105.7 ha of WCBs within ASRs (Table 64). The frequency of weed control efforts varied across ASRs; we did not control weeds within ASRs with weed densities below management thresholds. In some ASRs we controlled weeds less frequently than planned due to staffing shortages and inclement weather. During Summer 2018, the State of Hawaiʻi experienced the second wettest dry season in 30 years (NOAA 2018). Due to a flush in vegetation resulting from the increased precipitation, we were unable to maintain our planned level of weed control at some ASRs while concurrently maintaining fuel breaks. Additionally, we decreased the WCB area in several ASRs where the focal ESA-listed plants were no longer present. Most notably, we decreased the ASR 24 WCB area by almost half (7.2 ha) because it included a large area with no recorded ESA-listed plants and served only as a physical weed-free connection to the functional WCBs centered around ESA-listed plants. Further, our continued maintenance of this WCB area had no obvious benefits to the ESA-listed plants in the remainder of the ASR and took much needed resources away from other priorities. However, we implemented weed control in ASR 46 beginning in June 2018 and maintained it throughout the reporting period, adding 2.6 ha of WCB area, overall.

Table 64. Weed control in areas of species recovery in FY 2018-FY 2019

ASR	Primary Species	WCB Hectares	WC Frequency
3	*Silene hawaiiensis*	13.4	4
4	*Haplostachys haplostachya*	2.1	0
8	*Tetramolopium arenarium*	12.3	5
11	*Kadua coriacea/ Silene lanceolata*	4.8	2
12	*Silene lanceolata*	1.7	4
13	*Silene lanceolata*	4.8	4
16	*Silene lanceolata*	2.7	5
18	*Kadua coriacea/ Silene lanceolata*	3.4	3
19	*Silene hawaiiensis*	1.3	1
20	*Silene lanceolata*	0.8	5
21	*Kadua coriacea*	1.0	1
22	*Kadua coriacea*	0.6	1
24	*Neraudia ovata/ Solanum incompletum/ Silene lanceolata*	7.8	6
25	*Silene lanceolata*	1.4	6
28	*Tetramolopium* sp. 1[a]	0.9	1
29	*Kadua coriacea*	1.6	2
30	*Kadua coriacea*	26.3	1
31	*Silene lanceolata*	0.7	1
40	*Solanum incompletum*	2.7	3
41	*Schiedea hawaiiensis*	1.0	1
44	*Silene lanceolata/ Portulaca sclerocarpa*	2.9	4
46	*Isodendrion hosakae*	2.6	6
47	*Solanum incompletum*	0.3	2
48	*Lipochaeta venosa*	1.7	9
201	Several ESA-listed plant species (Off PTA)	0.6	2
203	Several ESA-listed plant species (Off PTA)	<0.1	0
205	Several ESA-listed plant species (Off PTA)	0.6	3
206	*Schiedea hawaiiensis/Neraudia ovata*	0.4	0
207	*Schiedea hawaiiensis*	<0.1	0
209	*Solanum incompletum*	1.6	1
211	*Silene lanceolata*	1.2	1
214	Several ESA-listed plant species	2.4	3
219	*Asplenium peruvianum var. insulare/Solanum incompletum*	0.1	0
	Total	**105.7**	

ASR, area of species recovery; WCB, weed control buffer; WC, weed control
[a] *Tetramolopium* sp. 1 is not aa ESA-listed plant. However, this undescribed species is managed due to its rarity.

There are 26 ASRs in which we either do not control weeds or we only control weeds for selected ESA-listed plant species (Table 65). In some ASRs, we managed weeds for some ESA-listed plants, for which WCBs were designated, but not for other ESA-listed plants (e.g., *Portulaca sclerocarpa* in ASR

11). In other ASRs, we have never controlled weeds due to the lack of or low densities of weeds in those areas (e.g., ASRs 1 and 2), unclear benefits to the primary ESA-listed plant species (e.g., *Zanthoxylum hawaiiense* ASRs), a lack of resources, funds, and/or planning, or because other challenges prevented effective and beneficial management.

Table 65. Areas of species recovery with primary species without weed control

ASR	Primary Species	Status	Reason
1	*Silene hawaiiensis*	Not Active	Weeds below threshold criteria
2	*Silene hawaiiensis*	Not Active	Weeds below threshold criteria
5	*Silene lanceolata*	Decommissioned	Plant(s) died
6	*Haplostachys haplostachya*	Suspended	Management challenges
7	*Zanthoxylum hawaiiense*	Suspended	Plant(s) died
9	*Zanthoxylum hawaiiense*	Not Active	Benefit from weed control unclear
10	*Haplostachys haplostachya*	Not Active	Not priority, insufficient resources
11	*Portulaca sclerocarpa*	Not Active	Weeds below threshold criteria
12	*Kadua coriacea*	Not Active	Plant(s) died
13	*Solanum incompletum*	Suspended	Plant(s) died
14	*Neraudia ovata*	Decommissioned	On State lands
15	*Tetramolopium arenarium* var*. arenarium*	Suspended	Plant(s) died
17	*Portulaca sclerocarpa*	Not Active	Weeds below threshold criteria
23	*Zanthoxylum hawaiiense*	Not Active	Not priority, benefit from weed control unclear
25	*Zanthoxylum hawaiiense*	Not Active	Not priority, benefit from weed control unclear
26	*Zanthoxylum hawaiiense*	Not Active	Not priority, benefit from weed control unclear
27	*Silene lanceolata* *Zanthoxylum hawaiiense*	Not Active	Not priority
32	*Spermolepis hawaiiensis*	Not Active	Management challenges, benefits unclear
33	*Asplenium peruvianum* var. *insulare*	Not Active	Management challenges
34	*Asplenium peruvianum* var. *insulare*	Not Active	Plant(s) died
35	*Asplenium peruvianum* var. *insulare*	Not Active	Management challenges
36	*Asplenium peruvianum* var. *insulare*	Not Active	Considered for decommission
37	*Silene hawaiiensis*	Not Active	Slated for decommission, Impact Area
38	*Asplenium peruvianum* var. *insulare*	Not Active	Weeds below threshold criteria
39	*Asplenium peruvianum* var. *insulare*	Not Active	Considered for decommission
45	*Vigna o-wahuensis*	Suspended	Management challenges

ASR, Area of Species Recovery

3.2.3 Hakalau Forest National Wildlife Refuge Hawaiian Goose Habitat Management

Habitat management at Hakalau Forest National Wildlife Refuge (HFNWR) meets SOO tasks 3.2(2)(b) and terms and conditions of the 2013 BO Incidental Take Statement. We control vegetation (i.e., cutting and mowing grass, and select herbicide application on *Ulex europaeus* and *Rubus sp.*) to manage habitat for the Hawaiian Goose at HFNWR. To be consistent with refuge goals, we developed a management action plan with HFNWR to include: 1) Hawaiian Goose monitoring, 2) nest monitoring, 3) predator control, and 4) habitat management. We implemented habitat management actions between September 2017 to July 2019 (see Section 4.2.3 for project details).

Over the course of 4 site visits, we maintained approximately 1.2 ha of habitat for the Hawaiian Goose by mowing and weed whacking grass in the Pua ʻĀkala Habitat Enhancement Area of the HFNWR. Following our management during the reporting period, we frequently observed Hawaiian Geese in the area.

3.2.4 Vegetation Control Discussion

Overall, we made satisfactory progress toward achieving SOO tasks and program goals. All but 5 ASRs on the schedule received weed control during the reporting period. We also implemented weed control in 1 new ASR on Puʻu Pāpapa. By conducting vegetation control in WCBs, with the objective of reducing threats from invasive plants to ESA-listed plants and their habitats, we believe we are achieving our goals as described. Our vegetation control actions at HFNWR also appear to be benefitting Hawaiian Geese by providing preferred habitat.

Our intent in controlling weeds in ASR WCBs, particularly *C. setaceus*, is to reduce invasive plant competition for resources needed by the native species, thereby increasing native cover, which ultimately creates conditions that we assume are favorable for ESA-listed plants to survive and reproduce. We are in the process of developing methods to determine the effect of our efforts on habitat improvement and ESA-listed plant population persistence, so that we can assess and modify our management approaches to maximize the potential for desired outcomes.

Invasive, non-native species pose several threats to native species, especially ESA-listed plant species (Cabin et al. 2002). Species such as *C. setaceus* compete for space, light, nutrients, and soil moisture. *C. setaceus* can deplete soil moisture, especially in the upper soil layer, which can make the germination and establishment of native and ESA-listed plant species difficult because their seedling root systems draw soil moisture from the same upper layers as *C. setaceus*. The root system of *C. setaceus* also competes for soil moisture with established native plants, as evidenced by noticeable increases in vigor and growth of native and ESA-listed plant species in the absence of *C. setaceus*. In addition, *C. setaceus* dramatically alters the fire regime, increasing fire frequency to a rate at which native ecosystems are not adapted (Cordell and Sandquist 2008; Ellsworth et al. 2014). Therefore, it is important to reduce *C. setaceus* cover not only to reduce competition for resources and improve habitat, but also to prevent fire impacts to ESA-listed plants and mitigate the effects of the grass-fire cycle at the ecosystem scale.

Several of our WCBs likely reduced direct impacts to ESA-listed plants during the July 2018 fire in Training Areas 18, 19, and 22 (CEMML 2018b) caused by an inadvertent discharge of flares from a US Marine Corps aircraft during aerial, live-fire training. The fire was within the Kīpuka Kālawamauna Endangered Plants Habitat, which is one of the most fire-prone areas at PTA. The area harbors 7 ESA-listed plant species, some of which are the rarest at the installation and one (*Tetramolopium arenarium* var. *arenarium*) that is found only within the impacted area. Our post-fire assessment showed that the fire burned right up to the edge of 4 WCBs and then stopped. Thus, the WCBs prevented fire from impacting the ESA-listed plant species within those WCBs, averting a potential extinction event for *T. arenarium* var. *arenarium*. We concluded that removal and control of weeds, particularly *C. setaceus*, within WCBs was a crucial factor in preventing impacts to the ESA-listed plant species in the area.

We had anticipated that weed control would require less effort over time as native vegetation recovered, relative to the surrounding landscape. We have observed that the effort required to control *C. setaceus* does decrease over time, but *S. madagascariensis* continues to require consistent treatment due to its seed bank and ingress into WCBs.

3.3 INVASIVE PLANT SURVEY AND MONITORING

3.3.1 Introduction

Our mission is to reduce the impacts of invasive plants on TES and their habitats by implementing INRMP objectives and BO conservation measures, to prevent the introduction and establishment of invasive plants, and to provide control and minimize ecological impacts per Executive Order 13112.

IPSM projects meet SOO task 3.2(3)(a) and address INRMP objectives and conservation measures identified in the 2003 BO regarding new invasive plants at PTA. The goals of the IPSM are to detect new introductions of invasive plant species before they become established, to contain or eradicate these species when possible, and to limit the ecological impacts of certain well-established, highly invasive or ecosystem-altering plant populations. These goals are met by conducting roadside weed surveys throughout the installation, identifying and ranking target invasive species according to risk level and potential for control, and implementing control measures as appropriate.

We developed methods for surveying, assessing, and prioritizing incipient and target invasive plant species (USAG-HI 2010). We use the term “secondary target weeds” to refer to highly invasive plant species occurring at PTA that could impact TES, high quality habitat, or alter the landscape and/or ecosystem if left unchecked, and for which eradication or control outside WCBs is deemed feasible. Thirty-two species have been designated secondary target weeds, and another 10 are on the proposed list, meriting some level of observation or action (Table 66).

Table 66. Secondary target weeds of Pōhakuloa Training Area

Rank	Scientific Name	Common Name
1	*Sphagneticola trilobata*	wedelia
2	*Psidium guajava*	common guava
3	*Pluchea carolinensis*	sourbush
4	*Prosopis pallida*	kiawe
5	*Acacia mearnsii*[a]	black wattle
6	*Ricinus communis*	castorbean
7	*Lantana camara*	lantana
8	*Ambrosia artemisiifolia*	common ragweed
9	*Foeniculum vulgare*	fennel
10	*Schinus mole*	California peppertree
11	*Grevillea robusta*	silk oak
12	*Sambucus Mexicana*	Mexican elderberry
13	*Olea europaea*	olive
14	*Rubus rosifolius*	thimbleberry
15	*Rhamnus californica*	California coffeeberry
16	*Eschscholzia californica*	California golden poppy
17	*Portulaca Pilosa*	hairy pigweed
18	*Lophospermum erubescens*	larger roving sailor
19	*Leucaena leucocephala*	ekoa
20	*Parthenium hysterophorus*	false ragweed
21	*Cupressus* species	cypress
22	*Nicotiana glauca*	tree tobacco
23	*Rubus niveus*[a]	hill raspberry
24	*Kalanchoe tubiflora*	chandelier plant
25	*Asclepias physocarpa*	balloon plant
26	*Passiflora tarminiana*[a]	banana poka
27	*Cirsium vulgare*	bull thistle
28	*Centaurea melitensis*	malta star thistle
29	*Salsola tragus*[a]	Russian thistle
30	*Delairea odorata*	cape ivy
31	*Tribulus terrestris*	goat's head
32	*Datura stramonium*	jimson weed
N/A	*Emex spinosa*[a]	devil's thorn
N/A	*Festuca arundinacea*	tall fescue
N/A	*Glycine wightii*	glycine
N/A	*Heteromeles arbutifolia*	toyon
N/A	*Melinis minutiflora*	molasses grass
N/A	*Nicotiana tabacum*	tobacco (smoking)
N/A	*Paspalum dilatatum*	dallisgrass
N/A	*Piptatherum miliaceum*	smilograss
N/A	*Portulaca Pilosa*	hairy pigweed
N/A	*Trifolium pratense*	red clover

[a] Indicates species is on the United States Department of Agriculture's Hawaiʻi State Noxious Weed List

Four of these species are listed on the United States Department of Agriculture's Hawaiʻi State Noxious Weed List. However, the state noxious weed list has not been updated for 16 years and many of our secondary target weeds have characteristics that make them potential candidates (e.g., plants that cause damage to natural resources).

The IPSM Section has several distinct operations, or projects, that work in concert to satisfy the requirements of the section. Annual roadside and quarterly Bradshaw Army Airfield (BAAF) and construction site surveys provide information on secondary target and incipient weed species in high-use, regularly traversed, and disturbed areas to allow early detection and eradication and to inform management and monitoring efforts to track the spread and distribution of weeds. Control and Monitoring (i.e., weed checks) provides information on efficacy of management actions and status of target weed locations and localized infestations. Site-specific surveys, which typically occur in more remote areas, provide more information on the spread and distribution of secondary target weeds, the potential impacts on high quality habitats and ESA-listed species, and alteration of the landscape and/or ecosystem. Each of these projects are discussed in more detail below.

3.3.2 Roadside Surveys

We use roadside weed survey methods similar to other early detection programs in Hawaiʻi. Approximately 331 km of roads within defined geographic areas at PTA are surveyed by 2 people driving 5 mph, scanning each side of the road for incipient and secondary target weeds. For large areas, we limit efforts to a defined distance from roadsides within the greater survey area.

Methods

We survey the perimeter of BAAF (Survey Area 1, Figure 60) quarterly and all earth works construction sites quarterly during construction and for 6 months after construction ends. Thereafter, we typically survey construction sites annually. We survey select roads in the KMA once each year (Figure 61). For scheduling purposes, the installation is divided into 4 geographic areas based on frequency of military use and vegetation cover types (Survey Areas 2–5, Figure 60).

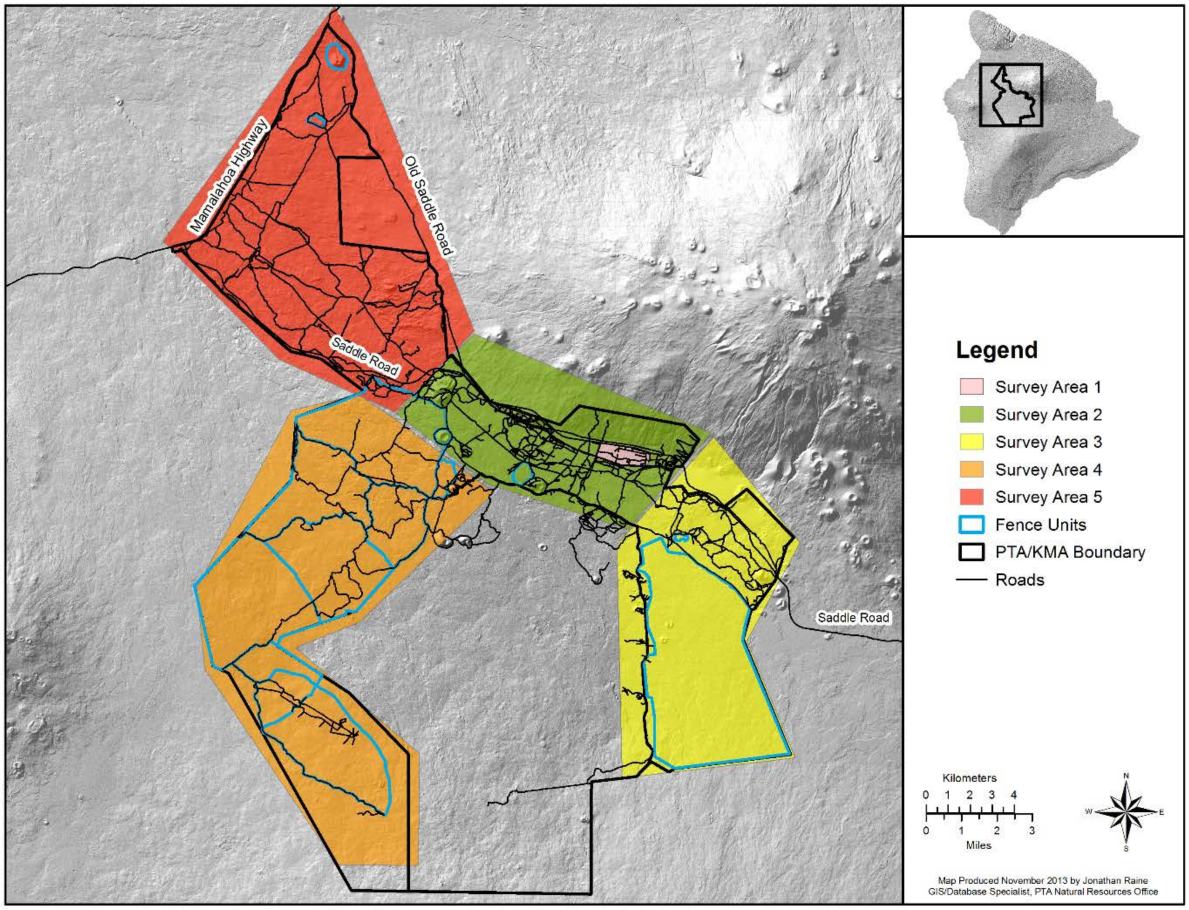

Figure 60. Invasive plant survey and monitoring areas at Pōhakuloa Training Area

Typically, IPSM Survey Areas 2 – 5 are surveyed during different quarters to account for seasonality of growth and flowering that affects species detection. However, between July and October conditions may be so dry that finding live, identifiable plants becomes difficult. We may truncate, reschedule, or cancel surveys during periods of drought or when other events have reduced any reasonable likelihood of weed germination or identification.

Due to the almost year-long vacancy of the IPSM Specialist position in FY 2019, we completed only a portion of the regularly scheduled roadside surveys. We surveyed Survey Areas 2, 4, and 5 once, as planned. In Survey Area 3, we surveyed 22 km of roadside or about 1/3 of the area at the end of FY 2019 (Table 67). We did not survey construction sites on a consistent quarterly basis, but we did survey BAAF every quarter during the reporting period.

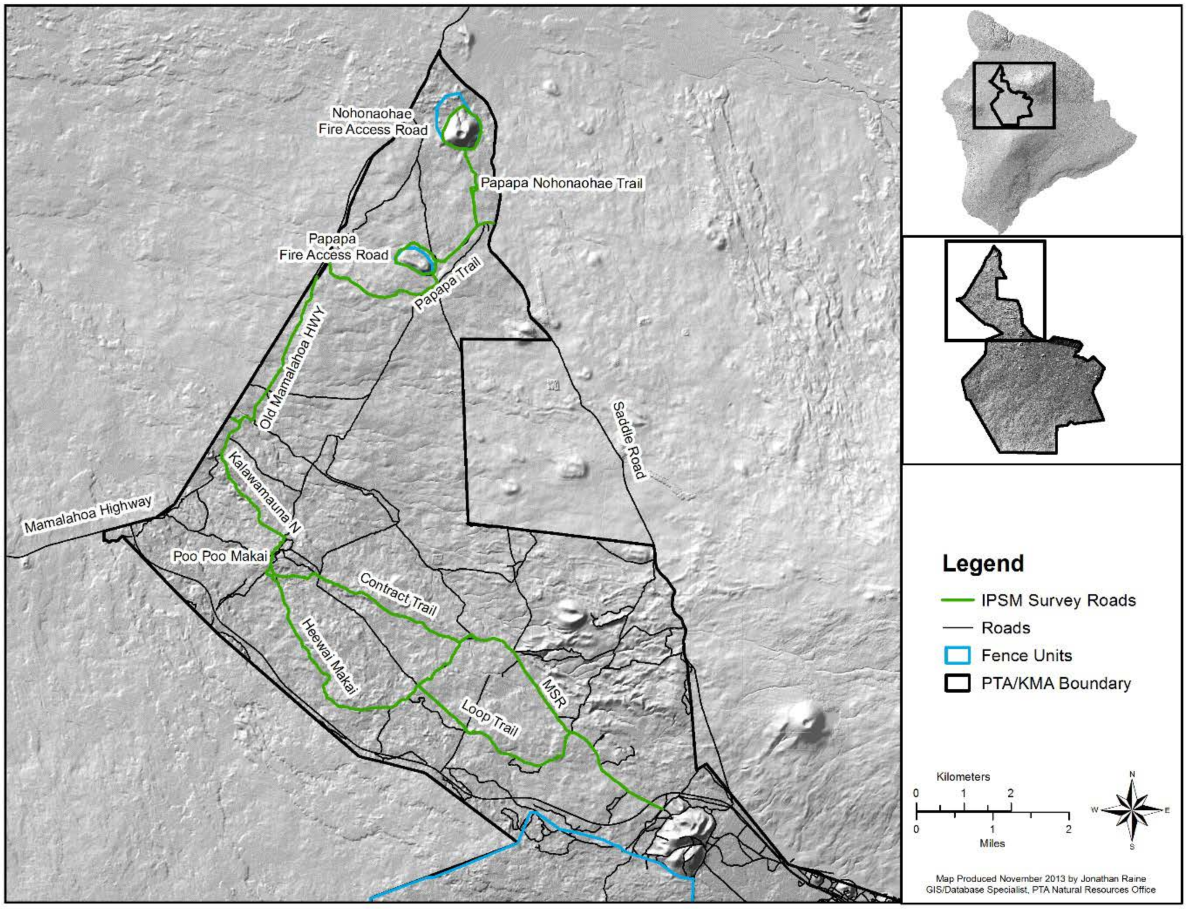

Figure 61. Invasive plant survey and monitoring roads in the Keʻāmuku Maneuver Area

Results

We found no incipient weed species during roadside surveys. However, in Survey Area 3, we found and controlled several secondary target weed species including *Emex spinosa*, *Tribulus terrestris*, and *Salsola tragus* in areas with few, if any, previously recorded locations (TA 3 and TA 21). In Survey Areas 1 (BAAF and construction sites), 2, 4, and 5 no species of note were found, meaning that all secondary target weeds encountered were already known to the area.

Table 67. Quarterly and annual surveys completed during FY 2018-FY 2019

Survey Description	Survey Area	General Area(s)	Survey Units	Survey Frequency[a]
Quarterly BAAF Survey	1	BAAF	5 km	8
Annual Roadside Surveys	2	TA 5–16, cantonment	106 km	1
	3	TA 1–4, 21	61 km[b]	0.3
	4	TA 17–20, 22–23	102 km	1
	5	KMA	45 km	1
Quarterly Construction Site Surveys[c]	2	Ahi Gate park area	<0.1 ha	3
	2	PTA Quarry	109 ha	3
	4	IPBA	12 km	2
	2	Well Hole No. 2	0.4 ha	3

BAAF, Bradshaw Army Airfield; IPBA, Infantry Platoon Battle Area; TA, Training Area

[a] Survey frequency refers to the number of times each general area was surveyed between the beginning of FY 2018 and the end of FY 2019. Additionally, the frequency with which construction sites are surveyed is subject to variation from year to year based upon the amount of time that has passed since construction was initiated and/or completed. Such normal variation in survey frequency occurred during FY 2018 and FY 2019.

[b] Survey Area 3 contains approximately 61 km of roadside, roughly 1/3 of the survey area was surveyed this reporting period.

[C] All construction sites are considered as Survey Area 1 for scheduling and operations, but physical location may be in other Survey Areas.

3.3.3 Control and Monitoring (Weed Checks)

We focus control and monitoring efforts on incipient and secondary target weeds. Generally, we treat incipient and secondary target weeds detected during roadside surveys immediately, if time and resources permit. However, if a weed population requires more resources than are available during surveys, or if conditions are not suitable for the treatment method selected, we schedule the treatment for a later date. Further, incipient and/or secondary target weeds found during regular field work are reported and scheduled for assessment and treatment as appropriate, based on priorities and as time and resources permit.

Treatments are selected based on the size of the population, recommendations from local experts and published literature, the herbicides and application tools currently stocked by the program, and safety to human health and the environment. Methods include hand pulling and various herbicide application techniques (e.g., spraying, cut/drip, drill-squirt, etc.). We strive to evaluate treatments of new species within several weeks to determine effectiveness. Regular monitoring and control are achieved through follow-up weed checks which include assessing the efficacy of the last treatment and re-treating as necessary. We schedule follow-up weed checks based on the reproductive period for the species and other factors, such as thoroughness or effectiveness of the initial treatment.

In general, secondary target weed species present in low numbers at PTA are treated installation-wide. However, we do not control widespread secondary targets due to lack of feasibility of control and low probability of having an overall benefit, except in ASRs or within close proximity to ESA-listed plants or other high value habitats.

We recorded and treated new locations of secondary target weeds when encountered, and monitored and treated some existing locations when time allowed (Table 68).

Table 68. Results of installation-wide monitoring and control in FY 2018–FY 2019

Secondary Target Weeds	Known Locations	New Locations	Locations Treated at Least Once[a]
Acacia mearnsii	26	5	8
Ambrosia artemisiifolia	26	2	6
Asclepias physocarpa	215	33	14
Centaurea melitensis	129	4	1
Cirsium vulgare	160	20	14
Cupressus species	3	0	0
Datura stramonium	15	4	3
Delairea odorata	134	76	27
Emex spinosa	97	9	4
Eschscholzia californica	8	0	0
Festuca arundinacea	28	0	0
Foeniculum vulgare	20	1	1
Glycine wightii	2	2	0
Grevillea robusta	31	24	21
Heteromeles arbutifolia	2	0	0
Kalanchoe tubiflora	47	3	2
Lantana camara	9	0	0
Leucaena leucocephala	104	1	1
Lophospermum erubescens[b]	244	89	135
Melinis minutiflora	27	12	16
Nicotiana glauca	580	106	80
Nicotiana tabacum	9	0	0
Olea europaea	8	0	0
Parthenium hysterophorus	48	0	0
Paspalum dilatatum	3	0	0
Passiflora tarminiana[b]	1,932	1,898	1,475
Piptatherum miliaceum	256	2	2
Pluchea carolinensis	27	15	7
Portulaca pilosa	14	2	0
Prosopis pallida	6	0	0
Psidium guajava	2	1	1
Rhamnus californica	25	2	0
Ricinus communis	23	1	1
Rubus niveus[b]	773	67	99
Rubus rosifolius	2	0	0

Table 68. Results of installation-wide monitoring and control in FY 2018–FY 2019 (cont.)

Secondary Target Weeds	Known Locations	New Locations	Locations Treated at Least Once[a]
Salsola tragus	119	5	7
Sambucus mexicana	38	2	2
Schinus molle	1	0	0
Sphagneticola trilobata	1	0	0
Tribulus terrestris	25	1	1
Trifolium pratense	1	0	0
Verbascum thapsus	6	0	0

[a] Locations Treated at Least Once refers to the number of locations that received treatment at least once during the reporting period; plant locations may include more than one individual
[b] Includes locations within site-specific survey grids (Table 69) and in outlying areas across the installation

3.3.4 Site-Specific Survey and Control of Secondary Target Species

Some secondary target species may be well-established throughout the installation or have dense infestations within specific areas but only receive control in delineated areas that contain or are in near ASRs and/or high quality or TES habitat. Our goal in these instances is not necessarily eradication but rather to reduce the density and/or contain the population, thus controlling spread into TES habitat.

We survey and control certain secondary target species with large areas of infestation using transects within defined survey grids. We typically hand-pull or apply herbicide (cut/drip or spray) to individuals found during surveys, and record weed locations and treatments.

Currently, there are defined survey grids in Kīpuka ʻAlalā in TA 23 for *Passiflora tarminiana* (Figure 62), *Rubus niveus* (Figure 63), and *Lophospermum erubescens* (Figure 64). There are also survey grids for *P. tarminiana* and *L. erubescens* in TA 22 (Figure 62 and Figure 64, respectively). Kīpuka ʻAlalā is a resource-rich area, providing habitat for several forest birds, the Hawaiian hoary bat (*Lasiurus cinereus semotus*), and hosting natural populations of ESA-listed plant species such as *Silene lanceolata*. Training Area 22 is ecologically significant because, in addition to providing habitat for TES, it hosts a relatively pristine ʻōhiʻa (*Metrosideros polymorpha*) forest, which is important given the decline of ʻōhiʻa forests on Hawaiʻi Island caused by the disease Rapid ʻŌhiʻa Death (see Section 3.3.5 for more details).

P. tarminiana is an invasive vine in mesic forests of Hawaiʻi, capable of smothering or shading out other types of vegetation, preventing regeneration of native species, and adversely affecting wildlife habitat. To address a large infestation of *P. tarminiana* in Kīpuka ʻAlalā, we aggressively surveyed for and controlled this species in the summer of 2018 (PastarNKA, Figure 62). Over the course of just a few months, we controlled *P. tarminiana* at 1,443 plant locations using mechanical and chemical control (Table 69). While *P. tarminiana* is present at great densities in TA 23, the species is also establishing in TA 22. Hence, we established a survey grid in TA 22 (Pastar22A, Figure 62) to control this outlying population.

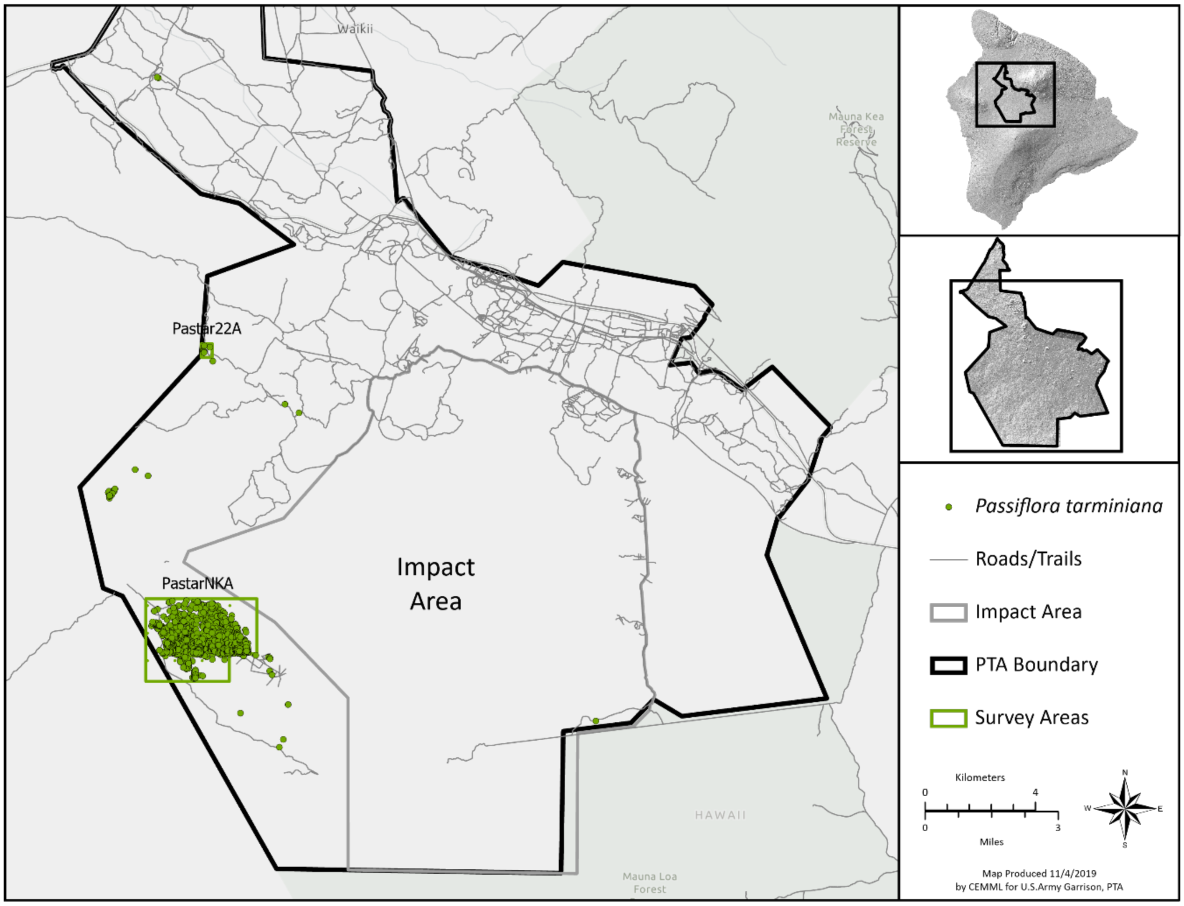

Figure 62. *Passiflora tarminiana* known locations and site-specific survey grids at Pōhakuloa Training Area

R. niveus is an invasive shrub that forms dense, impenetrable thickets due to the arching and intertwining stems. It displaces native vegetation, impedes regeneration of native shrubs and trees and impacts wildlife habitats (Weber 2003). The main infestations for *R. niveus* are in Kīpuka ʻAlalā (Figure 63), with few if any individuals documented in other areas of the installation. We surveyed 2 *R. niveus* grids this reporting period, Rubniv1 and Rubniv3B, with 81 and 11 plant locations requiring control, respectively (Table 69). We last monitored the grids in second quarter FY 2018 and are planning surveys in 2020. We also decommissioned 3 *R. niveus* grids (Rubniv 03A, Rubniv03C, and Rubniv04) in February 2018 because we have not found plants are these locations for several years.

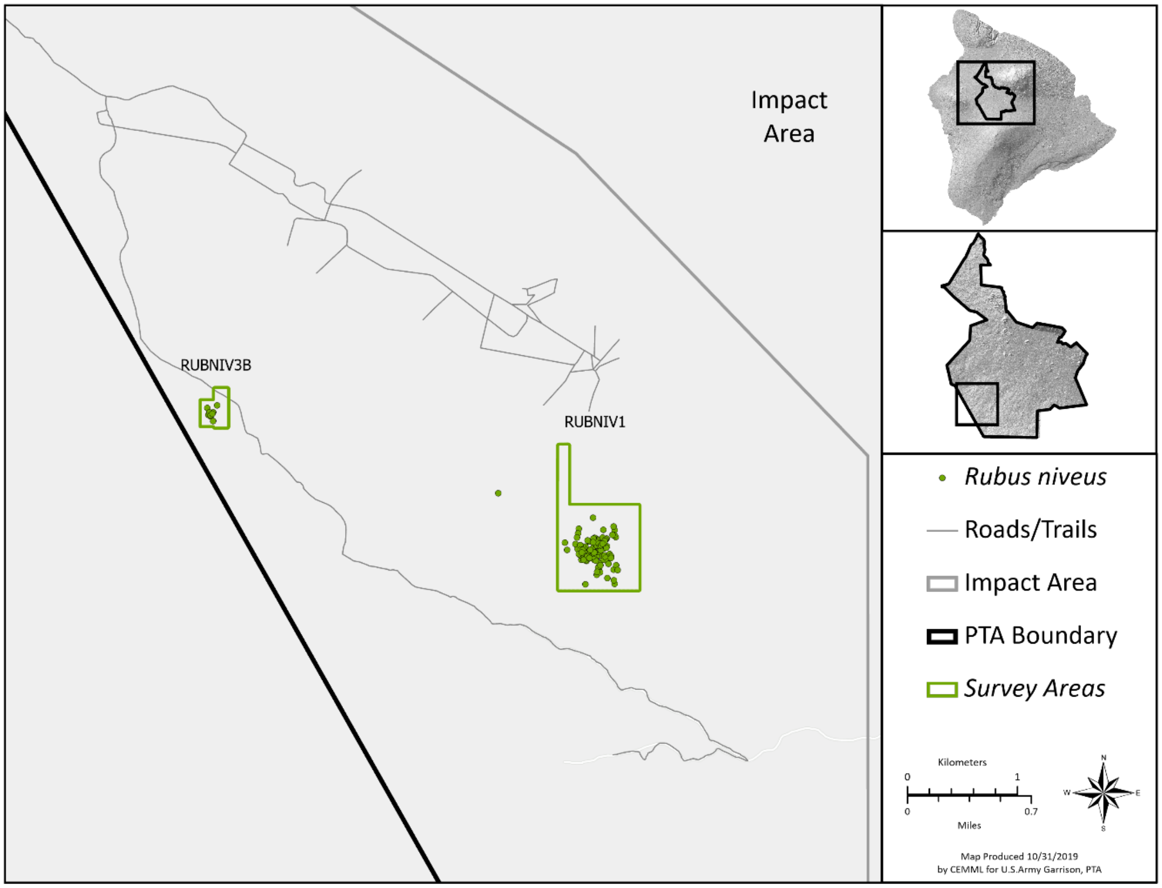

Figure 63. *Rubus niveus* known locations and site-specific survey grids at Pōhakuloa Training Area

L. erubescens is a fast-growing vine with a dense, smothering growth habit that can completely overtop trees. We have noted that *L. erubescens* has shown particularly aggressive growth at PTA when compared to other areas in Hawai'i. There are 6 established grids for *L. erubescens* in Kīpuka 'Alalā (Figure 64); we surveyed 3 of these grids once during the reporting period, and the other 3 twice (Table 68). Of these grids, at least 2 (Loperu01B and Loperu01C) had fewer plant locations than in the previous reporting period. However, the apparent reduction of plant locations since the last reporting period may be due to a reduction in survey effort rather than a reduction in plants. During the last reporting period, *L. erubescens* began to spread aggressively in TA 22, and we established several survey grids for the species in this area. We surveyed 6 ha within 2 of these grids and found and treated a total of 10 plant locations (Table 69).

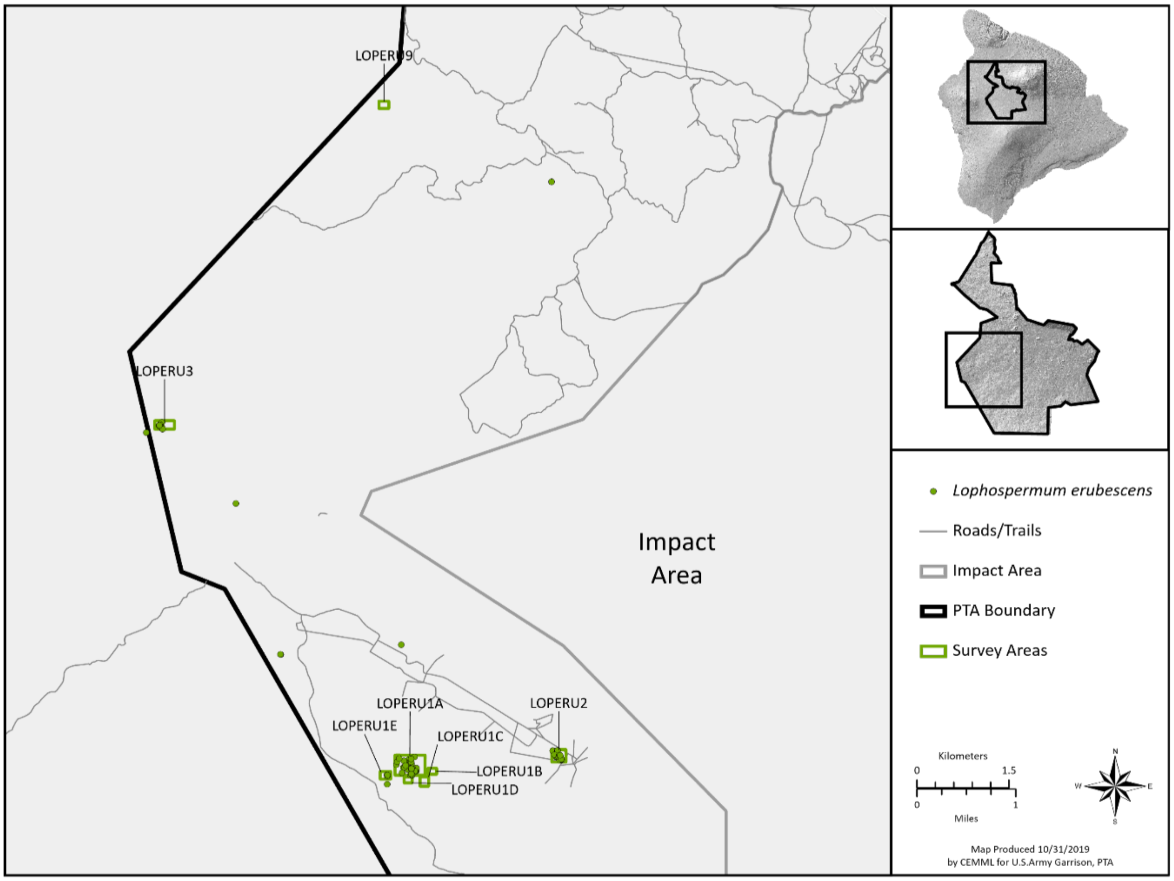

Figure 64. *Lophospermum erubescens* known locations and site-specific survey grids at Pōhakuloa Training Area

Table 69. Results of site-specific survey and control in FY 2018-FY 2019

Species	Grid	Grid Size (ha)	Locations Treated[ab]	Survey & Control Frequency
Lophospermum erubescens	Loperu01A	15.5	59	2
	Loperu01B	1.1	0	1
	Loperu01C	1.7	0	1
	Loperu01D	1.0	0	1
	Loperu01E	1.9	4	2
	Loperu02	4.4	34	2
	Loperu03	4.3	9	1
	Loperu09	1.7	1	1
Passiflora tarminiana	Pastar22A	18.0	4	1
	PastarNKA	690.0	1,443	1
Rubus niveus	Rubniv01	60.2	81	1
	Rubniv03B	6.5	11	1

[a] Locations Treated refers to the number of plant locations that received treatment at least once during the reporting period; plant locations may include more than 1 individual.
[b] *L. erubescens, P. tarminiana*, and *R. niveus* are managed installation-wide. Note that plant locations presented in Table 69 are a subset of those presented in Table 68.

3.3.5 Rapid ʻŌhiʻa Death Survey, Monitoring, and Sampling

Rapid ʻŌhiʻa Death (ROD) is a new fungal disease that attacks and kills ʻōhiʻa (*Metrosideros polymorpha*), the most abundant native tree and important keystone species in the state of Hawaii. Two non-native fungi new to science, *Ceratocystis lukuohia* and *Ceratocystis huliohia*, are the causative agents of ROD. Specifically, *C. lukuohia* causes a wilt disease and spreads quickly throughout a tree, impeding the flow of water and causing the tree to die within months. In contrast, *C. huliohia* causes a less virulent form of ROD characterized as a canker disease, impacting a tree more slowly and requiring several infections to kill trees.

Since PTA harbors approximately 5% (approximately 11,480 ha) of the total ʻōhiʻa forests on Hawaii Island, we collaborate with our state agency partners to survey for infected trees at PTA. Our surveys contribute to a statewide initiative to document the distribution of ROD-infected areas as part of an early detection and rapid response program. The objective is to map and monitor ROD-impacted areas, and track disease movement. The surveys are also important for informing the Army if further precautions need to be in place to prevent the spread of ROD to other areas, especially other islands and installations, by military personnel, vehicles and gear. If suspect ROD trees are identified during aerial surveys or incidentally by field staff, samples may be taken and delivered to the US Department of Agriculture (USDA) Agricultural Research Service pathology lab in Hilo for testing.

ROD has not been detected at PTA to date. We collected 2 samples from trees suspected of having ROD in the Spring of 2018. The USDA lab reported that no ROD-causing fungi were detected in the samples we submitted for testing. The State of Hawaiʻi Department of Land and Natural Resources, Department of Forestry and Wildlife and IPP Program Manger conducted an aerial survey of PTA ʻōhiʻa forests via helicopter in July 2018. No ROD suspect ʻōhiʻa trees were identified during the survey. As ROD continues to threaten ʻōhiʻa forests on Hawaiʻi Island, we will be monitoring forests at PTA for the disease. Trees suspected of being infected will be identified, monitored and, when necessary, samples will be tested for the fungi that cause ROD.

3.3.6 Invasive Plant Survey and Monitoring Discussion

We continue to manage invasive plants according to INRMP objectives and conservation measures identified in BOs. During the reporting period, we were challenged to keep pace with the flush of vegetation that resulted from increased precipitation during the last 6 months of 2018.

We satisfied our requirements for quarterly surveys at BAAF and implemented roadside surveys as time and resources allowed. Although, the immediate benefit of early detection programs may not be readily apparent, adequately funding and staffing such programs can help minimize potential future costs to control or manage new infestation of highly invasive species that degrade training lands and impact the mission (Boice et al. 2010). Supporting and implementing early detection and invasive control projects is aligned with Department of Defense Pest Management Program objectives (DoD 2008) and Army Regulation 200-1. Preventing the establishment of new invasive species typically requires less time, effort, and funding than responding to and managing infestations of new invasive species.

Addressing aggressive secondary target weeds, such as *P. tarminiana*, *R. niveus,* and *L. erubescens*, and their associated negative impacts, is vitally important to conserving native habitats that harbor TES and other native species that may be at risk of declining populations and possible listing under the Endangered Species Act. Managing for the impacts of invasive species and promoting native species aligns with the Army's Ecosystem Management principles, AR 200-1, and INRMP objectives. Preventing native habitat degradation via control of these invasive species can help minimize negative impacts to ASRs and other high quality or TES habitat and is consistent with and supports endangered species management efforts on Army lands.

In FY 2020, we plan to re-evaluate our methods and overall approach for assessing, prioritizing, and controlling secondary target weeds to best achieve our goals and associated requirements in the BOs and INRMP. Subsequently, we will revise the current IPSM protocol to clarify these methods and strategies. In addition, we plan to reassess our data collection and analyses to improve our ability to quantify our control efforts and make valid comparisons to evaluate control methods over time.

3.4 FUELS MANAGEMENT

3.4.1 Introduction

Fuels management meets SOO tasks 3.2(3)(b) and 3.2(3)(c) and addresses INRMP objectives and conservation measures in the 2003 and 2013 BOs. Our mission is to implement the Army's fire management plan and our goal is to reduce the threat of wildland fire to TES and their habitats through implementation and maintenance of selected firebreaks, fuel breaks, and fuel monitoring corridors per the 2019 USAG-P Integrated Wildland Fire Management Plan (IWFMP).

We create and maintain firebreaks, fuel breaks, and fuel monitoring corridors (FMC) identified in the IWFMP aimed at protecting listed species and their habitats to reduce the threat of wildfire and training-related fires. We refer to this system of breaks and corridors as the PTA Conservation Fuel Break System. These fuels management actions address conservation measures in the 2003 and 2013 BOs (USFWS 2003, USFWS 2013a).

Currently, the Fuel Break System consists of 14 fuel breaks totaling approximately 62 km (Figure 65). Eleven fuel breaks in the west section of PTA have firebreak roads embedded within them. Three fuel breaks in the KMA do not contain firebreaks but rather fire access roads that are navigable with a 4-wheel-drive vehicle. The Fuel Break System in the west section of PTA employs a 3-6-9 standard, which consists of 3 m of vegetation control, a 6 m-wide firebreak road, and an additional 9 m of vegetation control. KMA fuel breaks are 18 m-wide swaths of vegetation control within and around fire access roads. Standards in the IWFMP (USAG-P 2019b) dictate that fuel breaks be maintained at less than 20% crown cover via ocular estimation and grass less than 12 inches high. We monitor fuel loads within FMCs every 5 years, beginning in 2015, to ensure fuels do not exceed 20% total herbaceous cover.

The Fuel Break System and FMCs function together to protect valuable natural resources, including TES habitat and ESA-listed plants, from wildland fires occurring on the installation. Fuel breaks are designed for firefighters to conduct backburning operations; they are not meant to stop a fire in its tracks. Conservation fuel breaks are in strategic locations and configurations to protect ESA-listed plants. A network of fuel breaks in the northwest section of PTA, within the Kīpuka Kālawamana Endangered Plants Habitat (KKEPH), divides the area into discrete "cells" (Figure 65). The idea is that one catastrophic fire event will not destroy all individuals of a species that are located within more than one cell and gives firefighters several lines of defense for backburning operations. FMCs, described in Section 3.4.3 below, are natural barriers void of contiguous fuels within which fire is unlikely to spread. Thus, FMCs should function as a physical barrier to fire spread. Most FMCs are located around the border of the Impact Area, so they generally function to stop the spread of fires originating in the Impact Area, which firefighters do not and cannot contain or extinguish. Some fuel breaks and FMCs intersect or are located near each other (e.g., Keʻāmuku FMC located just north of the NW fuel break network). Thus, they create a mosaic of assets with little to no fuels, along with WCBs in fire-prone areas, that reduces threats to TES habitats from wildland fires.

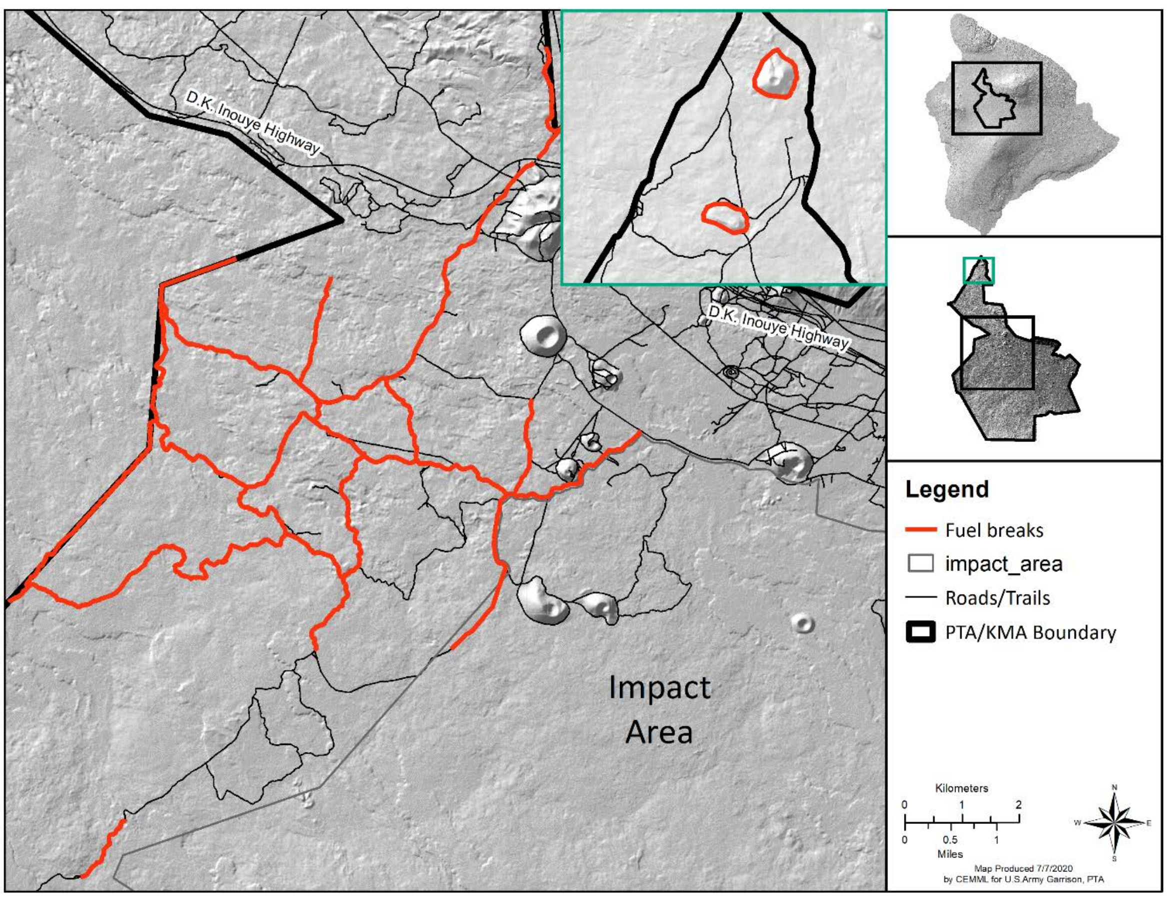

Figure 65. Fuel break system at Pōhakuloa Training Area

3.4.2 Maintenance of Fuel Breaks

We have fully implemented all fuel breaks and are currently maintaining fuels (Table 70). We mostly used herbicide to maintain the fuel breaks and removed shrubs as needed. However, for Fuel Breaks 311, 312, and 313 in the KMA, we mowed and cut fuels and selectively spot-sprayed *C. setaceus*. Like WCBs, frequency of maintenance for each fuel break segment varies based on projected need. In general, fuel breaks within shrubland and grassland communities invaded by *C. setaceus* require more frequent management. Precipitation tends to drive maintenance frequency. In summer of 2018, we spent more time and resources on fuel break maintenance due to increased precipitation, and less on other projects such as WCBs and IPSM projects.

3.4.3 Assessment of Fuel Monitoring Corridors

An FMC is a designated belt of land at PTA at least 100 m wide within which fuels are monitored to ensure separation of contiguous fuels that may exist on one side of an FMC from contiguous fuels on the other side of the FMC; a break in continuity is defined as an area where total herbaceous crown cover is less than 20%. Essentially, FMCs are natural barriers void of contiguous fine fuels within which fire is not likely to spread (i.e., burn across from one side of the FMC to the other). There are 5 FMCs at PTA (Figure 66). Note the gap shown for the ʻAlalā FMC at the most western extent of the Impact Area (Figure 66) is where FB 214 is located (Figure 65).

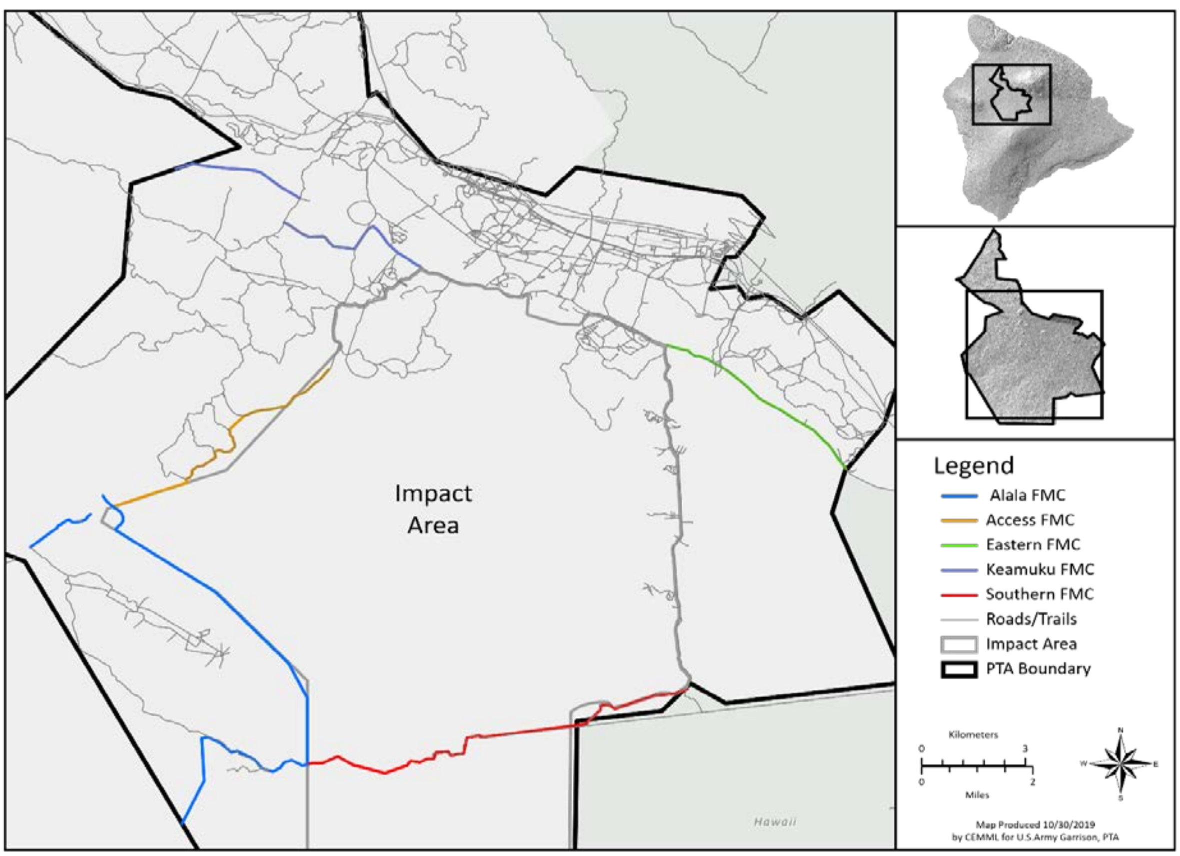

Figure 66 . Fuel monitoring corridors at Pōhakuloa Training Area

The original intent and purpose of FMCs as agreed upon during prior consultations and in the 2003 IWFMP, and approved by USFWS, was in lieu of fuel management control to ensure populations of ESA-listed plants were isolated and protected from wildland fire. We contended that several ESA-listed plant populations were already isolated by natural barriers (e.g., barren or sparsely vegetated lava flows), now designated as FMCs. As USFWS cautioned these areas could become invaded with fuels in the future, namely invasive grasses, we proposed monitoring these areas every 5 years for encroachment. Monitoring includes review of imagery, plotting a course, and flying over the FMCs via helicopter to make ocular estimates of fuels cover and determine if they are contiguous. FMCs are described in more detail in the current IWFMP (USAG-P 2019b).

We monitored the FMCs in FY 2015. Results and subsequent actions of that effort were detailed in the previous biennial report (CEMML 2019c). We plan to monitor the FMCs again in the latter part of FY 2020.

Table 70. Assessment and maintenance effort for fuel breaks in FY 2018–FY 2019

Fuel Break (FB)	Length (m)	Action	Frequency
301A	4,457	Assess FB	4
		Shrub/limb	3
		Spray	4
301B	2,380	Assess FB	6
		Shrub/limb	1
		Spray	8
301C	1,687	Assess FB	3
		Spray	8
302A	2,858	Assess FB	4
		Spray	7
302B	1,946	Assess FB	4
		Spray	9
302C	3,223	Assess FB	5
		Spray	7
303	4,029	Assess FB	5
		Spray	10
304A	2,015	Assess FB	5
		Spray	8
304B	1,440	Assess FB	5
		Spray	8
304C	3,192	Assess FB	4
		Shrub/limb	3
		Spray	6
304D	2,248	Assess FB	3
		Shrub/limb	1
		Spray	5
305A	1,768	Assess FB	4
		Spray	6

Table 70. Assessment and maintenance effort for fuel breaks in FY 2018-FY 2019 (cont.)

Fuel Break (FB)	Length (m)	Action	Frequency
305B	2,186	Assess FB	4
		Spray	8
305C	2,121	Assess FB	5
		Shrub/limb	2
		Spray	9
306	1,899	Assess FB	5
		Shrub/limb	1
		Spray	9
307	2,007	Assess FB	5
		Spray	7
308	5,929	Assess FB	3
		Shrub/limb	1
		Spray	4
309A	3,290	Assess FB	5
		Spray	8
309B	2,593	Assess FB	2
		Spray	6
310	2,212	Assess FB	3
		Shrub/limb	1
		Spray	5
311	2,719	Assess FB	5
		Mow	7
		Spray	9
		Weed whack	9
312	2,337	Assess FB	5
		Mow	6
		Weed whack	6
313	1,761	Assess FB	5
		Shrub/limb	1
		Mow	4
		Weed whack	5
314	1,415	Assess FB	8
		Spray	6
Total	**61,711**		

3.4.4 Fuels Management Discussion

All fuel breaks have been fully implemented and were maintained during the reporting period to ensure compliance with standards per the current IWFMP (USAG-P 2019b). The USAG-P IWFMP was finalized in March 2019 and is a separate plan specific to PTA and KMA, versus the previous version, which was contained within the comprehensive plan for all USAG-HI installations.

In concert with WCBs in fire-prone areas, the fuel breaks assisted for firefighters during the July 2018 fire in the KKEPH (CEMML 2018b). The official fire report identified the cause of the fire as an inadvertent discharge of flares from a US Marine Corps aircraft during aerial, live-fire training. Our post-fire assessment showed that the fire footprint was 585 ha. The site of ignition was within one of the most fire-prone areas, which harbors 7 ESA-listed plant species, some of which are the rarest on the installation and one (*Tetramolopium arenarium* var. *arenarium*) whose total distribution is within the impacted area. The fire spread westward from the ignition site in TA 19 to TAs 18 and 22. Overall, we found fuel breaks were effective in preventing the westward spread of the fire into additional TES habitat. Four WCBs were effective in preventing fire from impacting the ESA-listed plant species within those WCBs, averting a potential extinction event for *T. arenarium* var. *arenarium*. Feedback from the PTA Fire Department noted that fuel breaks significantly aided in the suppression and containment efforts of the fire. Thus, we concluded that pre-suppression of fuels within fuel breaks and WCBs were important factors in preventing impacts to the ESA-listed plant species in the area.

Continued support for fuel control on the Fuel Break System helps to reduce losses of ESA-listed plants. Loss of ESA-listed plants due to wildland fire can trigger the Army to reinitiate formal consultation under section 7 of the ESA for the affected species, which can be time-consuming, costly, and result in more restrictions of military activities. Fuel control has proven, under certain conditions, to be an effective means for minimizing fire risk to TES and the habitats on which they depend.

3.5 OVERALL SUMMARY DISCUSSION

At PTA, management of invasive plant species is essential to help conserve native habitats that support TES and species at risk[11]. Through the implementation of our SOO tasks, we continue to work towards our program goals, INRMP objectives, and maintain compliance with several conservation measures from the 2003 and 2013 BOs. In general, we met standards for vegetation control within ASRs, at HFNWR, and along the Fuel Break System despite challenging conditions with staff reductions and vacancies and increased precipitation and vegetation growth.

We are progressing toward our goal of protecting and improving habitats for ESA-listed plants by controlling vegetation in WCBs to reduce threats from invasive plants to natural resources, particularly rare plants. Although we currently do not formally evaluate habitat responses to our management, we observed regeneration of native shrubs and some ESA-listed plants within the WCBs. Based on these observations and other research demonstrating the benefits to native species from removing *C. setaceus* (Cabin et al. 2002; Cordell et al. 2002; Thaxton et al. 2012), we believe vegetation control within WCB is benefitting the species. In addition, our observations strongly support the effectiveness of WCBs in preventing fire impacts to ESA-listed plants. Further, our vegetation control actions at HFNWR appear to be benefitting Hawaiian Geese by providing improved habitat.

[11] Species at risk are defined as plant and animal species and associated habitats that are not federally listed as threatened or endangered under 16 USC Chapter 35 (ESA), but are either federally listed as candidates or are ranked by NatureServe as critically imperiled or imperiled throughout their range (AR 200-1, 2007).

Invasive species management supports Army readiness in multiple ways. Invasive plant species can modify landscapes, change fire regimes, and alter ecosystems, potentially degrading training lands and quality of military training. Early detection and rapid response to new invasions cost less in the long run than controlling invasive species once they are established and widespread (Boice et al. 2010). Likewise, control of secondary target weeds at newly found satellite locations, especially in high quality or TES habitat, are more cost effective and result in less impacts than the alternatives of no or delayed action. Thus, continued and consistent funding to manage invasive species is critical to ensure we can effectively address our goals of detecting, controlling, and/or eradicating invasive plants (i.e. secondary target weeds) to prevent impacts to TES and high value resources.

Our fuels management actions contributed to a positive outcome for ESA-listed plants during the July 2018 fire in TA 22. Our fuel breaks were a critical asset for firefighters, and, in conjunction with WCBs in fire-prone areas, helped to reduce, and in some cases prevent, impacts to ESA-listed plant species. Our post-fire assessment indicates fuel breaks were effective in preventing the westward spread of the fire into additional TES habitat. The fact that the PTA Fire Department noted that our fuel breaks significantly aided in fire suppression and containment efforts underscores their value as safe and effective pre-suppression assets.

We will continue to fine-tune our planning process to identify needs and establish priorities in FY 2020. We will also continue to refine existing and develop new protocols and SOPs to better align activities with program goals and objectives as driven by the SOO, the PTA INRMP, and other compliance obligations and to provide tight linkages in the adaptive management process.

4.0 WILDLIFE PROGRAM

4.1 INTRODUCTION

The purpose of the Wildlife Program is to gain insight and understanding of ESA-listed animal species distributions, habitat use, ecology, and the factors that impact their long-term survival to develop and implement appropriate and efficient management approaches in accordance with mandates that guide the Army's Natural Resources Programs. To this end, we monitor for presence and assess the distribution of ESA-listed animals to inform species management, military training and range development, and to report the status of the species. In addition, we manage introduced and invasive animals and their associated negative impacts to reduce effects on TES and their habitats.

To manage wildlife resources at PTA, we implement Statement of Objective (SOO) tasks 3.2(2)(a) through 3.2(2)(e) to comply with INRMP objectives (Sikes Act Improvement Act), ESA consultation requirements, the Migratory Bird Treaty Act (MBTA), regulatory outcomes from NEPA documents, and the conditions of federal and state TES permits.

The Wildlife Program manages for 6 ESA-listed animal species that use habitat at PTA and/or periodically transit the installation: Hawaiian Goose (*Branta sandvicensis*), Hawaiian Hawk (*Buteo solitarius*), anthricinan yellow-faced bee (*Hylaeus anthracinus*), Hawaiian hoary bat (*Lasiurus cinereus semotus*), Band-rumped Storm Petrel (*Oceanodroma castro*), and Hawaiian Petrel (*Pterodroma sandwichensis*). In July 2019, the Blackburn's sphinx moth (*Manduca blackburni*), also an ESA-listed species, was found at PTA. Additionally, 15 bird species protected under the MBTA occur at PTA.

Most SOO tasks and INRMP objectives overlap with regulatory outcomes from ESA consultations and the NEPA process, including MBTA requirements. In 2003, 2008, and 2013 the USFWS issued Biological Opinions (BOs) to the Army with conservation measures for Hawaiian Goose, Hawaiian Hawk, and the Hawaiian Petrel. The 2003 and 2008 BOs included Incidental Take Statements with Terms and Conditions to offset effects of military activities on the Hawaiian hoary bat. The 2008 and 2013 BOs included Incidental Take Statements with Terms and Conditions to offset effects of military training on the Hawaiian Goose. In 2013, we determined that military activities do not affect the Hawaiian Hawk and the USFWS concurred. We have not consulted with the USFWS under section 7(a)(2) of the ESA for the Band-rumped Storm Petrel, the anthricinan yellow-faced bee, or the Blackburn's sphinx moth. Without an ESA consultation, these species lack formal conservation measures.

We are currently preparing documents to formally consult with the USFWS in 2020 under section 7(a)(2) of the ESA regarding military activities at PTA and the potential effects on TES. We anticipate the issuance of a programmatic BO from the USFWS in 2020.

To work with TES, we obtained state and federal permits authorizing our activities. In 2020, we plan to amend our federal endangered species recovery permit (US Fish and Wildlife Recovery Permit TE40123A-2, issued under section 10(a)(1)(A) of the ESA) to include the Band-rumped Storm Petrel. We maintain State of Hawaiʻi protected wildlife permits for our work with the Band-rumped Storm Petrel (permit No. WL 19-42) and for the scientific collection of upland Game Bird species (permit No.

WL 19-37). We also have an MBTA scientific collection permit that authorizes us to collect Band-rumped Storm Petrel carcasses for scientific purposes (permit No. MB95880B-0). Our management complies with permit conditions; separate reports addressing these conditions are provided annually to USFWS and the State.

The Wildlife Program has 2 sections:

1) Wildlife Management
2) Threat Management

Each Wildlife Program section addresses specific SOO tasks, INRMP objectives, and regulatory requirements, which dictate the goals and objectives within that section. Specifically, projects implemented under the Wildlife Management Section address SOO tasks 3.2(2)(a) and 3.2(2)(b) and projects implemented under the Wildlife Threats Management Section address SOO tasks 3.2(1)(c), 3.2(2)(d) and 3.2(2)(e). For a list of drivers associated with each of the projects and sections in the Wildlife Program, please refer to Appendix C.

4.2 WILDLIFE MANAGEMENT

4.2.1 Introduction

We implement projects to manage and protect ESA-listed animal species as required by law, while minimizing impacts from wildlife to military activities that may degrade training realism or quality at PTA. Our objectives include surveying to determine presence of species, monitoring activity patterns, identifying habitat use, and reporting incidental take (direct and indirect) for the Hawaiian Goose, Hawaiian hoary bat, and bird species protected under the MBTA.

The overall operational goals of the Wildlife Management Section are to:

- Monitor Hawaiian Geese at PTA and implement management when needed;
- Manage conditions at an off-site location for Hawaiian Geese to improve nesting success and gosling survivorship to achieve an average production of 26 fledglings annually;
- Monitor Hawaiian Goose nest success and survival at an off-site location to evaluate progress toward annual fledgling production targets;
- Monitor Hawaiian hoary bat occupancy and seasonal activity patterns;
- Monitor for incidental take of the Hawaiian hoary bat and the Hawaiian Goose, including hazing events and nest and gosling relocations, and to comply with reporting requirements;
- Monitor for Hawaiian Petrel presence and habitat use at PTA;
- Monitor for Band-rumped Storm Petrels and manage conditions to promote nesting success;
- Monitor for Palila (*Loxioides bailleui*) presence and habitat use at PTA;
- Monitor for avian species listed under the MBTA presence and habitat use at PTA;
- Monitor for and report incidental take of avian species protected under the MBTA;

- Survey/monitor for anthricinan bee and Blackburn's sphinx moth presence and habitat use; and
- Educate military unit leaders (e.g., Commanders, Officers in Charge, Range Safety Officers, and Non-commissioned Officers) to avoid and minimize take and/or negative impacts to ESA-listed animals.

4.2.2 Hawaiian Goose Management at Pōhakuloa Training Area

We manage for Hawaiian Geese at PTA to meet SOO tasks 3.2(2)(a) and 3.2(2)(b) and to address INRMP objectives and conservation measures and terms and conditions from the 2013 BO and Incidental Take Statement.

Hawaiian Goose management at PTA consists of: 1) monitoring for goose presence and behavior, 2) implementing actions to reduce military training/goose conflicts, 3) monitoring incidental take, and 4) briefing personnel training and working at PTA.

In addition, to implement terms and conditions of the 2013 BO Incidental Take Statement, we manage Hawaiian Geese at Hakalau Forest National Wildlife Refuge (HFNWR). The goal of this project is to create suitable goose habitat and maximize gosling survival to adulthood; specifically, to produce an average of 26 fledgling geese per year to compensate for the potential incidental take of 20 adult geese annually at PTA (USFWS 2013a).

<u>Hawaiian Goose Monitoring</u>

We systematically monitor Hawaiian geese at PTA to better understand patterns of visitation and habitat use. We also monitor all nesting, breeding, molting, and incidental take that occurs at the installation. We collect and manage incidental goose sightings reported by military and PTA personnel.

Systematic Monitoring Methods

Systematic monitoring is intended to provide an indicator over a set sampling period of Hawaiian Goose presence (i.e., activity) in areas with historic, or newly discovered, goose activity (hereafter these areas are referred to as core monitoring areas). The purposes of systematic monitoring in core areas are: 1) to better understand patterns of goose presence and 2) to direct management based on our observations. Core monitoring areas include the Range 1 Complex, the Forward Operating Base (FOB) Warrior Search Area in Training Areas (TAs) 1, 3, and 4, TAs 6 and 7, and Bradshaw Army Airfield (BAAF) (Figure 67). For this reporting period, TAs 6 and 7 were established as core monitoring areas because a pair of geese nested in the vicinity in 2017.

We survey the core monitoring areas on foot by traversing the area and/or by driving on accessible roads and using binoculars to search for geese. If geese are observed on the ground or in flight, we record date/time, observer ID, location, number of geese, leg band identification, and general behavior. We also report if geese display signs of molting (e.g., missing flight feathers) and/or breeding activity (e.g., aggressive behavior, brood patches, nest building) and recommend management if needed.

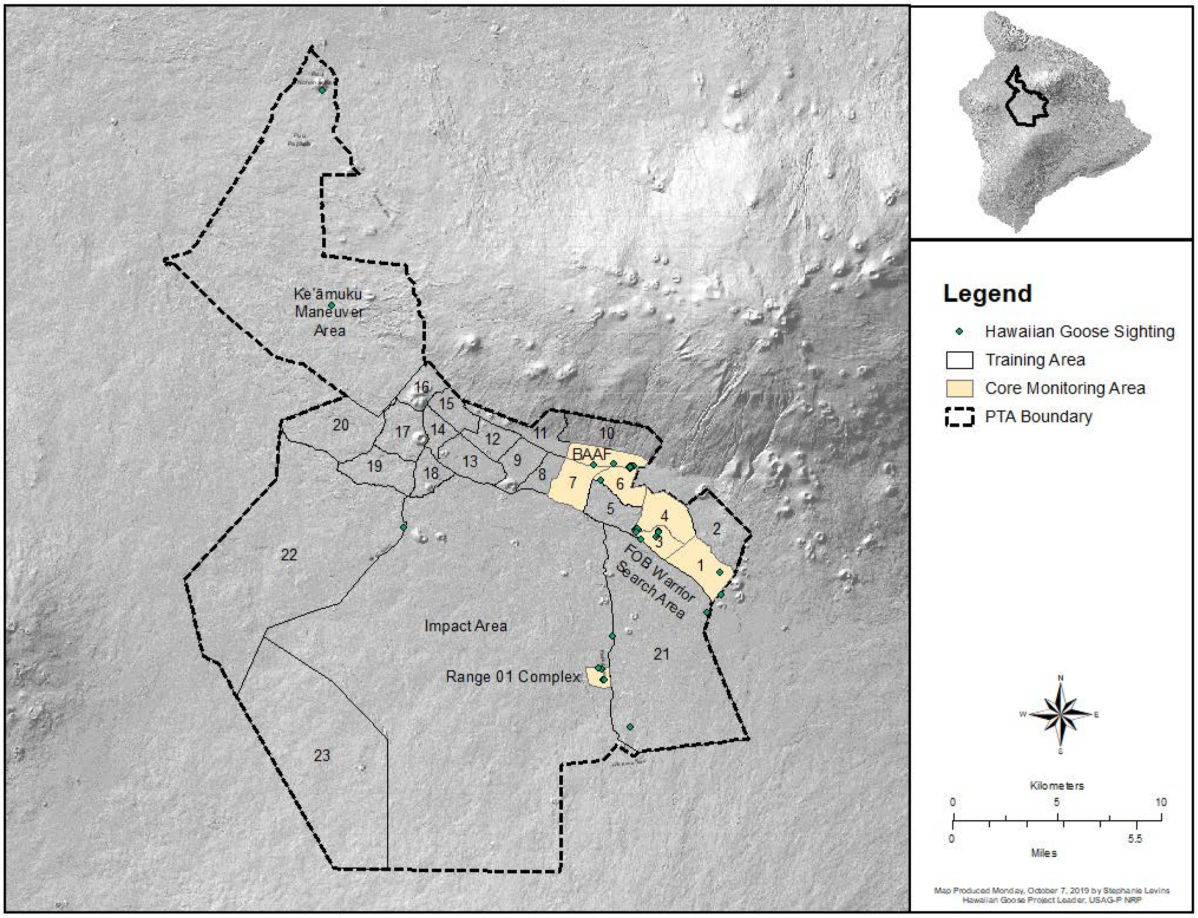

Figure 67. Hawaiian Goose sightings during FY 2018–FY 2019 in core and non-core monitoring areas at Pōhakuloa Training Area

More than 1 core monitoring area may be surveyed in a single day; therefore, we report survey effort by the number of surveys in a core monitoring area within a reporting period to provide a measure of effort per area. We report the number of surveys in which we observed geese. All goose observations over the reporting period are pooled by core monitoring area and reported as total observations, which includes all repeated observations of banded individuals and all observations of geese that were not banded or where we could not determine if bands were present. We do not adjust the survey data to account for imperfect detection of geese, which likely biases the number of reported observations. These observation data are an approximate measure of goose presence (i.e., activity) for the core monitoring areas and are helpful in guiding management efforts.

Incidental Sightings Methods

All personnel working and training at PTA report incidental sightings of geese encountered in core monitoring areas outside of systematic monitoring periods. Incidental sighting information includes location, time, number of geese, and notes about the bird's condition. If possible, we respond to the location of the reported sighting, identify birds by leg bands, and document any breeding, nesting, or molting activity. If the geese are located, we may monitor the geese, especially if breeding or molting behavior is observed. Monitoring may continue until the birds are no longer found in the area.

Targeted Monitoring Methods

We initiate targeted monitoring when breeding or molting activity is observed during systematic surveys or during a follow-up to incidental sighting reports. Targeted monitoring typically involves multiple visits to the same location to monitor the same individuals for as long as the individuals are present at the location. Targeted monitoring may involve nest monitoring as well.

Systematic Monitoring Results

In the core management areas, we made a total of 30 goose observations during 11 of 258 surveys (Figure 67). Geese were only observed at the Range 1 Complex and at FOB Warrior. From the leg-band information, we confirmed that 15 individuals with unique leg-bands visited these areas, with repeat visits by one or more individual in FOB Warrior (Table 71).

Table 71. Hawaiian Goose systematic monitoring data and leg-band information

Survey Areas	No. of Surveys	No. of Surveys with Goose Presence	Total Goose Observations[a]	With Bands	W/out Bands	Bands not Identified
Range 1 Complex	58	4	12	7	0	5
FOB[b] Warrior Search Area	70	7	18	8	0	8
Bradshaw Army Airfield	63	0	0	0	0	0
Training Areas 6 and 7	67	0	0	0	0	0

[a] Total goose observations includes all geese seen per core area and may include repeat visits by individual geese; therefore, the total number of goose observations may not equal the sum of the number of geese reported with bands, without bands and bands not identified for each core area.
[b] FOB, Forward Operating Base

Incidental Sighting Results

In the core monitoring areas, we observed a total of 39 geese (all observations pooled including repeat visits) from 14 incidental sighting events (Table 72). From the 39 observations, we identified 9 individual geese by their unique leg-bands, but we were unable to determine the presence of leg-bands for the other 26 observations; therefore, we cannot determine the number of individual birds these observations represent.

In non-core monitoring areas, we observed a total of 20 geese (all observations pooled including repeat visits) from 8 incidental sighting events. From the 20 observations, we identified 5 individual geese by their unique leg-bands and were unable to determine the presence of leg-bands for the other 15 observations. Therefore, we cannot determine the number of individual birds these observations represent (Figure 67).

Table 72. Hawaiian Goose incidental sightings by location and leg-band information[a]

Survey Area	Incidental Sighting Events	Total Goose Observations[b]	With Bands	W/out Bands	Band not Identified
Core Areas					
Range 1 Complex	0	0	0	0	0
FOB[c] Warrior Search Area	5	17	2	0	15
Bradshaw Army Airfield	1	3	0	0	3
Training Areas 6 and 7	8	19	7	0	8
Non-Core Areas	8	20	5	0	15

[a] Correction due to the implementation of a new Hawaiian Goose database. The FY 2018 Annual Letter had incorrect numbers for the incidental sighting events, total geese observations, and band not identified. There were 2 additional events that we did not account for in the letter. This FY 2018-FY 2019 table corrected the errors.
[b] Total goose observations includes all geese seen per area and may include repeat visits by individual geese; therefore, the total number of goose observations may not equal the sum of number of geese reported with bands, without bands and bands not identified for each area.
[c] FOB, Forward Operating Base

Targeted Monitoring Results

We monitored one pair of geese (leg bands Gray 97 and Gray 98) three times between October and December 2017. The pair were feeding and loafing near a construction contractor's base yard in TA 6 across the street from cantonment. The birds did not display any signs of breeding activity. We last observed the birds on 12 December 2017 and ceased monitoring the area on 20 December 2017.

In December 2017, we responded to an incidental sighting report of 2 geese in TAs 6 and 7. The day after the report, we observed a pair of geese (leg bands Green ECY and Gray 07K) and assume these were the same birds sighted the previous day. The birds did not display any signs of breeding activity. We only saw the birds once and we were not able to find the pair on subsequent visits to the area.

Other Survey Efforts

We did not detect geese at PTA during the statewide annual Hawaiian Goose surveys (26 September 2018 and 18 July 2019).

Hawaiian Goose Monitoring Discussion

We survey for and track sightings of Hawaiian Geese to monitor for changes in detection frequency, patterns of attendance, and activity (i.e., molting and breeding) to help guide management and to reduce potential conflicts with military activities. Although monitoring goose presence at PTA is not a specific conservation measure included in the 2013 BO, we monitor select locations that geese are known to frequent, based on historical observations or an uptick in incidental sightings, to better understand patterns of presence and to more efficiently manage potential disruptions to military activities.

Our monitoring data are a coarse index of goose activity because we do not correct our survey data for imperfect detection. Our monitoring efforts are not intended to estimate the number of geese present at PTA nor to investigate changes in that number over time, but instead are intended to help guide management of geese in potential high-conflict areas. We use detection frequencies as a coarse measure of activity within years and between years.

Over the last 2 years, fewer Hawaiian Geese were detected at PTA than in previous years, especially at the Range 1 Complex. For example, between October 2015 and September 2017, we recorded 56 goose observations over 173 surveys. For this reporting period, we recorded 30 goose observations over 258 surveys. While survey efforts were about 1.5 times greater for this reporting period (173 vs. 258 surveys), the recorded observations were about 2 times fewer (56 vs 30 observations). This pattern is also supported by the reduced number of interrupted training events and requests for our support due to geese on the ranges. Over the last 4 years, units training at the Range 1 Complex have only needed our assistance once to haze geese from the range in 2015.

We observed geese with greater frequency outside the systematic survey periods (i.e., a higher frequency of incidental sightings), except at the Range 1 Complex where geese were encountered more frequently during systematic surveys. Incidental sightings outside the core areas did not show any patterns indicating habitual use of the areas in which the geese were seen. Overall systematic survey results and incidental sightings support the notion that geese use habitats with a low but regular frequency. Because the detection frequency during systematic surveys is relatively low, we plan to reexamine the incidental sightings data to determine whether adjusting the timing of our systematic surveys is warranted.

Based on sightings reports, we applied targeted monitoring for several pairs of geese. Through repeated observations, we observed no breeding or molting activity; therefore, we did not implement any further management for these pairs. Although targeted monitoring and follow-up management can be labor intensive, these actions are extremely important to proactively identify potential conflicts between military operations and Hawaiian Geese, and to implement appropriate actions to manage potential conflicts.

Management Activities at Pōhakuloa Training Area

To further Hawaiian Goose management at PTA, we manage habitat at the Range 1 Complex and control small mammals, under select circumstances, when we discover molting or nesting geese. In addition, we brief military unit leaders on their responsibilities to protect geese at PTA, especially while driving and conducting live-fire exercises. We also brief all personnel training or working on the installation, outside the cantonment, about training/working near Hawaiian Geese and the process to report geese to PTA Range Control. We summarize reported goose sighting and our efforts to brief personnel below.

Actions to Manage Hawaiian Goose Breeding Activity

We did not implement management during the reporting period because we did not detect breeding or molting activity at PTA.

Actions to Minimize Conflicts between Training and Hawaiian Geese

We proactively manage habitat at the Range 1 Complex to comply with measures identified in the 2013 BO, to reduce the need for hazing to minimize conflicts between military training and geese. At the Range 1 Complex, we selectively eliminate food sources for the Hawaiian Goose, primarily hairy wallaby oatgrass (*Rytidosperma pilosum*), and allow other vegetation to persist. By creating a habitat with dense ground cover and limited food availability, we aim to deter geese from live-fire training areas at the Range 1 Complex where Hawaiian Geese often feed and loaf (Figure 67 and Figure 68).

Over a total of 5 days, we spot-treated *R. pilosum* with a cumulative total of 170 gallons of 1.5% Roundup PowerMax herbicide (active ingredient glyphosate) solution throughout 13 ha designated for control at the Range 1 Complex. Post-treatment evaluations indicate that Roundup PowerMax was effective in controlling *R. pilosum*.

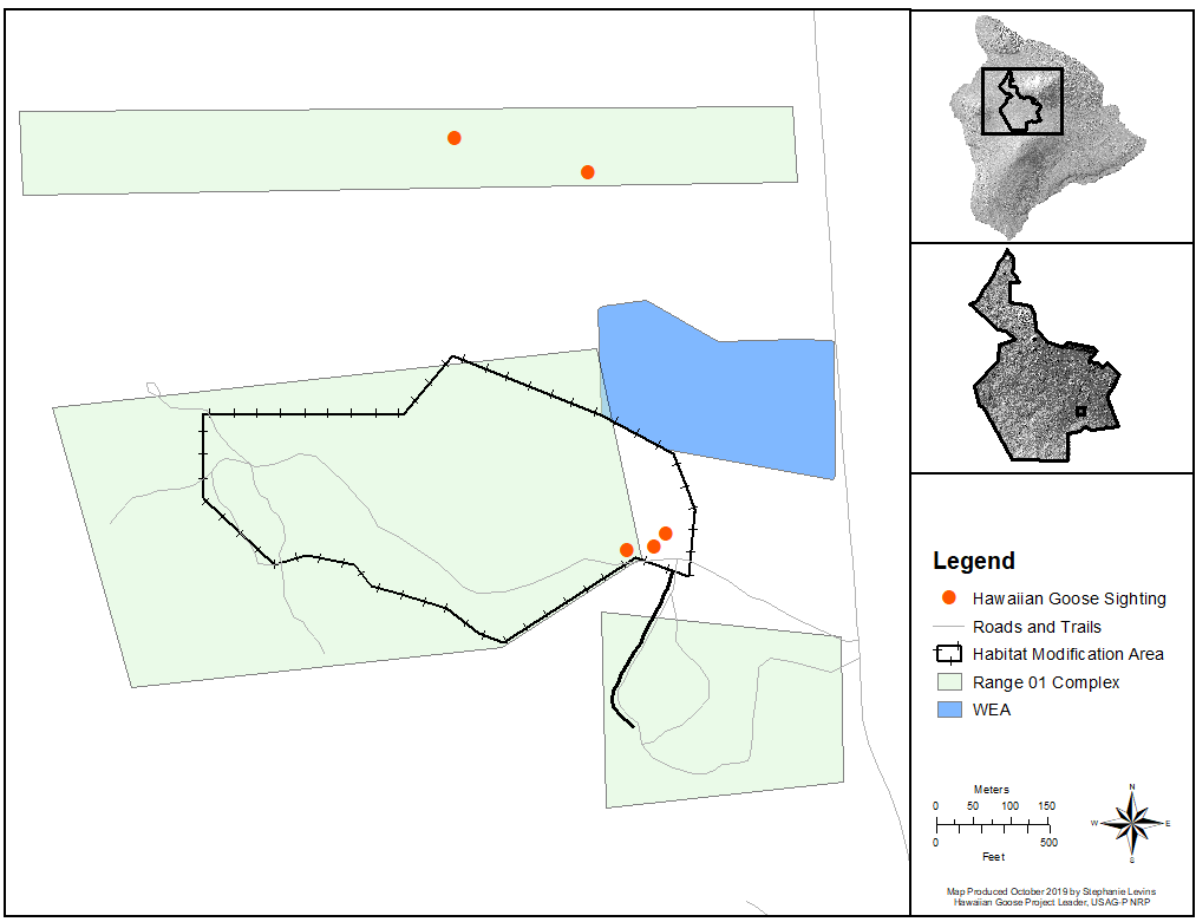

Figure 68. Hawaiian Goose habitat modification area and the Wildlife Enhancement Area at the Range 1 Complex, Pōhakuloa Training Area

In addition, we promote goose habitat and food resources within the Wildlife Enhancement Area (WEA) by selectively cutting and applying herbicide to unwanted weed species such as fireweed (*Senecio madagascariensis*), fountain grass (*Cenchrus setaceus*), and other non-native plants that outcompete plants preferred by geese. We aim to enhance the habitat to attract geese to the WEA and away from live-fire training areas at the Range 1 Complex (Table 72).

We did not control weeds at the WEA because there was ample *R. pilosum* growing and very little *S. madagascariensis* growth. We did not observe geese in the WEA.

Discussion for Hawaiian Goose Management at Pōhakuloa Training Area

Hawaiian Goose management at PTA is continually evolving to allow increased military training capacity while providing adequate protection for geese. Of the 25 geese identified by their leg bands at PTA, 12 (48%) come from the Puʻu ʻŌʻō Ranch population (translocated from Kauaʻi), 8 (32%) from the HFNWR population, and 5 (20%) from unknown origins. Since 2009, the majority of banded geese sighted at PTA have come from HFNWR. In 2011, the State of Hawaiʻi Department of Forestry and Wildlife translocated several hundred Hawaiian Geese from Kauaʻi to Puʻu ʻŌʻō Ranch (approximately 18 km southeast of PTA). Since this translocation, geese from Kauaʻi are the second largest group sighted at PTA, and they are the only group that has successfully nested at PTA (3 times) since 2014. We are uncertain what influences geese to visit and use PTA. Therefore, we recommend continuing systematic monitoring for geese in high-use areas and incidental monitoring elsewhere, and, when necessary, acting to reduce potential conflicts between military activities and the geese, especially during breeding and molting when geese are more vulnerable.

Projects implemented for Hawaiian Goose management at PTA meet SOO tasks 3.2(2)(a) and 3.2(2)(b) and address INRMP objectives and several conservation measures and terms and conditions from the 2013 BO. Although our monitoring results do not estimate numbers of geese using PTA, we have made fewer detections per survey effort over the past 2 years.

We have also noted that requests to support military training due to the presence of geese at the Range 1 Complex have decreased. Although we cannot directly attribute a reduction in sightings to our management at the complex, we observe geese less often in areas where we have controlled their preferred food grass, *R. pilosum*. However, we have not seen a commensurate increase in presence where we promote *R. pilosum* within the WEA.

Incidental sightings of geese continue at low frequencies at locations outside our core monitoring areas. However, we have not continued to observe geese at these reported locations; therefore, we believe these incidental sightings represent temporary visitations and not undiscovered or new high-frequency-use sites.

Monitoring goose presence helps us to better manage potential conflicts between geese and military activities in a timely and efficient manner and to minimize disruptions to training. Because Hawaiian Geese are highly mobile animals, we recommend continued monitoring to identify new areas of use and shifts in patterns of presence or activity (i.e., increases in breeding activity). Understanding where geese are, when they predominantly visit the base, and how they use the habitat will continue to guide management and minimize potential conflicts with military activities.

Incidental Take Statement Requirements

No incidental take was reported or detected, and no hazing events occurred at PTA during the reporting period.

Required Briefs

To minimize and avoid impacts to Hawaiian Geese, we brief military unit leaders (e.g., Commanders, Officers in Charge, Range Safety Officers, and Non-commissioned Officers) on their responsibilities to protect geese at PTA, especially while driving and conducting live-fire exercises, 90 and/or 30 days before the main body of the unit arrives at the installation.

We delivered 29 briefings to military unit leaders during the reporting period, briefed the PTA directorates at least annually, and provided briefs as necessary when new employees were hired. In addition, we placed educational signs and briefed 20 contractors from Goodfellow Bros LLC about minimizing and avoiding impacts to Hawaiian Geese.

4.2.3 Hawaiian Goose Management at Hakalau Forest National Wildlife Refuge

To implement terms and condition in the 2013 BO Incidental Take Statement, we manage Hawaiian Geese in collaboration with HFNWR. Our goal is to increase Hawaiian Goose productivity (i.e., the number of hatchlings surviving to adulthood) by improving forage and future nesting habitat, and by minimizing threats from predators to improve nesting success. We manage for geese in the Pua ʻĀkala and Middle Road management areas of HFNWR, collectively referred to hereafter as the Army-managed areas (Figure 69). Within the Pua ʻĀkala management area, we manage habitat only within the formerly proposed predator-proof fence (Pua ʻĀkala Habitat Enrichment in Figure 69).

To be consistent with refuge management goals, we developed a management action plan with HFNWR to include: 1) habitat management, 2) goose monitoring, 3) nest monitoring, and 4) predator control.

We submitted 2 technical reports regarding our work at HFNWR to the USFWS. The reports describe management activities for the 2017/2018 and the 2018/2019 Hawaiian Goose breeding seasons (CEMML 2018a; CEMML 2019a). In this biennial report, we summarize major highlights from each technical report.

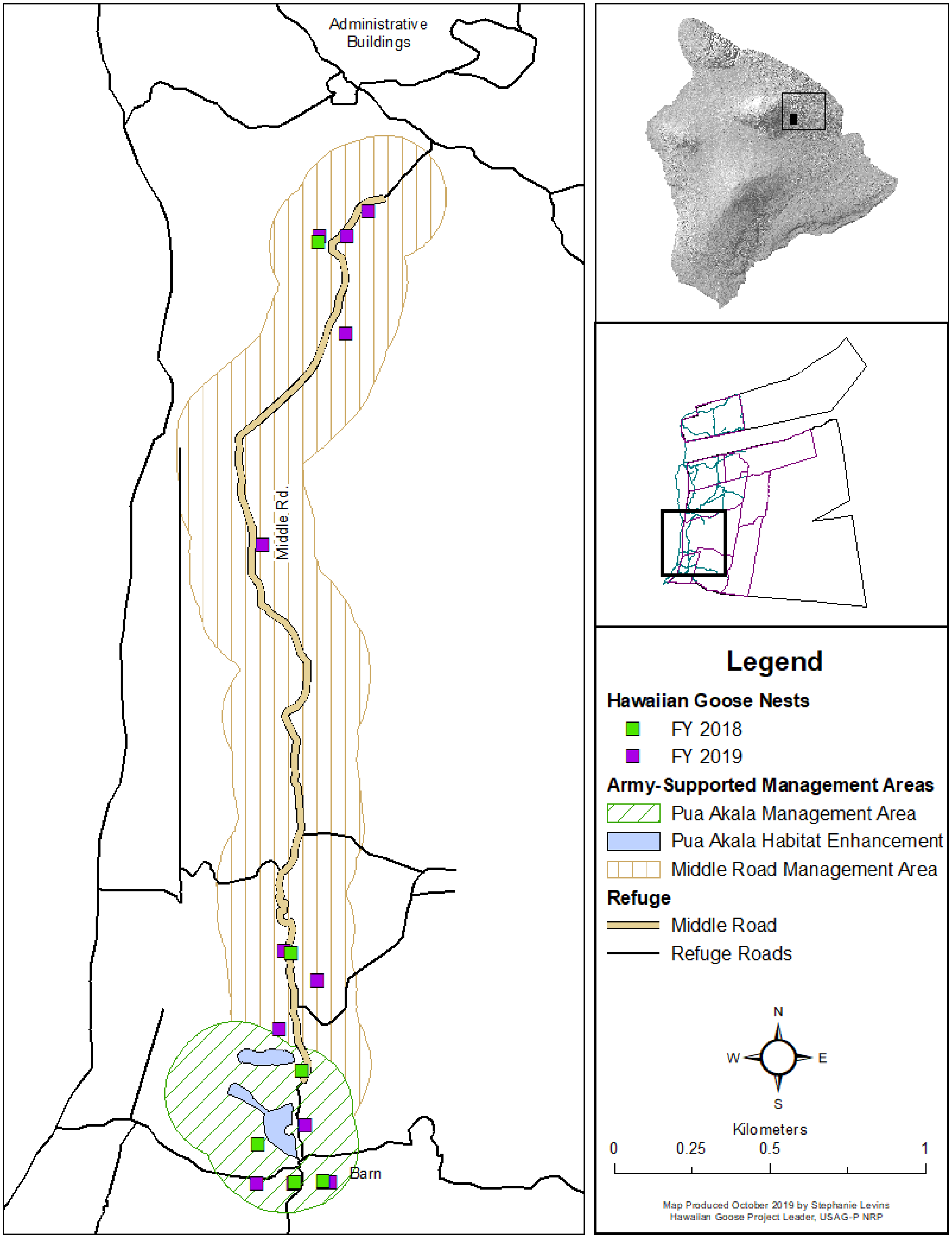

Figure 69. Army supported management areas during FY 2018 and FY 2019 and Hawaiian Goose nest locations at Hakalau Forest National Wildlife Refuge

Habitat Management

We manage habitat within the Pua ʻĀkala management area by cutting grass and removing invasive plant species (habitat enhancement) to create goose foraging grounds (Figure 69). Inadequate nutritional quality is a limiting factor for the reproduction of Hawaiian Geese and gosling survival at high elevation sites (USFWS 2004). Although the effects of habitat management (e.g., mowing grass or planting food plants) on geese productivity have not been well studied at high elevations, forage quality and availability is increased when habitat is managed in this way.

We cut ~2.3 ha of kikuyu grass (*Cenchrus clandestinus*) with weed whackers and a large deck mower within the Pua ʻĀkala management area 6 times. We also spot-sprayed blackberry (*Rubus discolor*), bull thistle (*Cirsium vulgare*), and gorse (*Ulex europaeus*). Six small wooden shelters were constructed and placed around the mowed area to provide additional protection for geese.

Hawaiian Goose Monitoring

We monitor geese inside the Army-managed areas at HFNWR during the breeding season between September and April (Figure 69). The purposes of monitoring are to record signs of breeding activity (e.g., aggressive behavior, copulation, and nest building), document the survival of fledglings, and record time spent foraging inside the management areas. Documenting the use of managed areas (areas with improved forage and/or reduced predators) by family groups with goslings helps determine the numbers of goslings that are supported to fledging through our management efforts. Fledglings that were consistently observed in management areas, regardless of whether or not they hatched from a nest outside the predator control area, are counted towards our goal of producing 26 fledglings per year.

Geese are also sighted and recorded while staff scan the management areas and/or perform other management actions. When possible, geese are identified by their leg-bands. Total numbers of geese using the management areas are recorded and family groups with goslings are noted.

Between October 2017 and April 2018, 78 geese were seen using the management areas: 68 banded individuals, 5 unbanded adults that were identifiable by their banded partner, and 5 unbanded fledglings that were identifiable by one or more banded parents. Between September 2018 and April 2019, 89 geese were seen using the management areas: 67 banded individuals, 6 unbanded adults that were identifiable by their banded partner, and 16 unbanded fledglings that were identifiable by one or more banded parents.

Hawaiian Goose Nest Monitoring

We search for and monitor goose nests in Army-managed areas to identify goose families, document habitat use, track movement, estimate survivorship, and count the total number of goslings that fledge from Army-managed areas.

We found and monitored 6 nests in Army-managed areas between October 2017 and April 2018, and 13 nests between September 2018 and April 2019 (Figure 69).

To include fledglings toward our fledging production goals, we established 2 criteria:

- For nests within Army-managed areas, we count goslings if they are banded, seen flying, or seen alive more than 10 weeks since hatching (when they may be capable of flight).

- For nests with unknown locations or with locations outside of the Army-managed areas, we count goslings if they are observed using the management areas on more than 25% of days staff are present/monitoring within the first 10 weeks of hatching, and are banded, seen flying, or seen alive after those 10 weeks.

Using these criteria, we counted a total of 7 fledglings produced between October 2017 and April 2018, and 20 fledglings produced between September 2018 and April 2019.

Predator Control at Hakalau Forest National Wildlife Refuge

We implement cat, mongoose, and rodent control in Army-managed areas where geese are likely to forage and nest, with the goal of increasing nest success and gosling survivorship (Figure 70).

We captured a total of 27 predators during the reporting period. Between October 2017 and April 2018, we deployed 102 traps and removed 11 predators (1 feral cat and 10 mongooses). Between September 2018 and April 2019, we deployed 55 traps and removed 16 predators (2 feral cats, 8 mongooses, and 6 rats)

Discussion for Hawaiian Goose Management at Hakalau Forest National Wildlife Refuge

Overall, implementation of the Hawaiian Goose conservation project at HFNWR was successful. Seven goslings fledged from Army-managed areas in 2017/2018, and 20 goslings fledged in 2018/2019, a nearly threefold increase. Our management increased the area of available forage, which geese, including family groups, utilized consistently. Although we don't know whether these management activities directly translate into numbers of geese fledged, they do directly support and benefit the HFNWR goose population with predator removal and enhanced nesting/foraging habitat for geese, which are important steps towards the overall success of goose conservation at the refuge.

Since 2017, management activities in the Army-managed areas have supported goslings to fledgling age across 3 breeding seasons. With continued management activities in the 2019/2020 breeding season, we hope to sustain high fledgling success to achieve the annual requirement of 26 fledglings.

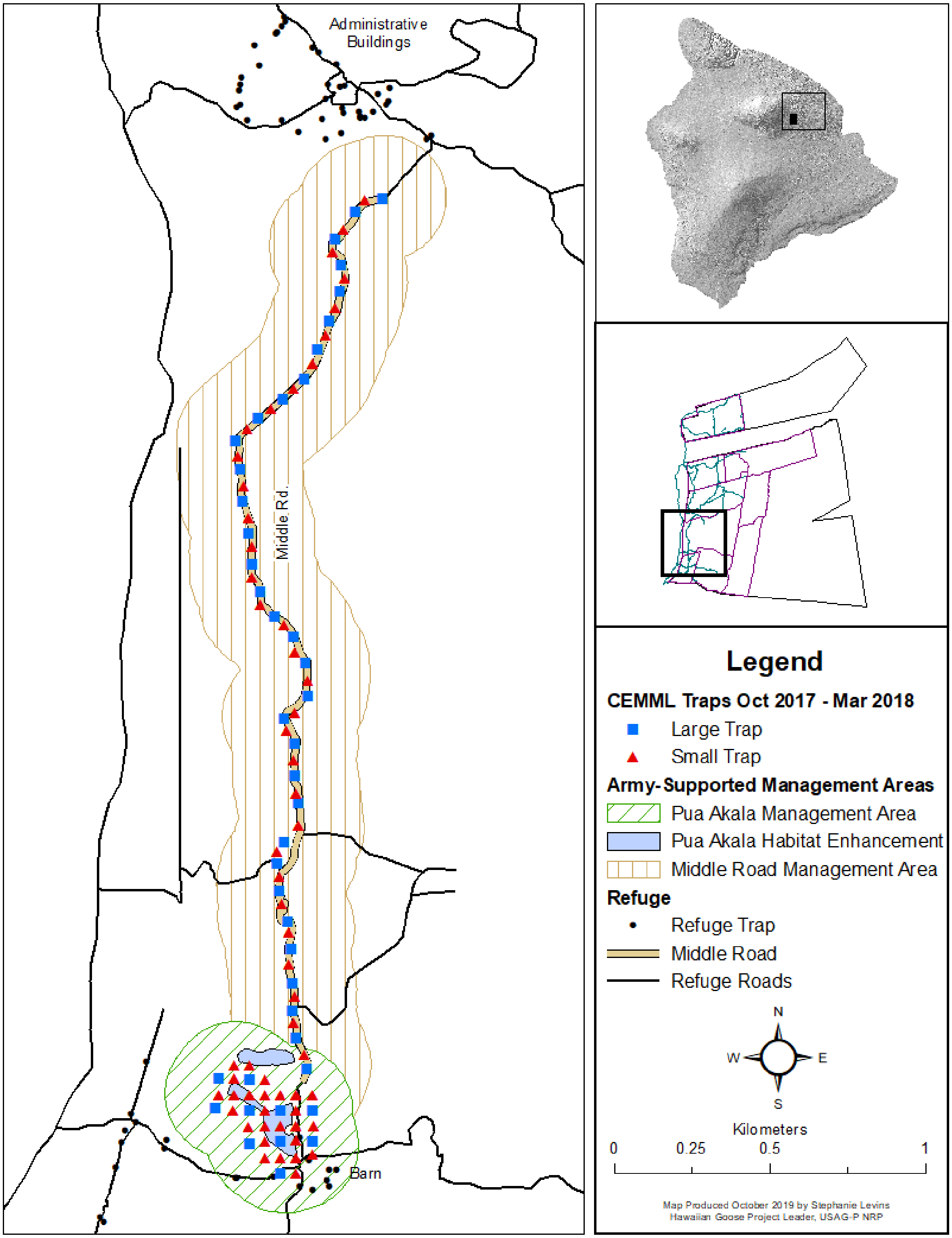

Figure 70. Predator trap layout during 2017/2018 and 2018/2019 Hawaiian Goose breeding season at Hakalau Forest National Wildlife Refuge

4.2.4 Hawaiian Hoary Bat

The Hawaiian hoary bat is an insectivorous bat endemic to the Hawaiian Islands and is currently known to reside on the islands of Hawaiʻi, Kauaʻi, and Maui, with the largest populations occurring on Hawaiʻi and Kauaʻi. Although the statewide population of bats is unknown, the population of the Hawaiian hoary bat on the island of Hawaiʻi is known to be stable and occupancy trends appear to be increasing (Gorressen et al. 2013). According to Hawaiʻi Natural Heritage Program data, the first incidental sighting of the Hawaiian hoary bat at PTA was in 1977, and the first documented inventory was conducted in 1992 (Gon et al. 1993).

We implement management for the Hawaiian hoary bat at PTA to meet SOO task 3.2(2)(a) and to address INRMP objectives and conservation measures and terms and conditions from the 2003 and 2008 BOs and associated Incidental Take Statements. Our goal is was to determine occupancy and seasonal activity patterns throughout the installation between 2014 and 2017. The project was also meant to identify habitat association based on 5 vegetation classes, and bat prevalence in potential treeland roosting habitats more generally. We present methods and results of the 2014–2019 seasonal activity analysis and the 2014–2017 occupancy analysis separately.

Seasonal Activity Methods

We conducted acoustic sampling at 5 established monitoring locations across PTA between June 2014 and September 2019 (Figure 71). Anabat SD2 (Titley Scientific, Ballina, Australia) detectors and microphones recorded bat calls from sunrise to sunset each night throughout the study. Each detector was powered by a 12 V battery connected to a solar panel. All calls were recorded using zero-crossings analysis which produced individual files of spectrograms for each acoustic event. Spectrograms were viewed in AnalookW (version 4.2n, Titley Electronics) to prevent misidentification. We created an activity index based on the number of 1-minute intervals per night in which bat echolocation calls were recorded (Miller 2001). We refer to this call frequency as bat-call minutes, and use "minutes" to describe overall estimates of nightly bat activity. Furthermore, we calculated the average number of calls specific to feeding activity and refer to them as feeding buzzes (Griffin et al. 1960). Refer to the FY 2014 Annual Report for the Natural Resources Program, Pōhakuloa Training Area, Island of Hawaiʻi (Peshut et al. 2015) for more detailed information regarding overall project design, goals and methods.

Seasonal sampling has biological significance outside of the traditional seasons in a year. The possibility of change in bat activity and occupancy between seasons can be driven by changing weather patterns or energetic requirements related to the bat's life cycle traits (Gorresen et al. 2013; Menard 2001). For this reason, quarterly sampling occurred as follows:

- Mid-June–August (lactation)
- September–December (mating/fledging)
- January–March (pre-pregnancy)
- April–mid-June (pregnancy)

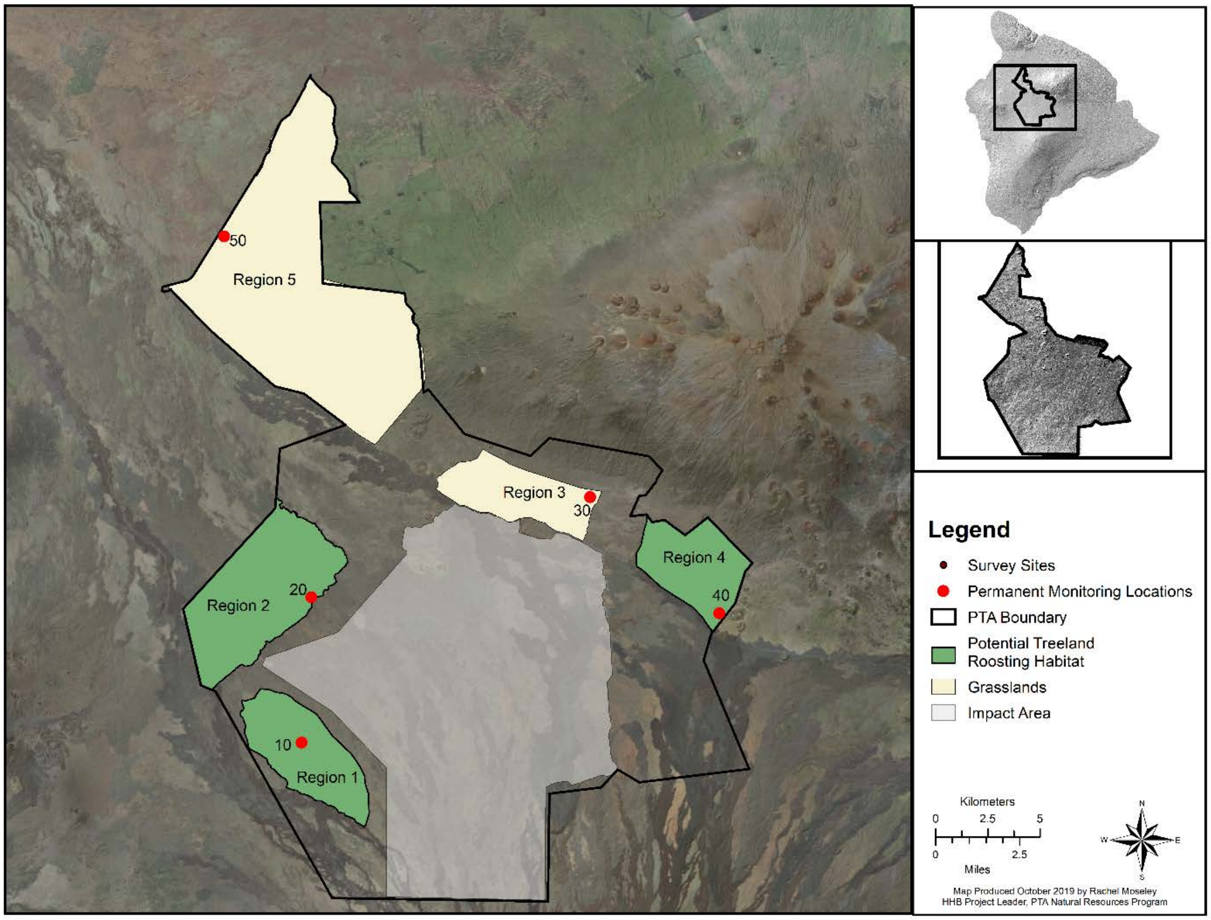

Figure 71. Survey sites and permanent monitoring locations for Hawaiian hoary bat

Seasonal Activity Analysis

The information presented here summarizes the results of acoustic bat activity data continuously collected at 5 locations from 2014–2019. Reproductive cycle and the term "season" are synonymous for this analysis. Because data collection followed a repeated measures design (multiple measures of the same variable taken on the same subjects over time) we could not assume independence among observations of the response variables. Moreover, the 5 locations are not a random sample of the population of all possible sampling locations at PTA, and sequential observations collected over a continuous timespan at the same location are subject to temporal autocorrelation. We account for temporal and spatial pseudoreplication using general linear mixed models (GLMMs). The generalized linear model (GLM) is used to describe the relationship between covariates and the conditional mean of a response variable and handles non-normal data by employing exponential distribution families (Bolker et al. 2009). The GLMM, however, allows for the inclusion of both fixed effects and random effects—effects which model the cause of correlation by defining the structure of the variance/covariance matrix (Millar and Anderson 2004; Bolker et al. 2009).

To examine effects to bat activity, we analyzed mean number of bat call minutes as a function of the fixed effect cycle. We included nested random effects of location, month, and year in the model to address non-independence. Including "month" allowed us to further deconstruct cycle and the possibility of variation among months in a calendar year. To correct for the correlation between values from night to night we included a lagged predictor which removed the first observation of the response variable for each location:month:year combination. Additionally, due to overdispersion (a measure of variance in the response variable) we used a negative binomial distribution to model the counts of call minutes. Using a GLMM allowed us to avoid log-transforming the counts to fit a normal distribution imposed by standard tests such as ANOVA (O'Hara and Kotze 2010; Frick 2013). We used the same approach and predictors in models to examine effects on feeding buzzes separately.

All analyses were conducted in program R (R Core Team 2019) version 3.6.1 using the package glmmTMB (Brooks et al. 2017). We compared models with and without the random effects using the corrected Akaike information criterion (AICc), which ranks all models based on deviance and the number of parameters (Burnham et al. 2002). We checked model fit by simulating data and checking the deviation from the expected distribution. Residual diagnostic plots were created with the package DHARMa (Hartig 2019).

Seasonal Activity Results

The best model showed a significant effect of cycle on call minutes and included the random effects year, month, and location (Table 73). Activity means were highest during mating and fledging September–December, followed by lactation June–August, and finally by pre-pregnancy and pregnancy (January–mid-June), which were not different from each other (Table 74). Inclusion of the lagged predictor "lagMin" improved the model significantly.

Table 73. Set of ranked models for the generalized linear mixed model on bat call minutes[a]

Model	Df	AICc	ΔAICc	AICcWt
cycle + lagMin + (1|year/month/location)	9	34389.4	0	1
year + (1|cycle/location)	9	36356.3	1966.9	<0.001
cycle + (1|year/location)	7	36489.5	2100.1	<0.001
cycle + (1|location)	6	36883.1	2493.8	<0.001
null	2	40607.8	6218.4	<0.001

[a] Models were ranked based on the degrees of freedom (Df), bias corrected Akaike information criterion (AICc), the change in AICc from the top ranked model (ΔAICc), and the model weight (AICcWt) which represents the relative likelihood. Variables were included as nested random effects if listed inside parentheses, and as fixed effects otherwise.

Table 74. Mean bat call minutes for parameters from the top-ranked generalized linear mixed model[a]

Parameter	Estimate	SE	Lower CI	Upper CI
Lactation	0.52	0.13	0.27	0.77
Mating/fledging	0.80	0.13	0.54	1.05
Pre-pregnancy	0.22	0.16	-0.10	0.54
Pregnancy	0.22	0.15	-0.07	0.51
lagMin	0.02	0.001	0.02	0.02
Sigma	0.97	*	0.92	1.02

[a] Sigma is the estimated overdispersion parameter. Standard error (SE), lower and upper confidence intervals of the odds ratios are presented. *Values not calculated for sigma.

Analysis on feeding buzzes also showed a significant effect of cycle on feeding buzzes and included the random effects year, month, and location (Table 75). The same seasonal patterns hold for mean feeding buzzes (Table 76).

Table 75. Set of ranked models for the generalized linear mixed model on feeding buzzes[a]

Model	Df	AICc	ΔAICc	AICcWt
cycle + lagMin + (1|year/month/location)	9	7523.7	0	1
year + (1|cycle/location)	7	7873.7	350	<0.001
cycle + (1|year/location)	9	7878.3	354.6	<0.001
cycle + (1|location)	6	8065	541.3	<0.001
null	2	8844.4	1320.7	<0.001

[a] Models were ranked based on the degrees of freedom (Df), bias corrected Akaike information criterion (AICc), the change in AICc from the top ranked model (ΔAICc), and the model weight (AICcWt). Variables were included as nested random effects if listed inside parentheses, and as fixed effects otherwise.

Table 76. Mean feeding buzzes for fixed parameter "cycle" from the top-ranked generalized linear mixed model[a]

Parameter	Estimate	SE	Lower CI	Upper CI
Lactation	-2.55	0.22	-2.98	-2.11
Mating/fledging	-2.27	0.22	-2.70	-1.84
Pre-pregnancy	-3.13	0.26	-3.64	-2.63
Pregnancy	-3.42	0.28	-3.96	-2.88
lagMin	0.02	0.01	0.01	0.02
Sigma	0.44	*	0.38	0.51

[a] Sigma is the estimated overdispersion parameter. Standard error (SE), lower and upper confidence intervals of the odds ratios are presented. *Values not calculated for sigma

Pooled data of mean monthly bat call minutes showed a distinct peak in activity during August and September (between lactation and mating/fledging) and a dip in activity during March and April (between pre-pregnancy and pregnancy; Figure 72). When activity was subset by year (Figure 73), mean monthly bat call minutes showed similar activity patterns. While both figures show seasonal patterns in activity, the specific monthly peak of activity appeared to vary annually.

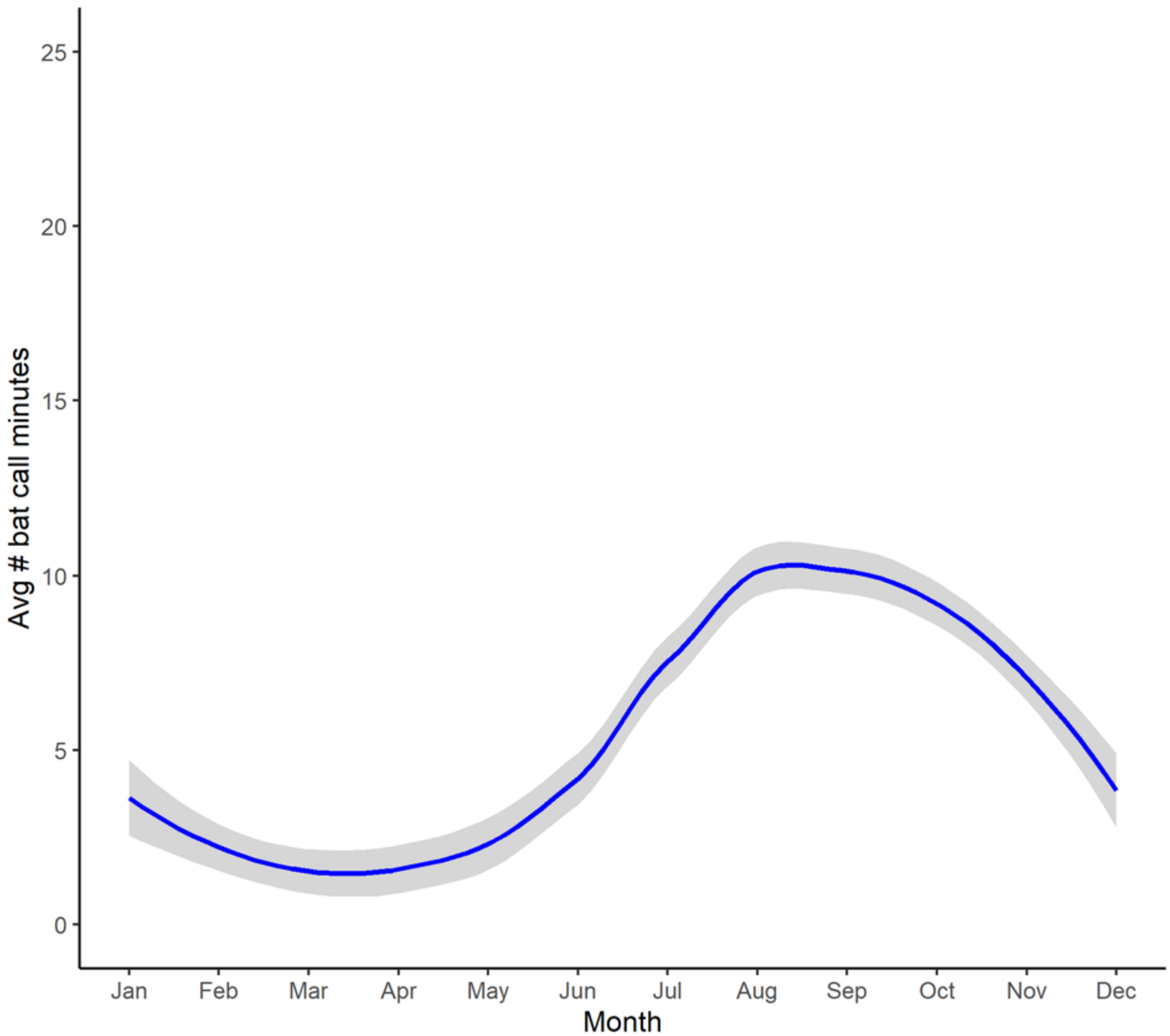

Figure 72. Mean nightly bat call minutes by month June 2014–August 2019[a]

[a] Monthly bat call minutes pooled by location and year. Trend line uses LOESS (locally estimated scatterplot smoothing) smooth curve and the shaded area represents the 95% confidence intervals.

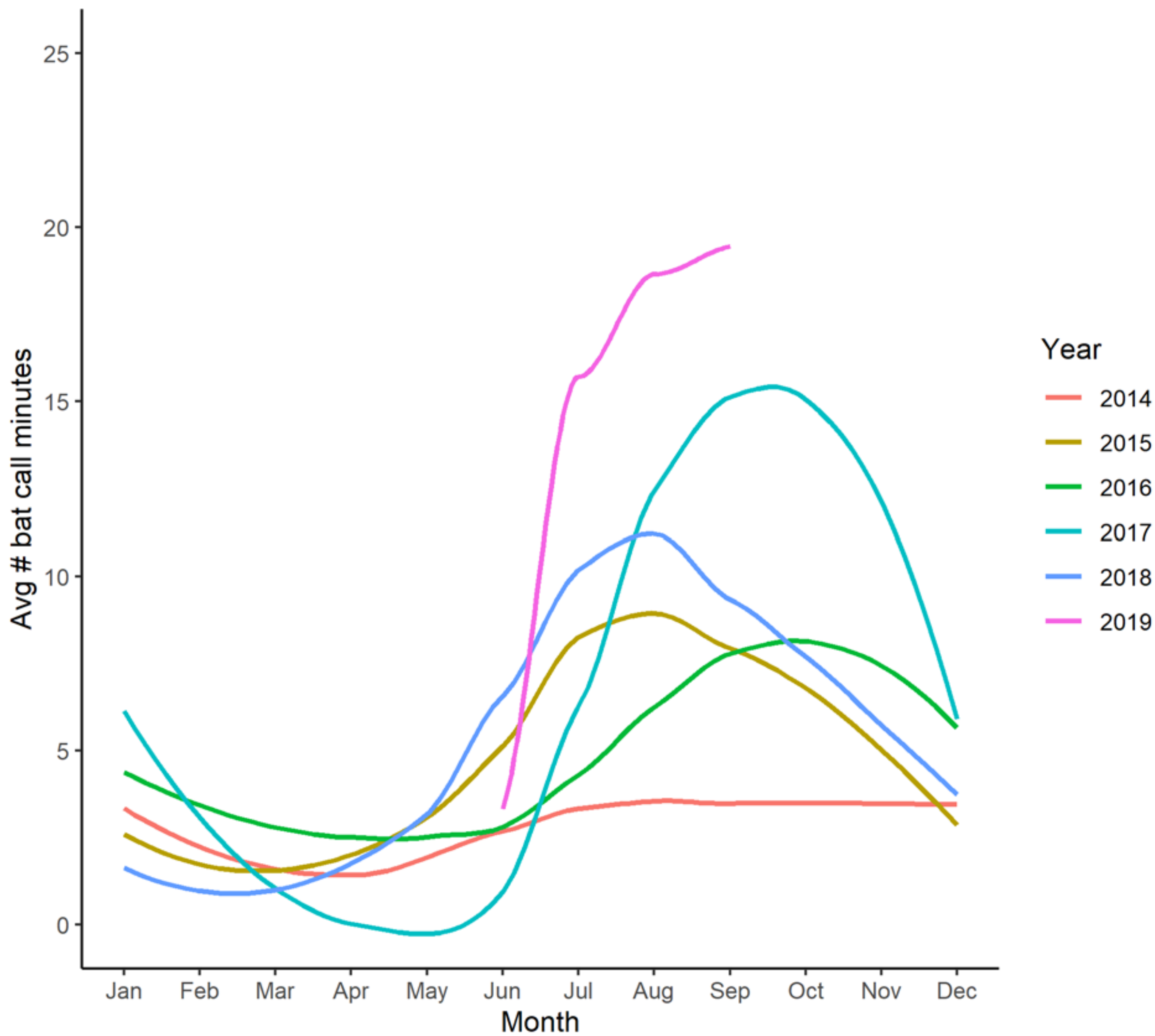

Figure 73. Mean monthly bat call minutes by year June 2014–August 2019[a]

[a] Trend lines shown are LOESS (locally estimated scatterplot smoothing) smooth curves. Year corresponds to the year in which sampling began rather than the actual calendar year since data collection begins mid-June in one year and runs through mid-June of the next.

Occupancy Analysis Methods

Occupancy (ψ) is defined as the probability that a randomly selected area of interest is occupied by a species (MacKenzie et al. 2003). Because detection is often imperfect MacKenzie et al. (2006), it is also important to estimate the probability of detecting the species given it is truly present during sampling (p). We used a stratified random design to collect occupancy data (presence/absence) acoustically for 7 nights for each of the 4 reproductive cycles at 45 sites across PTA (a total of 1260 observations per year). We assigned each site a "tree habitat" category, which is a binary covariate describing presence or absence of trees within a 100-m buffer of the detector, to further evaluate associations with bat occupancy and tree presence. Predictors used to model occupancy included general vegetation class of a site as well as tree habitat. Additionally, we used average nightly temperature and wind, and total rainfall values over the entire study period as measures of the overall quality or suitability of a site. Reproductive cycle and Julian date represented time of year predictors to estimate detectability (*p*). Multiple-season occupancy models incorporating various predictors were compared to the null model—a model without any predictors—and ranked using Akaike's Information Criterion (AIC). More information regarding methods is provided in the technical report *Hawaiian hoary bat (*Lasiurus cinereus semotus*) Occupancy and Activity at Pōhakuloa Training Area, Hawai'i* (report available upon request).

Occupancy Results

Results of the analyses yielded an occupancy probability of ~1.0, where a value of 1.0 indicates bats occupied all 45 sites. This was not unexpected given bats were detected at all 45 sites in the first season of sampling. The null model had the lowest AIC value indicating that none of the predictors increased the likelihood that a site would be occupied. Mean detection probability across all sites and seasons was 0.39, where a value of 1.0 means we detected bats on all nights. The probability of detecting bats varied with reproductive cycle and was highest September–December when adults mate and young fledge. Detection probability was also associated with the cycle and vegetation classification. Neither meteorological attributes nor proximity to trees explained the variation in occupancy or detection probabilities.

Incidental Take

We monitor for the incidental direct take of bats in the form of injury and/or mortality and report annually to the USFWS in compliance with the 2003 and 2008 BO Incidental Take Statements. In addition, we monitor for incidental indirect take of bats as the amount of treeland habitat destroyed outside the Impact Area annually. The Army is authorized for take associated with the loss of no more than 48 ha per year of potential available treeland roosting habitat outside the Impact Area and cumulative losses of no more than 1,345 ha outside the Impact Area. Treeland loss primarily occurs from wildland fire, but other military actions, such as maneuvers, live-fire, and construction also influence losses.

No Hawaiian hoary bat entanglements were discovered during fence inspections, so no direct take as a result of fences was reported in FY 2018 or FY 2019.

In FY 2018 a wildland fire occurred, igniting in Training Area 19 and spreading to Training Areas 18 and 22. The fire burned approximately 585 ha, of which 149 ha are considered potential treeland roosting habitat. This area exceeds the Army's annual take limits by a factor of 3 (149:48 hectares). While we are unable to quantify the effect of the fire on bats potentially roosting at PTA, it occurred during the lactation reproductive cycle, when pups tend to be non-volant and therefore more vulnerable to disturbance.

No wildland fires occurred in FY 2019 and no additional treeland habitat was lost due to military actions, such as maneuvers, live-fire, and construction.

On 5 September 2019, a Hawaiian hoary bat carcass was discovered on the PTA cantonment next to building 227A. The carcass (sex unknown) was on the ground 2.6 m away from the building. Based on a visual inspection of the carcass and the surrounding areas, we believe that military training activities were an unlikely cause of death. On 19 September 2019, we shipped the bat carcass to the Bishop Museum and an incidental report was submitted to the USFWS (Appendix D, Wildlife Enclosure 1).

Discussion for Hawaiian Hoary Bat Management

Acoustic occupancy and activity analyses show that bats are present across the installation throughout the year and that activity peaks during the autumn months. Both analyses complement each other by emphasizing time of year effects on bat prevalence. By deconstructing reproductive cycle into months, we gain more clarity about how the species uses resources at PTA. Furthermore, these activity and occupancy results are consistent with studies on other islands and at lower elevations (Menard 2001; Gorresen et al. 2013; Gorresen et al 2015; Pinzari et al. 2019). The overall increase in activity September—December may be attributed to newly volant pups beginning to forage with their mothers after being weaned. This increase in activity also reinforces the assumption that there may be a higher risk to the species from fire, military training or construction at PTA during summer months when non-volant pups depend heavily on females (Gorresen et al. 2017). The transition between the end of the lactation cycle (August) and the beginning of the mating/fledging cycle (September) appears to be significant and may be a cause of interannual variation in bat prevalence. To capture this critical window, we will collect occupancy data in 2019 and 2020 for 9 weeks starting in September, rather than centering data collection across the 4 months representing the mating/fledging cycle.

It is important to note that Gorresen et al. (2017) found that acoustic monitoring methods alone detect hoary bats less reliably than visual methods do. Simultaneous video and acoustic recordings showed that bats were acoustically detected one third of the time that they were visually detected, suggesting that bats may not always echolocate or may do so in a way that decreases detectability. Corcoran and Weller (2018) found that the North American hoary bat produced “micro” calls: discrete call types that produce shorter duration, higher frequency calls that emit 3 orders of magnitude less sound energy than normal calls, making them less detectable by microphones. These highly variable and cryptic foraging strategies should be considered when making inferences about hoary bat prevalence, given that we violate two assumptions of acoustic monitoring studies with this species: 1) that bats are reliably detected if present and calling, and 2) that the index of activity as well as the number of feeding buzzes in a sampling unit is correlated to the number of individuals and to the amount of foraging in a sampled area, respectively (Hayes 2000; Gannon et al. 2003; Gorresen et al. 2015).

Our work suggests that predictors such as weather and proximity to potential roosting habitat are not strongly associated with bat prevalence. Additionally, treeland roosting habitat may not be as limiting a factor for bats as previously thought. Bats are a highly mobile and cryptic species that may be feeding, roosting, or traversing the installation in a way that may not be adequately modeled with the variables collected.

Despite limitations of acoustic monitoring, results from this work will contribute to a better understanding of the natural history and ecology of the Hawaiian hoary bat, particularly in high elevation interior habitats on Hawaii Island not previously studied. Results also provide a baseline estimation of occupancy with which to compare future estimates over the years. In 2019 and 2020, we plan to focus sampling during the peak of activity to help clarify previous occupancy analysis results. Continued knowledge of seasonal activity and occupancy estimates at PTA helps the military anticipate and evaluate the impact of potential hazards to bats such as fire, military training or construction.

4.2.5 Seabird Management

Projects implemented for seabird management address SOO task 3.2(2)(a), INRMP objectives, and conservation measures from the 2003 BO to survey to determine presence, abundance, and habitat use by the Hawaiian Petrel (*Pterodroma sandwichensis*) at PTA. We determined that Hawaiian Petrels do not use PTA; rather they fly over the installation (CEMML 2016). While surveying for the Hawaiian Petrel, we regularly detected calls from Band-rumped Storm Petrels (BSTP, *Oceanodroma castro*), which was listed as endangered under the ESA in 2016.

In 2015, the first active BSTP nest in Hawaiʻi was detected at PTA. Since then we have continued to monitor and further study the extent of BSTP breeding activity at PTA. These efforts produced video documentation of 4 active nests and a better understanding of the BSTP breeding season for Hawaiʻi Island. BSTP arrive at PTA in late May, egg laying likely occurs during July, and with a 42-day incubation, hatching may occur in late August. We documented fledging from October to mid-November. However, we still need to learn more about BSTP presence and activity at PTA including:

1) The extent of the BSTP colony to better analyze potential effects to the birds from military activities;
2) The behavior of adults and chicks to minimize effects or risks to the birds where feasible;
3) BSTP life history to add information to the scientific community;
4) The impact of predators to BSTP to minimize depredation.

To better understand the extent of the BSTP colony, breeding phenology and pertinent behavioral characteristics, we survey for potential BSTP nests with a search dog, monitor potential nests via video surveillance, and control predators.

<u>Nest Surveys with a Search Dog</u>

Due to the cryptic burrowing habits of BSTP, we used a trained search dog (“Makalani”) and his handler to detect petrel nests. Makalani was chosen because of his ability to work at high elevations, his demonstrated ability to leave the target species unharmed, his lineage of working bird dogs, and his previous success at detecting BSTP specimens and potential burrows at PTA.

Methods

Searches were conducted along 400 m-long transects spaced 50 m apart. These transects served as guidelines, but in areas of interest to us, we increased search intensity by searching the area multiple times or decreasing the spacing between transects.

An Astro Garmin 320 GPS device was used to record Makalani's search track. The Astro GPS device consists of 2 components: a hand-held GPS device (Garmin Astro 320) and a dog collar GPS device (Astro T-5). GPS points and photos were taken when any bird specimen or potential nest spot was found. A spot was deemed a "potential nest" when Makalani demonstrated behavior indicating the presence of a target ("pointing"). A spot was deemed an area of "significant interest" when Makalani showed keen interest in the area but could not pinpoint a specific spot to point on.

Results

We conducted a total of 5 searches with Makalani between August 2018 and September 2019. The searches ranged from 8 to 10 hours. A total of 41 linear km was surveyed by Makalani, 13 km in FY 2018 and 28 km in FY 2019 (Figure 74). We did not find any BSTP carcasses or feathers during all five searches.

Makalani detected a total of 6 new potential nests, 3 in 2018 (PB801, PB802, and PB803) and 3 in 2019 (PB900, PB901, and PB903).

In 2018, Makalani revisited 9 locations and showed interest at N01 and N03 (Table 77). In addition, he detected 3 new potential nests (PB801, PB802, and PB803). We confirmed nesting activity via video surveillance at PB705 and PB801 and assigned the permanent nest numbers N03 and N04 to these locations, respectively.

In 2019, Makalani revisited 16 locations and showed interest at N01, N04, and PB803 (Table 77). In addition, he detected 3 new potential nests (PB900, PB901, and PB903). We confirmed nesting activity via video surveillance at PB803 and assigned the permanent nest number N05 to this location.

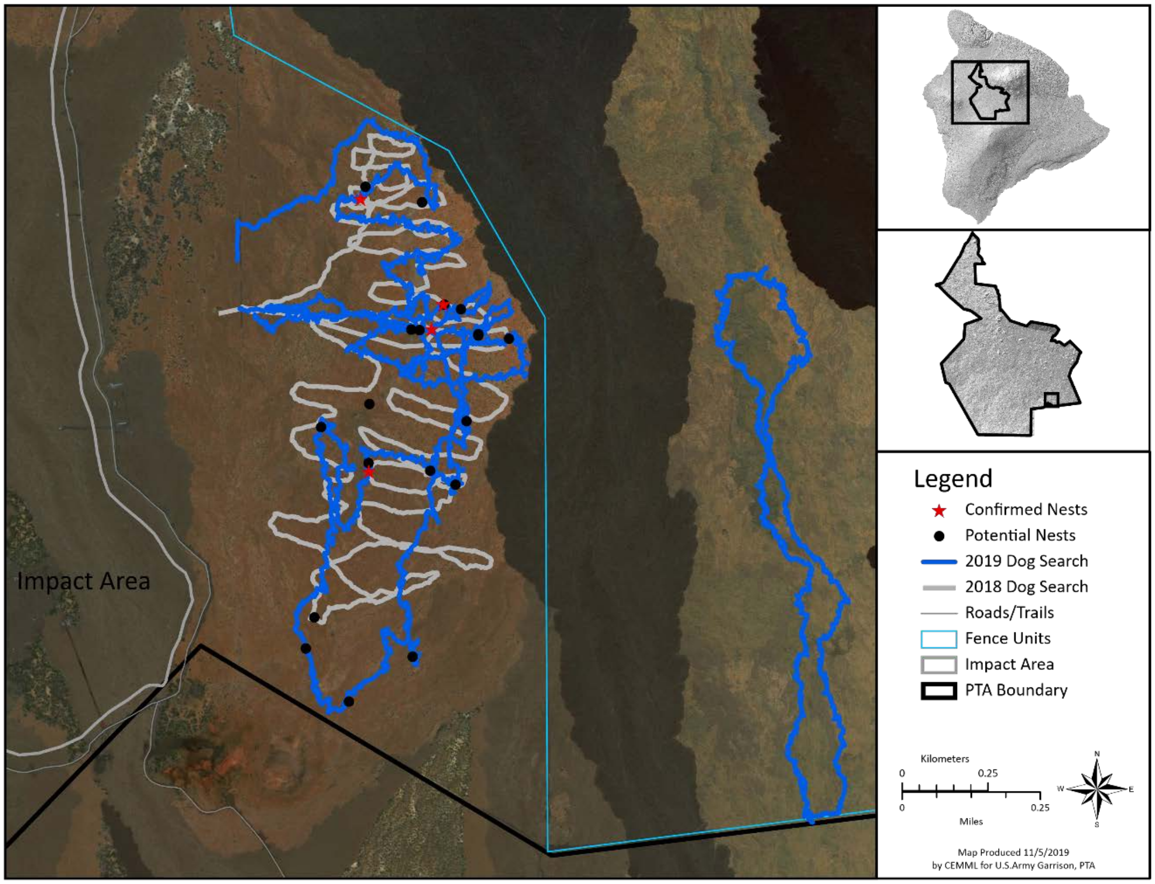

Figure 74. Dog search tracks (41 km) for Band-rumped Storm Petrel nests in FY 2018–2019 in Training Area 21 at Pōhakuloa Training Area

<u>Nest Video Surveillance</u>

Methods

Video surveillance cameras Sharx® and Reconyx XP-9 ultrafire professional covert camera traps™ were deployed from May through November at sites for which the detector dog indicated seabird activity. Videos may reveal behavioral information such as timing of adult visitation, predation pressures, and presence of fledglings. Cameras were programmed to record when motion was detected, and we placed the camera so that the burrow entrance was clearly visible in the video or photograph frame. We collected and reviewed the video SD cards at least every 2 weeks.

Table 77 . Dog search survey and nest monitoring results for 2018 and 2019

Potential Burrow No.	Year Discovered	Year Nest Confirmed	Permanent Nest No.	Dog Search Year	Scent Detected	Video Surveillance
PB01	2015	2015	N01	2018	Y	Y
		--	--	2019	Y	Y
PB03	2015	--	--	2018	N	N
		--	--	2019	N	Y
PB04	2015	--	--	2018	N	N
		--	--	2019	N	N
PB05	2015	--	--	2019	N	N
PB06	2015	--	--	2019	N	N
PB601	2016	--	--	2018	N	N
		--	--	2019	N	N
PB702	2017	--	--	2018	N	Y
		--	--	2019	N	Y
PB703	2017	2017	N02	2018	N	N
		--	--	2019	N	N
PB704	2017	--	--	2019	N	N
PB705	2017	2018	N03	2018	Y	Y
		--	--	2019	N	N
PB706	2017	--	--	2018	N	Y
		--	--	2019	N	Y
PB707	2017	--	--	2019	N	N
PB708	2017	--	--	2018	N	N
		--	--	2019	N	N
PB801	2018	2018	N04	2018	Y	Y
		--	--	2019	Y	Y
PB802	2018	--	--	2018	Y	Y
		--	--	2019	N	N
PB803	2018	2019	N05	2018	Y	Y
		--	--	2019	Y	Y
PB900	2019	--	--	2019	Y	Y
PB901	2019	--	--	2019	Y	Y
PB903	2019	--	--	2019	Y	Y

Results

In 2018, we deployed cameras at 9 locations from June through November and detected activity at three nests (Table 78). We documented an adult BSTP at PB705 and PB801 and assigned permanent nest numbers N03 and N04 to these locations, respectively. An adult and chick were detected at N01, a previously known nest, but we did not detect fledging activity. No BSTP depredation was detected.

In 2019, we deployed cameras at 12 locations from May through December and detected activity at 3 nests (Table 78). We confirmed adult BSTP at PB803 and assigned a permanent nest number N05 to this location. We detected an adult and a fledgling at N05 but did not detect the fledgling's final flight from the nest. We confirmed adult BSTP at N01 and N04 but did not detect evidence of chicks or fledglings at these locations. No BSTP depredation was detected.

Table 78. Confirmed and potential nest monitoring results via video surveillance

Location	Surveillance (Year)	Adult Detected	Chick Detected	Depredation Detected	Observed Nest Outcome
N01	2018	Y	Y	N	Chick observed, fledging not detected
	2019	Y	N	N	
N02	2018	N	N	N	
	2019	N	N	N	
N03[a]	2018	Y	N	N	
	2019	N	N	N	
N04[a]	2018	Y	N	N	
	2019	Y	N	N	
N05[a]	2018	N	N	N	
	2019	Y	Y	N	Chick observed, fledgling not detected
PB03	2019	N	N	N	
PB601	2018	N	N	N	
	2019	N	N	N	
PB702	2018	N	N	N	
	2019	N	N	N	
PB706	2018	N	N	N	
	2019	N	N	N	
PB802	2018	N	N	N	
PB900	2019	N	N	N	
PB901	2019	N	N	N	
PB903	2019	N	N	N	

[a] After confirming Band-rumped Storm Petrel activity, we assigned permanent nest numbers to potential burrows (PB): PB705 = N03, PB801=N04 and PB803=N05

We have detected activity at 2 nests over multiple years (N01 and N04). Below is a summary of each confirmed nest as well as summaries for nests discovered in 2018 (N03, N04) and 2019 (N05). We detected rodents, game birds, and ungulate activity in or around the nest sites.

N01

We placed a camera at N01 on 13 June 2018 and observed an adult entering the nest that evening. An adult last visited on 22 October 2018. On 8 November 2018, a chick sat in the nest entrance for less than two minutes before retreating into the nest. The chick was not detected again, and its fate is unknown. We did not detect depredation at the nest. No other activity was observed after 8 November and we removed the camera on 18 December 2018.

We placed a camera at N01 on 2 May 2019 and observed an adult entering the nest on 6 June 2019. An adult last visited on 26 June 2019. We did not detect a chick or depredation at the nest. No other activity was detected at the nest after 26 June, and the fate of the adult is unknown.

N03

Makalani indicated this location in 2017, but we did not capture activity on video that year. We placed a camera at N03 on 20 June 2018. On 7 August 2018, an adult entered the nest shortly after midnight and the adult last visited on 20 August 2019. We did not detect a chick or depredation at the nest. No other activity was detected after 20 August and the fate of the adult is unknown.

We placed a camera at N03 on 2 May 2019 and no activity was detected during the breeding season.

N04

We placed a camera at N04 on 8 August 2018. On 10 August 2018, an adult cleaned the nest entrance and entered the nest. An adult last visited on 11 September 2018. We did not detect a chick or depredation at the nest. We were unable to confirm the adult's fate and no other activity was detected after 11 September.

We placed a camera at N04 on 2 May 2019. An adult entered the nest on 9 June 2019 and last visited on 3 September 2019. We did not detect a chick or depredation at the nest. We were unable to confirm the adult's fate and no other activity was detected after 3 September.

N05

We placed a camera at N05 on 2 October 2018 but detected no activity.

On 29 August 2019, we place a camera at N05. An adult entered the nest on 20 October 2019 and was last recorded visiting the nest on 26 October 2019. A chick was detected on 7 November 2019 outside the nest. On this day, the bird flapped its wings and explored outside the burrow for about 10 minutes in the early morning and for about 10 minutes again in the evening. The final video of the night shows the chick exiting the nest, but we did not detect it re-entering. The chick was detected emerging from the nest for the last time on 8 November 2019 at 6:39 pm. Although we did not detect the final flight of the chick from the nest, we are optimistic that the chick fledged the colony that same evening.

Predator Control

Methods

We implement cat, mongoose, and rodent control in TA 21 within what we believe to be the extent of the BSTP breeding colony (Figure 75). A combination of live and lethal traps was used to remove small mammals.

Live Traps

We used Tomahawk® (30"X10"X12") traps spaced 200 m apart to capture cats and mongoose. All the traps were baited with a single can of sardines (Beach Cliff Sardines in soybean oil) with scent holes punctured in the top and were checked daily once they were set.

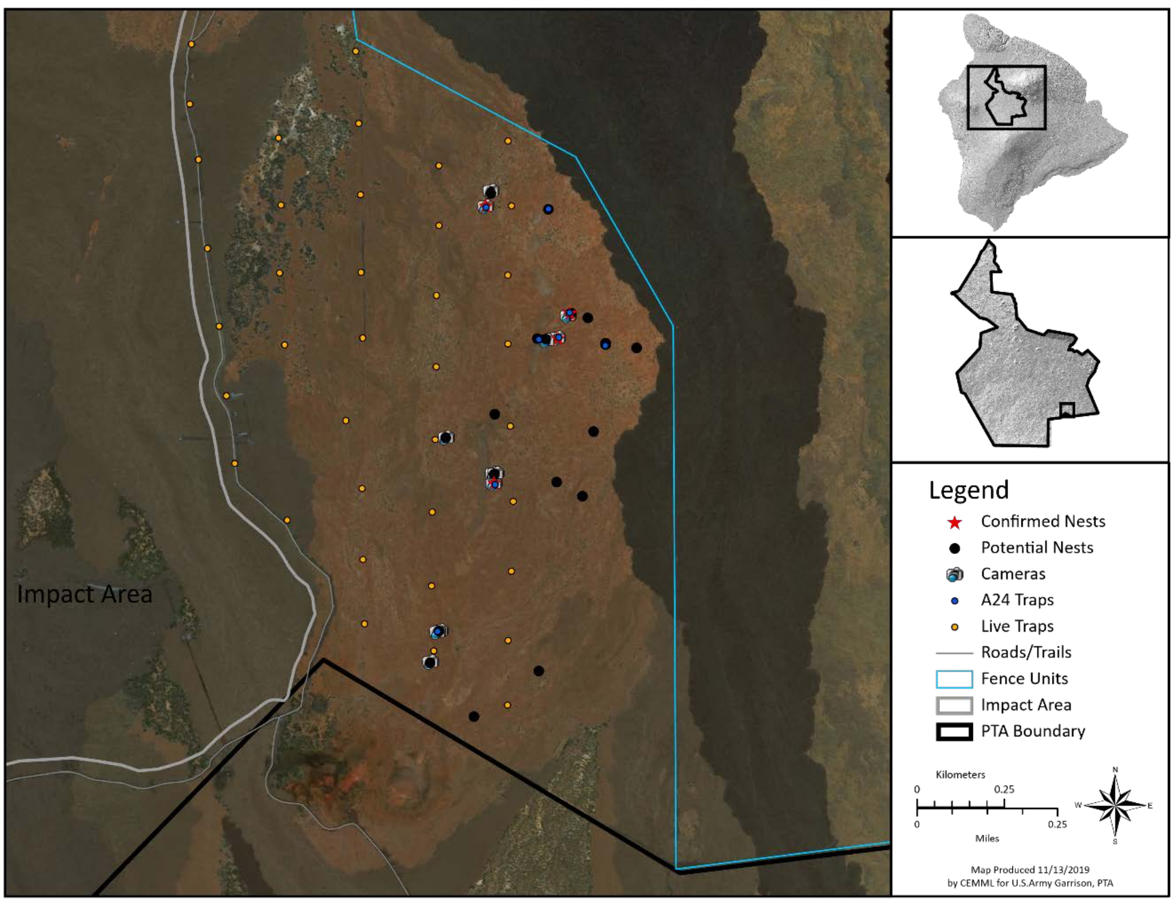

Figure 75. Predator trap and camera layout in the Band-rump Storm Petrel breeding colony site in Training Area 21 at Pōhakuloa Training Area for FY 2018–FY 2019

Lethal Traps

For lethal trapping of rodents, we used snap traps (Victor® or Kress™ Snap-E traps) and self-resetting traps (Goodnature® A24 rat + stoat traps, Goodnature Limited, Wellington, New Zealand), which can fire 24 times with 1 CO_2 cartridge. The self-resetting traps (hereafter referred to as A24 traps) are typically baited with a chocolate lure bait (Goodnature®) and we replace baits and CO_2 cartridges quarterly. We set A24 traps at least 1 m from the potential BSTP nests. Because A24 traps are not checked daily, we cannot accurately determine the total number of rodents killed. In many cases when checking the A24 traps, we found mongoose and rodent carcasses next to the traps.

Results

We captured 1 black rat and 3 feral cats in live traps. We found numerous black rat and mouse carcasses next to A24 traps. No non-target species were found. All rodent carcasses were collected and removed from the seabird colony site, to minimize attraction of other predators such as feral cats and barn owls to the colony site.

Discussion Seabirds

We confirmed BSTP activity at 4 nests (N01, N03, N04, and N05). At N01, we detected a chick. However, we did not detect depredation or a fledging, therefore the fate of the chick is unknown. At N05, we detected a fledgling exercising its wings but did not detect the final flight from the nest. Most of our camera detections at monitored nests recorded adult arrival and take-off flights but 2019 was the first year we observed extended cleaning activity at the entrance of a nest (N04). With Makalani, we revisited 16 of 20 locations that were identified as potential or confirmed nests between 2015 and 2018. Makalani showed interest at 8 of these sites (N01, N03, N04, N05, PB802, PB900, PB901, and PB903). We plan to continue checking these locations with Makalani and deploying video surveillance as needed.

We controlled predators prior to the arrival of the BSTP at the colony. In FY 2020, we plan to trap predator for the duration of breeding season (May through November).

We face many challenges in collecting additional BSTP information at the colony site. Finding and confirming new active nests is time consuming and slow and our knowledge of the area that BSTP use for breeding remains limited. With only a few active nests to monitor, our knowledge of breeding activity and behavior remains rudimentary. We are exploring ways to use acoustic monitoring to determine the colony extent. However, non-breeders typically call the most frequently at the colony (Buxton and Jones 2012) and breeding birds tend to be silent on the colony (Simons 1985). Therefore, an acoustic approach will map the colony boundaries for non-breeding birds and is not ideal for delineating the area used by breeders.

We continue to learn and improve our detection and monitoring techniques for this cryptic species. Our aim is to better understand the extent of the area used by breeding and non-breeding BSTP to more accurately analyze potential effects of military training on birds at PTA. To further these aims, we plan to redesign the acoustic monitoring study to identify areas of calling activity (non-breeders) and investigate relationships between areas of high call rates and known nests (breeders). We suspect that the area used by the non-breeders is greater in extent than the area occupied by known nests. Additional acoustic information will help bolster our knowledge of seasonal and nightly colony attendance patterns of non-breeders. Also, if feasible with available technology, we recommend investigating ingress and egress patterns to the colony.

We are preparing to initiate formal consultation for the BSTP under section 7 of the ESA with the USFWS. Because the BSTP colony at PTA is the only confirmed colony in the State of Hawaiʻi, we anticipate that the USFWS will consider this colony as extremely important. Investigating colony extent, colony attendance patterns, and breeding activity will help us more accurately assess potential effects from military activities on the birds and to guide the development of conservation measures commensurate with anticipated effects. To offset potential impacts to the species that are not military activity-related, we recommend updating the INRMP to address conservation activities for this species and to reduce the need to designate critical habitat on the installation for this species.

4.2.6 Avian Monitoring

We monitor birds annually and this project addresses SOO task 3.2(2), INRMP objectives, conservation measures from the 2003 BO, and obligations under the MBTA to monitor protected birds. We have annually monitored birds at PTA since 1998.

Our sampling design is based on variable circular-plot and distance sampling methods (Reynolds et al. 1980), which can be used to obtain relatively unbiased, regional information on bird abundance, and to track changes in population trends through time. Point-transect sampling enables us to monitor a wide range of bird species, each of which possesses a different singing style, and each of which may occur in a variety of acoustically different habitats (BCRIB 1999).

For most situations, distance sampling is the best method currently available for determining abundance and monitoring trends for land birds. Without a measure of the detection probability, counts of birds are an unreliable measure of differences in the actual number of birds present (Burnham 1981; Barker and Sauer 1995; Nelson and Fancy 1999). For distance sampling, we assign an exact distance measurement to each bird detected. Recording distance to each detected bird enables us to derive a species-specific density estimate adjusted by a species' detection probability (Ralph et al. 1995), allowing us to estimate the number of individuals missed. Thus, to obtain relatively unbiased long-term trend data the sampling design incorporates distance measures.

In addition, we can apply several qualitative and quantitative analytical methods to investigate changes in species composition and density of native and non-native birds relative to management actions (i.e., alien plant and animal control) including BACI (before-after-control-impact) analyses to investigate changes in bird composition and density due to changes in vegetation or other habitat characteristics.

Methods

Fifteen monitoring transects ranging between 2 to 3.5 km in length cover 3 study areas: TA 1–4 (4 transects), TA 22 (4 transects), and TA 23 (7 transects). Between 14 and 24 monitoring stations are spaced every 150 m along each transect (Figure 76). Transect and station spacing was selected to minimize the likelihood of counting the same bird at 2 or more stations and was adapted from methods used to monitor for Palila on Mauna Kea (Scott et al. 1984). We monitor each station for 6 minutes between 0630 and 1100. Every bird detected is recorded along with the detection type (aural, visual, or combined) and the horizontal distance, in meters, from the station to the bird (Reynolds et al. 1980; Buckland et al. 2008). Weather conditions, wind speed, and cloud cover are also noted. Counts are not conducted on days when the weather is not within established guidelines. At PTA, we monitor during December and early January.

Detection frequency (mean number of bird calls detected per station) is estimated by taking the ratio of the total number of bird detections, by species, to the total number of monitoring stations.

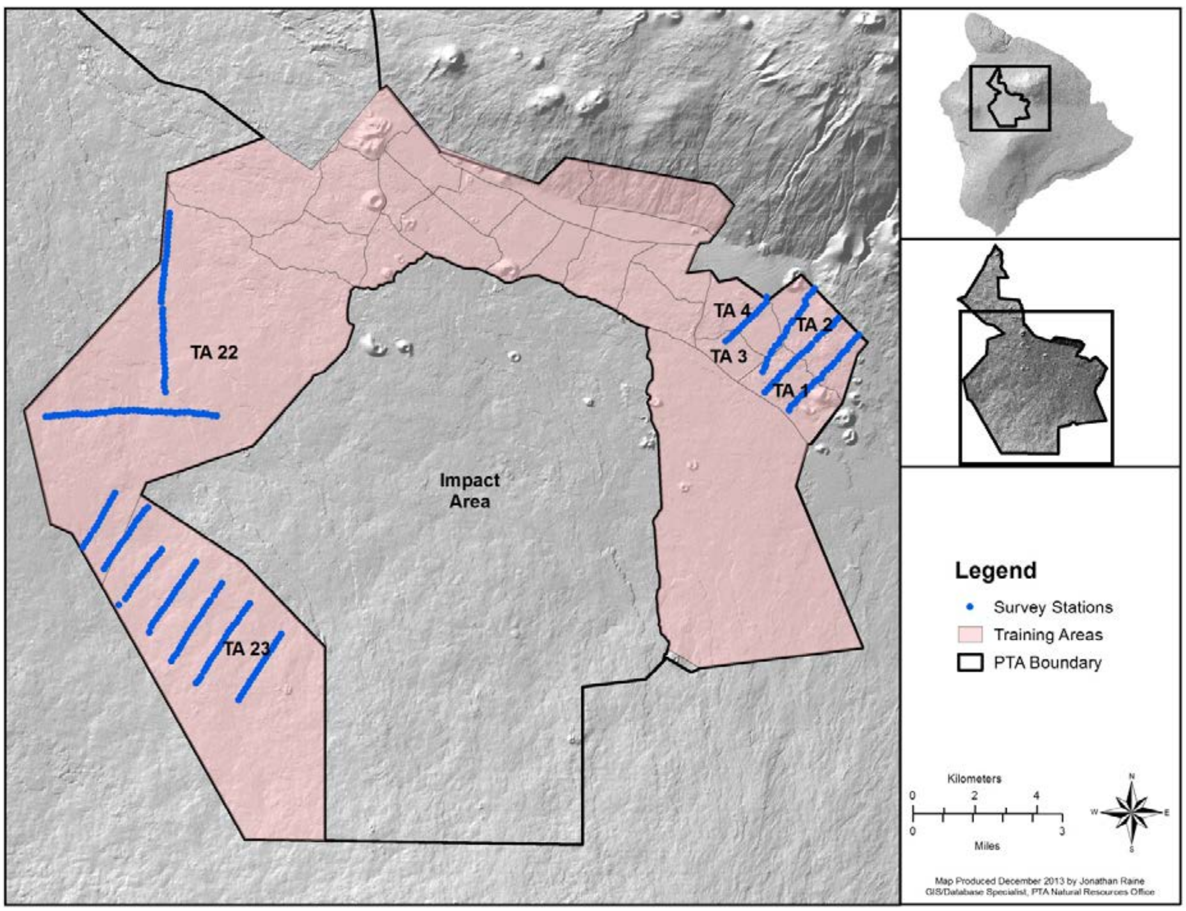

Figure 76. Avian monitoring transects at Pōhakuloa Training Area

Results

We did not count birds in FY 2018. Birds detected in FY 2019 are summarized in Table 79. Of the 20 birds detected, 4 were native species, 12 were non-native non-game species, and 4 were non-native game species. Eight species detected (native and non-native) are protected under the MBTA. Similar to previous years, Hawaiian Amakihi (*Hemignathus virens*) was the most frequently detected bird per station. We also frequently detected Japanese White-eye (*Zosterops japonicas*), House Finch (*Haemorhous mexicanus*), Yellow Fronted Canary (*Serinus mozambicus*), and Erckel's Francolin (*Pternistis erckelii*).

We did not detect the endangered Palila (*Loxioides bailleui*).

Table 79. Avian monitoring species counts and bird per station mean for FY 2019

Common Name	Species	Species counted	Mean birds/ station
African Silverbill[c]	*Lonchura cantans*	61	0.23
Apapane[ab]	*Himatione sanguinea*	29	0.11
Black Francolin[d]	*Francolinus francolinus*	47	0.17
California Quail[d]	*Callipepla californica*	31	0.12
Chukar[d]	*Alectoris chukar*	6	0.02
Common Myna[c]	*Acridotheres tristis*	3	0.01
Erckel's Francolin[d]	*Pternistis erckelii*	161	0.60
Hawaiian Amakihi[ab]	*Hemignathus virens*	1075	4.00
Hawaiian Hawk[ab]	*Buteo solitarius*	1	0.00
House Finch[ac]	*Haemorhous mexicanus*	373	1.39
House Sparrow[c]	*Passer domesticus*	1	0.00
Japanese Bush-Warbler[c]	*Cettia diphone*	27	0.10
Japanese White-eye[c]	*Zosterops japonicus*	484	1.80
Northern Cardinal[ac]	*Cardinalis*	11	0.04
Northern Mockingbird[ac]	*Mimus polyglottos*	53	0.20
Pueo[ab]	*Asio flammeus*	16	0.06
Red-billed Leiothrix[c]	*Leiothrix lutea*	1	0.00
Rock Dove[c]	*Columba livia*	2	0.01
Sky Lark[ac]	*Alauda arvensis*	133	0.49
Yellow Fronted Canary[c]	*Serinus mozambicus*	267	0.99

[a] Migratory Bird Treaty Act listed species
[b] Native species
[c] Non-native, non-game species
[d] Non-native, game species

Discussion Avian Monitoring

Annual bird surveys address SOO task 3.2(2), several INRMP stewardship objectives that pertain to monitoring species protected under the MBTA, and 2003 BO conservation measures to monitor Palila.

We did not detect Palila, but we did detect 7 native and non-native bird species protected under the MTBA (Table 79). Since 1998, Hawaiian Amakihi, Japanese White-eye, House Finch, and Yellow Fronted Canary are often the most frequently detected species as reported in previous annual and biennial reports.

In FY 2020, we plan to issue a technical report analyzing the bird monitoring dataset from 1998 through 2019. We plan to model the data set using the DISTANCE framework to estimate population densities and abundances. We will investigate data trends and assess the feasibility of additional analyses, such as BACI, to investigate changes in bird community composition and population densities following significant management actions (e.g., ungulate removal) or catastrophic events (e.g., wildland fire).

Avian monitoring provides baseline information for ʻAmakihi and ʻApapane, species the Department of Defense (DoD) has designated as "mission-sensitive priority bird species"[12]. Monitoring baseline and assessing population trends for these species can help us understand whether ecosystem management actions, such as fencing and ungulate removal and fire risk reduction, affect populations for these 2 species at PTA. We plan to use the pending data and trend analysis to develop management plans for these species per INRMP objectives and in accordance with the DoD Natural Resource Program's *Strategic Plan for Bird Conservation and Management on Department of Defense Lands* (DoD Partners in Flight, 2014).

In addition, distance sampling techniques are not well-suited for 2 other mission-sensitive bird species that occur at PTA: Pacific Golden Plover (*Pluvialis fulva*) and Hawaiian Short-eared Owl (*Asio flammeus sandwichensis*). Another mission-sensitive species, the Hawaiian Thrush (ʻŌmaʻo, *Myadestes obscurus*), is known to occupy sub-alpine habitats on the installation that are not currently included in our annual monitoring. We recommend that management needs for these species be included in the next update for the INRMP.

Avian monitoring addresses several compliance issues simultaneously. Understanding population trends for mission-sensitive species can aid in developing population change thresholds to trigger management actions that may help to minimize population declines and may help avert the potential listing of these bird species as threatened or endangered. Managing for species before they become listed under the ESA benefits the Army because it is likely to be more cost effective and can help to reduce or prevent constraints on mission activities.

MBTA Incidental Take

Incidental take of migratory birds was not reported or observed at PTA during the reporting period.

[12] Mission-sensitive priority bird species are bird species that occur on DoD lands and are at risk of becoming listed as threatened or endangered under the federal Endangered Species Act if current populations trends continue (Department of Defense Partners in Flight, 2015)

Incidental Hawk Sightings

In the 2013 BO, we determined that military activities at PTA have "no effect" on the Hawaiian Hawk. Therefore, we do not implement conservation measures for this species, but we continue to record incidental hawk sightings at the installation. All personnel working at PTA are briefed to report incidental Hawaiian Hawk sightings at the installation.

No incidental Hawk sightings were reported during the reporting period. However, we did observe a single Hawk in December 2018 in TA 23 during annual bird monitoring (Table 79).

4.2.7 Anthricinan Yellow-Faced Bee

We implement projects for the anthricinan yellow-faced bee under SOO section 3.2(2) and these projects satisfy INRMP stewardship objectives. The anthricinan yellow-faced bee was listed an endangered under the ESA in 2016. Because the anthricinan yellow-faced bee was recently listed as endangered, we are preparing information about this species for a formal consultation under section 7 of the ESA. Information gathered during these surveys will help us prepare a Biological Assessment that describes the status of the bee at PTA and evaluates the potential effects from military activities to the bee and its habitat. We plan additional surveys for bees in FY 2020.

A single anthricinan yellow-faced bee was collected at PTA in 2004, possibly a vagrant (USFWS 2013b, USFWS 2015). We do not know the precise location of the collection, but the bee was found resting in a fruit capsule of the endangered plant, *Kadua coriacea*, which typically occurs in open *Metrosideros* treeland, a generally poor habitat for *Hylaeus* (Magnacca and King 2013). The anthricinan yellow-faced bee is typically a coastal species. While other typically coastal species occur at PTA, namely *Hylaeus flavipes* and *Hylaeus ombrias*, no additional anthricinan yellow-faced bees have been found, and a permanent breeding population at the installation is questionable (Magnacca and King 2013).

From 25–28 June 2018, a *Hylaeus* specialist, Karl Magnacca, surveyed for *Hylaeus* spp. at the installation. He did not detect the anthricinan yellow-faced bee and we are uncertain if this species is present at PTA (Appendix D, Wildlife Enclosure 2). However, this and past survey efforts have documented at least 10 *Hylaeus* species at the installation. In addition, invasive ants, such as Argentine ants (*Linepithema humile*) and Bigheaded ants (*Pheidole megacephala*), competitively excluded *Hylaeus* spp. from ant-occupied plant communities. Therefore, we surveyed selected roadsides for invasive ant species to more efficiently guide future surveys for *Hylaeus*. Results of the roadside ant surveys are presented in Section 4.3.3.

4.2.8 Blackburn's Sphinx Month

We implement projects for Blackburn's sphinx moth (BSM, *Manduca blackburni*) under SOO section 3.2(2) and these projects satisfy INRMP stewardship objectives. BSM is listed as an endangered species under the ESA and was first found at PTA in 2019. Because BSM bee was recently discovered at PTA, we are preparing information about this species for a formal consultation under section 7 of the ESA. Information gathered will help us prepare a Biological Assessment that describes the status of the moth at PTA and evaluates the potential effects from military activities to the moth and its habitat. In FY 2020, we plan to train staff to recognize and report BSM.

The BSM is one of the largest native insects in Hawaiʻi. The moth is currently known to occur in Maui, Kahoʻolawe and Hawaiʻi Island. For the first time, we documented a single BSM caterpillar within the PTA boundary on 3 July 2019 (Appendix D, Wildlife Enclosure 3). The 5th instar caterpillar was discovered on a tree tobacco (*Nicotiana glauca*) in the Keʻāmuku Maneuver Area (KMA). In the past, we documented BSM along the Daniel K. Inouye Highway through KMA, but until July 2019, we had not detected it within the PTA boundary.

Because we recently discovered this species on PTA, we do not know much about its potential distribution or other possible host plants on the installation. However, the presence of BSM on tree tobacco may be a challenge for natural resources management and military operations in KMA. Tree tobacco continues to invade PTA and as it becomes established, especially in KMA and along the western PTA boundary, BSM numbers are also likely to increase. In addition, tree tobacco grows quickly in open areas, such as fire and fuel breaks, and forms dense thickets if not controlled. As BSM presence increases along with tree tobacco in KMA, off-road maneuvers and other operations that may impact tree tobacco may be constrained.

4.2.9 Overall Summary Discussion for the Wildlife Management Section

Management of native wildlife species at PTA not only addresses our SOO tasks and INRMP objectives but is essential for maintaining compliance with several conservation measures and terms and conditions from the 2003, 2008, and 2013 BOs. We continue to monitor Hawaiian Geese at PTA and to implement management to reduce conflicts. Our management efforts at HFNWR supported the fledging of 7 goslings in FY 2018 and 20 goslings in FY 2019, which is substantial progress toward our goal of supporting 26 goslings to fledgling age annually in Army-managed areas at HFNWR. Our analysis of the Hawaiian hoary bat monitoring data has given us a better understanding of seasonal activity patterns and the likelihood of occupancy across the installation. Similarly, we continue to improve our knowledge about the Band-rumped Storm Petrel and patterns of colony attendance and breeding activity and success.

With the listing of the anthricinan yellow-faced bee and the recent discovery of BSM, we continue to investigate the presence of these species at PTA. Information on presence and distribution is essential to developing management plans for these species.

Wildlife management projects directly support Army readiness by minimizing and compensating for military-related impacts to TES and their habitats. Many of our projects implement the non-discretionary terms and conditions identified in the 2003, 2008 and 2013 Incidental Take Statements that must be met to authorize the incidental take provisions associated with Army actions. Thus, continued and consistent funding to manage wildlife species is critical to ensure compliance with the ESA while maintaining training capacity, efficiency, and effectiveness. Through our efforts, we continue to strive to attain our goals for wildlife management and to minimize potential disruptions to military activities at PTA due to conflicts with protected wildlife.

We will continue to fine-tune our planning process to identify needs and establish priorities in FY 2020. We will also continue to refine existing and develop new protocols and SOPs to better align activities with program goals and objectives as driven by the SOO, the PTA INRMP, and other compliance obligations and to provide tight linkages in the adaptive management process.

4.3 Threat Management

We implement projects to reduce or eliminate impacts to TES and their habitats from non-native animals (ungulates, small mammals, and invertebrates) and their associated impacts; to prevent the introduction and establishment of new invasive animals via military actions; and to monitor and preserve the ungulate exclusion fence units that protect TES and their habitats. Our objectives include detecting and reporting the presence of incipient or previously undocumented invasive animal species, especially reptiles, controlling invasive animal species that threaten TES and rare species, and maintaining the integrity of the ungulate exclusion fences.

Principal threats to TES and their habitats include wild goats (*Capra hircus*), sheep (feral hybrids of *Ovis aries l.*), black rats (*Rattus rattus*), mice (*Mus musculus*), mongoose (*Herpestes auropunctatus*), cats (*Felis catus*), dogs (*Canis familiaris*), and various invertebrate species (e.g., ants, aphids, and scales). Depending on the target species, we implement several methods to control or deter invasive species: physical (live traps, lethal traps, shooting and fences), and chemical (pesticides).

The overall operational goals of the Threat Management Section are to:

- Maintain the ungulate exclusion fence integrity to prevent ingress by ungulates;
- Maintain ungulate-free status in all ungulate exclusion fence units;
- Survey, control, and minimize impacts from small mammals and rodents that threaten ESA-listed and rare plant species persistence at PTA;
- Survey for and control newly introduced invasive animal species discovered at PTA;
- Educate and increase awareness among military unit leaders (e.g., Commanders, Officers in Charge, Range Safety Officers, and Non-commissioned Officers) and contractors to avoid introduction of invasive species at PTA.

4.3.1 Ungulate Management in Ungulate Exclusion Fence Units

There are 15 ungulate exclusion fence units at PTA totaling 138 km in length that protect 15,092 ha of native habitat. Since 2017, all 15 fence units have been ungulate-free. To maintain the fences ungulate-free, we implement: 1) incidental sighting reporting, 2) camera surveillance monitoring, 3) fence line inspections, 4) ungulate monitoring with radio telemetry, and 5) aerial surveys. If ungulate ingress is detected from these actions, we then implement animal removal. Removal activities include live trapping, drives, and shooting.

Ingress Monitoring Methods

To monitor for ungulate ingress into the fence units, we collect incidental sighting data, use surveillance cameras to monitor high-use entry points into the fences, inspect all fence units on a rotational basis for damage or breaches, deploy radio-collared animals (i.e., Judas animals) inside fences if needed, and conduct aerial surveys for ungulates. Although each activity has deficiencies when used alone, when combined they create a successful comprehensive approach for detecting ungulate activity inside the fence units. Any ungulate ingress confirmed by one of these methods immediately initiates coordination for ungulate removal.

To coordinate incidental sightings, we train personnel to report sightings, ungulate calls, and physical evidence (fresh scat, tracks, plant browsing, and dens) of ungulates. If ungulates are sighted, then the following information is recorded location, date and time, and information about the animals (species, number, gender, and fur coloration). Reported sightings are tracked and stored in an ArcGIS online geodatabase.

To monitor for ungulate ingress into the fences at high-use entry points, we placed 19 Reconyx HyperFire™ HC600 and 2 Browning Dark Ops Pro HD surveillance cameras at selected gates (Figure 77). Camera locations were selected based on road traffic patterns, military and construction contractor use, sizes of fence units, and areas where ungulate sightings have been observed outside of the fence unit gates. These infrared-equipped cameras remain active 24 hours a day.

We may also deploy additional surveillance cameras if an ungulate is sighted inside a fence to help confirm herd numbers and movement patterns. We may deploy cameras near reported locations of ungulate calls or physical signs to attempt to confirm the incursion and gather information about the animals.

We collect all camera SD cards on a rotational basis, review photographs for ingress, and record and report pertinent information (e.g., ingress events and gates left open or damaged).

We regularly inspect ungulate exclusion fences and gates to ensure continued functionality (see Section 4.3.5). During inspections, we look for fence damage or breaches, unstable substrate, human interaction, vegetation, and aging fence material. We search for damage severe enough to allow an ungulate breach and watch for fresh ungulate signs (spoor, plant browsing, ungulate tracks, etc.). Inspection data are recorded in an ArcGIS database and data is reviewed monthly for organization and to guide management activities.

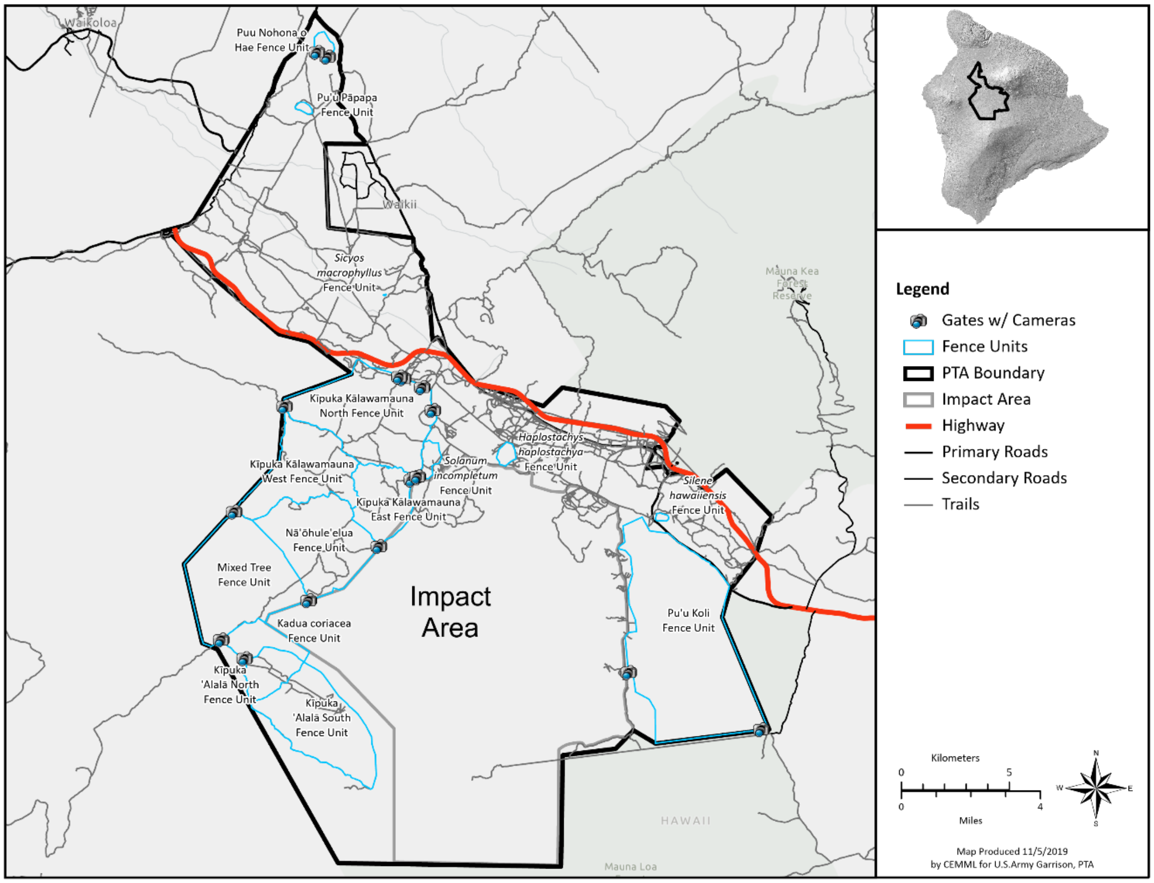

Figure 77. Ungulate exclusion fence units and surveillance camera locations at Pōhakuloa Training Area

When we suspect that animals may be present inside a fence unit, we may deploy animals fitted with VHF radio collars inside the same fence. We use collared animals when the herd location is unknown, if camera monitoring is unsuccessful at confirming animal presence, and in large fence units with dense vegetation and limited visibility. Since most ungulates prefer to herd together, the collared animal locates uncollared animals of the same species within the fence. After the collared animal joins the uncollared ungulates, we track herd movements with a VHF receiver and implement a control method (live trapping, ungulate drive, or shooting) to remove the uncollared ungulates. Once we remove all the uncollared ungulates, we then remove the collared animals. We aerial survey for ungulates within the ungulate exclusion fence units to address 2003 BO conservation measures. By helicopter we survey transects approximately 500 m apart within a fence unit, using GPS and ArcGIS maps to record the flight path. Any ungulate sighting is recorded and stored in the incidental sighting database.

For small fence units (<100 ha), we typically survey on foot since ungulates are easily tracked inside these units.

Ungulate Removal Methods

We remove any ungulates confirmed within the exclusion fences, usually by using several methods in conjunction. Methods include live trapping, drives, and shooting with or without aerial support.

To trap the animals, we use corral traps (3 to 4 interlocked panels of 12’ x 6’ galvanized welded wire) to capture ungulates. Water, plant material, or salt blocks are used to lure ungulates into the trap. We monitor traps daily and we safely release all captured ungulates outside the ungulate exclusion units. We typically use live traps when we know an animal is frequenting an area or location.

We will drive animals out of fence units if the unit is small or if the animals frequent a specific area or location. Ungulate drives are also practical in fence units with good visibility. We drive ungulates by forming a line with minimal spacing between personnel and walking toward an open gate, flushing and herding the ungulates ahead of the line and through the open gate.

We contract Hawaiʻi Game Management, LLC (HGM) to remove ungulates with lethal force. Shooters use live-fire weapons (shotgun or rifle) to kill the ungulates. All shooting operations are conducted on the ground (i.e., no aerial hunting is permitted), but shooters can use helicopter assistance to find the ungulates. Shooting is the most efficient method for removing ungulates from large fence units and is often coupled with the use of radio-collared animals.

Ungulate Management Results

We initiated monitoring to detect possible ungulate ingress into the exclusion fences based on 7 reports (4 incidental sightings, 2 camera surveillance, and 1 fence inspections). For 5 of the 7 reports, we confirmed ungulates in the fence units (Table 80). A total of 16 ungulates were detected and removed. For 1 ingress report, we were unable to confirm the presence of animals and terminated monitoring after a year. We are still investigating 1 ingress report.

Table 80. Ungulate ingress detections and their removals

Fence Unit	Area (ha)	Report Date	No. of Ungulates Detected	No. of Ungulates Removed	Methods Confirming Ingress Event			
					Incidental Sighting	Cameras	Fence inspection	Judas Animals
Kīpuka Kālawamauna North	2,155	Oct 2017	1	1	X	X		
Kīpuka Kālawamauna North	2,155	Nov 2017	1	1	X	X		
Puʻu Nohona O Hae	195	Nov 2017	6	6	X			
Nāʻōhuleʻelua	1,636	July 2018	5	5		X		X
Mixed Tree[a]	2,084	Dec 2018	Unknown	0				
Puʻu Nohona O Hae	195	Aug 2019	3	3			X	

[a] Two radio-collared animals were deployed in the Mixed Tree Fence Unit to assist in monitoring to confirm possible ungulate ingress. The collared ewe birthed 1 lamb; both animals were captured and removed from the fence unit. A single collared ram remains in the Mixed Tree Fence Unit.

Through our camera surveillance, we documented 96 times that vehicle gates were left open and unattended. One time, 5 ungulates entered the Nāʻōhuleʻelua Fence Unit (Figure 78). We investigated one other possible ungulate ingress associated with an open gate, but further investigations (e.g. surveillance cameras, ground surveys, and aerial surveys) failed to detect ungulates in the fence unit. Most of 717,052 photos recorded at the vehicle gates showed personnel entering and exiting the fence units. In addition, some photos detected mongoose, feral cats, dogs, game birds and ungulates (outside of the fence unit).

We supported 5 removal operations with camera surveillance. Cameras took a total of 121,254 photos. We documented uncollared ungulates inside the Kīpuka Kālawamauna North Fence Unit and Nāʻōhuleʻelua Fence Unit, and a collared ram inside the Mixed Tree Fence Unit.

Figure 78. A photo of sheep entering the Nāʻōhuleʻelua Fence Unit through an unattended open vehicle gate

We deployed 3 radio-collared animals into 2 fence units to confirm ungulate presence or assist removal operations. We deployed a collared ram to facilitate removal of 5 sheep from the large and densely vegetated Nāʻōhuleʻelua Fence Unit on 19 November 2018. Previously, we tried to remove the sheep with ungulate drives and live traps but were unsuccessful. On 15 December 2018, HGM personnel tracked the collared ram and shot it along with 4 uncollared sheep.

Two other Judas animals were deployed to the Mixed Tree Fence Unit to further investigate a possible ingress that was reported on December 2018. A collared ewe was released on 8 Jan 2019 and a collared ram on 21 February 2019. The ewe did not join other sheep and gave birth to a lamb in May 2019. We captured the ewe and lamb in a live trap and removed them from the fence unit on 4 June 2019. The ram remains inside the Mixed Tree Fence Unit and we continue to monitor it for association with other ungulates in the fence. We plan to remove the ram in December 2019.

HGM staff conducted aerial surveys in 2018 and 2019. HGM staff canvassed the ungulate exclusion fence units on 15, 20 and 22 June 2018 for a total of 8.9 hours over the 3 days (Figure 79). In addition, HGM staff surveyed the ungulate exclusion fence units on 15 and 20 June 2019 for a total of 9.4 hours over 2 days (Figure 79). No ungulates were detected during the aerial surveys.

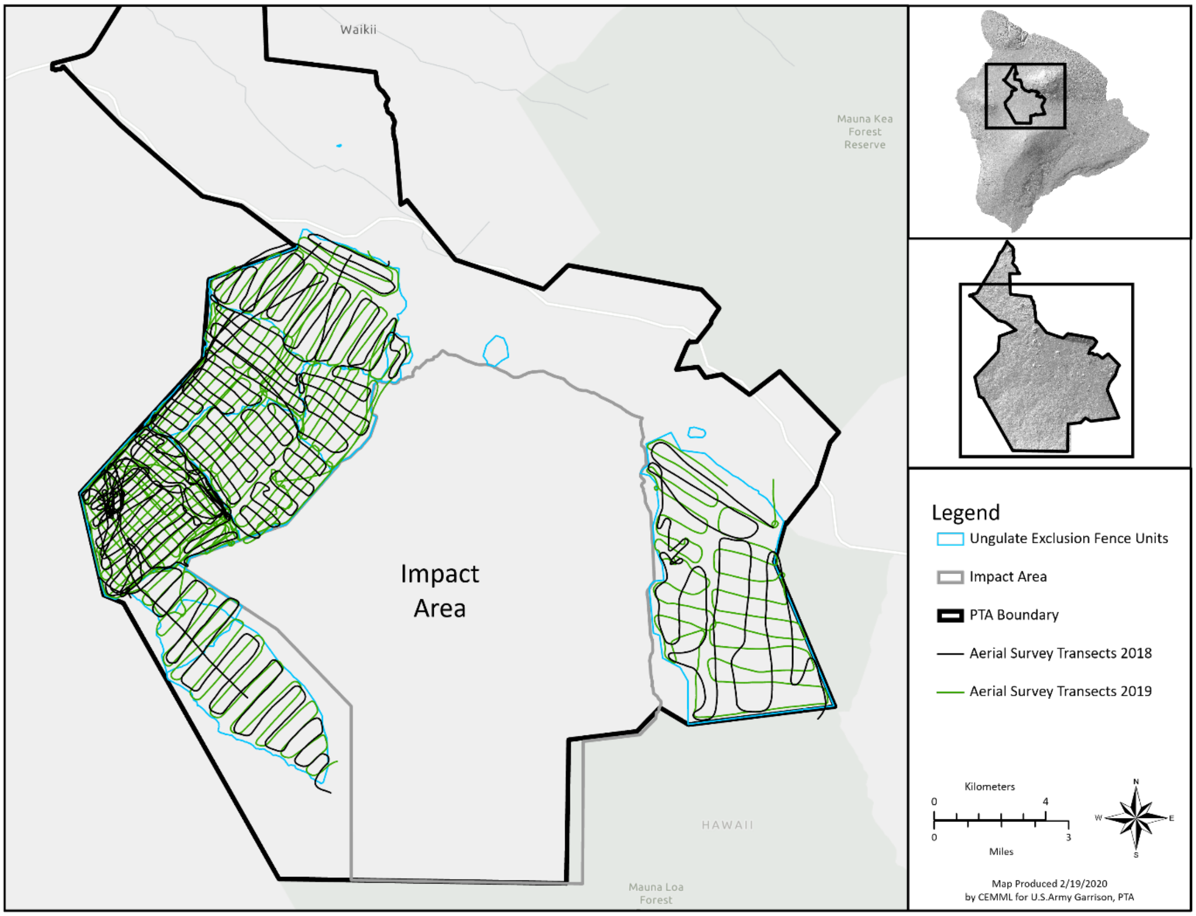

Figure 79. Hawai'i Game Management aerial survey transects conducted at Pōhakuloa Training Area during FY 2018–FY 2019

Ungulate Removal Results

We successfully removed the 16 uncollared ungulates that we confirmed, via our monitoring efforts, inside the fence units. During the reporting period, a total of 5 ungulate removal operations were conducted: 2 in the Kīpuka Kālawamauna North Fence Unit, 2 in the Puʻu Nohona O Hae Fence Unit, and 1 in the Nāʻōhuleʻelua Fence Unit (Table 81).

Base on ingress reports, we responded twice to remove animals from the Kīpuka Kālawamauna North Fence Unit. In October 2017, we shot and removed one animal. In November 2017, we deployed live corral traps and successfully removed 1 goat.

We removed 5 sheep from the Nāʻōhuleʻelua Fence Unit. We first attempted to drive the animals from the fence over 2 days, but only 1 ram exited the fence. HGM staff shot the remaining 4 uncollared animals and the collared ram in December 2018.

In addition, we trapped a collared ewe and her lamb that were deployed inside the Mixed Tree Fence Unit and removed them from the fence in February 2019.

Table 81. Ungulate removal operations per fence unit at Pōhakuloa Training Area during FY 2018–FY 2019

Fence Unit	Area (ha)	Report Date	No. of Ungulates Detected	No. of Ungulates Removed	Removal Methods		
					Live Trapping	Ungulate Drive	Shooting
Kīpuka Kālawamauna North	2,155	Oct 2017	1	1			1
Kīpuka Kālawamauna North	2,155	Nov 2017	1	1	1		
Puʻu Nohona O Hae	195	Nov 2017	6	6		6	
Nāʻōhuleʻelua	1,636	July 2018	5	5		1	4
Puʻu Nohona O Hae	195	Aug 2019	3	3		3	

Discussion for Ungulate Management

We successfully removed 16 ungulates from the PTA ungulate exclusion fence units, and we continue to meet regulatory obligations for sustaining ungulate-free fence areas. As demonstrated by the numerous incursions, our monitoring and removal efforts are essential to maintaining the fences ungulate-free. Constant pressure from ungulates outside the fence units, the need for civilian contractors and military personnel to travel into the fence units, and reoccurring fence damage from weather events, unstable substrates, and human activity increase the likelihood of future ungulate incursions. By maintaining a system to monitor for incursions and quickly remove ungulates, we meet our INRMP objectives and 2003 BO conservation measures to reduce the negative effects associated with ungulates to TES habitats and ESA-listed plants. Maintaining the fenced habitats ungulate-free demonstrates effective ecosystem management that confers benefits to a wide range of native species including the 20 ESA-listed plants and 27 additional plants that meet the definition of a species at risk of being listed as threatened or endangered under the ESA.

4.3.2 Small Mammal Management

Projects implemented under the Threat Management Section address SOO task 3.2(2)(d), INRMP objectives, and conservation measures identified in the 2003 BO. We control small mammals (rodents, mongoose, feral cats, and feral dogs) to minimize potential impacts to TES at PTA. Because small mammal control is resource intensive, we apply targeted control under specific conditions. For example, although rodent control for 3 ESA-listed plants[13] is described as on-going conservation actions and conservation measures in the 2003 BO, we typically apply rodent control only when we observe rodent damage to plants.

Rodents damage a wide variety of plants in Hawaiʻi and they severely reduce reproduction of certain plants by consuming many fruits or seeds (Sugihara 1997; Cole et al. 2000; Gillies and William 2013; Pender et al. 2013). For ESA-listed plants at PTA, we typically control rodents to minimize their damage to vegetative and reproductive parts of the plants. When rodent damage to plants warrants a management response, we monitor with surveillance cameras and tracking tunnels to assess rodent activity near the plants. Rodent control may include live trapping and lethal trapping.

We monitor the Priority Species 1 plants quarterly and record any plant damage caused by rodents (see Section 2.2.3). Once damage is detected, we control rodents to minimize rodent populations around the plants.

We continue to implement continuous rodent control for at ASR 41/213 to protect both a natural occurrence and outplantings of *Schiedea hawaiiensis* and outplantings of *N. ovata*, *S. incompletum*, and *Z. hawaiiense*.

In addition, per conservation measures in the 2013 BO, we control small mammals to reduce the number of predators that depredate Hawaiian Goose nests, eggs, goslings or molting geese inside designated safe areas (e.g., Wildlife Enhancement Area). If there is evidence of depredation of other ESA-listed animals, we evaluate the situation and apply control designed for each site. To manage for predatory small mammals (mongoose and cats), we deploy surveillance cameras to monitor for presence/absence of predators and use only live traps to remove them. If feral dog control is needed, HGM is contracted to remove the dogs.

Small Mammal Management Methods

Monitoring Methods

Tracking tunnels are used to detect the presence/absence of small mammals. This technique is widely used to assess if there is a change in rodent activity before and after the control event (Gillies and Williams 2013). At PTA, we space tracking tunnels 25 m apart and bait them with peanut butter or Goodnature® chocolate lure. Rodents pass through the tunnel and leave footprints behind, which in many cases can be used to identify the animal species. Activity levels by species (e.g., percent of tunnels with tracks of a given species) are compared before and after trapping periods. Tracking tunnels are deployed quarterly and left on site for 3 consecutive days.

We deploy Reconyx HyperFire™ HC600 and or Browning Dark Ops Pro HD surveillance cameras in areas where we observe plant damage. These infrared-equipped cameras remain active 24 hours a day and are set to record pictures or video by motion detection.

[13] *Neraudia ovata*, *Solanum incompletum*, and *Zanthoxylum hawaiiense*

Primarily, we use cameras to record the animals responsible for observed damage. For all cameras, we collect SD cards on a rotational basis and review photographs for rodent activity.

Control Methods

We used Little Giant® (36"X11.5"X13.5") and larger Tomahawk® (16"X5"X5") traps primarily for cats but these traps were also capable of capturing mongooses and rodents. We spaced these traps between 50 m and 100 m apart for mongoose and cats, respectively. We used a smaller Tomahawk® (30"X10"X12") trap spaced between 25 m and 50 m apart to capture rodents and mongooses, respectively. All the traps were baited with a single can of sardines (Beach Cliff Sardines in soybean oil) with scent holes punctured in the top and were checked daily.

For lethal trapping of rodents, we used snap traps (Victor® or Kress™ Snap-E traps) and self-resetting traps (Goodnature® A24 rat + stoat traps, Goodnature Limited, Wellington, New Zealand). The self-resetting traps (hereafter referred to as A24 traps) were spaced 50 m apart and typically baited with a Goodnature® chocolate lure bait. We replaced the bait and $C0^2$ canisters quarterly. Snap traps were spaced between 25 m and 50 m apart and baited with peanut butter or Goodnature® chocolate lure bait. We typically checked snap traps weekly. Because A24 traps are not checked daily, the total number of rodents killed cannot be accurately determined. In many cases when checking the A24 traps, we found mongoose and rodent carcasses next to the trap.

Small Mammal Management Results

Rodent Control for Schiedea hawaiiensis

We controlled rodents using various monitoring and control methods at ASR 41/213 for *Schiedea hawaiiensis* and other ESA-listed species that were outplanted. To track the presence of black rats and mice, we deployed 9 tracking tunnels every quarter from June 2018–September 2019. The percent of boards tracked by black rats and mice ranged from 0%–22% and 0%–88%, respectively (Table 82). We also deployed and maintained 9 A24 traps and observed evidence of kills.

Table 82. Percent of tracking tunnels tracked by species by monitoring quarter at ASR 41/213

Rodent Species	Dates					
	6/7/2018	9/24/2018	1/07/2019	3/25/2019	6/10/2019	9/16/2019
Black rat	0%	11%	22%	0%	0%	0%
House mouse	0%	55%	88%	0%	11%	22%

Small Mammal Control to Protect the Band-rumped Storm Petrel

In response to rodents and feral cat presence in Band-rumped Storm Petrel nesting areas, we controlled predators in TA21 for a total of 33 trap nights over 3 separate trapping periods: from 1–12 October 2017, 23 April 2018–30 May 2018, and 8 April 2019–8 May 2019.

We captured 1 black rat and 3 feral cats and found numerous black rat and mouse carcasses next to A24 traps. All rodent carcasses were collected and removed. Refer to Section 4.2.5 for a detailed description of the small mammal control operations for the Band-rumped Storm Petrel.

Small Mammal Control to Protect the Hawaiian Goose

We did not control predators at PTA for Hawaiian Geese because we did not observe any molting or breeding activity.

To protect goose nests, eggs, and goslings at Hakalau Forest National Wildlife Refuge (HFNWR) from rodents, mongoose and feral cats we controlled predators with live traps over 2 trapping periods; from 23 October 2017–18 April 2018 and from 18 September 2018–10 April 2019. Refer to Section 4.2.3 for a detailed description of the small mammal control operations at HFNWR.

Discussion for Small Mammal Management

At ASR 41/213 *Schiedea hawaiiensis* and *N. ovata* had high levels of rodent damage (i.e., bite marks on leaves and stems, broken stems). Following deployment of the A24 traps, we recorded a large decrease in black rat activity in the area, which ranged from 0–22% over the quarters monitored. We also noted a decrease in rodent damage on *Schiedea hawaiiensis* and *N. ovata* plants during quarterly Priority Species 1 plant monitoring. Studies have demonstrated a benefit to native plants and animals when tracking tunnel activity is approximately 20% or less post-treatment (Pender et al. 2013; Shiels et al. 2019). Pender et al. (2013) found a reproductive benefit to the endangered Hawaiian lobeliad (*Cyanea superba*) when rodent activity was reduced to 20% of tracking tunnels. In the future we plan a similar evaluation to determine a level of rodent activity at which rodent damage to the ESA-Listed plant is absent or minimal.

Next year we plan to mount the A24 traps on Goodnature® A24 portable rat trap stands. We used these stands in TA 21 and observed a higher kill of mice. In addition, we plan to evaluate the feasibility of implementing rodent control at other sites where ESA-listed plants are being impacted by rodents.

Although it is difficult to make a direct connection between small mammal control activities and survivorship of Hawaiian Geese and Band-rumped Storm Petrels, we assume that the removal of predators benefits these species. For example, the removal of 27 predators (3 feral cats, 18 mongooses, and 6 rats) at HFNWR is likely to have a positive effect by decreasing predator pressure on the Hawaiian Goose during breeding season. In addition, removing 3 feral cats and numerous rodents at the seabird colony likely decreased predator pressure on breeding Band-rumped Storm Petrels. In FY 2020, we plan to trap for the entire breeding season.

Control of small mammals that depredate ESA-listed plants and animals is a critical tool for minimizing the negative effects from these predators to the listed species and to maximizing the potential for the listed species to persist and successfully reproduce. However, small mammal control is costly and resource intensive, so we apply this tool strategically to maximize the potential benefits to the ESA-listed species. Because many of these small mammalian predators have high reproductive rates, we need to apply near-constant control measures either year-round (mostly for plants) or seasonally during key reproductive periods. Continuing small predator control projects will help reduce impacts from small mammals to ESA-listed species at select sites and help to ensure the persistence of these listed species.

4.3.3 Roadside Ant Mapping Project

Anthricinan yellow-faced bees (*Hylaeus* spp.) are competitively excluded from plant communities occupied by invasive ant species such as Argentine ants (*Linepithema humile*) and Bigheaded ants (*Pheidole megacephala*) (Karl Magnacca, personal communication, 2018). Because anthricinan yellow-faced bees pollinate many native Hawaiian plants, including keystone species such as *Metrosideros polymorpha* (ʻōhiʻa) and *Sophra crysophylla* (māmane), a reduction in the bee's pollinator services due to invasive ants likely has a cascading effect on native plant communities. In addition, in 2016, the USFWS listed the anthricinan yellow-faced bee (H*ylaeus anthracinus*) as endangered (see Section 4.2.7 for details). To help guide surveys for *Hylaeus* spp., particularly the anthricinan yellow-faced bee, we surveyed for invasive ants along selected roadsides at PTA.

Survey Methods

We used a systematic sampling design to investigate the presence of ants within 5 m of major roads. We sampled at 100-m intervals; where we found ants, we resampled at 25-m intervals until we did not detect ants at an adjacent station. Sample locations were generated in the GIS and staff used electronic GPS-equipped devices (Motorola phones) to navigate to the approximate location in the field.

We sampled only during clement weather with temperatures between 12.5° C–30.0° C. At the sample location, we deployed a single vial baited with a protein and a sugar source (peanut butter, Spam or tuna and jelly or jam) and placed bait vials in the shade where possible and near areas where ants might forage. We left the vials in place for a minimum of 45 minutes before collecting the vial.

We opportunistically searched the sample location if no ants were present in the vial upon retrieval after 45 minutes. We visually scanned key areas, such as flowering plants, under rocks/sticks, and near water, for about 30 seconds. Observed ants were captured via aspirator.

All ants collected were identified to the lowest taxon possible using dichotomous keys (Discover Life 2019; PIAkey 2019). For unknown species, we submitted specimens to the Hawaiʻi Department of Agriculture, Hawaiʻi Ant Lab for identification.

We mapped all detections of ants. We pooled presence data for all ant species to determine the overall frequency of occurrence of ants in the sampled areas. We examined presence data by species to determine the most commonly occurring species in the sampled areas and evaluated data for patterns of co-occurrence or exclusion of certain species.

Results

We sampled 1,990 survey points and detected ants using baited vials or opportunistic surveys at 943 or about 47% of the points (Figure 80). The Argentine ant (*Linepithema humile*) and the Cardiocondyla ant (*Cardiocondyla venustula*) were the most frequently detected species, accounting for 16% (320 points) and 13% (263 points) of all detections, respectively (Table 83).

Table 83. Invasive ant survey results by species and total number of locations at which each species was detected

Species	Number of Locations Present
Argentine ant (*Linepithema humile*)[a]	320
Cardiocondyla ant (*Cardiocondyla venustula*)	263
Pharaoh ant (*Monomorium pharaonic*)[a]	118
Big-headed ant (*Phiedole megacephala*)[a]	109
Tiny yellow house ant (*Tapinoma melanocephalum*)[a]	54
Unknow spp.	38
Hypoponera ant (*Hypononera opaciceps*)	33
White-footed ant (*Technomyrmex albpes*)	5
Black household ant (*Ochetellus glaber*)	1
Confusing yellow pennant ant (*Tetramorium caldarium*)[b]	1
Pennant ant (*Tetramorium bicarinatum*)[b]	1

Note: Species in bold were recorded for the first time at PTA during the survey in 2018. Species underlined were recorded on Army lands in Oahu in 2013.

[a] Species are included in a list of 8 major global ant pests (Wetterer and Garcia 2015).

[b] Species are included in a list of 15 ant species that are widespread globally, but are not considered significant pests (Wetterer and Garcia 2015).

At most sample sites with ants, we found a single species. However, at 4 locations we discovered the Cardiocondyla ant (*Cardiocondyla venustula*) and the pharaoh ant (*Monomorium pharaonic*) at the same site. These were the only 2 species that we discovered together.

We discovered 3 species that had not been previously recorded from PTA – the black house ant (*Ochetellus glaber*), the bicolored pennant ant (*Tetramorium bicarinatum*), and the confusing yellow pennant ant (*Tetramorium caldarium*) ant.

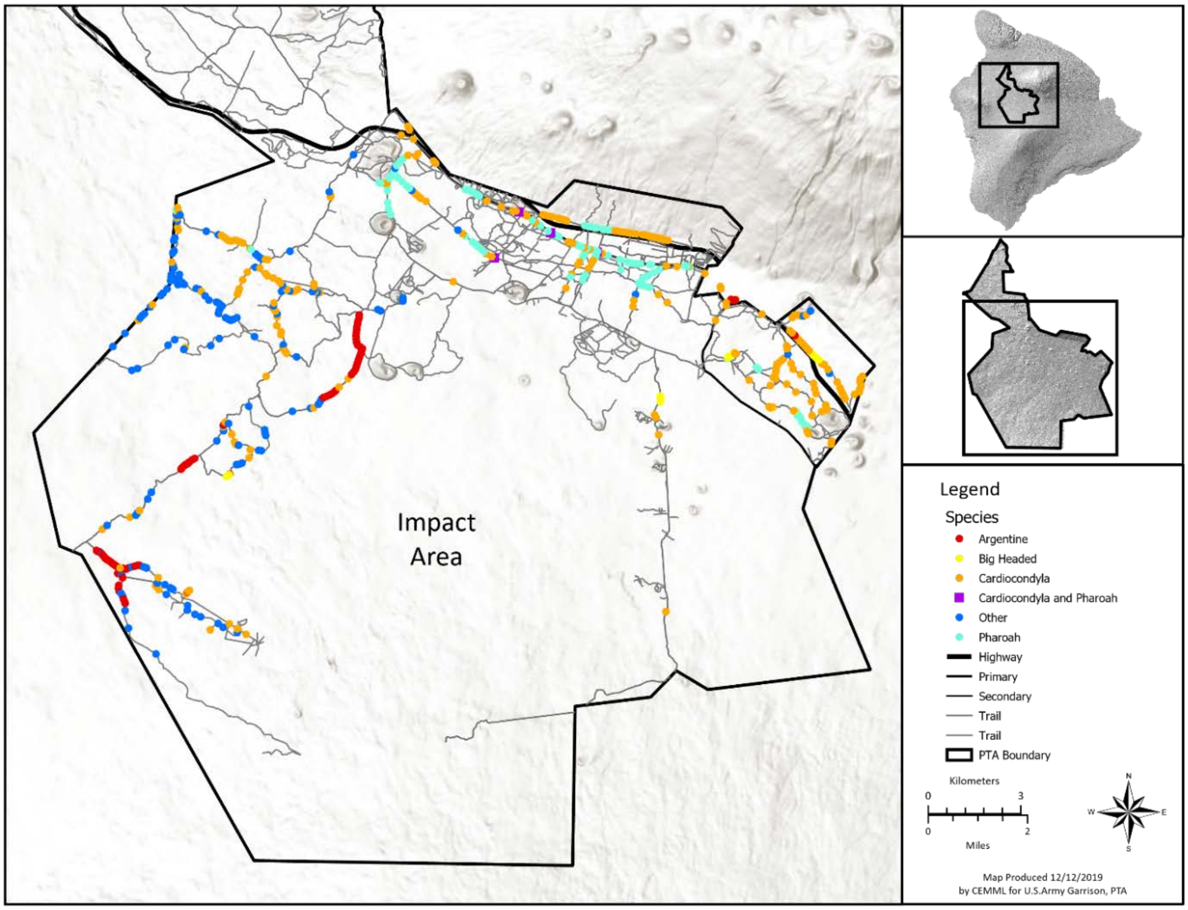

Figure 80. Roadside invasive ant mapping results at Pōhakuloa Training Area

Roadside Ant Mapping Discussion

Our efforts to map invasive ants will guide future surveys for *Hylaeus* spp. and help to determine if *H. anthracinus* is present at PTA. In addition, mapping ants addresses INRMP objectives and 2003 BO conservation measures.

We discovered the black household ant in TA 22 along the Multi-purpose Range Complex (MPRC) Access Road. We are uncertain of the distribution of this new species as we only surveyed within 5 m of the road. The black household ant was first reported in Hawaiʻi in 1977 and is considered an invasive species. The species is originally from Australia and it lives in rotten wood, in the ground, under rocks or stones and in urban areas. This species tends to associate with some insects, such as mealybugs and aphids. During the nuptial flight, queens mate with either one or multiple males. Sometimes, a subset of a colony will disperse from the main colony to an alternative nest site. The black household ant has the potential to cause long-term ecological impacts in areas where it is not native.

We recorded the bicolored pennant ant for the first time at PTA in TA 19 along a fuel break. We do not know the current extent of this ant at PTA because our efforts were limited to within 5 m of roadsides. The bicolored pennant ant is globally cosmopolitan and is likely established on all major Hawaiian Islands. The bicolored pennant ant nests in exposed soil or under stones, in rotting wood, under tree bark or in plant stems. Colonies of pennant ants are usually small to moderate in size. Nests can have multiple queens and workers can vary in color and size. It is believed that inseminated queens can find new colonies without the aid of worker ants. This species is not aggressive but occasionally stings humans. This ant farms sap-sucking insects such as scale insects and is considered a minor agricultural pest.

Lastly, we recorded the confusing yellow pennant ant for the first time at PTA along the Kona Highway between TA 20 and 22. We are uncertain of the distribution of this new species as we only surveyed within 5 m of the road. This ant derives its name from taxonomic confusion with another closely related species *Tetramorium simillimum* (Wetterer and Garcia 2015). Little is reported about the ecology of *T. caldarium*, but Wetterer and Garcia (2015) state that *T. caldarium* seems to prefer more arid environments than *T. simillimum*. At this time, *T. caldarium* is not considered a pest.

All 3 ant species that were recently discovered at PTA have been recorded on Army lands in Oʻahu by Natural Resources staff between 2013 and 2017 at several high-use military sites (Table 84). Although we cannot definitively know that these species were introduced from military activity, we need to examine ways to minimize transfer of invasive invertebrates between islands to minimize negative ecological impacts associated with invasive ants.

Table 84. Ant species reported from Oʻahu Army lands between 2013 and 2017 that are also found at PTA[a]

Oʻahu Management Unit	Ant Species Found at Oʻahu Management Site and Common to PTA
OANRP Base yard	*P. megacephala*
Ekahanui	*Technomyrmex albipes*
Kalaukauila	***Ochetellus glaber***, *Pheidole megacephala, T. albipes*
Kahanahaiki	*Cardiodondyla venustula, T. albipes,* ***Tetramorium simillimum***
Kaluaa	*P. megacephala*
Makaha	*P. megacephala, T. albipes*
Pahole mid-elevation nursery	***O. glaber***, *T. albipes,* ***Tetramorium bicarinatum***
Kaena east of Alau	***O. glaber***, ***T. simillimum***, and ***Tetramorium caldarium***

Note: Species in bold were documented at PTA for the first time at PTA during the survey in 2018.

[a] Data are from the 2013, 2015, and 2017 OANRP Makua and Oʻahu Implementation Plan Status Reports.

4.3.4 Early Detection and Control of Invasive Animal Species

We implement early detection and invasive species control projects to meet SOO tasks 3.2(2)(c) and 3.2(2)(d) and to address INRMP objectives and conservation measures from the 2003 and 2013 BOs. The goals for early detection are to detect new introductions of invasive animal species before they become established and to contain or eradicate the species when possible. These goals are met by conducting surveys within the Bradshaw Army Airfield (BAAF) environs, at construction and auxiliary sites, on plant or plant products brought to PTA, and on incoming machinery, vehicles, and construction equipment.

<u>Early Detection Survey and Monitoring Methods</u>

To fulfill conservation measures from the 2003 BO, we systematically survey and monitor for invasive animals and track incidental sightings.

Systematic Survey and Monitoring Methods

We use baited traps to systematically survey or monitor for invasive invertebrate species (e.g., invasive ant species) at construction sites, off-site quarries, auxiliary sites, on plants or plant products brought to PTA, and on incoming machinery, vehicles, and construction equipment. Bait traps are deployed in grid patterns, along roadsides, or on equipment or vehicles. Traps are baited with a small piece of a protein and a sugar source (peanut butter, Spam or tuna, and jelly or jam) and deployed between 5-m or 100-m intervals depending on the location or equipment/vehicle being inspected. We collect traps 45 minutes after deploying. All invertebrates found in or around the trap are collected or photographed and collected invertebrates are brought back to PTA for identification to the lowest taxon possible.

In addition, we implement visual encounter surveys along established transects within the BAAF environs and at construction and auxiliary sites. We search for basking reptiles and uncommon or new animals within 5 m of each transect line. Surveys are conducted primarily during mid-morning when reptiles or invertebrates are most likely to be active and visible. We search under rocks, branches, human-made structures; items that are moved are replaced in their original position to minimize disturbance to habitat. We collect or photograph any new or uncommon invertebrate and identify the animal to the lowest taxon possible. In addition, we inspect the security fences surrounding the perimeter of BAAF for brown tree snakes (e.g., skins or snakes coiled on fence) during the quarterly Hawaiian hoary bat barbed wire fence inspections.

Construction personnel are also trained to inspect for invasive ants, particularly the Little Fire Ant (LFA, *Wasmannia auropunctata*) on all heavy-duty, earth-moving equipment (e.g., bulldozers, excavators, rock crushers, rollers) and items that would remain in place for more than several days (e.g., temporary office buildings, storage containers). All incoming contractors are provided the PTA Invasive Pest Prevention SOP and other invasive species materials.

Incidental Observations Methods

We report incidental detections of all newly introduced animal detected outside systematic surveys. We brief all civilian and military personnel working at PTA to report incidental sighting of reptiles, particularly the brown tree snake. We train contractors on decontamination procedures for machinery, vehicles, and equipment prior to entering and before leaving PTA to minimize risk of transporting invasive animal species.

Incidental sightings include sightings, auditory reports (sound), or physical evidence of unknown or unusual animal species.

All reported sighting data are tracked and stored in a database. Data are reviewed monthly for organization and analysis.

Early Detection Survey and Monitoring Results

Systematic Monitoring Results

We inspected BAAF in 7 of 8 quarters (1 quarter was skipped due to heavy military training on the airfield). No newly introduced invasive animal species nor evidence of brown tree snakes (e.g., skins or snakes coiled on the perimeter BAAF fence) were detected

We inspected 3 different off-site aggregate quarries, for a combined total of 11 inspections, for invertebrate invasive species. During 1 inspection at one quarry, we found an ant (*Paratrechina* spp.) at an aggregate pile. While this genus is known to exist in the Hawaiian Islands, it has never been documented at PTA. Therefore, we recommended that the contractor use another quarry to prevent the risk of introducing a new ant species to PTA. The contractor selected a different quarry and the aggregate materials did not have any invasive invertebrates.

We completed 7 invasive invertebrate inspections on incoming equipment and materials. No invasive animals were detected during the inspections.

Contractors reported finding LFA during an inspection of their materials in September 2018. We confirmed the material had LFA and canceled delivery of the materials until new, clean materials could be obtained.

Incidental Sightings Results

During this reporting period, no incidental sighting reports were received, and no snakes or lizards were detected.

Early Detection and Control of Invasive Animals Species Discussion

We continue to implement projects to manage invasive animals according to INRMP objectives and conservation measures identified in BOs. Our early detection efforts prevented materials infested with highly invasive ant species (*Paratrechina* spp and LFA) from entering PTA on 2 occasions.

Although the immediate benefit of early detection programs may not be readily apparent, adequately funding and staffing such programs can help minimize potential future costs to control or manage new infestations of highly invasive species that degrade training lands and impact the mission (Boice et al. 2010). Supporting and implementing early detection and invasive control projects is aligned with Department of Defense Pest Management Program objectives (DoD 2008) and Army Regulation 200-1. Implementing actions to prevent the establishment of new invasive species (e.g., LFA, rabbits, and

African killer bees) typically requires less time, effort, and funding than responding to and managing infestations of new invasive species.

4.3.5 Fence Maintenance

Fence maintenance meets SOO task 3.2.(2)(e) and addresses INRMP objectives to protect TES habitats and several conservation measures in the 2003 and 2008 BOs. We regularly inspect 138 km of ungulate exclusion fence (15 fence units) and 107 gates to ensure continued functionality.

Fence Maintenance Methods

To maintain the 15 ungulate exclusion fence units ungulate-free, we systematically assess the fence integrity monthly, quarterly, or bi-yearly, based on the priority level of fence line. We check for breaches, identify objects along fence corridors that could potentially damage the fence (e.g., overhanging branches, loose rocks), identify potential ingress points, and monitor the fences for degradation. We ensure all locks and latches are working properly and gates are securely closed and functional. We also inspect all PTA barbed wire security fences on a quarterly basis for Hawaiian hoary bat entanglements and track incidental damage reports.

During inspections, we look for fence damage or breaches caused by adverse weather, unstable substrate, human interaction, vegetation, and aging of fence material. We search for damage severe enough to allow an ungulate breach and watch for fresh ungulate signs (spoor, plant browsing, ungulate tracks). To prevent premature aging of fence material and facilitate easier travel over the rough terrain for fence inspections, a 1-m corridor is cleared of vegetation, via mechanical (e.g., brush cutters, chainsaws) and chemical (e.g., herbicide) methods on each side of the fence line. We monitor the corridor during fence inspections for potential erosion risks and new vegetation growth.

Digital data collection devices (hand-held devices with ArcGIS software) streamline and optimize fence inspections. Information on fence and gate integrity, vegetation levels, and required repairs are documented, tracked, and mapped using these devices in 500-m segments. The data are used to coordinate and schedule the required repairs and vegetation control efforts as well as track fence maintenance activity over time. Inspection data are recorded in an ArcGIS database and reviewed monthly for organization and analysis.

Surveillance cameras monitor for damage at 21 ungulate exclusion gates. We review photographs and schedule gate repairs as needed. We immediately initiate repairs to maintain fence integrity.

Personnel working and training at PTA are briefed to report damage or issues with fences or gates. Reports are submitted using ESRI ArcGIS Collector and housed in ArcGIS Online geodatabases for organization and analysis.

Fence Maintenance Results

We inspected 1,023 km of fence line and completed 31 major fence repairs (damage severe enough to possibly allow an ungulate breach). We removed 8 fallen trees from fence lines, fixed 18 locations with erosion damage below the fence, and replaced fence damaged by vehicle strikes 7 times. In addition, 39 damaged gates were discovered and repaired. Gate repairs included replacing bent door frames and broken hinges, lubricating or replacing rusted locks, straightening or replacing bent drop rods, welding fence skirts, and replacing faded or cracked signs.

Numerous minor repairs were also completed during fence inspections and were not considered serious fence integrity issues. Therefore, these small maintenance repairs were not individually documented. Minor repairs during this reporting period included stretching fence wire in areas where fence had become loose, replacing fence clips, replacing fence anchors and t-posts, closing small gaps between fences and substrate, and replacing locks and latches on gates.

We spent over 672 hours clearing vegetation (approximately 592 hours applying herbicides, approximately 80 hours cutting brush) along the fence corridors. We applied 2,210 gallons of herbicides on invasive plants covering about 60 ha along fence line corridors. These vegetation-free corridors along the fence lines are crucial for maintaining fence line integrity and continue to play a major role in supporting the ungulate control project.

Cameras detected 6 instances where vehicle gates were damaged by vehicle strikes or by personnel forcing the gates open. Four of the damaged gates were reported (incidental reports) and 2 were not reported. All gates were repaired, and no ungulates were detected entering the fences through the damaged gates.

Military personnel, contractors, and our staff submitted 5 incidental fence damage reports (4 gates and 1 fence line). All damages were repaired, and no ungulates were detected entering the fences through the damaged gates.

Fence Maintenance Discussion

Maintaining fence and gate integrity is essential to preventing animals from accessing the fences and the habitats inside. Through these activities, we continue to meet INRMP objectives and conservation measures in BOs. We have successfully maintained the 15 ungulate exclusion fences ungulate-free for the last 2 years. Research has shown that excluding ungulates from fenced areas can result in increases in ESA-listed species (see Section 7.6.1 for more details about this research project conducted at PTA). Our efforts to maintain the fences and minimize opportunities for incursions further our efforts to increase the abundance and distribution of ESA-listed species and other plants at risk of being listed as threatened or endangered under the ESA.

4.3.6 Overall Summary Discussion for the Threat Management Section

At PTA, management of invasive species is essential to help conserve native habitats that support TES and species at risk[14]. Through the implementation of our SOO tasks, we continue to work towards our program goals and INRMP objectives and maintain compliance with several conservation measures from the 2003 and 2013 BOs. In general, we met standards for ungulate and small mammal control and maintained the fences to prevent ungulate ingress to protected areas. In addition, we continued with our early detection programs and efforts to map invasive ants. Through these efforts, we are progressing toward our goal of protecting and improving habitats for TES.

During the reporting period, operational goals were achieved for most projects in the Threat Management Section. Significant program achievements include removing predators prior to the Band-rumped Storm Petrel arrival to the colony, continuing to maintain an ungulate-free status (since 2017) in all of the ungulate exclusion fence units, roadside mapping of invasive ant distribution at PTA, and implementing a new request procedure for the use of off-site aggregate at PTA. In FY 2018 and FY 2019, electronic data collection methods were implemented to improve the process for recording control of small mammals and surveying for invasive invertebrates at PTA and off-site quarries.

Invasive species management supports Army readiness in multiple ways. Invasive animal species can modify ecosystems through impacts at multiple trophic levels (e.g., pollination by insects, seed dispersal by birds). Early detection and rapid response to new invasions cost less in the long run than controlling invasive species once they are established and widespread (Boice et al. 2010). Likewise, control of invasive invertebrates and other newly introduced animals in the BAAF environs or other monitored locations, are more cost effective and result in less impacts than the alternatives of no or delayed action. Thus, continued and consistent funding to manage invasive species is critical to ensure we can cost effectively address our goals of detecting, controlling, and/or eradicating invasive animals to prevent impacts to TES and high value resources.

We will continue to fine-tune our planning process to identify needs and establish priorities in FY 2020. We will also continue to refine existing and develop new protocols and SOPs to better align activities with program goals and objectives as driven by the SOO, the PTA INRMP, and other compliance obligations and to provide tight linkages in the adaptive management process.

[14] Species at risk are defined as plant and animal species and associated habitats that are not ESA-listed as threatened or endangered under 16 USC Chapter 35 (ESA), but are either ESA-listed as candidates or are ranked by NatureServe as critically imperiled or imperiled throughout their range (AR 200-1, 2007).

5.0 GAME MANAGEMENT PROGRAM

5.1 INTRODUCTION

The Game Management Program manages introduced game mammals within designated hunting areas to reduce negative impacts to Palila Critical Habitat (TAs 1–4, 10, 11) and to minimize potential ungulate ingress into the PTA ungulate exclusion fence units. The secondary benefit of the Game Management Program is to provide outdoor recreation and public access to military lands for hunting game mammals and upland game birds on approximately 156 km^2 at the installation (Figure 81). The Game Manager monitors game resources and hunter efficacy to reduce negative impact to protected natural resources and coordinates access to hunting areas for the public.

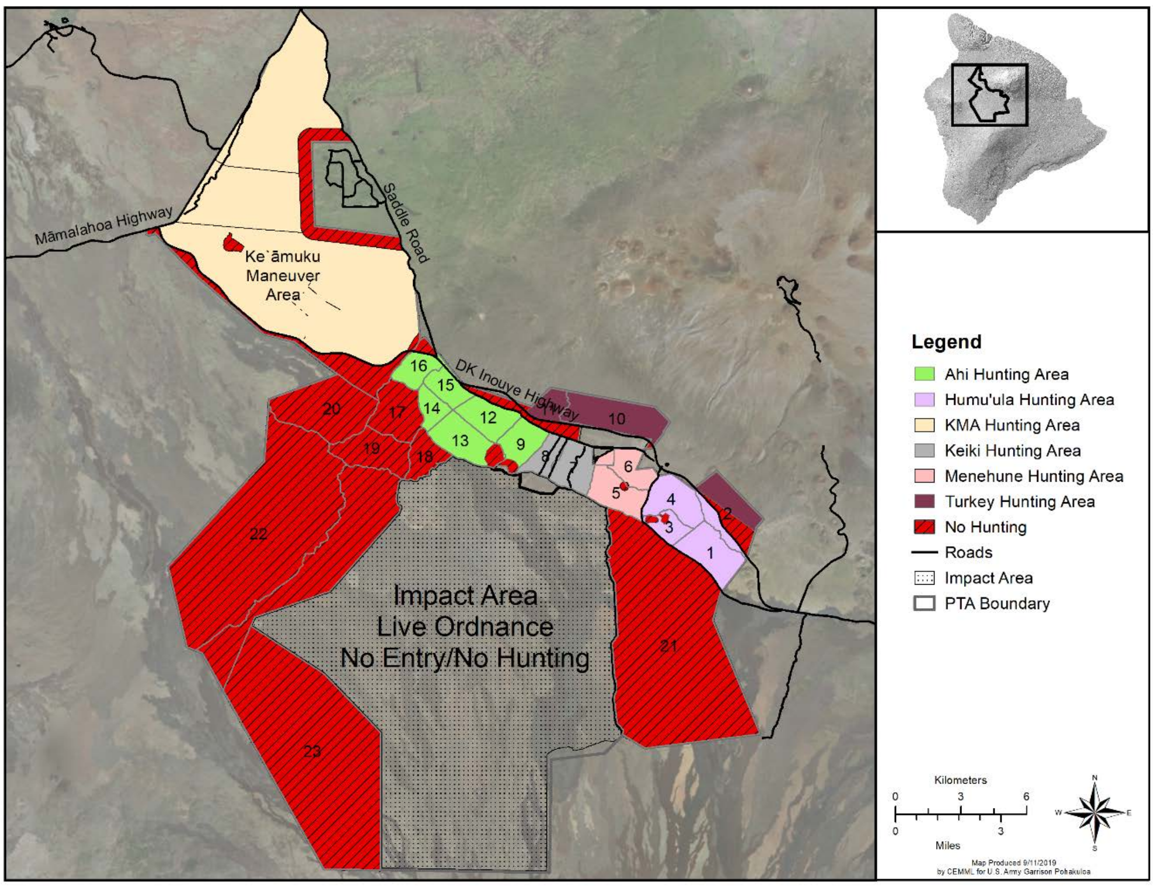

Figure 81. Public hunting unit locations at Pōhakuloa Training Area

To manage introduced game animals, we implement Statement of Objective (SOO) tasks 3.2(2)(c), 3.2(2)(f) and 3.2(2)(g) to comply with INRMP objectives (Sikes Act Improvement Act), and ESA consultation requirements.

All hunting activity at PTA and the Keʻāmuku Maneuver Area (KMA) is subordinate to military training. Based on the training schedule, the PTA Range Control staff identifies areas that are available for hunting activity. If training is scheduled for 1 or more training areas within a unit, the entire unit will not be opened that weekend for the safety of both hunters and military personnel.

Seven hunting units have been designated for game mammal and upland game bird hunting – KMA 1, KMA 2, KMA 3, Ahi, Keiki, Menehune, and Humuʻula; there are also 2 units designated specifically for spring turkey season (Figure 81). Game mammal species available for archery hunting include mouflon-domesticated hybrid sheep (*Ovis aries*), feral goats (*Capra hircus*), and feral pigs (*Sus scrofa*). Archery is the primary hunting activity and is offered during most months of the year. The upland game bird season is from November through January each year. Spring turkey season is from March to mid-April; however, wild turkeys can be hunted during the normal game bird season. Twelve species of upland game birds may be hunted with shotguns at the installation (Table 85). Rifles, muzzleloaders, and handguns are not approved for use at PTA. Disabled hunters with valid medical documentation are permitted to use crossbows.

Table 85. Upland game bird species present at Pōhakuloa Training Area

Common Name	Species	Origin
Black Francolin	*Francolinus francolinus*	Introduced
California Quail	*Callipela californica*	Introduced
Chestnut-bellied Sandgrouse	*Pterocles exustus*	Introduced
Chukar	*Alectoris chukar*	Introduced
Erckel's Francolin	*Francolinus erckelli*	Introduced
Gray Francolin	*Francolinus pondicerianus*	Introduced
Japanese Quail	*Coturnix japonica*	Introduced
Kalij Pheasant	*Lophura leucomelana*	Introduced
Ring-necked Pheasant	*Phasianus colchicus*	Introduced
Spotted Dove	*Streptopelia chinensis*	Introduced
Wild Turkey	*Meleagris gallopavo*	Introduced
Zebra Dove	*Geopelia striata*	Introduced

To coordinate access to hunting, we implement hunting policy, issue permits, establish protocols to control hunting access, and identify areas appropriate for public hunting activity each weekend. The hunting policy is updated annually and addresses access requirements, permits and associated fees, prohibited activities, restricted areas, safety zones, transport of firearms, and general hunting information.

In 2015, the Army purchased a web-based service, iSportsman, to manage public hunting activities. The PTA iSportsman portal became operational in 2016 and we have continued to use it since then. It is an easy-to-use, interactive service developed to assist natural resource managers with the coordination of hunting-related activities. The web-based program facilitates the issuance of hunting permits, provides information related to the hunting program, and can generate automated, customizable reports for hunter effort and harvest for analysis and reporting. Hunters use iSportsman to check in and out of the hunting units and to report their harvest from a smart phone or cell phone. In addition, the iSportsman portal allows the Conservation Law Enforcement Officer access to real-time information on hunter participation and location on the installation, enhancing his/her effectiveness in enforcing PTA hunting regulations and facilitating hunter safety.

There are 5 different hunting permits that can be purchased through iSportsman: general hunting permit (Game Mammal, Game Bird and Spring Turkey), game mammal hunting permit, game bird hunting permit, youth and senior hunting permit, and hunter assistant permit. All hunting permits are valid from 1 July through 30 June each year. During the reporting period, a total of 713 permits were distributed (including youth/senior: 248 general permits, 370 game mammal permits, and 95 game bird permits).

5.2 Field Operations

5.2.1 Game Management Facilities

A variety of facilities have been installed to support the Game Management Section: parking areas, fences, signs and check stations, and game bird guzzler units (water storage/delivery mechanisms). These activities meet SOO Objective 3.2(2)(g). We regularly maintain these facilities to ensure their proper function and appearance to the hunting public. Vegetation control and maintenance of water storage/delivery systems are part of regular maintenance. We cut vegetation and spot-spray using a 1.5% Roundup PowerMax herbicide mix (active ingredient glyphosate) to reduce fuel loads and to decrease the potential of fire in these parking areas.

5.2.2 Hunter Effort and Harvest

We coordinate and administer public hunting in conjunction with other entities at PTA to meet our SOO task 3.2(f). Tasks include scheduling hunts, advertising and administering hunts, coordinating available hunting areas, and coordinating with law enforcement personnel. There are 2 main hunting periods at PTA: upland game bird hunting season (first weekend in November through the second weekend in January) and game mammals the rest of the year.

Game Mammal Harvest

During the reporting period, 66 days were available for hunting with a total of 2,083 check-ins. Hunters harvested a total of 221 mammals (Table 86).

Table 86. Game mammals harvested in the public hunting units at Pōhakuloa Training Area

Game Mammal	Ahi	Humuʻula	KMA	Total by Species
Feral Pig	0	0	20	20
Wild Sheep	6	16	146	168
Feral Goat	4	0	29	33
Total by Hunting Unit	10	16	195	
			Total Harvest	221

KMA, Keʻāmuku Maneuver Area

<u>Game Bird Harvest</u>

During the reporting period, 26 days were open for upland game bird hunting and there were 591 hunter check-ins. Hunters harvested a total of 716 game birds representing 8 game species (Table 87).

Table 87. Game birds harvested in the public hunting units at Pōhakuloa Training Area

Species	Ahi	Humuʻula	KMA[a]	Total by Species
Black Francolin	42	3	65	110
California Quail	25	63	20	108
Chestnut-bellied Sandgrouse	1	0	1	2
Chukar Partridge	31	28	0	59
Erckel's Francolin	48	97	124	269
Japanese Quail	7	1	6	14
Ring-necked Pheasant	0	0	116	116
Wild Turkey	9	17	12	38
Total	163	209	344	
			Total Harvest	716

KMA, Keʻāmuku Maneuver Area
[a] Includes KMA 1, KMA 2, and KMA 3

5.3 Monitoring and Management

5.3.1 Introduction

Understanding the population dynamics of game species at PTA is essential to sustain hunting over the long-term. Information about game distributions, abundance, and activity can help select areas to open for hunting and determine the amount of hunting pressure resources can support. However, animal populations and detectability vary over space and time and direct estimation of population numbers is often difficult and costly (Stephens et al. 2015). To address these concerns, we developed and tested new methods to estimate abundance of game species. Models were also developed to estimate population parameters and identify abundance trends through time. We hope to use population parameter estimates to determine optimal harvest limits that result in the protection of sensitive species and habitats. Our activities to monitor and manage game animals addresses SOO task 3.2(2)(g).

5.3.2 Mammals

Instantaneous Sampling

To estimate density, we used a method of camera trapping called instantaneous sampling, where multiple cameras simultaneously take pictures at regular pre-defined intervals over an extended period of time (Moeller et al. 2018). Instantaneous sampling is ideal at PTA because it is a passive monitoring method that can be used to estimate abundance of unmarked animals; an active monitoring method such as mark-recapture would be unfeasible due to lack of resources.

Briefly, instantaneous sampling is implemented by placing cameras at randomly generated locations in an area where boundaries and total area are defined. The instantaneous sampling estimator uses counts of animals from randomly deployed time-lapse cameras. Over many spatial and temporal replicates, the mean count n_{ij} at location $i = 1, 2, \ldots, M$ and occasion $j = 1, 2, \ldots, J$ is an estimate of density ($\widehat{D}$) when divided by the cameras' viewable area (a_{ij}), following

$$\widehat{D} = \frac{1}{J}\frac{1}{M}\sum_{j=1}^{J}\sum_{i=1}^{M}\frac{n_{ij}}{a_{ij}} \qquad (1)$$

The camera angle of view (a_{ij}) is calculated as a circular sector defined by the lens angle (ϑij) in degrees and the maximum viewable distance (r_{ij}) as

$$a_{ij} = \pi r_{ij}^{2}\frac{\theta ij}{360} \qquad (2)$$

The maximum viewable distance is defined by field landmarks, measured with a range finder. Abundance ($\widehat{N}$) is then derived by multiplying density by the study area size (A)

$$\widehat{N} = A * \widehat{D} \qquad (3)$$

to provide inference to the entire study area. With temporal and spatial replication, this estimation becomes more accurate. Standard error and 95% confidence intervals were calculated using bootstrapping resampling with 10,000 iterations in the *boot* package in R version 3.5.1 (R Core Team 2019).

We randomly placed 20 cameras within the hunting area (Figure 82). The optimal number of cameras was determined based on a pilot study conducted by the State of Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife (BJ Adams, Brigham Young University, personal communication). Randomized points were found in the field with the use of a GPS device (Collector app, Version 18.0.3). We placed cameras in a way that maximized the viewable area at each location. To determine maximum viewable distance, we used a rangefinder to note the distances to field landmarks. Landmarks themselves were also noted for photo analysis.

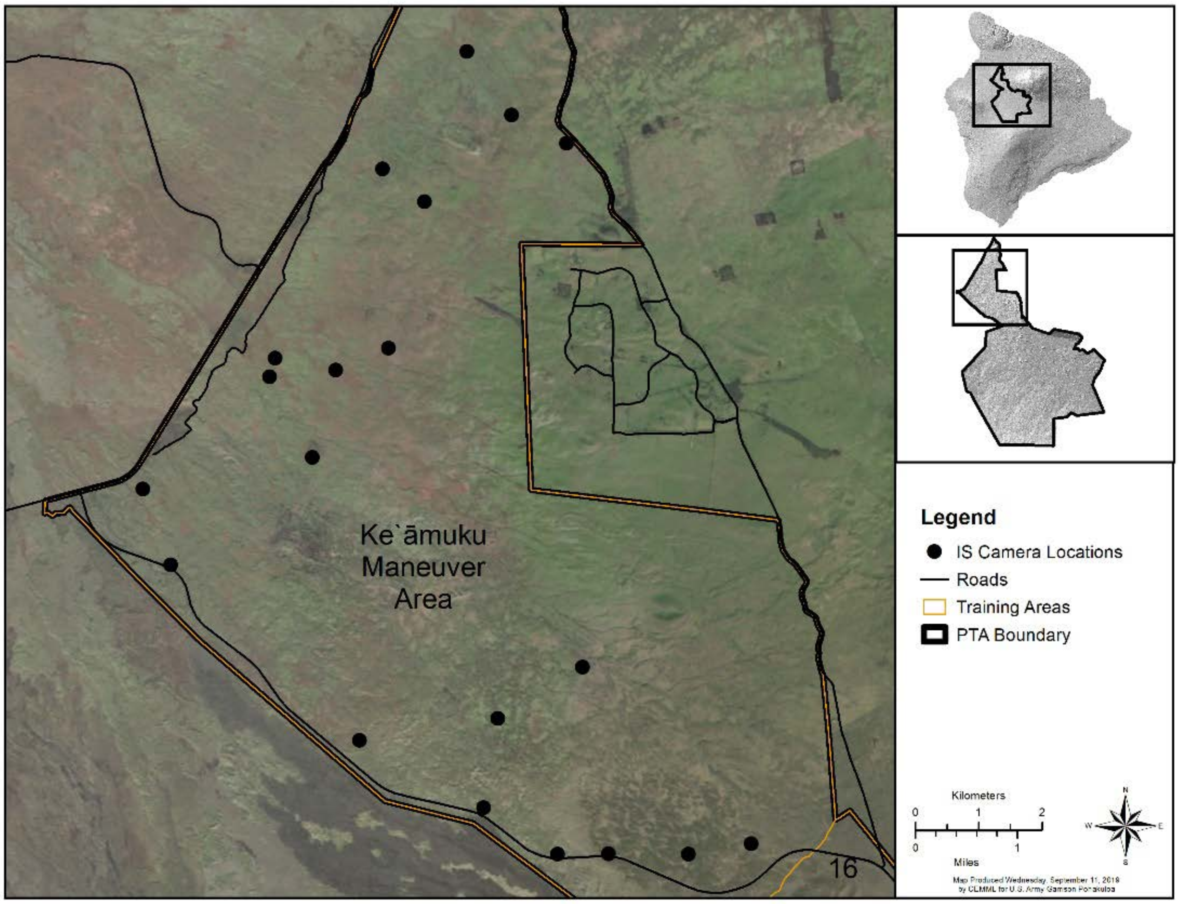

Figure 82. Instantaneous sampling design game camera locations in the Ke‘āmuku Maneuver Area

Results

Twenty cameras were deployed to randomized locations for 1 month, 16 November 2018–17 December 2018; however, 1 camera malfunctioned and was therefore omitted from analysis. The viewable range of the cameras during the night was much shorter than during the day for most cameras, which forced us to only use pictures taken from 06:15–18:00 in 15-minute intervals for all cameras. The calculation from equation 1 resulted in an estimate of 227 sheep (2.8 sheep/km²) with a standard error of 33.6 and 95% confidence interval of 161–292.

Population Modeling and Parameter Estimation

The model is designed using methodology outlined in Hilborn and Mangel (1997). We characterized the sheep population using a discrete form of the Schaefer model:

$$N_{t+1} = N_t + rN_t\left(1 - \frac{N_t}{K}\right) - R_t \tag{4}$$

where *N* is the estimated population at time *t*, *r* is the intrinsic rate of increase, *K* is the carrying capacity, and *R* is the number of sheep removed at time *t*. Gestation period is well documented for ewes, and reproductive seasonality has been shown to be highly correlated to changes in light levels for mouflon rams; therefore, we chose annual time intervals in the analysis because Hawai‘i experiences considerable shifts in day length annually (Rougeot 1969; Lincoln 1998; Garel et al. 2005).

We use a maximum likelihood framework to accomplish several objectives: 1) estimate parameters that provide the best fit to the data, 2) calculate Confidence Intervals (CIs) of estimated parameters using likelihood profiles, and 3) determine trends in abundance through time. The use of maximum likelihood techniques also allows for the incorporation of different data types into a single framework. Here, we include three data types to inform the model including: annual sheep removal rates, an independent calculation of population (using methods above) that we use as a proxy for population size in 2017 (initial population size, N_0), and an independent calculation of intrinsic rate of increase.

Values of abundance *N* were calculated based on observational data, in this case annual removal rates from archery hunters during the hunting season:

$$N_t = \frac{I_t}{q} \qquad (5)$$

Where q is catchability coefficient and I_t is number of sheep removed per hunter-day (calculated as the cumulative number of hours sheep were hunted among all hunters) for each year (t), or Catch Per Unit Effort (CPUE). The catchability coefficient is a parameter that relates an abundance index to population size. Here, it is calculated through a maximum likelihood optimization process and can be defined as the fraction of sheep removed from the population given one unit of effort. We assume that N_t is related to predicted population size with lognormal-distributed observation uncertainty; negative log likelihoods (NLLs) were calculated for each time period using the same distribution. Estimates for intrinsic rate of increase r and initial population size N_0 were calculated independent of the population model and NLLs were calculated for both parameters assuming normal distributions. Given the data and values of q, r, K, and N_0, the likelihood of that set of parameters was evaluated. Here we select the parameters that make the NLL as small as possible. This was done using the *optim* function in R version 3.5.1 (R Core Team 2019).

The model was parameterized to mimic the true ecological state of the sheep population; that is, a population that has been exposed to hunting prior to data collection. To accomplish this, the parameterization of the model allowed N_0 and K to be estimated separately. Indeed, it is known that hunting did occur in KMA prior to 2017; however, harvest and effort data are not available until 2017. We discuss those parameters for which we had no prior knowledge: K and q. Confidence intervals for K should be useful for maximum sustainable yield analyses, while CIs for q could be useful in future sensitivity analyses.

The maximum likelihood estimates were calculated using the likelihood framework described above. Each likelihood profile was created by systematically changing the parameter of interest, then computing the values of the other parameters that minimized the negative log-likelihood. Using the likelihood ratio test, the 95% CI is the range of parameter values for which the negative log-likelihood is within 1.92 of the minimum value of the negative log-likelihood.

Results

The model suggested that the population remained relatively stable, with an estimated 233 sheep in 2017, and 321 sheep in 2019 (Figure 83). Likelihood profiles revealed confidence intervals for *K* (515, 1235) and *q* (1.3E-03, 2.3E-03) (Table 88).

Table 88. Parameter estimates and 95% confidence intervals derived from the model

Parameter	**Estimate**	**95% Confidence Interval**	
		Lower	Upper
K	725	515	1235
q	1.67E-03	1.3E-03	2.3E-03
No	233	-	-
r	0.54	-	-

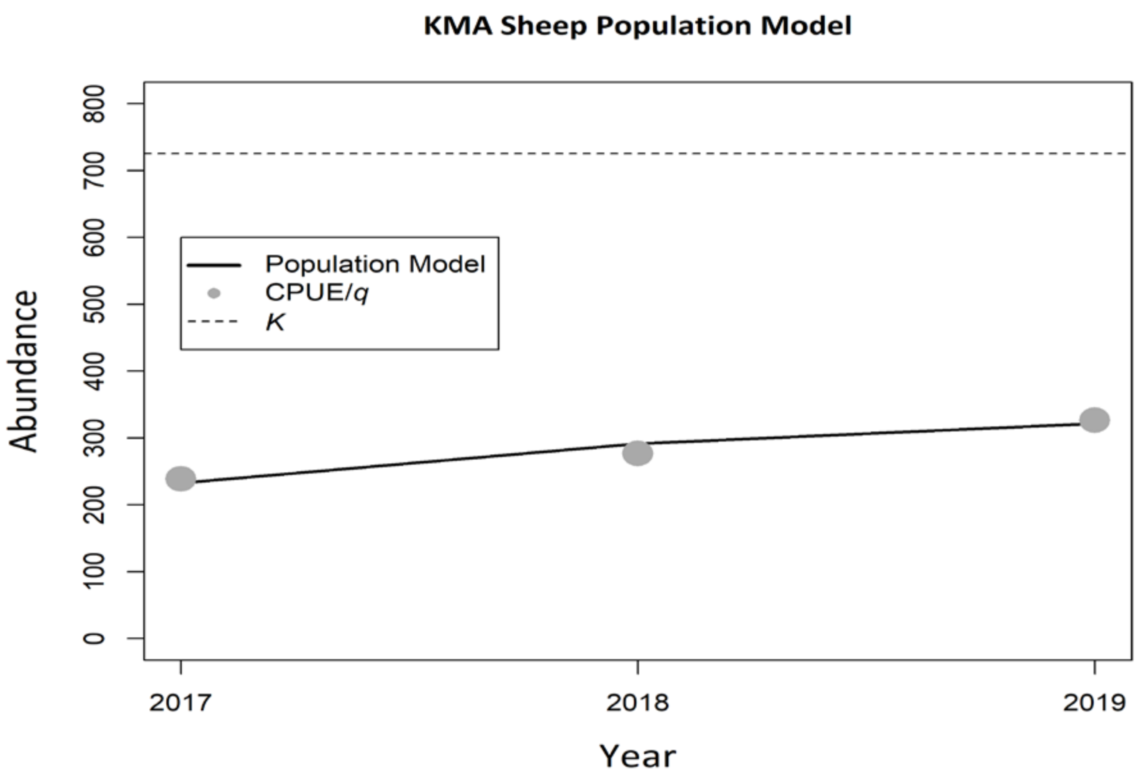

Figure 83. Abundance estimates and population trend derived from the model[a] in the Keʻāmuku Maneuver Area

[a] Dotted line indicates estimated carrying capacity (*K*), black line indicates abundance estimated from the model, gray dots indicate Catch Per Unit Effort and catchability coefficient(*q*) ratio.

Discussion

We recognize that equating the 2017 sheep density to the density that was derived from instantaneous sampling in 2018 was a strong assumption; however, the harvest data provided some support for this because the proportion of harvest to effort was stable among years. Additionally, sheep are relatively long lived, almost completely lack natural predators (with the exception of wild dogs), and are not exposed to harsh winter seasons. These facts support the validity of assuming low fluctuation of the population over a relatively short time period.

Unfortunately, only 3 years of harvest data were available for this analysis and the model would have benefitted from a larger dataset; however, the population estimate from the instantaneous sampling analysis was supported by a substantial dataset, which resulted in a relatively narrow standard error. Therefore, the strength of that estimate should make this model useful despite the paucity of harvest data. We do suggest that another population estimate from an independent method (e.g., aerial surveys) would be very useful because it would provide a datapoint with which to compare the estimate derived from instantaneous sampling. If it is unfeasible to obtain such an estimate, it should be noted that the density estimate presented here is similar to another that was calculated for mouflon elsewhere in Hawaiʻi (Hess et al. 2006).

We acknowledge that the form of the model presented here is relatively simple and leaves out parameters that could influence population size such as emigration, immigration, natural mortality, and poaching. Emigration and immigration may not be a huge factor for this population because of the relatively large size of KMA in comparison to sheep home range size. In nearby state land, average sheep home range size was shown to be 25 km^2 ($n = 42$), which is a quarter of the size of KMA (personal communication, BJ Adams, Brigham Young University).

Natural mortality information would benefit the model. Another unpublished study showed that annual survival for adults was 0.94 ($n = 35$) (personal communication, BJ Adams, Brigham Young University); perhaps with continued data collection and analysis, a reliable survival estimate could be used to better inform population models. There is no shortage of anecdotal evidence of poaching within KMA, but unfortunately that sort of activity is extremely difficult to observe.

Model behavior is in line with general expectations; one would expect a healthy population that was historically exposed to hunting pressure to be relatively stable at some abundance below *K*. In general, the model appears to fit the data well, and produced informative confidence intervals. We intend to use these estimates for future analyses such as determining maximum sustainable yield.

5.3.3 Game Birds

Introduction

The responsible and sustainable management of any hunting program requires information about the parameters of the populations that are harvested. Population density, or population abundance that is extrapolated from density, is an important parameter to directly estimate because it is an essential component in many population models that are used to inform management decisions. Game bird life history information exists in the literature; however, density is a variable parameter that depends heavily on area-specific environmental conditions and habitat quality. Therefore, it is prudent to estimate density using data collected from the game bird population to be managed.

The island of Hawaiʻi supports many upland game bird species, most of which were introduced in the 20th century (Lewin 1971; Lewin and Lewin 1984). Despite the popularity of game bird hunting, there is a lack of life history information for local populations in the literature. Here, we explore current avian density estimation techniques with the goal of developing the most efficient sampling method for all game bird species that occur at PTA.

Many avian density estimation methods exist (Thompson 2002). Index counts, or methods that use counts of bird detections as an index to relative abundance, were historically favored by ornithologists despite the well documented biases and limitations of that method (Verner 1985; Verner and Ritter 1985; Nichols et al. 2000; Rosenstock et al. 2002). Distance sampling has been recommended as an alternative method and has predominately been used and developed in the recent decades (Rosenstock et al. 2002; Thomas et al. 2010; Pandit and Gupta 2011; Miller et al. 2013; Miller and Thomas 2015); however, several challenges are presented if applied to game bird species. For example, Erckel's Francolin are often hidden in vegetation and do not flush unless under extreme duress. This creates difficulty if one is attempting line-transect distance sampling based on visual sightings (Buckland et al. 2001). Counting game birds based on vocalization also presents challenges. Males will often give territorial calls, but they are rarely seen while calling because of their cryptic nature. Determining observer-to-bird distance based on call alone is difficult because calls are emitted at relatively high volumes and can travel long distances.

Call-back methods have been used as a survey method for Galliformes species; however, it has been posited that detection distances could be biased because birds might not respond to calls immediately. Instead, they might first move closer to the observer, and then call. This would violate distance sampling assumptions and more research is recommended if that technique is to be used (Warren et al. 2018). Another complication with the vocalization counting method is that only males are known to emit territorial calls for most game bird species. This can be problematic for population estimation because sex ratios are not always the same. Indeed, Hill and Robertson (1988) demonstrated that among common pheasant populations, numbers of calling males can remain stable despite wide fluctuations in hen numbers (Conroy and Carroll 2001).

Other constraints such as cost and available personnel need to be considered when designing game bird surveys. Faced with these limitations, road surveys might appear a viable option because they can be done quickly by only one observer; however, the area sampled using this method would be composed only of roads and their adjacent areas. Consequently, inferences cannot be properly made to bird populations beyond the surveyed area unless one is willing to assume areas on adjacent roads support similar numbers of birds as those further away from roads. This assumption is questionable given that roads are not typically placed in random areas (Thompson 2002).

The use of trained pointer dogs has been shown to produce consistent but perhaps not accurate density estimates of red grouse, but those studies assumed that the entire survey area was covered and that dogs located and flushed all birds (Jenkins et al. 1963; Evans et al. 2007; Dahlgren et al. 2010). This method would not be feasible for large survey areas. Using radio telemetry, (Sisson et al. 2000) showed that pointing dogs only detected 53% of available northern bobwhite coveys, 25% of which were never seen by hunters. They concluded that information used by pointing dogs is probably more practical for evaluating population trends than it might be for a census technique.

It seems logical to combine the use of distance sampling and pointing dogs in this context because the strength of one method balances the weakness of the other. The primary issue with the application of distance sampling theory to game birds is the inaccuracy in determining observer-to-bird distances; pointing dogs offer a solution because they make it possible to identify the location, number, and species of birds once they are flushed. Likewise, pointer dogs have been shown to have imperfect detection capability; a problem that distance sampling theory is specifically designed to address. The pairing of methodologies will work so long as the assumptions of distance sampling outlined in Buckland et al. 2001 are not violated. The use of pointing dogs raises several concerns regarding these assumptions, especially assumption 2 (Buckland et al. 2001), which is that objects are detected at their initial location. Birds are highly mobile and certain game bird species are more likely to run instead of flush in response to dog pressure. We will discuss how this might bias estimates and ways to help reduce this source of bias.

Finally, non-conspecific game bird populations occur sympatrically at PTA; therefore, it would benefit managers if there were a sampling design that could allow for the simultaneous sampling of sympatric game bird species, especially if limited by time and funds. Here, we add to the work presented in Guthery and Mecozzi (2008), which integrates GPS, GIS technologies, and distance sampling theory to estimate bobwhite density using pointing dogs. The objectives of this section are to: 1) expand on the existing bird-dog distance sampling methodologies, and 2) estimate game bird densities for the responsible management of game species at PTA.

Methods

We applied line transect sampling design with the use of pointing hunting dogs (Thomas et al. 2010). Transects were 500 m in length and generated randomly within the hunting area using ArcMap 10.6.1. Random transect placement was executed in the Python coding language in ArcMap. Points were spatially randomized and assigned a randomized azimuth from 0–360 degrees and a transect was drawn according to that azimuth. Randomized points were buffered 500 m from the area boundary to ensure that the entirety of each transect was drawn within the survey area (Figure 84).

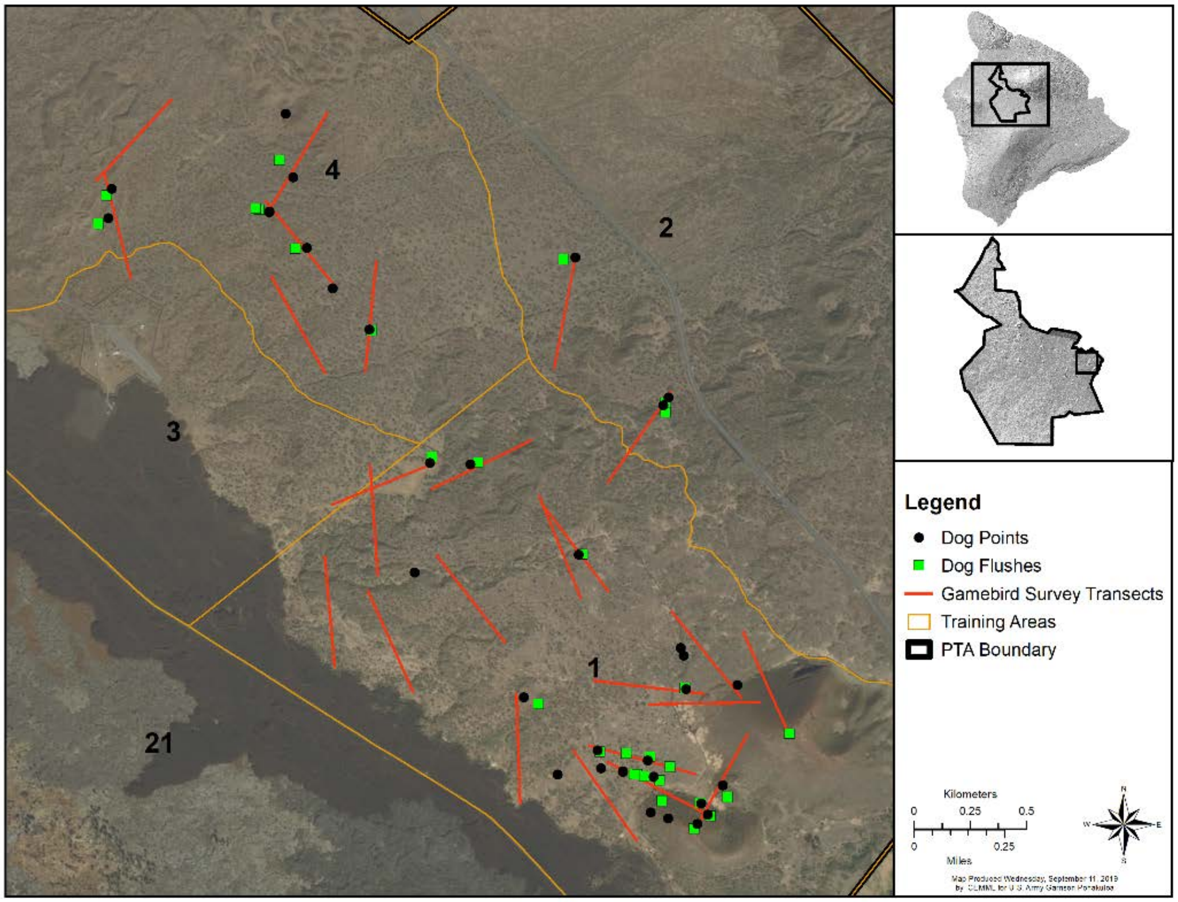

Figure 84. Game bird sampling design[a] at Pōhakuloa Training Area

[a] Red lines indicate randomized 500 m distance sampling transects. Green points represent locations where dogs first detected game birds. Black points represent bird flush locations.

Transect locations were uploaded into the Collector app (Collector for ArcGIS 2013–2018) and accessed on a smartphone (Moto G 3rd Generation Android version 6.0). Each transect was completed by 1 observer, 1 dog owner, and 1 hunting dog. A single dog was used in each transect to standardize effort, since we did not always have access to multiple dogs. The observer walked along the transect, careful to minimize deviation from the transect line using the Android GPS. Meanwhile, the dog owner walked nearby ensuring that the dog searched the area around the transect. When birds flushed, the observer marked the location with a GPS, recorded cover type, species, number of birds flushed and time of flush. The observer also recorded the GPS location of where the dog first went on point, since pointing behavior could be interpreted as the first true indication of a detection (Guthery and Mecozzi 2008). Perpendicular distances to the transect were calculated retroactively in ArcMap. Two distances were calculated for each flush event: distance from bird flush to the transect (hereafter, bird flush data), and distance to the transect from where the dog first went on point prior to bird flush (hereafter, dog point data). Distance sampling was done for both distances because for many species at PTA, birds will run instead of flush when pressured by dogs. Therefore, the dog-point data might provide a better estimate of birds' initial location and thus be less likely to violate assumption 2 in Buckland et al. (2001).

For each transect, environmental data were collected by the observer including date, start and end time, wind direction and speed, cloud cover percentage, visibility, and precipitation. Number of birds flushed and distances to transect were used to calculate a density estimate in the R coding language using the *mrds, distance, dsm, DSim, mads, dplyr* and *knitr* packages in R (Buckland et al. 2001). Density estimates from sampled areas were extrapolated to total area.

Before the implementation of the primary study, a pilot study was done to determine the minimum sample size needed to achieve a targeted coefficient of variation (CV) of 0.2 (Buckland et al. 2001). The pilot study used the methods above but with five 300-m transects. It was completed on 10 October 2018 and resulted in 4 detections of California Quail coveys. The preliminary analysis indicated that 75 would have been an adequate sample size for California quail, and that the total transect length should be 33.75 km (Buckland et al. 2001, p 242). Given available resources, that length was not feasible and would have resulted in an impractical amount of transect overlap, so we chose a total transect length that more closely matched the project resource availability – 12.5 km.

Results

Twenty-five 500-m transects were surveyed from 28 October 2018 through 8 November 2018. For bird flush data, 4 species were detected: Erckel's Francolin (24 groups), Black Francolin (1 individual), California Quail (3 groups), and Wild Turkey (1 individual). There were 4 fewer distance data points collected for the dog point data because there were several instances where birds flushed, but no apparent pointing behavior was exhibited by the dog. For dog point data, 3 species were detected: Erckel's Francolin (20 groups), California Quail (3 groups) and Wild Turkey (1 individual). Given the paucity of observations for all species except for Erckel's Francolin, that was the only species for which density was estimated. The environmental data that were collected were generally homogeneous among transects and the only covariate that was considered during the analysis was dog ID (individual dog used per transect).

Seven of 25 transects resulted in 24 observations of Erckel's Francolin for bird flush data (n = 24 groups; $\bar{x} = 2.4$; $\sigma = 2.1$), and 6 of 25 transects resulted in 20 observations of Erckel's Francolin (n = 20 groups; $\bar{x} = 2.7$; $\sigma = 2.2$) for dog point data. Following established methods in the literature, we use the most popular approach for selecting a formulation of the detection function, called the "key function plus adjustments", where the number of adjustment terms are selected using Akaike's Information Criterion (AIC) for half normal and hazard rate models (Buckland et al. 2001; Miller et al. 2019). We also included dog ID as an additional parameter for half normal and hazard model, since 4 dogs were used and we did not assume that detection probability was equal among dogs (Table 89). The AIC analysis selected the half normal key function with dog ID added as a covariate. A Cramer-von Mises(C-vM) goodness of fit test showed that the model was an adequate fit (C-vM p-value = 0.39).

Table 89. Summary of detection function model fitted to Erckel's francolin distance data collected at Pōhakuloa Training Area[a]

Key function	Formula	C-vM p-value	$\hat{P}_a$	se($\hat{P}_a$)	ΔAIC
Half-normal	~Dog ID	0.89	0.39	0.08	0.00
Hazard-rate	~Dog ID	0.87	0.43	0.09	3.01
Hazard-rate	~1	0.99	0.36	0.13	3.35
Half-normal with cosine adjustment term of order 2	~1	0.99	0.37	0.07	3.65
Uniform with cosine adjustment terms of order 1,2	NA	0.66	0.46	0.09	4.52

[a] The half-normal detection function with dog ID as a covariate produced the lowest AIC value. C-vM denotes Cramer-von Mises goodness of fit test results, $\hat{P}_a$ denotes average detectability, and se is standard error.

We therefore used the half-normal model with dog ID parameter to estimate abundance and standard error of Erckel's Francolin within the Humuʻula hunting area at PTA. The analysis returned an estimated density of 64 ± 28 birds/km^2 and an estimated abundance of 887 with a standard error of 389 and a coefficient of variation of 0.44 (Table 90).

Table 90. Summary of abundance estimation for the Erckel's francolin data for the half-normal model with dog ID parameter and the half normal model with cosine adjustment term of order 2 in the Humuʻula hunting area at Pōhakuloa Training Area

Data Type	Model	$\hat{N}$	se($\hat{N}$)	CV($\hat{N}$)	$\hat{D}$	se($\hat{D}$)
Flush	HN + DogID	886.66	388.51	0.44	64.5	28.24
Dog Point	HN + COS(2)	1922.75	869.72	0.45	139.8	63.23

The same analysis was done using the distance data calculated from dog point data. The AIC analysis selected for the half-normal model with cosine adjustment of order 2 (Table 91). A Cramer-von Mises(C-vM) goodness of fit test showed that the model was an adequate fit (C-vM p-value = 0.88).

Table 91. Summary of detection function model fitted to Erckel's francolin distance data collected in Pōhakuloa Training Area using location at which dogs first pointed for flushed birds[a]

Key function	Formula	C-vM p-value	$\hat{P}_a$	se($\hat{P}_a$)	ΔAIC
Half-normal with cosine adjustment term of order 2	~1	0.88	0.42	0.13	0.00
Uniform with cosine adjustment term of order 1	NA	0.46	0.61	0.08	0.22
Half-normal	~DogID	0.85	0.49	0.13	0.22
Hazard-rate	~1	0.94	0.50	0.17	0.70
Hazard-rate	~DogID	0.88	0.57	0.10	1.07

[a] The half-normal detection function with cosine adjustment form of order 2 model produced the lowest AIC value. C-vM denotes Cramer-von Mises goodness of fit test results, $\hat{P}_a$ denotes average detectability, and se is standard error.

We therefore used the half-normal model with cosine adjustment of order 2 parameter to estimate abundance and standard error of Erckel's Francolin using dog point data. The analysis returned an estimated density of 140 ± 63 birds/km^2 and abundance of 1,923 with a standard error of 870 and a coefficient of variation of 0.45 (Table 90).

Discussion

Assumptions

Buckland et al. (2001) list 3 main assumptions that must be met to obtain reliable density estimates from line-transect distance sampling: 1) objects on the line are detected with certainty, 2) objects are detected at their initial location, and 3) measurements are exact. There are several aspects of distance sampling at PTA using the methodology presented here that could lead to the violation of all 3 of these assumptions and therefore bring into question the reliability of density estimates; however, there are actions that can be taken to minimize that risk.

Assumption 1 comes into question because the terrain at PTA is treacherous; unstable lava substrate on very steep cliffs covered with sometimes impassible vegetation makes it difficult to walk the entirety of all transects at distance = 0 (directly on the transect line). In the hypothetical case of an impassible area occurring on a transect, it could be possible for a stoic game bird to hold within that area and go unnoticed while the observer circumvents the unwalkable part of the path that contains the bird, thus violating assumption number 1. One way to reduce this risk is to always use 2 hunting dogs. Dogs could also be specifically directed to inspect the area.

Assumption 2 is probably the most likely to be violated using the methodologies presented. It is not uncommon for game birds at PTA, especially Francolin spp. and California Quail, to run before they flush (Brian Leo, personal observation). If a dog exhibits pointing behavior and follows the scent trail for a long distance before the bird is flushed, it would be reasonable to assume that the bird was moving on the ground prior to the flush. As pointed out above, we attempt to correct for this by recording the location at which the dog first went on point. Whether or not that location is an accurate enough representation of the initial location of the bird is impossible to know. Buckland et al. (2001) suggest that if evasive movement did occur for a substantial portion of the population, then it would be apparent from examination of the distance data in a histogram; that is, one would expect more observations to occur more frequently at distances further from the transect than distance = 0. Upon examination of both the bird flush and dog point data histograms, there is no evidence of evasive movement. This is not proof that evasive movement did not occur; it could have occurred for a lower proportion of the sampled population. If evasive behavior prior to detection did occur and remained consistent for each species, density estimates would be biased low. Sources of bias should be controlled for if possible, but a low biased density estimate could be useful from a game management perspective. It would be an inherently conservative estimate and provide a buffer in the face of environmental stochasticity or when there are large error margins. No definitive conclusions can be made regarding density estimate accuracy or if evasive behavior occurred based on the data collected here, and we suggest more research be done to further this line of inquiry.

ArcMap-generated measurements are calculated without error, but there is error associated with GPS location fixes which bring assumption 3 into question. These errors are known but were not collected for this round of data collection. Further research and development need to be done to determine how to incorporate that source of error into the abundance estimate standard error.

Density estimates

The methodology presented here did not result in density estimates for all sympatric game bird species within the sampled area. If it is assumed that species occur at unequal densities and the amount of effort required for precise estimates for each species is proportional to their true underlying densities, then it is unfeasible to apply this method to the lower density species such as Chukar Partridge, Wild Turkey, Japanese Quail or Black Francolin at PTA. This claim is supported by harvest data collected directly after the surveys; 3 species that probably occur at low densities were harvested during hunting season but not observed during sampling (Table 92). This is an indication that line transect sampling will likely not be an effective density estimation method for those species.

Table 92. Number of birds harvested in the Humuʻula hunting area from November 2018–January 2019, Pōhakuloa Training Area

Species	Quantity
Erckel's Francolin	102
California Quail	80
Chukar Partridge	18
Wild Turkey	9
Japanese Quail	3
Black Francolin	1

The margin of error for Erckel's Francolin in Humuʻula was wide for density estimates based on bird flush and dog point data. Estimates with such a wide standard error will likely not be useful for population modeling purposes. To narrow the error margin, the expended effort should be doubled at a minimum.

The limiting factor was access to bird dogs and their owners. Survey areas are far away from most residential areas on the island which deters some people from volunteering. Also, it is difficult for the volunteers to devote valuable time during the work week. Given that bird dog availability is the primary challenge to obtaining a precise estimate, dog transect-time should be maximized. We chose not to use 2 dogs per transect because we knew we would not always have access to 2 dogs simultaneously. This was an attempt to keep the effort-per-transect as consistent as possible to improve the quality of the sampling design; however, these concerns are outweighed by the larger issue of the lack of observations and resulting wide error margin. We suggest that if 2 dogs are available, then they be used simultaneously to improve the probability of observation. Support for this practice is also apparent based on the model selection results for bird flush data, which provided evidence that each dog had a different detection probability estimate. Detection probability was inconsistent despite the attempt to standardize effort with the use of only 1 dog per transect, indicating there may be no benefit in applying a single dog constraint to the sampling design.

The distance analysis using dog point data showed an even wider margin of error than the distance analysis using the flush data. This may be because there were fewer data points for the dog point data and not necessarily because of an inherent difference in quality between the data types for this analysis; indeed, the C-vM p-value indicated a better fit for the modeled dog point data than the modeled flush data. With such a limited set of data, it is difficult to draw conclusions as to which model was best or what set of data is most appropriate for these analyses. It is concerning that the dog point data produced an abundance estimate over twice that of the flush data estimate. We suggest that both types of data continue to be collected until there is enough to distinguish a difference in quality between data types.

5.3.4 Game Management Discussion

One of the primary goals of the Game Management Program is to understand the dynamics of resident game populations and how they relate back to natural resource protection and conservation. We have successfully completed the first steps to understanding game populations during this reporting period; namely, we identified potential survey techniques, implemented them in the field, and calculated density estimates. This information acts as a baseline and will be important for future study of methods for the protection of TES and management of critical habitat. As we build on our understanding of game populations and their response to varying levels of harvest, we will be better suited and prepared to respond to changes in the status of TES.

The impacts of game birds to native plants, especially ESA-listed plants, is not well understood and is poorly documented. Some researchers suggest that game birds are beneficial to native plants as seed dispersers (Cole et al. 1995). However, recent field-based observations suggest that game birds may negatively affect native plants through physical disturbance (Dr. Christina Liang, personal communication, 2018) and selective feeding (Dr. Susan Cordell, personal communication, 2018). We documented an Erckel's Francolin positioned near the endangered *Schiedea hawaiiensis* proximate to what appear to be clipped branches. To address the knowledge gap of whether game birds have a positive or negative impact on native fauna, we will begin a game bird diet study in November 2019. Crops will be collected from public hunters and analyzed to determine primary components of game bird diets. An inquiry into whether game birds facilitate the spread of exotic seeds will contribute to the INRMP objective of preserving ESA-listed plant species. This information could then be used to manage bird habitat in a way that could enhance their availability as a game species if it is deemed appropriate to do so.

In addition to contributing to resource management, public hunting at PTA provides the Army an opportunity for positive community engagement. It is one of the only recreational activities for which the public can access the installation and this activity can serve as a bridge for positive community relations between the Army and the surrounding communities. The hunting community was mostly favorable and positive about USAG-P hunting access policy and the implementation of iSportsman.

6.0 ECOLOGICAL DATA PROGRAM

6.1 INTRODUCTION

To facilitate the planning and implementation of work conducted by technical programs (Botanical, Invasive Plants, Wildlife, and Game Management), the Ecological Data Program (EDP) implements Statement of Objective (SOO) tasks 3.2(4)(a) through 3.2(4)(e). The EDP provides guidance and support to technical programs to ensure that ecological data collection methodologies, data/GIS management, analysis, and reporting are aligned with overarching programmatic goals and objectives. This function is essential for the efficient fulfillment of PTA natural resources program obligations and to effectively utilize all available data to streamline natural resource management strategies. In addition, the EDP develops, implements, and maintains the necessary information technology (IT) infrastructure supporting management planning, scheduling, implementation, tracking, and reporting. The EDP also facilitates the coordination and incorporation of research results from external agencies toward the effective fulfillment of natural resources program goals and objectives. Due to staffing changes in FY 2019, the EDP also absorbed functions previously executed by the Administrative Program. These functions are in fulfillment of SOO tasks 3.2(4)(a) through 3.2(4)(e). The EDP is therefore now organized into 6 sections:

1) Centralized Data Support
2) Data Management Systems
3) Information Technology
4) External Research Support
5) General Support for Army Training Initiatives
6) Administrative Support

6.2 CENTRALIZED DATA SUPPORT AND DATA MANAGEMENT SYSTEMS

The EDP provides centralized guidance and support for geospatial and tabular data collection, management, and analysis to technical programs. To ensure the efficient, targeted expenditure of resources, we provide specialized expertise regarding appropriate field data collection methods, statistical sampling designs, data management approaches, and data analyses, for incorporation by technical programs into operational protocols. During the reporting period, we took on a significantly greater role in project development to ensure protocols can most efficiently address pre-established questions pertinent to the project purpose and intents, including assessments of management efficacy, strategy optimization, and budget tracking and accounting. In addition, we develop computer information systems (e.g., data input interfaces and databases) to ensure appropriate data management infrastructure exists to enter, store, analyze, and report results from data collected. Data management systems are necessary to facilitate day-to-day operations, planning, accounting, and reporting efforts. Systems are developed, implemented, and managed using established principles and theory of data management and database design.

6.2.1 Organizational-level Data Support

The primary focus of the EDP with regard to programmatic-level data support continues to be the development and improvement of mobile GIS frameworks that streamline the collection, organization, analysis, and use of geospatial data collected in the field to facilitate operations of technical programs. This framework allows for data to be collected quickly and efficiently in the field using navigation tools and drop-down menus. To this end, we implemented Environmental Systems Research Institute's (ESRI's) ArcGIS mapping and analytics platform. Through the use of mobile and desktop applications such as Collector, Survey123, Operations Dashboard, Insights, ArcMap and ArcGIS Pro, we developed custom data collection, management, and analysis solutions for a range of projects including incipient weed detection, Plant Surveys, Priority Species 1 Monitoring, fence inspection and maintenance, and Hawaiian hoary bat, Hawaiian Goose, and Band-rumped Storm Petrel surveys and monitoring. These solutions include strategies for complete and automated field-to-report workflows eliminating or minimizing the time needed for data entry, data quality assurance and control. The systems are also designed to facilitate data analysis and generation of maps and figures. Data collected in the field are automatically synced with geodatabases designed to facilitate these workflows. Incorporation of these technologies provides significant cost and time savings from project implementation through completion, allowing us to accomplish more of our important conservation goals with limited funds.

We also continued our work maintaining and managing the Management Actions Tracking System (MATS). The MATS stores and organizes information on the effort expended toward the fulfillment of statutory regulatory obligations. Specifically, technical programs use the MATS to enter data on the number of personnel hours and other costs spent toward executing the variety of management actions taking place in the field on a day-to-day basis. These management actions are linked to itemized statutory requirements so that all expenditures toward the fulfillment of obligations can be explicitly tracked and reported. This is essential for reporting, budgeting, accountability, and strategic planning. The hierarchical system of organizing and relating data elements in the MATS is aligned with the common framework providing structure for all levels of the organization. In the future, we will be working with the Army Biologist to further improve this system so it can better align with programmatic needs for tracking and reporting pertinent metrics.

We also completed and maintain an Electronic Literature Library to facilitate access to the considerable library of scientific articles and grey literature compiled over the years by staff. This database allows end-users to efficiently search for resources by using title, author, and keyword searches. References are tagged with relevant metadata for easy organization and access.

6.2.2 Botanical Program Support

The EDP assisted the Botanical Program in the development and implementation of the Plant Survey cycle 2 protocol. To ensure an efficient field-to-office flow of data, we developed and implemented a data collection system using ESRI's mobile Collector. We also developed a similar system for data collection and data management for the Priority Species 1 Monitoring and *Isodendrion hosakae* monitoring projects. Data collection systems for these efforts were designed and constructed on the ArcGIS platform using ArcGIS Collector, ArcGIS Desktop, ArcGIS Online, and ArcGIS Pro. For all projects, we continue to provide support and guidance regarding the effective and defensible analysis of data to provide meaningful end-products.

6.2.3 Invasive Plant Program Support

We continue to provide support to the Invasive Plant Program by developing spatially explicit data collection and management approaches for the Invasive Plant Survey and Monitoring and the Vegetation Control sections. These efforts include the development of databases housing pertinent project-specific data to facilitate analysis and the creation of key products for planning, tracking, and reporting. For the Vegetation Control section, we further provided guidance on collecting data on the distribution of secondary target weeds and responses to control efforts. This new, more targeted approach takes less time in the field and will ensure data are usable to answer specific management questions as determined by the Invasive Plant Program.

6.2.4 Wildlife Program Support

We supported the Wildlife Program primarily by providing technical support regarding data collection, storage, and analysis for projects related to the Hawaiian Goose, Hawaiian hoary bat, Seabird, and Fence Maintenance and Inspection projects. Specifically, we continued support of an operational database for the Hawaiian hoary bat project that functions in both ArcGIS and Access environments using Visual Basic and other script to import and process data from acoustic bat detectors and weather stations to facilitate QA/QC, analysis, and export of curated data sets for use in statistical occupancy modeling. We also provided support to both onsite and offsite Hawaiian Goose projects building and implementing data collection, management, and analysis systems on the ArcGIS platform. This allows for the efficient documentation and monitoring of spatial and seasonal trends in goose presence and behavior throughout the installation and offsite at Hakalau Forest National Wildlife Refuge. We also work closely with the Seabird project to create data collection, management, and analysis systems to streamline workflows for the efficient and successful fulfillment of project goals. Finally, we provide spatial data support systems for tracking and managing fence inspections and maintenance using ArcGIS collector.

6.3 Information Technology

A well-designed IT infrastructure is essential for programs to function effectively. Staff at all program levels require computer workstations, printers, and access to data stored on a central network server to conduct their day-to-day activities. The EDP oversees the acquisition, deployment, and maintenance of all computer systems, network, and telecommunications infrastructure.

During the reporting period, we continued work with CEMML, the Army, and representatives from Spectrum Business to bring broadband fiber optic communications (internet and phone) to facilities. We are hopeful that these services will be in place in FY 2020. Further, to most effectively support the

IT needs, we oversaw the acquisition of and upgrades to network infrastructure including workstations, network servers, switches, and printers. We also manage and maintain the centralized network server and backup domain controller, a network-attached storage system, and over 26 individual workstations, including automated backups of data at all levels of the network.

6.4 External Research Support

The Army receives occasional requests from outside agencies to conduct ecological research on the installation. Primarily comprising rare and important tropical dryland forest ecosystems, PTA is attractive to researchers throughout the country interested in understanding how best to restore native species and habitats. The EDP ensures the requesting agency provides a thorough description of the work proposed so that the Army Biologist can make an appropriate determination as to the suitability of supporting a given research effort. We discuss potential research efforts with program managers and make recommendations to the Army Biologist and CEMML Senior Program Manager as to whether to support the research. During this reporting period, the EDP provided support for several ongoing as well as newly initiated external research efforts.

During the reporting period, external researchers from the University of Hawaiʻi and the Institute of Pacific Islands Forestry completed 2 large projects. The first project involved better understanding how the removal of ungulates from PTA's ecosystems affects plant community dynamics; specifically, how reduced browsing pressure could impact the presence and problems posed by invasive weed species. Results from this work will provide considerable insight into how best to meet the regulatory mandates (i.e., management strategies) to maintain and protect populations of TES from greater competition and propensity for fire stemming from increased invasive species presence. The second project involved the investigation and quantification of impacts non-native predators have on native species and community pollination ecology. This is a poorly understood but essential component of ecosystem function at PTA and the results of this work will help guide the development of management approaches that can optimize seed set and reproduction of important target native plant species.

6.5 Support for Army Training Initiatives

The EDP continues to provide technical services to the Army regarding 1) initiatives to develop training capacity at PTA, 2) natural resources-related initiatives in cooperation with State and Federal resource agencies, and 3) technical support for defense in litigation proceedings. Additionally, we provided significant support to PTA Department of Emergency Services using imagery analysis and mapping tools to provide resources to aid in their wildland fire suppression efforts. To achieve these functions, the EDP provides expertise and support regarding ecological data acquisition, evaluation, and synthesis, mapping and graphics support, and document preparation.

6.6 ADMINISTRATIVE SUPPORT

To support ongoing organizational administrative needs, the EDP took on additional responsibilities including the preparation and tracking of budgets as directed by the CEMML Senior Program Manager, purchasing of equipment and supplies needed to accomplish technical program tasks, and compliance and safety oversight to ensure all staff and work activities are in compliance with applicable Army and federal and state regulations for hazardous materials, safety, and fire. We also provided administrative services for personnel actions, including accident and injury documentation and reporting and worker's compensation claims.

6.7 OVERALL SUMMARY DISCUSSION

The EDP continues to be an essential program within the Army natural resources program at PTA, supporting the efficient and effective accomplishment of goals and objectives. During the reporting period the EDP significantly increased its contributions to this end. This was largely due to increased authority and responsibility within the program to guide technical program in the development of project protocols to ensure alignment between project goals and effort expended. Significant effort also continues toward cultivating relationships with Colorado State University IT personnel to facilitate the acquisition of the ArcGIS Online permissions, accounts, and credits necessary for creation of projects designed to streamline field-to-office data and workflows.

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AREA 2: TECHNICAL ASSISTANCE FOR MILITARY INITIATIVES

7.0 PROJECTS THAT RECEIVED TECHNICAL SUPPORT

We provide technical services to the Army in the form of personnel expertise, data acquisition and evaluation, graphics support, and document preparation, for military initiatives for training capacity, for cooperative initiatives with state and federal resource agencies, and to provide for a defense in litigation proceedings. We also review proposed military actions to assess potential effects to TES and other species of concern. Technical assistance is provided under CEMML's Statement of Objectives (SOO) task 3.4.

During the reporting period, we assisted with the following military training, operations, and maintenance projects as well as public outreach and education initiatives. For a list of completed document deliverables produced to support military initiatives and compliance-related regulatory obligations during this reporting period, please refer to Appendix A.

7.1 ENDANGERED SPECIES ACT AND NATIONAL ENVIRONMENTAL POLICY ACT PROJECTS

7.1.1 Off-Road Maneuver Area

In April 2018, we sent an informal consultation letter to the USFWS regarding the use of free maneuver and non-fixed firing positions for live-fire artillery training at PTA. The Division Artillery requires free maneuver areas to meet battle doctrine for live-fire artillery training. Tactical vehicles will maneuver, while towing associated artillery equipment, in Training Areas 5 through 16 within the area designated as the off-road maneuver area in the 2003 BO. Artillery units will select opportune locations within approved artillery live-fire areas (i.e., within the PTA restricted airspace), instead of firing from fixed firing points, to engage specific targets in the impact area. The ability to freely maneuver and select firing positions will provide a more realistic training environment compared to firing from fixed positions.

In the informal consultation letter, the Army determined that the effects of free maneuver and firing from non-fixed firing positions will be no greater or substantially different from the effect of off-road maneuver as described in the 2003 BO. The 2003 BO included conservation measures to minimize training effects to 15 ESA-listed plants, the Hawaiian hoary bat and its habitat, and Palila Critical Habitat. The Army concluded that the 2003 BO adequately addresses military training-related impacts (including impacts from off-road maneuver and artillery live-fire) on these TES and that firing artillery from non-fixed firing positions is not likely to adversely affect these species or adversely modify Palila Critical Habitat.

In addition, based on the evaluations in the informal consultation letter, with continued implementation of required conservation measures and management activities as prescribed in past

BOs to avoid and minimize impacts, and with continued application of External Standard Operating Procedure requirements for training activities, we determined that the proposed action may impact, but is not likely to adversely affect, species not addressed under the 2003 BO including: *Exocarpos menziesii*, *Festuca hawaiiensis*, *Portulaca villosa*, *Schiedea hawaiiensis*, *Sicyos macrophyllus*, Band-rumped Storm Petrel (*Oceanodroma castro*), and anthricinan yellow-faced bee (*Hylaeus anthracinus*).

7.1.2 Programmatic Biological Assessment

During the reporting period, we assisted the PTA Army Biologist with preparing for the development of the installation's upcoming Programmatic Biological Assessment (PBA). The PBA is intended to be a comprehensive document that identifies and measures potential impacts to TES or critical habitat at PTA. Analyses will be presented effects on 20 plant species, 2 invertebrate species, 4 bird species, and 1 mammal species that are or may be present within the action area, as well as Palila Critical Habitat. The PBA will be prepared in accordance with legal requirements set forth under section 7 of the ESA (16 U.S.C. 1536 (c)) and will follow Department of Army requirements (Army Regulation 200-1).

The PBA for PTA will be modeled after the Oʻahu PBA, currently in draft form and under review. Actions considered within the PBA will include current routine military training, current non-military actions, and planned or proposed military and management-related activities. A variety of avoidance and minimization measures are ongoing at PTA to reduce potential impacts of military activities to TES, including wildland fire management, non-native species control, and integrated training management. The action area considered within the PBA, which may exceed the installation boundaries, shall be delineated based on the furthest likely extent of wildfire and weed spread that would be a result of military activities at PTA.

An effects analysis will be conducted for the 27 TES and the Palila Critical Habitat present within the action area. Direct effects may include risk of wildfire and trampling, based on probabilities of impacts as a function of the described actions. Indirect effects may include risk of non-native plant (weed) spread to ESA-listed populations. Cumulative effects of non-military actions will also be included. Ongoing avoidance and mitigation measures will be accounted for within these impact analyses. For those species where analyses indicate that military activities are likely to adversely affect the populations, additional on- and off-site conservation measures will be proposed. Specific management strategies will include ungulate fencing, invasive species control, and outplanting.

In July 2019, we participated in a PBA Kick-off Meeting with stakeholders including the US Army Garrison, Pōhakuloa; US Army Garrison, Hawaiʻi; US Fish and Wildlife Service; Army Environmental Command/Installation Management Command; US Army Corps of Engineers, Engineer Research and Development Center, Construction Engineering Research Laboratory, and the Center for Environmental Management of Military Lands. A series of presentations summarized the installation background, purpose and need for the PBA, training capabilities at PTA, construction and maintenance activities, wildland fire impacts and proposed fire model for the action area, discussion with the PTA Commander LTC Borce, proposed weed threat analysis, and TES that may be affected by the proposed action.

Action items discussed during the PBA Kick-off Meeting included finalizing the training descriptions for PTA, proposed conservation actions, permit activities covered under 10a(1)(A), timeline to get a final draft of the PBA to USFWS by Spring 2020 including AEC review/comments, inclusion of off-site areas in the project description, and incorporation of avoidance and minimization measures into the main body of the PBA.

We also provided technical assistance for various information/data requests including:

- Army Consultation History for PTA 2002 to 2017: Date, Resources Type, ESA Consultation, Title/Subject, Notes.
- Natural Resources Training Restrictions Map and Spreadsheet: Training Area/Range, Sub Area, Training Type and Restriction (Green: Permitted, Yellow: Modified, Red: Prohibited), ESA/NEPA/NHPA (Yes, No).
- Species Background Data: Plant Survey Data from FY 2016–2017 Biennial Report, RAMS Figures 2019 No Plots, Threatened and Endangered Plant Summaries.
- Species Information Spreadsheet: Taxonomic Group, Species Name, Available Reports, Survey/Monitoring Data Description, Spatial Data (GIS).

7.1.3 Records of Environmental Consideration

During the reporting period, we regularly assisted the PTA Army Biologist with reviewing Records of Environmental Consideration (RECs). RECs are submitted with project documentation under the National Environmental Policy Act (NEPA), and briefly document that an Army action has received environmental review. We provided technical reviews, comments, and recommendations. We concurred with RECs for military initiatives that did not have adverse effects on TES, or if the project's effects to natural resources were covered under previous consultations with USFWS.

In FY 2018 and FY 2019, we reviewed and commented on the following RECs:

- 4309 Repair Cantonment Utility System–Soils Disposal Area Amendment
- 4328 Cantonment Utilities Phase 2
- 4385 Geotechnical Investigation
- 4401 Paving at Building 31
- 4405 Construct New Wireless Communication Facility
- 4499 Install Main Gate Sign
- 4513 Fuel and Ammunition Refueling Point 19 Improvement
- 4518 High Mobility Artillery Rocket System Recurring Training
- 4521 Small Unmanned Aircraft Systems Training in Hawaiʻi
- 4522 Artillery Live-fire at LZ Rob and Dead Man's Curve
- 4534 Establish Firing Points 713, 714, and 715

- 4540 Install Siren System
- 4541 Renovate Dining Facility Building T-190
- 4542 Renovate Dining Facility Buildings T-185 and T-186
- 4555 Demolition of Hangar and Hazards Building 351
- 4571 Mauna to Mauna Ultra Race
- 4577 Explosive Ordnance Disposal-T Target Placement

Additional military projects that received technical assistance under Area 2 included:

- Asphalt Road Paving Project
- Degraded, Denied, and Disrupted Space Operations Environment during Lightning Strike 19
- Mortar Firing Points (711–715) at Charlie Circle
- Proposed Bivouac Activities in the Keʻāmuku Maneuver Area

7.2 Integrated Natural Resources Management Plan

In September 2017, we hosted an INRMP update meeting between the Army and relevant stakeholders. We prepared and delivered presentations to regulatory partners regarding the INRMP update process, stakeholder responsibilities, and PTA Natural Resources Program areas. We coordinated agency review of document updates and assisted with tracking the INRMP review by partner agencies (e.g., USFWS, Hawaiʻi DoFAW). We coordinated agency responses and worked with a CEMML contractor to ensure comments were incorporated to the INRMP. The INRMP was submitted to the Army to route to agencies for signature in March 2018.

In September 2018, we coordinated an annual INRMP review meeting between the Army and our regulatory partners. We prepared a series of presentations on our annual accomplishments toward INRMP goals. We also coordinated field visits for regulators and partners to see natural resource management areas at PTA.

In 2019, we coordinated and prepared for an annual update meeting scheduled for October 2019. We prepared a series of presentations on our annual accomplishments toward INRMP goals. The results of this INRMP review meeting will be reported on in the next biennial report.

7.3 Technical Reviews

7.3.1 Real Property Master Plan

During the reporting period, we reviewed and provided comments on the Draft Final PTA Real Property Master Plan (RPMP). The PTA RPMP was prepared in compliance with Army Regulation (AR) 210-20 “Real Property Master Planning for Army Installations”. The AR defines planning concepts and requirements and establishes procedures for implementing the planning process. The PTA RPMP is the Garrison Commander’s vision for how the installation will be modernized and improved over the next 20 years to meet evolving mission requirements. The RPMP is comprised of 5 components: 1)

Real Property Master Plan Digest, 2) Long Range Component, 3) Installation Design Guide Supplement, 4) Capital Investment Strategy, and 5) Short Range Component.

In April 2019, after reviewing the Draft Final PTA RPMP we determined that all previous comments had been incorporated and adequately addressed in the document. Comments and email communications were saved as part of the administrative record for this project.

7.3.2 Land Retention Initiatives for Lands Leased from the State of Hawaiʻi at PTA

We provided GIS and technical information to support meetings and document development throughout the reporting period. We provided technical review and assessment of project plans for a metes and bounds survey of the PTA boundary. We also provided recommendations for tree removal at the installation to avoid impacts to the Hawaiian hoary bat and to minimize damage to ʻōhiʻa (*Metrosideros polymorpha*) to reduce the chances of spreading or contracting the fungi that cause Rapid ʻŌhiʻa Death.

7.3.3 Directorate of Public Works Cattle Guards

We assisted the Directorate of Public Works (DPW) with research and design review for constructing cattle guards and critical fence openings to allow vehicles to pass freely without opening and closing gates. We also assisted with proof of concept. We constructed an animal corral, captured animals, and then monitored them to see if they could cross models of the proposed crossing guards. We documented that sheep could cross all cattle guard designs and shared our findings with DPW.

7.4 CONSERVATION REIMBURSABLE PROGRAMS

7.4.1 Fish and Wildlife Conservation Fund

The Fish and Wildlife Conservation Fund is an installation-level program where proceeds obtained from the sale of hunting permits are used for wildlife management projects to protect, conserve, and manage wildlife. During the reporting period, the PTA Army Biologist worked with Army Environmental Command and the US Army Garrison Resources Management team (fiscal) to establish proper procedures to deposit permit-sale revenue and to withdraw funds to reimburse approved expenditures for wildlife-related projects at the installation. We developed 2019 and 2020 Annual Work Plans and budgets, including annual projected revenue and requested reimbursements. We provided monthly accounting of permit sales to the Army.

7.4.2 Agricultural and Grazing Outlease Program

The Army's agriculture and grazing outlease program involves the leasing of Army lands to non-Army entities for agricultural and grazing purposes. This program is a reimbursable program because lease payments are used to cover the administrative costs of outleasing and the financing of multiple land use management. During the reporting period, we provided assistance to the PTA Army Biologist by reviewing program requirements, the current lease, and providing technical and natural resources information about the area under the current grazing lease in the Keʻāmuku Maneuver Area.

7.5 COLLABORATIONS WITH PARTNER AGENCIES

7.5.1 Hawaiʻi Wildfire Management Organization Island-wide Vegetation Mapping Project

We participated in a collaborative vegetative fuels management mapping workshop in Hilo in January 2018 as part of a statewide effort by Hawaiʻi Wildfire Management Organization (HWMO) and other stakeholders to identify fuels management priorities, improve access to funding for fuels treatment projects, enhance communication opportunities and clarity among stakeholders, and maximize fire protection by using resources for the highest shared priorities.

Subsequently, we provided geospatial data delineating the locations of our fuel breaks with current fuels management activities including details on management actions and frequency, as well as locations of Fuels Management Corridors at PTA for the purpose of collaboratively reducing wildfire risk on Hawaiʻi Island.

7.5.2 Rapid ʻŌhiʻa Death Working Group

During the reporting period, we participated in meetings of the Rapid ʻŌhiʻa Death (ROD) Working Group. The group was formed to respond to ROD, a new disease threatening Hawaiʻi's most important native forest tree (ʻōhiʻa, *Metrosideros polymorpha*). The working group is made up of nearly 200 individuals representing state, county, federal, university, nonprofit organizations, local and private businesses, and private citizens. The purpose of the group is to facilitate inclusive communication on all issues related to the fungal disease and share knowledge on a regular basis among group members, their organizations, and the people of Hawaiʻi.

The ROD Working Group meetings are held monthly in Hilo, but most members call in from around the state or the mainland for monthly updates. Committees focusing on research, surveys, control, and outreach provide reports to keep interested parties current on the latest information.

The threat posed by ROD and associated monitoring and testing at PTA are described in Section 3.3.5.

7.5.3 Mauna Kea Watershed Alliance

During the reporting period, we participated in meetings of the Mauna Kea Watershed Alliance (MKWA). The MKWA partnership boundaries span over 500,000 acres across the upper elevation Mauna Kea landscape, with partnership lands representing around 2/3 of the total acreage. The alliance is composed of several landholders including federal and state of Hawaiʻi agencies, land trusts, non-profits, and ranches. The MKWA vision is to protect and enhance watershed ecosystems, biodiversity, and resources through responsible management while promoting economic sustainability and providing recreational, subsistence, educational and research opportunities.

The MKWA seeks to manage critical watersheds on a landscape-level by initiating planning for priority areas with the goal of implementing management actions for threats such as feral ungulates, fire, and invasive alien weeds. Coordinated management of these watershed lands is critical to sustain adequate quality and quantity of water and provide important habitat for a wide diversity of native plants and animals, including many that are endangered.

7.5.4 Endangered Palila Management

Palila Working Group

In December 2017, we hosted members of the Palila Working Group on a field visit to Kīpuka ʻAlalā in Training Area 23. The group consisted of Dr. Paul Banko, Pacific Islands Ecosystems Research Center, Dr. Kevin Brink, Pacific Islands Ecosystems Research Center, Dr. Chris Farmer, American Bird Conservancy, and Eldridge Naboa, US Fish and Wildlife Service.

Kīpuka ʻAlalā was included in the Saddle Road Environmental Impact Statement as a mitigation project and the Army agreed to manage the area in a Memorandum of Understanding. The Palila Working Group is an ad hoc group of scientists and regulators involved in studying and managing Palila. This group carries no enforcement or regulatory authority. Periodically the group has requested to visit Kīpuka ʻAlalā to see how the area is recovering post fencing and ungulate removal.

Annual Statewide Palila Population Counts

During the reporting period, 1–4 CEMML staff participated in the annual statewide Palila population counts. We coordinated access with the Army to allow the people participating in the counts to exit survey areas on Mauna Kea though PTA. We ensured all survey participants accessing PTA received all required safety briefs from PTA Range Control. We have participated with this project since 1997.

7.5.5 Hawaiʻi Reforestation Program

In March 2019, the Botanical Program crew assisted with a reforestation project coordinated by the Hawaiʻi Reforestation Program (https://hawaiianreforestation.org/about/) conducted on Department of Hawaiian Home Lands on Mauna Kea. We usually help on such projects 1–4 times per year. It gives the crew a different project and allows them to interact with other programs.

7.6 External Research Support

The Army receives occasional requests from outside agencies to conduct ecological research on the installation. Primarily comprising rare and important tropical dryland forest ecosystems, PTA is attractive to researchers throughout the country interested in understanding how best to restore native species and habitats. During the reporting period, we provided support for the following external research efforts.

7.6.1 Strategic Environmental Research and Development Program

Title: The Impact of Non-Native Predators on Pollinators and Native Plant Reproduction in a Hawaiian Dryland Ecosystem

Principal Investigator: Dr. Christina Liang

Abstract: Oceanic islands are well known for their high endemism and unique biological diversity, which make them particularly susceptible to disturbances such as non-native species invasions. Such invasions can disrupt pollination services and result in strong negative impacts on native plant reproduction and genetic diversity. Non-native invasive predators (NIP) consume animal pollinators and, by doing so, reduce pollinator populations and possibly eliminate entire pollinator guilds. Loss of pollination services due to NIP is likely an important, although poorly understood, factor in both native plant conservation and management of long-term sustainability of native island ecosystems. Here we propose to determine the impacts of NIP on native and non-native pollinators and pollinator services for at-risk as well as common native plant species in an invaded Hawaiian tropical dryland ecosystem. We will 1) identify current pollinators and pollination effectiveness for focal plant species, 2) examine diets of study site NIP (rodents, ants, and yellowjackets), and 3) apply common NIP control techniques to experimentally determine their effectiveness at both reducing NIP populations and NIP impacts on pollination and native plant reproduction.

Title: Recovery of Native Plant Communities and Ecological Processes Following Removal of Nonnative, Invasive Ungulates from Pacific Island Forests.

Principal Investigator: Dr. Creighton Litton

Abstract: Non-native ungulates exert a large effect on native biodiversity and the structure and function of native ecosystems on islands throughout the Pacific region. In Hawaiʻi, removal of ungulates is broadly recognized as a crucial first step in conserving native ecosystems, especially threatened, endangered, and at-risk species. To this end, land managers, including those on DoD installations, fence and remove non-native ungulates where conservation of native biodiversity is a priority. However, these actions are labor and cost intensive, and the long-term outcomes are not well quantified. Surprisingly little information is available on the magnitude and time frame of native plant recovery, the potential for non-native plant invasions, and the response of critical, underlying ecological processes. The objectives of the proposed research are to quantify the impacts of non-native ungulate removal on the biodiversity, structure, and function of 2 major ecosystem types, tropical wet forest and tropical dry forest, found on DoD installations throughout the Pacific Island region, and to test if nutrient manipulation is a viable management strategy for promoting native plants. Specifically, we will explore pathways and mechanisms through which ungulate removal impacts long-term patterns of native and non-native plant dynamics. In addition, to understand how ungulate removal affects key underlying ecological processes we will quantify changes in ecosystem carbon (C), nitrogen (N) and phosphorus (P) cycling, availability, and storage following removal. Finally, we will test whether manipulation of soil N and P availability can be used as a management tool to favor native plants over non-native, invasive plants.

7.6.2 Legacy

Title: Post-Wildfire Plant Regeneration in Arid Ecosystems: Overcoming Biotic and Abiotic Soil Limitations

Principal Investigator: Dr. Rebecca Ostertag

Abstract: Increased wildfire frequency and severity due to climate change threatens dryland ecosystems throughout the country and Pacific Islands. Severe wildfires destroy vegetation and alter soil properties, leading to soil erosion and degraded habitat value for important species. To maintain optimal training conditions and military readiness and to meet standards of environmental stewardship, DoD land managers must employ effective science-based strategies to restore vegetation post-wildfire at the landscape scale. This project will develop and test methods to overcome limiting factors to natural tree regeneration caused by fire damage to soil properties in a dryland forest ecosystem using burned and unburned plots established following a 2010 wildfire. Developing and testing effective procedures to improve post-fire regeneration will provide DoD land managers with critical tools needed to adapt to increasing aridity from climate change and to optimize training conditions and military readiness into the future.

7.6.3 National Science Foundation

Title: Collaborative Research: Unlocking the evolutionary history of a rapid Hawaiian Islands radiation with extraordinary breeding system diversity

Principal Investigator: Dr. Stephen Weller

Abstract: Our research objectives are first to obtain a more highly resolved phylogeny of *Schiedea hawaiiensis* using next generation sequencing, and large numbers of single nucleotide polymorphisms for detecting hybridization between species. Using this more highly resolved phylogeny we have 2 major goals. The first is to understand the evolution of breeding systems and determine how many transitions to breeding systems with separate sexes have occurred. We will also determine how many transitions to selfing breeding systems have taken place. Genetic markers from next generation sequencing will be used to determine whether hybridization between species has been important in breeding system evolution through transfer of male sterility genes associated with the evolution of separate sexes. We believe that most cases of lateral gene transfer occur between recently evolved species lacking sterility barriers. More distantly related species appear to produce largely sterile offspring, based on preliminary studies. We are uncertain whether native pollinators transfer genes between species; at present we have pollination data for 2 hermaphroditic species. We hope to determine whether the same or different native moths pollinate hermaphroditic species of *Schiedea*, some of which we know are highly outcrossed. An additional factor is the evolution of wind pollination, which is associated with the evolution of separate sexes. Exchange of genes between species pairs where one or both species is wind pollinated may be more common than for species with biotic pollination. In summary, whether hybridization occurs in *Schiedea* may depend on whether sympatric species are distantly or more closely related, and the nature of the reproductive systems. The greatest gene exchange is predicted for recently evolved, closely related species with separate sexes and wind pollination.

7.6.4 Smithsonian Institution

Title: Genetic relationship between native plants in the daisy family as part of the Smithsonian's Global Genome Initiative

Principal Investigator: Dr. Matthew Knope

Abstract: This research project is funded through the Smithsonian Institution and implemented by researchers at the University of Hawaiʻi at Hilo. The project will investigate the familial relationships between several members of the aster or sunflower family. The researchers received a grant to collect samples of each native species of the Asteraceae (Daisy) Family on Hawaiʻi Island. PTA either cultivates or encompasses land where at least 7 of these species grow. The collections will lead to a physical herbarium specimen tied to a high-quality DNA extraction and DNA sequences used for species recognition. These genetic data can lead to better management and conservation decisions, and has the potential for other broader implications, as is elaborated on at the Smithsonian Institution's Global Genome Initiative website (https://ggi.si.edu/). For this study, the researchers are requesting access to PTA to take 2 small cuttings from each taxon. The cuttings will consist of a single branch or stem of the plant but will not kill the plant or remove a substantial portion of the organism. Specimens and DNA extractions will ultimately be deposited at the Smithsonian Institution Herbarium and information from these collections will be made publicly available. This project would likely involve 2 days of collection in KMA and western training areas.

7.6.5 University of Hawaiʻi at Mānoa

Title: Population genetics and adaptive variation within the Hawaiian Band-rumped Storm Petrel (*Oceanodroma castro*)

Principal Investigator: Carmen Antaky, Graduate Student, Department of Natural Resources and Environmental Management

Abstract: To evaluate reproductive ecology and nest-site selection of *O. castro*, the researchers are proposing a paired-design study within TA 21 at PTA. Factors potentially determining nest-site selection will be evaluated by comparing characteristics of nest sites with those of corresponding randomly-located points within 100 m of each confirmed nest site. Characters such as vegetation type, distance to nearest cover, cover type, and nearest distance to ocean will be evaluated for each nest site, as well as randomly located points. The researchers will work closely with and under the supervision of Nicole Galase, PTA Seabird Project Leader, throughout all field work activities. Access is requested to TA 21 during the end of the *O. castro* breeding season between August and September 2017. Support for this project comes from US Fish and Wildlife Service Species Funding to Carmen Antaky and Melissa Price of the Natural Resources and Environmental Management Department at University of Hawai'i at Mānoa to undertake scientific research on *O. castro*.

7.6.6 US Department of Agriculture – Agricultural Research Services

Title: Assessment of airborne dispersal as a mechanism of spread of *Ceratocystis lukuohia* and *Ceratocystis huliohia*, the causative agents of Rapid ʻŌhiʻa Death (ROD)

Principal Investigator: Dr. Wade Heller, USDA Agricultural Research Services, DKI US Pacific Basin Agricultural Research Center

Project Summary: The project aims to test the hypothesis that wind-blown spores are a significant dispersal mechanism for ROD, not only for short-range dispersal within infected stands, but also for long-range movement of the disease across the landscape. We request extension of the original study end date (1 August 2018) by 1 year (1 August 2019). We request coordination for access to 2 sampling sites in TA 22 by Dr. Wade Heller on 2 dates (exact dates TBD) to install upgraded Rotorod airborne spore collectors and remove older models. External researchers only need access on first and last days to set up and take down samplers, and will be accompanied by CEMML staff. Rotorods will be attached to existing fence posts. CEMML staff, Royce Daniels and Pamela Sullivan, will collect and replace sampler heads throughout the study.

7.6.7 Hawaiʻi Island Seed Bank

We provided access and escort to biologists from the Hawaiʻi Island Seed Bank and the Lyon Arboretum to collect seed from ʻŌhiʻa (*Metrosideros polymorpha*). This effort goes to support statewide efforts to collect and store ʻŌhiʻa seed due to the ROD epidemic.

7.6.8 Acadia University, Nova Scotia, Canada

Title: Collection of Heliothine moths to study insect pheromones

Principal Investigator: Dr. Kirk Hiller

Project Summary: Dr. Hiller, Acadia University, is collaborating with the University of Hawaiʻi at Mānoa for several projects on insect pheromones. At PTA specifically, he is interested in collecting Heliothine moths. In one of the more recent surveys of the PTA by Oboyoski (1998), 2 species were found at the installation: *Helicoverpa hawaiiensis* (Hawaiian budworm) and *Helicoverpa confusa* (confused budworm). Dr. Hiller has been looking for selected species of Heliothines throughout the Hawaiian Islands (and globally) and would be very interested in collecting *H. hawaiiensis* (and possibly *H. confusa*) at PTA. His goal is to examine the evolution of pheromone communication in these species and to compare benign and damaging species worldwide. Dr. Hiller requests to attempt selective pheromone trapping and light trapping in select areas at PTA identified by Oboyoski (1998). The pheromone trapping is very specific to only a handful of moth species, and the light trapping is done without insecticide, so any by-catch can be released.

Note: Original trip to PTA by Dr. Hiller was cancelled; field work is planned for March 2020.

7.6.9 Cabrillo Community College

Title: Photograph *Silene hawaiiensis, Silene lanceolata, Vigna o-wahuensis,* and *Sicyos macrophyllus*

Principal Investigator: Rebecca Ramos

Project Summary: Ms. Ramos, an instructor at Cabrillo College, is requesting access to PTA to photograph *Silene hawaiiensis, Silene lanceolata, Vigna o-wahuensis,* and if available in the greenhouse, *Sicyos macrophyllus*. She will photograph plants in the greenhouse and possibly in the field if CEMML staff are available to escort her. She is requesting access to TAs 3 and 22, and KMA (Puʻu Pāpapa) for 2 weeks between June and August 2019. Access is to support Ms. Ramos's efforts to link science and culture through art and to highlight the Army's efforts to conserve these plants with culturally historic importance. These ESA-listed plants were all collected during the first US Exploring Expedition ca. 1840 and the specimens collected are housed at the Smithsonian herbarium. She will make prints from the photographs/drawings she makes at PTA. She may sell the prints, but all proceeds will be donated to the Polynesian Voyaging Society.

7.6.10 University of Hawaiʻi at Hilo

Title: Seed Collection Hawaiian *Bidens*
Principal Investigators: Dr. Chris Muir (UH Mānoa), Matt Knoppe (UH Hilo), and Erin Datloff (UH Hilo)
Project Summary: The researchers are studying Hawaiian *Bidens* radiation and their physiological adaptations. We collected seeds (achenes, ~25–50/individual) from 10 individuals/population and voucher samples. We were in the field for 1 day on 16 August 2019.

7.7 Army Biologist and PTA Command

7.7.1 Installation Status Report Metrics

During the reporting period, we provided the Army Biologist the number of natural resources projects planned and accomplished for each quarter of the calendar years.

7.7.2 Installation Management Command Environmental Reporting System Data Support

During the reporting period, we assisted the PTA Army Biologist by gathering and summarizing information regarding natural resources at PTA as well as projects and accomplishments towards INRMP objectives. We assisted with developing written summaries of actions for upload to the national database by the Army Biologist.

7.7.3 Commander's Field Trips

On 2 occasions in 2018, we hosted members of the USAG-P Command Staff for field visits to several locations to showcase natural resource management activities at the installation. The purpose of the field trips was to educate the Commander and members of the Command staff about our ESA-listed plants and animals, the work that we do to support the Army, answer questions/facilitate discussion, promote camaraderie and improved relations between CEMML staff and the Army, and visit native ecosystems in the tropical sub-alpine dryland forests at PTA. The agenda for each field trip is provided below. At each stop, we briefed the Commander about the history of the location, ESA-listed species present, and management activities conducted in the vicinity. A binder containing hard copies of all educational materials was provided to each participant, along with maps and photos.

7 March 2018

1) **Keʻāmuku Maneuver Area**
    - Fuels control for endangered plants on Puʻu Nohona o Hae
    - Proximity to Land Zone Turkey

2) **ASR 40 *Solanum incompletum***
    - Conservation fence units
    - Wildland fire and fuels management system

3) **Redleg Trail (Range 6)**
    - ʻŌhiʻa resources at PTA
    - Preventing the spread of Rapid ʻŌhiʻa Death

4) **Seabirds**
    - Hike out to an active Band-rumped Storm Petrel colony

5) **Hawaiian Hoary Bats**
    - Bat monitoring station across from Bradshaw Army Airfield

24 July 2018

1) **Puʻu Leilani**
    - Summary of conservation fence project at PTA
    - Ungulate control and ingress monitoring
    - Fence inspections

2) **Fuels Management System**
    - Fuel breaks and firebreaks
    - Fuel monitoring corridors

3) **ASR 8 *Tetramolopium arenarium***
    - Species profile
    - Management efforts: weed control, outplanting
    - Weed control buffers

4) **ASR 40 *Solanum incompletum***
    - Species profile
    - Management challenges: clonal groups, fine fuels, high costs

5) **Rapid ʻŌhiʻa Death**
   - ʻŌhiʻa resources at PTA
   - How the Army is preventing the spread of Rapid ʻŌhiʻa Death

7.7.4 Greenhouse and Garden Tours for VIP Groups

Throughout the reporting period, we supported numerous Army Command and VIP Tours at PTA. We led groups through the greenhouse and interpretive garden and taught visitors about the ESA-listed plants found at the installation. The purpose of the tours was to showcase PTA's unique natural resources and the work that CEMML does to support the Army.

Additionally, management staff provided PowerPoint presentations highlighting the goals and objectives of each aspect of the PTA Natural Resources Program. To manage natural resources at the installation, we implement CEMML Statement of Objectives tasks to comply with INRMP objectives, ESA consultation requirements, regulatory outcomes from NEPA documents, the IWFMP, the MBTA, as well as various compliance-related documents and permits to work with TES. After the presentations, managers were available to answer questions and facilitate discussion about Natural Resources Program goals and how they relate to the military mission.

7.8 PERMITS

To work with TES on federal and state lands, we are required to obtain multiple permits to comply with several state and federal statutes and regulations. We prepare permit applications and coordinate with Army and regulatory agency officials to obtain valid permits. We perform management actions in accordance with permit terms and conditions and prepare annual reports as required by such permit conditions. Following is short description of each permit necessary to meet our SOO tasks and INRMP objectives.

7.8.1 Federal Permits Issued by the US Fish and Wildlife Service

Native Endangered & Threatened Species Recovery Endangered & Threatened Plants (TE040123A-2)

This permit is issued by the USFWS, Endangered Species Program to USAG-P under section 10(a)(1)(A) of the ESA to assist in the recovery of 20 threatened and endangered plants at PTA. The recovery permit allows us to engage in activities that are normally prohibited by section 9 of the ESA, such as seed collection from endangered plants, for scientific purposes or to enhance propagation or survival of the species listed in the permit. The permit establishes operational terms and conditions as well as data collection and reporting requirements. The USAG-P Deputy Garrison Commander is the permit holder and CEMML staff listed on the permit are authorized to perform specified tasks in accordance with permit terms and conditions. The permit is typically renewed every 5 years.

Federal Fish and Wildlife Permit – Scientific Collection with Import / Export (MB95880B-0)

This permit is issued to USAG-P by the USWFS, Migratory Birds Program under the Migratory Bird Treaty Act (MBTA) to authorize the collection and possession of remains of Band-rumped Storm Petrels (*Oceanodroma castro*). Normally, possession of remains of birds protected under MBTA is unlawful, but with the permit we are able to use these remains for scientific purposes. The USAG-P Commander is the permit holder and CEMML staff listed on the permit are authorized to perform the work. The permit is typically renewed every 5 years.

National Wildlife Refuge System Research and Monitoring Special Use Permit (12516-19006-G)

This permit is issued by the USFWS, National Wildlife Refuge System to USAG-P to authorize management activities for the Hawaiian Goose (*Branta sandvicensis*) at Hakalau Forest National Wildlife Refuge on Hawai'i Island. The Special Use Permit specifies terms and conditions for working on refuge lands with the endangered goose. The USAG-P Deputy Garrison Commander is the permit holder and CEMML staff listed on the permit are authorized to implement actions prescribed on the permit. The permit is typically renewed annually.

7.8.2 State of Hawai'i Permits issued by the Department of Land and Natural Resources, Division of Forestry and Wildlife under Hawai'i Revised Statues Title 12 and Hawai'i Administrative Rules Title 13

Permit for Threatened and Endangered Plant Species (I1347)

This permit authorizes us to collect, possess, propagate and outplant State-listed and ESA-listed threatened and endangered plant species. This permit is necessary to maintain the species we outplanted on State lands and to collect propagules from those plantings. The USAG-P Commander is the permit holder and CEMML staff listed on the permit are authorized to perform the work in accordance with the permit's terms and conditions. The permit is renewed annually.

Permit for Access and Research – Pending approval

This permit is necessary to maintain the species we outplanted on State lands and to collect propagules from those plantings. The permit is renewed annually but is currently expired. The renewal request will name the USAG-P Commander as the permit holder and CEMML staff will be listed on the permit for authorization to perform the work in accordance with the permit's terms and conditions.

Hawaii Experimental Tropical Forest Research Permit – Pending approval

This permit is jointly issued by the US Forest Service and the Hawai'i State Department of Land and Natural Resources, Division of Forestry and Wildlife. It is necessary to access outplanting sites on State land at Pu'u Wa'awa'a. For this permit to be valid, we must also possess the following valid permits: 1) Federal Native Endangered & Threatened Species Recovery Endangered & Threatened Plants (TE040123A-2); 2) State of Hawai'i Permit for Threatened and Endangered Plant Species (I1347); and 3) State of Hawai'i Permit for Access and Research. Permit approval is pending Army and State approvals of the other 2 State permits - Permit for Threatened and Endangered Plant Species (I1347) and Permit for Access and Research. We anticipate gaining approval for all permits early in 2020. The USAG-P Commander is the permit holder and CEMML staff listed on the permit are authorized to perform management in accordance with permit terms and conditions. This permit is renewed annually.

Protected Wildlife Permit - Scientific Collection (WL19-42) – Band-rumped Storm Petrel (Oceanodroma castro)

This permit authorizes the collection and possession of up to 25 Band-rumped Storm Petrel carcasses per year for the purpose of understanding predation level within PTA. It is also required to validate the Federal Fish and Wildlife Permit–Scientific Collection with Import/Export (MB95880B-0). The USAG-P Commander is the permit holder and CEMML staff are listed as the sub-permittees responsible to perform activities in accordance with permit terms and conditions. The permit is renewed every 2 years.

Protected Wildlife Permit–Scientific Collection (WL19-43: Upland Gamebirds

This permit authorizes the collection and possession of upland game birds to better understand the role gamebirds play in exotic seed dispersal by examining diet and movement patters within PTA. Outside of the upland gamebird hunting season, we are authorized to take 15 Erckel's Francolin (*Pternists erckelii*), 15 California Quail (*Callipepla californica*), 15 Ring-necked Pheasant (*Phasianus colchicus*), and 8 Wild Turkey (*Melegaris gallopavo intermedia*). The USAG-P Commander is the permit holder and a CEMML staff member is listed as the sub-permittee responsible to perform activities in accordance with permit terms and conditions. The permit is valid through 30 June 2020.

7.8.3 Permit Issued by the Hawai'i State Department of Hawaiian Home Lands

Limited Right of Entry - Outplanting & Maintenance of Native Indigenous at Pu'u Huluhulu, Hawai'i Island (18:061)

This permit is issued by the Hawai'i State Department of Hawaiian Home Lands under Hawai'i Administrative Rules Title 10, Chapter 4. This permit is needed to access Hawaiian Home Lands at Pu'u Huluhulu to facilitate access with vehicles to our worksite. The USAG-P Commander is the permit signatory and CEMML staff listed on the permit are authorized to access the Hawaiian Home Lands at Pu'u Huluhulu for up to 30 entry events. Since we visit this site quarterly, the permit is valid for approximately 7 years and will need to be renewed in 2023.

7.9 PUBLIC OUTREACH

Public outreach and educational initiatives regarding the Army's stewardship efforts to conserve natural resources at PTA, including TES management, are consistent with DoD guidance to the installation commander to develop and foster positive community involvement and relationships (DoD 2012). In addition, community involvement is 1 of the 3 lines of effort established by LTC Borce, the PTA Commander. To support these outreach and education efforts and to meet SOO tasks 3.2(5)(g) and INRMP objectives, we engage in various events, provide presentations, and publish information about natural resources projects that highlight the Army's natural resources program and stewardship efforts.

7.9.1 Earth Day Events

Experience PTA

In April 2018 and 2019, we participated in the annual "Experience PTA" event, during which the Army invites schools and the general public to celebrate Earth Day at the installation. The event included numerous eco-stations with multiple hands-on activities, educational displays, informative briefings, and live demonstrations. We showcased our management of TES and natural resources with interactive displays and games. Garden tours featured endangered plants such as *Solanum incompletum*, one of Hawai'i's few spiked plants. We also demonstrated how we use technology such as unmanned aerial vehicles to map the area to monitor natural resources and assess effects from wildland fires.

Additionally, the Cultural Resources team demonstrated how it manages and preserves cultural resources. Visitors were able to take a virtual lava tube habitation site tour, enjoy an interactive cave presentation, or participate in a hands-on petroglyph activity. PTA's Fire and Emergency Services exhibited its firefighting equipment, specialized vehicles, and an interactive exhibit on wildland fire prevention and suppression. The event also featured hands-on demonstrations on recycling and upcycling.

University of Hawai'i at Hilo Earth Day

On 26 April 2019, we participated in the 31st annual Earth Day Fair at the University of Hawai'i at Hilo campus. We showcased our management of TES and natural resources at PTA through educational displays, interactive games/activities, and live demonstrations.

The Earth Day Fair provided an excellent non-commercial forum to share messaging with students and members of the public regarding environmental conservation, natural resource awareness, conservation career pathways, and global unity. Each year, 1,000–2,500 invited K–12 students and their educators attend the Earth Day Fair and Conservation Career Day at the University of Hawai'i at Hilo. Recent years have shown a steady rise in middle and high school student attendance; in response event organizers aimed to increase opportunities for secondary and college/university students.

7.9.2 School Group Visits

Makua Lani Christian Academy

In December 2018, we coordinated access and assisted teachers and students from Makua Lani Christian Academy to collect soil from Mauna Kea soil deposits near Bradshaw Army Airfield. The soil structure is similar in nature to lunar regolith. The students used the soil to test how sloped shielding affects the penetration into the lunar regolith by high velocity particles (simulated by a bullet fired from a high-powered rifle). The students won first prize in their category at a NASA competition, the AeroSpace Meridian.

Hawaiʻi Preparatory Academy (HPA)

On 16 August 2018, we hosted a visiting group of 40 8th grade students from HPA as part of the Summer Nights at PTA program run by the Public Affairs Officer. We provided a greenhouse tour and taught the kids about the ESA-listed plants at PTA.

In May 2019, we hosted another group of 15 students in grades 10–12 from the HPA Agro Ecology class. We provided a greenhouse tour and taught the kids about the ESA-listed plants at PTA.

Waimea Middle School (WMS)

On 24 October 2018, we presented to about 50 students from WMS about natural resources management as a career. Half the presentation focused on types of activities and actions performed by natural resources managers and the educational requirements. The other half was hands-on activities to demonstrate tools of the trade.

On 24 May 2019, we hosted 80 8th grade students from WMS. The class focused on STEAM (Science, Technology, Engineering, Art, and Mathematics) curriculum. The purpose of the visit was to educate, inform, and inspire rising 8th grade students; specifically, the PTA Commander's intent was to send the WMS students home with the "wow" factor by communicating the essence of our program and how it relates to STEAM. The students were introduced to the Recycle Center, Cultural Resources, Natural Resources, Fire Department, and Emergency and Medical Services. During the visit, we provided a greenhouse tour and taught the kids about the ESA-listed plants at PTA.

NexTech

We designed and developed technology-based activities to demonstrate typical natural resources management activities to a group of 15 high school students and 10 adult chaperones. Activities included investigations with night vision technologies to survey for and manage endangered birds; use of electronic data devices, microscopes, and on-line dichotomous keys to collect and identify invasive ant species; use of electronic devices to navigate across terrain to specific locations, to outplant endangered plant species, and to collect data regarding the planting to automatically synch to GIS systems.

7.9.3 Nāhelehele Dryland Forest Symposium

On 9 February 2018, Lena Schnell, CEMML Senior Program Manager, gave a 30-minute presentation at the Nāhelehele Dryland Forest Symposium at the Courtyard Marriott King Kamehameha Kona Beach Hotel. The presentation summarized the Army's Natural Resources Program at PTA. We frequently attend this annual event. On several occasions, we have staffed an outreach booth with program materials at the symposium and have hosted a tour group to the installation. The non-profit group, Kaʻahahui ʻo ka Nāhelehele, organizes the Dryland Forest Symposium. Agencies and other organizations working to conserve dryland forest statewide attend this event.

On 10 February 2018, we hosted a tour group to the installation associated with the Nāhelehele Dryland Forest Symposium. Field trip participants visited sites within ungulate exclusion fence units in Training Areas 18, 19, 20, 22 and 23 to view ESA-listed plants, outplanting locations, places where we conduct management activities, and various natural resources in PTA's subalpine tropical dryland forest ecosystem. We ended the day at Puʻu Nohona o Hae in the Keʻāmuku Maneuver Area, where participants assisted natural resources staff with removing invasive grasses by hand from our endangered plant management site.

On 27 March 2019, Lena Schnell, CEMML Senior Program Manager, gave a 5-minute presentation at the Hilo Imiloa Astronomy Center as a follow-up to the presentation delivered at the 2018 Nāhelehele Dryland Forest Symposium. The presentation highlighted major accomplishments the CEMML team made at PTA over the past year. The purpose of the talk was to continue to provide high-quality information about the efforts to manage natural resources at PTA and improve information exchange and collaboration with the Big Island's community of natural resources managers and interested members of the public. The presentation was reviewed and approved by the PTA Public Affairs Officer.

7.9.4 Waimea Fall Festival

In October 2018 and 2019, we participated in the 3rd annual Waimea Fall Festival event at the Waimea District Park Complex. We showcased our management of TES and natural resources at PTA through educational displays, interactive games/activities, and live demonstrations. The family-friendly event featured live entertainment, a pumpkin patch, keiki activities, community information booths and exhibits, farmer's market, crafts, food and beverages. The Waimea Fall Festival is sponsored by Waimea Athletics and supported by various individuals and organizations, including PTA, the Waimea Community Association, and Parker Ranch.

PTA had a series of exhibits at the festival, ranging from an aircraft display to the always popular football toss and dog tag-making station hosted by recruiters. The aircraft display on the football field featured an MV-22 Marine Medium Tiltrotor Squadron 363, a United States Marine Corps tiltrotor squadron consisting of MV-22B Ospreys. The squadron, known as the "Lucky Red Lions," is based at Marine Corps Base Hawaiʻi and falls under the command of Marine Aircraft Group 24 and the 1st Marine Aircraft Wing. USAG-P leadership decided that bringing the aircraft to the festival would be a good way to inform the community with a show-and-tell. PTA also had its natural and cultural resource experts on hand to introduce and discuss their management of 27 TES as well as the installation's cultural and archaeological resources. The annual festival attracts more than 6,000 people.

7.9.5 Run for the Dryland Forest

In October 2017 and 2018, we participated in the annual Run for the Dryland Forest at the Puʻu Waʻawaʻa Forest Reserve. The People's Advocacy for Trail Hawaiʻi (PATH) hosted the event in partnership with the US Forest Service, Ironman Kokua Program, as well as the Program Manager and Ahupuaʻa Coordinator for Puʻu Waʻawaʻa. Event coordinators invited land management agencies and other conservation organizations to display public education and outreach materials. About 400–500 people attend the event each year, and ~15 agencies provide outreach booths.

We hosted an outreach booth at the event, to educate the public about the Army's Natural Resources Program at PTA. The display included a poster detailing program functions and accomplishments to manage 27 TES, several living endangered plants, and brochures.

7.9.6 Waimea and Hilo Library Displays

In April and May 2019, we set up informational displays at the Waimea and Hilo Public libraries. The purpose of the displays was to educate the general public about natural resources at PTA, TES found on the installation, PTA background, management activities that CEMML staff conduct to support the Army, and a summary of each of the PTA Natural Resources Program areas. Educational materials included photographs of TES, rare and native plants, staff conducting field work, the cantonment area, and PTA landscapes. We also displayed a TES fact sheet, vision and mission statements, and a map of the installation. Full-size posters included:

- An *Oceanodroma castro* Colony at Pōhakuloa Training Area, by Nicole Galase, Lena Schnell, and Rogelio Doratt.
- Seasonal Activity Patterns of the Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) at Pōhakuloa Training Area, by Rachel Moseley, Lena Schnell, and Rogelio Doratt.
- A Phased Approach to Improving Habitat for a Critically Endangered Species, by CEMML staff.
- How the Army Combats Rapid ʻŌhiʻa Death, by CEMML staff.
- PTA Natural Resources Office Overview.
- Natural Resources Infrastructure at PTA (map).

Each display was up for approximately 1 month, facilitating positive feedback from library staff and members of the public.

7.10 Publications and Presentations

7.10.1 National Military Fish and Wildlife Association

The National Military Fish and Wildlife Association connects, educates, supports, and advocates for natural resources professionals across the Department of Defense to protect and enhance the military mission through sustainable resource conservation. In March 2019, we hosted a technical session "Fire, Flora, and Feral Species: Lessons from Hawaiʻi Ecosystem" with 4 presentations:

- Approaches to Feral Ungulate Management in a Hawaiian Dryland Ecosystem. Lena Schnell, Senior Program Manager, CEMML at USAG-Pōhakuloa.
- Reaching Zero: 20 Years to Eradicate Non-native Ungulates in Conservation Fences at Pōhakuloa Training Area, Hawaiʻi. Rogelio Doratt, Wildlife Program Manager, CEMML at USAG-Pōhakuloa.
- Fire, Flurry, and Flora: Fuels Management Trumps Wildfire Impacts to Endangered Plants at Pōhakuloa Training Area, Hawaiʻi. Pamela Sullivan, Invasive Plants Program Manager, CEMML at USAG-Pōhakuloa.
- Development and Implementation of a Mobile GIS Framework for Natural Resources Management. Nikhil Narahari, Ecological Data Program Manager, CEMML at USAG-Pōhakuloa.

7.10.2 Hawaiʻi Conservation Conference

The Hawaiʻi Conservation Conference allows a diverse group of scientists, policymakers, conservation practitioners, educators, students and community members from Hawaiʻi and the Pacific to converge and discuss conservation. It's a time to connect, share and inspire, all with the common goal of caring for our natural resources. During the reporting period, we provided 1 presentation at the conference:

Title: Detector dog (and other methods) leads to the first confirmed Band-rump Storm Petrel colony in the Hawaiian Islands
Type: Oral presentation
Date: 9 July 2019
Description of Event: We presented our work as part of a symposium titled "Conservation's best friend? Detection dog's utility, efficacy, and science explored"
Number of People in Attendance: ~50 people attended the symposium

7.10.3 Hawaiʻi Ecosystems Meeting

The Hawaiʻi Ecosystems Meeting occurs annually on the campus of the University of Hawaiʻi at Hilo. The meeting consists of 5–10 min presentations, ranging from the results of major projects to "what I plan to do in my first summer of research". There is 1 session with many talks (no concurrent sessions) with some time for discussion or questions during the sessions, as well as long and informal breaks during which there is plenty of time and opportunity to explore ideas. The purpose of this format is to give participants a chance to see what others are doing, and to explore possible enrichments or collaborations. During the reporting period, we provided 1 presentation at the meeting:

Title: Fire, Flurry, and Flora: Fuels Management Trumps Wildfire Impacts to Endangered Plants at Pōhakuloa Training Area, Hawaiʻi
Type: Oral presentation

Date: 5 March 2019
Description of Event: 10-minute presentation by Pamela Sullivan
Number of People in Attendance: ~200 people attended the meeting

7.10.4 Band-rumped Storm Petrel Publications

During the reporting period, we produced 2 journal articles about the discovery of an active Band-rumped Storm Petrel colony at PTA. A colony with confirmed activity at a burrow was discovered in Training Area 21 in October 2015, which is significant because no active nesting burrows had been previously documented in the Hawaiian Islands.

<u>Marine Ornithology</u>

Title: First confirmed Band-rumped Storm Petrel (*Oceanodroma castro*) colony in the Hawaiian Islands
Date: February 2019
Type: Journal article
Publication: Marine Ornithology
Author(s): Nicole Galase
Abstract: The Band-rumped Storm Petrel is an endangered subtropical pelagic seabird found along the Atlantic and Pacific oceans. We used a combination of acoustic monitoring, night vision surveys, dog searches, and remote camera surveillance to search for occupied nests in support of the US Army's natural resource management requirements in Hawaiʻi. We discovered a breeding colony at 2,113 m elevation on the northern slope of Mauna Loa within the US Army's Pōhakuloa Training Area on Hawaiʻi Island. Camera surveillance confirmed active breeding nests. Because this is the first confirmed location of a colony in Hawaiʻi, it deserves further investigation.

<u>Wilson Journal of Ornithology</u>

Title: Nesting ecology in the Hawaiian population of an endangered seabird, the Band-rumped Storm Petrel (*Oceanodroma castro*)
Date: June 2019
Type: Journal article
Publication: Wilson Journal of Ornithology
Author(s): Carmen Antaky, Nicole Galase, Melissa Price
Abstract: The first confirmed nesting location of the Hawaiian population of the Band-rumped Storm Petrel (*Oceanodroma castro*), an endangered seabird, was recently discovered on Hawaiʻi Island after decades of searching. Following the discovery, we analyzed nest site preferences of the Band-rumped Storm Petrel at this site using a paired design. Band-rumped Storm Petrels preferred deeper crevices compared with those available within 100 m of the nest sites. Physical and environmental characteristics of Hawaiian Band-rumped Storm Petrel nest sites may aid conservation efforts including on-the-ground searches, removal of invasive mammalian predators, identification of potential translocation sites, and habitat restoration for this endangered species.

7.10.5 Ecosystem Management Program Bulletin

During the reporting period, we submitted 2 articles for the annual Ecosystem Management Program (EMP) Bulletin produced by the Oʻahu Army Natural Resources Program. The bulletin is designed to educate the public and the military community about the unique resources on Army-managed lands and the Army's efforts to conserve them. The goal is to encourage a collective conservation ethic, foster innovation and inspire and expand opportunities for collaboration and partnership with academia, industry, and beyond.

Title: A strategic approach to improving habitat for the critically endangered *Melanthera venosa* at Pōhakuloa Training Area
Date: September 2018
Type: Article
Publication: EMP Bulletin, US Army Garrison-Hawaiʻi
Author(s): Tiana Lackey
Summary: Nehe (*Melanthera venosa*) is an ESA-listed plant in the sunflower family that is currently only known to exist on Puʻu Nohona o Hae at PTA. Primary threats include loss and degradation of habitat from feral ungulates, wildland fire and invasive weeds. To help protect the species from the immense threat of feral ungulates and wildland fire, the Army enclosed the puʻu with a 1.8-m conservation fence and an 18-m fuel break; it has been ungulate-free since December 2009. Recent monitoring efforts showed that the nehe population was in decline, likely due, in part, to the fact that the puʻu is highly dominated by invasive plants such as fountain grass (*Cenchrus setaceus*). In January 2016, we implemented a phased approach to invasive plant management.

Title: First active Band-rumped Storm Petrel nest recorded in Hawaiʻi
Date: September 2018
Type: Article
Publication: EMP Bulletin, US Army Garrison-Hawaiʻi
Author(s): Nicole Galase
Summary: The Band-rumped Storm Petrel is the smallest seabird in Hawaiʻi and spends most of its life at sea. A vast pahoehoe leave field 40 miles from the nearest coast and 2,100 meters above sea level is not where most people would look for seabirds. This subalpine tropical dryland forest is a rare, sparsely vegetated ecosystem, dominated by ʻaʻā and pāhoehoe lava fields. Despite its barren appearance, this unique habitat, which falls within PTA on Hawai'i Island, is where the Army's natural resource program found the first active Band-rumped Storm Petrel nest in the Hawaiian Islands in October 2015. Search methods included acoustic data collection, night vision surveys, dog searches, and surveillance cameras.

Title: The US Army Garrison, Pōhakuloa Training Area helps to protect Hawaiian Geese at Hakalau Forest National Wildlife Refuge
Date: September 2019 (Draft*)
Type: Article

Publication: EMP Bulletin, US Army Garrison-Hawaiʻi
Author(s): Tiana Lackey and Stephanie Levins
Summary: In January 2017, the Army initiated a Hawaiian Goose Conservation Project in collaboration with Hakalau Forest National Wildlife Refuge (HFNWR) to satisfy regulatory requirements identified in the 2013 Biological Opinion issued by the USFWS. The goal of this partnership is to increase goose productivity (i.e., the number of hatchlings surviving to adulthood) by improving nesting success, forage, and future nesting conditions by managing habitat and minimizing threats from predators. Conservation management activities at HFNWR are implemented by CEMML staff through a cooperative agreement with the Army. To be consistent with refuge goals, the Army developed a management action plan with HFNWR to include: 1) goose monitoring, 2) nest monitoring, 3) predator control, and 4) habitat management. The article summarizes results of management actions completed during the September 2018 to April 2019 Hawaiian Goose breeding season.

*Note: We drafted this article in September 2019 and provided it to the PTA Army Biologist, but it was not submitted to the EMP Bulletin editors in time to meet the deadline for publication of the 2019 issue. We hope to submit the final version of the article for the 2020 issue.

7.10.6 Media Interviews/Information

During the reporting period, we provided interviews or information for the following publications:

<u>Hawaiʻi Tribune Herald</u>
27 December 2017
Rarest of the rare: colony of endangered seabirds discovered at PTA
By Tom Callis

<u>West Hawaiʻi Today</u>
27 December 2017
Endangered seabirds discovered at PTA nearly 7K feet above sea level
By Tom Callis

<u>Hawaiʻi Public Radio</u>
28 December 2017
Nesting area for endangered seabirds found on Big Island
By Casey Harlow

<u>Honolulu Magazine</u>
24 April 2018
These local dog detectives sniff out everything from drugs to diseases
By Kim Steutermann-Rogers

Hawaiʻi Civil Beat
5 June 2018
Military's live-fire training ignites resistance from some Big Island neighbors
By Jon Letman

Hakai Magazine
20 March 2019
Hidden Hawaiian bird nests finally found
By Frances Backhouse

7.10.7 Wildlife Posters

During the reporting period, we produced 2 scientific posters that the Wildlife Program team presented at various conferences, meetings, proceedings, and outreach events:

Title: An *Oceanodroma castro* colony at Pōhakuloa Training Area
Date: February 2019
Author(s): Nicole Galase, Lena Schnell, Rogelio Doratt
Summary: Poster documenting the first discovery of an active Band-rumped Storm Petrel nest in the Hawaiian Islands in October 2015. Search methods included acoustic monitoring, dog searches, and remote video surveillance. All criterion for an active colony were observed at PTA (e.g., circling flight patterns, ground calling, visual of seabird landing, and activity observed in burrow). Next steps include determining the extent of the colony through acoustic monitoring, characterizing the behavior and breeding phenology of the species through video surveillance, and predator control.

Title: Seasonal activity patterns of the Hawaiian hoary bat (*Lasiurus cinereus semotus*) at Pōhakuloa Training Area
Date: February 2019
Author(s): Rachel Moseley, Lena Schnell, Rogelio Doratt
Summary: Poster documenting results of a 3-year study to determine Hawaiian hoary bat occupancy and seasonal activity patterns in areas at PTA with and without potential treeland roosting habitat using acoustic monitoring. Preliminary bat and weather data collected between July 2014 and June 2015 is summarized. To study the effects of environmental conditions on regional trends in bat activity, we delineated 5 regions. Region was the largest contributing factor to variability in bat activity at PTA during the first year of monitoring. Overall activity was highest in the grassland regions.

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AREA 3: ASSESSMENTS AFTER DISTURBANCE EVENTS

8.0 EVENTS THAT REQUIRED ASSESSMENT

Following disturbance events such as wildland fire, drought, or flooding we provide technical assistance to the Army by assessing the condition of natural resources. Additionally, the Integrated Wildland Fire Management Plan (USAG-P 2019b) and 2003 Biological Opinion (USFWS 2003a) require the Army to assess and report all military training-related wildland fires occurring on the installation outside of the Impact Area to determine potential effects to TES and incidental take of Hawaiian hoary bats.

During the reporting period, we provided an assessment following a single wildland fire in July 2018. In this section, we summarize the key findings from the initial post-fire assessment submitted to the Army. For a discussion of ESA-listed plant recovery in the area impacted by the fire through the end of the report period, see the Plant Survey and Monitoring Section Discussion (Section 2.2.6).

8.1 JULY 2018 WILDLAND FIRE IN TRAINING AREAS 18, 19, AND 22

On 18 July 2018, at approximately 1800 hours, a wildland fire ignited in Training Area (TA) 19 at PTA. The fire eventually spread to adjacent TAs 18 and 22; it burned 585 ha before it was declared 100% contained on 1 August 2018. We conducted a post-fire survey within 2 weeks of the fire being extinguished.

The fire was most severe in the northwest portion of TA 22, where only stems of larger woody vegetation remained. This portion of TA 22 had high densities of fire prone grasses such as *Cenchrus setaceus* and *Eragrostis atropioides*. Areas with lower grass densities burned with much less intensity, with some areas left completely unburned. Because of the mosaic of substrates and vegetation types in the affected area, the overall impact of the fire was patchy and heterogenous. For example, while some areas burned almost completely, there were other areas with an abundance of native shrub species less than 2 meters in height remaining that retained their leaves and other plant parts. Of the 716 plant locations visited during post-fire surveys, 34% were determined to be fully burned, 49% partially burned, and 17% completely unburned.

8.1.1 Effects to Plant Species Listed under the Endangered Species Act

Data for the assessment of impacts to ESA-listed plant species came from direct counts from recent Priority Species 1 monitoring (*Portulaca sclerocarpa*, *Solanum incompletum*, and *Tetramolopium arenarium*), estimates based on count class from plant surveys conducted in 2013 (*Haplostachys haplostachya*, *Silene hawaiiensis*, *Silene lanceolata*, and *Stenogyne angustifolia*), and complete counts of individuals from a post-fire survey conducted for all species in the burn footprint.

Haplostachys haplostachya

There were approximately 228 locations of *H. haplostachya* within the burn footprint containing a pre-fire estimate of 3,030 individuals. We found 444 individuals in the burn footprint during post-fire surveys. It is important to note that the actual number of individuals present immediately preceding the fire is unknown, therefore it is not possible to accurately estimate the number of individuals directly lost due to the fire. While there are no weed control buffers (WCBs) specifically established for *H. haplostachya* in the burned area, this species is found within WCBs established for other ESA-listed species. *H. haplostachya* is found within a WCB in ASR 44 that did not burn.

Portulaca sclerocarpa

Two previously known *P. sclerocarpa* locations were within the burn footprint, containing a pre-fire estimate of 8 individuals. A single plant in the southern-most portion of the burn footprint was lost. A single plant in the western portion of the burn footprint was partially burned and experienced heat stress but was resprouting at the time of post-fire surveys. Neither location had a WCB. A previously unrecorded location of *P. sclerocarpa* was recorded during the post-fire survey. This newly recorded location had 7 individuals and occurs in an area that was partially burned. This new location does not have a WCB.

Silene hawaiiensis

Eight locations of *S. hawaiiensis* were within the burn footprint, all partially or fully burned. We found 5 individuals remaining at 2 of these locations; there were potentially 36 individuals lost due to the fire based upon an estimate from plant surveys conducted in 2013. Some locations were in ASR 19 which had a WCB but appears to have burned with higher intensity than other areas due to the density of *E. atropioides*.

Silene lanceolata

Four locations of *S. lanceolata* were within the burn footprint with an estimated 7 individuals based on 2013 plant survey data. During post-fire surveys, we found 25 plants at those 4 locations.

Solanum incompletum

Twelve known *S. incompletum* individuals were near the burn footprint (ASR 40), protected by several WCBs. These WCBs were implemented in 2008 and comprise 3 ha. The fire burned up to the WCB of the southernmost section of ASR 40 and stopped ~20 m from an individual *S. incompletum*. The WCB was instrumental in the survival of that individual. No *S. incompletum* were lost due to this fire event.

Stenogyne angustifolia

S. angustifolia was one of the species most impacted by this fire event. Approximately 463 locations were within the burn footprint (out of 1,087 total locations at PTA). Of these, 74 did not burn, 185 partially burned, and 204 fully burned. Based on 2013 plant survey data, we estimate there were 2,167 individuals in the burn footprint. The heterogeneity of the fire left patches of vegetation of various sizes that did not burn. Some patches of less than 5 m^2 still contain *S. angustifolia* and unburned plants were often found directly adjacent to burned plants. We found 904 individuals within the burn footprint during post-fire surveys. Six locations and 21 individuals were newly recorded within the burn footprint.

There are no WCBs established for *S. angustifolia* due to its abundance and distribution at PTA. It co-occurs with other high priority species in ASR 8 and 19 for which there are WCBs. In ASR 19, approximately 40 individuals remain.

Tetramolopium arenarium

The entire known distribution of *T. arenarium* occurs within the footprint of the fire. Prior to the fire, Priority Species 1 monitoring indicated there were 338 individuals. *T. arenarium* historically occurred in 3 clusters within ASR 8 and is currently only found in 1 cluster (ASR 8 North).

The WCBs in ASR 8 were instrumental in protecting this species. These WCBs were implemented in 2002 and comprise 12 ha. *T. arenarium* inside the WCBs are at minimum 45-50 m from the inside edge of the buffer. Post-fire surveys showed the fire burning up to the edge of the buffer, but no further. There was also only minimal damage to common native species at the edge of the buffer. The area of the WCB was almost entirely intact and not impacted by the fire. No *T. arenarium* individuals within the buffer were impacted by the fire.

8.1.2 Incidental Take of Hawaiian Hoary Bats

The 2003 Biological Opinion (BO) classifies the incidental take of Hawaiian hoary bats at PTA as:

1) Direct take resulting in the death or injury of individual bats;
2) Harm due to significant loss of potential available treeland roosting habitat;
3) Harassment by noise and ground disturbance.

In the 2003 BO Incidental Take Statement for the Hawaiian hoary bat, the USFWS has authorized and anticipates the take of bats associated with the loss of no more than 48 ha per year of treeland roosting habitat outside the Impact Area, and no more than 1,345 ha cumulatively. If the loss of treeland habitat exceeds the authorized annual or cumulative amounts, the Army is required to reinitiate consultation with the USFWS. Incidental take is indirectly monitored by determining the area, in hectares, of treeland roosting habitat that is lost or converted each year at PTA outside the Impact Area.

The July 2018 fire burned approximately 149 ha of vegetation considered “potential available” Hawaiian hoary bat roosting habitat. The 2003 BO defines roosting habitat as vegetation types that could provide available roosting habitat, currently or at some time in the future, including all treeland communities and shrubland communities with *Sophora chrysophylla* and *Myoporum sandwicense* as dominant or co-dominant. The area burned, estimated from imagery and through spot ground checks in selected areas, exceeded the Army's annual indirect, incidental take authorization by a factor of 3 (149:48 ha). However, it is important to note the fire did not burn completely or uniformly throughout the area. This resulted in a mosaic of burn intensities across the vegetation communities varying from completely burned to completely untouched by fire. Due to the unevenness of the burn, some roost trees will likely persist within the areas reported as burned. Also, some roost trees, such as *S. chrysophylla*, resprout from root tissue following fire, which will help speed the recovery of roosting habitat.

Some roosting habitat within the burn area was recovering from multiple years of impacts from sheep and goats. Additionally, some trees may not have met contemporary understanding of roosting tree characteristics (i.e., trees over 1.8 m) at the time of the fire. However, as previously mentioned, the 2003 BO and Incidental Take Statement includes the *potential* for treeland and shrubland to provide roosting habitat. Therefore, even if trees were under 1.8 m tall at the time of the fire, they may have become future roosting sites, and are therefore considered lost due to the fire.

Since the issuance of the 2003 BO, this was the only large training-related fire at PTA to exceed the authorized indirect, incidental Hawaiian hoary bat take amount. Even though the annual allowance was surpassed, the Army remains under the cumulative authorized incidental take limit.

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For more details on this fire and the incidental take of Hawaiian hoary bat treeland roosting habitat, please refer to the *Technical Report and Post-Disturbance Assessment for the July 2018 Wildland Fire in Training Areas 18, 19, and 22 at Pōhakuloa Training Area, Island of Hawaiʻi* (CEMML 2018b).
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9.0 CONCLUSION

This biennial report summarizes work performed jointly by the Army and CEMML regarding the management of natural resources at PTA. It documents CEMML accomplishments toward Statement of Objectives tasks and fulfills the deliverable requirement of Cooperative Agreement W9126G-16-2-0014 to provide a biennial report. The report is also produced to maintain compliance with the installation's INRMP and regulatory obligations under the ESA, NEPA, and MBTA.

As described in this report, ecosystems at PTA are highly complex and the challenges to manage natural resources multi-faceted. Through implementation of the Natural Resources Program at PTA, we work toward fulfilling goals and objectives congruent with the Army and Department of Defense mission to sustain and conserve natural resources on the installation.

By implementing management at ecosystem and landscape scales to control threats (e.g., from ungulates, wildland fire, and invasive weeds), we have reduced many of the negative impacts from these threats to ESA-listed species and their habitats. Through these actions, we assume a positive conservation benefit is conferred to the entire ecosystem as well as to TES and their habitats. For example, since feral ungulates were removed from the fence units, some ESA-listed plants have increased in number (Litton et al. 2018). However, some critically rare species may need more active management to persist. We recommend additional research into basic life history characteristics and their ecology to better design and implement management to encourage healthy, resilient populations that have a greater chance of persisting under changing climate conditions.

Implementing effective natural resources programs benefits the Army by improving the resiliency of the natural environment to training and other uses, thereby helping to ensure an enduring land base to maintain future training capacity. To maintain effective natural resources management embedded with a robust military training and operational environment, an integrated approach is essential. The INRMP is a critical planning tool to engage multiple partners, within and external to the Army, to ensure the successful management of the natural environment at PTA. To maintain maximum military training capacity and to meet the demanding training mission of the installation, we continue to maximize conservation benefits to TES and their habitats through the effective implementation of the INRMP and the Army's Natural Resources Program at PTA.

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11.0 REFERENCES

[AGOL] ArcGIS Online. 2020. Environmental Systems Research Institute. [accessed 2020 Jan 9]. http://csurams.maps.arcgis.com/home/item.html?id=01028029b9ba469bbcb870d8f3015c56

Arnett M. 2002. Report of surveys for rare plants on the Keʻāmuku Parcel. Center for Ecological Management of Military Lands, Colorado State University Report No: TPS 02-18.

Aplet GH and Laven RD. 1993. Relative performance of four Hawaiian shrubby plants (Asteraceae) under greenhouse conditions with implications for rarity. Biol Conserv. 65: 15-21.

Aplet GH, Laven RD, Shaw RB. 1994. Application of transition matrix models to the recovery of the rare Hawaiian shrub, *Tetramolopium arenarium* (Asteraceae). Nat Area J. 14(2): 99-106.

Aslan CE, Liang CT, Shiels AB, Haines W. 2018. Absence of native flower visitors for the endangered Hawaiian mint *Stenogyne angustifolia*: Impending ecological extinction? Global Ecol Conserv. 16: 1-8.

Aslan CE, Shiels AB, Haines W, Liang CT. 2019. Non-native insects dominate daytime pollination in a high-elevation Hawaiian dryland ecosystem. Am J Bot. 106(2): 1-12.

Barker RJ, Sauer JR. 1995. Statistical aspects of point count sampling. In: Ralph CJ, Sauer JR, Droege S, technical editors. Monitoring bird populations by point counts. Gen. Tech. Rep. PSW-GTR-149. Albany (CA): US Department of Agriculture, Forest Service, Pacific Southwest Research Station. p. 125-130.

[BCRIB] British Columbia Resource Inventory Branch. 1999. Inventory methods for forest and grassland songbirds: standards for components of British Columbia's biodiversity No. 15. Victoria (BC): Resource Inventory Branch, British Columbia Ministry of Environment, Lands and Parks.

Block P, Miller M, Woolf B, Hastings N. 2013. Vegetation classification and mapping, Pōhakuloa Training Area, including Keʻāmuku Maneuver Area, Hawaiʻi. Fort Collins (CO): Colorado State University, Center for Environmental Management of Military Lands. 79 p.

Block P, Cook R. 2017. Long-term vegetation monitoring at the US Army Garrison Pōhakuloa Training Area, Island of Hawaiʻi, 1989-2015. Fort Collins (CO): Colorado State University, Center for Environmental Management of Military Lands. 167 p.

Brown AHD, Briggs JD. 1991. Sampling Strategies for Genetic Variation in Ex Situ Collections of Endangered Plant Species. In: Falk DA, Holsinger KE, editors. Genetics and Conservation of Rare Plants. New York: Oxford University Press. p. 99-119.

Brown AHD, Marshall DR. 1995. A basic sampling strategy: theory and practice. In: Guarino L, Ramantha Rao V, Reid R, editors. Collecting plant genetic diversity: Technical guidelines. Oxfordshire, UK: CABI. p. 75-91.

Boice LP, Dalsimer AA, Golla D. 2010. Commander's guide on invasive species. DoD Legacy Resource Management Program. http://dodinvasives.org/Tools.html.

Bolker BM, Brooks ME, Clark CJ, Geange SW, Poulsen JR, Stevens MHH, White JS. 2009. Generalized linear mixed models: a practical guide for ecology and evolution. Trends Ecol Evol. 24(3):127–135.

Brooks ME, Kristensen K, Benthem KJ, Magnusson A, Berg CW, Nielsen A, Skaug HJ, Maechler M, Bolker BM. 2017. glmmTMB balances speed and flexibility among packages for zero-inflated generalized linear mixed modeling. R J. 9(2):378–400.

Buckland ST, Marsden SJ, Green RE. 2008. Estimating bird abundance: making methods work. Bird Conserv Int. 18: S91-S108.

Buckland ST, Anderson DR, Burnham KP, Laake JL, Borchers DL, Thomas L. 2001. Introduction to distance sampling: estimating abundance of biological populations. [accessed 2019 Jan 31]. http://agris.fao.org/ agris-search/search.do?recordID=XF2015043142.

Burnham KP. 1981. Summarizing remarks: environmental influences. In: Ralph CJ, Scott JM, editors. Estimating numbers of terrestrial birds. Stud Avian Biol. 6: 324-325.

Burnham KP, Anderson DR. 2002. Model selection and multimodel inference: a practical information-theoretic approach. 2nd ed. New York (NY): Springer. 515 p.

Buxton RT, Jones IL. 2012. An experimental study of social attraction in two species of storm-petrels by acoustic and olfactory cues. Condor. 114(4): 733-743.

Cabin RJ, Weller SG, Lorence DH, Cordell S, Hadway LJ, Montgomery R, Goo D, Urakami A. 2002. Effects of light, alien grass, and native species additions on Hawaiian dry forest restoration. Ecol Appl. 12(6): 1595-1610.

[CEMML] Center for Environmental Management of Military Lands. 2010. Natural Resources Program Annual Report, Pōhakuloa Training Area, Island of Hawai'i, 01 Oct 2009 - 30 Sep 2010. Fort Collins (CO): Colorado State University. 171 p.

[CEMML] Center for Environmental Management of Military Lands. 2011. Natural Resources Program Annual Report, Pōhakuloa Training Area, Island of Hawai'i, 01 Oct 2010 - 30 Sep 2011. Fort Collins (CO): Colorado State University. 52 p

[CEMML] Center for Environmental Management of Military Lands. 2014. Natural Resources Office Biennial Report, Pōhakuloa Training Area, Island of Hawai'i, 01 Oct 2011 - 30 Sep 2013. Fort Collins (CO): Colorado State University. 194 p.

[CEMML] Center for Environmental Management of Military Lands. 2016. Natural Resources Office Biennial Report, Pōhakuloa Training Area, Island of Hawai'i, 01 Oct 2013 - 30 Sep 2015. Fort Collins (CO): Colorado State University. 280 p.

[CEMML] Center for Environmental Management of Military Lands. 2017. Genetic Conservation and Outplanting Plan. Fort Collins (CO): Colorado State University.

[CEMML] Center for Environmental Management of Military Lands. 2018a. 2017/2018 breeding season report for the Hawaiian Goose conservation project at Hakalau Forest National Wildlife Refuge, Hawaiʻi Island, Hawaiʻi. Fort Collins (CO): Colorado State University. 10 p.

[CEMML] Center for Environmental Management of Military Lands. 2018b. Technical report and post-disturbance assessment for the July 2018 wildland fire in Training Areas 18, 19, and 22 at Pōhakuloa Training Area, Island of Hawaiʻi. Fort Collins (CO): Colorado State University. 14 p.

[CEMML] Center for Environmental Management of Military Lands. 2019a. 2018/2019 breeding season report for the Hawaiian Goose conservation project at Hakalau Forest National Wildlife Refuge, Hawaiʻi Island, Hawaiʻi. Fort Collins (CO): Colorado State University. 10 p.

[CEMML] Center for Environmental Management of Military Lands. 2019b. FY 2018 Annual Letter Report, Natural Resources Office, US Army Garrison - Pōhakuloa, Island of Hawai'i. Fort Collins (CO): Colorado State University. 63 p.

[CEMML] Center for Environmental Management of Military Lands. 2019c. Natural Resources Office Biennial Report, Pōhakuloa Training Area, Island of Hawai'i, 01 Oct 2015 - 30 Sep 2017. Fort Collins (CO): Colorado State University. 333 p.

Center for Plant Conservation. 1991. Genetic sampling guidelines for conservation collections of endangered plants. In: Genetics and Conservation of Rare Plants. Oxford University Press, New York, New York, USA. Oxford (UK): Oxford University Press on Demand.

Cole FR, Loope LL, Medeiros AC, Raikes JA, Wood CS. 1995. Conservation implications of introduced game birds in high-elevation Hawaiian shrubland. Conserv Biol. 9(2): 306–313.

Cole FR, Loope LL, Medeiros AC, Howe CE, Anderson LJ. 2000. Food habits of introduced rodents in high-elevation shrubland of Haleakalā National Park, Maui, Hawaiʻi. Pac Sci. 54(4): 313–329.

Conroy M, Carroll J. 2001. Estimating abundance of Galliformes: tools and application. Papers in Natural Resources. http://digitalcommons.unl.edu/natrespapers/582.

Corcoran AJ, Weller TJ. 2018. Inconspicuous echolocation in hoary bats (*Lasiurus cinereus*). Proceedings of the Royal Society B: Biological Sciences. 285(1878): 20180441.

Cordell S, Cabin RJ, Hadway LJ. 2002. Physiological ecology of native and alien dry forest shrubs in Hawaiʻi. Biol Inv. 4: 387-396.

Cordell S, Sandquist DR. 2008. The impact of an invasive African bunchgrass (*Pennisetum setaceum*) on water availability and productivity of canopy trees within a tropical dry forest in Hawaiʻi. Funct Ecol. 22: 1008-1017.

Cuddihy LW, Davis JA, Anderson SJ. 1982. A botanical survey of twelve cinder cones in South Kohala, island of Hawaiʻi. Hilo (HI): Department of Land and Natural Resources, Division of Forestry and Wildlife. 62 p.

Dahlgren DK, Messmer TA, Thacker ET, Guttery MR. 2010. Evaluation of brood detection techniques: recommendations for estimating greater sage-grouse productivity. West N Am Naturalist. 70(2): 233–237.

Discover Life: Ants of Hawaiʻi. c2004–. Athens (GA): University of Georgia; [accessed 2019 Dec 15]. US Geological Survey's National Biological Information Structure and The Polistes Foundation. https://www.discoverlife.org/mp/20q?guide=Ants_Hawaii.

[DoD] Department of Defense. 2008. DoD Pest Management Program. DoD Instruction No. 4150.07. Washington (DC): United States Department of Defense.

[DoD] Department of Defense. 2012. Commander's Guide to Community Involvement. Washington (DC): United States Department of Defense. Range Commanders Council, Sustainability Group. 48 p.

Edwards RD, Cantley JT, Chau MM, Keeley SC, Funk VA. 2018. Biogeography and relationships within the *Melanthera* alliance: A pan-tropical lineage (Compositae: Heliantheae: Ecliptinae). Taxon. [accessed 2018 Jun 20]. http://www.ingentaconnect.com/content/10.12705/673.6.

Ellsworth LM, Litton CM, Dale AP, Miura T. 2014. Invasive grasses change landscape structure and fire behaviour in Hawaiʻi. Appl Veg Sci. 17: 680-689.

Evans SA, Redpath SM, Leckie F, Mougeot F. 2007. Alternative methods for estimating density in an upland game bird: the red grouse Lagopus (*Lagopus scoticus*). Wildlife Biol. 13(2): 130–139.

Falkner MB, Laven RD, Aplet GH. 1997. Experiments on germination and early growth of three rare and endemic species of Hawaiian *Tetramolopium* (Asteraceae). Biol Conserv. 80: 39-47.

Frick WF. 2013. Acoustic monitoring of bats, considerations of options for long-term monitoring. Therya. 4(1): 69–78.

Gannon WL, Sherwin RE, Haymond S. 2003. On the importance of articulating assumptions when conducting acoustic studies of habitat use by bats. Wildlife Soc B. 31(1): 45–61.

Garel M, Cugnasse JM, Gaillard JM, Loison A, Gibert P, Douvre P, Dubray D. 2005. Reproductive output of female mouflon (*Ovis gmelini musimon* × *Ovis* sp.): a comparative analysis. J Zoology. 266(1): 65–71.

Giambelluca TW, Nullet MA, and Schroeder TA. 1986. Hawaiʻi Rainfall Atlas, Report R76, Hawaiʻi Division of Water and Land Development, Department of Land and Natural Resources, Honolulu. vi + 267 p. GIS layer downloaded from http://www.hawaii.gov/dbedt/gis.

Gillies CA, Williams D. 2013. DOC tracking tunnel guide v2.5.2: using tracking tunnels to monitor rodents and mustelids. Hamilton (NZ): Department of Conservation, Science and Compatibility Group. 14 p.

Gon SM, Honigman L, Zevin D, Fulks W, David RE. 1993. Vertebrate inventory surveys at the multi-purpose range complex, Pōhakuloa Training Area, island of Hawaiʻi. Honolulu (HI): The Nature Conservancy of Hawaiʻi, Hawaiʻi Heritage Program and Kailua-Kona (HI): Rana Productions Ltd. 176 p.

Gorressen MP, Bonaccorso FJ, Pinzari CA, Todd CM, Montoya-Aiona K, Brinck K. 2013. A 5-year study of Hawaiian hoary bat (*Lasiurus cinereus semotus*) occupancy on the island of Hawaiʻi. Hilo (HI): University of Hawaiʻi at Hilo, Hawaiʻi Cooperative Studies Unit. 54 p.

Gorresen PM, Cryan PM, Huso M, Hein C, Schirmacher M, Johnson J, Montoya-Aiona K, Brinck KW, Bonaccorso FJ. 2015. Behavior of the Hawaiian hoary bat (*Lasiurus cinereus semotus*) at wind turbines and its distribution across the north Koʻolau Mountains, Oʻahu. Technical Report HCSU-064. Hilo (HI): University of Hawaiʻi at Hilo. 74 p.

Gorresen PM, Cryan PM, Montoya-Aiona K, Bonaccorso FJ. 2017. Do you hear what I see? Vocalization relative to visual detection rates of Hawaiian hoary bats (*Lasiurus cinereus semotus*). Ecol Evol. 7(17): 6669–6679.

Griffin DR, Webster FA, Michael CR. 1960. The echolocation of flying insects by bats. Anim Behav 8: 141–154.

Guerrant EO, Fiedler PL, Havens K, Maunder M. 2004. Revised genetic sampling guidelines for conservation collections of rare and endangered plants. In: Guerrant EO, Havens K, Maunder M, editors. Ex Situ Plant Conservation: Supporting Species Survival in the Wild. Washington, DC: Island Press. p. 419-438.

Guthery FS, Mecozzi GE. 2008. Developing the concept of estimating bobwhite density with pointing dogs. J Wildlife Manage. 72(5): 1175–1180.

Hartig F. 2019. DHARMa: residual diagnostics for hierarchical (multi-Level/mixed) regression models. R package version 0.2.4. http://florianhartig.github.io/DHARMa/

Hayes JP. 2000. Assumptions and practical considerations in the design and interpretation of echolocation-monitoring studies. Acta Chiropterol. 2: 225-236.

Hess S, Kawakami J, Okita D, Medeiros K. 2006. A preliminary assessment of mouflon abundance at the Kahuku unit of Hawaiʻi Volcanoes National Park. Geological Survey Reston VA Report No: 2006-1193. [accessed 2019 Aug 14]. https://apps.dtic.mil/docs/citations/ADA454051.

Hilborn R, Mangel M. 1997. The ecological detective: confronting models with data. Princeton (NJ): Princeton University Press. 315 p.

Hill D, Robertson P. 1988. The pheasant: ecology, management and conservation. Oxford (UK): BSP Professional Books. 281 p.

Huston M, Smith T. 1987. Plant succession: life history and competition. Am Nat. 130: 168-198.

Jacobi JD. 2003. Baseline vegetation survey and long-term monitoring strategy for the Kīpuka ʻAlalā section of the US Army's Pōhakuloa Training Area, Island of Hawaiʻi. Hilo (HI): US Geological Survey, Pacific Island Ecosystems Research Center, Kilauea Field Station. 98 p.

Jenkins D, Watson A, Miller GR. 1963. Population studies on red grouse (*Lagopus scoticus*) in North-East Scotland. J Anim Ecol. 32(3): 317–376.

Laven RD, Shaw RB, Douglas PP, Diersing VE. 1991. Population structure of the recently discovered Hawaiian shrub *Tetramolopium arenarium* (Asteraceae). Ann. Missouri Bot. Gard. 78(4): 1073-1080.

Lewin V. 1971. Exotic game birds of the Puʻu Waʻawaʻa Ranch, Hawaiʻi. J Wildlife Manage. 35(1): 141–155.

Lewin V, Lewin G. 1984. The Kalij pheasant, a newly established game bird on the island of Hawaiʻi. The Wilson Bull. 96(4): 634–646.

Lincoln GA. 1998. Reproductive seasonality and maturation throughout the complete life-cycle in the mouflon ram. Anim Reprod Sci. 53(1-4): 87-105.

Lindqvist C, Albert VA. 2002. Origin of the Hawaiian endemic mints within North American *Stachys* (Lamiaceae). Am J Bot. 89(10): 1709-1724.

Litton CM, Cole RJ, Sparks JP, Giardina CP. 2018. Recovery of native plant communities and ecological processes following removal of nonnative, invasive ungulates from Pacific island forests. SERDP Project: RC-2433. Honolulu (HI): University of Hawaiʻi at Mānoa, Department of Natural Resources and Environmental Management. 85 p.

MacDonald SE. 2019. Manipulating social information to promote frugivory by birds on a Hawaiian island [master's thesis]. Urbana (IL): University of Illinois at Urbana-Champaign.

MacKenzie DI, Nichols JD, Hines JE, Knutson MG, Franklin AB. 2003. Estimating site occupancy, colonization, and local extinction when a species is detected imperfectly. Ecology. 84(8): 2200–2207.

MacKenzie DI, Nichols JD, Royle JA, Pollock KH, Bailey LL, and Hines JE. 2006. Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence. New York (NY): Academic Press. 344 pp.

Magnacca KN, King CBK. 2013. Assessing the presence and distribution of 23 Hawaiian yellow-faced bee species on lands adjacent to military installations on Oʻahu and Hawaiʻi Island. Technical Report No. 185. Honolulu (HI): Pacific Cooperative Studies Unit, University of Hawaiʻi. 39 p.

Menard T. 2001. Activity patterns of the Hawaiian hoary bat (*Lasiurus cinereus semotus*) in relation to reproductive time periods [master's thesis]. Honolulu (HI): University of Hawaiʻi.

Mengual X, Ruiz C, Rojo S, Stahls G, Thompson FC. 2009. A conspectus of the flower fly genus *Allograpta* (Diptera: Syrphidae) with description of a new subgenus and species. Zootaxa. 2214: 1-28.

Millar RB, Anderson MJ. 2004. Remedies for pseudoreplication. Fish Res. 70(2–3): 397–407.

Miller BW. 2001. A method for determining relative activity of free flying bats using a new activity index for acoustic monitoring. Acta Chiropterologica. 3(1): 93-105.

Miller DL, Burt ML, Rexstad EA, Thomas L. 2013. Spatial models for distance sampling data: recent developments and future directions. Method Ecol Evol. 4: 1001–1010.

Miller DL, Rexstad E, Thomas L, Marshall L, Laake J. 2019. Distance sampling in R. J Stat Softw. 89(1): 1-28.

Miller DL, Thomas L. 2015. Mixture models for distance sampling detection functions. PLoS ONE. 10(3): 1-19.

Moeller AK, Lukacs PM, Horne JS. 2018. Three novel methods to estimate abundance of unmarked animals using remote cameras. Ecosphere. 9(8): 1-15.

Morden CW, Loeffler W. 1999. Fragmentation and genetic differentiation among subpopulations of the endangered Hawaiian mint *Haplostachys haplostachya* (Lamiaceae). Mol Ecol. 8: 617-625

Nelson JT, Fancy SG. 1999. A test of the variable circular-plot method where exact density of a bird population was known. Pac Conserv Biol. 5(2): 139-143.

Nichols JD, Hines JE, Sauer JR, Fallon FW, Fallon JE, Heglund PJ. 2000. A double-observer approach for estimating detection probability and abundance from point counts. Auk. 117(2): 393–408.

[NOAA] National Oceanic and Atmospheric Administration. 2018. NOAA's wet season rainfall outlook report for 2018, as cited on Hawaiʻi News Now online article. [accessed 2018 Oct 12]. https://www.hawaiinewsnow.com/2018/10/12/hawaii-saw-record-breaking-wet-conditions-during-dry-season-noaa-report-says/

O'Hara RB, Kotze DJ. 2010. Do not log-transform count data. Methods Ecol Evol. 1(2): 118–122.

Pandit S, Gupta S. 2011. A comparative study on distance measuring approaches for clustering. Int J Res Comp Sci. 2(1): 29–31.

Pender RJ, Shiels AB, Bialic-Murphy L, Mosher SM. 2013. Large-scale rodent control reduced pre-and post dispersal seed predation of the endangered Hawaiian lobelia, *Cyanea superba* subsp. *superba* (Campanulaceae). Biol Invasions. 15(1): 213-223.

Peshut P, Schnell L, Lackey T, Doratt R, Evans S, Inman-Narahari N. 2015. FY 2014 annual letter report for the Natural Resources Office, Pōhakuloa Training Area, island of Hawaiʻi. Hilo (HI): United States Army Garrison-Pōhakuloa. 86 p.

[PIAkey] Pacific Invasive Any Key: Identification guide to invasive ants of the Pacific Islands. c2008–. Edition 2.0, Lucid v.3.4. Davis (CA): University of California Davis; [accessed 2019 Dec 15]. USDA/APHIS/PPQ Center for Plant Health Science and Technology. http://idtools.org/id/ants/pia/.

Pinzari C, Peck R, Zinn T, Gross D, Montoya-Aiona K, Brinck K, Gorresen M, Bonaccorso F. 2019. Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) activity, diet and prey availability at the Waihou Mitigation Area, Maui. Technical Report HCSU - 090. Hilo (HI): University of Hawaiʻi at Hilo. 65 p.

Pratt LW, VanDeMark JR, Euaparadorn M. 2012. Status and limiting factors of two rare plant species in dry montane communities of Hawaiʻi Volcanoes National Park. Technical Report HCSU-030. Hilo (HI): University of Hawaiʻi at Hilo. 61 p.

Ralph CJ, Sauer JR, Droege S, technical editors. 1995. Monitoring bird populations by point counts. Gen. Tech. Rep. PSW-GTR-149. Albany (CA): US Department of Agriculture, Forest Service, Pacific Southwest Research Station. 187 p.

R Core Team. 2019. R: a language and environment for statistical computing. Vienna (Austria): R Foundation for Statistical Computing. https://www.R-project.org/.

Reynolds RT, Scott JM, Nussbaum RA. 1980. A variable circular-plot method for estimating bird numbers. Condor. 82: 309-313.

Rosenstock SS, Anderson DR, Giesen KM, Leukering T, Carter MF. 2002. Landbird counting techniques: current practices and an alternative. Auk. 119(1): 46–53.

Rougeot J. 1969. Acceleration du rythme de la reproduction chez le mouflon de corse (*Ovis ammon musimon schreber*, 1782) au moyen de cycles photoperiodiques semestriels. Ann Biol anim Bioch Biophys. 9(3): 441–443.

Sakai AK, Weller SG, Wagner WL, Nepokroeff M, Culley TM. 2006. Adaptive radiation and evolution of breeding systems in *Schiedea* (Caryophyllaceae), an endemic Hawaiian genus. Ann. Missouri Bot. Gard. 93: 49-63.

Scott JM, Mountainspring S, van Ripper III C, Kepler CB, Jacobi JD, Burr TA, Giffin JG. 1984. Annual variation in the distribution, abundance, and habitat response of the Palila (*Loxioides Bailleui*). Auk. 101: 647-664.

Shaw RB, Castillo JM. 1997. Plant communities of Pōhakuloa Training Area, Hawaiʻi. Center for Ecological Management of Military Lands. Fort Collins (CO): Colorado State University. 105 p.

Shaw RB, Castillo JM, Laven RD. 1997. Impacts of wildfire on vegetation and rare plants within the Kīpuka Kālawamauna Endangered Plants Habitat area, Pōhakuloa Training Area, Hawaiʻi. In: Proceedings – Fire Effects on Rare and Endangered Species and Habitats Conference; 13-16 Nov 1995; Coeur d'Alene (ID): International Association of Wildland Fire. p. 253–264.

Shiels AB, Bogardus T, Rohrer J, Kawelo K. 2019. Effectiveness of snap and A24-automated traps and broadcast anticoagulant bait in suppressing commensal rodents in Hawaiʻi. Hum-Wildl Interact 12(2): 226-237.

Simons TR. 1985. Biology and behavior of the endangered Hawaiian Dark-rumped Petrel. Condor 87(2): 229–245.

Sisson DC, Stribling HL, Speake DW. 2000. Efficiency of pointing dogs in locating northern bobwhite coveys. National Quail Symposium Proceedings. Vol. 4: Article 25.

Stephens PA, Pettorelli N, Barlow J, Whittingham MJ, Cadotte MW. 2015. Management by proxy? The use of indices in applied ecology. J Appl Ecol. 52: 1-6.

Suding KN, Gross KL, Houseman GR. 2004. Alternative states and positive feedbacks in restoration ecology. Trends Ecol Evol. 19(1): 46-53.

Suding KN. 2011. Toward an era of restoration in ecology: successes, failures, and opportunities ahead. Annu Rev Ecol Evol S. 42: 465-487.

Sugihara RT. 1997. Abundance and diets of rats in two native Hawaiian forests. Pac Sci. 51(2): 189–198.

Tazik DJ, Warren SD, Diersing VE, Shaw RB, Brozka RJ, Bagley CF, Whitworth WR. 1992. US Army land condition-trend analysis (LCTA) plot inventory field methods. Champaign (IL): US Army Corps of Engineers Research Laboratory. 64 p.

Thomas L, Buckland ST, Rexstad EA, Laake JL, Strindberg S, Hedley SL, Bishop JRB, Marques TA, Burnham KP. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. J Appl Ecol. 47(1): 5–14.

Thompson WL. 2002. Towards reliable bird surveys: accounting for individuals present but not detected. Auk. 119(1): 18–25.

[USAG-HI] United States Army Garrison, Hawaiʻi. 2003. Integrated wildland fire management plan, Oʻahu and Pōhakuloa Training Areas. Fort Collins (CO): Center for the Environmental Management of Military Lands, Colorado State University and Honolulu (HI): Installation Fire and Safety Office, Army, Hawaii. 539 p.

USAG-HI] United States Army Garrison, Hawaiʻi. 2006. Report for the Ecosystem Management Program, Pōhakuloa Training Area, Island of Hawaiʻi, July 2003 to September 2005. Hilo (HI): US Army Garrison, Hawaii. 158 p.

[USAG-HI] United States Army Garrison, Hawaiʻi. 2010. Implementation plan, Pōhakuloa Training Area, Island of Hawaiʻi. Hilo (HI): US Army Garrison, Hawaii. 243 p.

[USAG-P] United States Army Garrison, Pōhakuloa Training Area. 2019a. Integrated natural resources management plan 2019-2023, Pōhakuloa Training Area, Hawaiʻi. Fort Collins (CO): Colorado State University, Center for Environmental Management of Military Lands. 191 p.

[USAG-P] United States Army Garrison, Pōhakuloa Training Area. 2019b. Integrated wildland fire management plan, United States Army Garrison, Pōhakuloa. Fort Collins (CO): Colorado State University, Center for Environmental Management of Military Lands; Hilo (HI): Fire and Emergency Services; and Hilo (HI): Directorate of Public Works, Environmental Division. 148 p.

[USDA] United States Department of Agriculture. 1973. Soil survey of Island of Hawaiʻi, State of Hawaiʻi. Honolulu (HI): US Department of Agriculture, Soil Conservation Service. 124 p.

[USFWS] United States Fish and Wildlife Service. 1994. Recovery plan for *Lipochaeta venosa* and *Isodendrion hosakae*. Portland (OR): US Fish and Wildlife Service, Pacific Region. 64 p.

[USFWS] United States Fish and Wildlife Service. 2003a. Biological Opinion of the US Fish and Wildlife Service for routine military training and transformation of the 2nd Brigade 25th Infantry Division (Light), Army Installations, Island of Hawaiʻi. Portland (OR): US Fish and Wildlife Service, Pacific Region. 215 p.

[USFWS] United States Fish and Wildlife Service. 2003b. Endangered and threatened wildlife and plants; Final designation and nondesignation of critical habitat for 46 plant species from the Island of Hawaiʻi, HI; Final Rule. Fed. Regist. 68 (127):39624-39761.

[USFWS] United States Fish and Wildlife Service. 2004. Draft revised recovery plan for the nēnē or Hawaiian Goose (*Branta sandvicensis*). Portland (OR): US Fish and Wildlife Service, Region 1. 148 p.

[USFWS] United States Fish and Wildlife Service. 2008. Biological Opinion of the US Fish and Wildlife Service regarding consultation for additional species and new training actions at Pōhakuloa Training Area, Hawaiʻi. Portland (OR): US Fish and Wildlife Service, Pacific Region. 54 p.

[USFWS] United States Fish and Wildlife Service. 2010. *Portulaca sclerocarpa* (Poe) 5-year review summary and evaluation. Honolulu (HI): Pacific Islands Fish and Wildlife Office. 28 p.

[USFWS] United States Fish and Wildlife Service. 2013a. Informal consultation and formal consultation with a biological opinion for the construction, maintenance, and operation of an Infantry Platoon Battle Area and installation-wide impacts of military training on Hawaiian Geese (*Branta sandvicensis*) at Pōhakuloa Training Area, Hawaiʻi. Portland (OR): US Fish and Wildlife Service, Pacific Region. 70 p.

[USFWS] United States Fish and Wildlife Service. 2013b. US Fish and Wildlife Service species assessment and listing priority assignment form for *Hylaeus anthracinus*. Portland (OR): US Fish and Wildlife Service, Pacific Region. 36 p.

[USFWS] United States Fish and Wildlife Service. 2015. Federal Register Vol. 80 No. 189: Endangered and threatened wildlife and plants; endangered status for 49 species from the Hawaiian Islands; proposed rule. 50 CFR Part 17. Washington (DC): Department of the Interior, US Fish and Wildlife Service. 91 p.

Verner J. 1985. Assessment of counting techniques. In: Johnston RF, editor. Current Ornithology: Vol 2. Boston (MA): Springer US. p. 247–302. [accessed 2019 Jan 19]. https://doi.org/10.1007/978-1-4613-2385-3_8.

Verner J, Ritter LV. 1985. A comparison of transects and point counts in oak-pine woodlands of California. Condor. 87(1): 47–68.

Warren P, Hornby T, Baines D. 2018. Comparing call-playback to an observation-only method to survey Grey Partridge (*Perdix perdix*) on hill farms in northern England. Bird Study. 65(2): 225–231.

Weber E. 2003. Invasive plant species of the world: a reference guide to environmental weeds. Wallingford (United Kingdom): CABI Publishing. viii + 548 pp. (ISBN: 0851996957).

Wetterer JK, Garcia FH. 2015. Worldwide spread of *Tetramorium caldarium* (Hymenoptera: Formicidae). Myrmecol News. 21:93-99

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APPENDIX A

FY 2018–FY 2019 COMPLETED DOCUMENT DELIVERABLES FOR THE ARMY'S NATURAL RESOURCES PROGRAM AT PŌHAKULOA TRAINING AREA

We produced the following document deliverables during the FY 2018–FY 2019 reporting period (01 October 2017 through 30 September 2019). This list includes important memoranda for record, technical reports, published articles, protocols, standard operating procedures, survey summaries, professional presentations, and compliance documents prepared in support of the regulatory process. It is meant to focus on completed product outputs and therefore does not include all internal "process" documents.

Area 1: Compliance with Regulatory Mandates and Reporting Requirements

We produced the following documents to maintain compliance with CEMML's Statement of Objectives for PTA, annual reporting requirements, and regulatory mandates such as the Integrated Natural Resources Management Plan (INRMP), Endangered Species Act (ESA) and National Environmental Policy Act (NEPA).

- **Results of DeLuz Quarry Inspection on 02 October 2017 (2017 10 03):** email correspondence summarizing the invasive species survey results for the aggregate inspection conducted at DeLuz Quarry. 1 p.

- **US Fish and Wildlife Service Recovery Permit TE-40123A-2 (2017 11 07)**: ESA section 10(a)(1)(A) recovery permit issued to the Army by the USFWS authorizing activities for threatened and endangered plant species. Valid 7 Nov 2017 through 6 Nov 2022. 19 p.

- **Realignment of ʻAlalā Fuel Monitoring Corridor (2017 11 08)**: memorandum from Pamela Sullivan to Joy Anamizu recommending the rerouting of a 700 m section of the ʻAlalā Fuel Monitoring Corridor due to fuel loads exceeding standards in the Integrated Wildland Fire Management Plan. The realignment is on an ʻaʻā lava flow with sufficiently discontinuous fuels to preclude fire spread across the corridor. 2 p.

- **Results of DeLuz Quarry Inspection on 11 November 2017 (2017 11 27):** email correspondence summarizing the invasive species survey results for the aggregate inspection conducted at DeLuz Quarry. 1 p.

- **Technical Documentation Protocol (2017 11 30)**: living document produced by the Ecological Data Program to provide a standardized "go to" reference for all professional staff to use in technical communications, to ensure that information is disseminated accurately and consistently. Updated on a semi-annual or annual basis. 197 p.

- **MBTA Scientific Collecting for BSTP 2017 Annual Report (2018 01 16):** annual report summarizing the collections of any Band-rumped Storm Petrels found during the 2017 petrel breeding season (USFWS migratory bird permit: MB95880B-0). 2 p.

- **Limited Right of Entry Permit 18-061 (2018 01 17)**: LROE permit issued to the Army by the State of Hawaiʻi Department of Hawaiian Home Lands authorizing outplanting and maintenance of native indigenous plant species at Puʻu Huluhulu. Varying dates, no expiration but limited to 30 days total. 4 p.

- **MBTA Scientific Collecting for BSTP 2017 Annual Report (2018 01 29):** annual report summarizing the collections of any Band-rumped Storm Petrels found during the 2018 petrel breeding season (USFWS migratory bird permit: MB95880B-0). 1 p.

- **Results of DeLuz Quarry Inspection for the S4C and 3B Fine Aggregate on 28 February 2018 (2018 03 01):** email correspondence summarizing the invasive species survey results for the aggregate inspection conducted at DeLuz Quarry. 1 p.

- **Results of DeLuz Quarry Inspection on 6 March 2018 (2018 03 06):** email correspondence summarizing the invasive species survey results for the aggregate inspection conducted at DeLuz Quarry. 1 p.

- **2017 Seabird Project Technical Report, Tracking Visitation at Active Band-rumped Storm Petrel (*Oceanodroma castro*) Nests at Pōhakuloa Training Area (2018 05 10)**: technical report summarizing 2017 activities and findings in the continued investigation of an active BSTP colony confirmed at the installation in 2015. This report summarizes work completed toward gaining knowledge of the extent of the BSTP colony, as well as behavioral characteristics of the species. 15 p.

- **Equipment Inspection, Little Red Fire Ants Intercepted Before Materials Entered Pōhakuloa Training Area (2018 06 14):** email correspondence summarizing the discovery of little red fire ants on soil erosion control materials prior to the equipment entering PTA. 1 p.

- **Pōhakuloa Training Area Invasive Pest Prevention Standard Operating Procedures (2018 07 03)**: document listing protocols for preventing the introduction of harmful invasive pests including, but not limited to reptiles, amphibians, invertebrates, weeds, and Rapid ʻŌhiʻa Death into PTA. It is the responsibility of the project leader and/or contractor to ensure compliance with these protocols. 3 p.

- **Equipment Inspection, Little Red Fire Ants Intercepted Before Materials Entered Pōhakuloa Training Area (2018 09 14):** email correspondence summarizing the discovery of little red fire ants on construction materials prior to the equipment entering PTA. 1 p.

- **Results of West Hawaiʻi Concrete Quarry Inspection on 27 September 2018 (2018 10 03):** memorandum summarizing the invasive species survey results for the aggregate inspection conducted at West Hawaiʻi Concrete. 9 p.

- **Results of Puna Rock Quarry Inspection on 17 October 2018 (2018 10 17):** memorandum summarizing the invasive species survey results for the aggregate inspection conducted at Puna Rock Quarry. 7 p.

- **PTA Natural Resources Program Conservation Fence and Gate Damage Report (2018 10 18**): report summarizing the damage discovered at one of the ungulate exclusion fence units at PTA. This damage occurred at the MPRC Access road vehicle gate in Training Area 22. 5 p.

- **Pōhakuloa Training Area Project Blocks A and B Results of West Hawaiʻi Concrete Quarry Inspection on 08 November 2018 (2018 11 08):** memorandum summarizing the invasive species survey results for the aggregate inspection conducted at West Hawaiʻi Concrete. 8 p.

- **Pōhakuloa Training Area Project for Repairing New and Existing Berms, Bivouac Areas and Down-range Roads Results of West Hawaiʻi Concrete Quarry Inspection on 15 November 2018 (2018 11 15):** memorandum summarizing the invasive species survey results for the aggregate inspection conducted at West Hawaiʻi Concrete. 8 p.

- **Results of Pōhakuloa Training Area Natural Resources Program Aggregate Inspection at West Hawaiʻi Concrete Quarry on 11 December 2018 (2018 12 11):** memorandum summarizing the invasive species survey results for the aggregate inspection conducted at West Hawaiʻi Concrete. 8 p.

- **Hakalau Forest National Wildlife Refuge Special Use Permit 12516-19006-G (2018 12 19)**: special use permit issued to the Army by the USFWS providing access to and allowing activities to be conducted at HFNWR for the Hawaiian Goose (e.g., nest searches, predator control, nest monitoring, habitat management). Valid 1 Jan 2017 through 30 Jun 2022. 16 p.

- **2017/2018 Breeding Season Report for Hawaiian Goose Conservation Project Hakalau Forest National Wildlife Refuge Hakalau, Hawaiʻi Island, Hawaiʻi (2018 12 17):** technical report summarizing the management activities (Hawaiian Goose habitat management, goose monitoring, nest monitoring, and predator control) we conducted for the 2017/2018 Hawaiian Goose breeding season. This report was submitted to comply with the Hakalau SUP annual report requirement. 10 p.

- **Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) Occupancy and Activity at Pōhakuloa Training Area (2018 12 17)**: technical report summarizing the results of a 3-year study conducted from 2014–2017 to investigate Hawaiian hoary bat occupancy and seasonal activity patterns at PTA. This is the first full-scale, long-term monitoring effort conducted on the installation to better understand the associated implications of military construction and training on species listed under the ESA at PTA. We conducted an occupancy modeling study and a seasonal activity study; the report presents the mean occupancy estimate across the study as well as seasonal occupancy estimates. Draft, pending final approval. 23 p.

- **PTA Natural Resources Program Conservation Fence and Gate Damage Report (2019 04 02)**: report summarizing the damage discovered at one of the ungulate exclusion fence units at PTA. This damage occurred at the MPRC Access road vehicle gate in Training Area 22. 6 p.

- **2018 Seabird Project Technical Report, Band-rumped Storm Petrel (*Oceanodroma castro*) Activity at Pōhakuloa Training Area (2019 04 10)**: technical report summarizing 2018 activities and findings in the continued investigation of an active BSTP colony confirmed at the installation in 2015. This report summarizes work completed toward gaining knowledge of the extent of the BSTP colony, as well as behavioral characteristics of the species. 22 p.

- **PTA Natural Resources Program Conservation Fence and Gate Damage Report (2019 05 04)**: report summarizing the damage discovered at one of the ungulate exclusion fence units at PTA. This gate damage occurred in the Kīpuka Kālawamauna North Fence Unit. 6 p.

- **Scientific Collecting for Band-rumped Storm Petrel MB95880B-0 (2019 05 14)**: permit issued to the Army by the USFWS Migratory Bird Permit Office allowing for the salvage, transport, and possession of the Band-rumped Storm Petrel at PTA for scientific purposes. Valid 1 Apr 2019 through 31 Mar 2022. 7 p.

- **Protected Wildlife Permit Scientific Collecting Band-rumped Storm Petrel WL19-42 (2019 06 28)**: permit issued to the Army by the State of Hawaiʻi Department of Land and Natural Resources allowing for the salvage, transport, and possession of BSTP at PTA for the purpose of scientific collecting. Valid 28 Jun 2019 through 30 Jun 2021. 5 p.

- **Protected Wildlife Permit Scientific Collecting Game Birds WL19-43 (2019 06 28)**: permit issued to the Army by the State of Hawaiʻi Department of Land and Natural Resources allowing for the salvage, transport, and possession of game birds at PTA for the purpose of scientific collecting. Valid 28 Jun 2019 through 30 Jun 2020. 5 p.

- **Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) Occupancy and Activity at Pōhakuloa Training Area, Hawaiʻi (2019 03 28):** technical report summarizing the results of a 3-year study conducted 2014–2017 by the PTA Natural Resources Program to investigate Hawaiian hoary bat (*Lasiurus cinereus semotus*) occupancy and seasonal activity patterns. 24 p.

- **US Army Garrison, Pōhakuloa Training Area, Natural Resource Program, Rare, ESA-listed Species and Migratory Bird Species Incidental Report WASH (2019 07 03):** incident report documenting the report of an unknown bird that struck a helicopter windscreen. Military personnel reported the bird strike, but the carcass of the bird was not found. 3 p.

- **US Army Garrison, Pōhakuloa Training Area, Natural Resource Program, Rare, ESA-listed Species and Migratory Bird Species Incidental Report BSM (2019 07 03):** incident report documenting the finding a Blackburn's Sphinx Moth (*Manduca blackburni*) at Pōhakuloa Training Area. This is the first report of the moth discovered at PTA. 3 p.

- **FY 2018 PTA Natural Resources Annual Letter Report (2019 08 12)**: report produced to satisfy annual reporting requirements mandated in regulatory and guiding documents. The report covers the period of FY 2018 (01 October 2017 through 30 September 2018). 62 p.

- **2017 Annual Report for Pōhakuloa Training Area Recovery Permit TE-40123A-2 (2019 08 13)**: technical report documenting activities performed collectively by Army and CEMML staff between 1 Oct 2016 and 31 Dec 2017 at PTA to satisfy annual recovery permit reporting requirements. Natural resource management activities are authorized under the US Fish and Wildlife Service recovery permit TE-40123A-2. 21 p.

- **2018 Annual Report for Pōhakuloa Training Area Recovery Permit TE-40123A-2 (2019 08 13)**: technical report documenting activities performed collectively by Army and CEMML staff during 2018 at PTA to satisfy annual recovery permit reporting requirements. Natural resource management activities are authorized under the US Fish and Wildlife Service recovery permit TE-40123A-2. 70 p.

- **2018/2019 Breeding Season Report for the Hawaiian Goose Conservation Project at Hakalau Forest National Wildlife Refuge (2019 08 15):** technical report prepared to comply with annual reporting requirements for federal permits issued to the Army for conservation management activities at HFNWR. The special use permits authorize HAGO management activities including Hawaiian Goose monitoring, Hawaiian Goose nest monitoring, predator control, and habitat management. 10 p.

- **2019 Hawaiian Goose Conservation Project Plan at Hakalau Forest National Wildlife Refuge (2019 08 15):** plan submitted by the Army to the USFWS proposing to maintain existing conservation management activities at HFNWR. Proposed activities for 2019 included Hawaiian Goose monitoring, Hawaiian Goose nest monitoring, predator control, and habitat management. Additional predator control activities with cameras and baited but inactive automatic kill traps were also planned. 4 p.

- **Report on the Rapid ʻŌhiʻa Death Aerial Survey at PTA on 3 July 2019 (2019 08 22)**: memorandum submitted to Joy Anamizu summarizing the findings of a Rapid ʻŌhiʻa Death (ROD) aerial survey conducted by DLNR DoFAW, BIISC, and CEMML staff on 3 July 2019 at PTA and Puʻu Anahulu Game Management Area as part of the island-wide and statewide survey efforts. No ʻōhiʻa trees were identified as ROD suspects. 2 p.

- **US Army Garrison, Pōhakuloa Training Area, Natural Resource Program, Rare, ESA-listed Species and Migratory Bird Species Incidental Report HHB (2019 09 05):** incident report documenting the finding a Hawaiian hoary bat carcass outside Building 227A in the PTA Cantonment area. Based on the visual observation of the carcass and the surrounding area it is unlikely that the bat died due to military training activities. 5 p.

- **Memorandum of Understanding between US Army Garrison, Pōhakuloa, Range Division Hawaiʻi, and the Center for Environmental Management of Military Lands (2019 09 11)**: draft MOU intended to provide guidance and document an agreement for general support between USAG-P, Range Control, and CEMML, to allow the use of training areas already used for public hunting at PTA to be used for scientific collection of game birds with the use of a shotgun. 2 p.

- **Field Observations from Puʻu Huluhulu Site Visit on 4 Sep 2019 (2019 09 12)**: memorandum written by Nikhil Narahari, Tiana Lackey, and Jason Dzurisin, referencing field notes from Pomai Lyman. The memo summarizes field observations from a site visit to Puʻu Huluhulu after DLNR received a report of potential impacts to natural resources. Overall, condition of the Army outplanting sites on the puʻu appeared normal. 2 p.

- **US Army Garrison, Pōhakuloa Training Area, Natural Resource Program, Ungulate Exclusion Fence and Gate Damage Incident Report (2019 09 20**): report summarizing the damage discovered at one of the ungulate exclusion fence units at PTA. This damage occurred at the Infantry Platoon Battle Course vehicle gate in Training Area 22. 6 p.

Area 2: Technical Assistance for Military Initiatives

We produced the following documents to provide technical assistance for military training, operations, and maintenance projects to maintain or increase training capacity at the installation, for cooperative initiatives with state and federal resources agencies, and to provide for a defense in litigation proceedings.

- **Section 7 Informal Consultation Request and Additional Information for the Proposed Establishment and Use of Non-fixed Artillery Firing Positions at PTA (2018 04 06):** informal consultation letter from the Army to the USFWS requesting concurrence with the determination that 8 federally-listed endangered species may be affected by the proposed establishment and use of non-fixed artillery positions. The letter also provides additional information on the effects of proposed training activities, an adaptation of existing live-fire and maneuver training activities, on ESA-listed species previously assessed in past consultations and biological opinions. 15 p.

- **No Effect Determination for the Band-rumped Storm Petrel (*Oceanodroma castro*) and Hawaiian Petrel (*Pterodroma sandwichensis*) Monitoring Activities at Pōhakuloa Training Area (2018 05 29):** MFR to document monitoring activities for Band-rumped Storm Petrel and Hawaiian Petrel in TA 21. Three types of monitoring activities were proposed: 1) acoustic monitoring, 2) daytime canine searches, and 3) video surveillance. 5 p.

- **PTA Nat Res Comments for REC 4499 Install Main Gate Sign (2018 11 01):** comments regarding installation of a sign at the PTA main gate. Potential TES issues were effects of exterior LED lighting to petrels and the Hawaiian hoary bat, and introduction of invasive species from imported fill material. ESA sec 7 consultation was recommended. 5 p.

- **Notice to Reinitiate Formal Consultation (2018 12 03)**: letter sent by the Army to USFWS providing notice of our intent to reinitiate formal consultation pursuant to sec 7 of the ESA and reinitiation triggers identified in an undated USFWS letter signed 15 Oct 2018. The letter summarizes actions we completed to move towards reinitiating consultation, coordination of internal activities, organization of available information to provide USFWS, and a proposed framework and plan for the draft Biological Assessment.

- **PTA Nat Res Comments for REC 4513 FARP 19 Lava Softening (2019 01 30):** comments regarding softening of lava at FARP 19. Potential TES issues were crushing/trampling of plants and introduction of invasive species. ESA sec 7 consultation TBD following results of TES surveys in project area. 5 p.

- **PTA Nat Res Comments for REC 4518 HIMARS Recurring Training (2019 02 11):** comments regarding proposed recurring HIMARS training (rocket launching). Potential TES issues were noise effects to the Hawaiian Goose and Hawaiian hoary bat, increased wildland fire risk, and introduction of invasive species. ESA sec 7 consultation TBD pending assessment of noise effects and determination of wildland fire risk. 6 p.

- **MFR KMA Bivouac Site (2019 02 20):** memorandum written by Steve Evans to Joy Anamizu and Lena Schnell documenting results of plant surveys at a proposed bivouac site for the 3-4 CAV in KMA; no ESA-listed plant species were found. 1 p.

- **Natural Resources Survey Results and Consultation Determination for REC 4513 FARP 19 Lava Softening Project at PTA (2019 02 27):** MFR documenting review of proposed lava softening at FARP 19 and an effects determination for impacts to TES species. Site survey was conducted on 15 Feb 2019 by Steve Evans; no ESA-listed plants or animals were observed. No ESA sec 7 consultation was recommended. 12 p.

- **PTA Nat Res Comments for REC 4522 Artillery Fire from LZ Rob and Dead Man's Curve (2019 02 27):** comments regarding proposed artillery live-fire from LZ Rob and Dead Man's Curve. Potential TES issues were increased wildland fire risk and introduction of invasive species. No ESA sec 7 consultation was recommended because the impacts of artillery fire at PTA have been assessed under previous consultations, and the proposed training is consistent with existing routine artillery training activities. 11 p.

- **PTA Nat Res Comments on Degraded, Denied, and Disrupted Space Operations Environment during Lightning Strike 2019 (2019 02 27):** comments regarding proposed D3SOE training activities during LS19. Potential TES issues were effects of GPS jamming technology to the Hawaiian hoary bat and invasive species. No ESA sec 7 consultation was recommended; D3SOE consistent with existing routine training activities. 10 p.

- **PTA Nat Res Comments for REC 4521 Unmanned Aircraft Systems Training (2019 03 04):** comments regarding proposed SUAS training. Potential TES issues were noise effects to the Hawaiian Goose and Hawaiian hoary bat, effects of artificial lights to petrels, air strikes, increased wildland fire risk, and introduction of invasive species. SUAS training at PTA is covered under NEPA, but no ESA sec 7 consultation has been completed. Therefore, ESA sec 7 consultation is required to assess effects to TES from the proposed action. 13 p.

- **PTA Nat Res Comments on Mortar Firing Points 711-715 at Charlie Circle (2019 03 06):** comments regarding the installation of live-fire mortar firing points in TA 22. Potential TES issues were wildland fire, crushing/trampling plants, and invasive species. We recommended formal ESA consultation due to change in species status after 2 wildland fires in 2012 and an additional fire in 2018. 12 p.

- **No Effect Determination for Continued Small Mammal Control for the Band-rumped Storm Petrel (*Oceanodroma castro*) Nest Sites (Phase 1.2 Pre-nesting Season) located at Pōhakuloa Training Area (2019 03 09):** MFR to document project to obtain additional information on the presence/absence and distribution of predators at the BSTP nest site in TA 21; the efficacy of trapping; and to reduce the number of predators and their activity near the nest site. Added activities included for video surveillance. 4 p.

- **PTA Nat Res Comments for REC 4534 Establish Firing Points 713, 714, and 715 (2019 04 03):** comments regarding the installation of live-fire mortar firing points 713, 714, and 714 in TA

22. Potential TES issues were wildland fire, crushing/trampling plants, effects to Hawaiian hoary bat habitat, and invasive species. We recommended formal ESA consultation because the use of firing points in TA 22 has not been consulted on, and the status of several species changed due to wildland fires in 2012 and 2018. 12 p.

- **No Effect Determination for Select ESA-listed Species and Degraded, Denied, and Disrupted Space Operations Environment Training Activities during Lightning Strike 2019 and Recurring Basis at PTA (2019 04 08):** MFR documenting review of D3SOE training (GPS jamming) and an effects determination for impacts to select TES species; no REC was initiated, impacts not assessed in existing BOs or past sec 7 ESA consultations. 21 p.

- **Natural Resources Survey Results and No Effect Determination for Proposed Bivouac Activities in KMA (2019 04 09):** MFR documenting review of proposed bivouac activities and an effects determination for impacts to TES species; no REC was initiated, impacts not assessed in existing BOs or past sec 7 ESA consultations. 8 p.

- **PTA Nat Res Comments for REC 4540 Install Siren System (2019 04 03):** comments regarding proposed installation of an emergency siren system at PTA. No effects to TES from installation of the siren system were expected; the impacts of cantonment construction projects have been assessed and evaluated under previous consultations. No ESA sec 7 consultation was recommended. 6 p.

- **PTA Nat Res Comments for REC 4541 Renovate DFAC Bldg. T-190 (2019 04 18):** comments regarding proposed renovation of Bldg. T-190 at PTA. No effects to TES from renovation of Bldg. T-190 were expected; the impacts of cantonment construction projects have been assessed and evaluated under previous ESA sec 7 consultations. Project consistent with PTA Facilities Improvement Plan. 6 p.

- **PTA Nat Res Comments for REC 4542 Renovate DFAC Bldgs. T-185 and T-186 (2019 04 18):** comments regarding proposed renovation of Bldgs. T-185 and T-186 at PTA. No effects to TES from renovation of Bldgs. T-185 and T-186 were expected; the impacts of cantonment construction projects have been assessed and evaluated under previous ESA sec 7 consultations. Project consistent with PTA Facilities Improvement Plan. 6 p.

- **PTA Nat Res Comments for REC 4555 Demo Hangar and Hazards BAAF 351 (2019 06 24):** comments regarding proposed demolition of BAAF 351 at PTA. No effects to TES from demolition of BAAF 351 were expected; the impacts of cantonment construction and demolition projects have been assessed and evaluated under previous ESA sec 7 consultations. Project consistent with PTA Facilities Improvement Plan. 6 p.

- **PTA Nat Res Comments for REC 4577 EOD-T Target Placement (2019 09 10):** comments regarding proposed placement of an EOD-T target near Range 1 at PTA. Potential TES issues were air strikes and introduction of invasive species. No effects to TES from placement of the target were expected; the impacts of routine military training operations have been assessed and evaluated under previous ESA sec 7 consultations. 12 p.

Area 3: Assessments After Disturbance Events

We produced the following documents to assess effects to natural resources, threatened and endangered species (TES), and their habitat after disturbance events (e.g., wildland fire, drought, flooding).

- **Ecological Data Program Products for the July 2018 Fire (2018 07 25)**: memorandum written by Nikhil Narahari to Joy Anamizu providing preliminary assessment of impacts to TES from the July 2018 wildland fire at PTA. Enclosures included 1) map of the burn area in TAs 18, 19, and 22 and potentially impacted TES locations, 2) information regarding management conducted in the burn area that minimized and/or avoided impacts to TES, and 3) table summarizing TES potentially impacted in the burn area. 7 p.

- **Op Ord Guidance and Nat Res SUAS Specs (2018 07 26):** memorandum written by Jason Dzurisin to Joy Anamizu summarizing SUAS products and data security for the July 2018 wildland fire at PTA. Includes guidance document excerpts, deconfliction points of emphasis, and SUAS technical specifications. 5 p.

- **Technical Report and Post-Disturbance Assessment July 2018 Wildland Fire in TAs 18, 19, and 22 at PTA (2018 09 11)**: report prepared to fulfill the Army's wildland fire reporting requirements per the 2003 BO. Summarizes effects to TES from a July 2018 fire that burned 585 ha in TAs 18, 19, and 22. Seven ESA-listed plant species were potentially affected by the fire; 149 ha of potential habitat for the Hawaiian hoary bat were burned. 14 p.

- **USFWS 2018 July Fire Letter (2018 09 27):** letter sent to USFWS to report the fire and its impact to ESA-listed plant species and the Hawaiian hoary bat that occurred on 18 July 2018 in Training Areas 18, 19, and 22 at Pōhakuloa Training Area. A loss of 149.07 ha of potential available Hawaiian hoary bat treeland roosting habitat resulted in incidental take. 3 p.

Outreach, Presentations, and Publications

- **How the Army Combats Rapid ʻŌhiʻa Death (2018 07 18)**: Poster and handout produced for annual outreach event. Content summarizes ʻōhiʻa resources at PTA (dryland forest habitat, life supported in lava tubes), the role of ʻōhiʻa in the dryland forest, and how the Army prevents the spread of ROD at the installation (e.g., monitoring, standard operating procedures for sanitation). 3 p. and 1 p.

- **A Strategic Approach to Improving Habitat for the Critically Endangered *Melanthera venosa* at Pōhakuloa Training Area (2018 09 25)**: article published in the 2018 US Army Garrison – Hawaiʻi Ecosystem Management Program Bulletin about a habitat improvement project on Puʻu Nohona o Hae for *M. venosa*. Written by Tiana Lackey. 6 p.

- **First Active Band-rumped Storm Petrel Nest Recorded in Hawaiʻi (2018 09 25):** article published in the 2018 US Army Garrison – Hawaiʻi Ecosystem Management Program Bulletin about the first active BSTP nest documented in the Hawaiian Islands. The active nest was confirmed in TA 21 at PTA in 2015. Written by Nicole Galase. 10 p.

- **First Confirmed Band-rumped Storm Petrel (*Oceanodroma castro*) Colony in the Hawaiian Islands (2019 02 04):** journal article written by Nicole Galase and published in Marine Ornithology. Using a combination of acoustic monitoring, night vision surveys, dog searches, and remote camera surveillance to search for occupied nests, we discovered a breeding BSTP colony in 2015 at PTA. Camera surveillance confirmed active breeding nests. This was the first confirmed location of a BSTP colony in Hawaiʻi. 4 p.

- **An *Oceanodroma castro* Colony at Pōhakuloa Training Area (2019 02 13):** updated version of poster documenting the discovery of an active Band-rumped Storm Petrel colony at PTA, the first documented in the Hawaiian Islands. 1 p.

- **Seasonal Activity Patterns of the Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) at Pōhakuloa Training Area (2019 02 13):** poster documenting the results of a 3-year study to determine Hawaiian hoary bat occupancy and seasonal activity patterns in areas with and without potential treeland roosting habitat at PTA. We are using passive acoustic monitoring to accomplish this goal. Preliminary bat and weather data collected Jul 2014–Jun 2015. 1 p.

- **Fire, Flurry, and Flora: Fuels Management Trumps Wildfire Impacts to Endangered Plants at Pōhakuloa Training Area, Hawaiʻi (2019 03 05):** 20-minute presentation by Pamela Sullivan at the National Military Fish and Wildlife Association Meeting in Denver.

- **Fire, Flurry, and Flora: Fuels Management Trumps Wildfire Impacts to Endangered Plants at Pōhakuloa Training Area, Hawaiʻi (2019 03 05):** 10-minute presentation by Pamela Sullivan at the Hawaiʻi Ecosystems Meeting in Hilo.

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APPENDIX B

THREATENED AND ENDANGERED SPECIES AT PŌHAKULOA TRAINING AREA

Hawaiʻi is the most isolated island chain in the world, located approximately 4,000 miles from the nearest continent. The small islands of the central and western Pacific are hundreds to thousands of miles downstream of prevailing oceanic and atmospheric currents. This isolation has significant implications for the biological resources of these islands. Many of the species at Pōhakuloa Training Area (PTA) are endemic to the Hawaiian Islands and species assemblages generally are limited in their distribution. Additionally, when native plants, insects and birds crossed the Pacific to get here, most of their natural predators did not travel with them. In many cases, the plants and insects of Hawaiʻi lost their thorns and chemical defenses. Due to these decreased defenses, introduced feral ungulates have decimated plant populations at PTA. Other threats to ecosystem health at the installation come from changes to the landscape as a result of invasive plants and wildland fire.

PTA includes a portion of the last remaining sub-alpine tropical dryland ecosystem in the world. Parts of the installation (Training Area 2 and parts of Training Areas 1, 4, 10 and 11) are also in critical habitat for the Palila (*Loxioides bailleui*) which is listed as endangered under the Endangered Species Act (ESA). Natural resources at PTA have been managed since 1995 through a series of cooperative agreements between the Center for Environmental Management of Military Lands and the Army. The installation provides potential habitat for a total 27 ESA-listed species.

There are 20 ESA-listed plant species at the installation and 1 plant species that is undescribed and not ESA-listed but is managed due to its rarity and limited distribution (Figure C1). Several of these plant species occur exclusively on the installation. For species-specific maps, refer to Sections 2.4 and 2.5 of this biennial report.

1. *Asplenium peruvianum* var. *insulare*
2. *Exocarpos menziesii*
3. *Festuca hawaiiensis*
4. *Haplostachys haplostachya*
5. *Isodendrion hosakae*
6. *Kadua coriacea*
7. *Lipochaeta venosa*
8. *Neraudia ovata*
9. *Portulaca sclerocarpa*
10. *Portulaca villosa*
11. *Schiedea hawaiiensis*
12. *Sicyos macrophyllus*
13. *Silene hawaiiensis*
14. *Silene lanceolata*
15. *Solanum incompletum*
16. *Spermolepis hawaiiensis*

17. *Stenogyne angustifolia* var. *angustifolia*
18. *Tetramolopium arenarium* ssp. *arenarium* var. *arenarium*
19. *Tetramolopium* sp.1 (not ESA-listed)
20. *Vigna o-wahuensis*
21. *Zanthoxylum hawaiiense*

One mammal species, 4 bird species, and 2 invertebrate species listed under the ESA may occasionally use habitat at PTA and/or periodically transit the installation. Additionally, 15 bird species listed under the Migratory Bird Treaty Act may use habitat at PTA.

1. Hawaiian hoary bat (*Lasiurus cinereus semotus*)
2. Hawaiian Goose (*Branta sandvicensis*)
3. Hawaiian Hawk (*Buteo solitarius*)
4. Band-rumped Storm Petrel (*Oceanodroma castro*)
5. Hawaiian Petrel (*Pterodroma sandwichensis*)
6. Anthricinan yellow-faced bee (*Hylaeus anthracinus*)
7. Blackburn’s sphinx moth (*Manduca blackburni*)

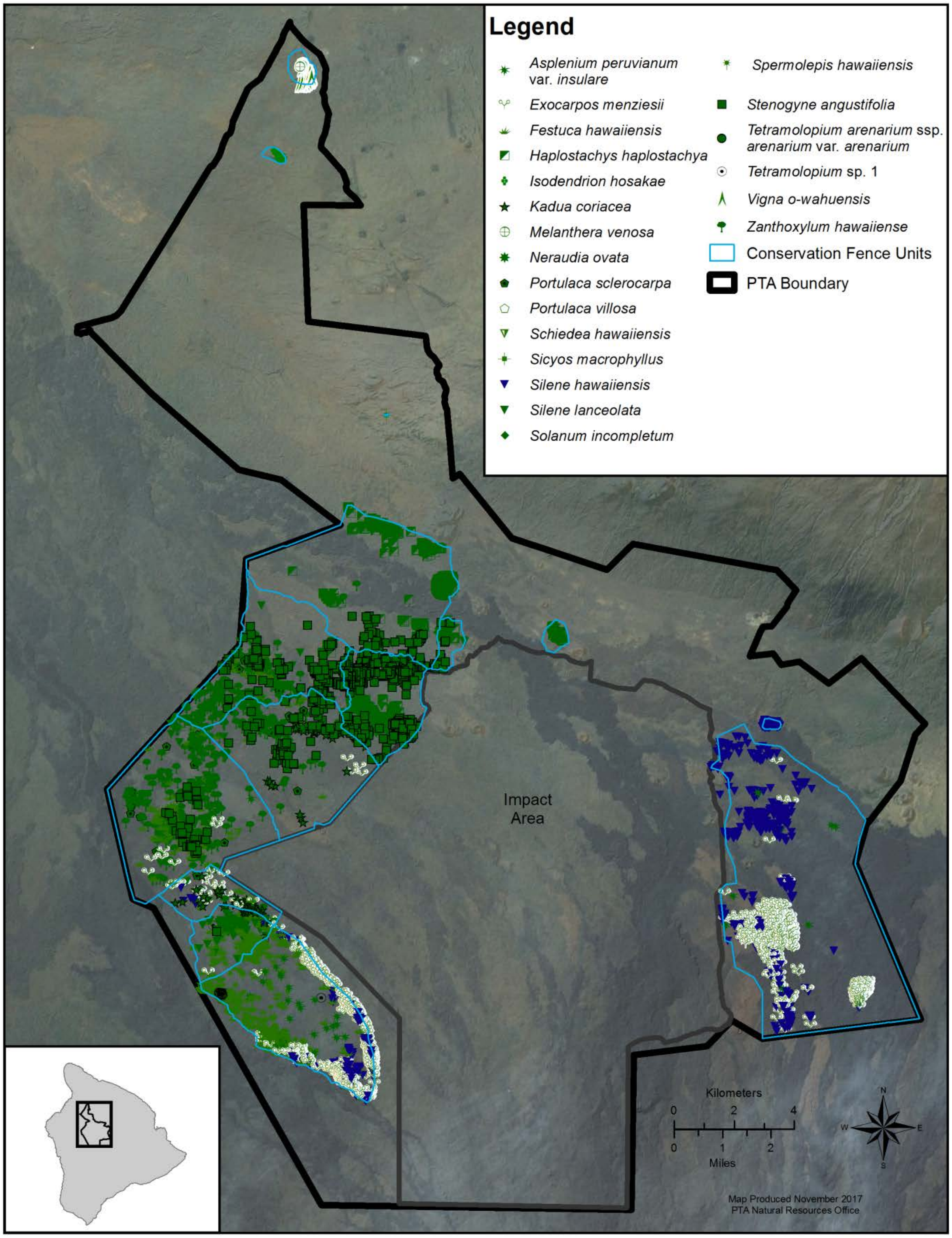


Figure B1. Current known distribution of threatened and endangered plant species at Pōhakuloa Training Area

Asplenium peruvianum var. *insulare* (Fragile Fern)

This endangered fern is a real cave dweller. At PTA, *A. peruvianum* var. *insulare* grows in moist and dark areas such as large lava tubes, pits, and deep cracks. It reproduces by spores located on the underside of the leaflets.

Description: *A. peruvianum* var. *insulare* is a terrestrial, delicate, small to medium-sized perennial fern with underground stems. Each plant has about 1 to 20 fronds, which are 15 to 46 cm long and 1 to 3 cm wide. The fronds are often proliferous with one-to-many proliferations on the upper stipes and lower rachises. Fronds are also narrow, long-linear, and pale green. The rhizomes are decumbent and 3 to 12 mm in diameter. Stipes are dull gray or brown with 2 greenish ridges on the upper surface. This species has occasional one-to-many plantlets on the upper stipes and lower rachises.

Habitat: On Maui *A. peruvianum* var. *insulare* is found in streamside hollows and grottoes that occur in mesic to dry subalpine shrubland dominated by *Leptecophylla tameiameiae* and *Sadleria cyatheoides* with scattered *Metrosideros polymorpha.* The species has also been observed in montane wet ʻōhiʻa forest in rocky gulches in association with other fern species. *A. peruvianum* var. *insulare* has been observed at elevations between 1,680 and 2,410 m. On the island of Hawaiʻi *A. peruvianum* var. *insulare* grows in moist and dark areas in large lava tubes, pits, and deep cracks on varying ages of lava that have moderate soil or ash accumulation, often in association with mosses and liverworts. This species can occasionally be found growing in the interface between young ʻaʻā and older pāhoehoe lava flow deposits. At PTA, the species is found in the *Metrosideros polymorpha* Woodland Alliance, *Myoporum sandwicense - Sophora chrysophylla* Shrubland Alliance, and *Dodonaea viscosa* Shrubland Alliance vegetation types. Plants are frequently found growing in white mineral deposits of caves without any soil or ash accumulation.

Life History: Little is known about the reproductive cycles, longevity, specific environmental requirements, and limiting factors for *A. peruvianum* var. *insulare*. Reproduction is by spores located on the underside of the pinnae.

Distribution: *A. peruvianum* var. *insulare* was known historically from east Maui and from the island of Hawaiʻi and currently remains on both islands. At PTA, this species is known to occur in TAs 21, 22, and 23. Prior to ungulate control the species was commonly found within skylights or in caves near the entrance. Plants have been recorded outside of caves now that ungulates have been controlled. As September 2019, there are 396 adults and juveniles and 312 seedlings in 42 locations at the installation.

Exocarpos menziesii (Menzie's Ballart, Heau)

This broom-like shrub belongs to the sandalwood family. The species gets its name from the Greek word *exo*, out of or without, and *karpos*, fruit, in reference to the fruit being partially embedded within a fleshy receptacle.

Description: *E. menziesii* is a shrub or small tree 0.5 to 2 m tall. Stems are densely branched toward the ends, the tips conspicuously maroon-tinged. Stems are stiff, upright, and conspicuously striate. Leaves are usually only scale-like with occasional foliaceous ones present, these elliptic to oblanceolate, 10-14 mm long. Flowers are perfect with 5 red petals that are 3 mm long. Fruits are reddish brown to red at maturity, ellipsoid to narrowly ovoid, 7-10 mm long. The exposed portion above the receptacle is 3-6 mm long, apex rounded with a small terminal beak partially embedded in a yellow, fleshy, receptacle.

Habitat: *E. menziesii* occupies the driest habitats of the 3 Hawaiian *Exocarpos* species. The 2 collections from Lānaʻi suggest a wider range in the past for this species. *E. menziesii* occurs in open *Metrosideros polymorpha* shrubland or on lava flows with sparse vegetation at elevations of 1,400 to 2,100 m in the montane dry ecosystem on the island of Hawaiʻi.

Life History: Three endemic *Exocarpus* species are found in Hawaiʻi. Both unisexual and perfect flowers have been reported in *E. gaudichaudii*; the breeding systems of all 3 species should be carefully studied.

Distribution: *E. menziesii* is historically known from the islands of Lānaʻi (Kaiholena Gulch) and Hawaiʻi (from Kahuku Ranch in the south up through Hualālai and Puʻu ka Pele on the leeward slopes of the island). Currently there is 1 scattered occurrence of *E. menziesii* of fewer than 20 individuals on the slopes of Hualālai; there are no known remaining occurrences of the species on Lānaʻi. At PTA, the species is widely distributed in TAs 21, 22, and 23. There are at least 1,802 individuals in 1,762 locations at the installation.

Festuca hawaiiensis (Hawaiian Fescue)

Prior to construction of conservation fence units and ungulate removal at PTA, this grass species commonly occurred growing with *Leptecophylla tameiameiae*. Since ungulate control, *F. hawaiiensis* is growing in open areas and is increasing in abundance throughout the installation.

Description: *F. hawaiiensis* is a perennial grass with tufted stems up to 150 cm in height. Both the stems and leaf sheaths are hairless. The ligule is 1-2 mm long, membrane-like with irregular margins. Leaf blades are 20-30 cm long and 3-5 cm wide, tapering towards the tip with the edges rolling upwards. The leaves are typically basal with the upper surface being rough and the lower surface smooth. The inflorescence is open with branches in clusters of 5 with each branch spreading or drooping. The fruit is a caryopsis that is reddish brown, oblong to elliptical, one-seeded, dry, and does not open at maturity.

Habitat: Typical habitat for this species is dry forest at 2,000 m, in the montane dry ecosystem. *F. hawaiiensis* occurs within the *Dodonaea viscosa* Shrubland Alliance, *Metrosideros polymorpha* Woodland Alliance, *Myoporum sandwicense – Sophora chrysophylla* Shrubland Alliance, and *Myoporum sandwicense – Sophora chrysophylla* Woodland Alliance. Associated native species include *Alyxia stellata, Chenopodium oahuense, Coprosma montana, Leptecophylla tameiameiae*, *Osteomeles anthyllidifolia*, *Myrsine lanaiensis, Santalum paniculatum,* and *Sida fallax.* The elevational range for this species at PTA is from 1,425 to 2,125 m.

Life History: Little is known about the life history of this species. *F. hawaiiensis* is easily established on bare ground, outcompeting other plants and persisting over several years. Invasion of habitat by alien plant species (particularly *Cenchrus setaceus*) presents the greatest threat to this species.

Distribution: *F. hawaiiensis* was known historically from Maui and Hawaiʻi. Currently, this species is only found on Hawaiʻi Island in the southwest portion of PTA. *F. hawaiiensis* is broadly distributed throughout TA 22 and there is a high density within and surrounding TA 23. There are at least 1,083 individuals in approximately 683 locations at the installation. Prior to ungulate control *F. hawaiiensis* was almost exclusively found growing within *L. tameiameiae*, whose dense and stiff, pointed leaves provided shelter for *F. hawaiiensis* from ungulates. After conservation fencing and ungulate control, *F. hawaiiensis* is now growing in the open and multiple individuals are often recorded at a location.

Haplostachys haplostachya (Hawaiian Mint, Honohono)

This endangered mint appears to be fire resistant. The success of *H. haplostachya* following fire events may be due to its ability to resprout and its frequent location on rocky slopes. Fires in rocky areas tend to occur at low and moderate intensities because of low fuel loads.

Description: *H. haplostachya* is a perennial, erect short-lived shrub that grows to 30 to 60 cm tall. The leaves are fleshy, heart-shaped, and narrowly cordate. The upper surface of the leaves is light green, densely puberlent, and rugose (sunken veinlets with elevated spaces between). Leaf lower surfaces are white and covered with densely matted woolly hairs. The inflorescence is a raceme with flowers that are tubular, pure white or tinged with purple and scented. Reproduction is by seed and basal sprouts. The taxon is distinguished by its slightly square and densely white tomentose stems.

Habitat: *H. haplostachya* grows in dry exposed areas on ash-veneered lava, very stony, shallow soils, and lava outcrops. It often establishes in large cracks on rocky ridges and on puʻu. *Haplostachys* was noted in 1880 as a component of the upper forest zone along with stunted vegetation, and in 1942 the taxon was described as being in the open forest and scrub zone. In 1990, the species was described as part of the *Dodonaea* montane shrubland habitat. At PTA, *H. haplostachya* is found in the *Metrosideros polymorpha* Woodland Alliance, *Myoporum sandwicense - Sophora chrysophylla* Woodland Alliance, *Myoporum sandwicense - Sophora chrysophylla* Shrubland Alliance, and *Dodonaea viscosa* Shrubland Alliance vegetation types. It occurs almost exclusively on old Mauna Kea flows, with 1 population on Mauna Loa pāhoehoe lava.

Life History: There is little information on the life history information of *H. haplostachya*. There is no documentation of pollination vectors, but it is plausible that the flowers are moth pollinated or may involve a variety of insects. Dispersal mechanisms, seed viability, longevity and dormancy requirements are unknown but the woody black nutlet coat suggests that the fruit persists intact for a long period of time. *H. haplostachya* may be sensitive to drought.

Distribution: *H. haplostachya* was once present on the islands of Hawaiʻi, Kauaʻi, and Maui but is currently only found on the island of Hawaiʻi. All these occurrences are located at PTA in TAs 7, 13, 17, 18, 19, 20, 22, KMA, and adjacent state lands in Puʻu Anahulu. There are at least 24,270 individuals in approximately 3,180 locations at the installation. This is the most abundant ESA-listed plant species found at PTA, accounting for more than half the known individuals of all species combined. *H. haplostachya* is distributed over more than 2,430 ha within several fence units.

Isodendrion hosakae (Aupaka)

This endangered shrub in the violet family is found on steep puʻu in the South Kohala District on the island of Hawaiʻi. Its habitat is surrounded by converted pasture lands. In the absence of grazing pressures from cattle and feral ungulates, *I. hosakae* would presumably be more widely distributed.

Description: *I. hosakae* is a branched, upright, short-lived evergreen shrub. Plants range from 8 to 82 cm tall. Flowers and fruits occur on woody stems. Leaves are leathery and lance-shaped, measuring 3 to 7 cm long and 0.6 to 2.0 cm wide. Stipules are persistent and conspicuously cover stem ends. Flowers are bilaterally symmetrical, yellowish-green to white, and up to 18 mm long. The fruit is a red-tinged, green elliptical capsule measuring 12 to 16 mm long, and contains up to 9 obovoid seeds. *I. hosakae* is most similar to *I. pyrifolium* differing in leaf shape and size of lower flower petal.

Habitat: *I. hosakae* occurs in areas that have been converted to pasture lands for more than a century. The species is now only found on puʻu, possibly due to less frequent access by cattle and feral herbivores. The species occurs in dry montane shrublands dominated by *Dodonaea viscosa*, *Sophora chrysophylla*, *Wikstroemia* sp., and *Santalum* sp. Currently, much of the habitat is dominated by non-native grass species (e.g., *Cenchrus setaceus*). *I. hosakae* has been observed at elevations from 900 to 1,030 m.

Life History: Little life history information is known for *I. hosakae.* Flowering and fruiting has been reported during all months when monitoring has been conducted. Sexual reproduction mechanisms are not known, including pollination agents. Flowers are white and produce a sweet scent in late afternoon and evening, suggesting moths may be a pollination vector. There is no evidence of vegetative reproduction occurring in nature. Seedlings have been observed in the field in the vicinity of natural plants. Recruitment rates in the field appear to be low, but data are limited.

Distribution: *I. hosakae* is limited in distribution to the South Kohala District on the island of Hawaiʻi. The historical distribution of the taxon is not known since the species was only described about 50 years ago. The species is historically known from Puʻu Pāpapa and Puʻu Nohona o Hae in KMA, as well as 1 other puʻu in the vicinity on private lands. Currently, *I. hosakae* is only found on Puʻu Pāpapa, no plants remain on Puʻu Nohona o Hae. Since 2003, the abundance has declined from 871 plants; as of September 2019, there are 125 adults and juveniles and 10 seedlings. The possible and estimated elevation range of *I. hosakae* range is 915-1,040 m.

Kadua coriacea (Leather-leaf Sweet Ear, Kioʻele)

Due to its extreme rarity, the reproductive biology for this endangered plant in the coffee family is poorly understood. In past years, an unexplained lack of regeneration has been observed for *K. coriacea* despite the fact that the majority of adults were reproductively active. However, several seedlings were located in the last few years at PTA.

Description: *K. coriacea* is a small, many-branched, erect shrub. Leaves are leathery and more or less oval-shaped. The leaves are opposite, hairless above, hairless or downy below, and 3 to 8 cm long with 5 to 10 mm sheath-like petioles. Stipules are reduced and attached to the petiole base. Flowers are small, clustered, trumpet-shaped, cream-colored, and fleshy. The flowers have calyx lobes that do not enlarge when the fruit develops. Fruits are cup or top-shaped, containing dark-brown, irregularly angled seeds. The fruits are longer than wide and flower buds are square in cross-section.

Habitat: On the island of Hawaiʻi, the species occurs on pāhoehoe lava flows in the *Metrosideros polymorpha* Woodland Alliance vegetation type. It is found at elevations from 1,500 to 1,700 m. Associated species include *Dodonaea viscosa*, *Leptecophylla tameiameiae*, *Metrosideros polymorpha*, *Myoporum sandwicense*, *Myrsine lanaiensis*, and *Osteomeles anthyllidifolia*.

Life History: Life history information for *K. coriacea* is poorly understood, including flowering cycles, pollination vectors, seed dispersal agents, longevity, and environmental requirements. Immature and mature fruits have been observed in August, flowers in September, vegetative growth in December, and immature fruits and flowers in January. Despite the common perception that this is a short-lived species, we have observed many individuals for more than 10 years and some for 20 years or more.

Distribution: Historically, *K. coriacea* was present on the islands of Hawaiʻi, Maui, and Oʻahu but is currently only found on Hawaiʻi Island at PTA. This species tends to grow as single to a few individuals at locations in TAs 22 and 23. Plants in ASRs 11, 13, 18, 21, and 22 in the north may have been part of a more continuous distribution prior to ungulate impacts and other disturbances. Plants in ASRs 29 and 30 are likely a continuous distribution that is separated from the northern *K. coriacea* ASRs by a younger lava flow. Recruitment at natural plant locations was unconfirmed until recently. In the last 5 years, approximately 7 juveniles have been observed. As of September 2019, there are 123 locations with 142 adults and 3 juveniles at the installation.

Lipochaeta venosa (Nehe)

This endangered flowering plant in the sunflower family is known only from the island of Hawaiʻi, where it grows on puʻu within dry shrublands. The main threat to the species is loss and degradation of its habitat; much of the area is ranchland grazed by cattle and roamed by feral pigs and goats. Non-native plants and fire also threaten *L. venosa* habitat.

Description: *L. venosa* is a low-growing, perennial herb with curved, spreading stems that are 50 cm long. The species is partly deciduous and loses leaves during periods of drought. The leaves are triangular with 2 basal lobes, pinnately dissected throughout, and 2.1 to 2.8 cm long and 1.5 to 2.2 cm wide. The upper surface of the leaves has minute, straight, appressed hairs. On the lower surface, the hairs are denser. Flower heads are solitary or in clusters of 2. Ray floret achenes are 2 to 2.4 mm long and 1.5 to 1.8 mm wide with minute wings. The disk floret achenes are about the same size but wingless.

Habitat: *L. venosa* is restricted to puʻu in montane dry shrublands, dominated by non-native grasses (e.g., *Cenchrus setaceus*) with some native shrubs (e.g., *Dodonaea viscosa*, *Chenopodium oahuense*, and *Osteomeles anthyllidifolia*), typically at elevations from 725 to 1,140 m. In the absence of grazing pressures this species most likely would be more widespread. In KMA, the species occurs on the very stony soils of a puʻu. *L. venosa* is known to root sprout and can recolonize areas following fire events.

Life History: Life history information is poorly known for *L. venosa*. This species flowers between March and July, but flowering periods may extend beyond this period. Flowers do not appear to be specialized. The species roots readily in greenhouse cultivation indicating that vegetative reproduction may occur in nature. Plants do not produce much seed and it is difficult to properly time collection before seed is scattered. Seedlings have been recently observed in the field in the vicinity of natural plants. *L. venosa* also seems to easily spread vegetatively, and this may be an important form of reproduction for the species.

Distribution: *L. venosa* is a narrow endemic species found on the island of Hawaiʻi. Currently, the species is known from occurrences on the leeward side, northwest flank of Mauna Kea. At PTA, *L. venosa* is found on Puʻu Nohona o Hae in KMA. The species is historically known from other puʻu in the vicinity on private lands. As of September 2019, there are 107 adults and juveniles on Puʻu Nohona o Hae.

Neraudia ovata (Spotted Nettle Bush, Maʻaloa)

This endangered nettle is endemic to the island of Hawaiʻi. *N. ovata* grows on lava flows in dry forests. Originally occurring from North Kona to Kaʻū, this species is now known from 2 subpopulations on privately owned land in Kaloko and at PTA. Major threats to this species are habitat loss, browsing by feral goats and sheep, and invasions of introduced plants.

Description: *N. ovata* is a sprawling, rarely erect, shrub with 1 to 3 m long stems or it can develop into a small tree. The leaves are grayish to greenish on the lower surface, thin, and ovate to elliptic. They are 4 to 12 cm long and 2 to 6.4 cm wide. This species is mostly dioecious, male and female flowers occurring on separate plants. Male flowers are short with a densely haired calyx and female flowers are sessile, densely haired, and have a boat-shaped calyx. The fruit is an achene. Diagnostic characteristics include the lack of a conspicuous tuft of hairs at the leaf base, the distribution of the hairs on the lower surface, and the shape of the female flower.

Habitat:: *N. ovata* occurs in dry forests, on open lava flows, and in subalpine forests on the leeward side of the island of Hawaiʻi at elevations from 115 to 1,520 m. Most plants are found on Mauna Loa ʻaʻā flows that are approximately 4,000 years old. Associated taxa include *Reynoldsia sandwicensis*, *Myoporum sandwicense*, *Cocculus orbiculatus*, *Myrisine* sp., *Schinus terebinthifolius*, *Nothocestrum breviflorum*, and *Pleomele hawaiiensis*. At PTA, the species grows in the *Metrosideros polymorpha* Woodland Alliance and *Myoporum sandwicense - Sophora chrysophylla* Shrubland Alliance.

Life History: Little information on the life history of *N. ovata* is available. This species has been observed in vegetative form during fall and winter, and in flower and fruit during spring and summer. Individuals may be somewhat variable in their phenology. Limited observations suggest plants are not truly dioecious, but facultatively monoecious, bearing male and female flowers at different times on the same plant. This variability may occur from year to year. Recruitment has been observed sporadically throughout the years at PTA and in large pulses with the winter rains of 2003-2004 and 2013-2014

Distribution: *N. ovata* is known currently and historically only from the island of Hawaiʻi. It has been found in wet forests in the northern part of the island in Laupāhoehoe, in drier portions of the island at PTA, north Kona in Kaloko, and in the southern part of the island in Manukā. At PTA, this species is found in a small portion of TA 22 along the western boundary. The *N. ovata* at PTA may represent the upper limit of the species range. As of September 2019, there are 19 locations with 58 adults and juveniles at the installation.

Portulaca sclerocarpa (Hard Fruit Purslane, Poʻe)

This endangered flowering herb in the purslane family is only found on the island of Hawaiʻi and an islet off Lānaʻi. On Hawaiʻi Island, *P. sclerocarpa* grows on cinders and lava substrates in dry habitats at Hawaiʻi Volcanoes National Park and PTA. Unfortunately, 90% of known individuals were lost in 2008 after a major decline in the national park population.

Description: *P. sclerocarpa* is a short, generally herbaceous perennial that has a fleshy tuberous taproot that becomes woody. Its stems are up to 20 cm long. The species has stalkless, succulent, grayish-green leaves that are almost circular in cross-section. Dense tufts of hairs are located in each leaf axial and underneath the tight clusters of 3 to 6 stalkless flowers. The flowers are grouped at the end of the stem and petals are white, pink, or pink with a white base. The sepals are 5 mm long with membranous edges. The hardened capsules are 5 mm long, and have thick walls that open late or not at all.

Habitat: *P. sclerocarpa* is found on weathered Mauna Kea soils, puʻu, or geologically young lavas in montane dry shrublands, and in open *Metrosideros polymorpha* woodlands from 1,030 to 1,630 m in elevation. At PTA, the species is found on barren lava and in the *Metrosideros polymorpha* Woodland Alliance and *Myoporum sandwicense - Sophora chrysophylla* Shrubland Alliance vegetation types. Associated taxa are *Sophora chrysophylla, Dodonaea viscosa*, and *Lipocaeta venosa*.

Life History: Little is known about the life history of *P. sclerocarpa*. This species has been observed flowering in March, June, and December. Juveniles are present in some locations, indicating that pollination and reproduction are taking place. The plant can be grown from seed under greenhouse conditions.

Distribution: The historical and current distribution of *P. sclerocarpa* is limited to the islands of Hawaiʻi and Lānaʻi. At PTA, this species occurs in TAs 22 and 23, and previously on Puʻu Nohona o Hae in KMA. As of September 2019, there are 40 *P. sclerocarpa* locations at the installation with 161 adults and juveniles and 108 seedlings. Locations are widely scattered in the western fence units with few individuals at each location.

Portulaca villosa (Hairy Purslane, ʻIhi)

This perennial herb belongs to the purslane family. There are number of cultivated species in the family, such as rose moss, a garden ornamental, and the common purslane, a cosmopolitan weed that is sometimes used as a pot herb. *Portulaca* is represented in Hawaiʻi by 7 species: 3 endemic, 1 indigenous, and 3 naturalized.

Description: *P. villosa* is an herb arising from a fleshy or woody taproot. Stems are trailing to slightly erect and are up to 30 cm long. Leaves are pale grayish green, linear, nearly round in cross-section, fleshy or slightly succulent, 5–25 mm long, and without a petiole. Leaves contain a dense tuft of yellowish-brown hairs 3–12 mm long in the axil. There are 3–6 flowers in heads at the tip of the branches, subtended by dense tufts of hairs 6–12 mm long and a series of reduced leaves. Petals are white or pink, obovate, 8–10 mm long, and notched at the tip. Fruits are thin walled capsules with numerous small reddish-brown seeds.

Habitat: *P. villosa* occurs on dry, rocky, clay, lava, or coralline reef sites from sea level to 490 m in coastal and lowland dry ecosystems, and in the montane dry ecosystem on Hawaiʻi Island. At PTA, this species historically existed on Mauna Kea rocky outcrops on the upper slopes of an old, heavily eroded puʻu. *P. villosa* is currently found in the *Dodonaea viscosa* Shrubland Alliance and the *Metrosideros polymorpha* Woodland Alliance.

Life History: *P. villosa* is a short-lived perennial herb, and little is known about the life history of the species. *Portulaca* is a pantropical and subtropical genus of 100-200 species. The native Hawaiian species are the result of 2 colonization events: 1 for *P. lutea* and *P. molokiniensis*, and the other for *P. villosa* and *P. sclerocarpa*.

Distribution: *P. villosa* has been reported on the small islets of Kaʻula and Lehua (west of Kauaʻi and Niʻihau) and from Nihoa in the Northwest Hawaiian Islands; however, their current status is unknown. The species is documented from all the main Hawaiian Islands except Niʻihau and Kauaʻi. At PTA, historical populations were located on the south and southwest facing slopes of Puʻu Keʻekeʻe; the species is currently found in 2 locations in TA 22. As of September 2019, there are 8 adults and juveniles and 1 seedling at the installation. The plants at PTA are the only known individuals on Hawaiʻi Island.

Schiedea hawaiiensis (Māʻoliʻoli)

This sprawling vine in the carnation family was thought to be extinct but was rediscovered at PTA in 1996. The species was first collected in 1888 by William Hillebrand, a German physician, near Waimea. The holotype specimen was deposited in an herbarium in Berlin, which was destroyed during WWII. When Warren Wagner wrote the Manual of Flowering Plants of Hawaiʻi, he combined *S. hawaiiensis* with *S. diffusa*. However, after finding the plant at PTA, he realized the species fit Hillebrand's original description and published a paper to rename a new holotype.

Description: *S. hawaiiensis* is a reclining or sprawling perennial vine. The stems are 30 to 70 cm long, flattened, 4-sided, and the angles of the stem are slightly winged. Stems are pale yellowish green throughout or purple-tinged in the lower portion of the plant. The leaves are opposite each other, 4 to 7.8 cm long and 1.7 to 2.8 cm wide, they are thin and leathery. The leaves are ovate to elliptic with only the midvein evident. The flowers are small, dull yellowish green, purple-tinged or purple, and arranged in clusters of 15–20 on an elongated and branched stem. The fruit is a small capsule with 9–20 seeds.

Habitat: At PTA, *S. hawaiiensis* is found in the *Metrosideros polymorpha* Woodland Alliance vegetation type. Associated species include *Myrsine lanaiensis*, *Dodonaea viscosa*, and *Leptecophylla tameiameiae* on the interface between ʻaʻā and pāhoehoe lava flows.

Life History: *S. hawaiiensis* has an autogamous breeding system. Self-pollination is facilitated by wind; when pollen is shaken from the anthers it is deposited on the stigma. The species is apparently not adapted to cross-pollination via wind, because there are so few pollen grains per flower. Most *Schiedea* species occurring in dry habitats have evolved sexual dimorphism rather than autogamy. Mutations to male sterility may not have occurred in *S. hawaiiensis*; sexual dimorphism does not occur in any closely related species.

Distribution: *S. hawaiiensis* is endemic to the island of Hawaiʻi. It was known from only 1 collection in Waimea prior to being recorded at PTA. The species is now found only in 1 location in TA 22 at PTA. As of September 2019, there are 10 adults and juveniles at the natural location.

Sicyos macrophyllus (Alpine Bur Cucumber, ʻĀnunu)

This perennial vine belongs to the gourd family, as *Sicyos* is the Greek word for cucumber. There are about 50 species in the genus in America, Hawaiʻi, southwestern Pacific, New Zealand and Australia. The Hawaiian group contains 14 endemic species; they are of obscure affinity, but probably are derived from a single colonist possibly from South America.

Description: *S. macrophyllus* has stems up to 15 m long and 4 cm in diameter that are sparsely pubescent and glabrate with black spots. Leaves are broadly ovate-cordate with a narrow basal sinus, deeply lobed, 7–25 cm long and 6–26 cm wide. The upper surface of the leaves is glabrous and the lower surface is densely pubescent. Tendrils are twice branched. Flowers are either male or female, occur in sparse to dense pubescent panicles 8–25 cm long, and have a greenish-yellow corolla. The fruit is round and green, obscurely ribbed, minutely puberulent, and usually beaked.

Habitat: Typical habitat for *S. macrophyllus* is wet *Metrosideros polymorpha* forest and *Sophora chrysophylla-Myoporum sandwicense* forest, at 1,200 to 2,000 m in the montane mesic (Hawaiʻi Island), montane wet (Maui), and montane dry (Hawaiʻi Island) ecosystems. On Hawaiʻi Island, the species is rare in wet forest and subalpine forest on the windward slopes of the Kohala Mountains, Mauna Kea, and the saddle region.

Life History: Little is known about the life history of this species. It is extremely rare and only a few individuals exist. *S. macrophyllus* was only recently rediscovered at PTA. Wild individuals at Kīpuka Kī at Hawaiʻi Volcanoes National Park are reportedly reproducing; however, seeds have not successfully germinated under nursery conditions.

Distribution: Historically, *S. macrophyllus* was known from Puʻu Waʻawaʻa, Laupāhoehoe, Puna, and South Kona on the island of Hawaiʻi, and from Kīpahulu Valley on the island of Maui. However, the individual on Maui has not been observed since 1987. Currently, the only known individuals are restricted to a few small areas on Hawaiʻi Island. There are 10 occurrences of *S. macrophyllus*, totaling between 24 and 26 individuals, on the island of Hawaiʻi at Puʻu Mali, Puʻu Waʻawaʻa, Hōnaunau, Hakalau NWR-Kona Unit, Kaʻohe, Kukui o Paʻe, Kīpuka Maunaʻiu, Kīpuka Kī, and Puʻu Huluhulu. At PTA, a single *S. macrophyllus* was discovered in a KMA gulch in 2015 but the individual has since died. The location is enclosed by a 1.8-m conservation fence.

Silene hawaiiensis (Hawaiian Catchfly)

This threatened shrub in the carnation family is only known from Hawaiʻi Island. *S. hawaiiensis* is highly palatable to feral ungulates. However, this species appears to be relatively hardy due to its ability to resprout from the large fleshy taproot after being severely browsed. Roots are spindle-shaped and sometimes grow exposed aboveground, which may also help the plant survive.

Description: *S. hawaiiensis* is a sprawling, short-lived shrub with slanting or climbing stems 15 to 40 cm long that arise from an enlarged root, and are generally covered with short, sticky hairs. Leaves are slender, often recurved, and stalkless. The stems are 6 to 15 mm long and 0.5 to 0.8 mm wide. Flowers are borne in loosely arranged, elongate, sticky clusters. The calyx is fused, 5-toothed, purple-tinged, and 11 to 14 mm long. Petals are green-white above and sometimes maroon or maroon-streaked below. Each petal is divided into 2 parts, a 2-lobed expanded blade and a long narrow, stalk-like base.

Habitat: *S. hawaiiensis* typically grows in montane and subalpine dry shrublands on weathered lava and ash, as well as on all ages of lava and cinder substrates at elevations from 900 to 1,300 m. At PTA, this species is found on barren lava, on disturbed sites, and in the *Metrosideros polymorpha* Woodland Alliance, *Chenopodium oahuense* Shrubland Alliance, *Dodonaea viscosa* Shrubland Alliance, *Myoporum sandwicense - Sophora chrysophylla* Shrubland Alliance, and *Eragrostis atropioides* Herbaceous Alliance vegetation types. Associated species include *Dodonaea viscosa*, *Leptecophylla tameiameiae*, *Metrosideros polymorpha*, *Rumex giganteus*, *Sophora chrysophylla,* and *Vaccinium reticulatum*.

Life History: Life history information for *S. hawaiiensis* is limited. This species has been observed to be in a vegetative state through the winter and spring with flowers and fruit present in summer and fall. *S. hawaiiensis* is considered short-lived; however, the plant may be longer lived than originally thought because it can resprout from the large, woody taproot (e.g., it has been documented to resprout from its large taproot following a fire). Seeds germinate readily and seedlings are easy to establish under greenhouse conditions.

Distribution: *S. hawaiiensis* is endemic to the island of Hawaiʻi. At PTA, the species is found in TAs 3, 21, 22, and 23. *S. hawaiiensis* has responded to conservation fencing and ungulate removal with an increased abundance and broader distribution. There are at least 2,344 individuals in approximately 1,324 locations at the installation. This is PTA's second most abundant species based upon locations, and it is the most widespread species at the installation with a distribution covering over 3,035 ha.

Silene lanceolata (Lance-leaf Catchfly)

The showy white flowers on this endangered shrub in the carnation family have a sticky base that "catch" invertebrates such as ants and flies. *S. lanceolata* is capable of establishing itself successfully in a wide range of habitats, growing on volcanic lava and ash substrates on the island of Hawaiʻi, and in dry and moist forests on cliffs and slopes on Oʻahu and Molokaʻi.

Description: *S. lanceoloata* is an upright, suffrutescent, perennial shrub with stems that range in length from 15 to 50 cm. This species is single-stemmed at the woody base and multiple branched above. Leaves are narrow, smooth, and fringed with hairs. The leaves are approximately 25 to 80 mm long and 2 to 11 mm wide. Flowers are small and arranged in open clusters with stalks 8 to 23 mm long. This species has stamens that are shorter than its sepals. The calyx is 5-toothed, 10-veined, and approximately 6 mm in length. Capsules are approximately 8 to 9 mm long and open at the top.

Habitat: On the island of Molokaʻi, *S. lanceolata* is restricted to cliff faces and ledges of gullies in dry to mesic shrublands due to ungulate impacts. On Oʻahu, this species is restricted to a steep cliff at the Mākua Military Reservation. On the island of Hawaiʻi, *S. lanceolata* grows on rocky tumuli or outcrops, on ʻaʻā lava, in deep ash deposits over pāhoehoe lava, and in Mauna Kea substrate in dry montane shrubland at elevations between 1,250 and 1,320 m. At PTA, *S. lanceolata* is found in the *Metrosideros polymorpha* Woodland Alliance, *Myoporum sandwicense – Sophora chrysophylla* Woodland Alliance, *Myoporum sandwicense – Sophora chrysophylla* Shrubland Alliance, and *Dodonaea viscosa* Shrubland Alliance vegetation types. Associated species include *Chenopodium oahuense, Dodonaea viscosa, Dubautia linearis*, *Eragrostis* sp., *Euphorbia* sp., *Leptecophylla tameiameiae, Metrosideros polymorpha*, *Myoporum sandwicense,* and *Sophora chrysophylla*.

Life History: Life history information for *S. lanceolata* is limited. Plants have been observed to be in flower and fruit during the winter and spring months and in vegetative form during the rest of the year. This species is propagated easily under greenhouse conditions.

Distribution: Historically, *S. lanceolata* was known from the islands of Hawaiʻi, Kauaʻi, Lānaʻi, Molokaʻi, and Oʻahu, but this species is currently only found on Hawaiʻi, Molokaʻi, and Oʻahu. At PTA, *S. lanceolata* is found in TAs 17, 19, 22, and 23. *S. lanceolata* has responded to conservation fencing and ungulate removal with an increase in abundance and a broader distribution. There are at least 3,882 individuals in approximately 372 locations at the installation. The species has a clumped and scattered distribution over approximately 2,835 ha at PTA.

Solanum incompletum (Hawaiian Prickle Leaf, Pōpolo Kū Mai)

For over half a century, this endangered nightshade was thought to be extinct until it was rediscovered at PTA in 1996. It is currently found in 3 locations at the installation. *S. incompletum* is one of the few native Hawaiian plant species that has developed or retained spiny reddish-orange prickles as a defense mechanism.

Description: *S. incompletum* is a woody shrub that reaches heights of up to 3 m. The stems and lower leaf surfaces are covered with prominent reddish prickles. Leaf margins are 1 to 4-lobed on each side. Leaves are oval to elliptic, 10 to 15 cm long and 7 cm wide and found on petioles of up to 7 cm in length. There are prominent veins on the lower leaf surface. Inflorescences are loose clusters of single-stalked flowers. The white petals form a star that is approximately 2 cm in diameter. Fruits are round berries, yellow-orange to black in color and approximately 1.5 cm in diameter.

Habitat: Historically, *S. incompletum* occurred in dry to mesic forests, diverse mesic forests, and subalpine forests. At PTA, this species is found on lava flows of various ages in the *Metrosideros polymorpha* Woodland Alliance, *Myoporum sandwicense – Sophora chrysophylla* Shrubland Alliance, and *Dodonaea viscosa* Shrubland Alliance vegetation types. Associated species include *Dodonaea viscosa*, *Sophora chrysophylla,* and *Myoporum sandwicense*.

Life History: Detailed life history information is not available for this species. However, *S. incompletum* is reproducing, based on the various age-classes represented in the natural population. The species is known to fruit in late summer and fall. Field-collected seeds have been successfully propagated under greenhouse conditions. *S. incompletum* appears to reproduce vegetatively as well as sexually. One or more rings of stems appear to sprout from the root of the main plant, so the number of individuals does not take into account this life history aspect of the species.

Distribution: Historically, *S. incompletum* was known from the islands of Hawaiʻi, Lānaʻi, and Maui. It is thought that the distribution of *S*. *incompletum* may also have included the islands of Kauaʻi and Molokaʻi. Currently, the species is only known from the island of Hawaiʻi. At PTA there are 3 main locations in TAs 18, 19, and 22 and a 4th extirpated location in TA 22. As of September 2019, there are approximately 94 adults and juveniles and 1 seedling at 20 locations. The species is also found in an adjacent kīpuka on state lands.

Spermolepis hawaiiensis (Hawaiian Parsley)

***Spermolepis* is a genus of 5 species from North America, Argentina, and the Hawaiian Islands in the parsley family with some 3,000 species worldwide. *S. hawaiiensis* is distinguished from other native members of the family by being a non-succulent annual with umbrella-shaped inflorescence. The feathery foliage is similar to some other members of the parsley family, such as dill, cilantro, carrot, and fennel.**

Description: *S. hawaiiensis* is a slender annual herb, has few branches, and grows to a height of 5 to 20 cm. Leaves are dissected into narrow, lance-shaped divisions; are oblong to somewhat oval; and grow on stalks about 2.5 cm long. Flowers are arranged in a loosely compound umbrella shape, with each inflorescence arising from the stem and opposite the leaves. Each inflorescence consists of 2 to 6 flowers with white elliptic to ovate petals. Fruits are oval, laterally compressed, and constricted at the line where the two halves meet. The fruits are 4 mm long and 3 mm wide, and are covered with curved bristles.

Habitat: *S. hawaiiensis* is known from a variety of plant communities throughout its range, including *Metrosideros* forests, *Dodonaea* lowland dry shrublands, cultivated fields, and pastures. It occurs at an elevation range of 300 to 600 m. Associated plant species include *Doryopteris* sp., *Gouania hillebrandii*, *Leucaena leucocephala*, and *Sida fallax*. On Hawaiʻi Island, *S. hawaiiensis* is known from shady spots in *Dodonaea viscosa* dry shrubland which occurs on pāhoehoe lava at elevations between 1,135 and 2,140 m. Associated native plant species include *Myoporum sandwicense*, *Osteomeles anthyllidifolia*, and *Sophora chrysophylla*. At PTA, this species occurs on lava, in ash, and in soil pockets where moisture accumulates, typically in the *Metrosideros polymorpha* Woodland Alliance and *Myoporum sandwicense* - *Sophora chrysophylla* Shrubland Alliance vegetation types.

Life History: At PTA, this species is heavily dependent upon rainfall to carry out its life cycle. Large recruitment events have been observed after periods of above average rainfall. Based on observations, it is likely that *S. hawaiiensis* does not germinate at all during long periods of inadequate rainfall.

Distribution: Historically, *S. hawaiiensis* was found on Hawaiʻi, Kauaʻi, Lānaʻi, Maui, Molokaʻi, and Oʻahu and is still extant on all of these islands. At PTA, this species is found in TAs 22 and 23. There are at least 595 individuals in approximately 195 locations at the installation. A previous distribution of *S. hawaiiensis* in TA 23 has now become dominated by *Senecio madagascariensis.*

Stenogyne angustifolia (Creeping Mint)

Mint is a chemical mechanism that plants evolved to defend against predators. However, in Hawaiʻi dozens of mint species have lost this defense due to the isolated location of the islands and the lack of natural predators. *S. angustifolia* is considered to be one of these "mintless" mints.

Description: *S. angustifolia* is a perennial, prostrate, trailing plant with glabrous slender stems and opposite branching. The stems are 4-sided, smooth, and occasionally pubescent at the nodes. Leaves are undivided, contracted at the base into a petiole approximately 1 cm in length, and smooth. The leaf blade is leathery, oblong to linear, wavy to serrate, and between 2 and 6 cm long and 6 and 12 mm wide. Flowers are tubular, smooth, and distinctly veined with a lip, 8 to 13 mm long. The upper lip of the flower is twice as long as the lower. Petals are yellow to dull brownish-pink and finely pubescent.

Habitat: *S. angustifolia* grows on relatively flat, ash-veneered lava and shallow soils in semi-arid shrublands and woodlands. This species has been described as abundant on various-aged lava or rock outcrops that support the following diversity of vegetation types: *Metrosideros polymorpha* Woodland Alliance, *Myoporum sandwicense – Sophora chrysophylla* Woodland Alliance, *Myoporum sandwicense – Sophora chrysophylla* Shrubland Alliance, *Dodonaea viscosa* Shrubland Alliance, *Chenopodium oahuense* Shrubland Alliance, and *Eragrostis atropioides* Herbaceous Alliance.

Life History: *S. angustifolia* vegetatively reproduces along by rhizomes, stolons and aerial shoots. Shoots root at leaf nodes and form ramets (genetically identical, potentially independent plants). The exact means of sexual reproduction are unknown although plants have been observed flowering during most months and flowers are bisexual. Although little is known about seed viability, dormancy, and longevity, it is believed that seed coat removal increases germination rates. The degree of pollinator specificity is currently unknown. The lack of odor, flower shape and color, stamen position and quantity of nectar suggested that this species may be pollinated by native birds; however, numerous insects have been observed crawling on the stems, leaves and flowers and may also serve as pollination vectors.

Distribution: Historically, *S. angustifolia* was known from the islands of Hawaiʻi, Maui, and Molokaʻi but currently occurs only on the island of Hawaiʻi. At PTA, this species is found in TAs 18, 19, 22, and 23. There are at least 2,517 individuals in approximately 1,087 locations at the installation. *S. angustifolia* is one of the more abundant ESA-listed plant species at PTA, with a nearly continuous distribution over 2,310 ha.

Tetramolopium arenarium var. *arenarium* (Mauna Kea Pāmakani)

This endangered plant in the sunflower family is extremely rare and only occurs in 3 clusters distributed over fewer than 2 ha at PTA. Following severe drought conditions, the *T. arenarium* var. *arenarium* population declined to just 12 individuals in 2010. We implemented emergency watering until weather conditions improved, and the species population was successfully sustained.

Description: *T. arenarium* var. *arenarium* is an erect tufted shrub 0.8 to 1.3 m tall. Plants are covered with tiny glands and straight hairs. Leaves are alternate, toothless or shallowly toothed, and more or less lance-shaped. The leaves range in length from 15 to 35 mm and in width from 3 to 9 mm. Flower clusters are at the end of each stem and have 5 to 10 heads. Each head has 20 to 34 bracts beneath a single series of white florets (male ray florets) on the outside and fewer than 15 inner bisexual maroon petalled florets (disk florets). The fruits are compressed achenes.

Habitat: *T. arenarium* var. *arenarium* occurs on very old Mauna Kea flows (greater than 10,000 years old) in *Dodonaea viscosa*-dominated lowlands and montane dry shrublands at elevations from 800 and 1,500 m. At PTA, the species is found in the *Dodonaea viscosa* Shrubland Alliance at elevations between 1,300 m and 1,700 m. Associated native plants include *Leptecophylla tameiameiae, Dubautia linearis, Euphorbia olowaluana, Sida fallax, Chenopodium oahuense*, *Haplostachys haplostachya*, and *Stenogyne angustifolia*.

Life History: This species flowers in January, April, and August and in the fall and early winter. Seed production has been observed in late winter and spring. *T. arenarium* var. *arenarium* is easy to germinate and establish under greenhouse conditions.

Distribution: Historically, *T. arenarium* var. *arenarium* was known from the islands of Hawaiʻi and Maui. The species is extremely rare and currently occurs only on the island of Hawaiʻi at a few locations at PTA in TA 19. As of September 2019, there are 381 adults and juveniles and 5 seedlings at 27 locations at the installation. Individual counts vary with precipitation and can fluctuate widely.

Tetramolopium sp. 1 (Tooth-leaf Pāmakani)

The plant in the sunflower family is undescribed and not ESA-listed but is managed at PTA due to its rarity and limited distribution. It is related to *T. arenarium*, *T. consanguineum*, and *T. humile*. Extremely small numbers make this species vulnerable to catastrophic disturbance.

Description: *T.* sp. 1 is a perennial shrub, up to 2 m in height, initiating from a single stem and branching with each flowering. The leaf edges are continuous or may be toothed, are 7–9 cm in length and 1.5–2.0 cm wide. The surface of the leaves have glands and straight, stiff hairs. The flower heads form a flat or round-topped open inflorescence. Bracts below the flower heads are maroon along the mid-rib. There are numerous ray flowers with white petals, which recurve as they mature. The disk flowers are fewer typically yellow and occasionally maroon. The fruit is a dry achene that does not open at maturity.

Habitat: *T.* sp. 1 occurs within the *Dodonaea viscosa* Shrubland Alliance, *Myoporum sandwicense* – *Sophora chrysophylla* Shrubland Alliance, and *Metrosideros polymorpha* Woodland Alliance. Associated native species include *Alyxia stellata, Chenopodium oahuense, Coprosma montana, Leptecophylla tameiameiae*, *Osteomeles anthyllidifolia*, *Myrsine lanaiensis, Santalum paniculatum,* and *Sida falax.* Non-native species present in these alliances include *Cenchrus setaceus, Ehrharta calycina, Melinis repens, Microlaena stipoides, Nassella ceruna, Passiflora tarminiana, and Senecio madagascariensis.* Elevation range for this species is from 1,525–1,725 m.

Life History: Little is known about the life history of *T.* sp. 1. Precipitation levels appear to drive much of the reproductive cycle for this species. Flowering tends to occur in the late winter and spring with fruiting in the late spring and summer. The plant can be readily propagated in the greenhouse.

Distribution: At PTA, *T*. sp. 1 occurs in TAs 22 and 23. As of September 2019, there are 151 adults and juveniles and 13 seedlings in 64 known locations at the installation. This species is new to science and may only occur at PTA, as it was discovered at the installation in the 1990's.

Vigna o-wahuensis (Oʻahu Cowpea)

This endangered legume is endemic to Hawaiʻi. Though *V. o-wahuensis* was described from a specimen collected on Oʻahu, it is now extirpated from that island. Unknown factors are driving an apparent decline in known locations of this species. Because of the highly ephemeral nature of *V. o-wahuensis,* definitively documenting declines in distribution and/or abundance is extremely difficult.

Description: *V. o-wahuensis* is a slender, short-lived, twining perennial herb with fuzzy stems that grow to 0.4 m. Leaves are compound, with three leaflets that are 1.2 to 8 cm long and 0.1 to 2.5 cm wide. Coarse hairs sparsely to moderately cover the leaflets. Flowers occur in clusters of 1 to 4 and have thin, translucent, pale yellow or greenish-yellow petals 2 to 2.5 cm long. The calyx is sparsely hairy and 4 to 8.0 mm long with asymmetrical lobes. Fruits are slender pods of 4 to 9 cm in length and 5 mm in width. Pods may be slightly inflated and contain between 7 and 15 gray or black seeds less than 6 mm long.

Habitat: *V. o-wahuensis* occurs in lowland dry to mesic grassland and shrubland at elevations from 10 m to 1,370 m. Associated plant species include *Sida fallax*, *Chenopodium* sp., *Dubautia menziesii,* and *Osteomeles anthyllidifolia*.

Life History: Life history information for *V. o-wahuensis* is currently unknown. The taxon has been observed flowering in March, April and July, with fruits present in July. *V. o-wahuensis* is an ephemeral species sensitive to drought conditions.

Distribution: *V. o-wahuensis* is currently known from the islands of Hawaiʻi, Kahoʻolawe, Lānaʻi, Maui, and Molokaʻi; there are currently fewer than 100 individuals total remaining on 5 main islands. At PTA, this species is found on Puʻu Nohona o Hae in KMA. *V. o-wahuensis* is an ephemeral species that tends to die back during drier periods. In addition, plants can senesce or emerge in a short period of time. As a result, monitoring can be challenging for this species. Also, distinguishing individual plants can be challenging if the plants are doing well as they will spread out over other plants making it difficult to distinguish individuals. As of September 2019, there are 275 adults and juveniles and 28 seedlings on Puʻu Nohona o Hae. A single individual was previously recorded on Puʻu Pāpapa, and 1 individual was recorded along the southwest KMA boundary, but neither has been relocated in the last few years.

Zanthoxylum hawaiiense (Hawaiian Yellow Wood, Aʻe)

In 2009 and 2010, extreme drought conditions at PTA led to an increase in ungulate pressure to rare plants and their habitat. We observed significant bark stripping on the endangered *Z. hawaiiense* and an emergency management response (i.e., tree protectors) was initiated. Since then, conservation fences have been constructed and ungulate removal is almost complete.

Description: *Z. hawaiiense* is a small, deciduous tree about 3 to 8 m tall with a trunk up to 25 cm in diameter. Leaves are alternate and are comprised of 3 leathery lance-shaped, lemon-scented, toothed leaflets. These leaflets are 3.4 to 10 cm long and 1.5 to 5 cm wide. The stalk of the opposite leaflets has 1 joint and the central, terminal leaflet has 2. Trees are dioecious, having either male or female flowers. Inflorescences contain 15 to 20 flowers with 4 triangular sepals each. Fruits are sickle-shaped follicles that range in length from 8 to 10 mm. The fruits contain a single black seed 6 to 8 mm in diameter.

Habitat: *Z. hawaiiense* typically grows in *Metrosideros*-dominated lowland dry or mesic forests, in montane dry forests, and on lava at elevations that range from 550 to 1,740 m. It is typically found in low areas where pockets of deeper soils accumulate within or at the edge of ʻaʻā lava flows. The species is associated with *Antidesma platyphyllum* and *Streblus pendulinus* on the island of Maui and with *Myrsine lanaiensis, Myoporum sandwicense*, and *Sophora chrysophylla* on the island of Hawaiʻi. Individuals of this species are widely scattered, and rarely will more than a few plants be found in close proximity to one another. At PTA, *Z. hawaiiense* is found on lava and in a variety of vegetation types including the *Metrosideros polymorpha* Woodland Alliance and *Myoporum sandwicense* – *Sophora chrysophylla* Shrubland Alliance.

Life History: Life history information for *Z. hawaiiense* is limited. Observations suggest that this species is susceptible to browse and bark stripping by ungulates and some seed predation by rodents. Seeds readily germinate under greenhouse conditions, and natural recruitment has been observed in the field since ungulates have been controlled. *Z. hawaiiense* is an extremely long-lived species (one individual has been observed continuously for more than 23 years).

Distribution: Historically, *Z. hawaiiense* occurred on Hawaiʻi, Kauaʻi, Lānaʻi, Maui, and Molokaʻi. This species has been extirpated from Lānaʻi but still persists on the other islands. *Z. hawaiiense* tends to grow in single occurrences at PTA or in very small clusters, and is found in TAs 19, 20, 22, and 23. There are at least 536 individuals in approximately 506 locations at the installation. The bulk of the distribution is in TA 22 (3,075 ha), but including the most remotely located individuals, the total distribution of *Z. hawaiiense* covers 4,050 ha at PTA.

Hawaiian Hoary Bat, ʻŌpeʻapeʻa (*Lasiurus cinereus semotus*)

This endangered bat is the only native land mammal in Hawaiʻi. This bat's common name was inspired by the hoary or "frosty" appearance of its fur, which is brown but frosted white on its back. The Hawaiian hoary bat is a nocturnal insectivore. It finds food through echolocation, meaning it emits calls and listens for their echoes.

Description: Hawaiian hoary bats are medium-sized, nocturnal and insectivorous bats weighing 14 to 22 grams with a wingspan of 27 to 35 cm. This species is heavily furred with a mixture of grayish brown or reddish-brown fur tinged with white, giving it a frosted or "hoary" appearance. Ears are short, thick, rounded and edged in black and the tail is furry. Although females are slightly larger than males, forearm lengths are similar in both genders. The Hawaiian hoary bat is about 45% smaller than the North American hoary bat, which it is believed to be related to. Flight is efficient and rapid in both open and closed habitats.

Habitat: The Hawaiian hoary bat has been detected in a wide variety of habitat types, from barren lava to open forests. Bats have been observed in a variety of native tree and shrub species, including *Metrosideros polymorpha* and *Leptecophylla tameiameiae*. Treeland, shrubland, and grassland communities at PTA provide sufficient available roosting and foraging habitat. Roosting (treeland) and foraging (shrubland) habitats are not mutually exclusive, as bats have been observed roosting in shrub vegetation and often forage in relatively closed forest. Roosts are typically located in dense canopy foliage or sub-canopy when canopy is sparse, with open access for launching into flight.

Life History: Hawaiian hoary bats are known to leave roost sites before sunset and return before midnight. Long-distance migration is unlikely due to the isolation of the Hawaiian Islands and the tropical climate. This species is not colonial and roosts solitarily in tree foliage. Breeding takes place in the lowlands during spring and summer with bats moving to higher elevations in fall and winter. Females typically give birth to twins between May and August and rear pups between May and September. Pups fledge from July through September, a critical time in the reproductive cycle.

Distribution: The Hawaiian hoary bat is endemic to Hawaiʻi where it is the only existing native terrestrial mammal. This species has been documented historically on the islands of Hawaiʻi, Kauaʻi, Maui, Molokaʻi, Oʻahu, and possibly Kahoʻolawe but is now resident only on Hawaiʻi, Kauaʻi, and Maui. Hawaiian hoary bat presence at PTA was first documented in 1992. Bats are thought to be present throughout the installation, but distribution and activity levels are currently unknown.

Hawaiian Goose, Nēnē (*Branta sandvicensis*)

This endangered goose is the state bird of Hawaiʻi. It is believed that the Hawaiian Goose was once common, with ~25,000 geese living in the islands when Captain James Cook arrived in 1778. Hunting and introduced predators reduced the population to 30 birds by 1952. The species breeds well in captivity and has been successfully re-introduced. The most recent statewide population estimate is just over 3,000 geese.

Description: The Hawaiian Goose is medium-sized, with an overall length of 63 to 69 cm. The crown and the back of the neck are black with a cream-colored cheek patch. The sides of the neck are white with black stripes and the bill, legs, feet, and tail feathers are black. Contour feathering of the back and upper wing areas are gray-brown with lighter distal edges. The feathering of the sides, chest, and belly are lighter gray-brown and the rump is pure white. Although categorized as waterfowl, the Hawaiian Goose has adapted to terrestrial life (e.g., reduced webbing between the toes and larger hind-limbs).

Habitat: The Hawaiian Goose is known to occupy various habitat types found at PTA including non-native grasslands, sparsely vegetated high-elevation lava flows, native alpine shrubland, and shrubland-woodland community types. Geese may seasonally move to grasslands in periods of low berry production in search of food sources with increased protein content. Nesting sites range from coastal lowlands to subalpine zones and are considerably variable in physiognomic features.

Life History: Hawaiian Geese are browsing grazers and their diet depends largely on the vegetative structure of the surrounding habitat. Geese appear to be opportunistic in their choice of food plants as long as nutritional demands are met. Nesting generally occurs between November and January. Hawaiian Geese nest on the ground, usually in the dense shade of a shrub or other vegetation. A clutch typically contains 3 to 5 eggs. While the female incubates the eggs, the male stands guard nearby. Once hatched, the young remain in the nest for 1–2 days. During molt, adults are flightless for a period of 4 to 6 weeks, generally attaining flight feathers at the same time as their offspring.

Distribution: Hawaiian Geese historically occurred on all the main Hawaiian Islands but are currently found on Hawaiʻi, Kauaʻi, Maui and Molokaʻi. In 2011, over 500 geese were relocated from Kauaʻi to Hawaiʻi Island. The largest populations of geese on the island of Hawaiʻi occur at Hawaiʻi Volcanoes National Park, Puʻu Anahulu, and Hakalau National Wildlife Refuge. This species has been observed at various locations at PTA, with most observations occurring at the Range 1 Complex. Several pairs recently nested successfully at the installation and were subsequently relocated.

Hawaiian Hawk, ʻIo (*Buteo solitarius*)

This endangered raptor is endemic to Hawaiʻi and was a symbol of royalty in Hawaiian legend. The Hawaiian hawk is solitary, remaining in and defending its territories year-round. During the nestling period, females perform most of the brooding while males provide food to chicks and females. After the egg is hatched, females only allow males to visit when delivering food to the nest.

Description: The Hawaiian hawk is a small, broad-winged hawk endemic to the Hawaiian Islands. This species has a light and dark color phase with intermediate plumages and individual variation. Light-phase hawks have dark brown heads and a dark brown, mottled back. The chest and abdomen are white with varying brown flaking on the sides and upper chest. Dark-phase hawks are dark brown all over. The Hawaiian hawk has bright yellow legs and pale-yellow legs and feet. The females are larger than males, averaging 46 cm long and 606 grams in comparison to males who average 40 cm long and 441 grams.

Habitat: The Hawaiian hawk utilizes a wide variety of habitats, including lowland non-native forests, urban areas, agricultural lands, pasturelands, and high elevation native forests. Nests have been recorded in a variety of native and non-native tree species, suggesting tree type may be unimportant in nest-site selection. Nests are more frequently found in *Metrosideros polymorpha* stands, a dominant native forest tree. This species shows site fidelity and maintains territories year-round. However, during the winter months hawks have been reported in subalpine *Sophora chrysophylla* - *Myoporum sandwicense* forests which suggests some seasonal movements.

Life History: Prior to the arrival of Polynesians, the Hawaiian hawk may have preyed exclusively on native birds, but their diet now includes native and non-native insects, bird and rodents. This species is socially monogamous and limited data indicates that individuals form long-term pair-bonds. Both sexes contribute to extended nest construction, which begins up to 2 months before the first egg is laid and continues into the nestling period. Clutch size is usually 1, although clutches of 2 and 3 have been reported. Females perform most of the brooding of nestlings, while males provide food to chicks and females. Both adults feed fledglings, which are dependent on adults for up 9 months.

Distribution: Fossil evidence indicates that the Hawaiian hawk historically occurred on Hawaiʻi, Kauaʻi, Molokaʻi, and Oʻahu, but distribution is currently limited to the island of Hawaiʻi in a range from sea level to 1,700 m. This species persists within its known historical range, occupying most native and exotic forests, but hawks are not common on the arid plains of PTA. The Hawaiian hawk may occasionally use habitat at the installation, but individuals are transient.

Band-rumped Storm Petrel, ʻAkēʻakē (*Oceanodroma castro*)

This elusive petrel is strictly nocturnal at its breeding sites to avoid predation by gulls and diurnal raptors and will even avoid coming to land on clear moonlit nights. Like most petrels, the walking ability of the Band-rumped Storm Petrel is limited to a short shuffle from/to the burrow. This species spends the non-breeding period out at sea.

Description: Band-rumped Storm Petrels are medium-sized, highly pelagic petrel with an estimated life span of 15–20 years. This species is 19–21 cm in length with a 43–46 cm wingspan and weighs 44-49 g. Beaks are sharply hooked with distinct tubular nostrils foreheads are steep. Adults are blackish-brown and have a sharply defined narrow white band across the rump area that extends slightly onto the under-tail coverts. This species also has a slightly paler, brownish-gray wing bar across the upper wing coverts, forming a V-shape on the back. The tail is vaguely forked, the wings are pointed, and the legs are short.

Habitat: Band-rumped Storm Petrel colonies exist on rough, inaccessible terrain such as steep, heavily vegetated cliffs and high-elevation barren lava flows, where predation pressure is presumably relaxed. Habitat is thought to be similar to the Hawaiian Petrel. The Band-rumped Storm Petrel is known to visit puʻu to swoop and call. The species' breeding biology in Hawaiʻi is not well known, but individuals are assumed to nest in burrows, crevices, or cracks in lava tubes at high-elevation, inland habitats.

Life History: The Band-rumped Storm Petrel feeds far from shore by hovering close to the water surface and scooping up minute food, often contacting the water with their feet. Breeding seasonality is assumed similar to the Hawaiian Petrel. Adults access inland colonies from February to November with a small period of absence around March and April. Females lay a single egg per season between May and June and young petrels fledge in October. The Band-rumped Storm Petrel is highly faithful to nesting sites, typically returning to the same site each year. Although little is known about courtship behaviors, birds, probably unpaired juveniles, swoop and call over the colony.

Distribution: Archaeological and subfossil evidence suggests Band-rumped Storm Petrels previously inhabited all of the main Hawaiian Islands. Currently, populations are extant on the islands of Kauaʻi, Maui, and Hawaiʻi. The species has been recorded at PTA between 2008–2015 (May–August) in TAs 21 and 23. Call activity suggests the Band-rumped Storm Petrel is present in portions of these training areas seasonally; however, at this time it is unclear how the petrels are using habitat at PTA. In 2015, a colony was discovered at PTA with confirmed activity at a burrow, which is significant because no active nesting burrows had been previously documented in the Hawaiian Islands.

Hawaiian Petrel, ʻUaʻu (*Pterodroma sandwichensis*)

This endangered petrel nests on land in burrows or rock crevices but feeds out at sea. Scientists previously thought that this species remained close to shore, but new research shows they travel as far as Alaska and Japan during 2-week long feeding trips. The Hawaiian Petrel's diet consists of squid, fish, and crustaceans.

Description: Hawaiian Petrels are large, nocturnal gadfly petrels that are endemic to the Hawaiian Islands. This species averages 40 cm long with a wingspan of 90 cm. The top of the body is dark gray, and the forehead and underside are white. The lower wing surface is white with conspicuous black margins. This species has a tail that is short and wedge-shaped. The legs and the upper part of the feet are pink to flesh colored. The webbing is black tipped. The bill is grayish-black, short, stout, and with a sharp decurved tip. The wings and tail are long and pointed compared to other taxa of *Pterodroma.*

Habitat: Hawaiian Petrel colonies are typically located at high elevation, xeric habitats or wet, dense forests. Nests are located in burrows, crevices, or cracks in lava tubes. Due to pressure from introduced predators and habitat degradation, modern Hawaiian Petrel colonies and nesting activity in Hawaiʻi typically takes place above 2,500 m.

Life History: Hawaiian Petrels nest in colonies and form long-term pair bonds. The adults arrive and depart colonies at night during the breeding season (March-October). Pairs return to the same nest site year after year, where females lay a single white egg. As the chicks mature, the parental care diminishes, and the adults leave the nest about 2 to 3 weeks before the chicks. Hawaiian Petrels often feed hundreds of kilometers from colonies, usually foraging with mixed-species feeding flocks, typically over schools of predatory fishes.

Distribution: Subfossil evidence indicates the Hawaiian Petrel was once common on all of the main Hawaiian Islands, but distribution is now limited to Hawaiʻi, Kauaʻi, and Maui. Additional populations may exist on Molokaʻi and Lānaʻi, and off the shores of Kahoʻolawe and Niʻihau, but there is limited survey data for these areas. Pelagic distribution during the non-breeding season is largely unknown but petrels remain near the islands during the nesting season. Extant breeding colonies are located in Hawaiʻi Volcanoes National Park on Mauna Loa and possibly on the windward side of Mauna Kea, but no colonies have been confirmed there to date. Archaeological evidence suggests that Hawaiian Petrels were once common at PTA. Currently, the species is believed to transit the area, but no active nesting colonies have been detected at the installation.

Anthricinan Yellow-faced Bee (*Hylaeus anthracinus*)

The genus *Hylaeus* is represented by about 60 species in Hawaiʻi. On Hawaiʻi Island there are 28 species, 18 of which are endemic to the island. Many species are morphologically similar but can be distinguished by microscopic examination of physical characteristics, with males having more distinguishable features than females. *Hylaeus* are known as yellow-faced bees or masked bees for their yellow to white facial markings.

Description: Anthricinan yellow-faced bees have 3 main body parts – a head, thorax, and abdomen. One pair of antennae arises from the front of the head, between the eyes. Two pairs of wings and 3 pairs of legs are attached to the thorax, the abdomen is composed of multiple segments. All *Hylaeus* bees roughly resemble small wasps in appearance. The anthricinan yellow-faced bee has clear to smoky wings and black legs. The male has a single large yellow spot on the face, and below the antennal sockets the face is yellow. The female is entirely black and can be distinguished by black hairs on the end of the abdomen and an unusual mandible with 3 teeth.

Habitat: Anthricinan yellow-faced bees occupy virtually all native habitats from the wettest to driest locales from the coastal strand to 3,000 m elevation. They typically are associated with native plant species even in a matrix of native and alien vegetation in which alien plants are abundant and flowering. It is not known whether this selectivity is exclusive, or whether it is caused by preference or by inability to recognize or handle alien plant flowers.

Life History: Anthricinan yellow-faced bees are solitary, without the caste system and associated genetics characteristic of social *Hymenoptera* found in Hawaiʻi such as honeybees, western yellow jacket wasps, and Argentine ants. Both females and males forage for nectar, and males search for females on the wing. They lay eggs in multi-chambered burrows in the ground or appropriate media (e.g., rotting wood) and provision the nests with pollen and nectar.

Distribution: Small populations of anthricinan yellow-faced bees are currently known from the islands of Maui, Kahoʻolawe, Molokaʻi, Oʻahu, and Hawaiʻi, but the number of individual bees is unknown. This bee is considered a coastal species, but there is evidence that it occurs in montane dryland forest habitat as well. One anthricinan yellow-faced bee was collected at PTA in 2004, possibly a vagrant. The precise locality is not known, but it was found resting in a fruit capsule of the endangered *Kadua coriacea*, which typically occurs in open *Metrosideros* treeland, a generally poor habitat for this species. No additional anthricinan yellow-faced bees have been found at PTA, and it is questionable whether a breeding population exists at the installation.

Blackburn's Sphinx Moth (*Manduca blackburni*)

This moth in the Sphingidae family is endemic to Hawai'i. It is closely related to the tomato hornworm (*Manduca quinquemaculata*), which it also physically resembles. The Blackburn's sphinx moth was listed as an endangered species by the US Fish and Wildlife Service in 2000, making it the first Hawaiian insect to receive such a status.

Description: With a wingspan of up to 12 cm, Blackburn's sphinx moth is Hawaii's largest native insect. Like other sphinx moths, it has long, narrow forewings and a thick, spindle shaped body that tapers at both ends. Blackburn's sphinx moth is grayish brown with black bands across the top margins of the hindwings and 5 orange spots along each side of the abdomen. The moth's caterpillar is large and occurs in 2 color morphs, bright green or gray. Variation in color does not appear until the fifth instar. Both morphs have scattered white speckles throughout the back and a horizontal white stripe on the side margin of each segment.

Habitat: Blackburn's sphinx moth is found in coastal mesic and dry forests at elevations ranging from sea level to 1,525 m. Larvae feed on plants in the nightshade family, Solanaceae, especially native 'aiea (*Nothocestrum* spp.), but also non-native tomatoes (*Solanum lycopersicum*), tobacco (*Nicotiana tabacum*), tree tobacco (*Nicotiana glauca*), jimson weed (*Datura stramonium*), and eggplant (*Solanum melongena*). The adult feeds on nectar from native plants such as Hawaiian morning glory (*Ipomoea indica*), Hawaiian caper (*Capparis sandwichiana*) and wild leadwort (*Plumbago zeylanica*).

Life History: Development from egg to adult can take as little as 56 days, but pupae may remain in a state of torpor (inactivity) in the soil for up to a year. Adult moths can be found throughout the year. In general, sphingids are known to live longer than most moths because of their ability to feed and take in water from a variety of sources, rather than relying only upon stored fat reserves. Because they live longer than most moths, female sphingid moths have less time pressure to mate and lay eggs, and often will take more time in locating the best host plants for egg laying.

Distribution: Historically Blackburn's sphinx moth has been recorded from the islands of Kaua'i, Kaho'olawe, O'ahu, Moloka'i, Maui, and Hawai'i. Most historical records were from coastal or lowland dry forest habitats in areas receiving less than 120 cm annual rainfall. By the 1970s, the speies was thought to be extinct. It was rediscovered on Maui when a single population was found in 1984. Subsequently, populations have been discovered on 2 other islands, Kaho'olawe and Hawai'i. Based on past sampling, Blackburn's sphinx moth population numbers are small; however, no reasonably accurate estimate of population sizes have been determinable due to the adult moths' wide-ranging behavior and its overall rarity.

APPENDIX C

REGULATORY DRIVERS FOR SECTIONS AND PROJECTS OF THE ARMY'S NATURAL RESOURCES PROGRAM AT PŌHAKULOA TRAINING AREA

Table C1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area

Program	Section	Project	Regulatory Document	Program Plan Requirement Wording (2014)
Botanical Program				
Rare Plant Survey and Monitoring Section				
Botanical	Plant Survey and Monitoring	Planning	Biological Opinion 2003	Develop and update Botanical Program Plan.
Botanical	Plant Survey and Monitoring	Plant Surveys	Biological Opinion 2003	Surveys for *Asp per, Hap hap, Iso hos, Kad cor, Mel ven, Ner ova, Por scl, Silene hawaiiensis, Sil lan, Sol inc, Spe haw, Ste ang, Tet are, Vig owa*, and *Zan haw to document abundance, distribution, and in situ reproduction.*
Botanical	Plant Survey and Monitoring	Plant Surveys	INRMP 2018	Survey for *Exo men, Fes haw, Por vil, Sic mac* to document abundance, distribution, and *in situ* reproduction.
Botanical	Plant Survey and Monitoring	Priority Species 1	Biological Opinion 2003	Monitor *Asp per, Hap hap, Iso hos, Kad cor, Mel ven, Ner ova, Por scl, Silene hawaiiensis, Sil lan, Sol inc, Spe haw, Ste ang, Tet are, Vig owa*, and *Zan haw* annually.
Botanical	Plant Survey and Monitoring	Vegetation Monitoring	Biological Opinion 2003	Monitor trends in treeland vegetation to determine the extent of regeneration of tree species, for Hawaiian hoary bat roosts, post-ungulate removal.
Botanical	Plant Survey and Monitoring	Vegetation Monitoring	Biological Opinion 2003	Develop tree land vegetation cover monitoring and reporting protocols.
Botanical	Plant Survey and Monitoring	Vegetation Monitoring	Biological Opinion 2003	Evaluate reasons for lack of mamane recruitment in Palila Critical Habitat Area B.
Botanical	Plant Survey and Monitoring	Vegetation Monitoring	Biological Opinion 2003	Study vegetative changes that may occur in Palila Critical Habitat post-Transformation. Focus on the effects of dust deposition. Note increases in non-native plants.

Table C1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Regulatory Document	Program Plan Requirement Wording (2014)
Botanical	Plant Survey and Monitoring	Vegetation Monitoring	Biological Opinion 2003	Determine dust effects on mamane/naio woodland and to assess the efficacy of the Palila Critical Habitat buffer.
Botanical	Plant Survey and Monitoring	Vegetation Monitoring	Biological Opinion 2003	Determine the long-term effect of dust deposition on listed plants near high traffic and/or off-road areas.
Botanical	Plant Survey and Monitoring	Vegetation Monitoring	Biological Opinion 2003	Evaluate the long-term effects of dust on *Hap hap* located in the southwest corner of KMA.
Botanical	Plant Survey and Monitoring	Species Specific Monitoring	Biological Opinion 2003	Outline the monitoring protocols for plants in the KMA. Assess population structure, vigor, and damage.
Botanical Program				
Genetic Conservation and Outplanting Section				
Botanical	Genetic Conservation and Outplanting	Genetic Conservation	Biological Opinion 2003	Collect and maintain genetic material for all new occurrences of KMA TES plants (outside existing populations) for propagation and eventual outplanting.
Botanical	Genetic Conservation and Outplanting	Genetic Conservation	Biological Opinion 2003	Collect and maintain a genetic stock ex situ for *Asp per, Hap hap, Iso hos, Kad cor, Mel ven, Ner ova, Por scl, Silene hawaiiensis, Sil lan, Sol inc, Ste ang, Tet are, Vig owa, and Zan haw* for long-term storage, propagation, and eventual outplanting.
Botanical	Genetic Conservation and Outplanting	Genetic Conservation	Biological Opinion 2003	Collect and maintain genetic material for *Hap hap* from BAX occurrences. Collect enough material to adequately replace the individuals impacted by the construction of the BAX.
Botanical	Genetic Conservation and Outplanting	Genetic Conservation	Biological Opinion 2003	Maintain a list of *Hap ha, Iso hos, Mel ven, and Vig owa* plants/seeds available and make the list available to other authorized agencies.
Botanical	Genetic Conservation and Outplanting	Genetic Conservation	Biological Opinion 2003	Provide *Iso hos and Vig owa* seeds and/or plants to appropriate agencies or private organizations to increase occurrences offsite.
Botanical	Genetic Conservation and Outplanting	Genetic Conservation	INRMP 2018	Collect and maintain genetic stock *ex situ* of *Exo men, Fes haw, Por vil, Schiedea hawaiiensis,* and *Sic mac* for long-term storage, propagation, and eventual outplanting.

Table C1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Regulatory Document	Program Plan Requirement Wording (2014)
Botanical	Genetic Conservation and Outplanting	Genetic Conservation	Biological Opinion 2003	Collect and maintain *Silene hawaiiensis* seeds *ex situ* prior to AALFTR and BAX construction for propagation and eventual outplanting.
Botanical	Genetic Conservation and Outplanting	Genetic Conservation	Biological Opinion 2003	Collect seed and cuttings from the *Vig owa* located along the western border of KMA.
Botanical	Genetic Conservation and Outplanting	Greenhouse Activities	Biological Opinion 2003	Propagate and outplant genetic material for all new occurrences of KMA TES plants (outside existing exclosures).
Botanical	Genetic Conservation and Outplanting	Greenhouse Activities	Biological Opinion 2003	Propagate and outplant *Asp per, Hap hap, Iso hos, Kad cor, Mel ven, Ner ova, Por scl, Silene hawaiiensis, Sil lan, Sol inc, Ste ang, Tet are, Vig owa,* and *Zan haw.*
Botanical	Genetic Conservation and Outplanting	Greenhouse Activities	Biological Opinion 2003	Propagate and grow *Hap hap* from the BAX propagules to adequately replace individuals impacted by BAX construction.
Botanical	Genetic Conservation and Outplanting	Greenhouse Activities	Biological Opinion 2003	Propagate and outplant *Sil haw* lost from AALFTR and BAX construction and off-road maneuvers.
Botanical	Genetic Conservation and Outplanting	Outplanting and Monitoring	Biological Opinion 2003	Outplant material propagated for newly found KMA individuals.
Botanical	Genetic Conservation and Outplanting	Outplanting and Monitoring	Biological Opinion 2003	Annually monitor outplanted *Ste ang* and *Tet are.*
Botanical	Genetic Conservation and Outplanting	Hawaiian Goose Off-site	Biological Opinion 2013	Collect seeds, for propagation and outplanting from common native species to provide Hawaiian Goose food plants and escape cover inside the predator-proof fences.
Invasive Plants Program				
Vegetation Control Section				
Invasive Plants	Vegetation Control	Planning	Biological Opinion 2003	Develop and update Invasive Plants Program Plan including cinder cones in KMA.
Invasive Plants	Vegetation Control	Weed Control Buffer	Biological Opinion 2003	Control invasive plants in proximity to natural occurrences of *Asp per, Hap hap, Iso hos, Kad cor, Mel ven, Ner ova, Por scl, Silene hawaiiensis, Sil lan, Spe haw, Sol inc, Ste ang, Tet are, Vig owa,* and *Zan haw*.

Table C1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Regulatory Document	Program Plan Requirement Wording (2014)
Invasive Plants	Vegetation Control	Weed Control Buffer	Biological Opinion 2003	Control invasive plants in proximity to outplanted *Asp per, Hap hap, Iso hos, Kad cor, Mel ven, Ner ova, Por scl, Silene hawaiiensis, Sil lan, Sol inc, Ste ang, Tet are, Vig owa,* and *Zan haw.*
Invasive Plants	Vegetation Control	Weed Control Buffer	INRMP 2018	Control invasive plants in proximity to natural occurrences of *Exo men, Fes haw, Por vil, Schiedea hawaiiensis,* and *Sic mac* within PTA.
Invasive Plants	Vegetation Control	Weed Control Buffer	Biological Opinion 2003	Evaluate the effect of *Cen set* on *Hap hap* at Puʻu Kapele.
Invasive Plants	Vegetation Control	Hawaiian Goose	Biological Opinion 2013	Modify Hawaiian Goose habitat at the Range 1 complex, by herbiciding food plants that attract Hawaiian Geese.
Invasive Plants	Vegetation Control	Hawaiian Goose Off-site	Biological Opinion 2013	Mow and control invasive plants inside predator-proof fences.
Invasive Plants Program				
Invasive Plants Survey and Monitoring				
Invasive Plants	Invasive Plants Survey and Monitoring	Planning	Biological Opinion 2003	Develop and implement a non-native invasive plant monitoring program.
Invasive Plants	Invasive Plants Survey and Monitoring	Planning	Biological Opinion 2003	Respond to requests for consultation for all auxiliary construction support sites and consult with DPW for approval or alternatives.
Invasive Plants	Invasive Plants Survey and Monitoring	Survey	Biological Opinion 2003	Inspect Bradshaw Airfield perimeter quarterly for alien species and remove invasive plants.
Invasive Plants	Invasive Plants Survey and Monitoring	Survey	Biological Opinion 2003	Inspect landing zones, trails, and roadsides for newly identified non-native plants.
Invasive Plants	Invasive Plants Survey and Monitoring	Survey	Biological Opinion 2003	Quarterly inspect construction and auxiliary support sites for invasive plant species.
Invasive Plants	Invasive Plants Survey and Monitoring	Survey	Informal Consultations 2013	Inspect the areas affected by the construction of High-Altitude trails and landing zones and UCAS.
Invasive Plants	Invasive Plants Survey and Monitoring	Survey	Biological Opinion 2013	Inspect the areas affected by the construction of the IPBA and monitor for introduction of incipient invasive plant species.

Table C1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Regulatory Document	Program Plan Requirement Wording (2014)
Invasive Plants	Invasive Plants Survey and Monitoring	Survey	Informal Consultation Well, 2014	Inspect the areas affected by site preparation at Hole No. 2 for the Deep Well project.
Invasive Plants	Invasive Plants Survey and Monitoring	Monitoring and Control	Biological Opinion 2003	Implement a non-native invasive plant monitoring program within, and adjacent to, landing zones, trails, and roadsides.
Invasive Plants	Invasive Plants Survey and Monitoring	Monitoring and Control	Biological Opinion 2003	Eradicate, contain, or control, as needed, newly found non-native plants species found during surveys.
Invasive Plants Program				
Fuels Control				
Invasive Plants	Fuels Control	Planning	Biological Opinion 2003	In the Invasive Plant Program Plan address management to reduce fire-related training impacts for *Asp per* and *Ner ova.*
Invasive Plants	Fuels Control	Planning	Biological Opinion 2013	Coordinate with Range Control to cease live-fire training if fuels exceed standards in FMC.
Invasive Plants	Fuels Control	Fuel Break System	Biological Opinion 2003	Modify fuel loads, reduce fuels by invasive plant control, and create fire/fuel breaks and fuel corridors to IWFMP standards.
Invasive Plants	Fuels Control	Fuel Monitoring Corridors System	Biological Opinion 2003	Establish and maintain fuel corridors and fire breaks.
Invasive Plants	Fuels Control	Fuel Break System	Biological Opinions 2003 & 2008	Develop and implement fuel/firebreaks around Puʻu Pāpapa and Puʻu Nohona o Hae. Modify fuels to minimize the occurrence and size of training-related fires within and escaping from the boundaries of KMA.
Invasive Plants	Fuels Control	Fuel Break System	Biological Opinion 2003	Remove all trees and shrubs in firebreaks and fuel breaks.
Invasive Plants	Fuels Control	Fuel Break System	Biological Opinion 2003	Control invasive non-native plants to minimize and offset HHB potential habitat losses from live-fire and wildfire.
Invasive Plants	Fuels Control	Fuel Break System	Biological Opinion 2013	Monitor the Fuels Monitoring Corridors every 5 years beginning in 2015.
Invasive Plants	Fuels Control	Fuel Break System	Biological Opinion 2013	If FMC fuel loads exceed established standards, implement fuels reduction.

Table C1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Regulatory Document	Program Plan Requirement Wording (2014)
Wildlife Program				
Management Section – Hawaiian Goose Project				
Wildlife	Wildlife Survey and Monitoring	Planning	Biological Opinions 2003 & 2008	Develop and update Wildlife Program Plan.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Biological Opinion 2013	Monitor Hawaiian Goose take limits and coordinate with the Service if the Army approaches take limits.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Biological Opinions 2003 & 2013	Notify the Service within one (1) business day of a take incident. Submit a written report describing the incident within three (3) business days of the incident.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Biological Opinions 2003 & 2013	Report Hawaiian Goose helicopter strikes to the Service to determine if this risk can be avoided in the future.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Biological Opinion 2008	Send dead Hawaiian Geese to the National Wildlife Health Center, Honolulu Field Station for a necropsy.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Biological Opinion 2013	Brief military units re: Natural Resources issues/restrictions.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Biological Opinion 2008	Coordinate with Range Control and other PTA Directorates to report Hawaiian Goose information.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Biological Opinion 2013	Modify Hawaiian Goose habitat at the Range 1 Complex prior to utilizing hazing options.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Biological Opinion 2013	Haze Hawaiian Geese from on or near any training range installation-wide at PTA when in conflict with training.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Biological Opinion 2013	Direct hazing operations in a manner that will minimize and avoid adverse impacts to Hawaiian Geese.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Biological Opinion 2013	Report overall hazing operations results at the end of each fiscal year to the Service.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Biological Opinion 2013	With prior approval and direction from the Service, relocate nests and goslings to a safe area when in conflict with training.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Biological Opinions 2003 & 2013	Notify and coordinate with the Service when a Hawaiian Goose nest is found.

Table C1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Regulatory Document	Program Plan Requirement Wording (2014)
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Biological Opinions 2003 & 2013	Notify the in 24 hours Service if a nest being monitored for translocation fails.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Biological Opinions 2003 & 2013	Immediately notify the Service if a Hawaiian Goose egg hatches. Service coordinates translocation efforts.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Biological Opinions 2003 & 2013	Coordinate with the Service if Hawaiian Goose adults and/or goslings require banding at PTA.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Biological Opinions 2003 & 2013	Implement regular monitoring and adaptive management of the WEA site to prevent attracting additional geese to PTA.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose	Biological Opinion 2013	Trap predators around the WEA when molting geese are present.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose Off-site	Biological Opinion 2013	Fund an off-site Hawaiian Goose conservation project for 20 years.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose Off-site	Biological Opinion 2013	Develop a MOA with a selected partner for the Hawaiian Goose conservation project.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose Off-site	Biological Opinion 2013	Strive to produce an average of 26 fledglings per year for the duration of the Hawaiian Goose conservation project.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose Off-site	Biological Opinion 2013	Fund, construct, maintain, and repair two, 20-acre predator-proof fences.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose Off-site	Biological Opinion 2013	Encourage Hawaiian Geese to use the predator-proof fenced areas both passively and aggressively.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose Off-site	Biological Opinion 2013	Control predators inside and outside of the predator-proof fences.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose Off-site	Biological Opinion 2013	Improve vegetation and maintain habitat by mowing 1 to 2 times per year inside the predator-proof fences.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose Off-site	Biological Opinion 2013	Construct a permanent water source inside each predator-proof fence.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose Off-site	Biological Opinion 2013	Construct a shade structure inside each predator-proof fence.
Wildlife	Wildlife Survey and Monitoring	Hawaiian Goose Off-site	Biological Opinion 2013	Collect and analyze data relative to fledging production, annual survivorship of Hawaiian Geese, and sightings of Hawaiian Geese banded as part of the conservation project.

Table C1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Regulatory Document	Program Plan Requirement Wording (2014)
Wildlife Program				
Management Section – Hawaiian Hoary Bat Project				
Wildlife	Wildlife Survey and Monitoring	Planning	Biological Opinion 2003	Develop and update Wildlife Program Plan.
Wildlife	Wildlife Survey and Monitoring	Planning	Biological Opinion 2003	Complete a comprehensive HHB project plan to implement the Terms and Conditions of the 2003 BO.
Wildlife	Wildlife Survey and Monitoring	Planning	Biological Opinion 2003	Develop appropriate HHB monitoring, survey and research methodologies plus reporting protocols.
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Biological Opinion 2003	Coordinate efforts to minimize direct and indirect effects on survival and reproduction of HHBs in the action area.
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Biological Opinion 2003	Notify the Service within three working days if any take of Hawaiian hoary bats occurs, or upon finding a dead, injured, or sick bat. Provide written reports to the Service.
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Biological Opinion 2008	Deposit bat remains with the B.P. Bishop Museum or the Service's Division of Law Enforcement.
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Biological Opinion 2008	Coordinate with the Army to cease training-related actions if HHB take is exceeded. Immediately consult with the Service.
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Biological Opinion 2003	Notify the Service within 24 hours if training, not conducted in accordance with the IWFMP, causes a wildfire that affects bat foraging or roosting habitat outside of the Impact Area.
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Biological Opinion 2003	Report annually to the Service Hawaiian hoary bat monitoring results and whether the estimated annual level of incidental take has been exceeded.
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Biological Opinion 2003	Minimize loss and degradation of roosting habitat for Hawaiian hoary bats in the action area.
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Biological Opinion 2003	Dedicate one or more staff as the Hawaiian hoary bat project lead.
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Biological Opinion 2003	Monitor trends in Hawaiian hoary bat occupancy at PTA.

Table C1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Regulatory Document	Program Plan Requirement Wording (2014)
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Biological Opinion 2003	Monitor the hectares of tree land vegetation destroyed outside the Impact Area as an indirect surrogate for HHB incidental take and provide an annual report to the Service.
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Biological Opinion 2003	Coordinate efforts to minimize noise and ground disturbance to Hawaiian hoary bats resulting from military activities in the action area.
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Biological Opinions 2003 & 2013	Avoid construction activities and fuel modification (i.e. felling trees from June 1 to September 15, to the maximum extent possible.
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Biological Opinion 2003	Coordinate efforts to minimize noise and ground disturbance to Hawaiian hoary bats resulting from military activities in the action area.
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Biological Opinion 2003	Brief military units: to minimize and avoid impacts to Hawaiian hoary bats and to report all bat strikes.
Wildlife	Wildlife Survey and Monitoring	Hawaiian hoary bat	Biological Opinion 2013	Coordinate with Range Control to implement conservation measures in the 2013 BO for the IPBA.
Wildlife Program				
Management Section - Seabirds Project				
Wildlife	Wildlife Survey and Monitoring	Planning	Biological Opinion 2003	In the Wildlife Program Plan address monitoring and definitions of success for the Hawaiian Petrel.
Wildlife	Wildlife Survey and Monitoring	Seabirds	Biological Opinion 2003	Survey for Hawaiian Petrel presence, abundance, and habitat use. Coordinate survey methods with the Service.
Wildlife	Wildlife Survey and Monitoring	Seabirds	Biological Opinion 2003	Conduct radar surveys for Hawaiian Petrel. Coordinate methods with the Service.
Wildlife	Wildlife Survey and Monitoring	Seabirds	Biological Opinion 2013	Coordinate with Range Control to implement conservation measures in the 2013 BO for the IPBA.
Wildlife	Wildlife Survey and Monitoring	Seabirds	Informal Consultation UCAS, 2013	Coordinate with Range Control to implement conservation measures for UCAS.

Table C1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Regulatory Document	Program Plan Requirement Wording (2014)
Wildlife Program				
Management Section – Avian Project				
Wildlife	Wildlife Survey and Monitoring	Avian Survey	Biological Opinion 2003	Conduct periodic surveys for Palila and MBTA-protected species within PTA.
Wildlife	Wildlife Survey and Monitoring	Avian Survey	INRMP 2018	Make information available for inclusion on environmental documentation, specifically for the NEPA process.
Wildlife	Wildlife Survey and Monitoring	Avian Survey	INRMP 2018	Document and report birds "taken" during military readiness activities.
Wildlife	Wildlife Survey and Monitoring	Avian Survey	INRMP 2018	Confer with USFWS if military readiness activities will result in a significant adverse effect to the population of a species protected under the MBTA.
Wildlife	Wildlife Survey and Monitoring	Avian Survey	INRMP 2018	Confer with US FWS if non-military readiness activities are being executed in the area of breeding migratory birds.
Wildlife Program				
Threats Management Section				
Wildlife	Wildlife Threat Management	Planning	Biological Opinion 2003	Develop and update the Wildlife Program Plan.
Wildlife	Wildlife Threat Management	Ungulate Control	Biological Opinion 2003	Aerial survey each fenced area annually to detect ingress. Maintain all fence units as ungulate free as practicable.
Wildlife	Wildlife Threat Management	Small Mammal Control	Biological Opinion 2003	Provide assistance, possibly financial, to complete the registration and National Environmental Policy Act (NEPA) compliance for aerial broadcast of rodenticide at PTA.
Wildlife	Wildlife Threat Management	Small Mammal Control	Biological Opinion 2003	Continue rodent control around each *Ner ova; for Sol inc* plants at ASRs 24 and 13*; and,* with small bait grids, *Zan haw* trees outside ASR 26.
Wildlife	Wildlife Threat Management	Early Detection and Control	Biological Opinion 2003	Brief military units and PTA personnel that all snake and lizard sightings must be reported.
Wildlife	Wildlife Threat Management	Early Detection and Control	Biological Opinion 2003	Coordinate mandatory reporting of all snake and lizard sightings to US FWS, DoFAW, and HDOA.

Table C1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Regulatory Document	Program Plan Requirement Wording (2014)
Wildlife	Wildlife Threat Management	Early Detection and Control	Biological Opinion 2003	Inspect all plant or plant products for frogs, lizards or snakes.
Wildlife	Wildlife Threat Management	Early Detection and Control	Biological Opinion 2003	Inspect the perimeter of the Bradshaw Airfield quarterly for newly introduced animal species and remove any found.
Wildlife	Wildlife Threat Management	Early Detection and Control	Biological Opinion 2003	Inspect construction and auxiliary sites quarterly for alien animal species and control or eradicate newly found species.
Wildlife	Wildlife Threat Management	Early Detection and Control	Biological Opinion 2003	Document newly introduced animals after initial discovery, implement surveys, and control, or eradicate.
Wildlife	Wildlife Threat Management	Fence Maintenance	Biological Opinion 2003	Ground surveys will ensure the fence lines are intact.
Wildlife	Wildlife Threat Management	Fence Maintenance	Biological Opinion 2008	Inspect barbed wire on security fences, quarterly, for entangled bats.
Wildlife	Wildlife Threat Management	Fence Maintenance	Biological Opinion 2003	Maintain large-scale fence units at a replacement rate of 3.5% annually.
Wildlife	Wildlife Threat Management	Fence Maintenance	Biological Opinion 2003	Address the frequency and logistics associated with fence maintenance to maintain fences ungulate free.
Wildlife	Wildlife Threat Management	Fence Maintenance	Biological Opinion 2003	Install established signage to identify areas that are off limits due to the presence of federally listed species.
Wildlife	Wildlife Threat Management	Fence Maintenance	Biological Opinion 2013	Maintain and repair predator-proof fences on partner lands and outside PTA.
Wildlife	Game Management	Planning	Biological Opinion 2003	Review hunting protocols and update to ensure that all privately owned vehicles will be restricted to established roads and trails.
Wildlife	Game Management	Game Mammal Surveys	INRMP 2018	Survey for game mammals and game birds in the hunting units.
Wildlife	Game Management	Physical Resources for Hunting Management	INRMP 2018	Construct facilities and control vegetation as needed to support the hunting project.
Wildlife	Game Management	Physical Resources for Hunting Management	INRMP 2018	Repair and maintain facilities to support the hunting project.
Wildlife	Game Management	Project Coordination Outreach	INRMP 2018	Attend public meeting and outreach activities.

Table C1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Regulatory Document	Program Plan Requirement Wording (2014)
Natural Resources Program				
Compliance	Consultations and Coordination	Communications Coordination	Biological Opinions 2003 & 2008	Reinitiate consultation if there are changes in species status, if an action may adversely affect a listed species, or if concurrence cannot be reached on the Implementation Plan.
Compliance	Consultations and Coordination	Communications Coordination	Biological Opinion 2003	Reinitiate consultation if prescribed burns are conducted and each time fire affects lands beyond the action area.
Compliance	Consultations and Coordination	Communications Coordination	Biological Opinions 2003 & 2008	Reinitiate consultation for the unauthorized take of listed birds or the bat as this represents new information requiring reinitiating of consultation and review of the reasonable and prudent measures.
Compliance	Consultations and Coordination	Communications Coordination	Biological Opinion 2003	Inform USFWS via phone or email within 24 hours after a fire occurs outside the Impact Area for live-fire training. A copy of the report will be sent to the Service within 3 working days.
Compliance	Consultations and Coordination	Communications Coordination	Biological Opinions 2003 & 2008	Report incidental take to the Service according to Take Statement requirements for each animal species.
Compliance	Consultations and Coordination	Communications Coordination	Biological Opinion 2008	Report dead nēnē to the Service within 48 hours.
Compliance	Consultations and Coordination	Communications Coordination	Biological Opinion 2008	Send dead Hawaiian geese, in good condition, with an unknown cause of death to the National Wildlife Health Center, Honolulu Field Station for a necropsy.
Compliance	Consultations and Coordination	Communications Coordination	Biological Opinion 2003	Coordinate night-time construction activities with the Service for all construction and maintenance activities of all Transformation construction projects.
Compliance	Consultations and Coordination	Communications Coordination	Biological Opinion 2003	Provide a copy of the KMA gulches and gullies survey results to the Service.
General	Program Administration	Planning	Biological Opinion 2003	Develop and update Natural Resources Program Plan.
General	Program Administration	Planning	Biological Opinion 2003	In Nat Res Program Plan, address dust abatement measures if dust is determined to be detrimental to woodland habitat in Palila Critical Habitat.

Table C1. Regulatory drivers for the Army's natural resources program at Pōhakuloa Training Area (cont.)

Program	Section	Project	Regulatory Document	Program Plan Requirement Wording (2014)
General	Program Administration	Planning	Biological Opinion 2003	Management Team identifies dust abetment measures.
General	Program Administration	Planning	Biological Opinion 2003	In the Nat Res Program Plan address a study to determine if rodents are limiting germination and recruitment of mamane.
General	Program Administration	Training Coordination	Biological Opinion 2003	Coordinate requests from aviators for alternative landing and pickup zones not already pre-approved and provide concurrence or suggest alternative sites.
General	Program Administration	Training Coordination	Biological Opinion 2003	Coordinate requests for new bivouac sites. Survey sites, establish buffers, and provide concurrence or suggest alternative sites.
General	Program Administration	Training Coordination	Biological Opinion 2008	Coordinate with military units to train in Training Area 21.
General	Program Administration	Training Coordination	Biological Opinion 2003	Review all current and future training scenarios to ensure compliance with this biological opinion.
General	Program Administration	Training Coordination	Biological Opinion 2003	Review SOPs for Stryker Brigade Combat Team Transformation and all training plans for potential impacts to listed species.
General	Program Administration	Training Coordination	Biological Opinion 2003	Develop and implement environmental awareness training for soldiers using PTA.
General	Program Administration	Training Coordination	Biological Opinion 2003	Provide soldiers with field cards during their safety briefing to remind them of training restrictions and the need to keep clothes and gear weed-seed free.
General	Program Administration	Training Coordination	Biological Opinion 2003	Establish signage to identify areas that are off limits due to the presence of federally listed species.
General	Program Administration	Training Coordination	Biological Opinion 2013	Adhere to the fire threat minimization measures in the most recent version of the IWFMP.
General	Program Administration	Training Coordination	Biological Opinion 2013	Coordinate with Range Control to implement training restrictions in IPBA per 2013 BO.
General	Program Administration	Training Coordination	Biological Opinion 2013	Brief military troops to adhere to the 15-mph speed limit, except when a waiver has been approved by the PTA CDR.
General	Community Relations	Public Outreach	Biological Opinion 2003	Review hunting protocols and update to ensure that all privately owned vehicles will be restricted to established roads and trails.

APPENDIX D

WILDLIFE ENCLOSURE 1

US ARMY GARRISON, PŌHAKULOA TRAINING AREA NATURAL RESOURCES PROGRAM RARE, ESA-LISTED SPECIES AND MIGRATORY BIRD SPECIES INCIDENT REPORT

HAWAIIAN HOARY BAT INCIDENTAL FIND

5 SEPTEMBER 2019

US Army Garrison, Pohakuloa Training Area Natural Resource Program

Rare, Federally- listed Species and Migratory Bird Species Incident Report

INCIDENT INFROMATION

Date of Incident: 5 September 2019

Time Observed: 11:00 am

Observer Name: James Whitney

Incidental or Routine Search: Incidental

Species Name: Hawaiian hoary Bat (*Lasiurus cinereus semotus)*

Species Status (ESA, MBTA): Federally Listed as Endangered

Age (Adult/Juvenilely), if known: Unknown

Sex (if known): Unknown

Condition of Specimen (Include a description of the animal's general condition, as well as any visible injuries, be specific, e.g., large cut on right wing tip): Bat carcass appeared intact, no visible injuries (blood or other bodily fluids). Carcass is desiccated and its wings and tail are tucked inward towards its body and there is no missing fur on its body (Figure 1). There were no ants or flies present when the carcass was found or during the collection process, but there was a faint foul odor to the carcass.

General Location: Natural Resource Office 227A Building

GPS Coordinates (UTM Easting, Northing): (234489, 2186590)

Distance to Base of Closest Structure and or Landmark: 2.6 meters from building 227A, 3.8 meters from telephone pole and 23.4 meters from the road (Figure 2).

Ground Cover Type: Gravel and wood chips

Temperature (˚F): 72°F

Precipitation (Inches): 0.00

Max Wind Speed (mph): 10.0

INCIDENT INFORMATION (continued)

Cloud Cover (%): 10

Incident Occurred during military Training (Yes/No): No

Probable Cause of Injury or death and Supportive Evidence (e.g., teeth marks visible on upper back, bullet wounds, found adjacent to tire marks): Probable cause of death is unknown. Upon further investigation by placing the bat carcass under a dissecting scope we found a small lesion (0.2 mm) on the dorsal side of the right shoulder region. When examining the wings' membranes, the both wings had some perforation on the chiropatagium membrane (Figure 3). The wing membranes (uropatagium, plagiopatagium and chiropatagium) appear desiccated and they cannot be stretched into an open (flight) position). It is unknown if these findings contribute to the death of the bat.

Additional Comments:

At 11:00 am on 5 September 2019 Mr. James Whitney (Cultural Resource Office) was exiting building 227A (north facing door) when he discovered the dead Hawaiian hoary bat on the ground. He then notified the Natural Resource Program of the discovery and Ms. Stephanie Levins (Hawaiian Goose Project Leader), Mr. Rogelio Doratt (Wildlife Program Manager) and Mr. Nikhil Narahari (Ecological Data Program Manager) went to investigate the bat. Mr. Doratt and Mr. Narahari examined the area, the bat carcass and documented the incident. There were no visual signs of the bat being killed by military training actions or direct evidence that the bat might have struck the building (2.6 meters away from carcass) or telephone pole (3.8 meter away from carcass). During the investigation no ants or flies were found on the carcass. During the examination, a couple of wind gusts were observed to lift the carcass off the ground, slightly moving it from where it was originally found. About thirty minutes after the carcass was removed, ants and flies began crawling and flying to the spot where the carcass was found.

At 11:18 am Mr. Doratt collected the bat carcass and placed it inside a labeled plastic bag and stored the specimen in the biological specimen refrigerator in the Natural Resource Program building 227C.

At 11:36 am Mr. Doratt notified his supervisors, Lena Schnell (Senior CEMML Manger) and Joy Anamizu (Army Biologist), via email of the discovery.

At 12:06 pm Mr. Doratt examined the bat carcass under a dissecting scope and discovered a small lesion on the dorsal side of the bat. The desiccated bat's wings also had some perforations on its membrane.

At 3:40 pm Mr. Doratt called the Bishop Museum to ask about recommendation for storing a bat carcass. At the time no researchers were in the museum to assist. Mr. Doratt then called the Wildlife Disease Specialist/Field & Lab Research, USGS National Wildlife Health Center and spoke with Ms. Julie Dagenais to confirm how to properly store a bat carcass and in the refrigerator for further examination. Ms. Dagenais recommend leaving the bat in the plastic bag and storing it as is in the refrigerator.

6 September 2019, Ms. Anamizu notified David Shaffer (Range Division PTA , Range Operations Manager) via email about the discovery of the dead bat and asked about what type of military training, if any, occurred the day of the discovery. Mr. Shaffer confirmed that no military training occurred down range (on the ground or aviation).The Hawaii Police Department was training (pistol) at Range 02 (over 10 km away from where the bat carcass was found).

On 6 September 2019, Ms. Anamizu notified John Webber (US Fish and Wildlife Service) via telephone about the discovery of the dead Hawaiian hoary bat.

In the next few days we will transfer the bat carcass to Bishop Museum as described in the 2003 and 2008 Biological Opinions terms and conditions.

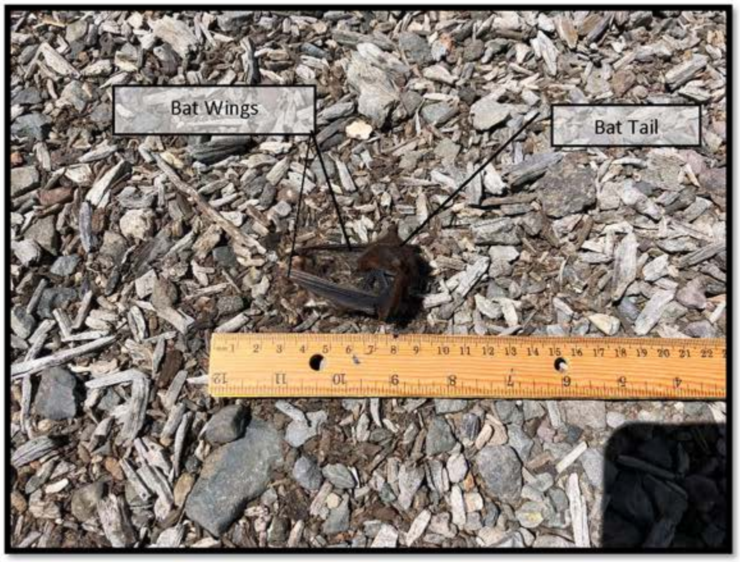


Figure 1. Carcass of the Hawaiian hoary bat discovered near the Natural Resources Program Building 227A

Figure 2. Natural Resources Program Building 227A and landmarks near the discovery of the Hawaiian hoary bat carcass. Carcass distance from the 227A building was 2.6 meters, 3.8 meters from telephone pole and 23.4 meters from road.

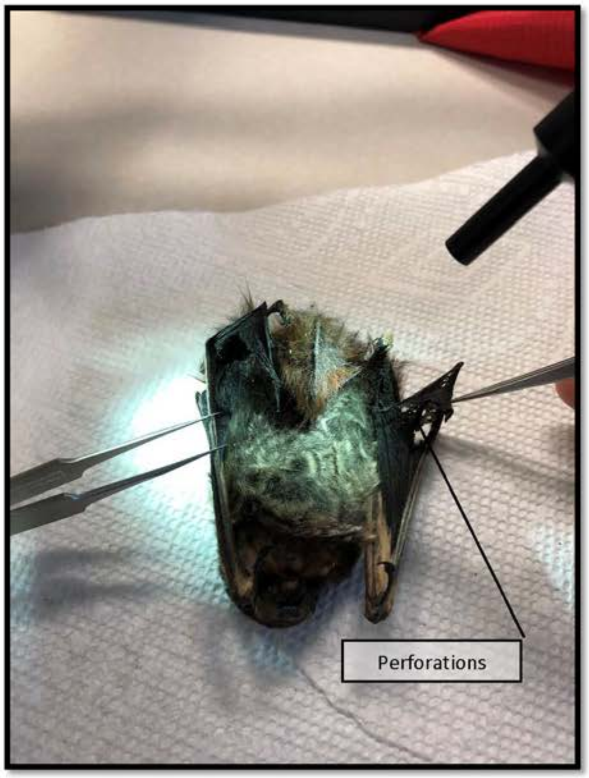


Figure 3. Hawaiian hoary bat's perforated wing membranes.

Please contact Lena Schnell at (808) 315-0300 or email lschnell@rams.colostate.edu for further discussions on this wildlife incident report.

Report generated by (Rogelio E Doratt, 9 September 2019)

WILDLIFE ENCLOSURE 2

PŌHAKULOA *HYLAEUS* SURVEY REPORT

25-28 JUNE 2018

KARL MAGNACCA

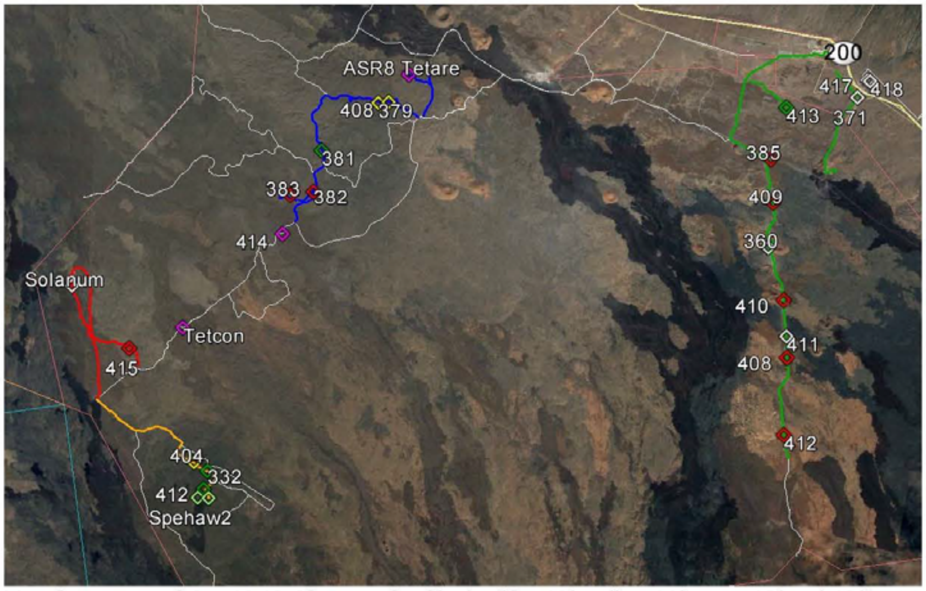
Pohakuloa *Hylaeus* Survey Report
June 25–28, 2018
Karl Magnacca

On June 25, we started at ASR 8. There were only a few *Tetramolopium arenarium* flowering, most of them in a small patch in the corner of a fence; the great majority of plants were smaller and immature. Several large *Sida fallax* near the flowering ones were also in heavy flower. However, there were no bees seen at any of these. *Dodonaea* was abundant, but few were flowering.

We continued on around the north and west sides of the Kipuka Kalawamauna fence. Numerous *Hylaeus difficilis* were found at a patch of *Sida* (wp 408), with males sitting in flowers, and on *Bidens menziesii* (wp 379), and on *Euphorbia* (=*Chamaesyce*) *olowaluana* (wp 381). Further down the road in open ohia woodland, *H. difficilis* was also abundant on *Metrosideros polymorpha* (wp 382). The last site may include *H. rugulosus*, as all-black individuals were not separated. From the southern end of the Kipuka Kalawamauna fence, we went out to the *Kadua coriacea* patch to the west (wp Kadualand) and to a couple of plants on east side, which are the most likely habitat for *H. anthracinus* based on its collection location. No bees were present in the area away from the road, even on *Metrosideros*.

June 26 was spent at Kipuka Alala. We stopped at a patch of *Tetramolopium consanguineum* near the road along the way. Some were large and flowering, but no bees were present; most plants had already gone to seed. At Kipuka Alala, *H. difficilis* was abundant on *Bidens* lower down (wp 404). Further up there were fewer bees, and very few on *Euphorbia* at the fence crossing (wp 332). The *Euphorbia* were not flowering much in this area. From the lower MAT site, we walked a loop out to check on *Spermolepis hawaiiensis*, but the plants were clearly too small to be visited and were also now in fruit. On the way back, we checked a *Zanthoxylum hawaiiense* but it was found to be in fruit with the seeds dehiscing. There were few bees at *Metrosideros* along the road near Kipuka Alala.

On June 27 we visited. Redleg trail and the east side. The weather was sunny but with very strong wind. We entered at gate 8 about 1 mile past MKSP, then went west along Humuula Road to old Saddle. A *Myoporum* in this area (wp 371) had good flowering but no bees. No mamane were flowering. *Metrosideros* was flowering heavily all over. Near the top of Redleg Trail (wp 385), a moderate number of *Hylaeus* were observed at flowers despite the strong wind (mostly on the lee side); all were females or possibly *H. rugulosus*. About 1.5 miles down Redleg Trail (wp 360), most *Myoporum* were dead; one with one flower, another with no flowers but smelling sweet, and several male *H. difficilis* around it. In July 2012, the rare species *H. kona* was found at this spot. We continued on as far as Range 1, where rare *Hylaeus* had been most frequently found before, but since the range was still hot we decided to turn around rather than continue to Puu Koli. At *Metrosideros* in the way back (wp 412), we found many *Hylaeus* including a lot of *H. rugulosus* and some *H. difficilis*. After returning, we went out with Lena to the vicinity of the ASP to check an area marked as *Euphorbia-Myoporum* woodland on the vegetation map. The site is now almost barren of trees, with a few scattered *Sophora* and only one or two *Euphorbia*, having been hit hard by drought, ungulates, and thrips.



Map of areas surveyed, June 25–28. Lines are colored by day (blue: 25th; yellow: 26th; green: 27th; red: 28th). Specific sites searched are colored by the predominant flower. Red: *Metrosideros polymorpha*; white: *Myoporum sandwicense*; yellow: *Bidens menziesii* and *Sida fallax*; green: *Euphorbia olowaluana*; purple: *Tetramolopium* spp.; light green: *Spermolepis hawaiiensis*.

On June 28, I hiked out with Lena, Kapua, and David Jones to the kipuka camp on the west side of the installation. For the most part, *Metrosideros* was by far the dominant flower available all throughout the area. *Hylaeus rugulosus* was found abundantly closer to the road on pahoehoe substrate, shifting to mostly *H. difficilis* further in on aa. The density of bees appeared to be higher on aa, but due to the time we didn't stop to check as much after reaching the big crack (where the transition to large blocky aa was) due to lateness. The introduced *H. albonitens* was also abundant in some places, especially on aa further in. Several large patches of *Tetramolopium consanguineum* were found with moderately heavy flowering, but no bees were seen around them. *Santalum* was scattered throughout and also flowering, but strangely *Hylaeus* were not visiting them either. They have been found on both of these at other sites. At the camp kipuka (wp 415), *H. albonitens* was found visiting *Solanum incompletum*, one of very few records of this species visiting a flower other than *Metrosideros* in Hawaii. After returning to the road, we went back up to check *Portulaca sclerocarpa*. The plants were tiny, and only a few were alive, none flowering; probably these would not be attractive to bees. In the afternoon, I visited Mauna Kea Park and found one *Myoporum* tree with *H. kona*. Several of the trees here that had bees in 2012 have since been cut down.

In general, *Metrosideros polymorpha*, *Bidens menziesii*, and *Sida fallax* were flowering heavily, *Euphorbia olowaluana* moderately at Kipuka Kalawamauna and little at Kipuka Alala, *Sophora chrysophylla* very little, and *Dubautia linearis* not at all. Both species of *Tetramolopium* were flowering but were past their peak; however, no bees were seen on *T. consanguineum* even in large aggregations where relatively large numbers of flowers were present. In previous years, peak bee diversity has been during collections made in mid-July, with both numbers and diversity dropping off in the fall. Most of the rarer species recently were found on *Myoporum*, and this year its flowering was very low even compared to how it was in 2012 when the thrips had already had significant impacts. There has previously been at least some *Sophora* flowering as well, and these had all nearly finished flowering at least several weeks prior to the visit. The prior surveys in 1999 and 2012 were conducted during dry years, while early 2018 was quite wet, which may have contributed to a shift in *Sophora* flowering time. *Metrosideros* and *Bidens* were still in full bloom, and many more individual bees were seen than in previous years, but the diversity remained low. The persistent absence of several species previously collected on *Bidens* in particular suggests that the observed decrease in *Hylaeus* diversity is probably real. The best remaining areas are probably on the east side, including to the east of Puu Koohi and Mauna Kea Park, where *Myoporum* tend to be more healthy.

The question of whether a population of the listed endangered species *H. anthracinus* occurs at PTA is uncertain. The location of the original 2004 collection is unclear, although based on the fact that it was found on *Kadua coriacea* and the sites where the collector was working in, it is believed to be ASR 11. This site has been searched several times, in 2009, 2012, and the present survey, but none have been found. Somewhat surprisingly, each time *Hylaeus* have been found on *Metrosideros* close to the road but not away from it en route to the *Kadua* cluster. There are no plants that one might expect to find *H. anthracinus* on in these areas, suggesting that the earlier specimen was a vagrant at least within PTA if not from further away. The most likely floral host for *H. anthracinus* at PTA is *Argemone glauca*, which occurs sporadically but sometimes in moderately large patches. The only other collections of *H. anthracinus* away from the shoreline are from Maui at 2000 ft, and also came from *Argemone*. Only a few non-flowering plants were observed on this visit.

WILDLIFE ENCLOSURE 3

ARMY'S NATURAL RESOURCES PROGRAM AT PŌHAKULOA TRAINING AREA RARE AND ESA-LISTED SPECIES AND MIGRATORY BIRD SPECIES INCIDENT REPORT FORM

BLACKBURN'S SPHINX MOTH INCIDENTAL FIND

3 JULY 2019

Army's Natural Resources Program at Pohakuloa Training Area (PTA),
Rare and Federally- listed Species and Migratory Bird Species Incident Report Form

DISCOVERY INFORMATION

Date Discovered: 07/03/2019 **Time Discovered:** 10:33 AM **Observer(s):** Ryder Souza, Gideon Brosius

Type of Discovery (circle): Scheduled Search Incidental Find Reported

Species Scientific Name: *Manduca blackburni*

Species CommonName: Blackburn's Spinx Moth

Special Status (e.g. ESA, MBTA, etc.): ESA **Number of animals:** 1

Incident Type (e.g. individual animal, nest, etc): single caterpillar

General Location (e.g. Range 01, BAAX, etc.): KMA Priority 3, near Daniel K. Inouye Highway

GPS Location (UTM Easting/Northing): 212539 2195898

Weather at Time of Discovery (if known):

Temperature	Precipitation	Wind Speed/Direction	Cloud Cover (%)
75-85 degrees	None	Light and variable	15%

INCIDENT INFORMATION

Band Identification (for Hawaiian Geese) or other (if available):

(species code_State leg band ID_ US FWS leg band ID (if known) (Hawaiian Goose species code HAGO). Example: HAGO_Black LL_788-26089, UNB for unbanded, UNK for unknown identification)

Sex (circle): male female unknown **Age (circle):** adult juvenile unknown

Condition (circle): injured intact scavenged dismembered other (describe):

Band Identification (for Hawaiian Geese) or other (if available):

Sex (circle): male female unknown **Age (circle):** adult juvenile unknown

Condition (circle): injured intact scavenged dismembered other (describe):

INCIDENT INFORMATION (continued)

Additional ID Information: N/A

Estimated Date and Time of Incident: N / A **Incident Occurred During Training? (circle) Y N**

Probable Cause of Death or Injury:

N/A

Storage Location of Specimen:

N/A

Comments:

On 07/03/2019 Ryder Souza and Gideon Brosius were controlling tree tobacco (*Nicotiana glauca*) along the sides of Daniel K. Inouye Highway in KMA Priority 3 as an effort to stop the spread of *Nicotiana glauca* further into KMA. Several plants were treated, and information was recorded on an invasive plants application (IPSM Collector) GPS locations were taken and can be viewed on the application. The tree with the *Manduca blackburni* larva was a very large reproductive adult with a high proportion of seed and flower production. The leaves were smaller and showed no obvious sign of herbivory for the overall plant. The larva was located at the top of the tree (roughly 12 feet+ in height) and located and identified by Ryder Souza. The larva was a grey 5th instar and full size (most likely 4 inches or so). The plant was not treated and no other larvae were observed in any other plants within the area.

MANAGEMENT/CARE for TAKE SPECIMEN (e.g delivered to rehabilitation center, etc. describe below)

No specimen was collected

INCIDENT REPORTING

PTA- Natural Resource Office Contact Information:

Date: 7/01/2019 **Time:** 16:00 h

Contact Person(s): Rogelio Doratt (Wildlife Program Manager), (808) 937-4717, Pamela Sullivan (808) 217-5058

Comments: Rogelio Doratt (Wildlife Program Manager) was verbally contacted on the day of the original incident. We were instructed to contact Pamela Sullivan. She was not in that day, so an email was sent on the same day. She did not receive/read the email until 7/03/2019.

PTA- Range Control Contact Information:

Date: N/A **Time:**

Contact Person(s):

Comments:

US FWS Contact Information:

Date: **Time:**

Contact Person(s):

Comments:

Other Contact Information:

Date: **Time:**

Contact Person(s):

Comments:

Please contact Lena Schnell at (808) 315-0300 or email lschnell@rams.colostate.edu for further discussions on this wildlife incident report.

Report generated by (name, date):
Jennifer Navarra and
Ryder Souaza on 8/12/2019

APPENDIX E

FY 2019 ANNUAL REPORT FOR THE ARMY'S NATURAL RESOURCES PROGRAM AT PŌHAKULOA TRAINING AREA, ISLAND OF HAWAIʻI

We produce a full programmatic report biennially (every 2 years). Each biennial report includes an appendix that satisfies annual reporting requirements identified in the Statement of Objectives for work conducted by the Center for Environmental Management of Military Lands at Pōhakuloa Training Area (PTA), as well as regulatory and guiding documents including the 2003, 2008, and 2013 Biological Opinions (BOs) issued to PTA by the US Fish and Wildlife Service (USFWS). The report is also produced to maintain compliance with the installation's Integrated Natural Resources Management Plan (INRMP) and regulatory obligations under the Endangered Species Act (ESA), National Environmental Policy Act (NEPA), and Migratory Bird Treaty Act (MBTA).

This appendix covers the reporting period of FY 2019 (01 October 2018 through 30 September 2019). A report covering FY 2018 (01 October 2017 through 30 September 2018) is available separately.

Natural resources are managed at PTA under 5 major program areas: Botanical, Invasive Plants, Wildlife, Game Management, and Ecological Data. All annual reporting requirements set forth in regulatory and guiding documents are reportable under the Botanical and Wildlife Programs. Therefore, other program areas are not included in this appendix.

1.0 BOTANICAL PROGRAM

1.1 INTRODUCTION

The Botanical Program implements conservation measures for 15 ESA-listed plant species at PTA: *Asplenium peruvianum* var. *insulare* (fragile fern), *Haplostachys haplostachya* (Hawaiian mint or honohono), *Isodendrion hosakae* (aupaka), *Kadua coriacea* (leather-leaf sweet ear or kioʻele), *Lipochaeta venosa* (nehe)[1], *Neraudia ovata* (spotted nettle bush or maʻaloa), *Portulaca sclerocarpa* (hard fruit purslane or poʻe), *Silene hawaiiensis* (Hawaiian catchfly), *Silene lanceolata* (lance-leaf catchfly), *Solanum incompletum* (Hawaiian prickle leaf or pōpolo kū mai), *Spermolepis hawaiiensis* (Hawaiian parsley), *Stenogyne angustifolia* var. *angustifolia* (creeping mint), *Tetramolopium arenarium* ssp. *arenarium* var. *arenarium*[2] (Mauna Kea pāmakani), *Vigna o-wahuensis* (Oʻahu cowpea), and *Zanthoxylum hawaiiense* (Hawaiian yellow wood or aʻe).

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[1] The name for this species was recently changed to *Lipochaeta venosa*, which remains synonymous with *Melanthera venosa* (Edwards et al. 2018).

[2] From here forward *Tetramolopium arenarium* ssp. *arenarium* var. *arenarium* will be abbreviated *T. arenarium* var. *arenarium* in accordance with the Council of Scientific Editors (CSE) guidance for abbreviating intraspecific taxa. The CSE recommends using a trinomial encompassing the genus, the specific epithet, and the name of the lowest rank.

Additionally, we implement management for 5 ESA-listed plant species: *Exocarpos menziesii* (Menzie's ballart or heau), *Festuca hawaiiensis* (Hawaiian fescue), *Portulaca villosa* (hairy purslane or ʻihi), *Schiedea hawaiiensis* (māʻoliʻoli), and *Sicyos macrophyllus* (Alpine bur cucumber or ʻānunu). We have not formally consulted under the ESA with the USFWS to assess the potential effects to these 5 species from military activities at PTA; therefore, there are no conservation measures or annual reporting requirements for these species. In addition, we manage for a rare, undescribed species, *Tetramolopium* sp. 1. Management for these 6 species includes delimiting plant species distribution and abundance, monitoring for threats, seed and propagule collection, and outplanting.

The botanical section of this appendix is divided into 2 sub-sections:

1) Plant Survey and Monitoring
2) Wildland Fire Effects to Plants

1.2 PLANT SURVEY AND MONITORING

1.2.1 Plant Surveys

The purpose of plant surveys is to estimate the distribution and abundance of ESA-listed plant species at PTA. In FY 2017, we initiated a second cycle of plant surveys. In previous reports, our stated goal was to survey approximately 65 km² of habitat within ungulate exclusion fences over a 5-year period. In summer 2019, we adjusted the planned survey area by removing segments of the kilometer-long transects that extended outside of ungulate exclusion fences or onto barren lava. Through this process, the area planned for survey was reduced to about 56 km^2. We report our FY 2019 progress toward completing the second cycle of surveys in relation to the goal of surveying 56 km^2, or 5,634 linear km. To complete the survey within the 5-year time period, on average, we need to survey 282 linear km per quarter.

For a complete description of the plant survey methodology see Section 2.2.2 of this biennial report.

Plant Survey Results and Discussion

In FY 2019, we surveyed 856 linear km, which was about 76% of our annual survey goal (Table E1). Adding our progress in FY 2019 to work completed between January 2017 and August 2019, we have cumulatively surveyed 1,501 linear km, which is 27% of our 5-year survey goal of 5,634 linear km.

Table E1. Survey progress toward annual survey goal by quarter for FY 2019

FY 2019 Quarter	Quarter Survey Goal (km)	Surveys Completed (km)	% of Annual Survey Goal
1	282	148	52%
2	282	180	64%
3	282	260	92%
4	282	268	95%
Total	**1,128**	**856**	**76%**

During FY 2019, we recorded 3,396 locations of ESA-listed plant species representing at least 21,250 ESA-listed plants (Table E2).

Table E2. Plant survey results for FY 2019

Species	Number of Locations	Minimum No. of Individuals
Asplenium peruvianum var. *insulare*	9	123
Exocarpos menziesii	846	945
Festuca hawaiiensis	358	2055
Haplostachys haplostachya	959	8985
Kadua coriacea	38	41
Portulaca sclerocarpa	12	59
Schiedea hawaiiensis	1	1
Silene hawaiiensis	410	1770
Silene lanceolata	380	5744
Spermolepis hawaiiensis	13	63
Stenogyne angustifolia	291	1329
Tetramolopium sp. 1	45	95
Zanthoxylum hawaiiense	34	40

The minimum number of individuals stated in Table E2 reflects the use of count classes to estimate abundance for ESA-listed plant species that had more than 25 individuals at a given location. The low value from each count class was summed to provide an estimate of the minimum number of individuals for each species.

For most of the species ranked Priority Species (PS) 2 and 3, we use count class data collected during surveys to estimate abundance (see Section 2.5 of this biennial report for details). Before we can refresh abundance estimates for these species, we need to complete the second cycle of rare plant surveys. Although we made moderate progress in our quarterly and annual goals for surveying, progress towards the 5-year goals was below targets. Even if we improve our survey pace, we will still need 1 to 2 years to complete the surveys and update abundance estimates.

We are also assisting with the preparation of a Biological Assessment and toward that end, updated abundance estimates are necessary to have more current species baseline descriptions. Further, a refreshed estimate of abundance and species status will allow for better threats analysis by more accurately representing the numbers of plants present within the known distributions. Therefore, to expedite the survey effort and generate abundance estimates in a more suitable time frame, we implemented a new sampling strategy in August 2019. The strategy entails randomly sampling 30% of the known distribution of 6 plant species within ungulate-exclusion fence units by the end of March 2020. This sampling approach will yield better estimates of abundances for 6 ESA-listed focal species: *E. menziesii, F. hawaiiensis, H. haplostachya, Silene hawaiiensis, S. lanceolata,* and *S. angustifolia.*

We excluded *Spermolepis hawaiiensis* and *Z. hawaiiense* from the sampling analysis based on their life history attributes. *Spermolepis hawaiiensis* is an annual species that episodically recruits when environmental conditions are favorable. Because of these attributes, we decided the selected survey sampling approach for estimating abundance was not well-suited to this species. We plan to investigate monitoring approaches more suited to short-lived species in 2020. *Zanthoxylum hawaiiense* is a long-lived tree that occurs in small, but widely dispersed, clusters distributed across thousands of acres. We also decided the selected survey sampling approach was not well-suited to this species. Because of the long-lived nature of *Z. hawaiiense,* we are confident that the abundance estimate from the first cycle of plant surveys (2011 to 2015) is still fairly accurate. We plan to investigate more suitable monitoring approaches for this species in 2020.

1.2.2 Priority Species 1 Monitoring

We monitor and census the following PS 1 plants quarterly: *A. peruvianum* var. *insulare, K. coriacea, L. venosa, N. ovata, P. sclerocarpa, P. villosa, Schiedea hawaiiensis*, *S. macrophyllus, S. incompletum, T. arenarium* var*. arenarium*, *T*. sp.1, and *V. o-wahuensis.* We use a similar, but different monitoring method for *I. hosakae*.

Although we aimed to monitor and census all known PS 1 individuals each quarter, monitoring efforts for a given species sometimes extended beyond a calendar quarter. Because our work did not strictly adhere to quarters, we use the term "census period" to represent the period required to complete a full census of monitoring plots for each species. When needed for clarity, a date range is included with the census period.

Priority Species 1 Monitoring Results and Discussion

We completed monitoring for PS 1 plants each census period in FY 2019 (Table E3). Most species remained relatively stable over the year, except *V. o-wahuensis,* which declined from 472 adults and juveniles in the first census period to 177 adults and juveniles.

For a more detailed discussion of PS 1 monitoring, see Section 2.2.3 of this biennial report.

In addition, refer to the species summaries in Section 2.4 and Section 2.5 of the biennial report for a more detailed discussion of monitoring results for each species.

Table E3. Priority Species 1 monitoring results for FY 2019

Species	Oct-Dec 2018 Plots Read	Oct-Dec 2018 Plant No.	Jan-Mar 2019 Plots Read	Jan-Mar 2019 Plant No.	Apr-Jun 2019 Plots Read	Apr-Jun 2019 Plant No.	Jul-Sep 2019 Plots Read	Jul-Sep 2019 Plant No.
Asplenium peruvianum var. *insulare*	41	271	41	237	41	398	42	396
Isodendrion hosakae	21	93	20	101	20	131	18	125
Kadua coriacea	120	136	120	137	120	139	123	145
Lipochaeta venosa	17	136	17	184	17	162	17	107
Neraudia ovata	18	49	19	55	19	58	19	58
Portulaca sclerocarpa	36	169	36	108	40	186	40	161
Portulaca villosa	2	6	2	8	2	8	2	8
Sicyos macrophyllus	1	0	1	0	1	0	1	0
Schiedea hawaiiensis	1	4	1	5	1	2	2	10
Solanum incompletum	20	78	20	80	20	82	20	94
Tetramolopium arenarium var. *arenarium*	27	376	27	332	37	381	27	398
Tetramolopium sp. 1	64	110	64	128	64	146	64	151
Vigna o-wahuensis	40	472	45	380	45	275	45	177

Note: The reported number of plants per census period is adult and juvenile plants only. The number of adults and juveniles reported for the first 2 census periods (October 2018 to March 2019), to the left of the dotted line, are reported as weighted averages based on the estimated proportions of adults and juveniles. To the right of the dotted line, we report the direct count of adults and juveniles present.

1.3 WILDLAND FIRE IMPACTS TO PLANTS

The 2003 BO (USFWS 2003) and the INRMP (USAG-P 2019) require the Army to assess and report all military training-related wildland fires occurring on the installation outside of the Impact Area to determine potential effects to TES.

No wildland fires occurred at PTA outside of the Impact Area in FY 2019.

2.0 WILDLIFE PROGRAM

2.1 INTRODUCTION

The Wildlife Program implements conservation measures for 1 ESA-listed mammal species and 2 ESA-listed bird species that may occasionally use habitat at PTA and/or periodically transit the installation: Hawaiian hoary bat (*Lasiurus cinereus semotus*), Hawaiian Goose (*Branta sandvicensis)*, and Hawaiian Petrel (*Pterodroma sandwichensis)*. The Band-rumped Storm Petrel (*Oceanodroma castro*) and the anthricinan yellow-faced bee (*Hylaeus anthracinus*) were recently listed under the ESA (2016), and in July 2019, the ESA-listed Blackburn's sphinx moth (*Manduca blackburni*) was discovered at PTA. The Army is in the process of reinitiating section 7 consultation with the USFWS for these species, as well as 6 species of ESA-listed plants. Conservation measures and reporting requirements for the Band-rumped Storm Petrel, anthricinan yellow-faced bee, and the Blackburn's sphinx moth will be addressed in future reports.

In the 2013 BO, the USFWS acknowledged a "no effect" determination for the Hawaiian Hawk (*Buteo solitarius)* for all military training activities at PTA. Therefore, the Army is no longer responsible for implementing conservation measures for this species, but we will continue to record incidental hawk sightings at the installation.

The wildlife section of this appendix is divided into 4 sub-sections:

1) Hawaiian Goose
2) Hawaiian Hoary Bat
3) Wildland Fire Impacts to Wildlife
4) Migratory Bird Incidental Take Summary

The information contained herein satisfies annual reporting requirements identified in regulatory and guiding documents for PTA.

2.2 HAWAIIAN GOOSE

2.2.1 Hawaiian Goose Management at Pōhakuloa Training Area

In January 2013, the USFWS issued a new BO that addressed installation-wide impacts to the Hawaiian Goose from military training at PTA. The 2013 BO authorized an Incidental Take Statement for the goose, removing several earlier imposed restrictions on military training. The 2013 BO supersedes the requirements of the 2008 BO for surveying, monitoring and managing Hawaiian Geese, and removes restrictions to military personnel training at live-fire ranges and vehicle maneuver areas when geese are present at PTA.

Hawaiian Goose management at PTA consists of 4 categories: 1) monitoring for goose presence and behavior, 2) implementing actions to reduce military training/goose conflicts, 3) monitoring incidental take, and 4) briefing personnel training and working at PTA.

As required by the Incidental Take Statement and Terms and Conditions from the 2013 BO, the Army implements a Hawaiian Goose conservation project located at Hakalau Forest National Wildlife Refuge (HFNWR) to benefit Hawaiian Geese. The goal of this partnership is to create suitable goose habitat and maximize gosling survival to adulthood; specifically, to produce an average of 26 fledgling geese per year to compensate for the potential incidental take of 20 adult geese annually at PTA (USFWS 2013).

To avoid and minimize impacts to the Hawaiian Goose at PTA, the 2013 BO requires us to brief military unit leaders on their responsibilities to protect geese at PTA, especially while driving and conducting live-fire exercises. The PTA External Standard Operating Procedures requires all personnel training or working on the installation, outside the cantonment, to receive a brief including information about training/working near Hawaiian Geese and the process to report goose presence to PTA Range Control.

The 2013 BO also requires that we modify the habitat at the Range 1 Complex, control for small mammals during molting and breeding activities, and to report annually to the USFWS regarding Hawaiian Goose hazing activities, breeding activities, and incidental take events. In addition, we continue to monitor Hawaiian Goose presence at PTA and manage the Wildlife Enhancement Area (WEA), a 5.3-ha safe area for geese to occupy at the Range 1 Complex.

Hawaiian Goose Monitoring

The Army is required to report and monitor all Hawaiian Goose nesting, breeding, and molting activity and incidental take that occurs at PTA. To meet this requirement, we systematically monitor for geese and track incidental sightings.

Systematic Monitoring Methods

Hawaiian Goose presence, both on the ground and in flight, is systematically monitored with foot surveys and/or vehicle surveys within core areas of PTA where geese have been consistently observed and in areas where geese have nested. Core monitoring areas at PTA include the Range 1 Complex, the Forward Operating Base (FOB) Warrior Search Area (Training Areas 1, 3, and 4), Training Areas 6 and 7, and Bradshaw Army Airfield (BAAF). More than 1 core area may be surveyed in a single day; therefore, observation data are reported per survey for each core area.

Foot surveys consist of 1-2 biologists traversing the area and recording the presence of Hawaiian Geese. Vehicle surveys consist of 1-2 biologists driving on accessible roads using binoculars to search for geese. We record geese monitoring type (systemic or incidental), geese seen on the ground or in flight (use of PTA air space as a flyway), date/time, observer ID, location, number of geese, leg band identification, and general behavior notes. We also report if geese molt (e.g., missing flight feathers) or breed (e.g., aggressive behavior, brood patches, nest building) at PTA.

Systematic monitoring is intended to provide an indicator of Hawaiian Goose presence in areas with historic, or newly discovered, goose activity over a set sampling period. We tracked effort by reporting the number of surveys within a reporting period. No adjustments are made to the survey data to account for imperfect detection of geese and this likely adds bias to the number of reported observations. Although the relationship between the population of geese using PTA and the population of geese detected during surveys is unknown, we assume changes in detection reflect changes in the population using PTA. However, these observation data are a rough measure of goose presence for the core monitoring areas and are helpful in guiding management efforts.

Incidental Sightings Methods

All personnel working and training at PTA report incidental Hawaiian Goose sightings at the installation. These sightings may include geese encountered in core monitoring areas, but outside systematic monitoring periods. Incidental sighting data collected include location, time, number of geese, and possible injury. If possible, we respond to the location of the reported sighting to document band identification and any breeding, nesting, or molting activity. If the geese are located, we may monitor the geese, especially if breeding or molting behavior is observed. Monitoring may continue until the birds are no longer found in the area.

Targeted Monitoring Methods

We initiate targeted monitoring when breeding or molting activity is observed during systematic surveys or to follow up on incidental sighting reports. Targeted monitoring typically involves multiple visits to the same location to monitor the same individuals for as long as the individuals are present at the location. Targeted monitoring may involve nest monitoring as well.

Systematic Monitoring Results

In the core management areas, we detected a total of 20 geese during 8 of 140 surveys (Figure E1). Seven individual geese were identified by their leg-bands and we were unable to identify leg-bands for 5 geese (Table E4). We observed geese at 2 of the 4 core areas.

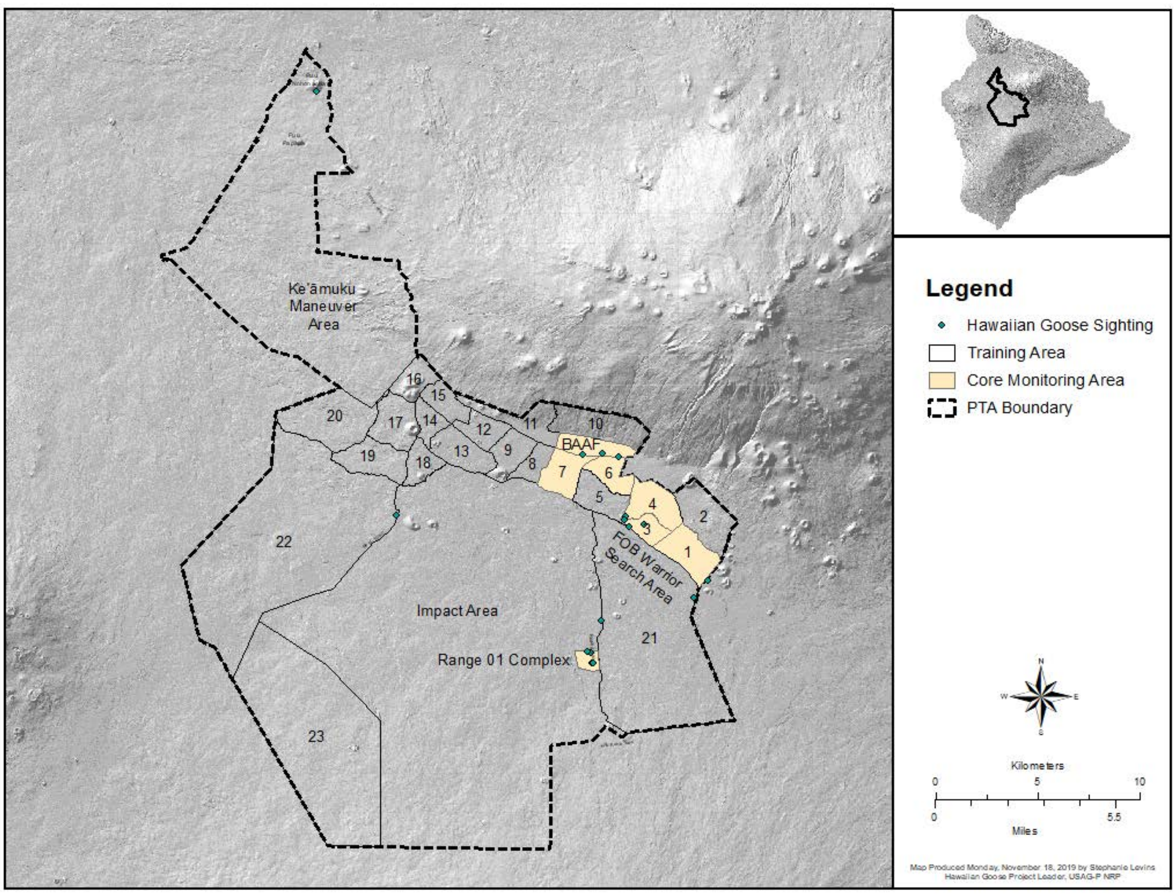

Figure E1. Hawaiian Goose sightings in FY 2019 and core monitoring areas at Pōhakuloa Training Area

Table E4. Hawaiian Goose systematic monitoring data

Survey Areas	No. of Surveys	No. of Surveys with Goose Presence	Total Goose Observations[a]	With Bands	W/out Bands	Band not Identified
Range 1 Complex	34	4	12	7	0	5
FOB[b] Warrior Search Area	35	4	8	0	0	8
Bradshaw Army Airfield	36	0	0	0	0	0
Training Areas 6 and 7	35	0	0	0	0	0

[a] Total goose observations included repeated visits of geese with leg-bands and repeat visits of birds without bands or when the bands could not be identified.
[b] FOB, Forward Operating Base

Incidental Sightings Results

We observed 18 geese from 5 incidental sighting events in the core monitoring areas (Figure E1 and Table E5). Two individual geese were identified by their leg-bands and we were unable to identify leg-bands for the remaining 16 geese (Table E5). In non-core areas, 12 goose observations were reported from 4 incidental sighting events. We were unable to determine the presence of leg-bands for all 12 geese observed (Table E5).

Table E5. Hawaiian Goose incidental sightings by location and geese leg-band information

Survey Areas	Incidental Sighting Events	Total Goose Observations[a]	With Bands	W/out Bands	Band not Identified
Core Area					
Range 1 Complex	0	0	0	0	0
FOB[b] Warrior Search Area	2	11	0	0	11
Bradshaw Army Airfield	1	3	0	0	3
Training Areas 6 and 7	2	4	2	0	2
Non-Core Areas	4	12	0	0	12

[a] Total goose observations included repeated visits of geese with leg-bands and repeat visits of birds without bands or when the bands could not be identified.
[b] FOB, Forward Operating Base

Targeted Monitoring Results

No Hawaiian Goose molting or breeding occurred at PTA during the reporting period. Therefore, we did not initiate targeted monitoring.

Management Activities

Actions to Monitor and Manage Hawaiian Goose Breeding Activity

No Hawaiian Goose breeding activity occurred at PTA during the reporting period.

Actions to Minimize Conflicts between Training and Hawaiian Geese

The 2013 BO requires the Army to modify the habitat at the Range 1 Complex before selecting hazing as an option. This requirement involves 2 operations: habitat modification and habitat enhancement. Habitat modification involves selectively controlling and eliminating food availability for the Hawaiian Goose, primarily hairy wallaby oatgrass (*Rytidosperma pilosum*), and allowing other vegetation to persist. By creating a habitat with dense ground cover and limited food availability, the Army's goal is to deter geese from live-fire training areas at the Range 1 Complex. Habitat modification is limited to a general area at the complex where Hawaiian Geese often feed and loaf (Figure E2).

Hawaiian Goose habitat enhancement occurs within the WEA fence unit proximate to the Range 1 Complex (Figure E2). Habitat enhancement includes promoting habitat and food availability by selectively cutting and applying herbicide to unwanted weed species, such as fireweed (*Senecio madagascariensis*), fountain grass (*Cenchrus setaceus*), and other non-native plants that outcompete plants preferred by geese. The Army's goal for habitat enhancement is to attract geese to the WEA and away from live-fire training areas at the Range 1 Complex.

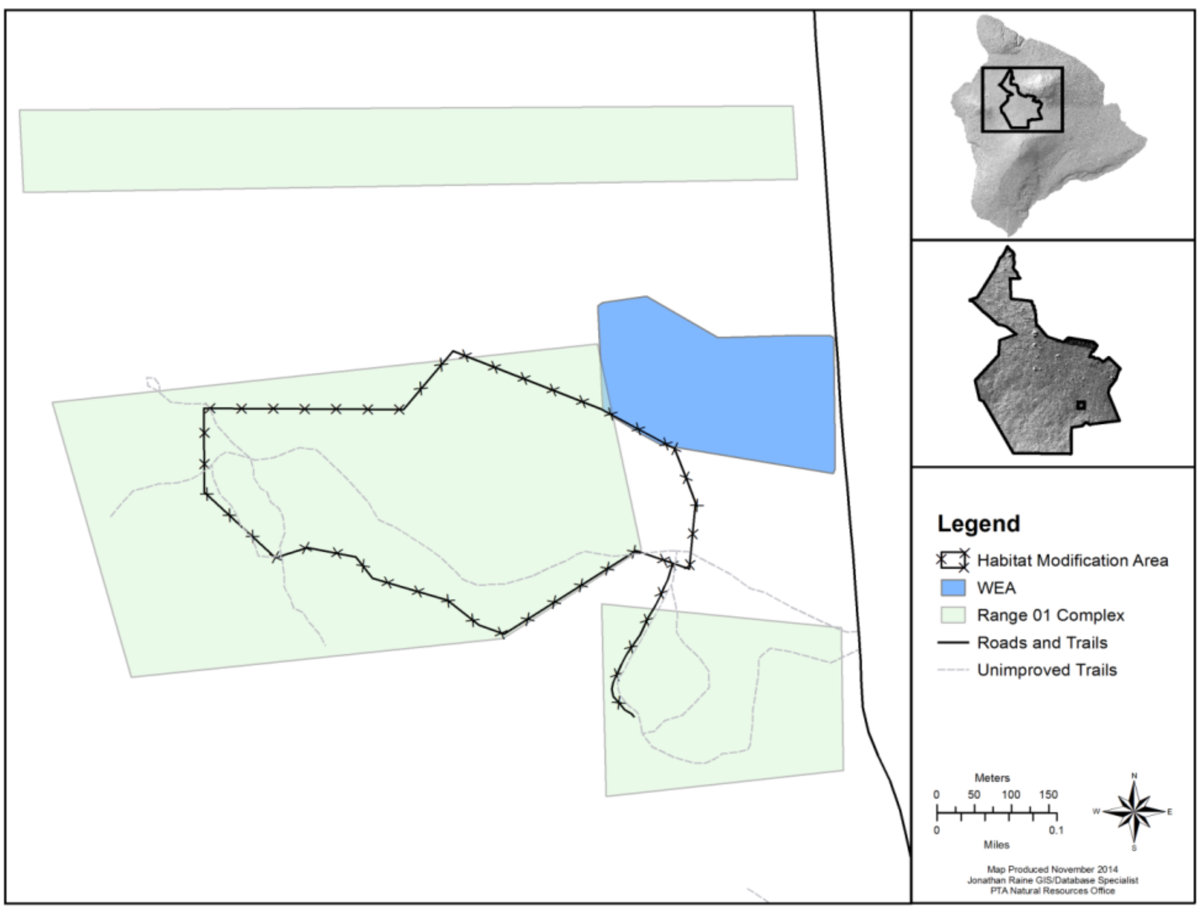

Figure E2. Hawaiian Goose habitat modification area and the Wildlife Enhancement Area at Range 1 Complex, Pōhakuloa Training Area

No habitat enhancement occurred at the WEA during the reporting period. There was very little *S. madagascariensis* growth and lots of *R. pilosum* growing at the WEA. In addition, due to scheduling conflicts with military training we were unable to access the WEA. Therefore, cutting or spraying for invasive plants did not occur. No geese were observed in the WEA.

Incidental Take Statement Requirements

Hazing Operations at Live-fire and Maneuvering Ranges

No hazing occurred at PTA during the reporting period.

Hawaiian Goose Incidental Take Report

No incidental take occurred at PTA during the reporting period.

Required Briefs

To minimize and avoid impacts to Hawaiian Geese, we brief military unit leaders (e.g., Commanders, Officers in Charge, Range Safety Officers, and Non-commissioned Officers) 90 and/or 30 days before the main body of the unit arrives at the installation on their responsibilities to protect geese at PTA, especially while driving and conducting live-fire exercises.

We delivered 16 briefings to military unit leaders, briefed the PTA directorates at least annually, and provided briefs as necessary when new employees were hired.

Discussion for Hawaiian Goose Management at Pōhakuloa Training Area

Overall the number of geese detected during systematic surveys for all core areas pooled has remained low over the past 3 years with 8 detections over 77 surveys in FY 2017, 3 detections over 84 surveys in FY 2018, and 8 detections over 140 surveys in FY 2019. Systematic and opportunistic observations of geese suggest that the birds are spending less time in high-conflict areas such as the Range 1 Complex. This pattern is also supported by the reduced number of interrupted training events and requests for natural resources program support due to geese on the ranges. We will continue management actions to discourage geese from feeding and loafing in high-conflict areas.

2.2.2 Off-site Hawaiian Goose Management at Hakalau National Forest Wildlife Refuge

In January 2017, the Army initiated a Hawaiian Goose conservation project in collaboration with HFNWR to satisfy 2013 BO requirements identified in the project description and Terms and Conditions. The goal of this project is to increase Hawaiian Goose productivity (i.e., the number of hatchlings surviving to adulthood) by improving nesting success, forage, and future nesting habitat, and by minimizing threats from predators. The Army is managing for geese in the Pua ʻĀkala and Middle Road management areas of HFNWR, collectively referred to hereafter as the Army-supported management areas (Figure E3). Habitat management activities within the Pua ʻĀkala management area only occur within the formerly proposed predator-proof fence.

To be consistent with refuge goals, we developed a management action plan with HFNWR to include: (1) habitat management, (2) goose monitoring, (3) nest monitoring, and (4) predator control.

On 16 August 2019, we submitted the *2018/2019 Breeding Season Report for Hawaiian Goose Conservation Project, Hakalau Forest National Wildlife Refuge* to HFNWR and USFWS (CEMML 2019). The report summarizes the management activities for the 2018/2019 Hawaiian Goose breeding season. This letter presents only major highlights from the report for Hawaiian Goose habitat management, goose monitoring, nest monitoring, and predator control.

Habitat Management

The Army manages habitat within the Pua ʻĀkala management area by cutting grass and removing invasive plant species to enhance goose foraging grounds. Inadequate nutritional quality is a limiting factor for the reproduction of Hawaiian Geese and gosling survival at high elevation sites (USFWS 2004). Although the effects of habitat management (e.g., mowing grass or planting food plants) on geese productivity have not been well studied at high elevations, forage quality and availability is increased when managed.

In November 2018, March 2019, and July 2019, we cut 1.2 ha of thick kikuyu grass (*Cenchrus clandestinus*) with weed whackers and a large deck mower within the Pua ʻĀkala management area (Figure F3). We also spot-sprayed 3 invasive plants: blackberry (*Rubus discolor*), bull thistle (*Cirsium* vulgare), and gorse (U*lex europaeus*).

Hawaiian Goose Monitoring

We monitored Hawaiian Geese between September 2018–April 2019. We sighted and recorded 89 geese foraging and loafing inside the Army-managed areas: 67 banded individuals, 6 unbanded individuals that were identifiable by their banded partner, and 16 unbanded fledglings that were identifiable by one or more banded parents (Figure E3).

Hawaiian Goose Nest Searching and Monitoring

Between September 2018 and April 2019, 13 nests were discovered and monitored from 13 pairs of geese (Figure E3). In total, 20 goslings fledged from the Army-managed areas. This was 77% of our target production of 26 fledglings per year, as per the 2013 BO. As acknowledged by the USFWS in the BO, conservation projects will take several years to refine before production targets can be fully actualized. We plan to continue to refine management and monitoring techniques to improve nesting success and fledging rates.

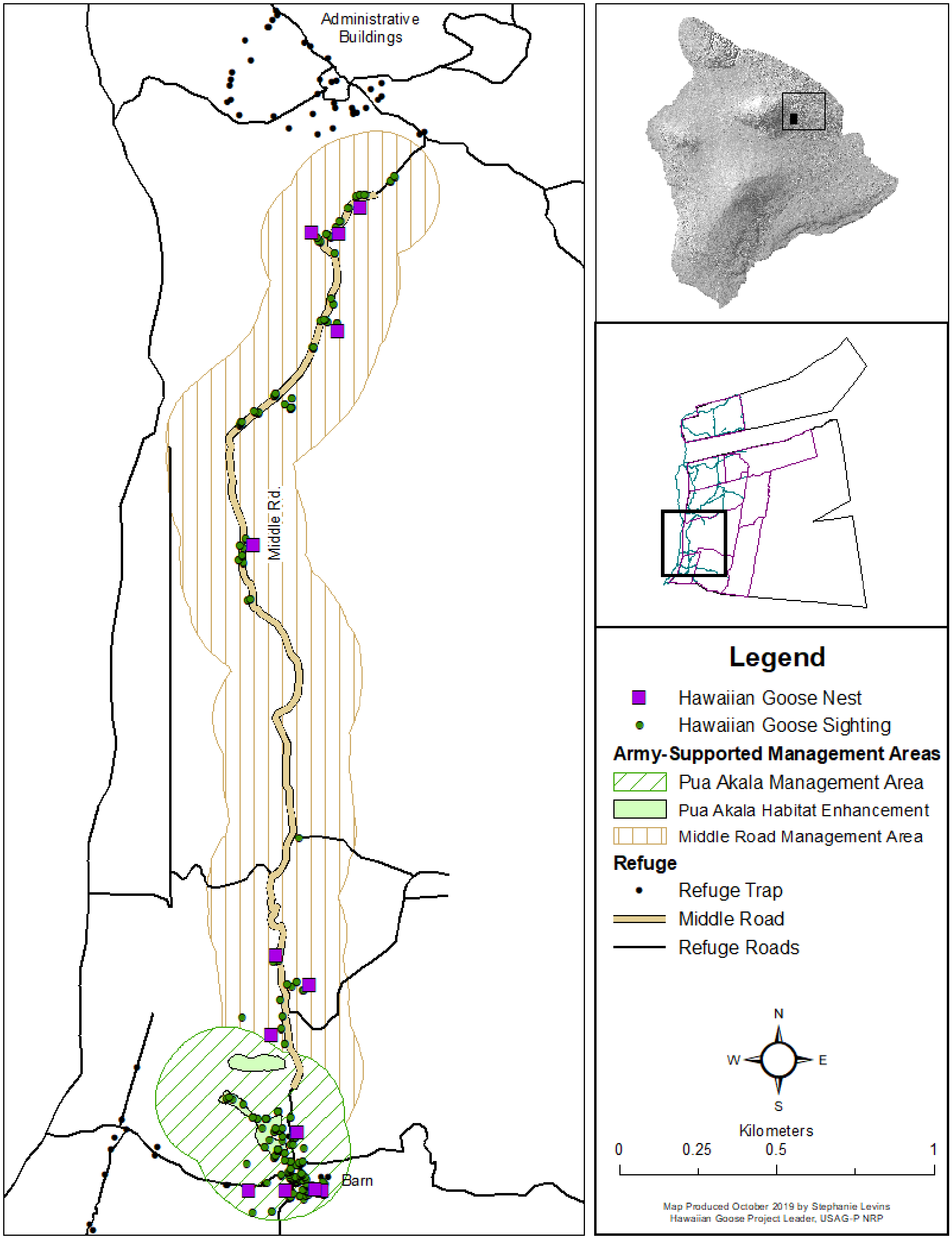

Figure E3. Hawaiian Goose sightings, nest locations, and Army-supported management areas at Hakalau Forest National Wildlife

Predator Control at Hakalau National Forest Wildlife Refuge

We implement cat, mongoose, and rodent control in the Army-managed areas and wherever geese are likely to nest, with the goal of increasing nest success and gosling survivorship. Overall a total of 2 feral cats, 8 mongooses, and 6 rats were removed from the management areas.

Discussion for Hawaiian Goose Management at Hakalau National Forest Wildlife Refuge

Overall, implementation of the Hawaiian Goose conservation project at HFNWR during the reporting period was successful. Twenty goslings fledged from Army-managed areas. Geese continued to be attracted to and use the habitat enhancement area due to the maintenance activities performed, which resulted in relatively uniform grass re-growth that can be maintained with a mower and minimize the amount of resources (i.e., personnel time and labor) needed to maintain the site. Although these management activities do not directly translate into numbers of geese fledged, they do directly support and benefit the HFNWR goose population with predator removal and enhanced nesting/foraging habitat for geese, which are important steps towards the overall success of goose conservation at the refuge.

Since January 2017, management activities in the Army-managed areas have supported 32 Hawaiian Geese fledglings across 3 breeding seasons. With continued management activities in the next 2019/2020 breeding season, we anticipated that the fledging numbers may be sustained and/or may ideally increase; other influencing factors not withstanding (i.e., weather, disease, etc.). This may result in meeting the annual 26 fledging requirements within the near future.

2.3 HAWAIIAN HOARY BAT

2.3.1 Introduction

The 2003 and 2008 USFWS BOs require the Army to implement a bat monitoring program to determine Hawaiian hoary bat presence and habitat use at PTA. The goal of the Hawaiian hoary bat monitoring project was to determine occupancy and seasonal activity patterns throughout the installation. The study was also meant to identify habitat association based on 5 vegetation classes, and bat prevalence in potential treeland roosting habitats more generally.

2.3.2 Monitoring for the Hawaiian Hoary Bat at PTA

Refer to the Hawaiian hoary bat Section 4.2.4 of this biennial report for a detailed description of the methods, results and discussion of the 2014–2019 seasonal activity analysis and the 2014–2017 occupancy analysis.

Overall, the acoustic occupancy and activity analyses show that bats are present across the installation throughout the year and that activity is highest during the autumn months and lowest during the winter months. In FY 2020 we will focus on sampling on the peak of activity in 2019 to help clarify previous occupancy estimates. We will continue collecting seasonal activity data throughout the year.

The collection of seasonal activity and occupancy data at PTA helps the military anticipate potential hazards to bats such as fire, military training or construction.

Incidental Take Statement Requirements

Direct take due to military activities

No Hawaiian hoary bats were taken at PTA during the reporting period.

Direct take due to bat entanglements on barbed wire security fences

No Hawaiian hoary bat entanglements were discovered at PTA during the reporting period.

On 5 September 2019, a Cultural Resource Program staff member discovered and reported a Hawaiian hoary bat carcass next to the Natural Resources Program building 227A at PTA. The carcass (sex unknown) was on the ground 2.6 m away from the 227A building. Based on a visual observation of the carcass and the surrounding areas it is unlikely that the bat died due to military training activities. On 19 September 2019, we shipped the bat carcass to the Bishop Museum and an incidental report was submitted to the USFWS (see Appendix D, Wildlife Enclosure 1).

2.4 WILDLAND FIRE IMPACTS TO WILDLIFE

The 2003 BO (USFWS 2003) requires the Army to indirectly monitor Hawaiian hoary bat incidental take as the amount of treeland habitat destroyed outside the Impact Area annually. The Army is covered for take associated with the loss of no more than 48 ha per year of potential available treeland roosting habitat outside the Impact Area and cumulative losses of no more than 1,345 ha outside the Impact Area. Treeland loss primarily occurs from wildland fire, but other military actions, such as maneuvers, live-fire, and construction also influence losses.

No wildland fires occurred in FY 2019 and no additional treeland habitat was lost by military actions, such as maneuvers, live-fire, and construction.

2.5 MIGRATORY BIRD INCIDENTAL TAKE SUMMARY

The Army is required to protect migratory birds and their habitats. The USFWS has authorized incidental take of MBTA-protected species for Department of Defense projects that are deemed military readiness activities. NEPA documents for military activities and the PTA INRMP (USAG-P 2019) both address management for MBTA-protected species. The INRMP also establishes annual reporting requirements for incidental take that results from military readiness activities.

No incidental take occurred for migratory birds due to military readiness activities at PTA in FY 2019.

APPENDIX E REFERENCES

[CEMML] Center for Environmental Management of Military Lands. 2019. 2018/2019 breeding season report for the Hawaiian Goose conservation project at Hakalau Forest National Wildlife Refuge, Hawaiʻi Island, Hawaiʻi. Fort Collins (CO): Colorado State University. 10 p.

[USAG-P] United States Army Garrison, Pōhakuloa Training Area. 2019. Integrated natural resources management plan 2019-2023, Pōhakuloa Training Area, Hawaiʻi. Fort Collins (CO): Colorado State University, Center for Environmental Management of Military Lands. 191 p.

[USFWS] United States Fish and Wildlife Service. 2003. Biological Opinion of the US Fish and Wildlife Service for routine military training and transformation of the 2nd Brigade 25th Infantry Division (Light), Army Installations, Island of Hawaiʻi. Portland (OR): US Fish and Wildlife Service, Pacific Region. 215 p.

[USFWS] United States Fish and Wildlife Service. 2004. Draft revised recovery plan for the nēnē or Hawaiian Goose (*Branta sandvicensis*). Portland (OR): US Fish and Wildlife Service, Pacific Region. 148 p.

[USFWS] United States Fish and Wildlife Service. 2013. Informal consultation and formal consultation with a biological opinion for the construction, maintenance, and operation of an Infantry Platoon Battle Area and installation-wide impacts of military training on Hawaiian Geese at Pōhakuloa Training Area, Hawaiʻi. Honolulu (HI): US Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office. 68 p.